Erick Poletto
Ricardo Alexandre Fiorelli

Title of the Thesis

Milan – IT

July/2009

Erick Poletto
Ricardo Alexandre Fiorelli

Nome Tesina

commentario

Orientator: Prof. Chiara Francalanci

Laurea Specialistica in Ingegneria Informatica
Dipartimento di Elettronica ed Informazione (DEI)
Politecnico di Milano

Milan – IT

July/2009

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Acknowledgements

Dedico meus sinceros agradecimentos para:

*“It’s the only home we know. Yet everyday, we take the earth for granted.
Everytime we leave the lights on, we are doing the earth harm.
When we forget to turn off our computers, energy is also wasted.
But together we can help make the world a greener place, one simple act at a time.
Because when it comes to the environment, small changes can make a world of
difference.”*, ***The “Power To Change” manifest***

Glossary of Abrevitations

x	x
DDR	Double-Data Rate
HDD	Harddisk Drive
IBM	
MFD	Multi Function Devices
MPN	Manufacturer Part Number
ROI	Return on Investment
TOC	Total Cost of Ownership
SaaS	Software as a Service
x	x

Abstract

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Motivation

O greenict tem sido muito importatne para o mundo, as empresas, depois da crise economica, comecaram a ver que Ã© importante, pois, reduz muitos custos, alÃ©m de contribuirem apra o meio ambiente… bla bla bla

1 Introduction

Purpose of the study.

1.1 Definition of the problem

1.2 Solution Strategy

1.3 Structure

2 State of the Art

In terms of hardware and equipment, the main measures to be taken towards a Green ICT environment can be grouped in the following categories:

- Workstation Configuration;
- Policies / Tools / Labels;
- Thin client architectures;
- Servers and Virtualization;
- Data Storage;
- Power Architectures;
- Data Center Infrastructure.

For each of those categories there are several types of information that are relevant to the evaluation of the intervention and their consequent energy savings. For each one a list of possible interventions will be made, and after that analyzed if they are either purely conceptual or available in the market. Moreover, it is important to know exactly where the power is going and where the energy is being wasted. In hands with that information, it is possible to redirect it to the places with more necessity and ameliorate the computers with more idle time, by applying one of the above categories before. Therefore, it is feasible to draw a more realistic figure of what is going on with the energy consumed in the place.

It is possible to compare how much energy is spent by three types of components, Computers on Table 1, Monitors on Table 2 and an Apple on Table 3.

Computers	
Desktop Computer	60-250 watts
On screen Saver[a]	60-250 watts
Sleep / Standby	1-6 watts
Laptop	15-45 watts

[a] no difference

Table 1: Energy used by a standard computer

Monitors	
Typical 17” CRT	80 watts
Typical 17” LCD	35 watts
Apple MS 17” CRT[a]	63 watts
Apple MS 17” CRT[b]	54 watts
Screen saver[c]	same as above
Sleeping monitor[d]	0-15 watts
Monitor turned off at switch	0-10 watts

[a] mostly white (blank IE window)
[b] mostly black (black Windows desktop with just a few icons)
[c] any image on screen
[d] dark screen

Table 2: Energy used by Monitors

Apple iMac G5 with built in 20” LCD screen	
Idle	97 watts
Monitor dimmed	84 watts
Monitor sleep	62 watts
Copying files	110 watts
Watching a DVD	110 watts
Opening a lot of pictures	120 watts
Computer sleep	3.5 watts

Table 3: Energy used by Apple iMac G5 with built in 20” LCD screen

2.1 Computer Energy Management Categories

2.1.1 Workstation Configuration

This category represents the components used in a certain machine configuration. All the information about each component performance and power consumption can be obtained from several sources, such as the manufacturer specifications, benchmarks or direct measurements in the case of energy consumption Listed below are the necessary information to evaluate interventions and their energy savings:

Single-core / Multi-core processors

CPU Type

Type and dimension of RAM memory

Type and dimension of cache memory

Chassis (power supply, fan)

Monitor type It is important to say that using flat panel liquid crystal display (LCD) monitors and not conventional CRT monitors can reduce energy consumption by a third. LCD monitors also run cooler, which helps save on air conditioning costs. In addition to that, selecting the right-sized monitor to meet the needsof the user helps, because the bigger the monitor, the more energy it uses.

Hard drives (number and type)

Auto-sleep, remote sleep and screen saver Enabling the energy saving settings on PCs and peripherals is also valuable act, due to the fat that a computer in idle mode uses 20 to 50 times the power of a computer in standby mode. For example, when the computer is in standby mode the computer uses 0 to 6 watts. Reducing the time delay in which the computer will enter in the power saving mode is also a good thing to be done. Another thing to be done, is to disable the screen saver. Studies shown that a monitor in screen saving mode uses significantly more energy than in standby mode.

Efficiency benchmarks fat/thin

Performance benchmarks

Overall and single components power consumption benchmarks, in several load conditions (idle, SO, main applications)

Trade off between performance and consumption

2.1.2 Policies / Tools / Labels

The amount of saved energy depends also on technology acquisition and managerial policies. There are a number of specialized tools that may be used in order to help enforcing these policies and tools.

These policies can be made as acquisition of new computers or components labeled as green by the manufacturer, purchase of dual or multi-core processors, or even the discourage of purchasing or use of other parts, such as dual or large monitors. Likewise, other kinds of policies are a good idea to be defined, and they concern in the use of the workstation, for instance, to turn off the computer if they are going to be unused for a long time, shutdown over nights, and others. These policies, or rules, are important either to enforce the company's position through the green idea either to keep track of the list of thing yet to be prepared in order to convert the computers and workers as green as possible.

Furthermore, the use of tools that automates these methods is welcome to the enterprise. There are many tools, which let the computer in standby mode, or even turn off after a long period of no utilization. In addition, the use of networked pieces of hardware can be an effective way to achieve the green. Additionally, networked systems allow several nearby users to share a single (faster) printer generally save time, cost, and energy compared with each computer having a dedicated printer, it will decrease their idle time and provide for more cost-effective use of the equipment. Above that, choosing multifunction devices (MFD) that do the work that used to require several machines. In addition to saving space and materials, these All-in-Ones save energy compared to several products working in parallel. Select printers or multifunction products that offer two-sided printing

Efficiency Recommendation		
Printer Speed	Recommended "Sleep" Mode[a]	
	Laser B/W + All Ink jet[b]	Laser Color[c]
$\geq$10 pages/min	10 watts or less	35 watts or less
11-20 pages/min	20 watts or less	45 watts or less
21-30 pages/min	30 watts or less	70 watts or less
31-44 pages/min	40 watts or less	70 watts or less
>44 pages/min	75 watts or less	70 watts or less

[a] "Sleep" mode is a low-power standby condition, it restores automatically with a print request.
[b] Includes both black-ink and color ink jets, and printer/fax combinations.
[c] Also includes LED and thermal transfer color printers.

Table 4: Energy Recommendation to an Energy-Efficient Printer

to reduce paper and energy usage. The Table 4[1] describes the characteristics that am energy-efficient networked printer should have, in relation to the number of pages per minute it prints.

Besides these facts, it is also a choice to buy only eco-labeled products. Eco-label is a category given to products, which comply some of the energy efficiency specifications provided by the owner companies of these labels. The most famous of these labels is the ENERGY STAR®, which is a voluntary energy efficiency program sponsored by the U.S. Environmental Protection Agency. For example, An ENERGY STAR® qualified computer is possible to use up to 70% less electricity than computers without enabled power management features.

2.1.3 Thin Clients Architectures

O que sao thin clients...

PC vs. Thin Client: Performance

In order to analyze and give a base for a comparison of the performance between standard PCs and two types of thin clients, a set of tests were executed, on networks varying the number of active clients, each running the same typical office applications tasks. The following client platforms participated in this study:

- PC: OptiPlex 210L PCs, basic managed PC desktops running Windows XP Professional;

[1] `http://www1.eere.energy.gov/femp/procurement/eep_printer.html`

- Sun thin client: Sun Ray 2 running Sun Ray proprietary software;
- Wyse thin client: Wyse Winterm 5150SE, Linux-based thin clients running Wyse Linux V6.

Each network used a standard file server, an HP ProLiant DL360 3.4MHz with and Intel Xeon processor and Microsoft Server 2003 Enterprise Edition. For test reasons, all files were manipulated by the PC were stored at the server. The tests are listed below:

- Calculating subtotal in Microsoft Office Excel 2003 (Figure 1 and Table 5)
- Compressing a PDF within Adobe Acrobat 7.0 Standard (Figure 2 and Table 6)

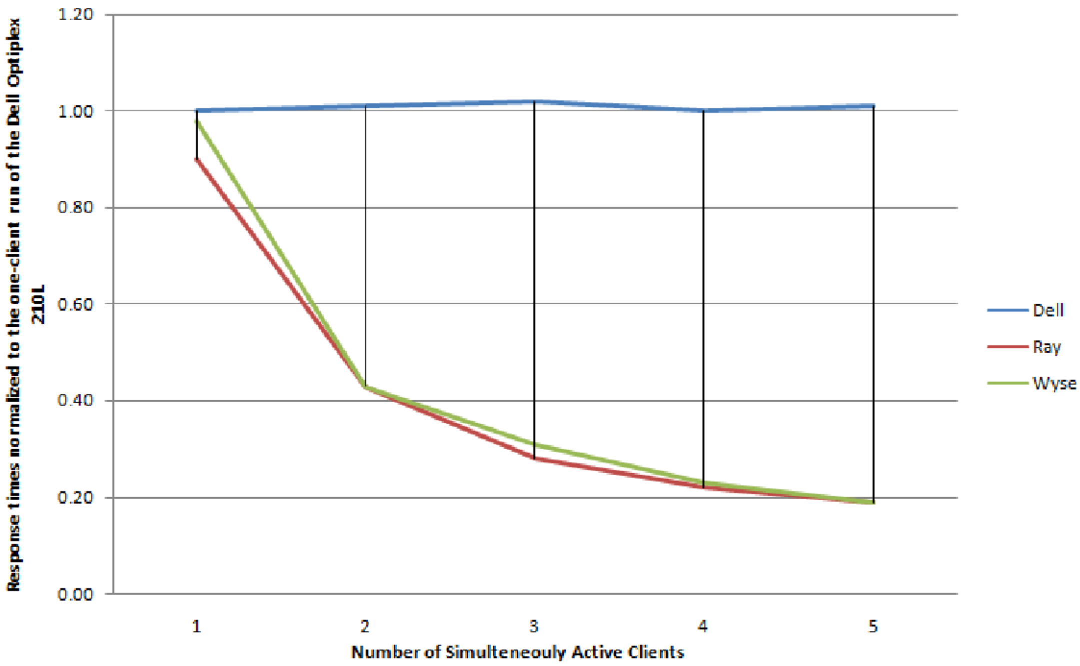

Figure 1: Normalized Excel Subtotals Task Response Times

Performance Results				Comparative Rating		
PC solution	Thin-client solutions		Number of	PC solution	Thin-client solutions	
Dell OptiPlex 210L	Sun Ray 2	Wyse Winterm 5150SE	concurrent active clients	Dell OptiPlex 210L	Sun Ray 2	Wyse Winterm 5150SE
12.9	13.2	13.1	1	1.00	0.90	0.98
12.8	30.2	29.7	2	1.01	0.43	0.43
12.7	45.5	41.9	3	1.02	0.28	0.31
12.9	58.3	57.3	4	1.00	0.22	0.23
12.8	68.1	67.9	5	1.01	0.19	0.19

Table 5: Performance Results for Excel Subtotals Calculation

Performance Results				Comparative Rating		
PC solution	Thin-client solutions		Number of	PC solution	Thin-client solutions	
Dell OptiPlex 210L	Sun Ray 2	Wyse Winterm 5150SE	concurrent active clients	Dell OptiPlex 210L	Sun Ray 2	Wyse Winterm 5150SE
16.1	16.0	15.6	1	1.00	1.01	1.03
16.4	23.8	24	2	0.98	0.68	0.67
16.5	33.0	33.1	3	0.98	0.49	0.49
16.6	43.7	44.3	4	0.97	0.37	0.36
16.7	54.0	55.1	5	0.96	0.30	0.29

Table 6: Performance Results for PDF Compression Subtotals Calculation

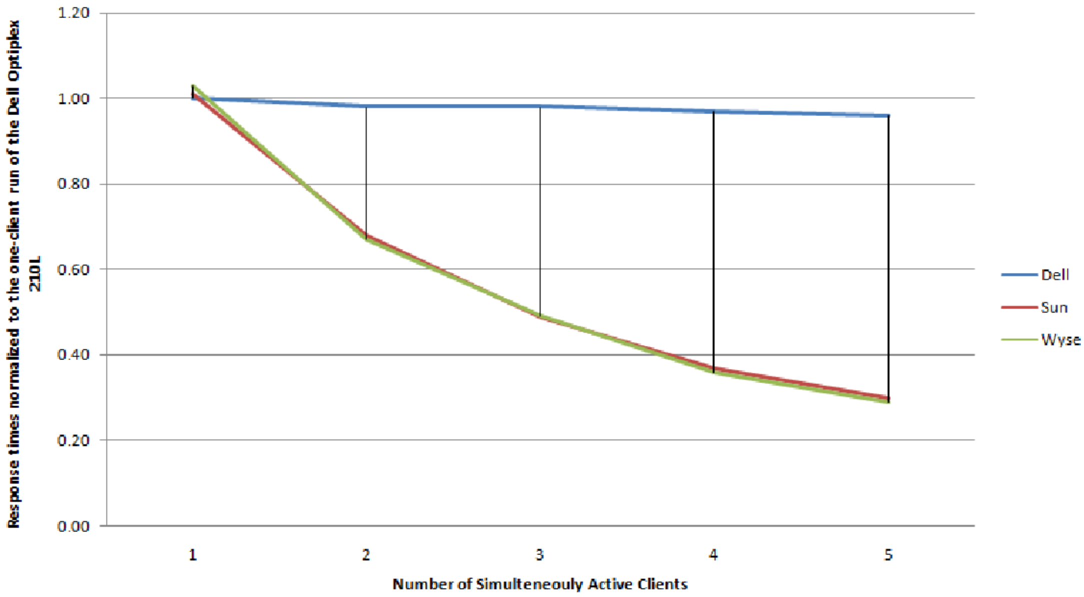

Figure 2: Normalized PDF Subtotals Task Response Times

	Thin Client	**PC**
Weight	2.2 - 7.7 lbs	22 - 33 lbs
Volume	1.5 - 3 dm^3	30 - 35 dm^3
Packing material	2.2 - 4.4 lbs	3 - 5 kg
Power consumption(including monitor)	20 - 50 watt	300 - 400 watt
Heat rejection	5 - 35 watt	85 - 115 watt
Noise level	0 dbA	50 - 60 dbA

Table 7: PC and thin client power consumption

PC vs. Thin Client: Power Consumption

Supposing 30 thin users share a 400W server, the total power consumption will be 1300W - a yearly cost of €640.00. 30 PCs would consume 10000W instead - a yearly cost of €4900.00 (assuming the MWh cost is €80.00). The Table 7 shows the power consumption of thin-client and PC.

Hardware Savings

Savings on client hardware The economy brought by the substitution of PCs with thin clients was estimated around US$ 208 per PC per year. The estimative considered the average prices of a PC, an adequate thin client and the PC upgrade costs every 3 years. If energy consumption is considered, the savings will be even greater.

The following considerations were taken:

- Thin client cost: US$250.00 x PC cost: US$750.00;
- PC needs to be upgraded every 3 years and thin clients need to be replaced every 6 years.

Therefore, in a 6-year period US$1500.00 will be spent on a PC against $250.00 that will be spent on a thin client.

Extra server hardware costs Considering that:

- On average 30 users will need a dual processor server with 4 GB of RAM and SCSI hard disks;
- A brand new server should cost around US$4,500.00 and will depreciate on average in 3 years.

For 60 users, the thin client solution should out-price the PC one by US$11,300.00 per year, excluding the administration costs of both solutions.

2.1.4 Servers and Virtualization

bla bla bla...

Rack vs. Blade

According to Goldworm(GOLDWORM, 2007), Blade servers are a package of "ultra-high density components including servers, storage, and communications interfaces in a pre-wired chassis with shared components such as power, cooling, and networking. In contrast to the conventional *horizontal* positioning within a rack (rack mounted servers), blades are typically (though not always) installed *vertically* in a blade chassis, like books in a bookshelf". This disposition of the servers provide a high density of the components and thus performance, for example, 60 blade servers can fit in the same physical space as 42 rack-mounted servers. Another improvement reached with this type of server is the integration of a remote system management, differently form the ordinary (rack or standalone), where it is an add-on. An example of this type of server can be seen on Figure 3. Moreover, Blade servers[2] are computer servers designed to minimize the use

[2] http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?tp=&arnumber=1362591&isnumber=29851

of physical space. A blade enclosure, which can hold from 8 to 24 (REHN, 2008) blade servers, provides common services such as power supply, cooling and networking thus eliminating redundancies in each individual blade server. More than 250 blade servers can be easily accommodated in a single rack. On the other hand approximately 42 servers can be accommodated to a standard rack when it comes to the other lower end servers available in the market. Whereas, rack-mounted servers are those arrange in industrial rack. A single rack is capable of holding 10 to 20 servers. Therefore, this type of servers come with rails or slides to ease inserting and removing of the components(BAILEY, 2009).

In the Table 8, a comparison is made between IBM HS21 blades and x3550 rack servers.

(a) IBM LS20 **(b)** Sun 6000 Series Blade Enclosure **(c)** HP Intros Rack

Figure 3: Examples of Blade Servers

The blades and rack servers have comparable performance.

- 2.0 GHz intel quad core;
- 8 GB DDR2 memory;
- Both in standard configuration, with no HDDs.

Thus, a possible conclusion to this comparison is that with Blade servers the gain with space, performance and, more importantly, power consumption is much smaller than with Rack-mounted devices.

(a) Chenbro 5U RM51924 (b) Rack Server

Figure 4: Examples of Rack Servers

IBM server model	Base Power Consumption	kWh consumed over 5 years	Total cost ($0.03/kWh) over 5 years
BC-H Chassis, no blades	0.510 kWh	22,350	$670.50
BC-H HS21 blade	0.318 kWh	13,936	$418.08
x3550 server	0.373 kWh	16,346	$490.39
x3650 server	0.455 kWh	19,940	$598.20
BC-H chassis with 14 HS21 blades	4.962 kWh	217,455	$6,523.65
14 x3550 servers	5.222 kWh	228,849	$6,865.46
14 x3650 servers	6.370 kWh	279,259	$8,374.80

Table 8: Power consumption for several servers, excluding cooling and redundancy

- Space saving and efficiency - packaging more computer power in a significantly smaller area;
- Consolidation of servers to improve and centralize management as well as utilization;
- Return on investment (ROI) and improved total cost of ownership (TOC) through increased hardware utilization and reduced operating expenses;
- More energy efficient, due to existence of centralized power supply, cooling and networking.

According to the figures, the choice of using a blade server provides roughly 5% power saving over a similar rack-mount configuration. The main benefit brought by the use of blade servers, however, is the processing density, as a rack filled with blade servers may carry up to 50% more servers than one with rackable servers. Other benefits are that blade servers are easier to service and reduce the number of power cables needed from as many as 80% (HENDERSON, 2007).

However, the high power density might prove to be a problem to server farms in terms of overheating[3].

Virtualization

There are two kinds of virtualization that may be used in a data center: storage and computing virtualization.

Storage Virtualization

Computing Virtualization

2.1.5 Data Storage

2.1.6 Power Architectures

2.1.7 Data Center Infrastructure

2.2 Green ICT

2.3 Devices Consumption

2.4 Measurement Tools

[3]—- falar disso na parte de cooling

3 Methodology

Write a review point of the problem and the solution we want to achieve.... Describe the general and specific objective ...

Phase 0: Thesis - In this part the work subject was defined, along with its hypothesis and goals.

Phase 1: Examination - This was the first step taken to begin the research, in which, many components were analyzed and cataloged to later use;

Phase 2: Analysis of Benchmarking Softwares - A number of existing softwares were analyzed and those that met the requirements and specifications previously made were chosen. A list of these other softwares can be found in Appendix B;

Phase 3: Catalog - The tools provided information about computer components that were used to create a component database.

Phase 4: Build Database -

Phase 5: Analysis -

Phase 6: -

3.1 Overview

This research was conducted in order to determine how much energy a computer's components, for instance, CPU[1], Memory and Hard Drives spend and also how much it would affect the cost of acquisition of new workstations as a whole. Above that, the advantages and disadvantages as well as the reliability of these measures and benchmarks played also an important role in the requirements of this thesis work. With regard to

[1]Central Processing Unit

the topic in hand, the analysis was carried out with the help of specialized softwares, which will be described in the following sections and also analytical measures using an energy measurement device to counterbalance and compare the benchmarking measures obtained from these softwares. Concretely, more than 1000 components were analyzed and categorized in a database, whose schema can be further analyzed on Figure ??. Firstly, it was used the Sandra's database 3.3.1 to collect the components and separate them by categories, along with their benchmark related data. Secondly, WebSPHINX 3.3.3 was used to create a collection of components and their respective MPNs. Thirdly, an energy measurement device 3.3.2 was used for the comparison and validation of the results given by the other benchmarks and acquisition of new data.

Finally, these data were all linked in a database for later comparison and choice.

3.2 Research Design

The experimental method of research was used in this study. Figure 5 draws the steps of the method used. To define the experimental type of research, Bryman (BRYMAN, 1989) stated that "the experimental design (...) allows the causal hypothesis that underpins the question to be examined", which means that this method is a systematic and scientific approach to research in which the researcher manipulates one or more variables, controlling and measuring any changes in other variables. The emphasis given is on the results and analysis of the benchmarks provided and theirs measures. It allows to verify the thesis in which this work is based on, by making use of empirical methods changing the benchmark used and the purpose of it.

/********* Os proximos paragraphs foram criados para direcionar o pensamento e deve ser mantidos como comentario, ou retirados do texto Ã© preciso que sejam melhor desenvolvidos*******/

Universe o Study In this study, the empirical method was employed so as to identify which parts of the computer manage energy more efficiently with the reason of building the most green data center.

Subject of Study The choice of analyzing each component separately was made in order to have a better control of the energy consumed and the ability to compare the different combination

Relationship Between certain variables The benchmarks were executed to obtain

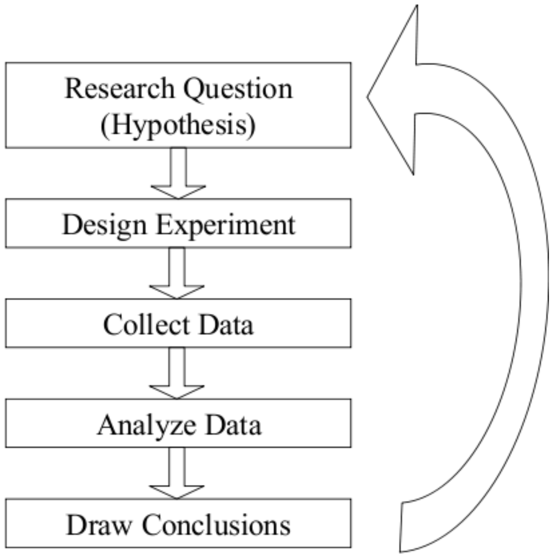

Figure 5: The Experimental Design Process

information about the components, such as speed(MHz), energy consumed (Watts), size(GB, MB),

Set of selected methods for obtain data In order to obtain relevant data, it was chosen two analysis' methods: empirical and benchmarking. In the empirical method, it was used an energy measurement device (section 3.3.2) that connected the electrical plug to the computer, and the measure was taken down in a spreadsheet. While doing this, the benchmarking tool (section 3.3.1) was performed in the host computer

Analytical Categories In a later stage, all the data acquired by the measurement approaches were separated by categories and components

3.3 Energy Management and Benchmarking Tools

In order to obtain relevant information about the data required for making the comparison between the components, it was needed to use some energy management and benchmarking tools.

The softwares used, were selected from many of existents softwares in the area for the following reasons: There exists many softwares

Size of Database The database of components, in order to get a good result should be considerably big;

Characteristics of Benchmarks The benchmarks provided by the software should provide information about the energy consumed for each component;

Number of Benchmarks The software should have a good database of benchmarks;

Quality of Benchmarks Although, the number of benchmarks should be sufficiently, the quality, precision and relevancy were, also, important in the decision method;

Ease of Use In the sense that, the software should provide an ambient of work that is intuitively and comfortable;

something1 explain ;

something2 explain ;

something3 explain ;

The acquisition of data was made analyzing the results of these benchmarks, making use of their database

3.3.1 SiSoftware SANDRA

SiSoftware Sandra[2] is an information and diagnostic utility. It provides most of the information (including undocumented) one need to know about their hardware, software and other devices whether hardware or software. SANDRA was the main software utilized to benchmark the data in this thesis work. It contains a huge database of components to make sure the benchmarks provided have the best results and accurate comparisons.

The software goes beyond the point of other Windows Utilities, by giving the user, the possibility of benchmarking and comparing at both high and low level the computer devices. Moreover, it is a tool for monitoring the performance on systems and even benchmarking many parts of the computer, this includes, CPU[3], memory, hard disks, CD/DVD ROM, network, PSU[4], etc. For that reason, it is considered one of the most complete benchmarking tools available. Besides the benchmarking, Sandra also provides access to information about the Hardware, including the Motherboard, processor, disks, printers, etc; and Software, such as, key softwares (web browsers, e-mail program, etc.), OS information, processes, memory usage and more.

[2]The **S**ystem **AN**alyser, **D**iagnostic and **R**eporting **A**ssistant
[3]Central Processing Unit
[4]Power Supply Unit

The detailed list of modules utilized by SiSoftware Sandra can be found in Appendix A.

Furthermore, the Sandra has a great functionality that is a catalog of pricing, which, in addition to the power consumption and other important characteristics, the best combination (which means the most green) of devices can be chosen to the server.

3.3.2 Energy Measurement Instrument

Figure 6: Energy Measurement Instrument

The device, which can be seen on Figure 6, was used for comparing and validating with the results of the benchmarks given by Sandra.

After the result of the benchmark was obtained from the SiSoftware Sandra, this equipment that was connected to the computer read how much energy it was consumed and it was inserted in the database.

3.3.3 WebSPHINX - A Personal, Customized Web Crawler

WebSPHINX[5] is a Java class library used for web crawling. It provides a way to browse and process web pages automatically.

This piece of software was used to establish the pricing, linking it with the MPN[6], and, afterwards, composing the database explained in 4.1.

[5] Website-Specific Processors for HTML Information Extraction
[6] Manufacturer's Part Number

3.3.4 CPU-Z

CPU-Z detects information about the CPU, RAM Memory, motherboard, chip-set and more. That program was used to complete the database with missing information about the components.

3.4 Data Processing and Analysis

4 Analysis and Results

4.1 Analysis

here it is explained the database, how it was built, the database schema and etc...

4.1.1 Overview

4.2 Results

4.2.1 Benchmark Results

Conclusions

Perspectives and Future Developments

Suggestions for future developments, there are

- Link this research with SaaS
-
-
-
-

References

BAILEY. *What are the difference between servers?* [S.l.], 2009.

BRYMAN, A. *Research Methods and Organization Studies*. [S.l.]: Routledge, 1989. ISBN 0415084040.

GOLDWORM, B. *Blade Servers and Virtualization*. [S.l.]: Wiley-India, 2007. ISBN 8126512156, 9788126512157.

HENDERSON, T. Blade servers vs. rack servers. *NetworkWorld*, 2007.

REHN, R. *What Else Do You Know About Blade Servers*. [S.l.], 2008.

APPENDIX A – List of SiSoftware Sandra Modules

Here is the list of principal modules used in this research work.

•System Summary

•Mainboard/Chipset/System Monitors Info

•CPU/BIOS Info

•APM & ACPI (Advanced Power Management) Info

•PCI(e), AGP, CardBus, PCMCIA bus and devices Info

•Video Information (monitor, card, video bios, caps, etc.)

•OpenGL Information

•Keyboard Info

•Windows Memory Info

•Windows Info

•Font (Raster, Vector, TrueType, OpenType) Information

•Modem/ISDN TA Information

•Network Information*

•IP Network Information*

•WinSock & Internet Security Information

•Drives Information (Removable Hard Disks, CD-ROM/DVD, RamDrives, etc.)

•Ports (Serial/Parallel) Info

•Remote Access Service Connections (Dial-Up, Internet)*

•OLE objects/servers Info*

•Processes (Tasks) & Threads Info

•Modules (DLL, DRV) Info

•Services & Device Drivers (SYS) Info*

•SCSI, SAS Information*

•ATA, ATAPI, SATA, RAID Information

•Data Sources Information*

•CMOS/RTC Information*

•Smart Card & SIM Card Information*

List of Benchmarks

•Arithmetic Benchmark (including SSE2, SSSE3)

•Multi-Media Benchmark

•Multi-Core Efficiency Benchmark

•Power Management Efficiency Benchmark

•File System (Removable, Hard Disks, Network, RamDrives) Benchmark

•Removable Storage/Flash Benchmark

•CD-ROM/DVD Benchmark

•Memory Bandwidth Benchmark

•Cache & Memory Bandwidth Benchmark

•Network/LAN Bandwidth Benchmark

•Internet/ISP Connection Benchmark

•Internet/ISP Peerage Benchmark

Applications and Usage

- Hardware Interrupts Usage*
- DMA Channel Usage*
- I/O Ports Usage*
- Memory Range Usage*
- Plug & Play Enumerator*
- Hardware registry settings
- Environment settings
- Registered File Types
- Key Applications* (web-browser, e-mail, news, anti-virus, firewall, etc.)
- Installed Applications*
- Installed Programs*
- Start Menu Applications*
- Installed Web Packages* (ActiveX, Java classes)
- System Event Logs*

* Commercial version only

APPENDIX B – List of Other Energy Management Tools

B.1 Power To Change

Power To Change is a widget for desktops that measures how much energy was saved when the computer is turned-off. With this application installed, when the machine is turned on, the user can receive information about how much energy and carbon footprint it was saved while it was turned off, and also, compare with global results and others. The widget can be downloaded from `http://www.hp.com/powertochange`.

B.2 PlateSpin - Recon

This software did not compose the ones used for doing this thesis. Yet, it is important to notice this, because it is almost the same of Sandra, but it provides a more incisive work on Data Centers in general. It provides workload profiling, analysis and planning of complex server consolidation, disaster recovery, capacity planning, asset management and green data center initiatives. It also provides forecasting for optimizing the data center by collecting hardware, software and services inventory for all server workloads. Furthermore, it results an statistics work for the server workloads running on data center and how their resources are being used.

B.3 APC Virtualization Energy Cost Calculation

`http://www.techworld.com/green-it/news/index.cfm?RSS&NewsID=116650`

APPENDIX C – Database Schema