CardBay — Next generation of PC card standard

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Abstract

PC card technology has been widely adopted by the personal computer industry, ranging from high performance PCs to notebook computers to ultra-portable specialized-function devices, such as palmtops, pen computers and other embedded application hosts. The PC card family includes 16-bit PCMCIA cards to serve the needs of modest-performance and older "legacy" PC card application, as well as the PCI-like 32-bit CardBus to satisfy the most demanding of today's computing add-in needs.

Today, CardBus provides the ideal add-in solution in PCI-based systems. As a "hot-pluggable PCI", CardBus has become a tightly integrated extension of the host system. The high performance (up to 132 Mb/sec), low voltage and PCI-like power management capabilities of CardBus make it well suited for use in mobile systems.

Next generation PC card standards, however, need to support a growing array of applications. CardBay, developed through PCMCIA, is the new interface for next generation PC card standards. In addition to being backward compatible with 16-bit PCMCIA cards and 32 bit CardBus cards, the CardBay PC card standard incorporates the popular Universal Serial Bus (USB) into the PC card format widely embraced by today's mobile device developers. Also some proposals are under development recently in PCMCIA to supports today's emerging popularity of media cards such as the Smart Media card, Multi Media Card, Secure Digital memory card, Memory Stick, Smart Card through the standard PC Card slot.

This paper will review the CardBay standard and its further development for future applications.

PC Card standards Background

In 1985, the standardizing activity of PC card technology began with the Japan Electronic Industry Development Association (JEIDA). The organization was formed to promote memory cards, personal computers and other portable information products. The Personal Computer Memory Card International Association (PCMCIA) was founded in 1989 by a small group of companies that wanted to standardize memory cards for the classic reasons behind standardization - multiple sources, lower and shared risks, and larger markets.

PCMCIA in association with JEIDA has worldwide support from more than 500 member companies for its PC card and represents the culmination of various improvements to earlier releases of memory and I/O cards for PCs. The PC card standard encompasses both 16-bit PCMCIA cards and 32-bit CardBus cards. This ensures backward compatibility in the PC card specification.

From the physical specification aspect, the PC Card standard defines a 68-pin interface between the peripheral card and the PC card socket into which it gets inserted. It also defines three standard PC card sizes, called Type I, Type II, and Type III. The difference between Type I, II, and III cards are the mechanical dimensions of the PC Card. All PC Cards measure the same length and width, roughly the size of a credit card. Where they differ is in thickness. Type I, the smallest form factor, often used for memory cards, measures 3.3mm in thickness. Type II, available for those peripherals requiring taller components such as LAN cards and modems, measures 5mm thick. Type III is the tallest form factor and measures 10.5 mm thick. Type III PC Cards can support small rotating disks and other tall components. Whereas, the electrical specification defines three basic classes of PC card: 16-bit PCMCIA cards, 32-bit CardBus PC cards, and newly defined CardBay PC cards. Defined are characteristics of each interface including power, signaling, configuration, and timing requirements.

CardBay Introductions

CardBay is the next generation PC Card Standard that is in work by the PCMCIA organization, expected to release in PC card standard ver:8.0.

The new CardBay PC Card standard incorporates the popular Universal Serial Bus (USB) into the PC Card format as the migration path for the most popular add-in card solutions. Just like CardBus and the original 16-bit PC Card standards, CardBay enables plug-in functions to become tightly integrated within a mobile device, such as a notebook computer or PDA.

CardBay standard complements the existing PCI-based PC card technology by allowing the same connector to bring the popular USB serial interface into the PC card form factor. CardBay essentially substitutes USB for the existing PC card interface while retaining the CardBus physical connector and

PC card format with USB specification supported. Potential uses of CardBay include USB-based advanced wired and wireless modems; security devices for fast secure encryption/decryption and authentication; and bulk memory devices, such as USB-based memory card-to-PC adapters for video cameras and media players.

The desktop industry trends are growing towards lower and lower profiles, and are currently looking at the PC Card form factor for future adoption. CardBay uses will fall right in line with consumer desktop needs at home, as well as commercial uses at work. CardBay is also seen as the next enhancement for mobile markets and will reside along with the current 16 bit PCMCIA card and 32-bit CardBus card technologies.

The goals of CardBay technology announced are as follows:

- Retain ease of use and operating system plug and play capabilities
- Opens up a whole new market for USB-based product in mobile devices.
- Maintain backward electrical and form-factor compatibility with 32 bits CardBus and 16 bit PC card technology
- Provide a growth path for PC Card technology
- Provide for easily porting desktop technology implementations to mobile PC card implementation.
- Open up doors for PC Card uses in the desktop environment
- Build on the software and power management base of USB specification.

Further development of CardBay

From an applications viewpoint, a CardBay PC card may prove useful for a wide range of solutions. Communications and networking products, especially those already embracing USB as a host interface, will benefit from the simplicity and ease-of-use of the CardBay solution. Possible communications and networking CardBay examples include analog data modems, IEEE 802.11 wireless LAN, Bluetooth wireless PAN, and GPRS wireless WAN. Small format memory card adapters using CardBay will be a natural solution for notebook PCs as a migration from the existing USB memory card adapter units finding popularity in the consumer desktop PC Market. Possible memory card technologies that would benefit from this solution include SmartMedia, MultiMediaCard (MMC), Secure Digital (SD) memory card and Memory Stick. Smart Cards readers and a number of other security-related technologies can also operate on USB, again another opportunity to mobilize the technology using CardBay. Essentially all of these applications are technically available today and the adaptation of them to the CardBay solution is a relatively easy step that will be mostly driven by the availability of CardBay-enabled host platforms.

Further development of the PC card standard is intended to accommodate today's market needs and demands for memory cards as well as accept the various media cards out in the market today. Finally, further development of CardBay specification addresses the hot topic of security concerns that have recently evolved.

Media cards are typically used with consumer electronics and are seeing a need for interfaces into desktop and mobile computers for video editing and various other needs. One current PCMCIA proposal defines a common socket and interface to accommodate all of these various media cards out in today and tomorrow's marketplace.

Below introductions gives a brief overview of the different media cards whose interfaces are currently included in proposal 262 in development by the PCMCIA organization.

Smart Media

Formerly called SSFDC (Solid State Floppy Disk Card), SmartMedia Cards are about 1/3 the area of a standard PC Card and only 0.76 mm in thickness. The specifications for SmartMedia Cards are governed by the SSFDC Forum. There are two basic types of SmartMedia cards, flash memory cards and mask ROM cards. The majority of SmartMedia cards use an embedded NAND type flash memory and are based on the package = card concept. This allows the cards to be very thin, and does not require a controller to be included on the SmartMedia card.

Almost all SmartMedia cards are 3.3V cards, but there are also 5V versions of the 1, 2, and 4 MByte flash memory based cards. Additionally, all SmartMedia cards have a 22-pin, 8-bit interface. The recommended logical format of SmartMedia cards is based on the DOS/FAT format. SmartMedia cards are currently used in many types of consumer electronic devices and can even be incorporated in postcards that can then be accessed by a special reader. The most popular applications are in digital cameras and portable music players. It can also be used in equipment that requires a removable memory chip for portability, version upgrades or memory upgrades for applications.

MultiMediaCard (MMC)

The MultiMediaCard is a flash memory card about the size of a postage stamp and 1.4 mm in thickness The specification for MMC is governed by the MultiMediaCard Association (MMCA). The interface for MMC cards is based on a 7-pin serial bus. The MultiMediaCard System Specification defines a communication protocol for MMC cards, referred to as MultiMediaCard mode. In addition, all MMC cards will work in the alternate SPI mode. The SPI mode allows a microcontroller to interface directly to the MMC card, but at the cost of slower performance.

The voltage range for communication with MMC cards is 2.0 to 3.6 V, and the memory access voltage range is a card specific subrange of the communication voltage range. Like SmartMedia cards, MMC cards can be read-only or read/write; however, MMC cards can also have I/O functionality.

MMC cards are designed to be used in either a stand alone implementation or in a system with other MMC cards. When in the MultiMediaCard mode, the bus protocol can address up to 64k cards, with up to 30 cards on a single physical bus. However, the maximum data rate is only available with up to 10 MMC cards on the bus. In order to accommodate such a wide variety of system implementations, the MMC clock rate can be varied from 0 to 20 MHz. Proposal 262 will support one MMC card per PC card socket.

MMC cards, like SmartMedia cards, are also used in many types of consumer electronic devices. Because of their small size, they are primarily used in portable music players and phones.

Secure Digital (SD)

SD cards are the same size as MMC cards, except for the thickness, which at 2.1 mm is slightly thicker than an MMC card. SD cards are based upon MMC cards, with the addition of two pins. The use of these two pins and a reserved pin on MMC cards allows the data bus on SD cards to be up to four bits wide instead of the one-bit width of the MMC data bus. Like MMC, SD cards can communicate in either SD mode or SPI mode.

The voltage range for basic communication with SD cards is 2.0 to 3.6 V, and the voltage range for other commands and

memory access is 2.7 to 3.6 V. SD cards can be read-only or read/write.

SD is essentially a superset of MMC, in that MMC cards will work in SD systems, but SD cards will not work in current MMC systems. Unlike MMC, each SD card in a system must have a dedicated bus. One of the primary benefits of SD cards is the added security that they provide. SD cards comply with the highest security of SDMI (Secure Digital Music Initiative), have built-in write protect features, and include a mechanical write protect switch.

SD cards are used in many of the same devices as MMC cards. The additional security features of the SD cards also allow their use in more secure applications or in devices where content protection is essential.

Memory Stick

Memory Stick cards are about the size of a stick of gum and are 2.8 mm thick. Developed by Sony, Memory Stick cards have a 10-pin interface of which three pins are used for serial communication and two pins are reserved for future use. Each card also includes an erasure-prevention switch to protect data stored on the card.

The voltage range for Memory Stick cards is 2.7 to 3.6 V, and the clock speed can be up to 20 MHz. Memory Stick cards use the FAT file system to allow for easy communication with PC's.

There are two types of Memory Stick cards, the standard Memory Stick and the MagicGate Memory Stick. MagicGate technology provides security to Memory Stick cards so that they can be used to store and protect copyrighted data.

The concept behind Memory Stick is easy to grasp. It's a temporary storage space for pictures, music, words, sounds, movies, ideas, photographs, or anything else that can be converted into digital data. It's compact enough to be carried anywhere, simple enough to be used by anyone, of any age, at any time, and versatile enough to be used with practically any digital product, for almost any digital application.

Smart Card

Smart Cards, also called Integrated Circuit Cards or ICC's, are the same size as a credit card, and it has an electronic microchip embedded in it. The chip stores electronic data and programs that are protected by advanced security features. Smart Cards can either have contacts or be contactless. In addition, there are both asynchronous and synchronous versions of Smart Cards with contacts. The size of the card is determined by the international standard (ISO 7810). The ISO 7816 standard also defines the physical characteristics of the plastic, including the temperature range and flexibility, position of the electrical contacts and how the microchip communicates with the outside world.

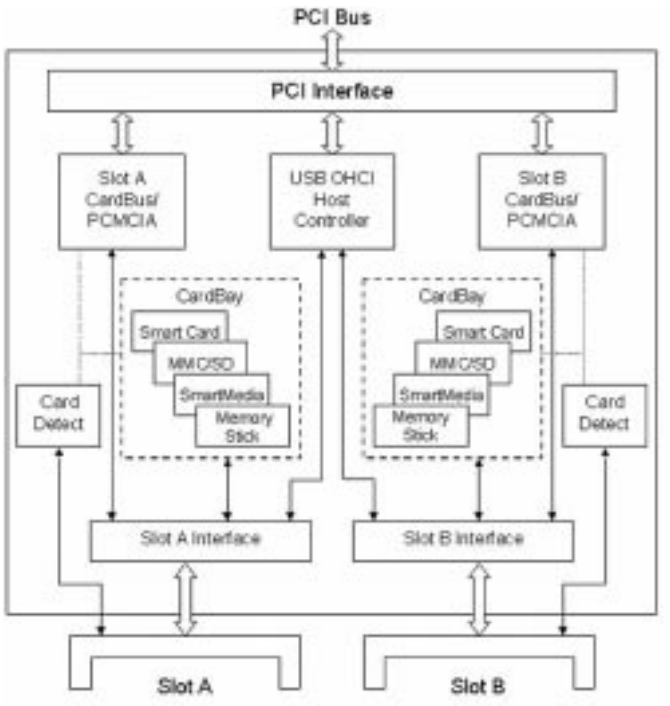
There are two types of smart cards:

A contact-based smart card requires direct contact with the reading device in order to read and process the data.

A contactless smart card transfers data to a reading device over a magnetic field, thereby not requiring direct contact with the reading device.

Smart Cards contain eight contacts, however two of the contacts are reserved for future use and are not included in the proposal 262 PC card interface. Smart Cards can be either 5V or 3V cards; however, all 3V cards are designed to also work at 5V. The primary use of Smart Cards is in security related applications. They are also used in credit cards, debit systems, and identification systems.

Below is the block diagram of proposal 262 PC card H/W structure as well as the media specification comparison.



Media specification Comparison

Media Card	Size (mm)	Pin Count	Max Security Level	Read Speed	Licensing Organization
SmartMedia	45 * 37 * 0.76	22	SDMI 1	12.5 MB/s	SSFDC Forum
MMC	32 * 24 * 1.4	7	SDMI 1	2.5 MB/s	MMCA
SD	32 * 24 * 2.1	9	SDMI 1 & 2	10 MB/s	SD Association
Memory Stick	21.5 * 50 * 2.8	10	SDMI 1 & 2	2.45 MB/s	Sony
CompactFlash	36.4 * 42.8 * 2.8	50	SMDI 1	10 MB/s	SanDisk

Conclusion

PC card technology is used in a wide variety of products including notebook computers, sub-notebook computers, palmtop computers, pen computers, desktop computers, cameras, DLP projector, printers, E-books, television set-top boxes and other embedded application hosts. And with new CardBay and further development of the PC card specification released, PC card technology will be pushed even further to new emerging applications. The future will also see the PC card interface evolve to include higher speed serial buses to support high speed networking, video and other applications. Any applications that require a small, portable and rugged industry standard interface to a system bus will find PC card technology and the PC card standard suitable to their needs.

References

- PC card standard
- PCMCIA Proposal number 0215, 0262

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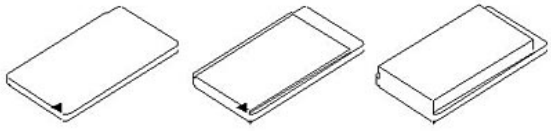
Agenda

PC Card Standard Background
How CardBay got started
CardBay Introduction
Implementation Element
Future Development of CardBay

The Beginnings of PCMCIA

- 1985 - Japanese Electronics Industry Development Association(JEIDA) begins working on memory card standardization issues
- 1989 - PCMCIA adopted the JEIDA 68 pin connector
- 1990 - PC card Release 1.0, memory only
- 1991 - PC card Release 2.0, Memory and I/O
- 1995 - PC card Release 5.0, Memory, I/O, and 32 bit Cardbus
- 1998 - PC card Release 6.0, CardBus Power Management
- 2001 - PC card Release 8.0, CardBay and Further Development

Type I, II, and III PC Card Comparison



TYPE I TYPE II TYPE III

	Length	Width	Height	
			Interconnect Area	Substrate Area
Type I	85.6mm	54.0mm	3.3mm	3.3mm
Type II	85.6mm	54.0mm	3.3mm	5mm
Type III	85.6mm	54.0mm	3.3mm	10.5mm

PC Card Interface Functionality

- **PCMCIA/16-bit**
  - ISA 8- and 16- bit interface functionality
  - Zoomed Video Support
  - 5V and 3.3V support
- **CardBus**
  - 32-bit PCI cards with PCI performance
  - 3.3V support only
- **CardBay**
  - USB serial interface, 1.8v core
- **Further Development of CardBay/Proposal 262**
  - SmartMedia, SD, MMC, Memory Stick, and SmartCard interfaces

In the beginning of CardBay

- **1997: PCMCIA P 215, Compaq**
  - Originally called Card-X
  - Proposed addition of new I/O types
  - USB, 1394, ZV, SMBUS
  - Alignment with future platform I/O

Recent Developments, p215

- **Proposal 215**
  - Reduced functionality to only USB
  - Reserves signals to add 1394
  - Card-X name was dropped
- **CardBay was the name given to the new interface specified in PC Card v8.0**

What is CardBay ?

- **"Next Generation" PC card Standard**
  - 16-bit PCMCIA Card
  - 32-bit CardBus Card
  - CardBay! ... a new type of Card
- **CardBay adds USB to PC Cards**

CardBay Card Applications

- **Wireless communications**
  - **Bluetooth, Home RF**
  - **802.11 and/or HIPERLAN2**
  - **Wireless modems**

CardBay Goals

- **Maintain backward form-factor and electrical compatibility with 16-bit PC Card and 32-bit Cardbus card**
- **Provide a growth path for PC Card technology**
- **Minimize power requirements**
- **Retain ease of use and OS plug and play capabilities**
- **Utilize software and power mgmt based USB**
- **Lower cost of interfacing flash media and SmartCards**

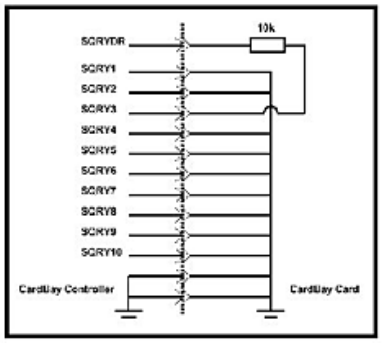
Card Detection Scheme

Adopted in PC Card v8.0

CD2#/CCD2# (pin 67)	CD1#/CCD1# (pin 36)	VS2/RFU (pin 57)	VS1/RFU (pin 40)	Card Type			
				Key	Interface	V_{cc} Voltage	V_{PP} Voltage
ground	ground	open	open	5 V	16-bit PC Card	5 V	per DS
ground	ground	open	ground	5 V	16-bit PC Card	5 V and 3.3 V	per DS
ground	ground	ground	ground	5 V	16-bit PC Card	5 V, 3.3 V and X.X V	per DS
ground	ground	open	ground	LV	16-bit PC Card	3.3 V	per DS
ground	connect to CVS1	open	connect to CCD1#	LV	CardBus PC Card	3.3 V	per DS
ground	ground	ground	ground	LV	16-bit PC Card	3.3 V and X.X V	per DS
connect to CVS2	ground	connect to CCD2#	ground	LV	CardBus PC Card	3.3 V and X.X V	per DS
connect to CVS1	ground	ground	connect to CCD2#	LV	CardBus PC Card	3.3 V, X.X V and Y.Y V	per DS
ground	ground	ground	open	LV	16-bit PC Card	X.X V	per DS
connect to CVS2	ground	connect to CCD2#	open	LV	CardBus PC Card	3.3 V	1.8 V (Vccor)
ground	connect to CVS2	connect to CCD1#	open	LV	CardBus PC Card	X.X V and Y.Y V	per DS
connect to CVS1	ground	open	connect to CCD2#	LV	CardBus PC Card	Y.Y V	per DS
ground	connect to CVS1	ground	connect to CCD1#	LV	CardBay PC Card	per CardBay query	
ground	connect to CVS2	connect to CCD1#	ground	reserved			

CardBay Query Scheme

- Process determines power requirements
- Controller drives SQRYDR driver and reads parallel inputs SQRY[10::0]



SQRY 7-10 are reserved

SQRY6	SQRY5	SQRY4	SQRY3	Definition
0	0	0	0	USB Interface
Other Combinations				Reserved

SQRY2	SQRY1	Definition
0	0	Vcc = 3.3V, Vpp/Vcore = 1.8V
0	1	Vcc = 5V, Vpp/Vcore = 3.3V
1	0	Reserved
1	1	Reserved

Implementation Elements

For USB CardBay Cards

- **Power Management**
  - Should report "self-powered" to USB
  - Wake should be implemented using standard USB signaling. Sideband signals should not be used to initiate wake from a CardBay card
- **No External USB Ports**
  - USB CardBay applications cannot provide external USB ports!
  - Power management and boot issues
- **USB 2.0**
  - Don't count on it from the host controller

Implementation Elements
For CardBay Controllers

- Enabling USB to the socket
  - Recommend integrated USB host controller
    - » USB host resistors are implemented on the card
    - » Additional external switch required without HC
- Pin compatible CardBus/CardBay solutions
  - USB HC requires new clock source
  - Power switch has new requirements
- Host registers and software
  - No host interface specified by PC Card v8.0
  - Host controller vendors can currently solve this problem with hardware and/or software solutions

Implementation Elements
For CardBay Systems

- PC Card Socket Power
  - Consider removing 12V Vpp support
  - Consider thermal issues in dual-socket systems
- Pin-compatible silicon upgrade to CardBay
  - Power switch device as well as host controller
  - Accommodate 48MHz clock routing for USB HC
- Consider p262 enhancements and bundling passive adapters

Summary of Key Points

- PC Card v8.0 releases in June, 2001
- CardBay cards
  - Should be reported to USB as self-powered
  - May now consume 3.3W average power
- CardBay controllers
  - Should implement a USB host controller
  - Can be pin-compatible to CardBus controllers
  - Have to solve host interface/software issues
- CardBay systems
  - Need to consider dual-socket thermal issues

Recent Developments, Proposal 262

- 2000: PCMCIA p262, Toshiba & TI
  - Originally called MediaBay
  - Adds flash memory interfaces
  - Adds Smart Card ISO7816-3 interface
  - Aligns technically with p215
- P 262 will includes several interfaces
  - SmartCard
  - SmartMedia (SSFDC)
  - Memory Stick
  - MultiMediaCard (MMC) & SD Flash

Why needs proposal 262?

- Proposal 262 will increase the use of Flash (for example, Memory Stick)
- Consumers can use any type of memory interface and Smart Card on their notebook or desktop
- Consumers will need only an inexpensive passive adapter.
- Proposal 262 will open new customers for flash memory because consumers can utilize flash memory on any notebook or desktop with a CardBay controller. A dedicated flash memory socket is not required.
- A special the laptop is not required. The existing PCMCIA socket is used. The notebook and desktop manufactures have no additional mechanical costs.

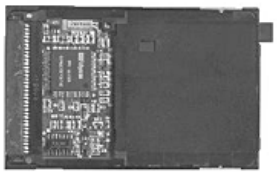
Proposal 262 Benefits

- Problem: There is not a standard interface for Memory Cards, only unique card sockets for each type of interface.
- Solution: proposal 262 utilizes the existing 68 pin PCMCIA socket for the numerous memory interfaces available today (Memory Stick, MMC, SD, Smart Media, and Smart Card)

Proposal 262 Benefits

- **CardBay will standardize one common interface through the existing PCMCIA socket.**
- **CardBay reduces the cost of adapters by moving the silicon from the PCMCIA card to the host. This allows for passive adapters similar to those used with CompactFlash.**

CompactFlash Adapter
- Interface maps directly to PCMCIA
- Passive adapter
- Very low cost



Other Adapters
- Interfaces are bridged with on-board silicon
- Can be very expensive

Flash Media

- SmartMedia
- Memory Stick
- MMC & SD Flash
- CompactFlash
- Smart Card

Flash Media Comparison

	Size	Pin Count	Security	I/O Read Speed	Licensing	2000 Capacity
MMC	32 X 24 X 1.4mm	7	SDMI 1	2.5 MB/sec	No, fee	64MB
SD Flash	32 X 24 X 2.1mm	9	Key	10 MB/sec	NDA, fee	64MB
Memory Stick	21.5 X 50 X 2.8mm	10	Key	2.45 MB/sec	Yes	32MB
CompactFlash	36.4 X 42.8 X 2.8mm	50	SDMI 1	10 MB/sec	No, open	128MB
CompactFlash II	36.4 X 42.8 X 5.0mm	50	SDMI 1	10 MB/sec	No, open	340MB
SmartMedia	45 X 37 X 0.76mm	22	SDMI 1	12.5 MB/sec	No, purchase	128MB