TOSHIBA

Advanced Configuration and Power Interface Specification

White Paper

Introduction

The Advanced Configuration and Power Interface (ACPI) is a new interface to the system board enabling a PC to automatically turn on and off:

- ❖ Motherboard devices such as CD-ROMs, hard disk drives, displays and modems using technology such as OnNow.
- ❖ Consumer devices connected to the PC such as VCRs, TVs, phones and stereos.

ACPI facilitates the transmission of commands from these peripherals and devices to activate the PC when it is in a low-power sleep mode. For example, moving a mouse can wake up the system and turn on the monitor.

ACPI is an essential part of Operating System Directed Power Management (OSPM), which allows system designers to implement power management features using a standard operating system drivers instead of individual BIOS (Basic Input Output System) programs.

ACPI transfers control of the Plug and Play feature from the BIOS to the operating system, making Plug and Play more flexible and robust.

What is Toshiba’s contribution to ACPI?

Co-development with Intel and Microsoft

At WinHEC 96, the Microsoft-sponsored Windows Hardware Conference, Microsoft, Intel and Toshiba announced their intention to solicit broad industry participation in shaping the Advanced Configuration and Power Interface (ACPI) specification.

ACPI initiative goals

The principal goals of the ACPI specification are to:

- ❖ Enable all PCs—whether mobile, desktop, workstation or server—to implement configuration and power management functions using the operating system.
- ❖ Enhance power management functionality and dependability by unifying the control in the operating system, thus improving reliability.
- ❖ Facilitate and accelerate industry-wide implementation of power management, thus allowing all ACPI-compatible machines and hardware to gain the benefits of operating system improvements and innovations.
- ❖ Create a robust interface for configuring motherboard devices, allowing new advanced designs.

What are the co-developers doing?

Microsoft is integrating ACPI into Windows NT Version 5.0 (bringing Plug and Play and power management to Windows NT) as well as Windows 98. ACPI is the foundation of the Microsoft OnNow initiative. The OnNow PC platform will be:

- Ready for use immediately when the user presses the On button.
- Perceived to be off when not in use but still capable of being activated by events, such as a phone ringing or a software request for the PC to wake up at a predetermined time.
- Able to coordinate the operating system and software, adjusting their behavior when the PC's power state changes in accordance with the user's current needs and expectations.

Intel will include ACPI on its chipsets and desktop motherboards.

What does ACPI do?

ACPI enables the operating system to respond to events and manage the power for all parts of the system and all connected devices. The ACPI specification covers the following specific functions:

System Power Management

Using the features of the ACPI specification, the operating system manages the power states of the computer and all motherboard devices. It turns off devices that are not being used. When the operating system determines from applications and user settings that no part of the system is being used, it puts the entire system into a low-power sleep state.

Device Power Management

The ACPI enables the operating system to put idle devices into low-power states. To do this, the operating system calls on the descriptions for motherboard devices, their power states, the power planes the devices are connected to and the controls for putting devices into different power states stored in the ACPI tables.

Processor power management

When the operating system is idle, ACPI allows the operating system to put the CPU into one of the low-power states. In these low-power states, the CPU does not run any instructions, but it wakes up when it receives a signal from one of the applications or devices on the system.

Plug and Play

ACPI provides controls and information so that the operating system can direct Plug and Play devices. The ACPI description table includes information on the hardware resources each device needs and those that are currently in use. Plug and Play uses this information to dynamically configure resources to support each device. Using the ACPI to manage resource configuration is more efficient than the current management system.

System events

ACPI's event mechanism monitors and responds to system events, such as an overheated component, changes in the power management and device insertion or removal.

Battery management

With ACPI, the operating system determines the low battery and battery warning points. It also calculates the remaining battery capacity and life of the battery. An ACPI-compatible battery needs either a Smart Battery subsystem interface, which is controlled by the operating system directly, or a Control Method Battery (CMBatt) interface.

Thermal management

Since the operating system controls the power states of devices and processors, ACPI also monitors and responds to the thermal conditions of the system. ACPI provides a simple, scalable model that allows system manufacturers to define thermal zones, thermal indicators, and methods for cooling thermal zones. The operating system uses both passive cooling methods, such as reducing the power consumption of the processor, and active cooling, such as turning on a fan.

Embedded controller and system management controller

The definition of standard hardware and software communication interfaces with the operating system and the controllers, and enables proprietary system features from manufacturers to be more closely integrated into the operating system and applications.

How does ACPI work?

Scope of ACPI specification

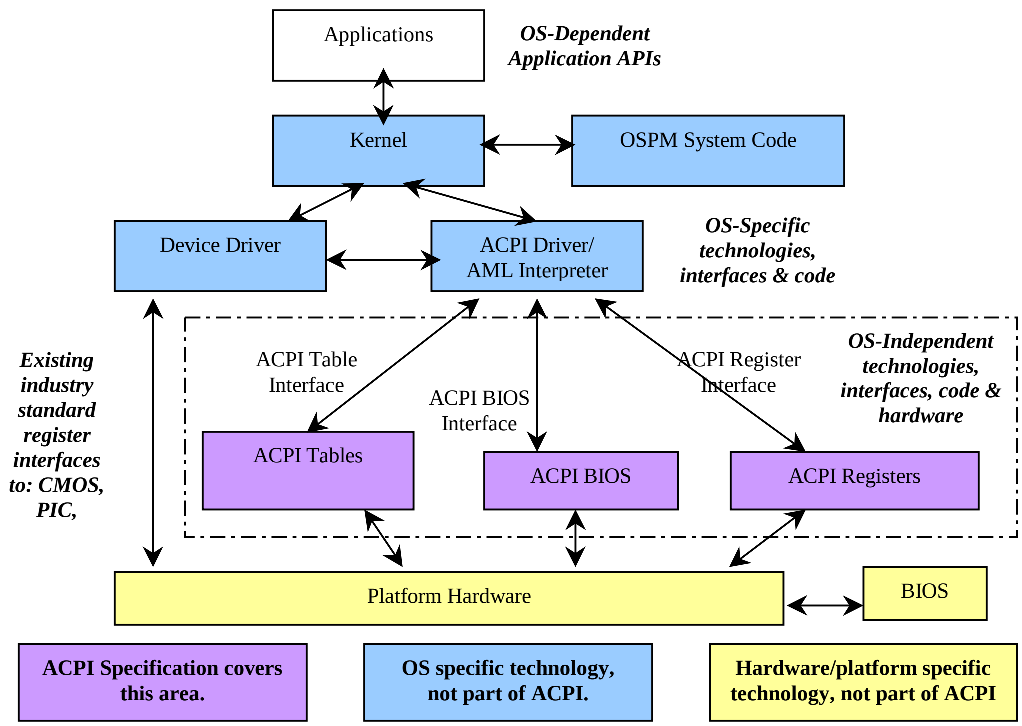
Unlike the Plug and Play and Advanced Power Management specifications, ACPI is not a library of BIOS routines.

The ACPI specification defines an interface, which uses a combination of fixed hardware registers to report information about the hardware. The specification includes definitions of the methods by which ACPI controls the devices.

ACPI relationships

The following diagram shows how the applications (software) relate to the hardware (chipsets and the motherboard). The operating system, along with its various components, stands between the applications and ACPI. The operating system no longer communicates indirectly with the hardware via the BIOS. Instead, it communicates through ACPI, which is the interface between the operating system and the hardware. Because ACPI stores descriptions of the proprietary hardware and proprietary enhancements in tables that are separate from the operating system, the interface can address the hardware directly, without going through the system BIOS.

System information is stored in the ACPI Hardware Registers, ACPI BIOS and ACPI Tables.



ACPI Tables

These tables describe the specific platform's hardware. Since ACPI is an interface between the operating system and the hardware, the operating system can avoid involvement with the system BIOS. Thus, manufacturers can include proprietary hardware enhancements while maintaining cross-platform compatibility with configuration (Plug and Play) and power management features. These tables are important because this is where the information necessary to control and configure Plug and Play and Power Management is stored.

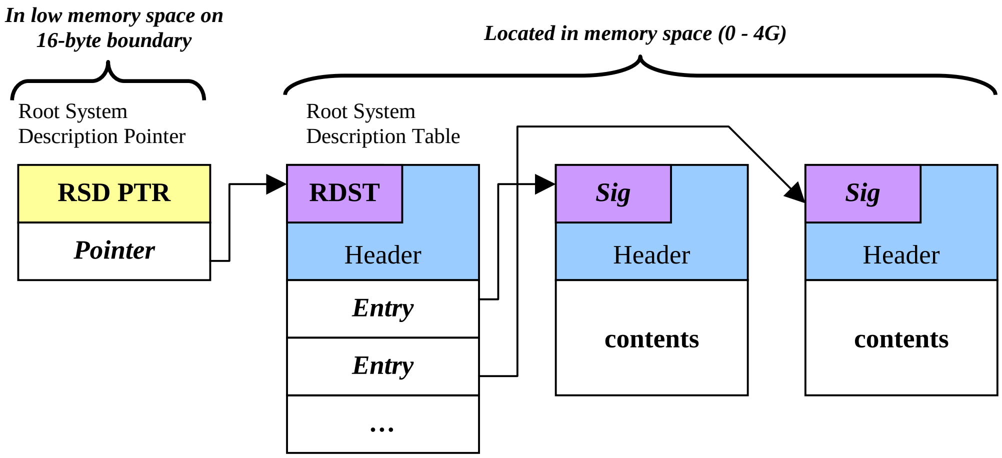
ACPI Hardware Registers

This part of ACPI contains the registers for events, controls, the timer, processor control registers and general purpose events. There are fixed registers that provide cross-platform features available to all computer systems. Using the generic programming model, manufacturers can assign other registers to proprietary enhancements. The location of these registers is reported in the BIOS tables.

TOSHIBA

ACPI BIOS

To allow cross-platform configuration and power management features while providing manufacturers with the ability to make specific proprietary enhancements, the system BIOS sets up a system of pointers containing addresses to information stored in the ACPI tables. The BIOS also supplies the operating system with information about the hardware.



Description Header Signatures

One of the benefits of industry-wide acceptance of the ACPI specification as a standard is consistency in the design of the tables that store hardware information. Use of standard table designs allows many support functions to be automated. The ACPI tables store information about the platform hardware and connected devices as well as pointers to proprietary enhancements.

Control methods

ACPI stores information in the BIOS tables that tell the operating system how to access and control the hardware. Manufacturers can use ASL, a pseudo-code scripting language defined in the ACPI specification, to tell the operating system (via ACPI) what to do when a particular system event such as overheating occurs. This feature is very powerful and can be used to control every device connected to the system in a variety of ways.

System events

ACPI defines two event registers: the event status register and the event-enable register. Manufacturers can use these registers to control proprietary events in very specific ways. The general events in the specifications cover:

- Thermal events
- Power management events
- Docking
- Device insertion and removal

Power state terminology

The power management features include a greater variety of states for the entire system, devices and the processor.

G0–Working:

In this state, the computer is fully on and responds to external events in real time. The system dynamically manages the power states of peripheral devices. The user can choose between maximum performance or minimum battery power through a user interface. It is not safe to take the computer apart in this state.

G1–Sleeping:

In this state, the computer consumes a small amount of power, but since the monitor or display is off, the computer appears to the user to be off. Depending upon the wake-up options selected prior to the sleeping state (such as a telephone ringing), the system can return to the working state quicker than when it is in the "soft off" state. The user can return to work quickly because the operating system does not have to be restarted. The hardware saves a large portion of the current settings of the system and the system software saves the rest. It is not safe to take the computer apart in this state.

G2/S5–Soft Off:

In this state, the computer uses a small amount of power. No user or system code is being run. The system takes a long time to return to the working state because it must be restarted. The hardware does not retain the current settings of the system. It is not safe to take the computer apart in this state.

G3–Mechanical Off:

The computer enters and leaves this state by mechanical means, such as turning off the system's power by pressing a button. In this state, as required by various government agencies, no electrical current is running through the circuits. Service personnel can work on the system without damaging the hardware or endangering themselves. Except for the real-time clock, power consumption is zero.

S4–Non-Volatile Sleep:

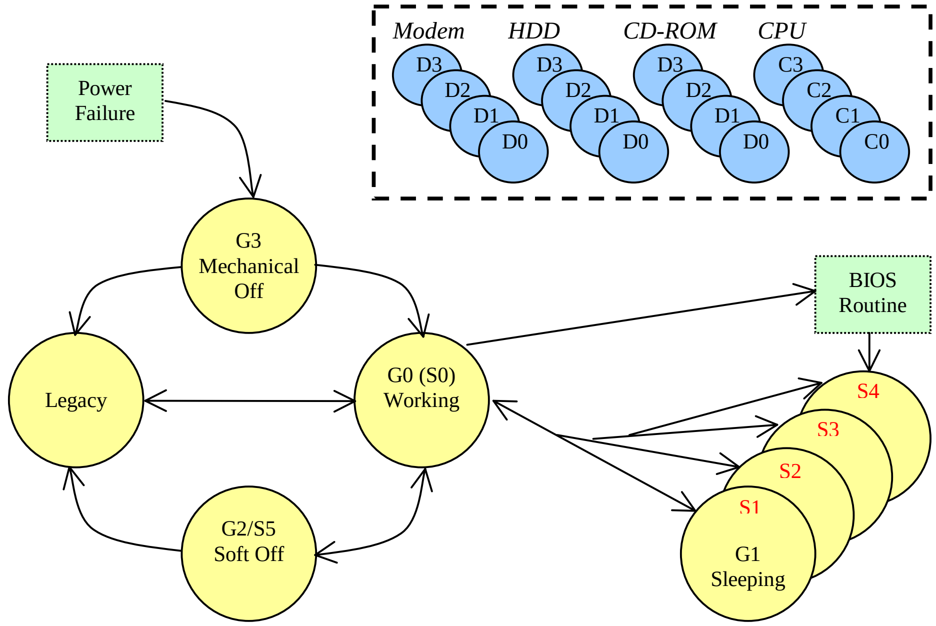
This is a special global system state that allows the current settings of the system to be saved and restored (relatively slowly) when power is lost to the motherboard. When the system is commanded to enter non-volatile sleep, the operating system writes the system settings to a non-volatile storage file, such as a hard disk, and leaves appropriate context markers for it to use when it is reactivated. Restoring the system from non-volatile sleep looks to the user like returning from the sleeping state (albeit more slowly). In order for the system to use the information about the system settings, certain aspects of the machine configuration must not change. These include, but are not limited to, disk layout and memory size.

Because the non-volatile sleep state relies only on non-volatile storage, a machine can save the system settings for a relatively long period of time (many years).

Global System State	Software Runs?	Latency?	Power Consumption?	OS Restart Required?	Exit State Electronically?
G0 – Working	Yes	0	High	No	Yes
G1 – Sleeping	No	0 (varies w/sleep state)	Lower	No	Yes
G2/S5 – Soft Off	No	Long	Very near 0	Yes	Yes
G3 – Mechanical Off	No	Long	RTC Battery	Yes	No

Generally, computers alternate between working and sleeping states. In the working state, software applications are running. Processors and individual devices can be in low-power states when not being used. Any device the system turns off because it is not actively in use can be turned back on after a short wait period (less than a few minutes).

When the computer is idle, the operating system puts the computer into one of the sleeping states. While the computer is in a sleep state, it appears to be off. The four sleep sub-states allow different events to wake the system and return it to a working state. ACPI differentiates between the various requests, thus saving power and time.



Device states

Device states apply to particular devices. These states may or may not be visible to the user. For example, some devices may be off even though the system is in a working state. Various devices have separate Device Class Power Management Specifications. The following table defines the different device states.

Device State	Power Consumption	Device Context Retained	Driver Restoration
D0 – Fully On	As needed for operation	All	None
D1	D0, D1, D2, D3	D2	D2
D2	D0, D1, D2, D3	D1	D1
D3 – Off	0	None	Full init. and load

D0–Fully On:

This is the highest level of power consumption. The device is completely active and responsive, and is expected to remember all relevant settings.

D1:

The characteristics of this state are defined by each class of device, but some classes may not define it. In general, D1 is expected to save less power and preserve more device settings than D2.

D2:

The characteristics of this state are defined by each class of device, but some classes may not define it. In general, D2 is expected to save less power and preserve more device settings than D3. Reducing the power on busses in D2 may force the device to turn off some of its functions.

D3–Off:

Power has been fully removed from the device. The device settings are lost. When the operating system turns the device on again, it reinitializes the device.

What does ACPI compatibility require?

An OSPM/ACPI-compatible system

The minimum requirements for an OSPM/ACPI-compatible system are:

- A power-management timer
- A power or sleep button
- A real time clock wakeup alarm
- Implementation of at least one sleep state
- System Control Interrupts generated by interrupt events
- A Description Table provided in firmware
- A user-accessible fail-safe mechanism to either unconditionally reset or turn off the machine

Web Sites with ACPI Technology Information

ACPI homepage

http://www.teleport.com/~acpi

Press notices

http://www.teleport.com/~acpi/press.htm

http://www.intellitech-media.com:80/cee-var-news/issues/en/row/9701/970112-qc2.htm

http://www.winmag.com/people/melgan/future.htm

Microsoft support

http://www.winntmag.com/news/nt50list.html

http://www.it.pw.edu.pl/PL-iso/newspapers/winnews/v3n11.html#A4

http://www.microsoft.com...:80/hwdev/pcfuture/acpifaq2.HTM