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PC Power Management

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Abstract

The purpose of this study is to explore the area surrounding computer energy consumption. After reviewing general background on related fields we measured energy consumption among different computers and monitors. Based on the results we constructed a survey aimed at Swedish schools. Using a quantitative approach we draw some conclusions, a majority of the respondents lacked someone responsible of shutting down computers after hours; even more lacked a tool to do so. With the help of our survey result we demonstrate how organization could reduce energy waste and receive financial benefits, with a minimal effort. To enhance the power management in an environment with computer networks we introduced related techniques and describe how they operate. We then suggest a centralized solution based on open source. Our intention is to provide references and discuss several of the open source implementations that freely exist.

Acknowledgements

We would like to thank those who have supported and encouraged us during this work. Special consideration is given to Umberto Fiaccadori, Campeon Frigymnasium, LAN Zone and all the schools across Sweden for participating in our survey. We gratefully hand you this thesis and bow for your interest and invested time.

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1 Introduction

1.1 Background

This study is a direct response to the increasing energy consumptions among PC computers used within organisations around the world. Our attention was recently caught while reading articles concerning computer energy consumption being unnecessary wasteful. Surprisingly to us, there is obvious potential for savings. This would clearly be beneficial for both economical and environmental reasons. A survey recently issued by FujitsuSiemens claimed that £123m is wasted every year in the UK alone, simply by not shutting down computers during periods of non-use (Fujitsu-Siemens, *Big Turn Off Campaign,* 2005) The European Commission has presented legislation directive, Eco-Design of Energy Using Products (EUP). EUP strive to lower the inefficient energy consumption in products such as computers and household appliances (Energy Demand Management, 2006) In the US the Environmental Protection Agency (EPA) launched the voluntary Energy Star program in 1992 to provide the industry with a standard for conserving energy. These functions now exist in nearly every PC on the market but unfortunately they are often not activated or configured properly (Nordman et al 1997). We intend to further study this among organizations in Sweden.

1.2 Purpose

The purpose of this study is to explore the area surrounding computer energy consumption and relate this to existing knowledge. We investigate available techniques for energy conservation and management options concerning desktop computers. To better understand how these functions are used we held a survey with a number of Swedish schools. We investigate available techniques and propose open source software solution to reduce the energy consumption. Our ambition is to demonstrate how a minimal effort could provide a substantial environmental and economical benefit, with a minimal implementation cost and inconvenience to the end user.

1.3 Target audience

The intended target for this study is both managers and technical staff within small to medium sized organizations using standard desktop computers and networks.
Chapter 7 contain technical suggestions that we deem to be important for an optimal use of computers energy consumption. Therefore, this chapter might interest a more technical orientated crowd interested in solving the energy inefficient computer usage.
We also think information regarding energy management is something that might appeal to system designers and administrators since it involves saving energy and money with minimal efforts, this is why we believe this is a relevant issue in the field of system design science.

1.4 Delimitations

Our research is delimited to desktop computers and monitors; we exclude other computer related office equipment such as speakers, scanners, printers and network equipment like hubs and routers. We also limit our survey respondents to Swedish schools; we choose schools because of the multiple users per computer environment suitable for major savings in energy. They have a very distinct use during the day, this making the schools grateful subjects of our research. Schools also present an easy implementation of power management functions since their IT platform usually is straightforward with a dense number of computers located in a few classrooms. Never the less the technical platforms used in schools are found in many other types of organizations, thus this thesis could be interesting for a wider audience. When talking about computers energy consumption and environmental issues it could be of interest to research these issues in a lifecycle perspective. In a lifecycle perspective our focus will be on PC energy consumption and PC power management, thus we are not researching the complete lifecycle of a computer. Involving other areas of the PC lifecycle would be an overwhelming task.

1.5 Thesis structure

Chapter 2 is dedicated to the general background on related fields. We present the environmental and economical consequences of wasteful energy consumption. We introduce the organizations responsible for industry standards and platform development used for power management. Lastly we discuss the current trends in hardware and software in the aspect of energy consumption.

Chapters 3 offer a presentation of different hardware and software energy conservation techniques and describe how they work. We also discuss different dilemmas that could affect users and administrators view on power management and resulting in disabling it.

Chapter 4 describes our methodology, presenting for the reader our way of collecting data, the thoughts behind our survey and our view on knowledge, reliability and validity.

Chapter 5 presents our empirical research. We analyze the results of both our energy measurement study and our survey which was conducted with Swedish organizations to better understand computer energy consumption and how power management is used.

Chapter 6 tries to give an understanding of how much energy one single computer consumes when being on for a certain period of time. We use these energy calculations to present the economical costs and potential savings involved when using power management functions. We are using our energy measurements from chapter 5 to create, in our opinion, realistic calculations.

Chapter 7 presents our proposed power management solution. Taking into account our energy measurements and our energy survey in chapter 5 together with our energy calculations from chapter 6 we present available tools that could be used to create an effective solution for centralized and automated power management. Different techniques for network communication and power management command issuing over a typical school network is discussed. We give a few directions on how to develop a cost-effective, open source based energy management system suitable for many organizations.

Chapter 8 concludes the thesis and summarises our research results. We reflect on the impacts of energy conservation and power management and discuss further work.

2 General background on related fields

Our intention with this chapter is to introduce the area surrounding energy consumption caused by computers, its effects and organizations concerned with establishing energy conservation techniques among computer systems, also known as power management. These organizations are responsible for standardization and guideline development. We briefly introduce some of the environmental, economical and organizational impacts that the inefficient uses of computers causes. This is followed by a quick introduction to the amounts of electricity used by components in a modern desktop computer.

2.1 Environmental Issues

We are using more energy than ever (IEA International Energy Outlook, 2005), new technology often demands more energy than the old technology, cars are getting bigger and computers are getting faster. To satisfy our way of life we need to use more energy than ever.

In 1896 the Swedish scientist Arrhenius conducted research on past ice ages and how they developed. Arrhenius predicted that the decrease in CO_2 caused these past ice ages. Today, he is now seen as one of scientists that made the earliest scientific observations on global climate change. If one would take Arrhenius work and reverse it, we get global warming, the backside of the energy demanding society that we all live in and contribute to. When the ice ages developed because of the decrease of CO2, the global warming is developing because of the increase of CO2. This is possible because the energy from the sun drives the earth's weather and climate. It heats the surface of the earth and the earth radiates energy back through the atmosphere into the space. For more than a century, mankind has relied on fossil fuels such as oil, coal and gas for their energy needs. Burning these fossil fuels releases the global warming inducing gas carbon dioxide into the atmosphere. These gasses are enhancing the heat-trapping effect of the atmosphere; the heat normally would have been going back into space is now trapped between the earth and the atmosphere (EPA Global Warming - Climate, 2000). You can compare this function to the glass panels in a greenhouse that keeps the solar energy inside, thus it's called the 'greenhouse effect'.

2.2 Economical Issues

Inefficient energy use is a waste of financial resources. Since many organizations worldwide are becoming more and more computerized, energy consumption adds up to a noticeable cost. Newer and faster computers usually do not have ambitions to use less energy, instead new computer components uses more energy than their predecessors do. This trend is however not true for the LCD flat screen monitors. The new LCD typically draws 57 percent less energy than an equally sized CRT display (Rocky Mountain Institute, 2004). In addition to this CRT monitors draws 7 watts in sleep mode while the LCD monitors use only 2 watt. If the users acknowledge this and activates power management or turns off the monitor while not used, it would present a significant energy savings potential. If just an additional 10 % of monitors in the U.S. were shut off at night and on weekends, about $140 million of electricity could be saved each year (Nordman et al 1997)

The Energy Star organization provides a voluntarily labeling program for computer systems manufacturers. According to Energy Star the organization General Electric (GE) is saving 42 million kilowatt hours per year by using Energy Star functions, that is enough energy to light nearly 400 000 U.S homes per month. According to Energy Star these actions have reduced emission of greenhouse gasses by over 27 000 metric tons per year (Energy Star GM Press release, 2003). The North Thurston Public Schools (NTPS) that in a case study done by Energy Star saves $45 000 by enabling power saving features. These features, also known as "sleep settings," place computers components and monitors into a low-power sleep mode when idle. While the NTPS see economical savings on these features, it prevents waste of 900 000kWh annually reducing 600 tons of greenhouse gasses to be released (North Thurston case study, 2006).

Tufts University is committed to meeting or beating the Kyoto target for university-related greenhouse gas emissions. According to the Tufts Climate Initiative (TCI) PCs and monitors in the U.S commercial sector uses 32 billion kWh electricity each year, more than half of this could be saved by using power management such as turning of the monitor and turning off the PC during non-office hours (Tufts Climate Initiative FAQ, 2006).

2.3 Industry standards and organizations

In our power consuming societies we acknowledge the fact that we need more and more energy to sustain our modern lives and its standards. In response to this, organizations and governments seek to minimize the waste of electricity in for example offices with computers, monitors and other office equipment. The two largest of these organizations are Energy Star and TCO Development. The Energy Star (ES) is the world's most widespread energy management standard. Since 1992 more than 2 billion products certified by ES has been sold. Of these 2 billion products 49% was computers, monitors and other office equipment. In the year of 2005 alone 175 million ES certified precuts have been sold in the US (Energy Star achievements, 2005). TCO Development is an organization which labels products that meet specific requirements in among else energy, ecology and emission of brominated flame-retardants. TCO is most successful with its monitor labeling program. Half of all monitors sold worldwide since 1992 has the TCO label (Nordin, 2005).

2.3.1 Energy Star

Energy Star (ES) was a program established back in 1992 sponsored and developed by the U.S environmental protection agency (EPA). The programs goal is to reduce the greenhouse gas emission by voluntarily labeling products with low power consumption. The first products to be labeled were computers and monitors. The success with labeling of computers and monitors made energy star expand into other areas as well. In 1995 the voluntarily labeling also included office products and residential heating and cooling equipment. The program now covers a wide range of equipment including certifications of entire buildings and new homes. The organization claims to have delivered energy and cost savings to a value of 12$ billion dollars during the year of 2005 in the U.S alone (Energy Star; about, 2005). The Energy Star has played a large role in making the office equipment and home electronics more energy efficient. ES recognizes that much of these products consume most of their energy when in standby mode, not apparent to the user. Through ES, the energy needs during standby have been greatly reduced with no change in product performance (Energy star; history, 2005).

In December 2000 an agreement between the Government of the United States of America and the European Community was signed. The agreement concluded that the ES program was to be established in the European Union. A similar agreement is also established between Australia and the US. According to the European Community Energy Star Program (ECESP) office equipment is the group of products with the highest saving potential. Energy saving potential of office equipment with appropriate policies and measures is over 50%. (EU Energy star, 060513)

According to European Climate Change Program (ECCP), office equipment will make up some 8.9% of the electricity bill of the average EU household. Total annual electricity expenditure for EU-15 citizens for home office equipment will be close to € 7-8 billion (€ 7000-8000 million). The ECCP indicates that if energy saving program is used electricity consumption could drop to 31 TWh/yr, meaning total annual electricity usage for EU-15 citizens for home office equipment could be able to drop to € 4 billion (EU Energy star, 060513).

In 2007 Energy Star intend to revise its requirements for computers by introducing new, stricter, measurement demands of energy consumption while in idle mode. That is, when the computer is on but with no usage. The requirements are still being developed.

2.3.2 Energy Star product guidelines

The Energy Star program certifies that products are compliant and fitted with energy conservation technology. For computers this mean that computers should have the ability to 1) Automatically enter a low-power "sleep" mode after a period of inactivity. 2) Include mechanisms through which the low-power modes can be activated on monitors. 3) Have energy-efficiency specifications based on power supply

Table 1 Key Product Criteria for ENERGY STAR Qualified Computers. Note that manufacturers may qualify computers as ES qualified under one of the two above guidelines (Energy Star Key Product Criteria, 2006).

Ship date	Guideline	Power Consumption	
July 1, 2000		Power Supply	Watts (W) in Sleep Mode
	Shall enter a sleep mode within 30 minutes of inactivity If shipped with network capability, shall sleep on networks and respond to wake events	< 200W > 200W	< 15% of power supply's maximum continuous output rating
After July 1, 2000	Shall enter a sleep mode within 30 minutes of inactivity If shipped with network capability, shall sleep on ne respond to wake events	Guideline **A:** < 200W > 200W < 300W > 300W < 350W > 350W < 400W > 400W	< 15W < 20W < 25W < 30W < 10% of power supply's maximum continuous output rating
		Guideline **B***	< 15% of power supply maximum continuous outpu

2.3.3 TCO Development

AT the start of the 80's, a growing number of computer users had been affected by stress injuries and sight impairing issues as a result of daylong work in front of computer monitors. During this time concerns emerged regarding the electrical and magnetic field from monitors (TCO Website, 060510). The Swedish Confederation of Professional Employees, TCO or "Tjänstemännens Centralorganisation", acknowledged the problems and a TCO computer group started discussions about the possibility of testing and thereby grading monitors.

The initial work started in 1992 and a TCO passed resolution to introduce labeling of computer displays and keyboards. By the end on 1992 a co-operative alliance launched the first TCO labeling program called TCO'92. The labeling has since them emerged with TCO'95, TCO'99, TCO'03 and the latest TCO'05. Along with the introduction of new labels follows stricter and harder requirements to be met. Today the organizations program contains requirements involving ergonomics, emission, energy and ecology (TCO Website, 060510).

The TCO'05 ergonomic requirements are, among others, that a monitor should be flicker free with good brightness and contrast. The emission requirements include reduction of magnetic and electric fields and another requirement is a low noise level. Energy requirement involves low energy consumption and energy saving function that provides a better indoor air quality, by reducing heat emission the air humidity can be retained. The newest requirements are concerning the ecology aspects. They seek to reduce emission of toxic substances such as brominated flame-retardants, mercury, cadmium, lead and hexavalent chromium (TCO 05 specifications, 2005). In line with this another requirement stresses that the equipment should be easily recycled and instructions on how to do so are included with the sale of the computer.

According to TCO Development there are both outdoor and indoor aspects of the energy consumption of desktop computers. The electricity consumed by a desktop computer is largely converted into heat energy and warms up the air inside building. In many cases this air needs to be cooled down again to provide a good working temperature, consuming more energy..

In their current program a desktop computer in sleep mode to consume a maximum of 5W and in off-mode a maximum of 2W (TCO 05 specifications, 2005).

TCO Development is awaiting the revised Energy Star criteria for computers. When the new criteria are released TCO may decide to change the energy criteria in TCO'05 desktop. TCO has an ambition to harmonize the energy criteria with Energy Star. Both organizations strive to counteract the current trend for global warming.

2.4 Computer power consumption

As computers become more and more integrated with our lives and society, we feel that it is necessary to reflect on how this affects the utilisation of energy. According to Roth et al. (2002) computers and monitors account for approximately 40% of the energy consumption used by office and telecommunication equipment in U.S commercial buildings. Our main concern for this thesis is how energy consumption reflects the actual use. Research presented by Nordman et al. (1997) shows that most of the time when computers are on they are not actively in use.

Nordman et. al (1997) estimates that typical PC's are used actively 4 hours on each workday, while being idle for 5.5 hours. In addition to this, one out of five office computers are left running during nights and weekends. Later on, we intend to survey important factors such as individual responsibility, policy and efficient tools.

The design of desktop computers today often relates to performance rather than efficient energy use. However, initiatives by the environmental, government and industry organizations have resulted in a widespread range of power management functionality. Sadly, we do not often see it advertised as a top selling argument for consumers, causing a limitation in its active use. With the prices for electricity steadily rising, we cannot help to wonder why.

2.5 Component energy consumption

2.5.1 Processors

The constant need for faster computers has led to a state where obvious problems have arisen. First, the high processor frequency levels have led to a situation where the heat dissipation poses a problem to efficiently cooling the processors using conventional methods, such as fans and metal heat sinks. This brings higher noise levels since the systems need multiple fans to remain at an acceptable working temperature. The two major manufactures of personal computer CPU's, Intel and AMD, have therefore revised the circuit layout and initiated a trend to move away from a single core working at a high frequency to multiple processor cores with lower frequencies. These work together within a single chip. In addition, both companies have also presented solutions to dynamically adjust the frequencies to match the utilization and load of running systems. Intel's solution is called SpeedStep and AMD's Cool n' Quiet. Both manufactures are constantly moving to reduce the internal size of the chip to decrease the amount of heat and power consumption while offering higher performance. This trend should be considered from the manufacturing cost, a smaller chip size enables more chips from each wafer production (C-Net News, 20020515) However, a typical computer consists of many different components with various levels of energy consumption.

2.5.2 Monitors

Due to their attractive, space saving design and clear image the flat panel LCD monitors are they are a natural choice for most consumers today. Most manufactures no longer produce the CRT monitors and they are increasingly harder to come by. However, the CRT monitors are still widely spread and used daily in a large number of organizations and therefore relevant for inclusion.

According to Roberson et al (2002) LCD monitors use less energy than the CRT monitors. Their study on monitors and personal computers shows that a 15" LCD monitor consume only 30% as much power as a 15" CRT monitor and it also show that a 17" LCD consumes 51% as much power as a 17" CRT, these numbers shows the energy use when the equipment is powered on and not in sleep mode.

According to the DisplaySearch report, "The Quarterly Desktop Monitor Shipment and Forecast Report" (DisplaySearch, 2005) the 15", 17" and 19" models are the most popular sizes, collectively accounting for 95.5% of all LCD desktop monitors sold in Q4 2005. Based on the measurements of Nordman (2002) these monitors consume less of the energy and generate less heat then traditional CRT monitors. However, as displayed in figure 1 the watt per square inch follows different patterns between the two types, suggesting that large LCD monitors (>21") consume equal or more energy than similar sized CRT monitors.

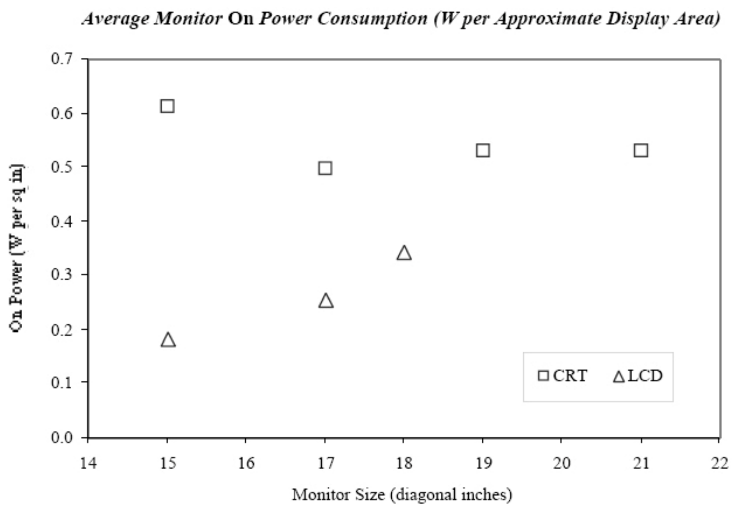


Figure 1 Nordman et al (2002) Monitor power consumption, watts per approximate display area.

2.5.3 Other computer components

The current trend within graphic cards is that the processor is running at higher frequencies for every new model, due to the evolution of 3D graphics with evermore complex models and higher levels of details. Most organizations may not need the 3D functionality but the standard desktop this year usually contains a more powerful graphics card than it did the year before. The top-of-the-line 3D graphics cards consume vast amounts of energy, in some cases up to 158 watts in two dimensional environments such as Windows XP and 287 watts while rendering 3D graphics (Toms Hardware, December 9, 2005). The upcoming version of Microsoft Windows, known as Vista, will take advantage of 3D graphics for normal desktop operations. This will most likely create a demand for more powerful graphics in business desktop computers. According to Jon Peddie Research (Mikrodatorn, IDG Network, pp. 34 issue 5 2006), there is roughly one billion computers spread world wide with aged internal graphics capabilities. During the last three years, more than 600 million computers were sold and many are not equipped with advanced 3D graphics.

The energy consumption among other components varies but does not come close to the processor, graphics card or monitor. However, since more and more functionality is put in by default the watts still adds up. A hard drive usually requires 8-14W, with an average on 11.5W for random read/write operation (StorageReview, Nov. 3, 2005). The figures are similar for CD/DVD drives. The efficiency of the power supply deserves attention, it generally lose 15% of the incoming electricity to heat. These figures depend on manufacturer and component quality. (Tanenbaum, 2006)

2.6 Summary

As we have seen in this chapter different computer components use different amounts of energy. As a result of this some computers may use more or less energy than other computers, even if their performance is equal. This is important to know when handling power management. Industry standards and organization are trying to minimize the waste of energy with the voluntarily labeling of computers and monitors. We can see that those organizations are developing new guidelines which in the future will lead to harder requirements of using their label of energy efficiency.

3 Energy conservation using power management

The progress that has been made on power management originally came from the laptop computers, where it was essential to enhance the time it could operate on batteries. The design of the desktop computers has benefited by having some of those functions incorporated. These are generally a combination of hardware and software techniques working together to initiate a state of lower energy consumption. Today most computers have energy saving functions built in, either at a low-level hardware or in the operating system software. In this chapter we try clarify the most common of these techniques. We also discuss some dilemmas that may result in disabling these energy conserving techniques.

3.1 How power management techniques function

The trend in the industry has been to relocate the functions from the lower hardware application level (BIOS) to the operating system. This leads to more advanced software capable of dynamically monitoring current application activity, involving more complex usage patterns algorithms to predict use and increasing potential energy savings.

3.1.1 Power management modes

There are generally four different states that a power management equipped computer can initiate. Besides the obvious on and off, the systems are usually capable of initiating a doze state after a period of inactivity. After a given time in this state a second deeper standby or suspend mode could be activated. Every state saves more energy but also increases the time it takes to resume the normal operating state. The number of different modes varies among different BIOS systems. The delay between the different modes is usually defined in the BIOS software (Nordman et al. 1997)

3.1.2 Advanced Power Management (APM)

The APM protocol was introduced by Intel and Microsoft in 1993 and has become the de facto industry standard for power management. The protocol defines how power management commands are communicated within the different software and hardware layers in the system. (Nordman et al, 1997) In APM the Basic Input/Output System (BIOS) software solely controls power management functions. The APM is located close to the hardware in the BIOS level of the system with no communication with the operating system or applications. In 1996, the architecture was revised, adding more control to the operating system. (Nordman et al. 1997)

3.1.3 Advanced Configuration and Power Interface (ACPI)

Intel, Toshiba and Microsoft launched the ACPI in 1997 with the ambition to transfer the power management features from the hardware to the operating system. This allows software running in the computer to dynamically adjust energy requirements and initiate various levels of energy saving states. Usually this is called Dynamic Power Management (DPM) and offers functionality to adjust the processor speed dynamically and shutting down external devices after a time of inactivity. Some implementations are equipped with more intelligent algorithms that predict when idle situations are to appear. The software is also capable of rearranging the task execution to maximize idle time, thus increasing the potential energy saving state (Swaminathan et al 2003) However, it becomes increasingly challenging to create platform independent power management applications the further they are moved from the hardware layer. To handle the wide range of hardware and software platforms it is important that the software is built upon portable Application Program Interfaces (API's) based on the standard Portable Operating System Interface (POSIX) (Pereira et al, 1997)

3.1.4 Hibernate – Computer sleep mode

Many mammals in the nature and computers in wild offices have the ability to hibernate, thus initiating a dormant state during inactive periods. The idea of hibernation on computers is to save the current state of the applications running to the hard drive before shutting down. It provides a faster resume to the saved state, in a significant shorter time than a traditional start up. This functionality has been introduced to the majority of desktop computers since it is supported by Microsoft's Windows operating system (Power Management in Windows, 2006-06-04). It is a convenient way to conserve battery power on laptops when constantly moving around. This is where the technique most frequently is used. The hibernation can be set in Windows to initiate after a period of inactivity. However, hibernate does not fit in an environment where computers are shared among multiple users using roaming profiles since it saves the state that the applications are in. Among shared computers, the usual state when not in use is to display a login screen. Not much of a state to save, in our opinion, it would be better to shut the computer down outside office hours and initiate a low power mode when inactive for a specified length of time. However, to automatically shutdown the computers outside office hours will cause the open applications and files to close and not being saved. According to a presentation by Microsoft regarding "Longhorn Power Management Update" (P. Stemen & G. Miller, 2005) there has been several problems with hibernation such as component vetoes, hiberfile generation failure, state transition bugs etcetera.

3.2 Reasons for not using power management

3.2.1 Application intervention – network connectivity

Network connectivity is a main source of issues related to actions for disabling energy management functions. On a typical network, the server broadcasts requests to confirm that the client computers still are connected. If the computer is halted in energy saving state chances are that it will not respond to these calls and thereby disconnected. If it does respond, the activity might wake the computer from its sleep mode and thereby defeating the power management (Nordman et. al, 1997)

3.2.2 Myths about power management: Equipment damage and wear out

Another reason for disabling the power management features is the belief that components inside the computer, such as a hard drive, could be damaged by frequent start-up and shutdowns (Nordman et al, 1997). According to Nordman et al. (1997) these ideas persists from a time when hard disks had a different mechanical layout. The early hard drives did not park their writing and reading heads when they were shut off, frequent on and off cycling could actually harm these drives. Modern hard drives are not significantly affected like this by turning on and off. The US department of Energy Efficiency and Renewable Energy (EERE) confirms this with stating that most PCs are not used for a very long time, they reach the end of their ”useful” life before they reach their mechanical end of life. The less time a PC is on, the longer it will "last”.

3.2.3 Updates and patches

The distributed management of software updates is a clear trend in product support from many software resellers. Frequent virus definition files and application patches are updated using the Internet daily. In many cases, these updates are triggered by a connection to the update servers on the Internet, suggesting the need for constant network access. However, we believe that this activity does not generate massive amounts of downloads to justify a constant 24x7 operation. In organizations where software updates are actively managed and distributed we believe that a software tool used for starting and shutting down computers at any given time, would be a more flexible and energy effective solution. We intend to include this potential need in our empirical survey.

3.2.4 Energy, performance & response time

One of the most important aspects of power management is that it never should bring an unacceptable level of inconvenience for the end user, if it does its likely to be disabled. The time it takes to resume from a low power state should be kept as low as possible. The US department of Energy Efficiency and Renewable Energy (EERE) states that for cost effectiveness, an organization should consider how much time it takes to turn the computer off and on. If this takes too long the value of your time will probably be greater than the amount of energy saved by turning the computer off. Typically, it takes 3-10 seconds for a hard drive to resume operations after being shut off. The potential savings from a hard drive that consumes approximately 10 watts might not be worth the inconvenience for the end user.

The more important factor we believe is to minimize the idle on-time by shutting down computers outside office hours. According to the After-hours Power Status of Office Equipment and Inventory of Miscellaneous Plug-Load Equipment (Roberson et al, 2004) sixty percent of the desktop computers in typical offices are left running. The same report found that only 4% were in a low power state while 36% actually were turned off when not in use. These findings present, in our opinion, the most substantial savings potential that we intend to further investigate.

4 Research Method

In this chapter we will explain how we have conducted our research, by explaining the thoughts behind our measurement study and our survey we will create an understanding of how we have worked with our thesis. We describe what methodology we have used and our view on objectivity and reliability.

4.1 Procedure

Our first step in producing this thesis was a review of the general background to created an overview of the area. In our background study we found several studies which for example claimed that different types of monitors consumed various amounts of energy. As this was relevant to our study we conducted our own energy measurements involving different types of monitors and computers. Reviewing the area of energy management, techniques, studies and articles along with our energy measurements we found key factors regarding energy management. With this information we could create a survey with relevant questions regarding computers, their hardware and software and the use of energy management. We describe these questions more in our section on data collection. With the information gathered from our energy measurements and our survey we try to show how a minimal effort can save a substantial amount of energy and money. Our examples are applied to a single computer as well as an example organization created with data from our survey and theories described in our general background. Lastly we provide a proposed solution for centralized power managing and show how this solution could be implemented.

4.1.1 Positivistic approach

Our study was made in a positivistic spirit and our method, conducting a survey and analyzing it statistically is a clear positivistic approach. Studies in a positivistic spirit often seek quantities of empirical data which can be analyzed statistically. Since our study consist of a background review, energy measurements and a conducted survey it is fair to believe that if we do the same procedure again, we would get the same result. This is a typical positivistic opinion, if a study can be conducted several times and produce the same result as the first time, then the study is reliable and proper (Weber 2004). According to Bryman (2002) a positivistic approach is a knowledge theoretical standpoint which uses the approach of natural science in the study of the social reality and all its aspects.

4.2 Reliability and validity

In all science the reliability and validity aspects are important. We, the authors, need to give you, the reader, a proper analysis of the way we have handled these important aspects. Bryman (2002) classifies reliability in some important factors, the factors being stability and internal reliability.

4.2.1 Reliability and stability

With stability Bryman (2002) means that if we conduct the survey twice, we should get the same response both times. If we would get different sets of answer each time we conduct the survey, our research would not be seen as stable according to Bryman (2002). Since we have no possibility of conducting our survey twice, the time and effort of conducting an additional survey would exceed our given time, we acknowledge some factors that show our surveys stability. The first factor being that since we conduct our survey via the Internet the respondents can make their contribution whenever they feel that they have time, there is no pressure of having to take the survey a specific date or time. The respondents can decide to not take part. Another factor that we think contribute to the stability of our survey is that we have no or little possibility of trying to influence the respondents in any way since we lack the direct personal contact with the respondents. On the other hand, our measurements of the energy consumption regarding computers and monitors we presume to be stable if conducted on the same equipment twice unless computer energy consumption is affected by unknown factors.

4.2.2 Internal reliability

Internal reliability is according to Bryman (2002) the reliability of the respondents answers. Bryman (2002) means that different questions can contradict other questions in the same survey. We believe that since we have designed our survey with relatively few questions which are not contradicting, this making our surveys internal reliability satisfying. Bryman (2002) also focuses on the interpreting of the respondents answers, according to his theory there is always a risk of interpreting the questions in different ways. We believe that this is mainly a risk with other kinds of surveys since our survey has a number of questions which cannot be answered by any other way than marking out the answer the respondents feel is the right ones. We believe that since we have internal reliability in our survey, according to Bryman (2002), the main risk of compromising the research is in the interpreting stadium when we collect the answers and compile the results. This risk is minimized since we compile and review all parts of our data in a statistical manner. All answers have the same value to the compilation. We can also affect the validity of our survey by asking the right questions. To ask the right questions you have to investigate the context background, and this investigation can be seen in our chapter involving the general background on related fields.

4.2.3 Objectivity

In research it is important to be objective, this meaning that we don't take sides in any way giving our own opinions room, making our work reflect our own opinions and not the result of our scientific work. With this in mind, it is hard, if not impossible, to completely steer away our own valuations and thought to obtain a pure objective work. It is of great importance that researchers, as our selves, are aware of this problem and always strive for objectivity in for example surveys, choosing of method and the analysis of data (Bryman 2002). It is very hard or even impossible to make a entirely objective assessment since scientists always make some kind of interpretation of the material they observe (Weber 2004).

With this in mind, we will try to stay objective throughout our work, keeping an objective view and striving for value free formulations and perform our work, including the survey, in an objective manner. However, since we come from the informatics area we believe that issues created by the use of IT are rather solved with correcting the IT environment, rather than changing the behavior of the rest of the world.

4.3 Data Collection

Our primary data has been collected through our conducted survey and our energy measurement studies. We believe that it is important to know anything about the world to be able to say something about it, and in our case this knowledge requires the use of surveys and measurements. With our survey, which we aimed at Swedish schools and were answered by 137 respondents, we tried to create an understanding of how these organizations utilize power management features.

With our energy measurements study, involving computers and monitors, we could clearly see that older and newer computers and monitors were using various amounts of energy, even when they were not doing anything at all. Because of this, we involved questions about the schools computer setups in our survey. The combination of our survey and our energy measurements helped us create an understanding, which we could compare with earlier research by in the area. Our secondary data involved this earlier research, being mostly different academic papers and reports found and acquired through the Internet.

Conducting a survey among schools in Sweden gave us something to work with in our paper. It gave us information on how these schools work with power management and we used that information in this paper, we are aware of that our survey do not represent all organizations and their use of power management, the results can bee seen more as indications.

4.3.1 The Internet

When using Internet in the search of relevant information a critical point of view is necessary. When we found relevant information that we deemed interesting we made sure to check its source and location. Information that we found in academic papers and reports we regarded as valuable, this involved reports from different governments' health and energy departments. When browsing for information regarding our subject we found that the commercial powers were strong in this area, these websites were trying to promote themselves as for example providers of efficient software energy solutions. We have not used any of these commercial sources to gather any information because of the fact that they in a critical point of view cannot be seen as reliable. The techniques used in the commercial software are proprietary and concealed.

4.4 Survey

We conducted our survey to create an understanding in the area of our subject, power management. With questions regarding computer hardware, software and user habits, we created our own image of power managing and user habits.

The creation of our survey took place after we had researched the general background on related fields, this meaning that we created our survey when we knew what kind of questions that we would benefit of asking. Inspired by the research that we had been reading we came up with twelve questions suitable for non-technical staff. The full survey can be found in the appendix.

4.4.1 Hardware

When we conducted our research on the general background on related fields, we could see that the computers hardware could power manage in different ways, mostly depending of the age of the hardware. With our energy measurements, we also noticed that a computer monitor could be a crucial component when calculating energy use.

The older CRT-monitors used far more electricity in comparison with the newer LCD-monitors, because of this we felt it was important to know what kind of monitor the respondents were using in their organizations. By asking questions about the age of the hardware and the type of monitor, we could provide appropriate advice in this paper. For example, if none of the schools would have any CRT-monitors it would not have been very meaningful for us to provide energy savings calculations and power management advice regarding computer with this type of monitor.

4.4.2 Software

In our researching we also found that different types of operating system could power manage with different levels of efficiency and in different ways. Because of this we asked questions regarding the operating systems used in the respondents' organization. This would also provide us with a pointer on what platforms to consider when discussing technical solutions.

5 Empirical findings

In this chapter we present our empirical data, collected with our energy measurements and our survey. With our energy measurements we will show how much energy computers and different types of monitors can consume. Our survey respondents answered questions regarding the organization hardware, software, policies and responsibility.

5.1.1 Measuring equipment energy consumption

Since the subject's nature is rather technology orientated, we have used quantitative empirical surveys to investigate and contribute to the awareness of energy consumption among common computer equipment. To understand how the energy consumption is affected by different computer configurations we measured 13 computers and 23 monitors. These results are then compared to the more extensive surveys conducted by Nordman el al. (1997) and Roberson et al. (2004).

5.1.2 Energy consumption metering equipment

To measure the power consumption we used a power line meters (PLM) in our study. The model was PM300 from ETech. The manufacturer tested and calibrated them in Q2 2005 before released to the reseller. The PLM was acquired for the purpose of this survey and has not been used elsewhere. We performed a few tests to verify its accuracy. Three 40W incandescent lamps were measured to 38-41W. While off the digital display showed zero watt consumption. If the variations lie in the lamps or the PLM is hard to tell, we suggest in the lamps. However, we believe the PLM to be accurate enough to provide an idea of the energy consumption. All readings where taken when the consumption had reached a stable level, usually after login when all services applications were started. All measurements with decimal figures were recorded as nearest whole watt.

5.1.3 Field measurements

Initially we selected a school and an Internet cafe located in the south of Sweden for our field survey. They were willing to provide access for us to their computer labs and showed interest in the results of our study. We focused on the school with its wider range of desktop models. There were 58 computers present; of these fifty-two were desktops, six laptops and three servers. The servers and laptops were excluded from the survey. The components in the desktop computers varied since they have been acquired over the last four years. This presents an option to discuss trends in power consumption.

To get a reading in the various locations we simply connected the PLM between the cord from the power supply and the wall socket/plug. The goal was to establish an overview of how the component configuration a) affects power consumption and b) verifying power management's effect on energy consumption and how this relates to the actual use.

When we measured the energy consumption on the various computers we noticed that computers of the exact same model and same monitor model didn't always consume the exact same amount of energy. To resolve this situation we measured a total of four computers of each kind with identical configuration on both hardware and software. The results were divided by the same amount and are what we present in the table below. Each computer was left to run for ten minutes in each mode since during the services startup the computer uses slightly more electricity

Our measurements are divided into three different computer states.

- The "off" mode is when the computer is turned off and only a lower level of electricity is consumed. This electricity is among other things used to keep the network interface online and listening to the network. The only way to completely make sure that a computer is not consuming energy while switched off is to disconnect it from the wall socket; alternatively a switch could be placed at the socket.

- The "on" mode is when the computer is turned on as well as the computer monitor; this mode does not involve any kind of heavy load on the computers components. With heavy load we mean for example scanning after viruses or other actions that utilizes the computers CPU or GPU (Graphical Processing Unit).

- The "low" mode means measuring of the computer in the "on"-mode but with the difference that the monitor is in an energy saving mode. This mode often occurs on computers which are not used in a certain amount of time. In the environments that we have measured computer energy use in, the computer monitors power saving mode was set to initialize within 15 – 30 minutes of inactivity.

5.2 Survey for energy consumption

5.2.1 Monitors

We performed measurements on 13 LCD displays and 10 CRT monitors.

Table 2 Measured TFT/LCD Monitors

Brand	Model	Size	Year	No. surveyed	Stand-by	On
Samsung	172T	17”	2003	4	3W	38W
Samsung	720T	17”	2005	4	2W	35W
Samsung	193T	17”	2005	4	2W	37W
Dell	2405FPW	24”	2005	1	3W	89W

Note: The Dell 24” reached 89W while displaying an empty white document on full screen with the maximum brightness setting. This exceeds the manufacturer’s specification on 80W maximum consumption. This monitor was in addition added by us to get an idea of larger LCD consumption; most likely it is not used in any schools anywhere.

Table 3 Measured CRT Monitors

Brand	Model	Size	Year	No. surveyed	Stand-by	On
Acer	AC713	17”	2004	1	5W	75W
Fujitsu Siemens	B772-1	17”	2005	4	2W	81W
ViewSonic	G70f	17”	2002	4	4W	72W
IBM	C71	17”	1998	1	5W	84W

5.2.2 Computers

The reviewed computers were, as expected, equipped with energy saving features and functions. The Energy Star compliant functions were found in all computers. All computers were equipped with Microsoft Windows XP, the only found power management activated by default was for the monitors which were set to “sleep” after a certain amount of time. No other power management features were enabled.

Other precautions was that we turned off the automatic windows update function on each of the computers since we initially noticed that if the computer was involved in applying or downloading these updates, the power consumption would be seemingly higher. Since we could not control these events these computers we excluded from our survey.

Table 4 Measured computers and monitors combined

Equipment	Year	CPU/Monitor size	Off	On	Low
Dell Precision 380	2005	Intel P4 2.8Gzh	18W	122W	87W
Samsung 720t		17" LCD			
Dell Precision 360	2003	Intel P4 2.4Gzh	20W	106W	73W
Samsung 172t		17" LCD			
Average computer	2005	AMD 64 3200+	20W	82W	64W
Samsung 193T		19" LCD			
High performance Media Workstation	2004	AMD 64 3200+	22W	270W	181W
Dell 2405FPW		24" LCD + 5 Hard drives			

The high performance Media Workstation was intentionally included to survey a broader spectrum. It is not likely to be found at any school and is further excluded. Available specifications are listed in the appendix.

5.3 Discussion on metering survey

We can clearly identify a clear trend, in all computers the relation between the processor speed and energy consumption. The megahertz race between Intel and AMD has led to energy inefficient processors. The consumers will in some aspects pay the price for this since many of the computers used today has been acquired within the last four years. The current trend with multiple processor cores and dynamic processor clock speed is clearly a more feasible solution. The energy consumed by advanced 3D graphics is beyond the scope of this comparison, it is simply not important in school or business use today. This might all change when Microsoft introduce their new operating system, Vista, with built-in support for 3D desktop graphics. We believe that graphics processors will most likely follow the trend with multiple cores and possibilities for a dynamic performance adjustment, thus enabling advanced 3D graphics when needed.

For energy conservation reasons a computer may be shutdown, in our opinion, if it's not going to be used for five minutes. However, this poses an inconvenience to the end user waiting for the system to boot when needed. The energy and money saved during this period has to be weighted against lost productivity and stress.

5.4 Surveying organizations

5.4.1 Introduction

To better understand how power management is used we conducted a survey with 137 schools in Sweden. We invited to three types of Swedish schools to participate, the state operated gymnasiums, the privately owned gymnasiums and the folk high school. All types conduct education at a level of high school or above with students of 16 years of age or older. The two first type most likely uses computers since they are needed in common courses within the standard education programs. The folk high school is somewhat different and freer in its form. Some of these schools are totally orientated to a specific field, such as arts, while others provide a wide range of adult education.

We choose schools because of the multiple users per computer environment suitable for major savings in energy. They also represent a very distinct usage of the equipment during the day. Typical network and computer configuration is mainly used, usually the best of breed acquired on a limited budget.

5.4.2 Response rate

We collected the contact information from the government national school database held by Skolverket (Department of Education). The medium of the survey was a specially designed website that houses information, interesting links and a presentation of the results. An invitation was sent by generating individual emails, providing an introduction and a link to the website, with the survey and further information.

The contact information we collected and used for the invitation was in some ways incomplete, we only choose those schools that provided an email address in their contact information. This could affect the possibilities to generalize on the survey since we might reach more technology friendly organizations. The total number of schools in the database with email as contact information was 820 distributed among 498 state operated, 172 privately owned and 148 folk high schools. The rate of responses is shown in table 5.

Table 5 Response rate on the invitations to the survey

	Total sent out	Known as unsuccessful	Survey participants	Unknown
State	498	152	70	276
Private	172	17	23	132
Folk high school	148	0	44	104
TOTAL	*818*	*169*	*137*	*512*

1 Total sent out: The number of individual emails generated and sent out.
2 Known as unsuccessful: E-mail's that bounced and came in return for various reasons, change of staff, wrong person, invalid host, spam filters etcetera. This also includes individual requests for not participating.
3 Survey participants: Number of schools that participated and filled out the survey.
4 Unknown: The rest that did not produce an error or didn't perform the survey.

We believe that the number of respondents is large enough to provide indicators for specific trends but clearly, there is a limitation in generalisation. For example, there is another 198 state and private schools in the national database without email as a contact option. The rates of responses are fluctuating between the different types of schools and we decided to isolate the types where it could provide interesting results.

5.4.3 Survey questions

The conducted survey contains twelve questions to form an understanding on what type of equipment is used and if there is any form of power management functions activated. These results are later used to create different examples of what benefits could be achieved by a more effective energy use. In the survey two questions were focused on policy and responsibility for shutting down computers after hours, this would show if a computer based automatic power management tool could be useful for these organisations. We also included a question to survey if any tools were present today. Since the emails were not sent to specific technical staff but mainly administrative positions, we formulated the questions in a general non-technical language. This may reduce the sharpness of our survey, but on the other hand provided us with more responses. For example, we did not ask for the exact number of computers but instead provided ranges from 1-50, 50-100, 100-200 and 200 or more.

5.4.4 General statistics on hardware equipment

The first question in our survey was to establish an understanding of how many computers were used in Swedish schools. However, since the response rate was not evenly distributed among different types of schools we decided to combine the type to the number of computers shown in the three diagrams below. It would in addition bring forward, if any, differences in acquirement and equipment lifecycle.

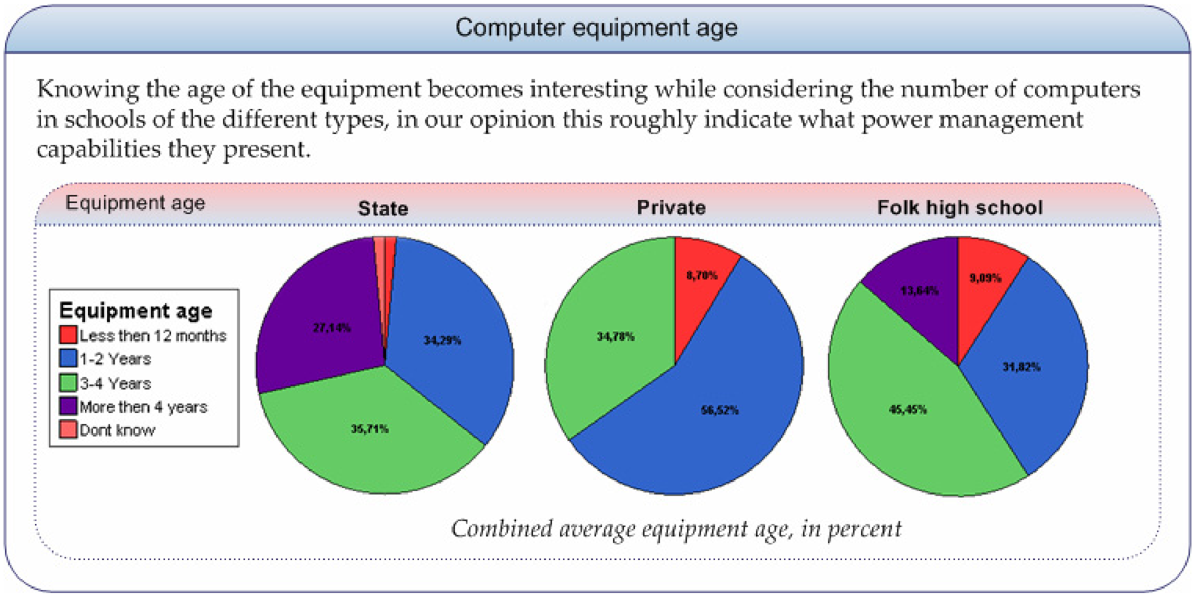
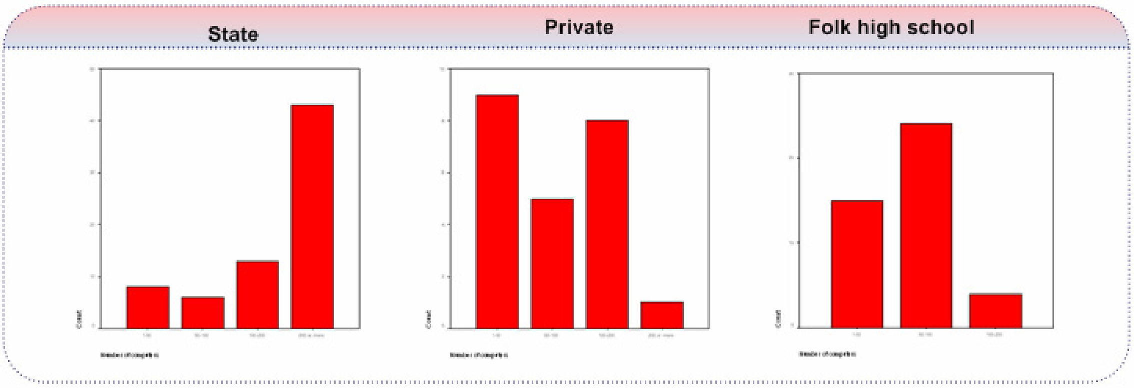


Figure 2 Survey: Computer equipment age

These results indicate that the privately operated schools have newer equipment. This should be considered against the fact that many of them were started in recent years since the de-regulation of this sector. This becomes obvious when none of them reported equipment older than four years.

Numbers of computer per school type

These results were somewhat expected, demonstrating that the state operated schools generally are lager and house more computers. However, every single case of energy inefficient use is a waste of money, and in the end a proportionally equal waste of schools budget.



The bars represent the following ranges, from left to right, 1-50, 50-100, 100-200 and 200 or more computers. None of the folk high schools had more than 200 computers. Bars show count of responses.

Figure 3 Survey: Numbers of computer per school type

5.4.5 Policy, responsibility and tools

The next step would be to investigate how aware the schools are and if they have an established policy and responsible staff for shutting down computers outside hours. According to our survey, the figures for a defined policy about shutting down computer are similar among the different types of schools, shown below.

Table 6 Survey: Policy for shutting down or leaving computers on. In percent.

	Always shut off	Always on	No policy	Not aware
Government	53	6	40	1
Private	52	9	39	0
Folk high schools	59	2	39	0

1. *Always shut off – Computers are to be shut down at the end of the day.*
2. *Always on – Computers are to be left running.*
3. *No policy*
4. *Not aware*

These figures become more interesting while looking at a single dedicated staff responsibility, this is important to ensure that the policy is enforced. We acknowledge that this only shows responsibility by a formal direction and that there might be more or less of unofficial individual efforts.

Table 7 Responsible staff for shutting down computers after hours. In percent.

	Responsible staff	None	Not aware
State	19	80	1
Private	52	48	0
Folk high schools	27	73	0

We also included a question to see if there was any centralized hardware or software support for those responsible. The hardware switch is a centralized mechanical mechanism to cut the power while its software equivalent uses a network or similar device to issue on/off commands to the computers. We found that either method is not used commonly in the surveyed schools and is an area that deserves special attention. The correlation between responsible staff and a centralized tool was 0,30.

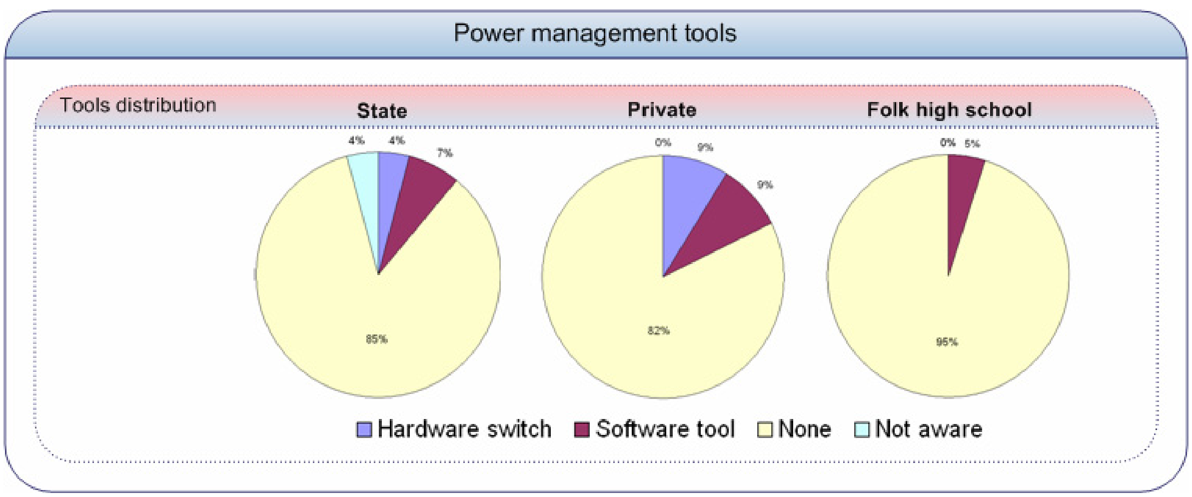


Figure 4 Survey: Power managment tools

Table 8 Survey: Available tools for shutdown responsible personnel, percent figures and table.

	Hardware switch	Software tool	None	Not aware
State	4	7	84	4
Private	9	9	83	0
Folk high schools	0	5	95	0

5.4.6 Government operated gymnasiums

This type of school represents nearly half of the responses we received (70/137) as shown they are generally larger schools. About half have a policy stating that they should turn of the computers when they leave at the end of the day. However, the lack of responsibility and tools for this might leave some computers running. We can see that computers used by only one individual is much more likely to be shut off. In the case of government operated schools 69 percent of the administrative staff shut off their own computer at the end of the day, about half (49.28%) of these also reported that the computers would initiate a lower power management state if not in use. 74% reported that their monitor has power management features enabled.

5.4.7 Privately operated gymnasiums

This type of school represents 23 out of 137 received responses and account for many of the smaller, more specialized schools. Nearly half of them have someone responsible for shutting down the computers at the end of the day, still only eighteen percent have some form of centralized support. A convenient tool could clearly improve this cumbersome daily routine. Among the administrative staff, 83% turn of their own computer at the end of the day. From our survey, we can see that 57% reports that their computer initiates a low power mode when not in use. Seventy percent of the schools report power management capable monitors.

5.4.8 Folk high schools

The Folk high school (folkhögskola) differs from the others since they are not required to have any computers at all. They can be totally orientated towards a specific subject, such as art. We received 44 replies from this type of school. None of these schools had more than 200 computers. They have the highest rate on organization policy but again the lack of responsibility and tools enforce an efficient power management. Eighty-four percent of the administrative staff shuts off their personal computer at the end of the day. They report a 60% computer and 80% monitor power management enabled equipment.

5.4.9 Notes on computer and monitor power management state

As show above, the schools reported between 70-80 percent of monitor power management utilization. The figures for computers range from 49-60 percent. These two states of power management is easily confused since the monitor usually goes black in low power mode, therefore it could be hard to see if the computer is in a low mode or if it's only the monitor. Therefore, the figure about monitors has, in our opinion, higher reliability. We do not know which mode/level of power management that were enabled in the computers, this requires further investigation.

5.4.10 Monitor distribution between CRT/LCD and types of schools

Monitor type distribution

State

They have the largest share of computers older than four years with 27%, a total of 63% is above three years. Only 5% have 80% or more LCD monitors, while half have less then 30% thin LCD's.

Private

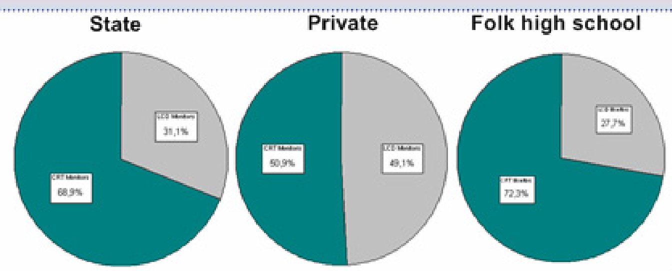
Nearly every second monitor is a thin LCD, which perfectly makes sense considering that 65% of the computers were purchased within the last two years ago. One out of three have more than 80% LCD.

Folk high schools

The traditional CRT dominates, two thirds have less than 20% LCD monitors. According to the survey results there are 13% with above 80% LCD's.

Average percent, school/monitor type

Each respondents reported their share of CRT vs. LCD monitors. This is the combined average of the results, in percent.



Light grey represents thin LCD screens

Figure 5 Survey: Monitor type distribution

5.4.11 Operating Systems distribution

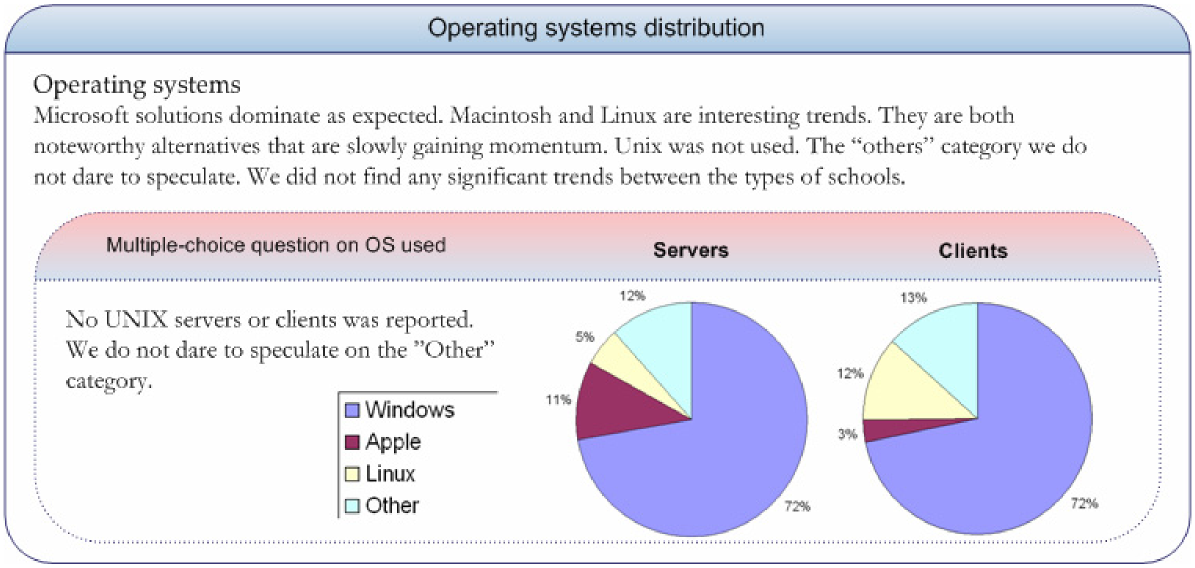


Figure 6 Survey: Operating systems distribution

5.5 Summary

In this chapter we have based on our energy measurements, seen that the newer LCD-monitors consume less energy than the older, and newer, CRT-monitors. This confirms facts presented earlier in our chapter on general background on related fields. We have also seen that different computer configurations consume different amounts of energy which confirms the facts we have written on this topic in our general background. In this chapter we also presented data from our survey, how the different types of schools responded and what the results were.

We believe that policy, responsibility and good tools combined are the most crucial factors ensuring a lower level of energy consumption. Good tools are usually very important, especially when considering computers where boring tasks often can be automated, more on this in chapter 7 "Proposed technical solution".

6 Energy consumption

This chapter is dedicated to calculations on how typical computers in the surveyed environment consume energy and what impact this has in a financial perspective. We will apply different kinds of power management to these computers to show how much energy and money a single user can save. At the end of this chapter we will calculate these numbers with a larger numbers of computers and show that there is a possibility for substantial savings from power management. With the help of our energy measurement study we can calculate how much energy a single computer is using, knowing this we can calculate the economical factors of enabling different kinds of energy management.

As seen in our energy measurement studies different computers use different amounts of energy. To calculate the energy use of one computer we need to establish a typical computer used and monitor. The type of monitor is especially important since the difference between CRT and LCD monitors are noticeable, this fact we established in our energy measurement study.

6.1 Calculating average current electrical pricing

To calculate the economical cost of the average organization we multiply the result with the current electrical price. The average electrical price is currently 96.8 Swedish "öre" per kilowatt-hour. This average price is based on the Swedish consumer agency webpage numbers. (As of 20060503 exchanges to $0.13 and €0,10, fsb.se) Since different organizations reside in different kinds of building we take the three kinds of electrical pricing that the Swedish consumer agency provides. The three kinds of buildings on the Swedish consumer agency webpage are "apartment", "house" and "electrical heated houses". As we can see in table 9 the average in these categories is the following (Figures noted 2006-05-09).

Table 9 *Average electrical price*

Average electrical price in öre / kWh based on the Swedish Consumer Agency (06-05-09)			
Apartment	House	Electrical heated house	Average
103.3	95.5	91.6	96.8

6.1.1 Introducing the typical computer

To establish a typical computer we use the results from our measurement study to calculate an average consumption, as seen in table 10. Please note that we are calculating with the computers "low" mode, this meaning that the computer screen is "sleeping". We use "low"-mode since we need to calculate the energy consumption of computers with both CRT and LCD monitors.

Table 10 The typical computer

All computers total energy consumption / Amount of computer = Average PC power consumption

405 / 4 = 101 (all numbers in Watts)

The result, 101W, is our typical computer energy use, this is the base for our calculations on possible savings when this typical computer is power managed.

6.1.2 Introducing the typical CRT-monitor

Table 11 The typical CRT-monitor

All CRT-monitors total energy consumption / Amount of CRT-monitors = Average CRT-monitor power consumption

312 / 4 = 78 (all numbers in Watts)

As we can see in table 11 the average CRT-monitor power consumption is not very far from the power consumption of our typical computer. Now we know both the power consumption of a typical computer and the power consumption of a typical CRT-monitor. As stated earlier these numbers are based on our power consumption study.

6.1.3 Introducing the typical LCD-monitor

The new thin LCD-monitors are conquering the market and as we have seen in our energy survey these LCD-monitors are using noticeably less energy compared to the old CRT-monitors. We use the same formula to calculate energy use of a typical LCD-monitor. As in our previous calculation of typical computer and CRT-monitor energy usage we use numbers from our energy measurement study.

Table 12 The typical LCD-monitor

All LCD-monitors total energy consumption / Amount of LCD-monitors = Average LCD-monitor power consumption

110 / 3 = 37 (all numbers in Watts)

As we earlier stated, the new LCD type monitors are using close to half of the energy when compared to typical CRT-monitor. This shows why it is important to separate these two kinds of monitors when performing energy calculations on computers and monitors.

6.1.4 Calculating energy- and economical costs of running typical equipment

To demonstrate how much energy and money that can be saved by enabling power management in one single computer we will use our definitions of typical computer and CRT-monitor and calculate with our previous defined average energy price. To get a clear view over the energy consumption we start by calculating the energy consumption over a period of twenty-four hours. These 24 hours are then multiplied to weeks, months and an entire year. This would roughly show how much energy computer and monitors are using during a certain given amount of time if they are left in a full on state. As we can see in Table 13 a typical computer with CRT-monitor consumes 4.29kWh when on for 24 hours. By using these numbers we can calculate the energy consumption of having one computer running for one week or year.

Table 13 Energy consumption of typical computer with CRT-monitor

Typical computer with typical CRT-monitor			
Computer	Monitor	On-time	Daily consumption
101W	78W	24 hours	4.29kWh
Typical computer with typical CRT-monitor			
Daily (24h)	Weekly (7 days)	Yearly (52 weeks)	
4.29kWh	30.07kWh	1563kWh	

These numbers become even more interesting when we calculate with the average electrical price, which we have established earlier in this paper.

Table 14 Economical calculations with typical computer with CRT-monitor

Typical computer with typical CRT-monitor		
Daily (24 h)	Weekly (7 days)	Yearly (52 weeks)
4.15 Skr	29.05 Skr	1510,6 Skr

As we can see in table 14 even only one computer consumes energy which generates a significant cost which can be seen when applied to a longer period of time. One easy way of saving energy can be to replace the CRT-monitors with newer LCD-monitors. As seen in table 15 the total energy consumption for a typical computer with a typical LCD-monitor is noticeably lower than the comparable CRT-monitor setup, the saving will be almost 1000W every day when turned on for 24 hours.

Table 15 Energy consumption of typical computer and LCD-monitor

Typical computer with typical LCD-monitor			
Computer	Monitor	On-time	Daily consumption
101W	37W	24 hours	3.31kWh

Applying the daily energy consumption from table 15 to a longer period of time make it even more visible that the typical LCD-monitors are more energy efficient than the old typical CRT-monitors.

Table 16 Energy consumption of typical computer and LCD-monitor during 1day, 1 week, 1 year

Typical computer with typical LCD-monitor		
Daily	Weekly	Yearly (52 weeks)
3.31kWh	23.18kWh	1205kWh

The economical results of running a typical computer with a typical LCD-monitor over longer period of times can be seen in table 17 these results clearly shows that there is a large saving potential when using the newer LCD-monitors instead on the older CRT-monitors, saving 349 Skr when calculating with an entire year.

Table 17 Economical calculations with typical computer and LCD-monitor

Typical computer with typical LCD-monitor		
Daily	Weekly	Yearly (52 weeks)
3,19 Skr	22,33 Skr	1161,16 Skr

6.1.5 Energy savings calculated

Since we now have established how much energy one computer is using and the cost of this, we can calculate how much energy and money can be saved by power managing. Earlier we established that one typical computer and one typical CRT-monitor are using 4296W when powered on for 24 hours. To find our how much energy this typical setup requires every hour we simply divide this numbers by these 24 hours, this giving us the result 179W. The equal computer with CRT-monitor consumes 138W.As we have seen in our survey, schools often don't have someone responsible of shutting down computers by the end of the day, and even more often these schools didn't have any software that could manage these shutdowns at all.

With our proposed solution, which we introduce later in this paper, the shutdown and startup of computers can be centralized, saving unnecessary waste of energy and money. Our energy savings calculations are based on our proposed solution with centralized shutdown and startup management, meaning that computers are powered on only during office hours and they are shutdown during weekends. Please note that we are not taking any consideration of schools holiday seasons since our work are not only considered for school use, we use a period of 52 weeks on our calculations to comply with all different kinds of organizations, making it easier to see the impact of centralized power management.

If we calculate with a single computer being powered on during normal office hours, 8 hours, instead of 24 hours we can see an example of how much money and energy which can be saved for one single computer. In our energy measurements earlier in this paper we also observed that when computers were shutdown they were still consuming 20 W of energy. To comply with these facts we calculate that the computer is using 20 W during the 16 hours which it is shutdown.

Please note that that we calculate with one week equaling 5 working days and one year equaling 52 weeks.

Table 18 Typical computer and CRT-monitor during office hours

Typical computer with typical CRT-monitor		
Daily (8 hours)	Weekly (5 days)	Yearly (52 weeks)
1432W	7.16kWh	372kWh
Typical computer with typical CRT-monitor		
Daily (8 hours)	Weekly (5 days)	Yearly (52 weeks)
1,38 Skr	6,90 Skr	358,8 Skr

As we can see above in table 18, the computer and monitors energy consuming has drastically decreased. This is even more visible when we see what this means in economical terms. As seen in table 18 and table 19 the decrease in terms of money is 67% when comparing a computer being turned on for 24 hours every day and a computer being turned on for 8 hours and during weekdays only. Since LCD-monitors are using less energy we have also calculated with these monitors, as you can see in table 19.

Table 19 Typical computer and LCD-monitor during office hours

Typical computer with typical LCD-monitor		
Daily (8 hours)	Weekly (5 days)	Yearly (52 weeks)
1104W	5.52kWh	287kWh
Typical computer with typical LCD-monitor		
Daily (8 hours)	Weekly (5 days)	Yearly (52 weeks)
1,06 Skr	5,30 Skr	275,6 Skr

Not very surprising the percentage of energy and money saved with typical computer and typical LCD-monitor is correlating with the percentage we presented above, regarding typical computer and typical CRT-monitor. We are providing these numbers since the respondents in our survey responded in average that they have 67% CRT and 33% LCD monitors.

6.1.6 Applying energy saving theory

To be able to calculate how much energy our survey respondents could save we would need to study their daily routines and behaviours when working with their computer. This would be an overwhelming work for us and we have no means of doing such studies. Instead we demonstrate the impact of one single hour of energy saving in an example organisation. In the end we calculate with Nordman (1997) results on energy managing and present how much money could be saved in the different examples.

6.1.7 Hourly savings in example organisation

To demonstrate how much energy and money an ordinary organisation could save by using power management we construct an example organisation consisting of 200 computers. Based on the data from our survey the average organisation had 67% CRT-monitors and 33% LCD-monitors. This meaning that our example organisation consist of 130 CRT-monitors and 70 LCD-monitors.

When calculating what the example organisations computer and monitor energy use would be, we use the model seen below. Populating the model with the numbers of our example organisation will give us an answer on how much the energy cost would be for one single hour. We use one hour as our result value in this model since we want to show you how much energy can be saved with a minimal effort in energy managing.

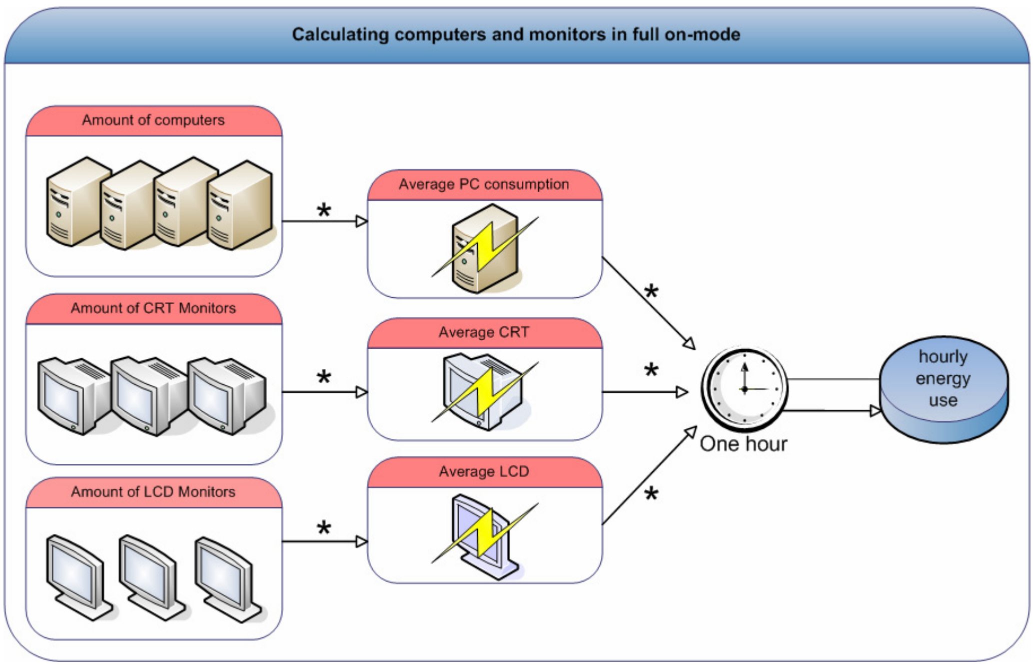


Figure 7 Model for example organizations hourly energy use

By using the model in figure 7 we are calculating the energy cost for one hour in on-mode. This mode involves that the computers are to be powered on as well as the monitors; the model assumed that no energy managing functions would be enabled.

Table 20 below shows how many watts the example organization would use for one hour, calculated with the use of figure 6.

Table 20 Average organizations daily energy usage in 1 hours on-mode

Average organizations daily energy usage when in 1 hours on-mode				
200 computer	101W	1 hour	20.2kWh	TOTAL 32.93kWh
70 LCD-monitors	37W	1 hour	2.59kWh	
130 CRT-monitors	78W	1 hour	10.14kWh	

When we calculate the result with the current average energy price the result will be 32 Skr per hour. (24h a' 768Skr) To show how a minimal effort can save substantial amount of energy we take our example company and enable the monitor's power saving functions. In this example we calculate with the computers being in on-mode and the monitors being in low-mode, this mode involves the screen going blank when it is power managing functions kicks in. And, please note that graphic screensavers are another story and have nothing to do with monitor power managing

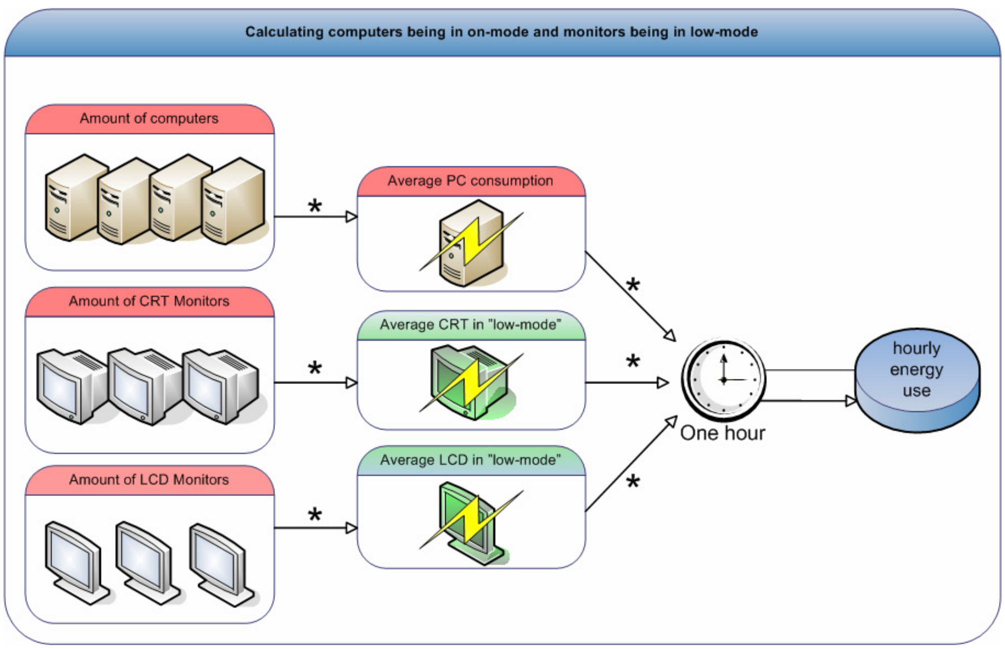


Figure 8 Model for example organizations hourly energy use when monitors are powermanaged

Table 21 below shows how many watts that are used when we power manage the typical organizations monitors.

Table 21 Average organizations hourly energy usage when in on-mode with monitors in low-mode

Average organizations hourly energy usage when in on-mode with monitors in low-mode				
200 computer	101W	1 hour	20 200W	TOTAL 20860
70 LCD-monitors	2W	1 hour	140W	
130 CRT-monitors	4W	1 hour	520W	

As seen in table 21 the total usage would be 20860W, in economical terms this would mean 20,13 Skr. In comparison with the on-mode displayed in table 20 we can see that the saving would be 12070W and 11,6 Skr every hour.

6.1.8 Applying Nordmans theories on our example organization

We use the work of Nordman et al (1997) as a calculation example, which as discussed in our chapter on general background. It estimated that a typical PC is actively used 4 hours each work day and idle for another 5.5 hours. First we calculate how much energy the average computer consumes when being in on-mode a normal office day with no power management. We use two examples, one with CRT-monitor and one with LCD-monitor since both these types of monitor are still in use as we have seen in our survey.

Table 22 Typical computer and monitors on for 9.5h

Typical computer with typical CRT-monitor			
Computer	*Monitor*	*On-time*	*Daily consumption*
101W	78W	9.5 hours	1700.5W
Typical computer with typical LCD-monitor			
Computer	*Monitor*	*On-time*	*Daily consumption*
101W	37W	9.5 hours	1311W

Calculating with the average energy price, we find that a typical computer with CRT-monitor costs 1.64 Skr when it is on for 9.5 hours. The LCD equivalent costs 1.24 Skr. To show how much energy and money can be saved with a minimal effort we use Nordman et al's (1997) on-time and let the monitor power manage the 5.5 idle hours, as seen in table 23.

Table 23 Typical computer and monitors when on for 4h and monitor in low for 5.5h

Typical computer with typical CRT-monitor			
Computer	*Monitor*	*On-time*	*Daily consumption*
101W	78W	4 hours on	1283,5W
101W	4W	5.5 hours idle	
Typical computer with typical LCD-monitor			
Computer	*Monitor*	*On-time*	*Daily consumption*
101W	37W	4 hours on	1118,5W
101W	2W	5.5 hours idle	

When we calculate the results with the average energy price we find that the computer with CRT-monitor now costs 1.24 Skr a regular office day, the LCD-monitor setup costs 1.08 Skr, showing that this minimal power management effort saves 24% when using the computer with CRT-monitor and 14% with the LCD-monitor. This may not seem much at first glance, but when we apply these numbers to our example organization, as seen in table 24, we can see how much savings this minimal effort results in.

Table 24 Example organisation with Nordman theoretical 5.5h idle time in low-mode

Average organizations daily energy with Nordman office hours			
Full mode 4 hours			
200 computer	101W	20.20kWh x 4h = 80.8kWh	**TOTAL** 135,29kWh
70 LCD-monitors	37W	2.59kWh x 4h = 10.36kWh	
130 CRT-monitors	78W	10.14kWh x 4h = 40.5 kWh	
Low mode 5.5 hours			
70 LCD-monitors	2W	0.14kWh x 5.5h = 0.77kWh	
130 CRT-monitors	4W	0.52kWh x 5.5h = 2.86kWh	

Table 25 Example organisation with Nordman theoretical 9.5h office day in on-mode

Daily office computers energy use lacking energy managing			
200 computer	101W	20.20kWh x 9.5h = 191.9kWh	**TOTAL** 312.83kWh
70 LCD-monitors	37W	2.59kWh x 9.5 h = 24.60kWh	
130 CRT-monitors	78W	10.14kWh x 9.5 h = 96.33kWh	

When comparing the result of table 24 with the result of running the example organization computers in on-mode for 9.5 hours, as seen in table 25, we can see that this minimal effort saves 177.54 kWh, this allowing the example organization to save 171.85 Skr, every working day. Applied these numbers over one year, calculating that one week is 5 working days and one year 52 weeks, the saving would be 44 681 Skr and 46160 kWh (56%).

6.1.9 Summary

In this chapter we have demonstrated how much energy and money a single user can save by enabling power management or by simply turning off the computer when not in use. By establishing how much energy one single computer consumes during one hour and during 24h we showed the energy saving potential when minimizing the computers time on on-mode. We have also shown how organizations can save a substantial amount of money and energy by enabling power management. Our example organization consisting of 200 computers saved 56% energy when enabling their monitors' power management, a saving worth more than 44 600 Skr when applied for one year.

7 Proposed technical solution

During our survey, we came across a few requirements that would be ideal for a software solution for power management. We believe that this tool must have a centralized form since it is hard to enforce energy conservation on an individual base. If the end users, such as students, were responsible there still would have to be some form of verification and control. We believe that a more effective solution could be presented using available techniques and issuing automated power management commands over the network. According to the schools we surveyed 87,59% does not have any tool of any kind to turn on or switch off their computer equipment. The low figures for software tools, 6,57%, clearly demonstrates the need for a simple to use tool, ideally released as open source free software so that it could be tailor-made for each organizations specific needs and quickly extended to support more platforms.

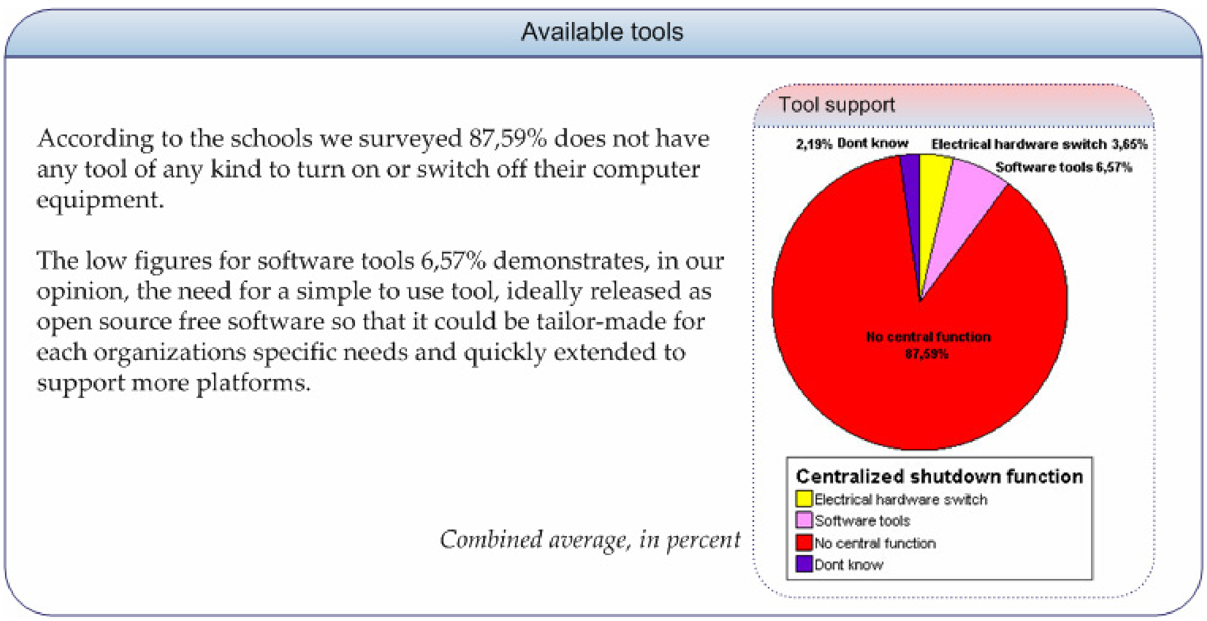


Figure 9 Surveyed schools, responsible staff utilizing a centralized tool or function to shut down computers.

7.1 Platforms and operating systems

As we have stated earlier the most effective way to save energy is to shut down the computers outside working hours. First, we will look on the possibilities that exist by default and discuss their practical implementation and limitations. We will only considering Microsoft Windows as client operating system due to its dominating position. This dominance will might change over time. We expect more government based organizations to use open solutions over time. More and more applications are running inside web browsers and there is a strong movement for an open document standard, making the brand of the operating system less important. However, the fact remains for today. Microsoft Windows is used within most of the surveyed organizations and therefore the main subject for an example solution. On the server side there is a stronger support for alternatives, mainly Linux. We will therefore suggest a platform independent solution when it comes to the server side applications.

7.2 Network tools and commands

7.2.1 Windows Native Shutdown RCP Command

In every installed copy of the Windows operating system, version XP or 2003, there is a utility for shutting down the computer with a number of different options. This utility can be used to remotely shut down clients over the network. However; it requires administrator privileges and therefore must be issued by the managerial staff. One can however apply different policies to this program using group policy tool, gpedit.exe, under Windows settings – Security settings – User rights & Security options. This will make the command available to other users than the administrator. We suggest creating a specific user for automated network operations with privileges to perform shutdowns.

Technical information: **Windows 'shutdown.exe' native RPC command**

Usage: shutdown [-i | -l | -s | -r | -a] [-f] [-m \\computername] [-t xx] [-c "comment"] [-d up:xx:yy]

No args Display this message (same as -?)
-i Display GUI interface, must be the first option
-l Log off (cannot be used with -m option)
-s Shutdown the computer
-r Shutdown and restart the computer
-a Abort a system shutdown
-m \\computername Remote computer to shutdown/restart/abort
-t xx Set timeout for shutdown to xx seconds
-c "comment" Shutdown comment (maximum of 127 characters)
-f Forces running applications to close without warning
-d [u][p]:xx:yy The reason code for the shutdown
u is the user code
p is a planned shutdown code
xx is the major reason code
yy is the minor reason code

Example:
The command for shutting down the client "computer123" with a 10-minute delay would be:

```
shutdown -m \\computer123 -s -t 600
```

Figure 10 technical information Windows shutdown.exe native RPC command

Technical information: **Shutdown.exe**

The execution of the shutdown command will present a notification message on the selected client. The suffix '-c' can be used to display a message to the user.

There sadly isn't any option to cancel the process in the notification dialog. However, using the command line based alternative the parameter "-a" aborts a shutdown.

On the affected client	On the remote PC
`shutdown -a`	`shutdown -m \\client123 -a`

Figure 11 Technical information: Shutdown.exe

There is another option available that provides an option to cancel the process by simply clicking on a button. This neat little replacement for the Windows XP shutdown utility named Beyond Logic Shutdown, created by Craig Peacock (BeyondLogic, 2006-06-04). It is a part of his solution for spawning processes and shutting down multiple computers, named the BeyondExec software suite. It consists of a command line tool for remote managing. It is available a freeware, unfortunately no source code can be downloaded. This BeyondExec software contains interesting features for an effective solution, most of them relevant for power managing we will isolate and discuss. However, to be a truly feasible solution it has to be further developed, with user interfaces, automation and features that are more intelligent. Ideas we will expand further on.

Basically all system commands can be placed in the Windows internal scheduler for automatic issuing at a specific time. Consider the following example executed at the command shell, scheduling a shutdown at the local client for weekly workdays.

```
C:\ at 16:50 /every:M,T,W,Th,F shutdown -s -t 600
```

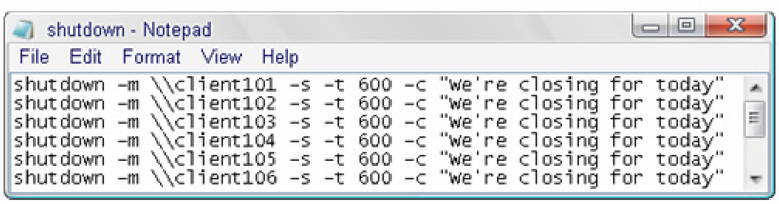
Unless an application is responsible for issuing this command to all the clients in the network, this command would have to be initiated on every machine. This also requires that the internal scheduler mechanism is correctly working on all machines.

7.2.2 Windows batch-files

The first solution we present for remotely shutting down the clients is very simple. We believe anyone could do this in a few minutes. The idea of batch files is to put a collection of commands into a text file. When the batch file is executed the computer will run all the commands listed inside the file.

Technical information: **Windows batchfiles**

This is an example of how to create a batch file that issues the shutdown command to multiple computers. The file should be saved with the extension ".bat" instead of the normal ".txt"
This file could be automatically executed by placing it in the internal Windows scheduling or eqivilent Linux alternative (cron) as shown above.



```
shutdown -m \\client101 -s -t 600 -c "we're closing for today"
shutdown -m \\client102 -s -t 600 -c "we're closing for today"
shutdown -m \\client103 -s -t 600 -c "we're closing for today"
shutdown -m \\client104 -s -t 600 -c "we're closing for today"
shutdown -m \\client105 -s -t 600 -c "we're closing for today"
shutdown -m \\client106 -s -t 600 -c "we're closing for today"
```

Then to start the process simply double-click on the batch file.

Figure 12 Technical information: Windows batchfiles

7.2.3 Linux server and Windows clients

Similar batchfiles can be created and executed from a Linux server to a network of ordinary Windows clients. The command equivalent to Windows shutdown.exe is 'net rpc shutdown' with various suffixes listed below. This software comes packaged with the popular and stable Samba file server. This server software emulates a typical Windows fileserver and provides a range of functionality, released as under open source, free of license cost.

Technical information: **Linux-to-windows shutdown equivalent**

'net rpc shutdown' also accepts the following miscellaneous options:

-r or –reboot request remote server reboot on shutdown
-f or –force request the remote server force its shutdown
-t or --timeout=<timeout> number of seconds before shutdown
-c or --comment=<message> text message to display on impending shutdown

The shutdown process can also be aborted using the 'net rpc abortshutdown' command.

Figure 13 Technical information: Linux-to-Windows shutdown equivalent

7.2.4 Limitations of batch files

There is no automatic discovery of the computers in the network. This will be problematic for two reasons; first, new clients will not be added and secondly, the command will be issued against computers that might not be running. This will cause the process to halt before it eventually times out. We have measured the default timeout to approximately 10 seconds. To solve this problem a simple application could be developed that uses threads to issue multiple shutdown requests at once. This allows multitasking so that, for example, 100 computers can be issued a command at once. This command will then run inside a separate thread that is handled by a thread engine. This will provide more control and the possibility to specify the timeout. A number of programming languages support threads. The Java language has both a native implementation and numerous open source alternatives with different strengths and purposes. With a platform independent solution in mind, we will further analyze how these commands are issued and transported over the network.

7.2.5 How Windows remote shutdown works - Named Pipes

"Named pipe communication consists of a named pipe server and a named pipe client. A named pipe server is an application that creates a named pipe to which clients can connect. A named pipe's name

has the format \\Server\Pipe\PipeName. The Server component of the name specifies the computer on which the named pipe server is executing. (A named pipe server cannot create a named pipe on a remote system.) The name can be a DNS name (for example, mspress.microsoft.com), a NetBIOS name (mspress), or an IP address (131.107.0.1)" (M. Russinovich & D.Solomon, 2004)

The referenced book above is available in full on the web; see the reference list for address. It is an in-depth guide to most Windows internal functions, such as RPC and Named pipes. It also contains information about how the shutdown process is initiated internally and how the process deals with open applications.

Technical information: **List open pipes**

The **InitShutdown** on the second row is the pipe used to shut down a Windows client from a remote computer. The pipe is created by the Winlogon process and accepts remote shutdown commands over named pipes. This pipe could be called from any programming language that supports Named Pipes calls.

To the right is the output from running the small PipeList utilitity from Sysinternals. It can be downloaded at:

http://www.sysinternals.com/Files/PipeList.zip

Running PipeList from Sysinternals

```
PipeList v1.01
by Mark Russinovich
http://www.sysinternals.com

Pipe Name                                    Instances  Max Instances
---------                                    ---------  -------------
TerminalServer\AutoReconnect                     1             1
InitShutdown                                     2            -1
lsass                                            4            -1
protected_storage                                2            -1
ntsvcs                                           2            -1
scerpc                                           2            -1
net\NtControlPipe1                               1             1
ExtEventPipe_Service                             1            30
net\NtControlPipe2                               1             1
SfcApi                                           2            -1
net\NtControlPipe3                               1             1
Winsock2\CatalogChangeListener-500-0             1             1
net\NtControlPipe4                               1             1
net\NtControlPipe0                               1             1
net\NtControlPipe5                               1             1
net\NtControlPipe6                               1             1
net\NtControlPipe7                               1             1
winlogonrpc                                      2            -1
ExtEventPipe_s0                                  1            30
net\NtControlPipe9                               1             1
spoolss                                          2            -1
wkssvc                                           3            -1
DAV RPC SERVICE                                  2            -1
net\NtControlPipe10                              1             1
aswUpdSv                                         1            -1
net\NtControlPipe12                              1             1
net\NtControlPipe13                              1             1
net\NtControlPipe14                              1             1
keysvc                                           2            -1
net\NtControlPipe15                              1             1
winreg                                           2            -1
epmapper                                         2            -1
trkwks                                           2            -1
net\NtControlPipe16                              1             1
srvsvc                                           3            -1
W32TIME                                          3            -1
PIPE_EVENTROOT\CIMV2SCM EVENT PROVIDER           2            -1
net\NtControlPipe17                              1             1
Ctx_WinStation_API_service                       2            -1
net\NtControlPipe18                              1             1
```

Figure 14 Technical information: List open pipes

7.3 Finding active computers

7.3.1 SMB LAN protocol

The first step to identify running computers is to survey the network; this can be done using several different methods. In Microsoft Windows networks, the clients usually send announcements to the domain server and thereby to listening browsers. In addition, the SMB protocol used enables the sharing of files and printers (and much more).

Technical information: **SMB LAN Protocol**

SMB (Server Message Block)
The network protocol is running on port 445. In earlier versions of Windows such as 95, 98, 2000 and NT the port 137-139 we also used to transfer UDP packets utilizing NetBIOS/NBT. Since Windows 2000 it's all TCP (know as raw or naked SMB) this newer version will fall back to traditional Netbios on UDP if the TCP/IP protocol is disabled.

Hiding computers from the network neighbourhood / domain can be done using the command 'net config server /hidden:yes|no' type net config server /hidden:yes at the command prompt, and then press ENTER. It can be brought back to the domain list by '/hidden:no' Sometimes there is a delay, up to 30 minutes before for the computer to disappear from the lists. The Windows register file can also be manipulated to achieve the same results.

More information:
http://support.microsoft.com/?kbid=188001
http://ubiqx.org/cifs/SMB.html

Figure 15 Technical information: SMB LAN Protocol

To verify if a machine is using the SMB services on specified ports we have included a reference to a Java implementation of a Java service detection portscan in our appendix, and discussed further on.

7.3.2 JCIFS Open Source Java implementation of MS Networking/CIFS standard

The JCIFS is an excellent SMB client library written entirely in Java. It supports named pipes, encrypted authentication, domain/workgroup/host enumerations, NetBIOS sockets and name services, SMB protocol, RAP calls etcetera. It's a great source when developing Java applications that interacts with a Windows network and solves many of the basic issues for this project. It is a widely adapted and well documented with sample code. If a solution was to be developed in full, and it needed to run on multiple platforms, this would be the first place to start. (JCIFS, 2006-06-04)

7.3.3 Ping

The ping program is a network administrator tool originally developed by Mike Muuss for the American Army Research Laboratory in 1983. The ping command is used to verify that network connections are up and that the remote computer is responding, thus available for the central power management computer to issue a shutdown command to. This command is available on virtually all existing platforms.

Technical information: **Ping**

Ping uses the Internet Control Message Protocol (ICMP) to send a small packet containing 64 bytes, 56 data bytes and 8 bytes of protocol reader information. The issuing computer then waits for the response. The complete specification of ICMP can be found in RFC792.

More information:
http://www.ping127001.com/pingpage.htm
http://www.freesoft.org/CIE/RFC/792/
http://www.microsoft.com/resources/documentation/windows/xp/all/proddocs/en-us/ping.mspx?mfr=true

Figure 16 Technical information: Ping

The ping command can be used to sweep the network similar to how U-boats sends pings with their sonar to detect objects. A ping scan sweep would detect running computers within two specified addresses, one for where the network starts and one for where it ends.

7.3.4 Network port scan

This method is used to scan the network for hosts and then try to access services running on the specific host. Comparable to one running down the street, knocking on every door and window to see if someone is at home. This method is often used by hackers that survey the target organizations networks to identify computers with software that's not patched and up to date. However, there are legitimate uses for portscans, in this case finding active computers and determine their status, populating a list of available machines for power management operations. Unfortunately, portscans tend to take some time to perform, but to verify the state of a computer for our purpose the scan can be limited by only checking for a few services with an aggressive time out strategy on the running threads. A typical network computer should respond within a few hundred milliseconds. Since port scanning is often misused, the firewall on the remote client might block and report this activity. We have provided links to a few open source Java implementations in appendix 10.1.

7.3.5 Checking for logged in users

Mark Russinovich and Bryce Cogswel of Sysinternals have developed a freeware tools that could be used to see what users are logged on to a certain machine or to scan the network to see if a certain user is logged in at any computer. This tool is named PSLoggedOn and comes with full source code. They also provides a range of other useful network tools, suitable for our purpose, however most does not come with source code.

7.4 Wake-On-Lan

The Wake-On-LAN (WOL) technique that is a defacto industry standard, incorporated in every new computer since the 90's. The Wake-On-LAN feature gives the possibility to wake the clients up over the network after they are shut off. The WOL technology is independent of the operating systems, i.e. a linux box can wake up a windows client and vice versa. This could be used to start up the computers automatically shortly before they are needed every morning. Ideally initiated by a scheduling option or even better, automatic detection of usage patterns, more on this further on.

Technical information: **Magick-Packets for Wake-On-Lan**

Packet sequence: A0-10-A1-04-09-AA

Sent 16 times to the MAC address on the client computer causing the network interface card to issue a system start-up. We have provided an example implementation using the Java programming langue in the appendix.

Figure 17 Technical information: Magick-Packets for Wake-On-LAN

7.4.1 NetBIOS MAC address localization

Since the Magick-Packets for Wake-On-LAN work at the NetBIOS level, it is crucial to discover and store the MAC address of the clients. Thus, the scan for clients and their MAC address must be performed while the computers are up and running. The manufacturer incorporates the unique MAC address in the hardware. By default, it ensures that all machines have a unique low-level address on the network. It can however be emulated and manipulated by software. There are several open source tools available; we have provided links to a few of them in appendix 10.1.

7.5 Manipulating client power management configuration

7.5.1 Initiating various degrees of power management states

The typical usage of a computer is most cases not a full period or day. In a normal organization, there are weekly meetings, lunch breaks and other more or less regular events resulting in non-use. Previous research by Nordman et al (1997) shows that computers are actively in use only 4,5 hours on a typical day. This provides further possibilities to conserve energy by initiating various levels of power management. After running various pattern detection algorithms over time an understanding of a typical usage pattern would appear. The server could, based upon this pattern, send out commands to the specific client initiating standby, sleep or shut down etc. Using remote register distribution and WMI (windows management instrumentation), an individual configuration could be distributed to each computer client on the network. Thus, they would be ideally configured to maximize energy utilization based upon the actual use. We will therefore look further into individual configuration distribution.

7.5.2 Using remote registry manipulation

This enables the Windows register settings to be modified by a remote computer, this could be used to modify specific parts of the register that concerns power management. This would allow the server to distribute power management settings and configuration to all computers in the network. Of course, the register can be distributed by other means such as placing a register file on the logon server and placing it in the logon sequence script. We have provided references to further information regarding remote registry in our appendix. The article "Utilising remote registry access" (Brian Venn, IBM 2002) is an good introduction to how this technique works.

Technical information: **Windows Registry Power Management Keys**

There are several keys in the Windows register that affects power management settings. To utilize the built in default power policies see:

`HKEY_USERS\.DEFAULT\Control Panel\PowerCfg\PowerPolicies`

Under this key we find the different policies and what they represent
0 - Home/Office Desk (plugged in all the time)
1 - Portable/Laptop (extended battery life)
2 - Presentation (monitor always on)
3 - Always on
4 - Minimal power management (optimized for high performance)
5 - Max battery (aggressive for saving power)

These settings can be applied to individual users by the key:
`HKEY_CURRENT_USERS\Control Panel\PowerCfg\PowerPolicies`

The settings for monitor sleep and timeout is found at
`HKEY_USERS\.DEFAULT\Control Panel\Desktop\PowerOffActive`
`HKEY_USERS\.DEFAULT\Control Panel\Desktop\PowerOffTimeOut` (in seconds)

All these settings could be view, modified and exported by the built in tool `regedit.exe` (Microsoft) The exported register update files can then be distributed to the clients by any normal means of file transfer.

Figure 18 Technical informaton: Windows Registry Power Managment Keys

7.5.3 Using netlogon scripts for distribution

The 'netlogon' script usually executing when logging in to a Windows client is an easy way to distribute settings. For more advanced scripting options, we recommend KiXtart. It is a highly mature set of functions for scripting, well crafted, rich documented and comes under nice licensing terms (it works!)

Technical information: Kixtart

"The KiXtart free-format scripting language has rich built-in functionality for easy scripting. It also supports COM (providing access to ADSI, ADO, WMI, etc) and thus is easily extensible. With the amazing KiXforms GUI for KiXtart, there is so little, if anything you can't accomplish with KiXtart. And because of the User Defined Functions (about 500 ready UDF's on korg already), there is very little you need to code by yourself as much of the complex things have already been coded for you! KiXtart is developed by Ruud van Velsen of Microsoft Netherlands. KiXtart is now provided to you as CareWare"

More information:
http://www.kixtart.org -
http://www.kixtart.org/manual.html

Figure 19 Technical information: Kixtart

7.5.4 Using WMI

The Windows Management Instrumentations allows the collection of a wide range of information from a computer. Used by remote this would allow the server to communicate with the client to verify power management settings and states. The WMI can be used to read the processor load or the states of different applications.

"Windows Management Instrumentation (WMI) enables a large amount of data to be available for a target computer. This data can be hardware and software inventory settings, or configuration information. In Windows XP, WMI Filtering allows the IT professional to determine dynamically whether to apply a group policy object (GPO) based on a query of WMI data." (Christoffer Frisell – Microsoft, 2002-10-01)

7.6 Application - interface, scheduling, usage pattern detection

7.6.1 Scheduling start-ups and shutdowns

Once the functionality for detecting running computers, shutting down and starting them up again is in place, it would be helpful to have the possibility to schedule this function. For example, all computers would start up 7:30 every weekday and automatically turn them self off at 18:00. This could rather easily be achieved using open source job-scheduling systems such as Quarts for Java (see link in appendix 10.1) or even built in operating system functionality. There would have to be some form of interface to this scheduling, we suggest a web system based on standard browser techniques. This for two apparent reasons, first, the application does not need to be installed at the client and, secondly, that it can be accessed from multiple computers on the network. Placing the application on the server ensures that the program is running at all times and does not rely on a single workstation to function.

7.6.2 Usage pattern detection service

A more subtle and intelligent solution would be to develop a solution that during the day automatically surveys the network to identify which computers that are in use, and at which times.

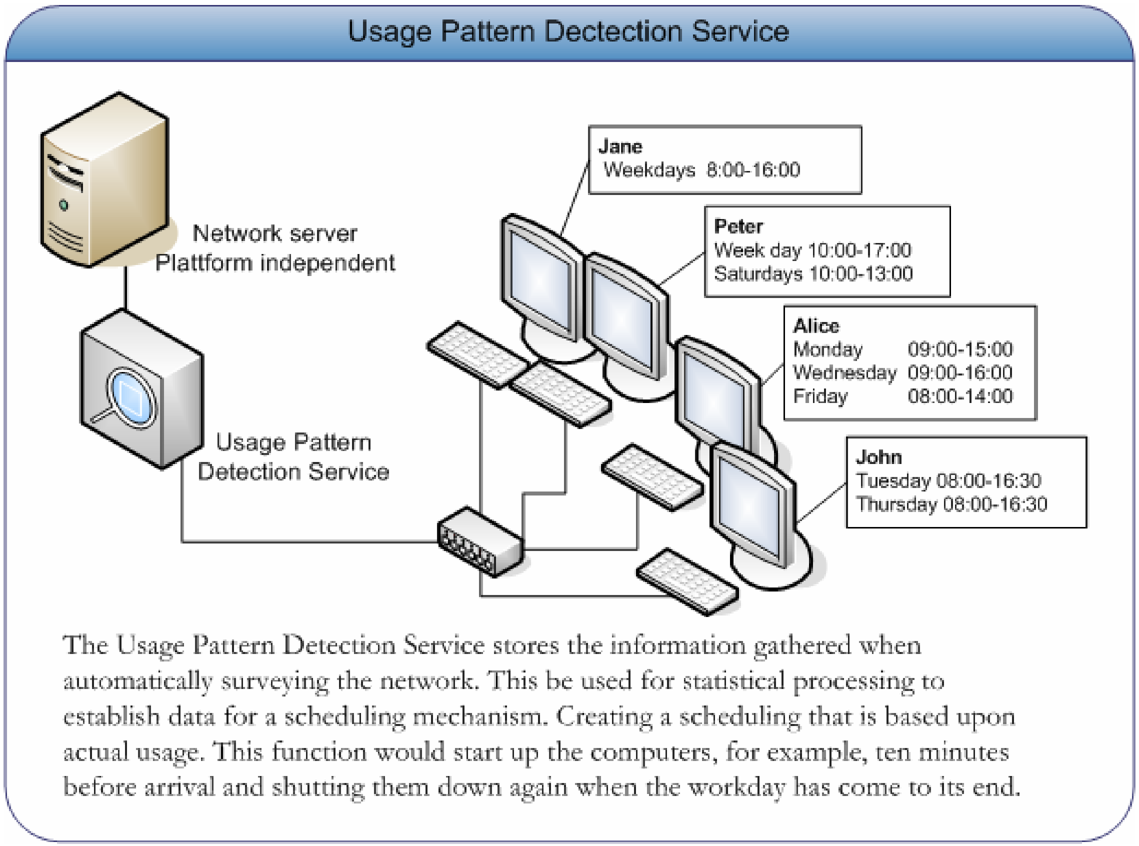


Figure 20 Model for usage pattern detection service

This pattern identification would ideally be running on a server within the local network as a service daemon that gathers usage information every X interval. The power management functions that are automatically initiated should be easy for the user to cancel. Alternatively, there should be a way to affect and redefine the scheduling database from a simple to use interface. Ideally, he or she would never see the actual shutdown since no such commands would be issued to a computer with someone logged on.

7.6.3 Why do we propose open source?

According to the Open Source Definition (OSI, 2006) version 1.9, a project that wishes to distribute its content in open source license needs to fulfill certain criteria's, it is not just a matter of giving access to the source code. Below we provide you, the reader, with our philosophy on meeting the open source criteria.

We believe in distributing our proposed application under the open source license and we have no intentions on restricting the software to be used only as a standalone application. Our intentions of distributing our software is stated above and we would have no interest in making any money on our development. The free distribution of source code is an important reason for us to choose the open source license. We believe in sharing our work and this also means sharing our source code. The benefit of this is that other developers can review our code and solution and perhaps even modify it the way they want to. This leading to a more extended use of our program and as stated above this is what we want.

We also believe in the free distribution of our proposed solution and we also fulfill this criterion as our intention is to maximize the distribution of our proposed software, in one form or another. We believe that it is positive if software based on our solution is used in a greater extent even if it is modified or integrated into other projects. We have no opinions on in what kind of environment our proposed software will be used. As stated several times before, we believe in the free distribution of our software to help people save energy and health, not restricting where the software is used and not restricting the context of the software.

7.6.4 GNU General Public License

The General Public License (GPL), maintained by the Free Software Foundation (FSF,), is a commonly used license that is used as an open source license. We prefer the GPL because it adds criteria that we believe is important for the distribution of our proposed software solution. The GPL specifies under what kind of warranty the program is used and sets criteria's for copying, distribution and modification of the software. The GPL clearly states that the authors, or distributors, are free on decisions to charge for the sole distribution of the software. The charge is for the service and not for the software itself. (GPL Philosophy, 2006).

We find the GPL to stand for an important and useful for the world wide community of software developers.

8 General conclusion and future work

Our ambition was to demonstrate how a minimal effort could provide noticeable environmental and economical benefits with a minimal implementation cost and inconvenience to the end user.

In our chapter on the general background we presented several interesting facts regarding computer components energy use, this information helped us understand the complexity of energy use of computer components such as processor and monitors. Since we knew that different industry standards and organizations was engaged in minimizing computers energy consumption use we felt it was necessary to find out how they worked and if we could use them in our proposed solution. We discovered that these standards were widespread, virtually existing in all PC computers. Both organizations were striving for the same goal, minimizing energy waste and saving health, the environment and off course money.

When reviewing environmental impacts of energy waste we identified two major issues that are related to the use of computers and their energy consumption. Firstly, the need of burning fossil fuels to obtain energy. Secondly we believe that it's of critical concern that we minimize the release of brominated flame retardants. These neuro toxicol chemicals are capable of transporting up the food chain and an animal study has show these chemicals to be harming brain development. We believe that these facts cannot be ignored.

To clarify how much energy computers and monitors really was using we conducted our energy measurement study. Where we identified that LCD monitors generally uses half of the energy consumed by a CRT. Contradictory, the newer computers consumed more that the previous models. These observations helped us with the construction of our survey. We focused on asking questions related to the above facts. By adding a couple of more questions on hardware and software we were able to get more information on how Swedish schools are using power management and if there were a centralized tool available.

A majority of our responding schools did not have a delegated responsibility in the organization. And if they did, there was a clear lack in modern tools to perform these
dull duties.

Taking into account these results we demonstrated how one single computer can save energy and money by enabling power management. These examples were based on typical computers and monitors that were based on facts from our energy measurements. When showing the impact of power management we also divided our examples into two different computer setups, one setup with a computer with CRT-monitor and one computer with LCD-monitor. The reason of this was that in our survey we observed that the majority of our survey respondents were using CRT-monitors, but almost all respondents claimed that they had both CRT and LCD-monitors. Therefore we created an example organization with 200 computers having both types of monitors. We applied Nordman (1997) figures which states that a computer is turned on 9 hours during a regular office day, and out of those 9 hours the computer is idle for 5.5 hours. With our example we let the example computers be turned on during all of these 9 hours and then compared this to the results of power managing all computers during the 5.5 idle hours. The result was clear, by enabling power management the example organization would save 44 681 Skr every year, that is 223 new books every year, if one book would cost 200 Skr. If one was to power manage other components than just the monitor even more energy could be saved, these solutions demands a work effort. Distributing register settings automatically is a simple solution that could be performed in a couple of hours. Scheduled automatic shutdown is does exists as Microsoft Windows desktop software by commercial suppliers. Since this could be beneficial for a wide range of organizations we suggest an open source solution to be the most sound and flexible way. By providing our readers with this information regarding power management and our proposed solution we encourage our readers to think locally and act globally, saving both energy and our environment.

8.1 Technical conclusion and further work

With our proposed solution we have striven to demonstrate the use of standard functionality to provide a flexible and multilayered solution to enhance power management. We have strived to prevent the need for installing additional software onto the clients. Most commands that are necessary to issue for power management can be solved using build in functionality. However, eventually communication between the client and the server is necessary to support functions that are more advanced. This introduce a number of concerns, software running on the clients has to be compatible with the current version of the operating system and other installed programs. In addition, any changes and updates must be installed to all of the computers. The whole application becomes several degrees more advanced and potential issues beside pure technical ones have to be resolved. A client – server configuration has to be justified by its benefits. We believe that a service running on the server is the right place to start. It could survey usage; issues power management commands and generate configuration files for individual users/computers based on collected statistics. In the next step a internal web interface would be used to configure and manage the application. A standard SQL database could be used by both the network service and the web management interface. Together presenting statistics and logs of operation. The web interface would also be used if the end users wished to change settings or disable certain functions. In the end the golden rule of power management is to reduce the inefficient energy consumption without altering the performance of the equipment. We give you our example.

Conceptual schema for the first version

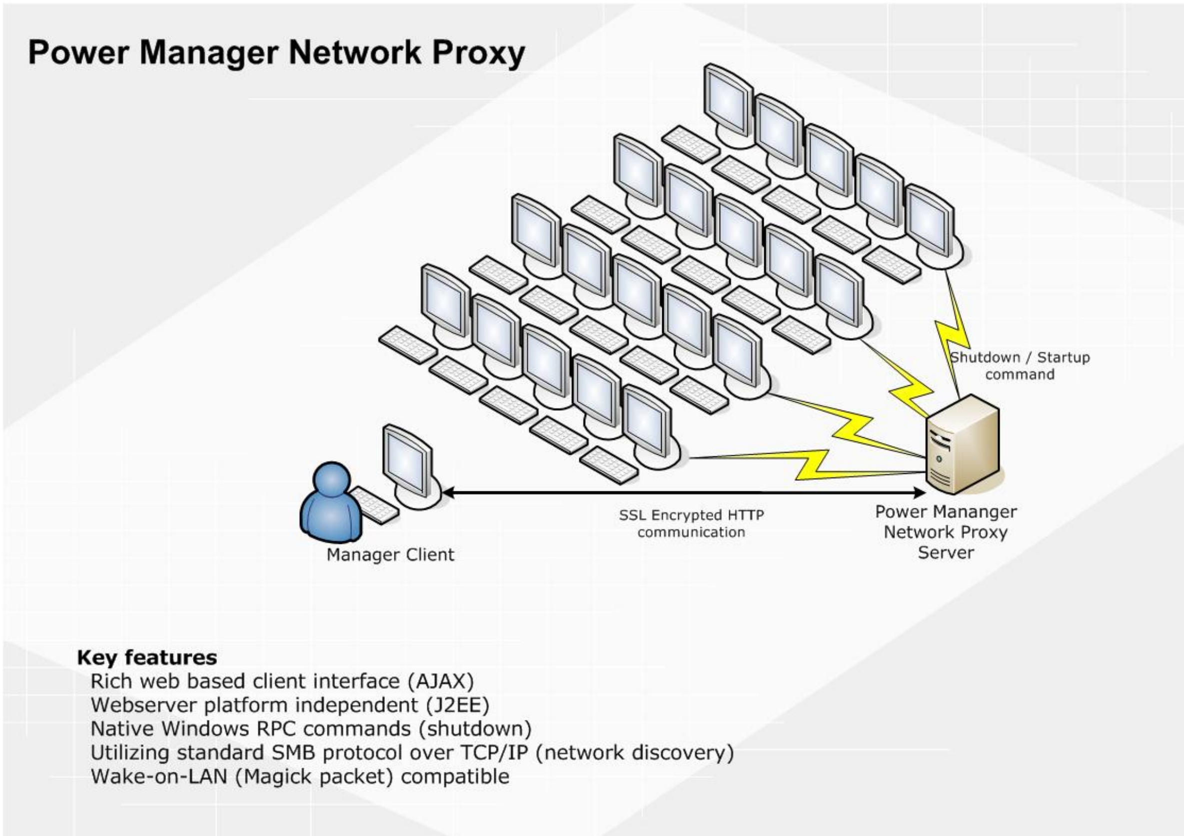


Figure 21 Conceptual schema for the first version

In all, we hope this thesis has provided a sound and somewhat read-worthy thesis. Please do not hesitate to contact us if you are working on a similar project.

Martin Thall, martin_thall@yahoo.com - Niclas Bjuväng, admin@highone.nu

9 References

Bryman, A. (2002) Strategier i samhällsvetenskaplig forskning. Chapter 1 in Samhällsvetenskapliga metoder. 1. ed., Liber ekonomi, Malmö.

Weber, R. (2004): Editor's Comments: The Rhetoric of Positivism Versus Interpretivism: A Personal View. MIS Quarterly, 28(1), iii-xii.

9.1 Reports

Nordman et al (1997) *User Guide to Power Management for PCs and Monitors* Lawrence Berkeley National Laboratory, University of California (Electronic)
PDF Format
Accessible: < http://enduse.lbl.gov/info/LBNL-39466.pdf > (2006-05-05)

Roberson et al (2002) *Energy Use and Power Levels in New Monitors and Personal Computers,* Ernest Orlando Lawrence Berkeley National Laboratory, University of California (Electronic)
PDF Format
Accessible: < http://enduse.lbl.gov/Info/LBNL-48581.pdf > (2006-05-09)

TCO Development, Nordin (2005) *Experience from TCO: development, operation and challenges for an international ecolabeling scheme* (Electronic) PDF Format
Accessible:
<http://www.edf.org.tw/2005conference/Symposium/5%20Experience%20from%20TCO.pdf > (2006-05-08)

9.2 Industry standards and organisations

Energy Star (2006) *North Thurston Case Study* (Electronic) PDF Format:
Accessible:
<
http://www.energystar.gov/ia/products/power_mgt/North_Thurston_Case_Stud
y.pdf > (2006-05-13)

Energy Information Administration (2005) *International Energy Outlook 2005* (Electronic)
Accessible: < http://www.eia.doe.gov/oiaf/ieo/world.html > (2006-05-13)

Energy Star (2003) *Press release: General Electric Joins Energy Star* (Electronic) Word Format
Accessible:
< http://www.energystar.gov/ia/products/power_mgt/GEJoinsMMD.doc >
(2006-05-15)

Energy Star (2006) *Energy Star key product criteria* (Electronic)
Accessible:
< http://www.energystar.gov/index.cfm?c=computers.pr_crit_computers >
(2006-05-15)

Energy Star (2005) *Energy Star achievements 2005* (Electronic) PDF Format
Accessible:
< http://www.energystar.gov/ia/news/downloads/2005_achievements.pdf >
(2006-05-08)

Energy Star (2005) *Energy Star Website, about Energy Star* (Electronic)
Accessible: < http://www.energystar.gov/index.cfm?c=about.ab_index >
(2006-05-08)

Energy Star (2005) *Energy Star Website, history* (Electronic)
Accessible < http://www.energystar.gov/index.cfm?c=about.ab_history >
(2006-05-09)

Energy Star European Union, *EU figures* (Electronic)
Accessible: < http://www.eu-energystar.org/en/en_012.htm > (2006-05-07)

Free Software Foundation (2006) *The GNU Public License philosophy* (Electronic)
Accessible: < http://www.gnu.org/philosophy/ > (2006-05-15)

Open Source Initiative (2006) *The open source definition, version 1.9* (Electronic)
Accessible: < http://www.opensource.org/docs/definition.php > (2006-05-14)

TCO Development (2005) *TCO 05 Desktop version 1.0* (Electronic) PDF Format
Accessible:
<http://www.tcodevelopment.com/tcodevelopment1200/Datorer/TCO05/TCO05_Desktopversion_1.0.pdf > (2006-05-09)

TCO Development (2005) *TCO Development operations* (Electronic) PDF Format
Accessible:
<http://www.tcodevelopment.com/pls/nvp/Document.Show?CID=1200&MID=34 > (2006-05-09)

TCO Development (2005) *TCO 05 Specifications* (Electronic)
Accessible:
<http://www.tcodevelopment.com/pls/nvp/Document.Show?CID=1200&MID=966 > (2006-05-09)

Tufts Climate Initiative. *Frequently Asked Questions About Computer Power Management* (Electronic)
Accessible: < http://www.tufts.edu/tie/tci/pcpowermanagement/FAQ.html > (2006-05-12)

9.3 Technical information

JCIFS
Accessible: < http://jcifs.samba.org >(2006-06-04)
This document contains more information on how to call Windows Named Pipes from JCIFS: Accessible: < http://jcifs.samba.org/src/docs/pipes.html >(2006-06-04)

Mark E. Russinovich, David A. Solomon (2004) Microsoft® Windows® Internals, Fourth Edition: Microsoft Windows Server™ 2003, Windows XP, and Windows 2000 (Microsoft Press) (Electronic)
Accessible:
<http://book.itzero.com/read/microsoft/0507/Microsoft.Press.Microsoft.Windows.Internals.Fourth.Edition.Dec.2004.internal.Fixed.eBook-DDU_html/0735619174/toc.html > (2006-05-05)

Microsoft (2002), *Power Management in Windows* (Electronic)
Accessible:
<http://www.microsoft.com/windowsxp/using/setup/learnmore/russel_02march25.mspx > (2006-06-04)

Andrew S. Tanenbaum (2006) Power Management in Operating Systems, Prentice Hall (Electronic)
Accessible: < http://www.phptr.com/articles/article.asp?p=25451&rl=1 > (2006-06-04)

9.4 Other information

C-Net News (2002-05-15), *Intel, AMD neck and neck in chip costs* (Electronic)
Accessible:
< http://news.com.com/Intel,+AMD+neck+and+neck+in+chip+costs/2100-1001_3-914985.html > (2006-05-07)

European Commission (2006), *Energy Demand Management* (Electronic)
Accessible:
< http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm > (2006-05-10)

Environmental Protection Agency (2000) *Global Warming – Climate* (Electronic)
Accessible: < http://yosemite.epa.gov/oar/globalwarming.nsf/content/climate.html > (2006-05-13)

Fujitsu-Siemens, *Big Turn Off Campaign*
Accessible: < http://www.fujitsu-siemens.co.uk/rl/news/241005.html > (2005-10-24)

Rocky Mountain Institute (2004) *Home energy brief #7* (Electronic) PDF Format Accessible:
< http://www.rmi.org/images/other/Energy/E04-17_HEB7Electronics.pdf > (2006-05-08)

Swedish Consumer Agency (2006) *Konsumentverket/KO Elpriser* (Electronic) Accessible: < http://www.elpriser.konsumentverket.se/ > (2006-05-09)

10Appendices

10.1 Software, source code and programming guidelines

Beyond Logic 2006-06-04
http://www.beyondlogic.org/consulting/remoteprocess/BeyondExec.htm

IBM: Utilising remote registry access (Brian Venn, 2002)
http://www-128.ibm.com/developerworks/library/s-remote/index.html

Java implementation of Portscan
http://slashtom.org/Software/index.php?package=jmap

NBTScan (C) NetBIOS Name Network Scanner.
http://www.inetcat.org/software/nbtscan.html

NetBios Scan (C++ code)
https://sourceforge.net/project/showfiles.php?group_id=37515

NMBSCAN
Discovers NMB/SMB/NetBIOS/Windows hostname, IP address, IP hostname, ethernet MAC address, Windows username, NMB/SMB/NetBIOS/Windows domain name, and master browser.
http://gbarbier.free.fr/prj/dev/#nmbscan

PsLoggedOn
http://www.sysinternals.com/Utilities/PsLoggedOn.html

Quartz for Java – Scheduling software (guide)
http://www.onjava.com/pub/a/onjava/2004/03/10/quartz.html

SMB accessible registry
http://www.nessus.org/plugins/index.php?view=viewsrc&id=10428
http://www.nessus.org/plugins/index.php?view=viewsrc&id=10400

10.1.1 Sample code

Java WOL implementation

```
import java.net.*;

public class WolTools
{

  public int WakeOnLan(String ip, String mac, int port)
  {
    return sendPacket(ip, mac, port);
  }

  public int WakeOnLan(String ip, String mac)
  {
     int port=9;
     return sendPacket(ip, mac, port);
  }

  private int sendPacket(String ip, String mac, int port)
  {
    try
    {
      byte[] macBytes = getBytes(mac);
      byte[] bytes = new byte[6 + 16 * macBytes.length];

        for (int i = 0; i < 6; i++)
        {
          bytes[i] = (byte) 0xff;
        }

        for (int i = 6; i < bytes.length; i += macBytes.length)
        {
           System.arraycopy(macBytes, 0, bytes, i, macBytes.length);
        }

     InetAddress address = InetAddress.getByName(ip);
     DatagramPacket packet = new DatagramPacket(bytes, bytes.length, address,
port);
     DatagramSocket socket = new DatagramSocket();
      socket.send(packet);
      socket.close();
     return 0;

     }
     catch (Exception e)
```

```
        {
           return -1;
        }
     }


      private static byte[] getBytes(String mac) throws IllegalArgumentException
      {
          byte[] bytes = new byte[6];
          String[] hex = mac.split("(\\:|\\-)");

          if (hex.length != 6)
          {
             throw new IllegalArgumentException("MAC ADDRESS IS INVALID");
          }
```

Sample code, Java WOL implementation, continued.

```
         try
           {
             for (int i = 0; i < 6; i++)
             {
                bytes[i] = (byte) Integer.parseInt(hex[i], 16);
             }
          }
         catch (NumberFormatException e)
         {
          throw new IllegalArgumentException("MAC ADDRESS CONTAINS INVALID HEX");
         }
         return bytes;
      }
   }
```

10.2 Computer configuration

Average Computer	The average computer is a multipurpose computer used for both Internet related activities and playing games and media.
Processor	AMD 64 3200+
Memory	Samsung 512MB DDR
Graphics	Gigabyte 6600GT PCI-Express
Main board	Gigabyte NForce3
Drives	1 x 200GB Maxtor
Monitor	Samsung 19" 193T

Workstation	This workstation is used primarily for multimedia purposes. The graphics card is fast alhough not top-of-the-line as of 2006. Storage is important; there are five hard in this computer. The large 24” monitor contributes to the high-energy consumption.
Processor	AMD 64 3200+
Memory	1GB Kingston PC3200
Graphics	ATI Radeon 9800PRO AGP
Main board	MSI K8T Neo2
Drives	1 x 120GB Seagate 1 x 200GB Maxtor 2 x 300 GB Seagate 1 x 400 GB Western Digital
Monitor	Dell 2405FPW 24” LCD

10.3 Survey questions (in Swedish)

1. Hur många datorer används inom Er organisation ?

- 1-50
- 50-100
- 100-200
- 200 eller fler
- Vet ej

2. Vet Ni om er arbetsplats har en policy angående avstängning av datorer, monitorer osv.

- Ja, datorerna skall stängas av vid arbetsdagens slut
- Ja, datorerna skall lämnas påslagna dygnet runt
- Nej, vi har ingen sådan policy
- Vet ej

3. Brukar ni stänga av er dator när ni går hem för dagen?

- Ja
- Nej

4. Brukar ni stänga av er skärm/monitor när ni går hem för dagen?

- Ja

Nej

5. Stänger er dator av sig automatiskt om den inte används (viloläge) ?

Ja

Nej

6. Stänger er skärm/monitor av sig automatiskt om den inte används (viloläge)

Ja

Nej

Vet ej

7. Finns det någon som är ansvarig för att stänga av datorerna vid dagens slut?

Ja

Nej

Vet ej

8. Om Ja i föregående fråga, brukar den ansvarige använda någon form av central funktion för att stänga av datorerna?

Ja, det finns en huvudströmbrytare

Ja, det finns mjukvara/program för ändamålet

Nej

Vet ej

9. När införskaffades merparten av organisationens datorer?

Mindre än tolv månader

1-2 år

3-4 år

Mer än 4 år

Vet ej

10. Andel tunna LCD skärmar inom er organisation?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90%

100%

11. Andel äldre traditionella CRT-monitorerna (större, djupare skärmarna)?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

12. Vilka operativsystem använder ni?

Microsoft Windows användarklient(PC)

Microsoft Windows server(PC)

- ☐ Apple Macintosh/OS X användarklient
- ☐ Apple Macintosh/OS X server
- ☐ Linux användarklient
- ☐ Linux server
- ☐ Unix användarklient
- ☐ Unix server
- ☐ Annat