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Intel® vPro™ Technology

Power Efficiency and Sustainable Information Technology

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[Glen Anderson](#), Channel Platforms Group, Intel Corporation
[Philip J. Corriveau](#), Channel Platforms Group, Intel Corporation
[Doug DeVetter](#), Information Technology, Intel Corporation
[Frank Engelman](#), Information Technology, Intel Corporation
[Subhashini Ganapathy](#), Channel Platforms Group, Intel Corporation
[Robert F. Reed](#), Digital Enterprise Group, Intel Corporation
[Alan Ross](#), Information Technology, Intel Corporation

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Abstract

Energy efficiency in large data centers is already a concern for many businesses because of the high density of energy consumption. Rising energy costs and global environmental concerns have prompted Information Technology (IT) professionals to also take a closer look at client personal computer (PC) energy consumption. Intel researchers interviewed IT professionals about the monitoring and control of client PC energy consumption. This article describes findings from that study and we discuss how Intel® vPro™ technology can be used to address client PC energy efficiency. Intel vPro technology allows a business to manage energy consumption while ensuring that systems can still be awakened in a reliable, secure manner, allowing energy savings while still providing a high level of operational stability. Both internal Intel pilot studies and an external case study show how Intel vPro technology is already being used to address the client PC energy efficiency challenge. Utilizing Intel power-management technologies will pave the way for the active energy-management capabilities that are required to reduce energy consumption in the office computing domain.

Introduction

IT professionals in many businesses have become more aware of the cost of energy consumption. Energy consumption in data centers has long been a concern [1], but more recently, IT managers have

realized that the enormous installed base of client personal computers (PCs) offers at least as much opportunity for energy savings as data centers [2]. Since IT organizations are being held more accountable than they have in the past for energy consumption within enterprises [3, 4], IT professionals need methods and tools to monitor and control energy consumption.

According to a 2002 study by Lawrence Berkeley National Laboratory [5], typical PCs can save .064 kW in a sleep state, versus running in idle mode. A 17-inch LCD display can save .033 kW in a sleep state. Using a United States Department of Energy estimate of \$.0931 per kWh [6], a company can save \$.009 per hour of sleep time for a PC and display together (.097 kW multiplied by \$.0931). If a PC remains in a sleep state for 14 hours per work day (this assumes a 10-hour work day for the PC) and 48 hours per weekend, a savings of \$55.22 annually per PC can be realized. Across an installed base of thousands, such a savings can be substantial.

Many factors drive increased interest in managing client PC energy consumption, such as cost savings and environmental concerns. However, there are also factors that work against the management of energy consumption, such as perceived additional system management overhead and lack of reward for saving energy.

Intel has many activities in the energy-efficiency domain, including producing increasingly energy-efficient products, collaborating with governments and industry workgroups on energy-efficient products, and active programs across our manufacturing facilities to reduce the impact on the

environment. Intel® vPro™ technology for business PCs can play a key role in managing business client PC energy consumption as its specific features allow IT professionals to address energy efficiency.

In this article we look at the findings from a study of IT professionals who were asked how they would like to manage client PC energy consumption, what would motivate them to manage it more efficiently, and what tools would they need to do the job. We then show how Intel vPro technology can be used in businesses to help manage client PC energy consumption, and finally we look at case studies on reduced energy consumption as a result of the implementation of Intel vPro technology.

Factors Influencing IT Professionals

The findings discussed here are based on data collected from semi-structured, on-site interviews with 28 IT professionals in the United States and the United Kingdom during August and September of 2007. We questioned participants about their current practices of energy conservation and about their views on using monitoring technologies to lower the energy consumption of client PCs. The businesses were in a variety of industries, including banking, insurance, manufacturing, government, and education. To be selected for the study, participants had to have indicated during screening that IT was strategically important to their businesses. The US sample included 18 US businesses in Denver and San Diego. The UK sample comprised 10 businesses in London. About an equal number of participants were selected from small (30-99 managed PCs), medium (100-499 managed PCs), and large businesses (1000 or more managed PCs).

Cost Savings

The primary driver for energy efficiency in for-profit companies is to save money. In conversations with IT professionals, we found that they often cited savings within 10 to 15 percent as being meaningful for client PCs. We found a general trend in the interviews that indicated that the larger the business, the more likely the IT personnel believed a system for client PC energy efficiency would be worthwhile. When IT professionals were responsible for thousands of client PCs, they said that multiplying the benefit of saving a relatively small amount of dollars or Euros across thousands of PCs would be something they could show to upper management as constituting a meaningful cost savings.

For small and medium business, IT professionals believed that they could make little financial

difference by saving power on relatively few devices. Even if a feature of technology could make policy enforcement and monitoring reliable and easy, the cost savings would not add up to enough to make it worthy of consideration.

In many businesses, we found that it can be difficult to account for energy consumption costs, and IT professionals are generally unaware of the cost of electricity needed to run a PC. IT professionals in some small and medium businesses said they rent office space as part of a package that includes utilities. IT professionals in these situations have difficulty using cost savings as an argument for energy-efficient technology, because the business would not save the money directly. Moreover, the savings involved would likely not be enough to justify renegotiating leases with landlords. Even in large enterprises, since electricity consumption is part of operational expenditures, and IT is part of capital expenditures, it may be difficult for IT organizations to get credit for conserving electricity.

Governmental Regulation

IT professionals in London more often cited possible future governmental requirements as a driver toward client PC energy efficiency, though the topic did occasionally come up with US IT professionals also. In the US, IT professionals sometimes expressed a desire to comply with Energy Star, a US government program that sets standards for the energy efficiency of products. There was a general perception across groups in both the US and London, that, over time, government regulations would compel them toward greater client PC power efficiency.

Looking Green from the Outside

We also found that companies with an outward-facing public relations (PR) strategy and companies with users who could observe their client PCs firsthand often believed there was an advantage in presenting a “green” image to the outside world. Knowing that a green image might influence purchase decisions, IT professionals in these companies thought a visible program of energy efficiency, such as a special logo on the PC, could be financially beneficial because of its good PR. This logo could be from a government agency or some other organization that sets a well-known standard for energy efficiency.

Feeling Green from the Inside

Like people in many other occupations, IT professionals often have a personal commitment to save energy based on their own environmental philosophies. In our study, we found that some IT

professionals perceive their company's energy usage as having a direct impact on the environment, so they feel that by helping to reduce their company's energy consumption, they are helping to reduce greenhouse gases. Technology that reduces client PC energy consumption, therefore, appealed to these individuals, even if there were no tangible, economic benefits for the business.

IT Usage Requirements for Energy-Efficient Client PCs

Our research found that in order to make an energy-efficient client PC enticing to IT professionals, there were certain requirements and conditions that had to be met:

- Return on investment was top of the list. IT professionals have to do more work with fewer resources all the time, as they are pressured to reduce costs. Any additional tasks, including energy-conservation efforts, must show a return on investment. IT professionals want to enforce simple, basic, power-saving rules in relation to client PCs, such as reliable off or hibernation states at night and limited alerts, mostly just monthly reporting.
- Energy savings cannot hinder perceived performance for users. The PCs need to come out of sleep states quickly, and power-saving policies cannot lower perceived performance.
- Users don't usually give much time or attention to IT professionals: they just want them to keep their PCs running well and not interfere too much with their work. IT professionals often have to persuade users to allow them to install software patches, or they need to get users to adopt certain usage behaviors. None of these things are easily done, so making users aware of how a PC may behave in relation to a power-saving feature is just an additional training issue with which they have to contend, and it is something that draws their attention away from other IT concerns.
- Energy solutions must be integrated into other manageability solutions. Power monitoring should be implemented with enterprise manageability solutions such as those provided by original equipment manufacturers, operating system vendors, and independent software vendors.
- Metrics are important. IT professionals need explicit measures of how much energy they can conserve, and if it's not at least 10-15 percent, they're not interested.
- The focus of our study was desktop PCs, not notebook PCs. Client PC energy conservation has limited relevance to notebook PCs, except to the

extent that some notebook PCs are being used as desktop PCs. IT professionals did not want to try to control energy consumption of remote users or users whose computers run on battery power.

- Use cases (that is, proof points) are important to IT personnel. They like to look at what-if scenarios vis-à-vis their energy-saving policies. For example, when X number of PCs shut down or go to sleep at night, the company will save Y amount of money.

In the next section we describe the capabilities of Intel vPro technology that help address the factors that influence the energy-consumption policies of IT organizations.

PC Power Management with Intel® vPro™ Technology

Intel vPro technology offers several ways to impact energy efficiency.

Reliable Wake and Power Up

As we showed in our calculations on energy costs, substantial savings can be realized if desktop PCs are shut down or put to sleep during the non-use hours, typically overnight. This is especially applicable to computers that are used by shift workers in government agencies, financial institutions, or insurance industries, where workers do not typically take their computers home. While businesses could just ask employees to turn their systems off before leaving and then back on when they arrive at work the next day, there are three major problems with this approach.

1. Employees may simply forget to turn their systems off.
2. When employees turn their systems back on when they return to work, they will experience lost productivity while they wait for the system to boot up.
3. The start-up time, or even system performance, may be degraded by system updates or inventories that were not performed during the evening (because the system was off).

By using Intel vPro technology, all of these problems can be resolved. System shutdowns can be scheduled for when employees leave, or they can be delayed if the system is still active. The system can be woken up at a fixed time before the employees return to work. Finally, the system can be woken up during off hours to perform system updates or inventory; it can then be shut down again when these tasks are complete.

In all these cases, Intel vPro technology is used to perform a secure, robust system power-on that is not based on Wake on LAN (WoL). WoL technology is known to be insecure and difficult to manage. Intel vPro technology can also be used to gracefully shut down the systems by using Windows* Management Instrumentation.

How an application is configured for energy efficiency is now emerging as an important area of consideration. As some IT organizations become more application/service centric and less operating system-centric, management applications can utilize Advanced Configuration and Power Interface (ACPI) capabilities to work directly with the hardware and BIOS to most effectively manage platform energy consumption. The native management capabilities of platforms enabled with Intel vPro technology grant administrators the opportunity to seamlessly integrate manageability with security consoles to help control when and how systems are updated.

Integrated Energy Consumption Data Across the Enterprise

It is imperative that enterprise IT organizations implement monitoring systems to provide a comprehensive view of the energy consumed outside the data center. While the industry focuses on reducing energy consumption within the data center, we recognize the opportunity for reducing energy consumption in the entire office computing environment.

Utilizing Out of Band Capabilities to Maximize Energy Efficiency

Traditional PC management is accomplished through agents installed on the operating system. This means that the agent must be running in order for common manageability tasks to occur. Intel vPro technology provides out of band (OOB) capabilities that allow IT system administrators to access systems, independent of the operating system type or the state. This is important because utilizing Intel vPro technology OOB permits the client PCs to gravitate toward the lowest possible power state and still be available to be queried, inventoried, and patched. This integration of enterprise operations management capabilities is unique in that there is now a capacity to manage notebook PCs remotely, independent of their location. We are in an era in which robust OOB management capabilities exist and can be implemented to provide the enterprise a way to balance productivity, manageability, and energy efficiency.

Mobile PCs with Intel® vPro™ Technology

In addition to the obvious solutions described in this article for desktop PCs, there is a less well-understood Intel vPro technology solution for notebook PCs. Notebook PCs are routinely taken home by employees and therefore they cannot be managed on the internal corporate network. Employees who turn their notebook PCs off at night have experienced significant disruption when first connecting to the corporate network in the morning, especially if they are remotely connecting.

However, notebook PCs enabled with Intel® Centrino® 2 processor technology and with Intel vPro technology also have the ability to be managed outside the corporate network. In this scenario, when employees are finished using their notebook PCs at home, they would turn them off to conserve energy, but not turn off the AC power source. The notebook PC can be configured to wake up on a timed basis and securely call back into the corporate network to process any needed updates and then turn itself off. In this manner, employees can avoid time-consuming updates and be assured that their notebook PC is fully compliant with corporate policies before they connect to the corporate network remotely through the Virtual Private Network (VPN).

BIOS Configuration Elements

Intel vPro technology gives administrators the ability to remotely access BIOS power configuration elements on client PCs to ensure adherence to corporate policies via the ACPI standard. Across the board the adoption of the ACPI standard (in conjunction with the operating system and applications) helps to standardize the power state functionality of the hardware device (for example, what happens when you close a notebook PC). There are also C-states for idle central processing units (CPUs) as well as P-states for active CPUs: these states can control frequency and voltage for more efficient operation. The most popular utilization of the ACPI specifications is the S-state, that is, the sleep state (see Table 1).

Operating System Considerations

Operating system configuration is important for energy efficiency. There is robust support for ACPI power-management functionality in many client operating systems. Intel vPro technology capabilities can be utilized in conjunction with configuration management software to set the appropriate configuration, based on the type and version of operating system software installed on the client PC. It is important to conduct an appropriate amount of testing before integrating BIOS and operating system, power-management configuration options.

Table 1: Sleep states and their energy usage

S-state	Description	Comment
S1	All system context retained	Lowest energy savings
S2	CPU and cache context lost	Not often used
S3	Memory context saved ("sleep")	Typical balanced policy
S4	Platform context only saved ("hibernate")	Longer resume cycle
S5	No context saved ("soft off")	Best energy savings

Future Enterprise Integration and Client Power Management in IT Organizations

Enabling a comprehensive environment for client PC energy consumption takes a combination of forces: understanding the environment, monitoring energy consumption, and managing towards a common goal. As the capabilities of Intel vPro technology evolve, IT professionals will have a complete set of tools to reach that goal.

ISV Console within the Enterprise

In order to achieve the results we have described, any additional features of Intel vPro technology that provide client power monitoring and control need to be fully integrated into the ISV consoles. Utilizing that information enables IT personnel to get the maximum value out of their resources and to minimally impact the company's users. Monitoring the performance and activity profile of client PCs enables optimal energy efficiency in the enterprise. We advocate the flexibility to run monitoring and control software as an agent, or as firmware native to the platform, to enable flexible deployment, management, and policy definition. Moving forward we see two major areas of interest to the industry for power management:

1. Monitor alternating current (AC) power used by the client to accurately measure energy consumption and to provide an auditable energy-savings trail.
2. Control the client power states to save money, be environmentally conscious, and reduce the carbon footprint of the industry as a whole.

Estimating Power Consumption: Methodology and Practice

Existing estimation technology is limited to software that estimates power, based on time and system states, and then looks up the power profile of the

system logged. There are inherent inaccuracies in this methodology due to the inability of the software to be able to accurately model the users' real behavior: the software measures keyboard or mouse inputs, and the system state to estimate the time the system spent in various power states. Once these measurements are taken, the time and state information is translated into power by performing a calculation on a database of "known" or characterized devices. A worst-case scenario is when IT professionals "characterize" systems and manually input and maintain the data. This method is not only expensive, but it is time-consuming and highly susceptible to obsolescence.

Key drivers for improvements in power management are the accuracy of information collected and the additional hardware costs associated with the collection of that information. Intel is investigating adding centralized sensors to the client PC that are standards-based and have minimal impact on cost.

Desktop PCs, enabled with Intel vPro technology, that utilize the embedded Intel Manageability Engine (Intel ME) can potentially run firmware that can provide a standard Application Programming Interface (API) to provide information, through standard network management protocols, to agents that run in the Capability Operating System (COS) [7]. This firmware would collect data from sensors on the desktop PC and would accurately monitor power usage, taking into account basic faults, such as a fan or temperature sensor failure: the findings would be relayed back to the console agent (see Figure 1).

The firmware would be flexible enough to enable the end user, via the console, to determine the time between samples and also the time intervals in which data are sent back to the console.

By using software that can access the CPU and the Platform Controller Hub (PCH) registers, the firmware would be able to provide those data to the application software or the console (depending upon which implementation is used, that is, native or agent). By using Intel vPro technology with the embedded security provided by the Intel ME, a platform enabled with this technology, can provide a "tamper resistant" audit path. Also, by using these technology OOB capabilities, any information stored in the Intel ME can be retrieved after hours: the console can wake the client PC, download the information back to the console and then shut down the client PC to its original sleep state.

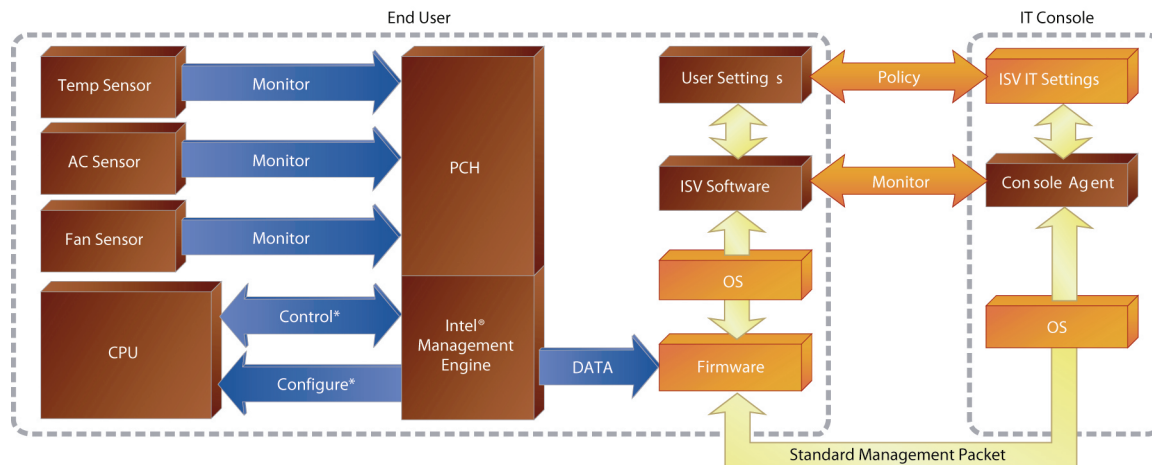


Figure 1: Platform and system overview

For client PCs, utilizing existing sensors and standardizing around those make economical sense and expedite industry adoption.

By using Intel vPro technology through the Intel ME that resides in the PCH, it will be possible to monitor and control the platform by using standards-based management console software.

Future Power Management Configuration Settings and Policies

Having accurate and auditable information enables IT managers to gather statistics and characterize the energy used in the enterprise.

Policies can be applied to control the time of day to shut down or power on computers. This is a major power-savings action for a corporation that, as discussed previously, can be accomplished successfully with Intel vPro technology. Other methods can also allow control parameters such as when to power down the hard drive, turn off the display, or suspend the platform. However, such settings do not allow for fine-grain power management of platform components that have to be kept on when the platform is in the ACPI S0 state. It has been determined that even though client PCs in an S0 state are in an idle state for 80 to 90 percent of the time, several platform components are kept in high-power states to meet the service latency requirements of devices and applications in the platform [8].

If the devices and applications could dynamically convey their service latency requirements to the platform based on workload (low latency tolerance when active and high latency tolerance when idle), that could dramatically reduce the energy consumption of the platforms when in an idle state.

Such information would allow for future policies that would integrate the local requirements with the remote policy settings to enable substantial power savings without sacrificing performance and reliability.

Enforcing software policy controls locally in each client PC, will lead to significant gains in energy reduction. However, Intel also recognizes systemic issues in existing platforms that cannot be addressed by software: the software cannot service the request to save power fast enough, and moreover, it is not cognizant enough of the entire system state to ensure stable operation. When an operating system or agent issues low-power state commands, they are not instantaneous. Commands take time to traverse the driver stack, and real-time hybrid operation is not possible, due to added system latencies.

A platform is comprised of core logic components, a CPU and PCH, and the devices that connect to these, such as the Universal Serial Bus (USB) devices. These USB devices can be a keyboard or mouse for basic Input/Output (I/O). Other examples of devices are wireless or wired Network Interface Cards (NICs), and discrete graphics cards. Each one of these devices is typically routed through the PCH or CPU (see Figure 2).

Having power control and subsystem logic embedded in the hardware of the platform means the devices can generate power-management messages when they transition from high-power states to low-power states. The platform will act on these messages without having to generate an interrupt that would unnecessarily cause the CPU to use high power to process these messages. In this new method of platform power control, the

operating system can provide the guidance and constraints that allow the hardware to make policy decisions to a granularity and latency unattainable by software.

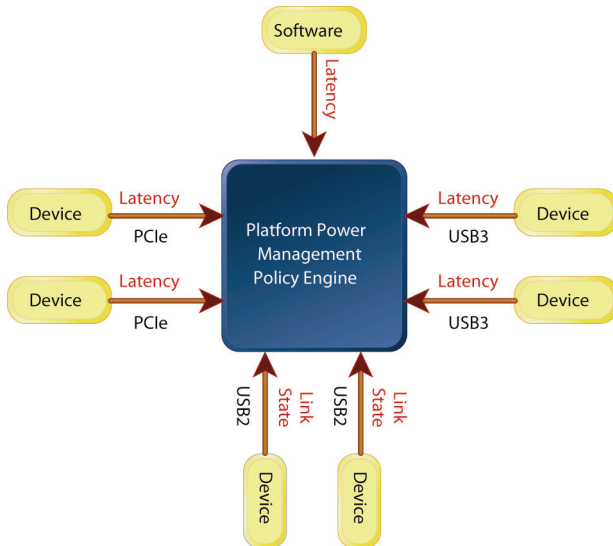


Figure 2: Device latency and power-management concept

The Role of Energy Efficiency Standards

It is important to continue to drive for adoption of ACPI and other standards and services that expose energy-efficiency capabilities across the client PC. It is also important to provide common methods to connect energy efficiency to other enterprise tasks, such as security and manageability. We have seen a promising evolution of the ACPI standards over the past few years along with the uptake of these standards across multiple OEMs and operating system vendors. Most IT organizations do not consider the notion of integrating power management into their enterprise applications, but the infrastructure to do this has been around for almost a decade with robust capabilities available that can be utilized where possible.

To continue to grow in today’s world of diminishing energy resources and higher costs, all computing sectors of the PC industry should work together to reach a goal in which desktop and notebook PCs in an enterprise can use a combination of hardware, firmware, BIOS, and operating system and application configuration elements and policies to maximize the energy efficiency of enterprise client PCs, independent of their location. This concept can then extend beyond the PC and extend to office equipment and additional form-factors over time. For now, however, this is a call for action in the area of enterprise business systems.

Case Studies

In the following section we present two real-world examples of how client PCs enabled with Intel vPro technology have successfully been implemented in the enterprise and how this technology has helped IT organizations manage and save power.

Case Study 1: Intel IT Training Room Environment

The IT training room environment within Intel consists of approximately 1000 desktop PCs in 41 rooms at 30 sites. Prior to the deployment of PCs with Intel vPro technology, the PCs were powered up 24 hours a day to enable after-hours remote maintenance. Remote maintenance consists of asset management, hardware diagnosis, software diagnosis, and patching.

With the deployment of desktop PCs enabled with Intel vPro technology, systems are now powered off when not in use, but they can be woken up remotely for maintenance and can be ready when students arrive for a class. Intel estimates that by shutting down the systems when not in use, their projected savings will be 35 to 45 percent of IT training room PC energy consumption.

In 2006, Intel started a pilot program: it deployed 24 desktop PCs enabled with Intel vPro technology to one room. Based on the success of the pilot, Intel deployed 300 more of these PCs in 7 sites during 2007, replacing older equipment. The deployment of desktop PCs enabled with Intel vPro technology continues in 2009, with plans to deploy about 600 more in the training room environment.

Partially based on the success of our deployment of computers enabled with Intel vPro technology in IT training rooms, we have begun widespread Intel ME activation of desktop and notebook PCs enabled with Intel vPro technology throughout the enterprise.

Case Study 2: National Law School of India

The focus of this study was to observe the reactions, behaviors, and attitudes toward the Intel vPro technology solutions for power management. The research included semi-structured interviews across two cities in India. As one of the emerging markets with a strong economic growth and increasing adoption of IT solutions, India offers a great opportunity to understand the current experience of small and medium businesses in a managed, service-provider space. The Law School building was managed by two IT administrators maintaining 200 PCs. The Law School wanted to move the PC lab to the library, and the library was not in the same

building. The reason for the move was that the library was open until midnight whereas the Law School building was closed earlier in the evening. By moving the lab, IT administrators thought they would reduce the amount of electricity they would have to use in the Law Building by having to keep it open until midnight so that students could use the PC lab for longer hours.

The downside to the plan was that the IT administrators would then have to physically walk to the library to manage the PCs. So after trying different solutions such as streaming, the IT administrators chose Intel vPro technology so they could remotely control the PCs by using the Intel vPro technology management tool LANDesk*. This allowed them to shut systems down remotely and to wake them up in time for the students in the morning.

Summary

As energy costs and environmental concerns rise, IT professionals in many organizations want to increase energy efficiency, and they recognize that client PCs provide an opportunity to improve the cost structure of their departments. IT professionals are motivated by personal and professional reasons to conserve energy, but energy-saving solutions have to fit with other goals of the business, such as improving IT and end-user productivity. Computers enabled with Intel vPro technology provide an infrastructure that allows IT professionals to take practical steps to ensure energy efficiency, such as allowing greater control over power states during remote manageability. This technology also provides an infrastructure to allow the rest of the ecosystem to improve the monitoring of energy consumption. Intel is taking the initiative to provide its own testing of this technology in real-world applications, while understanding the challenges and successes of customers. Intel will continue to work with the ecosystem and customers to explore new ways to both monitor and improve the energy efficiency of client PCs.

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Authors' Biographies

Glen Anderson has worked in human factors engineering for 17 years and is the manager of the User Research Group. His interests include applied-research methodologies, mobile device design, online help systems, and patenting of user-oriented technology. Glen has a Ph.D. degree in human factors psychology from the University of South Dakota (1993).

Philip J. Corriveau has 20 years of video and research expertise and has worked at the Communications Research Centre, a Canadian Government Research and Development facility, and more recently at Intel Corporation investigating all aspects of user experience and video quality standards for Intel platforms. Phil holds a bachelor's of science honors degree from Carleton University in Ottawa, Canada (1990).

Doug DeVetter has 20 years of IT experience in software development, data architecture, technical program management, and IT research and development. Doug's recent work has focused on PC energy efficiency topics and solid state drives. Doug holds an M.B.A. from California State University, Hayward (1994).

Frank Engelman has 18 years of IT experience in IT research and development. Frank's recent work has focused on implementation of Intel® vPro™ technology both within Intel and for external companies. Frank holds an M.S.E.E. degree from California State University, Sacramento (1974).

Subhashini Ganapathy joined Intel in 2006 and works in the IT Security Application Services group. She currently conducts human-factors-related research for businesses and consumers in the User Experience Research Group. Her research interests include modeling human interactions on complex systems, decision making, information protection, and model-based information technology systems. Subhashini received her Ph.D. degree in human factors engineering from Wright State University, Dayton OH (2006).

Robert F. Reed has 15 years of networking and communication-standards experience in areas such as system design, manufacturing, strategic marketing, and architecture. Rob's recent work at Intel has focused on systems architecture and platform power innovation on Intel's future platforms with Intel vPro technology. Rob holds a bachelor's of engineering honors degree in electronics and communications engineering from Huddersfield University, England (1994).

Alan Ross is a principal engineer and lead enterprise architect for Intel's Information Technology division. Alan has led architecture development across several domains at Intel including data center, client, energy efficiency, and security, and he has driven industry development of technologies, standards, and products. He is currently focused on disruptive computing models, innovative form factors, and energy-efficient

architectural initiatives. Alan has 18 patents pending related to the security and manageability of systems and networks. Alan has a B.Sc. degree from Myers College (1998) and is CISSP-ISSAP certified by ISC2.

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