Low Emission IT

The Internet Meets The Oil Crisis

Low Emission IT

By

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Overview

Approximately 2% of the electricity produced in the US is used to power computers and other IT related equipment. If the energy required by manufacturing equipment such as microprocessors, cables and printers is included then the proportion of electricity used by the IT sector is 3%. These figures may not seem large compared to the amount of electricity used, for example, by packaging manufacturers or to power home appliances. However, the increased use of computers, driven by the introduction of new communications technologies such as the Internet, means IT related energy consumption, and the carbon emissions resulting from the conversion of that energy from fossil fuel to electricity, are rising.

A typical PC consumes 600 kWh of electricity a year. In addition to the energy used by the PCs themselves, the data centres that lie at the core of the Internet also need large amounts of electrical energy both to power equipment and to cool the rooms in which the equipment is installed. In the order of 1 billion PCs are in use worldwide and in the US over 75% of the population have some form of computing device, with replacement rates running at over 50%. The number of Internet users crossed the 1 billon mark in 2005, and this is expected to rise to 2 billion in 2011 with growth being driven by emerging markets such as China, Russia, Brazil, Indonesia, and India. It is therefore the rate of growth of the IT market and not just its present size that is causing particular concern.

Concerns over the environmental impact of their products have encouraged manufacturers to jointly develop standards for low carbon emission technology. Eco-labelling is being used to encourage users to buy energy efficient computing equipment. Computer data centre managers are trying to find ways to cut the energy costs associated with data centres. Governments are encouraging equipment manufacturers to find new ways of cutting down standby power (the power consumed when a piece of equipment is idle), and consumers to switch off equipment when not in use, especially overnight.

For the IT manager, who until recently was focused on maximising the speed at which data is processed and minimising the cost of storing that data, energy use is now influencing equipment purchasing decisions.

Low emission IT has also created both challenges and opportunities for the major players within the IT industry and has provided an important boost to products that support thin client computing. A number of smaller vendors who have power management solutions have seen their products move out of what has until recently been a niche market into mainstream computing.

This report examines a range of low emission computing technologies and initiatives and assesses their impact on equipment manufacturers and organisations who intend to modify their IT infrastructure in order to minimise energy bills and to meet emissions targets.

At a glance

Approximately 2% of the electricity produced in the US is used to power computers and other IT related equipment. IT related energy consumption, and the carbon emissions resulting from the conversation of that energy from fossil fuel to electricity, are rising.

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Concerns over the growth of IT related emissions and energy use has encouraged government bodies and the IT industry itself to introduce measures to minimise the impact of IT equipment and installations.

IT managers now have found themselves on a steep learning curve as energy use has been added to the list of parameters they have to work within when building a corporate IT system.

This report examines a range of energy saving technologies and catalogues the low emission and energy saving initiatives currently in place. Profiled in this report are NEC, Verdiem, Rackable Systems and Intel.

1 Introduction

Even though the cost and size of computing devices have decreased over the years, the cost of the energy that powers them has been increasing. During the mid-1990s large organisations and multi-national companies started to actively manage the power that their IT equipment uses. Department managers began asking workers to switch off their monitors, then mostly made of cathode ray tubes (CRT), when they left the building at the end of the day or when the monitors were not in use. Initially, there was concern that powering monitors on and off would reduce their mean time between failures, due to the nature of electrical circuits, and increase the cost of replacing them. Lowering the brightness was recommended as a substitute for powering them off. At the same time pressure was being put on computer manufacturers to provide power management features that would reduce power consumption in idle computers. These power management features duly appeared on computers, but users could not be relied upon to configure them appropriately for the purpose for which they were created. It was realised that power management would have to be the responsibility of system administrators and innovators in technology.

Today, with energy prices at historic highs and concerns over climate change prominent on political agendas in developed countries, the IT industry has found that small innovations, such as PC power management, are not enough and that a broader and all embracing approach to IT related energy use is required.

Today, with energy prices at historic highs and concerns over climate change prominent on political agendas in developed countries, the IT industry has found that small innovations, such as PC power management, are not enough and that a broader and all embracing approach to IT related energy use is required. Potential solutions range from requiring all computer equipment purchased to comply with Energy Star (an energy efficiency standard) criteria, replacing networked PCs with networked thin client and server configurations, replacing hardware-based servers with virtualised servers, replacing CRTs with Liquid Crystal Displays (LCDs), directing air conditioning to hot spots, installing power management software on networks, offsetting carbon emissions, and using renewable energy suppliers for their power needs. This drive by organisations to reduce their IT related energy use is increasing the complexity of IT purchasing decisions and forcing IT managers and CIOs onto steep learning curves.

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2 Energy Efficient Computers and Peripherals

2.1 Operational modes and terminology

There are currently three main criteria for determining the energy efficiency of a piece of IT equipment: the power consumption in the different operating modes (off, hibernation, standby, and fully active), the power consumption of the monitor, and the power consumption and configuration of the power supply to the device.

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The power management features of a computer enable it to save power by turning off certain components such as the monitor, hard disk drives, and other peripherals. There is often confusion in the nomenclature used for describing the various power management states, especially the states that are entered into when a computer is

idle. Idle states on various operating system platforms are described as sleep, standby, suspend to RAM, hibernate, safe sleep, etc.

The current standard for power management is the Advanced Configuration and Power Interface (ACPI). It is an open industry standard first released in December 1996. It was developed by Hewlett Packard (HP), Intel, Microsoft, Phoenix, and Toshiba and defines common interfaces for hardware recognition, motherboard and device configuration, and power management.

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The ACPI specification defines the following modes:

G0 (Working): This is the normal state of the computer while the operating system and applications are running. Within this state, it is possible, without entering the sleeping states, for devices such as hard disk and digital versatile disk (DVD) drives to be repeatedly put into and taken out of low energy states.

The ACPI specification defines the following modes: G0 (Working), G1 (Sleeping), G2 (Soft Off) and G3 (Mechanical Off).

G1 (Sleeping): This state is subdivided into four states S1 to S4. The time needed to bring the system from here back into G0 Working (wake-latency time) is shortest for S1, short for S2 and S3, and not so short for S4.

- S1: Of the sleep modes, this state consumes the most power. All processor temporary storages (caches) are cleared, and the central processing unit (CPU) stops executing instructions. Power to the CPU and random access memory (RAM) is maintained. Devices that do not indicate they must remain on may be powered off. Some newer machines do not support S1. Older machines are more likely to support S1 than S3.

- S2: A deeper sleep state than S1, where the CPU is powered off. It is not commonly implemented.

- S3: Called 'Standby' in Windows, 'Sleep' in Mac OS X, and sometimes also 'Suspend to RAM (STR)', although the ACPI specification mentions only the terms S3 and Sleep. In this state, the main memory (RAM) is still powered, and is usually the only component that is. Since the state of the operating system, applications, open documents, etc. lies all in the main memory, the user can resume work exactly where he/she left off. More components are powered down in S3 than in S2.

- S4: Called 'Hibernation' in Windows, 'Safe Sleep' in Mac OS X, and sometimes also 'Suspend to disk'. In this state, all content of main memory is saved to a hard drive, preserving the state of the operating system, all applications, open documents etc. That means that after coming back from S4, the user can resume work where it was left off in much the same way as with S3.

G2 (S5 or Soft Off): In G2 some components remain powered so the computer can resume from input from the keyboard, local area network (LAN), or a Universal Serial Bus (USB) device. The start-up (boot) procedure must be run to bring the system from G2 to G0 Working. G2 is initiated by the operating system. The computer is not safe for disassembly in the G2 state due to the components

In G2 some components remain powered so the computer can resume from input from the keyboard, local area network (LAN), or a Universal Serial Bus (USB) device.

that remain powered; however, it is safe to unplug the computer, and, after approximately 20 seconds, the computer enters the G3 state.

G3 (Mechanical Off): G3 is entered only when a power loss occurs. The computer's power consumption is very close to zero, to the point that the power cord can be removed and the system is safe for disassembly. Typically, only the real-time clock is running off its own small battery. Once power is restored, a full start-up procedure is necessary to bring the system from G3 to G0 Working.

The ACPI specification gives the computer manufacturer plenty of options in using these power management features. In addition, manufacturers want to differentiate their products from other manufacturer's products in terms of user interface design and terminology while also simplifying the user's experience of configuring power management. These are the reasons why confusion exists about what each state does. Sleep is often confused with standby, standby with hibernation, etc. It is up to the user to understand what actions are performed in each state specified for a particular computer.

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2.2 Benchmark

In order to facilitate a comparison in terminology between the ACPI standard and the standard used by most procurement departments, the Energy Star specifications, the latter is set out below.

The Energy Star specification defines three categories of operational modes:

The Energy Star specification defines three categories of operational modes: Idle Mode, Sleep Mode and Standby Level.

Idle mode: This is the state in which the operating system and other software have completed loading, the machine is not asleep, and activity is limited to those basic applications that the system starts by default.

Sleep mode (ACPI S3): A low power state that the computer is capable of entering automatically after a period of inactivity or by manual selection. A computer with sleep capability can quickly 'wake' in response to network connections or user interface devices.

Standby Level (Off mode, ACPI S4 or S5): The power consumption level in the lowest power mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions.

It is quite logical to use Energy Star specifications as the benchmark for energy efficiency in IT. As will be seen in section 3.2, several eco-labelling organisations specify it as their energy efficiency standard. As such, this report will consider a computer or power supply conforming to these specifications as an energy-efficient device in today's environment. However, it should be noted that they provide criteria for non-fully active modes.

Several eco-labelling organisations specify Energy Star as their energy efficiency standard.

Energy Star 4.0 computer specifications require at least 80% efficiency for power supplies. Desktop systems must consume 2 W or less while in standby mode. During sleep mode, where the system can quickly resume full working capacity, desktop systems must consume 4 W or less. The requirements set 50 W or less as the consumption benchmark for desktop systems in an idle state.

Energy Star 4.0 computer specifications require at least 80% efficiency for power supplies. The specifications for notebook computers are more stringent.

The specifications for notebook computers are more stringent. They must use 1 W or less while in standby mode, 1.7 W or less in sleep mode, and 14 W or less while in an idle state. Monitors must consume 2 W or less while in sleep mode and 1 W or less in off mode.

Internal power supplies are required to perform at 80% efficiency at 20%, 50%, and 100% of rated output power, and a power factor of at least 0.9 at 100% of rated output. External power supplies in active mode are required to perform at a minimum of 84% efficiency. This is the ratio of power actually used in an electric circuit, the real power (expressed in Watts), to the power that is apparently being drawn from the power source, the apparent power (expressed in Volt Amperes). It is an indication of the efficiency of an electrical system, and is generally expressed as a decimal fraction. The closer to 1 it is, the better.

2.3 The Average Computer

Power consumption will differ with computers of different capabilities, and from different manufacturers. Two thirds of the energy used by a PC is consumed by the monitor. Screen savers prolong the lives of monitors but do not save energy. According to testing carried out by the University of Waterloo, Canada, the total power consumption of a typical PC and monitor with a Pentium 4 processor running at 1.7 GHz clock speed consumes 175 W or less when in heavy use. Table 1 shows the results of tests carried out by the University of Oxford Estates Directorate on a variety of office IT equipment.

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Item	Average Power Consumption (W)	Standby Energy Consumption Obtainable (W)
Personal computers and monitors	120	30 – 40
Personal computers	40	20 – 30
Monitors	80	10 – 15
Laser printers	90 – 130	20 – 30
Photocopiers	120 – 1000	30 – 250
Facsimile machines	30 – 40	10

A PC power consumption calculator is available at:

www.distortionwave.com/power.html

The standby consumption figures show in the table reveal that the average computer's energy use is far below those recommended by Energy Star and therefore highly inefficient.

In 1997, The Thai Green Label scheme estimated that most offices have their computers and monitors on for approximately nine hours a day, while actual use is at an average of four hours, causing energy loss and heat build up in offices. Approximately 10% of users leave their computers and monitors on at night and weekends.

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3 Energy Efficiency Standards and Eco-Labelling Schemes

Eco-labelling is a method of certifying products or services against defined environmental performance criteria. Recognising the importance of communication on environmental standards and the potential for inaccurate and misleading claims, the International Organization for Standardization (ISO) has drawn up a group of standards, the ISO 14020 family comprising 14020 to 14024, specifically governing environmental labelling. ISO classifies environmental labels into three categories:

Eco-labelling is a method of certifying products or services against defined environmental performance criteria.

Type I claims are examined and accredited based on criteria set by an impartial and neutral third party. Typically, criteria are developed for a specific product type such as personal computers or monitors. Products must be certified to these criteria through the third party entity before manufacturers are allowed to display the third party's environmental seal. Examples of Type I programmes with established criteria for electronic products include the Blue Angel (Germany), Eco-Flower (European Union (EU)), Tjänstemännens Centralorganisation (TCO) label (Sweden), and Eco-Mark (Japan), Environmental Choice Program (Canada), Thai Green Label Scheme (Thailand), Environmentally Friendly Label (Hungary), Environmental Choice New Zealand (New Zealand) and Green Mark (Taiwan).

Of these Type I programmes, only the TCO eco-label has gained significant market acceptance. Today, TCO compliance is considered by many to be a de facto requirement for the sale of monitors in Europe. While not regarded as important as TCO compliance for monitors, the Blue Angel eco-label has gained some acceptance with customers, particularly those involved with government procurement in Germany. There has been no significant movement by computer manufacturers to certify their products against the Eco-flower criteria. Outside Europe, the only Type I environmental label of significance is the Japanese Eco Mark.

While Type I eco-labels continue to gain acceptance among customers as a simple way to ascertain the environmental preference of products, they present a difficult situation for manufacturers. The time and costs associated with obtaining a Type I eco-label are generally high. At the same time, the low-end electronic products to which these eco-labels apply are marketed for only a short time. Thus many products are replaced in the time that it would take to obtain an eco-label.

The time and costs associated with obtaining a Type I eco-label are generally high and they are subject to differing and constantly changing criteria.

Another problem with Type I eco-labels is their differing and constantly changing criteria. No two Type I eco-label programs have the same product criteria, and no single Type I program is accepted worldwide, or even within a majority of geographic areas.

Type II claims are based on a company's self-declaration about how environmentally friendly its products and services are based on its own criteria. These declarations can be made on a single attribute such as energy efficiency or use of recycled content materials, or they may take the form of a comprehensive declaration of many environmental attributes. Two widely recognised Type II labelling initiatives exist in Europe: The European Computer Manufacturers Association (ECMA) and the Nordic IT Eco Declaration (formerly NITO). Both of them have developed standardised formats for manufacturer self-declaration of environmental attributes for electronic products, the latter also including non-environmental attributes such as ergonomics and product safety. The Japan Electronics Information Technology Association (JEITA) has also developed guidelines and criteria for an eco-label for PCs called the PC Green Label, which allows manufacturer self-declaration.

The IT Eco Declaration has gained widespread acceptance in the Nordic countries as a viable alternative to Type I labels on many product types. Individual manufacturer Type II environmental claims have become commonplace in Japan, as manufacturers try to promote the environmental attributes of their products.

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Type III claims consist of quantified information on a product's environmental impacts over its life cycle (from resource extraction to product disposal). BS ISO 14025:2006: Environmental Labels and Declarations document defines a standard which establishes the principles and procedures for developing Type III environmental claims. Quantified data makes it easier to compare products by different manufacturers. Categories and parameters are pre-set by a qualified third party. Examples are Japan's EcoLeaf and Sweden's Environmental Product Declarations (EPD).

Like Type I labels, Type III claims require third party certification. Due to the extreme difficulty in obtaining life cycle data on complicated products such as computers and other electronic products, Type III labels have seen little acceptance within the IT industry. However, recent pilots of Type III labels in Japan and increased research into life cycle assessment (LCA) methodologies in Europe may indicate increased interest in these types of labels.

Many environmental professionals believe that Type III labels are most beneficial for business to business or business to government purchases where those purchasing products are typically better educated on environmental criteria.

Like Type I labels, Type III claims require third party certification. Many environmental professionals believe that Type III labels are most beneficial for business to business or business to government purchases.

Just as the layman is confused about the various terms used to describe a computer's operating mode, so they are with energy efficiency standards and eco-labels. There are many eco-labels in use around the world and different geographical blocks tend to have their own set of eco-labelling schemes. There is increasing consolidation along regional lines, and some agencies have set up mutual recognition agreements. For example, although Taiwan has its own eco-label, the Green Mark, regional eco-labels are accepted as equivalent, such as Green Seal, Environmental Choice Programmes in

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New Zealand and Australia, Green Label, and Japan's EcoMark. Several groups are also working towards harmonisation of national and international product specifications.

3.1 The Benefits of Eco-Labels

There are several benefits to having eco-labels:

- Eco-labels provide reliable information, guide customers in their product choices, and create an opportunity for consumers to make environmentally-conscious decisions. This in turn creates a market incentive for manufacturers to supply environmentally-friendly products.
- Having eco-labels rewards investment in environmentally friendly products, which gives the public greater choice in determining how they want to contribute to creating a cleaner and healthier environment.
- Eco-labels use market forces to effect behavioural change. This is highly preferable to having choices made for people by the state, and produces a variety of choice and price differentials.
- Eco-labelling results in environmental benefits, and promotes the concept of resource conservation and reduction in environmental impacts throughout the life cycles of products.
- Eco-labelling encourages manufacturers, suppliers and retailers to develop products and processes that are in compliance with published product specifications.
- Eco-labelling promotes responsible procurement policies by central and local governments, organisations, and businesses.

Eco-labels provide reliable information and guide customers in their product choices, reward investment in environmentally friendly products and promote responsible procurement policies.

3.2 Energy Efficiency Standardisation Organisations Around the World

This section describes some of the energy efficiency standardisation organisations around the world and what they specify as energy consumption criteria for IT products.

3.2.1 Energy Star

Energy Star is an international voluntary labelling scheme that promotes energy efficient consumer products. It is the only internationally-accepted label that focuses solely on energy conservation. Energy Star was started by the US Environmental Protection Agency (EPA) in 1992 and computer products were the first to be labelled. It provides performance specifications for notebook computers, workstations, integrated computers, desktop-derived servers (a server that is designed in a similar size to a desktop computer) and game consoles. It has since expanded to include major appliances, office equipment, lighting, home electronics, and even new homes and commercial and industrial buildings. Large institutional and

www.energystar.gov

private consumers and retailers are able to become Energy Star Partners.

Through an agreement with the US, the EU (www.eu-energystar.org) participates in the programme as far as it relates to computer and office equipment. Other participants are Canada, Japan, Taiwan, New Zealand and Australia.

Currently, the EU represents a market of over 494 million consumers, or 49% of the total of all Energy Star countries, and one third of the total IT hardware market of these countries. The EU Energy Star database provides a list of Energy Star-qualified equipment showing, among other attributes, the amount of energy consumed in idle mode, on standby, and in sleep mode, as well as the output power supply, thus allowing the consumer to select the most energy efficient models according to his/her criteria. In addition, it puts limits on the energy used by devices when inactive and requires systems to be shipped with power management features enabled.

Energy Star specifications version 4.0 is the current version and came into force in July 2007. Energy Star has been a driving force behind the more widespread use of power management systems for office equipment, and low standby energy use. The criteria for energy efficiency are stated in section 3.2.2 below.

3.2.2 European Union Eco-label

The EU eco-label (http://ec.europa.eu/environment/ecolabel) is a voluntary scheme devised to encourage businesses to sell non-food products and services that are environmentally friendly, and to help consumers identify these products. Criteria are defined for product groups based on life cycle considerations of the environmental impacts of each group. Recycling potential, use of toxic materials, life time extension, energy use, waste etc are considered, from raw material extraction, production, distribution, use or service performance, and disposal. A manufacturer, retailer or service provider who meets the criteria for a product group and who applies for the award of the Eco-label, can market its eco-labelled product throughout the 25 Member States of the European Union. The Flower is also accepted and present in those counties which are signatories to the European Economic Area (EEA) Agreement, ie Norway, Iceland and Liechtenstein.

ec.europa.eu/environment/ecolabel

For personal computers, the energy efficiency criteria are set out below.

The computer system unit shall meet the Energy Star configuration requirements:

- The computer shall support the ACPI S3 sleep state (suspend to RAM) ≤ 4W.
- The portable computer shall have an off-mode consumption ≤ 2W.

The monitor shall:

- have a sleep mode power consumption ≤ 2W.

- have an off-mode consumption ≤ 1W.
- not exceed the Energy Star Version 4 requirements for Tier II, maximum active power consumption linked to the number of mega-pixels. (Tier II is the second revision of the specification due to come into effect in 2009).

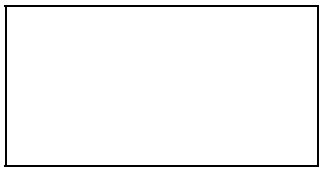
For portable computers, the energy saving requirements are:

- The portable computer shall support the ACPI S3 sleep rate (suspend to RAM) ≤ 3 W.
- The portable computer shall have an off-mode consumption ≤ 2 W.
- Power supply shall consume ≤ 0.75 W.

The label is awarded to products with the lowest environmental impact in a product range. Each member state has a designated 'Competent Body' which is responsible for receiving applications from manufacturers, retailers, service providers or importers for the award of the Eco-label to their products and services.

3.2.3 IEEE 1680 – 2006

The US Institution of Electrical and Electronic Engineers (IEEE) standard 1680 sets out environmental performance criteria for desktop and notebook computers and monitors. This standard also takes a life-cycle view of a product's environmental performance, setting criteria for the use of hazardous substances, materials selection, design for end-of-life, product longevity, end-of-life management, corporate environmental responsibility and packaging, as well as energy conservation.



www.ieee.org

Its energy conservation specification mandates compliance with the Energy Star specification, and states the early adoption (in advance of its effective date) of the Energy Star specifications, and the provision of renewable energy accessories as options.

3.2.4 ECMA International

ECMA International formerly known as the European Computer Manufacturer's Association, was founded in 1961. It was set up to standardise computer systems in Europe. It is now an international, membership-based standards organisation for information and communication technology (ICT) systems producing specifications mainly for programming languages and file formats for storage devices, but also for electronic hardware.

www.ecma-international.org

ECMA standard ECMA-341 on the environmental design considerations for electronic products sets out best practise for designing IT products with a rated output voltage of 1000 V or under. The standard covers energy efficiency, material efficiency, consumables and batteries, chemicals and noise emissions, extension of product lifetime and end of life considerations, packaging, substances requiring special attention, and documentation. The standard does not break the IT goods into categories or groups for which to provide specific technical criteria for conformance on power usage or management. In the case

of energy efficiency, it simply states that products belonging to the categories covered by the Energy Star programme should be compliant to the programme's requirements.

3.2.5 The Swedish Confederation of Professional Employees (TCO)

The Swedish Confederation of Professional Employees (Tjänstemännens Centralorganisation or TCO) was founded by a merger of two organisations in Sweden in 1944 and is the national trade union and umbrella for 18 trade unions in Sweden. It represents professionals within the public and private sectors. The TCO was inspired to offer an international labelling system, after the United Nations (UN) Conference on Environment and Development in Rio de Janeiro in 1992. Before this, the organisation was well known for its work in putting pressure on manufacturers to improve the ergonomics of monitors and keyboards. The labelling system addresses issues such as electromagnetic radiation, ergonomics, ecology and energy with regard to office equipment, including computers, monitors, printers, and mobile phones.

www.tcodevelopment.com

TCO Development (www.tcodevelopment.com), the wholly-owned subsidiary of TCO, is responsible for the development of the certification system, developing requirements and test methods for IT office equipment. The requirements and test methods for TCO certification, as well as a database which include a list of certified products, are today easily accessible through its website.

TCO'05 and TCO'99 are the current specifications for notebook and desktop (including portable) computers respectively. The TCO defines two modes of operation:

- Sleep mode/low power: The reduced power state that the notebook computer enters after receiving instructions from the software or via other functions.
- Off mode/standby power: The lowest power consumption mode which cannot be switched off by the user and that may persist for an indefinite time when a notebook computer is connected to the main electricity supply. Off mode is the power state when the notebook computer is connected to a power source, does not charge its battery, produces no images, and is waiting to be switched to the on mode by a direct signal from a user/computer.

For desktop computers, the specifications mandate a maximum power consumption of 5 W or less in sleep mode, and 2 W or less in off/standby mode. For notebooks, it mandates a maximum power consumption of 4 W or less in sleep mode, and 2 W or less in off/sleep mode. TCO Development is planning to harmonise the energy criteria in TCO'05 with Energy Star.

3.2.6 New Zealand's Environmental Choice

Environmental Choice is a voluntary programme initiated by the New Zealand government in 1990, but operates independently of the

www.enviro-choice.org.nz

government. Environmental Choice New Zealand mandates computer manufacturers to meet the Energy Star criteria for power management.

3.2.7 Canada's Environmental Choice

Environmental Choice (www.ns.ec.gc.ca/g7/eco-can.html) was established in 1988 and is Environment Canada's eco-labelling programme. It sets criteria over 300 product categories. It is operated by a private company called Terra Choice Environmental Services Inc., who also provides verification testing. It is based on the life cycle performance of products. The criteria for notebooks and desktop computers mandate conformance to Energy Star specifications.

www.ns.ec.gc.ca/g7/eco-can.html

3.2.8 German Blue Angel

The Blue Angel specification for desktop and notebook computers (RAL-UZ 78) states that the power consumption of monitors shall meet the Energy Star requirements version 4.0 Tier II.

www.blauer-engel.de

3.2.9 Japan's Eco Mark

The Eco Mark was introduced in 1999 to encourage manufacturers to produce more energy-saving and environmentally-friendly photo-copiers. The Eco Mark bases its specification on ISO 14024 standards, which sets out the principles and protocols that third party labelling seal or practitioner programmes should follow in developing environmental criteria for a particular product. It considers the environmental impact of the products throughout its life cycle – from mining of resources to recycling of used products. It covers many products from plastics to paper. The IT products covered include PCs, monitors, copiers, printers and power sources. For PCs, the manufacturer is required to disclose a description of the equipment's design for energy saving. For the others, Energy Star compliance is required.

www.ecomark.jp

3.2.10 Japan's Ecoleaf

The Japanese Ecoleaf programme, a Type III labelling programme, was launched in 2002. The programme encompasses industrial goods, durable consumer goods, daily necessities, energy, buildings, food, and services associated with these products.

www.jemai.or.jp

3.2.11 Thai Green Label

The Thai Green Label scheme was initiated by the Thailand Business Council for Sustainable Development (TBCSD) in 1993 and was launched in 1994 by the Thailand Environmental Institute in association with the Ministry of Industry. This voluntary eco-label certifies many product groups. Within IT equipment it certifies computers, TVs, mobile phones, printers, and video media players and recorders. For computer system units, monitors and all-in-one systems, it stipulates a power consumption of less than 30 W, 5 W, and 35 W respectively in low power consumption mode, although the site does not define what 'low power consumption mode' is. A technical sub-committee comprising experts from relevant institutes,

www.tei.or.th/greenlabel

industry, and environmental groups, and the Thai Industry standards Institute administers the programme and sets the life cycle-based criteria.

3.2.12 IT Eco Declaration (formerly NITO) – Denmark, Norway, Sweden

The IT Eco Declaration is the creation of the Association of the Swedish IT and telecommunications industry, the Norwegian IKT (an interest group for the development of the IT sector in Norway), the Danish IT-Brancheforeningen (ITB, an organisation representing the IT business in Denmark), and the Finnish Association of Office Technology Traders (TTK RY). It was formerly called the NITO (Nordic IT Organisations) Declaration, being developed by the Nordic information technology trade organisations. It is not a label but a self declaration system. The IT Eco Declaration includes information on the environmental practices of the manufacturer as well as product features, such as environmentally conscious design, acoustic noise, electrical safety, energy consumption, chemical emissions, substances and materials included, and packaging. IT equipment suppliers such as Nokia, HP, LG, and Fujitsu have published IT Eco Declarations of their products.

www.itecodeclaration.org

3.2.13 Korean Eco-Label

The Korean Eco-labelling programme is a voluntary certification programme managed by the Korean Ministry of Environment and the Korean Eco-Products Institute. Its set of criteria, including the use of performance criteria, cover power management, noise, the use of hazardous substances, disassembly and recycling, and safety.

The criteria for power consumption for desktop and notebook computers are set out in the Energy Standby programme, which is in compliance with the Energy User Rationalization Act. However, if a product meets the criteria for the Energy Star programme, then the product is certified. Monitors are required to consume 2 W or less in sleep mode. System units (desktop) are required to consume 5 W or less in sleep or manual off modes. Third party agencies selected by the programme's administrators do the testing within Korea and the surrounding regions of Taiwan, Thailand, Japan, Australia, China and New Zealand.

www.koeco.or.kr

3.2.14 Taiwanese Green Mark

The Green Mark Program was launched in 1992 by Taiwan's Environmental Protection Administration. The program is voluntary, and aims to promote recycling, pollution reduction, and resource conservation. The Environment and Development Foundation, a private institution, oversees the program. The Green Mark has 41 product categories and has awarded the label to 451 products.

Taiwan has a series of agreements with other eco-labelling organisations that allows products with these foreign eco-labels to be given the Taiwanese Green Mark under stated conditions. It does not appear to have set its own performance criteria. It has a list of certified products.

greenmark.epa.gov.tw

3.2.15 Group for Energy Efficient Appliances (GEEA)

GEEA is group of representatives of European national energy agencies and government departments (Denmark, Holland, Sweden, Switzerland, and the European Energy Network) working with industry to share information on, and promote energy efficient, home electronics, office equipment, and IT equipment. It develops performance criteria while outsourcing the registration of products that meet the set criteria to Homespeed (www.homespeed.org).

www.efficient-appliances.org

GEEA sets performance criteria for desktop and notebook PCs including tablets, desktop-derived servers, workstations and monitors, broadband equipment (modems and access points, Voice-over-Internet Protocol (VoIP) devices, and small hubs and switches) as well as TVs, video recording and playback equipment, set top boxes, audio equipment, external power supplies, portable consumer electronics, battery chargers, and imaging equipment (photocopiers, fax machines, printers, multifunction devices). For PCs, certification requires compliance to the Energy Star 4.0 specifications. However, it also specifies maximum energy consumption for off (standby), sleep (low power), and on (idle) modes. For PCs, these are 2 W, 4 W, and up to 95 W (depending on the category of equipment) respectively. For notebooks and tablets, these are 1 Watt, 1.7 W, and up to 22 W (depending on the category of equipment) respectively. For monitors, these are 1 W, 2 W, and up to 28 W (depending on the resolution) respectively.

3.2.16 Swiss Ordinances On Standby Power

Swiss legislation allows for voluntary agreements relating to standby power consumption. If the agreements do not meet their objectives, legal instruments are enacted by the government to set limits on standby power consumption.

4 Green Computing Initiatives

Many groups around the world are also contributing to the impetus that is driving IT equipment to becoming more energy efficient. Some of them are described here.

4.1 80 Plus

The 80 Plus programme is a forum that brings together electricity suppliers, the computer industry, and consumers in an effort to bring energy-efficient power supplies to desktop computers and servers. The 80 Plus standard defines power supplies that operate at an 80% efficiency level. The 80 Plus performance specification requires power supplies in computers and servers to have energy efficiencies of 80% or greater at 20%, 50% and 100% of rated output with a true power factor of 0.9 or greater. To date, the organisation claims that over 200 power supplies have been certified by companies such as Dell and HP.

The 80 Plus programme is a forum that brings together electricity. It is funded by electricity suppliers in North America and is administered by Ecos Consulting.

www.80plus.org

www.ecosconsulting.com

The programme is funded by the electricity suppliers in North America, and is administered by Ecos Consulting, an organisation that conducts

research into products and services that address pollution prevention and energy efficiency and designs programmes that result in positive environmental impact.

4.2 Climate Savers Computing Initiative (CSCI)

The Climate Savers Computing Initiative, a collaboration of eco-conscious organisations, was launched by Google and Intel in June 2007 in a move to help combat climate change by promoting the development, deployment and adoption of smart technologies that improve the power efficiency of computers and reduce power consumption when they are inactive. Their aim is to reduce carbon dioxide emissions from computers by 54 million metric tonnes per year, and reduce their power consumption by 50% of 2007 levels by 2010. This collaboration was started in the spirit of the World Wildlife Fund's (WWF) Climate Savers Programme which is a business initiative organised by the WWF to mobilise companies to cut carbon dioxide emissions. As such, "Climate Savers" is a registered trademark of WWF used under license.

The Climate Savers Computing Initiative, a collaboration of eco-conscious organisations, was launched by Google and Intel in June 2007.

www.climatesaverscomputing.org

Climate Savers claim that the average desktop PC wastes over half the power delivered to it as heat, while the average server wastes about one-third. According to Luiz Andre Barroso, Distinguished Engineer at Google, the waste heat from power supplies could be reduced to 10% of input power with relatively simple modifications.

The CSCI now has an organisational membership of at least 38, including computer and component manufacturers such as Dell, HP, Rackable Systems, and Advanced Micro Devices (AMD); consumer electronics firms such as Hitachi and Fujitsu; software companies and consortia such as Linux Foundation, Red Hat, and Microsoft; non-IT manufacturing concerns such as Starbucks and eBay; educational institutions and facilitators such as the Massachusetts Institute of Technology (MIT), and One Laptop Per Child; and environmental non-governmental organisations (NGOs) and government agencies such as the WWF and the US EPA. Ordinary consumers are also welcome into the organisation. Membership entails making a pledge to further CSCI's objectives: computer and component manufacturers commit to producing products that meet or surpass the Energy Star guidelines. Businesses commit to buying power-efficient computing products, and using power management tools on their PCs. Individuals pledge to buy systems that are certified by the CSCI, and to use power management tools on their PCs. Energy companies commit to providing rebate programmes for those who buy energy-efficient products that meet or exceed the CSCI's energy efficiency standards.

Membership entails making a pledge to further CSCI's objectives: computer and component manufacturers commit to producing products that meet or surpass the Energy Star guidelines.

CSCI's plan is to draw up a set of energy efficiency standards. Initially, the standards will follow the new Energy Star Computer Specification 4.0, but will become more stringent with time, for example, requiring a minimum of 90% efficiency for PC power supplies by 2010. The timetable for strengthening the standards is as follows:

- From July 2007 through June 2008, PCs must meet the Energy Star requirements. This means 80% minimum efficiency for the power supply unit (PSU) at 20%, 50%, and 100% of rated output, a power factor of at least 0.9 at 100% of rated output,

From July 2007 through June 2008, PCs must meet the Energy Star requirements.

and meeting the maximum power requirements in standby, sleep, and idle modes.

- From July 2008 through June 2009 the standard increases to 85% minimum efficiency for the PSU at 50% of rated output (and 82% minimum efficiency at 20% and 100% of rated output).

- From July 2009 through June 2010, the standard increases to 88% minimum efficiency for the PSU at 50% of rated output (and 85% minimum efficiency at 20% and 100% of rated output).

- From July 2010 through June 2011, the standard increases to 90% minimum efficiency for the PSU at 50% of rated output (and 87% minimum efficiency at 20% and 100% of rated output).

In addition, the Initiative sets the following high-efficiency targets for volume servers (1U/2U single and dual-socket servers –1U servers are the smallest servers that can be purchased that are designed to fit into a rack mount. A 2U server is double the height of a 1U server and a 4U server is four times the height of a 1U server):

From July 2007 through June 2008, volume servers must have 85% minimum efficiency for the power supply unit (PSU) at 50% of rated output.

- From July 2007 through June 2008, volume servers must have 85% minimum efficiency for the power supply unit (PSU) at 50% of rated output (and 81% minimum efficiency at 20% and 100% of rated output), and power factor of at least 0.9 at 100% of rated output.

- From July 2008 through June 2009 the standard increases to 89% minimum efficiency for the PSU at 50% of rated output (and 85% minimum efficiency at 20% and 100% of rated output).

- From July 2009 through June 2010, the standard increases to 92% minimum efficiency for the PSU at 50% of rated output (and 88% minimum efficiency at 20% and 100% of rated output).

Products that meet its efficiency standards will qualify for power supplier rebates under the 80 Plus program

In the near future, the CSCI website will provide a list of equipment and manufacturers that meets its energy efficiency criteria. Members will benefit from the advertisement of member's products on the Google and Intel websites, co-marketing opportunities with other members of the organisation, and an anticipated increase in demand for energy-efficient equipment. Consumers will benefit from being able to identify and purchase equipment they know is energy-efficient.

Members will benefit from the advertisement of member's products on the Google and Intel websites and co-marketing opportunities with other members of the organisation.

4.3 The Green Grid

The Green Grid (www.thegreengrid.org) is a non-profit consortium of IT companies and professionals seeking to lower the overall consumption of power in data centres around the world. The organisation is chartered to develop platform-neutral standards, measurement methods, processes, and new technologies to improve energy efficient performance of global data centres. Membership is open to companies and IT professionals with an interest in helping to support the movement to improve data centre power consumption, and improve overall efficiency.

The Green Grid is a non-profit consortium of IT companies and professionals seeking to lower the overall consumption of power in data centres around the world.

www.thegreengrid.org

4.4 Linux Foundation's Green Linux Initiative

The Linux Foundation is a non-profit consortium dedicated to promoting the growth of the open source (non-proprietary) operating system, Linux, on the server, desktop, and mobile devices. The Foundation launched its Green Linux initiative in June 2007 to focus on reducing the operating system's power consumption. The initiative is aimed at helping companies integrate Linux into the enterprise to help reduce energy consumption in data centres through server consolidation. IBM launched its own Big Green Linux initiative in August 2007. It announced plans to cut energy consumption in its data centres by 80% by consolidating 3,900 of its own servers on to System Z mainframes running the Linux operating system. IBM anticipates that the new server environment will consume approximately 80% less energy than the current set up, resulting in significant savings over five years in energy, software and system support costs.

The Linux Foundation is a non-profit consortium dedicated to promoting the growth of the open source (non-proprietary) operating system, Linux, on the server, desktop, and mobile devices.

www.linux-foundation.org

4.5 The Electronic Product Environmental Assessment Tool (EPEAT)

EPEAT (www.epeat.net) is an online tool that helps institutional purchasers select and compare desktops, notebooks, and monitors based on 51 environmental attributes. Its development was partially funded by the US EPA.

All EPEAT registered products must meet 23 mandatory environmental criteria. An additional 28 optional criteria are used to determine whether products earn EPEAT Bronze, Silver, or Gold recognition. Bronze recognition is given to products that meet all 23 required criteria. Silver recognition is given to products that meet all 23 required criteria and at least 50% of the optional criteria. Gold recognition is given to products that meet all 23 required criteria and at least 75% of the optional criteria.

EPEAT registered products are high-performance business class computers and cost no more than conventional products. However, compared to traditional computer equipment, all EPEAT-registered computers have reduced levels of cadmium, lead, and mercury to better protect human health and the environment. They are more energy efficient, and easier to upgrade and recycle. Manufacturers are required to offer institutional purchasers safe and cost effective recycling options for EPEAT-registered products.

EPEAT is an online tool that helps institutional purchasers select and compare desktops, notebooks and monitors based on 51 environmental attributes.

www.epeat.net

In January 2007, President Bush signed an executive order requiring all federal government purchases of electronic products to be EPEAT-registered. In addition, many state and local government, large private sector organisations and a growing number of individual consumers also demand EPEAT-registered products.

5 Low-Emission IT Technology

The use of computers for business, home, education, and pleasure has been increasing phenomenally since the invention of the desktop personal computer in the mid 1970s. A PC can be found on the desks of the employees of most commercial businesses today. It has become the most ubiquitous tool on the planet. As the use of computers has increased, so has the amount of money spent on powering and cooling them. In the advent of increasing pressure to reduce energy consumption, computer scientists and IT managers have been at work looking for ways to improve the energy efficiency of IT equipment and consumer electronics. Some of these are discussed below.

As the use of computers has increased, so has the amount of money spent on powering and cooling them.

5.1 Low Power and Power-Efficient Processors

Microprocessors are designed for different applications: desktops, notebooks, servers, workstations, network and communications, and for those applications that are time critical (embedded processors). The power consumption of processors has been coming down over the past couple of years, and energy efficiency is now being measured in terms of the number of instructions per Watt. Intel's Core 2 dual-core Conroe with a maximum power or thermal design power (TDP) of 65 W, consumes only half of the power of the less capable, but also dual core Pentium D branded desktop chips with a TDP of up to 130 W.

Using low power processors has the advantage that they can be included in fan-less designs or passively-cooled systems thereby further reducing cooling requirements.

Lowering power consumption is in itself a challenge given that computer manufacturers are always trying to increase the processing capability of processors for new power-hungry applications and the feature-hungry consumers. Manufacturers such as Intel, AMD, and VIA are in the forefront of this competitive market.

Using low power processors has the advantage that they can be included in fan-less designs or passively-cooled systems thereby further reducing cooling requirements. Low power processors are normally targeted at the market that has concerns about low power and energy efficiency such as embedded applications and the battery operated mobile devices sector.

Here are some examples of low power processors:

- AMD's Geode series of microprocessors are optimised for low power consumption and are best suited for thin clients, servers, set top boxes, and embedded computing applications.
- The Geode GX family comprises the GX 466, GX 500, and GX 533 operate at TDPs of 0.9 W, 1.0 W, and 1.1 W and run at clock speeds of 333 MHz, 366 MHz and 400 MHz respectively.

- The Geode LX700, LX800, and LX900 processors have TDPs of 3.1 W, 3.6 W, and 511 W, and run at 433 MHz, 500 MHz, and 600 MHz respectively.

- The Geode NX processor family comprises the NX 1250 and the NX 1500, both with TDPs of 9 W run fan-less, and the NX 1750 with a TDP of 25 W.

- Transmeta designs and licenses low power microprocessors. Its low power processors are the Crusoe and Efficeon family. The Crusoe processors range from 500 MHz to 1.2 GHz and draw 1 W. The Efficeon processors are the higher end processors and they run at up to 1.6 GHz and draw 3 W at 1 GHz.

- VIA, the Taiwanese manufacturer is focusing on fan-less, low-powered processors. VIA's range of low power, fan-less processors include the C7, C3, Eden, and CoreFusion processors. The power consumption of the Eden and C3 processors varies from only 7 W to 15 W. The VIA Eden-N processor achieves a maximum TDP of 2.5 W at 533 MHz, 5 W at 800 MHz, and 7 W at 1Gz.

5.2 Server Based Computing

5.2.1 Server-Based Computing with Thin Clients

Most PC users do not use all the processing power or disk space that is available on their computers. The power available on most desktops can thus be reduced by concentrating the provision of processing power, power supply, data storage, and software applications on network servers that are located in dedicated remote data centres away from offices, and providing networked access through intelligent terminals called or 'thin clients' on users' desk tops.

Given that a single server can support dozens of client devices, there is considerable resource and energy efficiency that can be gained from a network where a majority of the processing and storage is carried out using a powerful central server.

Given that a single server can support dozens of client devices, there is considerable resource and energy efficiency that can be gained. Firstly, rather than providing cooling for most areas of a building, it can be provided only in these data centres thereby reducing energy bills. Secondly, the client-server equipment configuration is lower in cost and energy consumption than the one-PC-per-desktop configuration. On average, a thin client-server configuration will consume 57% of the energy that an average PC configuration uses. Some thin client models use 85% less power than their PC rivals. Sun Microsystems claimed in June 2005 that on average one of its SunRay thin clients requires just 15 W versus 300 W for the average PC. It also claims that heat output and the energy required during manufacturing are also considerably lower.

Both PCs and thin clients display the same commonly used Windows desktop interface to the end-user, and have the same features such as keyboard, mouse, serial and parallel ports and network connectivity. Thin clients are smaller, some the size of a compact disk (CD) case, and most lack removable drives (or any drives), making it difficult for people to use them to steal electronic data or introduce viruses to the network.

Thin clients are smaller, some the size of a compact disk (CD) case, and most lack removable drives (or any drives), making it difficult for people to use them to steal electronic data.

Many thin client devices run only web browsers and remote desktop software that allows instructions to be conveyed to the application and the output of the application to be displayed on the terminal's screen. Some devices recently being marketed as thin clients run complete operating systems such as Debian or GNU/Linux and are much better described as 'diskless nodes' or 'hybrid clients'. The operating system on these hybrid clients is stored on a flash drive on the terminal. Examples of thin client devices are Wyse's Winterms, Neoware's c-, e-, and m-series of thin clients, Hewlett Packard's Compaq t-series, Sun Microsystems's SunRay series, and Chip PC's Jack PC.

As well as higher energy efficiency and resource usage, the client-server configuration has other advantages. It allows network administrators to maintain applications on a single server or small group of servers instead of on every desktop device. The amount of storage, processing power, and power supply can be tailored exactly to meet users' needs simply by upgrading or removing the relevant component. According to Sun Microsystems, this client-server model has seen usage statistics of 30 users per processor, and similar savings with disk storage and memory.

As well as higher energy efficiency and resource usage, the client-server configuration also allows network administrators to maintain applications on a single server or small group of servers instead of on every desktop device.

This client-server architecture has been around for a long time. It has been used in functions such as application service provision (where computer applications are run from a different location from the user, and also possibly on a different operating system platform from the one the user is using). From the early 1970s to the mid 1980s, dumb terminals were typically attached to computers in client-server configurations when it was too expensive to have computers on every desktop. Only recently has it been regarded as a means of reducing energy consumption.

This client-server architecture has been around for a long time and only recently has it been regarded as a means of reducing energy consumption.

5.2.2 Server-Based Computing as a Business And Service

This is similar to the above-mentioned concept of application service provision where a company provides applications such as medical billing software or credit card payment processing as a service to its customers, and also takes care of upgrades, updates, and round-the-clock technical support for them. The customer does not have ownership of the application suite nor is s/he able to download it. The application is launched and run from the server. The customer accesses the software through the web or special client software provided by the company and pays a subscription.

The growing popularity and sophistication of the World Wide Web means it is now possible to run a number of key applications remotely and use software as a service as and when required.

Server-based computing can be provided as a service too. In this case, a company provides, for a subscription fee, the storage, all the essential software to run a typical computing session such as an operating system, a set of applications that a typical user uses (such as word processor, spreadsheet, email, web browser, messenger, drawing tool, database, presentation tool), and the minimal hardware that the client software runs on. In addition, it offers upgrades, technical support, regular backup, and data security. An example of this type of service provider is Zonbu (www.zonbu.com). Zonbu markets its product as 'an environmentally responsible computer' and so it should given that, other than having to buy a monitor and a mouse, it saves its customers the need to buy, manage, upgrade, and maintain expensive computers, external hard disks, and expensive

Zinbu provides access to server based computing for subscription.

www.zonbu.com

proprietary software. It reduces carbon emissions that would otherwise be generated by its clients' equipment.

5.2.3 Server Technology Using Low Power Processors

Servers based on low power processors are smaller than conventional servers. A data centre can therefore pack more low-power processor based servers than standard servers in the same space. Data centres use a profitability matrix based on performance per Watt per cubic metre. Most low powered processors work only at about 1.2 GHz or lower, so they are not as fast as the standard ones which typically run at 2.4 – 3.8 GHz (Pentium 4). This means that a data centre would have to host fewer sites per server to maintain the same level of performance. A standard server would be able to host around 600 sites. One with a low power processor on the other hand should comfortably host about 200 sites. One might ask where the advantage lies.

Most low powered processors work only at about 1.2 GHz or lower, so they are not as fast as the standard ones, which typically run at 2.4 – 3.8 GHz (Pentium 4). This means that a data centre would have to host fewer sites per server to maintain the same level of performance.

One of the biggest factors influencing the performance of sites on the internet is the capability of the network card. When all the sites are hosted on just one server, they would use the same network card to transfer data. If these sites are distributed on three servers, the data that the sites can transfer would be three times more, which means faster access to the sites. Also, if one of the servers with a low power processor goes down only 200 out of 600 sites would be affected. Lastly, low power processors are very affordable at typically a third of the price of mainstream processors.

5.3 Power Supply and Management

5.3.1 Switched Mode Power Supplies

Switched mode power supplies (SMPS) are energy-efficient and can be used instead of linear power supplies in powering computers and electronic devices. Linear power supplies regulate the output voltage or current by expending excess power as heat, which is inefficient. SMPSs on the other hand regulate the output voltage using a duty cycle control which draws only the power required by the equipment. Thus, in theory, the SMPS is 100% efficient, but losses in its components (such as losses in the transistors, inductors, and capacitors), as well as a rectifier voltage drop lower the SMPS's efficiency to about 95%.

Switched mode power supplies (SMPS) are energy-efficient and can be used instead of linear power supplies in powering computers and electronic devices.

5.3.2 Fan-Less Power Supplies

As PCs get more powerful, their power requirements increase. This increase is satisfied with power supplies with higher ratings and which both generate more heat and require additional air conditioning.

One way to reduce some of this heat and power requirement is to have an external fan-less power supply unit (PSU). Having an external power supply for desktop PCs means that a fan, which in itself consumes power, is not necessary to cool down the power circuitry since the power supply is not in an enclosed space. However, fans are still necessary to cool the main CPU and the video processors. An added bonus is that fewer fans make for less noisy PCs.

One way to reduce the heat and input power requirement of a device is to use an external fan-less power supply unit.

Examples of fan-less computers with external power supplies are Advanced Modular Computer's AMC-S113E and AMC-S113C PCs and Shuttle's XPC mini X 200B. PC World's proposed Green PC due to be launched in October 2007, will have an external power supply. The company says that at around 40 W, its PC will use between 13% and 17% of the energy of a standard desktop. In addition, the case is designed to act as a heat sink for the processor, and by using an external power supply the computer will be fan-less. PC World also claims that despite the energy efficiency, the machine will have the same capacity as a standard desktop.

It is also possible to have internally-hosted fan-less power supplies. Manufacturers of these include Antec, Silentmaxx and Yesico.

An example of a fan-less computer with an external power supply is Advanced Modular Computer's AMC-S113E.

www.amcuk.com/amcs113e.html

Fan-less power supply vendors include:

Antec - www.antec.com
Silentmaxx - www.silentmaxx.de
and Yesico - www.yesico.de

5.3.3 Power Supply in the Data Centre

Data centres have among the highest densities of energy-consuming equipment of any modern building and use 100 times the electricity of a typical office building on a per square metre basis. It is estimated that for every 100 W used to power a server, typically an additional 60 W to70 W of power is required to cool it. The issue of consumption is therefore one of great concern.

Data centres have among the highest densities of energy-consuming equipment of any modern building and use 100 times the electricity of a typical office building on a per square metre basis.

Advancements such as the half-depth sizing and back-to-back mounting of servers enable density levels as high as 80 1U rack-mount servers per cabinet. The newest multi-core processors from AMD and Intel are enabling extremely high CPU core densities, and the introduction of quad-core computing has enabled an unprecedented 640 processing cores in a cabinet just 2.1 m tall and 1 m deep.

There are three steps required in establishing an energy-efficient data centre: the selection of low power components in IT equipment, better power distribution techniques, and better cooling strategies.

Selection of Low Power Components

A system administrator can carefully specify high efficiency, low power components to go inside the servers and power supplies. Each and every component not only requires power to function, but also exhausts heat in return. Only the components and devices that are needed by the operations being carried out in the data centre should be specified, ie no unused compact disk read-only memory (CD-ROM) or floppy drives, unnecessary motherboard components or memory. For example, a 250 W power supply would be appropriate for a server with a 200 W requirement. Yet some manufacturers sell power supplies of up to 500 W that satisfy the same 200 W need, resulting in poor power efficiency. Typical power supplies function most efficiently when driven at a high percentage of their maximum rating. Traditional servers use alternating current to direct current (AC-DC) power supplies that convert AC power into the DC voltages required by system components. Data centre administrators can take advantage of recent advancements in AC power supply technology that have increased power supply efficiency from between 59% and 65% to 90% or higher.

Data centre administrators can take advantage of recent advancements in AC power supply technology that have increased power supply efficiency from between 59% and 65% to 90% or higher.

Better Power Distribution Techniques

In 2003, the first distributed DC power technologies became available for large-scale data centre server deployments. DC power options provide a more efficient power standard, eliminating the need for wasteful AC-DC power conversion. Energy efficiency can be improved by replacing the AC power supply inside each server with a 93% efficient DC power card, and carrying out the AC-DC conversion using external rectifiers at the cabinet level. Converting the power within the external rectifiers produces 20% to 40% less heat dissipation within the servers.

Energy efficiency can be improved by replacing the AC power supply inside each server with a 93% efficient DC power card, and carrying out the AC-DC conversion using external rectifiers at the cabinet level.

Better Cooling Strategies

Traditional data centres rely upon a 'hot aisle/cold aisle' layout, where standard-depth rack-mount systems draw in cool air in the front and expel hot air out the back of the rack. Expelling heat back into the data centre environment naturally warms the air and puts a high load on the air conditioning infrastructure. Moreover, if not positioned properly, hot air expelled from these traditional AC servers can make its way into a neighbouring row of servers, thus increasing the ambient temperature of those systems as well as the likelihood of failure.

Using half-depth servers mounted back-to-back inside the cabinet can greatly improve the efficiency at which a data centre can be cooled.

Using half-depth servers mounted back-to-back inside the cabinet can greatly improve the efficiency at which a data centre can be cooled. Back-to-back mounting not only improves serviceability by positioning ports and connectors on the easily accessible front of each server, but it also creates a natural plenum—or chimney—inside the cabinet. Fans inside each server and carefully placed louvers built into the cabinet can direct airflow upwards through the plenum, evacuating heat though the top and directly into the air conditioning infrastructure. By changing the direction of the fans and louvers, heat can also be directed downward toward the floor and evacuated through in-floor cooling devices. Better still, designing special shrouds that seal the top of a cabinet and connect directly to air conditioning ducting, enable the movement of heat directly out of the cabinet into the cooling framework without ever entering the data centre. These techniques eliminate both the hot aisle/cold aisle problem as well the issue of re-circulating hot air exhaust into the data centre.

To improve energy efficiency even further, the hot air evacuated from a data centre can be directed towards offices and used for space heating during the winter months.

Degree Controls specialises in data centre and electronics cooling. With its product the Hotspotr Airmover, it can create a network of sensors that can pin-point hot spots in a server room and direct cool air there. HotSpotr consists of a family of powered airflow improvement products that move chilled data centre air to precisely where it is needed the most, and remove heated exhaust air directly back to air conditioners. The top-of-the-range models are thermostatically controlled by the temperature sensors that are included with the product. The airflow rates of less expensive models can be controlled by operators or will run continuously. The company claims that directional air flow can cut data centre energy bills by 30%.

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www.degreec.com

5.4 Power Management Software

5.4.1 AMD's PowerNow!

Power consumption increases with frequency (clock speed), and voltage. Lower power and greater efficiency can be achieved by using power management software to adjust the processor's clock and voltage on the fly in response to the power needs of the operations being carried out at any one time. Doing both can result in major power savings. However, lowering the frequency also reduces the number of instructions that can be carried out per second resulting in slower response. This technique is called 'soft cooling.'

PowerNow! dynamically adjusts the operating frequency and voltage many times per second, according to the task at hand. When an application does not require full performance, significant amounts of power can be saved.

PowerNow! is a piece of software that conserves power in AMD mobile processor-based notebook computers. It dynamically adjusts the operating frequency and voltage many times per second, according to the task at hand. When an application does not require full performance, significant amounts of power can be saved. The processor can still instantaneously respond to increased workloads. Users should experience significantly longer battery life and quieter and cooler PCs.

5.4.2 Energy Star's EZ Wizards

The monitor is by far the component that consumes the most energy and Energy Star offers two free downloads to help achieve power savings on them: EZ Save and EZ Wizard. EZ Wizard enables power management for monitors on individual workstations, while EZ Save allows system administrators to enable power management on all the monitors on a network from one central location. These programs function by using existing power management feature if Windows 95, 98, ME, 2000, and XP.

EZ Wizard enables power management for monitors on individual workstations, while EZ Save allows system administrators to enable power management on all the monitors on a network from one central location.

EZ Wizard enables the existing power management features of Microsoft Windows to turn off a computer monitor when the computer is idle. It asks the user how long the system should be idle for before the monitor goes to sleep. The choices are 10, 15, and 20 minutes. EZ Wizard is designed to be integrated into an organisation's intranet or emailed to all users in an organisation. EZ Wizard is available in four languages: English, Spanish, Portuguese, and Chinese. There are plans to introduce English versions of the software in South Africa and India.

From its experience in the USA, Energy Star claims that running the software on a single PC for a year could save about 200 kWh. The Tulane University's Kennedy School of Government claims to be saving about 160,000 kWh of electricity per year through the use of EZ Wizard. The savings are estimated to be $14,000 per year.

5.4.3 Intel's PowerTOP

Intel offers a free tool called PowerTOP that allows notebook users to monitor the power consumption of Intel-based Linux systems. It tracks which applications wake up the processor from its low power sleep mode, allowing users to stop using or tweak certain power hungry applications. Early results have yielded a one-hour increase in battery

Intel offers a free tool called PowerTOP that allows notebook users to monitor the power consumption of Intel-based Linux systems.

life on some notebook computers, but the technology can also benefit desktop systems and servers.

5.4.4 Verdiem's Surveyor

Verdiem's Surveyor software takes the task of managing power usage settings away from the computer user. Surveyor remotely controls when and how desktops and notebook computers on a network go into energy-saving sleep mode. The company claims that the software can cut power bills by $20 per PC per year.

Surveyor remotely controls when and how desktops and notebook computers on a network go into energy-saving sleep mode.

5.5 Cooling

A computer's many components produce large amounts of heat during operation, including, but not limited to, integrated circuits such as CPUs, chipsets, and graphics cards, along with hard drives. This heat must be dissipated in order to keep these components within their safe operating temperatures, and both manufacturing methods and additional parts are used to keep the heat at a safe level. This is done mainly using heat sinks to increase the surface area over which heat is dissipated, fans to speed up the heat exchange between the air heated by the computer parts and cooler ambient air, and in some cases soft cooling, the throttling of computer parts in order to decrease heat generation. Greater energy efficiency can be obtained when cooling can be achieved without using parts that require power themselves, ie using passive cooling techniques. The action of heat sinks is already well known. This section describes two methods of cooling processors in pre-assembled computers.

Cooling is mainly achieved with the use of heat sinks to increase the surface area over which heat is dissipated, and fans to speed up the heat exchange between the air heated by the computer parts and cooler ambient air.

5.5.1 Casing Acting as a Heat Sink

Some laptop components such as hard drives and optical drives can be cooled by having them make contact with the computer's frame, increasing the surface area that radiates heat.

5.5.2 Liquid Submersion Cooling

One method is to submerse the computer's components in a thermally conductive liquid. Personal computers that are cooled in this manner do not generally require any fans or pumps, and may be cooled exclusively by passive heat exchange between the computer's parts, the cooling fluid, and the ambient air. Various liquids such as Fluorinert have been invented and manufactured for this purpose. Various oils, including but not limited to, cooking, motor and silicone oils have all been successfully used for cooling personal computers.

5.6 Massive Array of Idle Disks (MAID)

This is a system that uses hundreds to thousands of hard disk drives for an intermediate type of storage – a compromise between frequent and very rapid access to data and infrequent access for backup or long-tern storage. In MAID, each drive is only spun up as needed to access data. MAID systems have the advantages of decreased electrical power and cooling requirements at a cost of increased latency of the order of tens of seconds and lower throughput. Most large hard drives are designed for near-continuous spinning, and their

MAID systems have the advantages of decreased electrical power and cooling requirements at a cost of increased latency of the order of tens of seconds and lower throughput.

reliability decreases if spun up repeatedly to save power. MAID is designed for Write Once Read Occasionally (WORO) applications.

MAID systems can be used to replace tape libraries or supplement storage management of persistent data, ie data that does not change frequently. Large scale disk storage systems based on MAID architecture allow dense packaging of drives and are designed to have only 25% of disks spinning at any one time. This allows for high throughput to get data to this platform quickly. Since persistent data is accessed very little, any data can be accessed at any time, and stay within the power budget of 25% of drives spinning.

5.7 Virtualisation

Virtualization in the context of computing refers to the technique used to hide the physical characteristics of computing resources from the way in which other systems, applications, or end users interact with those resources. This includes making a single physical resource (such as a server, an operating system, an application, or storage device) appear to function as multiple logical resources; or it can include making multiple physical resources (such as storage devices or servers) appear as a single logical resource.

Computer hardware was originally designed to run only a single operating system and a single application, but virtualisation software bundled with computer hardware makes it possible to run multiple operating systems and multiple applications on the same computer at the same time, increasing the utilisation and flexibility of hardware resources. Using this technology can reduce energy costs significantly through the reduction in the amount of equipment needed to serve an IT community.

Computer hardware was originally designed to run only a single operating system and a single application, but virtualisation software bundled with computer hardware makes it possible to run multiple operating systems and multiple applications on the same computer.

Operating systems that facilitate virtualisation include Red Hat Enterprise Linux 5 and SWsoft Virtuozzo. Servers that include virtualisation software are VMware's ESX Server 3i and Dell's PowerEdge 1950 and 2950.

5.8 Monitors – CRT or LCD?

Monitors are responsible for about 60% of a PC's electrical consumption and therefore deserve as much attention, if not more, as the other parts a computer.

Besides being compact, space saving, and producing less eye fatigue, LCD monitors are extremely economical when it comes to power consumption. Their consumption is in the region of 25 W to 50 W compared to the CRT which consumes between 60 W and 80 W for a 15" model and between 70 W and 150 W for 17" and 19" models.

Besides being compact, space saving, and producing less eye fatigue, LCD monitors are extremely economical when it comes to power consumption.

Colour rendering is the primary advantage that CRT monitors held over LCD monitors. The depths of colours displayed and contrast ratios were much greater and better with CRT monitors than LCD monitors. Graphic designers still use the costly large CRT monitors because of the colour benefits they get. However, the difference is not as great as once it was. On the other hand, CRT monitors are known to emit harmful radiation, whereas LCD monitors do not.

Regardless of the type of monitor, it should be turned off when not in use.

5.9 Telecommuting Enablers

Technologies that enable a reduction in the use of cars and aeroplanes, thereby reducing vehicle carbon emissions, also count as low emission IT. Among these are virtual private networks, and video and audio conferencing.

A virtual private network allows the employees of a company or organisation to work away from the office by enabling computer communication that incorporates data security over the public network. Of course, the technology is not only meant for commuters. It also allows organisations that have several sites to communicate between these sites.

A virtual private network allows the employees of a company or organisation to work at home by enabling computer communication that incorporates data security over the public network.

Video and audio conferencing offer the same energy saving advantage. Conferencing can take place over a leased line, or more commonly these days, using VoIP software such as Skype and Yahoo and Microsoft 'Messenger' applications to achieve communication over the Internet.

6 Other Energy Reduction Options

6.1 System Upgrades

In the past, it was common for system administrators to ask computer users to log out of their computers but not to switch off their systems when going home at the end of the day. This enabled the system administrators to carry out software upgrades and maintenance activities overnight. More system administrators are now requesting that computers should be switched off at the end of the day except for only one day in the week when these maintenance activities are carried out. Radically reducing the number of hours computers are left on is resulting in large energy savings.

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6.2 Carbon Offsetting

Some organisations that have high IT usage are finding ways of being 'greener' by buying energy from renewable energy suppliers, or by funding projects that plant tress, use renewable energy, improve energy efficiency, or that use zero carbon technology.

In June 2007, Centrinet, a provider of managed network and secure data hosting services, announced the launch of 'Smartbunker', a 2,787 square metre purpose-built data centre using energy derived solely from wind power bought from Ecotricity.

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In September 2006, VIA's C7-D processor was marketed as being carbon-neutral because VIA offset every kilogram of carbon dioxide produced in the generation of electricity to power the VIA C7-D processor. VIA works with Carbon Footprint Ltd., a private company that provides information on how to reduce carbon emissions, to invest

in regional projects in energy conservation, reforestation, and alternative energy.

Salesforce.com is another company that announced in January 2007 that it is offsetting 20,000 tonnes of carbon dioxide that it estimates will be released due to the energy needs of its offices, data centres and staff commuting this year.

In June 2007, Dell launched a new zero carbon initiative that will ensure that its suppliers have green credentials. Dell has committed to reducing the carbon intensity of its global operations by 15% by 2012 and extended its 'Plant a Tree for Me' programme to Europe, allowing computer users to offset the emissions associated with the electricity their systems use.

7 Impact of Current Low-Emission IT on Emissions Targets

Until recently, little attention has been paid to the contribution of IT to global carbon dioxide emissions due to the low percentage of this contribution compared with the transport industry and energy use in buildings that each account for 40%. Therefore, little has been done in articulating how much the adoption of low-emission IT technology will impact emissions targets.

Legislation to enforce low-emission IT has only just begun to appear in the last decade. In May 2007, the UK government announced that a task force is to attempt to reduce the 'cyber carbon footprint'. Dubbed 'Green Shift', the project will replace energy-absorbing PCs with greener alternatives in up to 10 cities by the end of 2009. Initiatives such as these that compare the emissions of the airline industry, a subject which is generating a lot of debate about how to legislate internationally to reduce these emissions, with those of the IT industry is bound to increase the pace at which more legislation is rolled out to control IT related emissions using the technologies and practical methods described in this report.

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8 The Market

With the help of government inspired schemes and high energy prices the market for low emission IT is growing year on year. Manufacturers of IT equipment and software providers are tapping into the rising global consciousness about climate change to market their products, and also to develop more energy-efficient technologies given their corporate customers' demand for solutions that will lower their energy bills. Improving their green credentials is also encouraging both corporate and private IT users to buy their energy efficient products.

The market is expected to expand as more governments legislate to increase the use of low emission IT. Government IT departments also have a role to play in driving the market as they are responsible for a significant share of IT spending and tend to define the standards a large cross section of equipment manufacturers and systems integrators work to.

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Globally, Communications and Information Technology is a multi million dollar market which is still growing rapidly in emerging countries such as Russia, China, Indonesia, India, and Brazil. It is expected that energy-hungry China will aim to manufacture IT equipment that focuses on energy efficiency. Increasing mobility is also driving growth in the market for low power processors. Increasing oil prices continues to be a force for growth. All in all, the trend is for the market to keep growing for the foreseeable future.

Two potential growth areas for low emission IT are the introduction of new devices and systems that consume less energy and the introduction of new technologies that enable users of existing technologies to reduce their energy bills. It is expected that incumbent IT vendors will dominate the former market while the latter will provide important opportunities for new entrants into the IT market. Capturing even a small share of the low emission market would generate significant revenues for any new entrant with a credible and demonstrably workable low emission IT product or service.

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9 Conclusions

The IT industry has seen enormous change over the past 50 years. The change has brought about the use of computing in all walks of life from scientific research, to business and entertainment. The resulting proliferation in IT equipment has brought about concerns about their contribution to climate change due to their energy consumption and consequent carbon emissions.

Proliferation of IT equipment has brought about concerns about their contribution to climate change due to their energy consumption and consequent carbon emissions.

The average computer in use today is highly energy inefficient. Governments throughout the world have instituted eco-labels and energy efficiency standards in an attempt to bring the energy issue to the attention of industry in order to change business practices and procurement behaviours. Computer manufacturers, energy supply companies, and individual members of the public have joined in initiatives to strive for better energy performance standards. All this has stimulated market forces into providing a diversity of products and options that in turn is benefiting the environment.

Computer manufacturers, energy supply companies, and individual members of the public have joined in initiatives to strive for better energy performance standards.

Low-emission IT technology currently in use includes server-based computing, the use of low power processors, innovative cooling techniques, software-enabled hardware resource management, software power management tools, and more efficient data centre power supply and cooling techniques. These technologies are available now, but unless corporate energy management schemes are enforced through effective corporate environmental policies backed up by share holder support and government legislation, they will remain ineffective as tools to bring about a reduction in IT carbon footprints.

Unless corporate energy management schemes are enforced through effective corporate environmental policies, backed up by share holder support and government legislation, IT carbon footprints will not be reduced.

The next 50 years will see even more people, especially in developing countries, having access to computers. It is conceivable that 50 years from now, the computer will be as commonplace as a refrigerator is in a home today. More needs to be done now to tackle the increasing power requirements of computers – how the carbon dioxide they produce can be reduced, offset, or eliminated altogether. New power technologies such as fuel cells may provide part of the answer.

More needs to be done now to tackle the increasing power requirements of computers. New power technologies such as fuel cells may provide part of the answer.

IT managers have found themselves on a steep learning curve as an extra parameter has been introduced to the equipment buying process. Whereas until recently their focus was on providing their company with the fastest information processing at the lowest cost they must now take into consideration the energy cost of processing and storing a byte of data. They must also decide which low emission IT scheme or standard is likely to provide the best energy saving without compromising the performance of their department.

The IT industry's recent focus in low emission technologies has provided important opportunities for small vendors who, until recently, were perceived as marginal players in a niche market. As energy saving has moved centre stage in the IT market, so these marginal players have begun to move into the mainstream. Larger players have been able to capitalise on the growing interest in low energy computing either by differentiating their products using eco related benchmarks or reintroducing concepts such as thin client computing as a low emission IT solution.

IT managers have found themselves on a steep learning curve as an extra parameter, energy use and related carbon emissions, has been introduced to the equipment buying process.

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10 Vendor Profiles

10.1 NEC

In response to the need to reduce energy costs NEC offers solutions based around thin client design and PC virtualisation. Its thin client offerings include the C50, e90, US100 desktop terminal (that supports multimedia and VoIP), TCM160 (notebook thin client terminal) and TCM160 XPe. The thin client terminals do not have hard disks and each is equipped with an electronic card and a pre-loaded operating system such as Citrix or Microsoft TSE. Citrix's Integrated Computing Architecture (ICA) and Microsoft's Remote Desktop Protocol (RDP) networking protocols allow them to be connected to centralised application servers. Connections can be made on Ethernet, Wi-Fi, or 3G networks depending on the model.

NEC's new Virtual PC Class (VPCC) thin client system has full PC functionality, including multimedia capabilities, data security, and VoIP, and is designed to replace the PC desktop. This solution is able to deliver the same user experience as a traditional PC, with the security and IT management benefits of a virtualised environment at a lower total cost of ownership.

NEC Corporation is a multi-national organisation with operations on all five continents, manufacturing products such as PCs and servers, computer peripherals, storage devices, networking devices, software, semiconductors and components, and home appliances among others. As such, its thin client solutions find their way to customers in all these regions.

NEC at a Glance

NEC Computers, a subsidiary of NEC Corporation, Japan, designs, manufactures, markets and supports desktop PCs, notebooks, servers, storage solutions as well as turnkey solutions for small to medium-sized businesses and the public sector.

www.nec-computers.com

See Also

Netvoyager
www.netvoyager.co.uk

Fujitsu-Siemens
www.fujitsu-siemens.com

Wyse
www.wyse.com

Analysis

NEC's products show the variety in thin client-server configurations that are available today. It is possible that thin client-server solutions will soon begin to replace a great number of PCs currently in use in large organisations, corporations, and data centres. Getting more IT service providers to offer thin client-server services to individuals will be the next step in revolutionising the PC desktop industry.

10.2 Verdiem

Verdiem's key product, 'Surveyor', is a tool that allows its user to measure, manage, and reduce the energy consumption of a computer network. Surveyor works by placing PCs into lower power settings (such as standby, hibernation, or shut down) when not in use. It analyses user behaviour, monitoring the times the user does not use the computer (eg lunchtimes and weekends). This information is used to control the power settings, ensuring that networked PCs are in the right power state (on, hibernate, standby, etc.) at the right time. Surveyor also generates reports on energy use and cost savings.

The company claims to cut 100 to 300 kWh of energy from every PC in an organisation annually, resulting in an average cost saving of $20 per computer per year. It also claims that Surveyor consistently reduces consumption by about a third.

Verdiem has agreements with several power companies who provide rebates to organisations that buy and install the software.

Verdiem's competitors in the power management software space include 1E with their NightWatchman software which automates the remote power management of PCs by putting them into different power states according to a schedule centrally-controlled by system administrators. Snap.com's CO2 Saver and Faronics's PowerSave perform similar tasks.

Verdiem's clients tend to be those that have 4,000 or more networked PCs in their organisation. These include government agencies and schools districts.

Verdiem at a Glance

Verdiem was founded in 2001. Based in Seattle, USA, Verdiem develops power management software for PC networks.

www.verdiem.com

See Also

1E	www.1E.com
Snap	co2saver.snap.com
Faronic	www.faronics.com

Analysis

Although Verdiem is still enjoying venture capitalist funding, it is very likely that it will move to initial public offering (IPO) status in the not too distant future due to the success and growth in the use of power management software. As more businesses are being compelled by legislation to produce reports on their corporate social responsibility and sustainability programmes, and the increasing cost of energy, the uptake of this type of software is likely to increase substantially. It is encouraging to see large public organisations taking up the use of power management software. The corporate world is, however, lagging behind chiefly because systems administrators are not responsible for paying energy bills. Since computing resources are seen as essential rather than optional in many businesses, focus must be placed on using them as efficiently as possible, and that includes paying attention to the energy they consume.

10.3 Rackable

Rackable System's products are designed to run Microsoft Windows and Linux operating systems. It is the fourth largest provider of x86-processor-based servers. It pioneered the first back-to-back (or half-depth) rack-mounted systems allowing twice as many devices to be installed in the same space as standard rack-mounted solutions. It uses its fan-less back-to-back servers, a centralised cooling solution, and DC power supply technology in all its current product offerings to increase processing power while improving energy efficiency.

Its Foundation Series servers for single, dual, and quad processor motherboards support AMD and Intel 32 and 32/64-bit processors such as the AMD Opteron, Intel Pentium 4, Intel Itanium 2 processor, Intel quad-core Xeon, and AMD quad-core Opteron 800 series processors. Rackable Systems also offer virtualised servers based on VMware's virtualisation software.

Its storage devices include the RapidScale Storage Appliance and Foundation Series Storage Server. Its OmniStor SE3016 expansion system provides a scalable means of adding external storage to its servers. Storage accounts for approximately 10% of Rackable's revenues

Rackable also offers the ICE (Integrated Concentro Environment) Cube which is a mobile data centre which packs all data centre essentials into a shipping container. Mobile data centres are used for disaster recovery situations. With ICE, customers have the choice of either a 6m x 2.4m x 2.4m or a 12m x 2.4m x 2.4m trailer. These can house up to 1,400 of its 1U servers. Installed with servers based on Intel's quad-core Xeon processor, the mobile data centre can contain a maximum of 11,200 processor cores. In addition, the container has 4.1 petabytes (10^{15} bytes) of storage. The 12m containers fit on to the back of a lorry and, as such, can be transported to the customer's location. A number of these containers can be hooked up together should even more processing power be required.

A relatively small number of their customers have historically accounted for a significant portion of revenue, and this trend is expected to continue. Rackable's biggest customers are Microsoft and Yahoo accounting for 34% and 26% of their revenue respectively in 2006. Other customers include Google, Amazon.com, Deutsche Bank, University of Florida, Webex, nVIDIA, and Oracle.

Rackable at a Glance

Rackable Systems was founded in 1999 and is headquartered in California, USA. It designs and manufactures high density server and storage products for large data centres based on an open architecture using standard components from Intel and AMD.

www.rackable.com

See Also

Rackable's major competitors include Dell, Hewlett-Packard, IBM, Sun Microsystems, EMC, Hitachi Data Systems, and Network Appliance. Rackable's closest competitor in the mobile data centre market is Sun Microsystems' Project Blackbox, which combines storage, computing and network infrastructure hardware and software, along with high-efficiency power and liquid cooling, into modular units based on standard 6m x 2.4m x 2.4m shipping containers. A smaller competitor that serves the UK and European market is ICM.

www.icmcomputer.co.uk

Analysis

Rackable's combination of half depth fan-less servers, centralised cooling systems, and DC power supply to racks makes its rack-mounted solutions one of the most energy efficient in the industry. Rackable Systems seem to have made serious inroads into the market consisting of large corporations with sophisticated and high processing throughput needs. However, it needs to diversify its business, spreading its products across more diverse client bases – perhaps venturing into other large organisations such as government agencies and banks that carry out a lot of data processing and that perhaps could do with more energy efficient resource and power management.

10.4 Intel

Intel manufactures processors for desktops, notebooks, servers and workstations, networking and communications, and for time-critical (embedded) applications. Intel's quad-core Xeon processors have twice the performance per Watt of the previous generation dual-core processors.

Intel was an early developer of static and dynamic random access memory chips (SRAMs and DRAMs), but it wasn't until the emergence of the IBM personal computer that microprocessors became their primary business. During the 1990s, Intel became the dominant supplier of microprocessors for PCs, and this fuelled the rapid growth of the PC industry.

In 2005, Apple Computers decided that its PowerPC processor architecture was not able to satisfy its needs, so it went into partnership with Intel. Apple had its entire consumer product line and the Xserve server running on Intel processors by November 2006.

In conjunction with Google, Intel has set up the Climate Savers Computing Initiative and is attempting to increase the energy efficiency of computers and servers. It also, in collaboration with private and government organisations, is attempting to help to drive global standards, solutions, and products that ensure the delivery of energy-efficient performance while reducing overall environmental impact.

Intel's major competitor on the x86 processor market is AMD. Smaller competitors such as VIA and Transmeta produce low-power processors for small computers and portable equipment. Other top semiconductor companies include Samsung, Texas Instruments, Toshiba, and STMicroelectronics. Competitors in PC chipsets include VIA Technologies, SiS, ATI, and nVIDIA. Intel's competitors in networking include Freescale, Infineon, Broadcom, Marvell Technology Group and AMCC, and its competitors in flash memory include Spansion, Samsung, Qimonda, Toshiba, STMicroelectronics, and Hynix.

Intel at a Glance

Intel Corporation, based in California, USA, was founded in 1968 as INTegrated ELectronics (INTEL) Corporation. It is the world's largest semiconductor company and the inventor of the x86 series of microprocessors, the processors found in many personal computers.

www.intel.com

See Also

www.amd.com
www.transmeta.com
www.samsung.com
www.ti.com
www.toshiba.com
www.nvidia.com
www.ati.com
www.sis.com
www.freescale.com
www.broadcom.com

Analysis

Intel has cornered the PC processor market for the last 10 years with its 'intel inside' campaign, and has been in the top 10 list of semiconductor companies for most of its existence. It is difficult to see how Intel, with its size, influence within the industry, and diversity of products, could go wrong. However, Intel will need to maintain its leadership role in innovating new processors as there are many competitors some of whom are claiming that their products are more environmentally friendly and less power hungry than devices supplied by incumbent semiconductor manufacturers.

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