Chapter 1
Introduction

Personal computers (PCs) and the Internet have become an integral part of every day life in the home, office, and on the road. The ability to readily access the latest information has become a baseline user expectation. Meeting these expectations requires that the next generation of PC be instantly available to both the user and to communications applications. At the same time, the PC must become more efficient in its use of electricity as more computers come on-line with a limited supply of clean, inexpensive energy.

The Environmental Protection Agency's Energy Star office equipment labeling program motivates PC manufacturers to pay close attention to the energy consumption of their products while the products are in the Standby state. In the past, with BIOS-based power management techniques, power savings typically came at the expense of system stability, connectivity, and/or performance. Today's generation of power-managed PCs brings together many new technology ingredients that enable user expectations of power-efficient PCs to be met for the volume PC market. A power-managed architecture ensures that the PC gets all the power it requires for full performance when being used, yet aggressively manages devices that are not in use to consume less power.

The most challenging technical hurdle to overcome is achieving extremely low power consumption while maintaining connectivity. The overall goal of having the PC be instantly available while also maximizing energy savings requires the designer to make implementation tradeoffs.

Technological advances in computer hardware and software allow us today to design a low idle power and Instantly Available PC (IAPC). The IAPC appears to be off in that there is no noise from fans or disk drives, yet it snaps back to its fully ready state within seconds at the push of a button, or in response to the phone ringing for voice, fax, or answering machine applications. This technology is possible because most of the computer's components implement special low power modes that can be enabled by software. The new memory components define several power

savings modes, and a self-refresh feature makes it simple to preserve data with very little power.

To take full advantage of low power capabilities, industry standards had to be developed to define programming interfaces between software and hardware components. The specifications, such as Advanced Configuration and Power Interface (ACPI) and Peripheral Component Interconnect bus Power Management (PCI PM), were written to enable robust power management in today's PCs.

Today's operating systems support interfaces that take full advantage of power management capabilities by disabling devices that are not being used by the computer system. The new industry standards allow many companies to design new peripheral devices and special software to enable power management.

Enabling standardized power management capabilities for all computers is the goal, and it requires development of new power-aware peripherals and new PC architectures to support low power modes.

This book describes the platform integration of new power management technologies that deliver on the user expectation of instant availability regardless of the system's power management state. The objective is to give the reader detailed information about the hardware and software technology ingredients required to build a power-efficient PC.

Note that the integration of the technologies described in this book delivers a baseline set of platform power management capabilities that can be applied to all classes of computers including desktop PCs, mobile computers, workstations, and servers.

Operating System Directed Power Management

Operating System Directed Power Management (OSPM) is a model for power (and system) management in which the operating system (OS) plays the central role using global information only it possesses to optimize the system's behavior. The key advantage of OSPM over BIOS-based power management is that it offers system-wide visibility where all elements of the system operate as an integrated, power-managed whole according to defined roles, responsibilities, and standard interfaces. Standards-based communication between the OS, hardware, and

applications lets the operating system use its knowledge of application workloads for robust platform power management unachievable in systems using the earlier Advanced Power Management (APM) standard.

The centerpiece of OSPM is the Advanced Configuration and Power Interface Specification, which defines a standard set of interfaces for hardware and applications to communicate power control capabilities and requirements to the operating system. An ACPI-enabled operating system binds all power-managed elements in the system, establishing an intelligent platform-wide power management solution. Intel, Microsoft and Toshiba originally developed the ACPI specification, and were joined by Compaq and Phoenix for Version 2.0 released in July 2000.

Benefits of Instantly Available PCs

Intel developed a prototype system for technology demonstration, and started the Instantly Available PC initiative, to demonstrate new power management technology based on the ACPI specification. The end user benefits of the Instantly Available PC manifest themselves differently depending upon the PC's usage. The two main usage models are the office desktop PC and the home PC.

Office Desktop PC

PCs incorporate management capabilities to reduce cost of ownership. Being able to manage a PC's software inventory from across the network is one example of how the cost of ownership can be reduced. Today's manageable PCs have a special mode where they can be remotely rebooted to a manageable state from which, for example, new software can be installed, diagnostics run, etc.

The Instantly Available PC architecture takes these manageability capabilities to the next level, yet because the computer activates when required from a sleeping state, the idle energy consumption stays at the same low levels. Architectural improvements include:

- Replacing the boot process with a resume process.
- Keeping the PC completely connected to the network.

The goal for power-managed office PCs—desktops and eventually servers—is that rather than rebooting the PC, network traffic (or programmed events) of interest cause the PC to resume to precisely the

same system state it was in before entering a sleeping state. Intelligent pattern filtering allows the network connection to remain active for programmed access out onto the net as well as for incoming network traffic, enabling file sharing, print server, and web server applications to function even when the PC is "off."

Home PC

The home PC, whether a traditional desktop PC or a high-end multimedia PC, benefits by taking on many of the attributes of consumer electronic devices already present in the home. Instantly available operation conforms to the user's expectations created by consumer devices such as televisions and telephones. Architectural improvements for modems let computers capture otherwise-lost Caller-ID information and support new telephony applications. The improvements also eliminate the lengthy boot-up process by providing always-on broadband connections to let users access the Internet at their whim.

Architecture and System Overview

The ACPI power management architecture is defined by widely adopted industry standards, but taking full advantage of ACPI power management architecture requires standards-compliant hardware and software. ACPI power-managed components implement these key specifications:

- *Advanced Configuration and Power Interface 2.0*–describes how the operating system interfaces to the hardware on the motherboard and defines the operation of the BIOS in support of power management.
- ACPI Device Class specifications–describe how to classify and power-manage system devices.
- *PCI 2.2 Specification*–specifies pins needed to support wake events.
- *PCI PM Rev. 1.1*–describes registers needed to enable PCI peripheral power management capabilities.
- Intel's Instantly Available PC Power Delivery specifications and recommendation–describes new power delivery requirements.
- Microsoft's On Now white papers–describe key requirements for writing new 32-bit drivers.

The power-managed components implementing these specifications and recommendations are:

- ACPI operating system.
- ACPI enabled processor and chipset components.
- ACPI enabled BIOS.
- Motherboard incorporating power delivery circuits capable of providing either operating or standby power to selected parts of the system.
- Dual mode power supply with additional standby power capabilities.
- Power managed PCI add-in cards.
- Power managed PCI communication cards supporting wake up.
- Power managed external peripheral devices (IEEE USB, 1394).
- Drivers properly supporting power management.
- Applications supporting power management.

Systems incorporating all the required hardware and software capabilities reduce the power draw of a sleeping PC to levels no higher than televisions or VCRs, are quiet when idle, and replace lengthy system boots with resumes taking no more than five seconds. This book covers all these areas, including the special considerations you must address to properly implement power management.