Computer Busses, Ports and Peripheral Devices

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In computer architecture, a bus (related to the Latin "omnibus", meaning "for all") is a communication system that transfers data between components inside a computer, or between computers. This expression covers all related hardware components (wire, optical fiber, etc.) and software, including communication protocols.

Early computer buses were parallel electrical wires with multiple connections, but the term is now used for any physical arrangement that provides the same logical functionality as a parallel electrical bus. Modern computer buses can use both parallel and bit serial connections, and can be wired in either a multidrop (electrical parallel) or daisy chain topology, or connected by switched hubs, as in case of USB.

Background and nomenclature

Computer systems generally consist of three main parts: the central processing unit (CPU) that processes data, memory that holds the programs and data to be processed, and I/O (input/output) devices as peripherals that communicate with the outside world. An early computer might use a hand-wired CPU of vacuum tubes, a magnetic drum for main memory, and a punch tape and printer for reading and writing data. In a modern system we might find a multi-core CPU, DDR3 SDRAM for memory, a hard drive for secondary storage, a graphics card and LCD display as a display system, a mouse and keyboard for interaction, and a Wi-Fi connection for networking. In both examples, computer buses of one form or another move data between all of these devices.

In most traditional computer architectures, the CPU and main memory tend to be tightly coupled. A microprocessor conventionally is a single chip which has a number of electrical connections on its pins that can be used to select an "address" in the main memory and another set of pins to read and write the data stored at that location. In most cases, the CPU and memory share signaling characteristics and operate in synchrony. The bus connecting the CPU and memory is one of the defining characteristics of the system, and often referred to simply as the system bus.

It is possible to allow peripherals to communicate with memory in the same fashion, attaching adaptors in the form of expansion cards directly to the system bus. This is commonly accomplished through some sort of standardized electrical connector, several of these forming the expansion bus or local bus. However, as the performance differences between the CPU and peripherals varies widely, some solution is generally needed to ensure that peripherals do not slow overall system performance. Many CPUs feature a second set of pins similar to those for communicating with memory, but able to operate at very different speeds and using different protocols. Others use smart controllers to place the data directly in memory, a concept known as direct memory access. Most modern systems combine both solutions, where appropriate.

As the number of potential peripherals grew, using an expansion card for every peripheral became increasingly untenable. This has led to the introduction of bus systems designed specifically to support multiple peripherals. Common examples are the SATA ports in modern computers, which allow a number of hard drives to be connected without the need for a card. However, these high-performance systems are generally too expensive to implement in low-end devices, like a mouse. This has led to the parallel development of a number of low-performance bus systems for these solutions, the most common example being Universal Serial Bus. All such examples may be referred to as peripheral buses, although this terminology is not universal.

In modern systems the performance difference between the CPU and main memory has grown so great that increasing amounts of high-speed memory is built directly into the CPU, known as a cache. In such systems, CPUs communicate using high-performance buses that operate at speeds much greater than memory, and communicate with memory using protocols similar to those used solely for peripherals in the past. These system buses are also used to communicate with most (or all) other peripherals, through adaptors, which in turn talk to other peripherals and controllers. Such systems are architecturally more similar to multicomputers, communicating over a bus rather than a network. In these cases, expansion buses are entirely separate and no longer share any architecture with their host CPU (and may in fact support many different CPUs, as is the case with PCI). What would have formerly been a system bus is now often known as a front-side bus.

Given these changes, the classical terms "system", "expansion" and "peripheral" no longer have the same connotations. Other common categorization systems are based on the buses primary role, connecting devices internally or externally, PCI vs. SCSI for instance. However, many common modern bus systems can be used for both; SATA and the associated eSATA are one example of a system that would formerly be described as internal, while in certain automotive applications use the primarily external IEEE 1394 in a fashion more similar to a system bus. Other examples, like InfiniBand and I²C were designed from the start to be used both internally and externally.

Internal bus

The internal bus, also known as internal data bus, memory bus, system bus or Front-Side-Bus, connects all the internal components of a computer, such as CPU and memory, to the motherboard. Internal data buses are also referred to as a local bus, because they are intended to connect to local devices. This bus is typically rather quick and is independent of the rest of the computer operations.

External bus

The external bus, or expansion bus, is made up of the electronic pathways that connect the different external devices, such as printer etc., to the computer.

Implementation details

Buses can be parallel buses, which carry data words in parallel on multiple wires, or serial buses, which carry data in bit-serial form. The addition of extra power and control connections, differential drivers, and data connections in each direction usually means that most serial buses have more conductors than the minimum of one used in 1-Wire and UNI/O. As data rates increase, the problems of timing skew, power consumption, electromagnetic interference and crosstalk across parallel buses become more and more difficult to circumvent. One partial solution to this problem has been to double pump the bus. Often, a serial bus can be operated at higher overall data rates than a parallel bus, despite having fewer electrical connections, because a serial bus inherently has no timing skew or crosstalk. USB, FireWire, and Serial ATA are examples of this. Multidrop connections do not work well for fast serial buses, so most modern serial buses use daisy-chain or hub designs.

Network connections such as Ethernet are not generally regarded as buses, although the difference is largely conceptual rather than practical. An attribute generally used to characterize a bus is that power is provided by the bus for the connected hardware. This emphasizes the busbar origins of bus architecture as supplying switched or distributed power. This excludes, as buses, schemes such as serial RS-232, parallel Centronics, IEEE 1284 interfaces and Ethernet, since these devices also needed separate power supplies. Universal Serial Bus devices may use the bus supplied power, but often use a separate power source. This distinction is exemplified by a telephone system with a connected modem, where the RJ11 connection and associated modulated signaling scheme is not considered a bus, and is analogous to an Ethernet connection. A phone line connection scheme is not considered to be a bus with respect to signals, but the Central Office uses buses with cross-bar switches for connections between phones.

However, this distinction—that power is provided by the bus—is not the case in many avionic systems, where data connections such as ARINC 429, ARINC 629, MIL-STD-1553B (STANAG 3838), and EFABus (STANAG 3910) are commonly referred to as “data buses” or, sometimes, "databuses". Such avionic data buses are usually characterized by having several equipment or Line Replaceable Items/Units (LRI/LRUs) connected to a common, shared media. They may, as with ARINC 429, be simplex, i.e. have a single source LRI/LRU or, as with ARINC 629, MIL-STD-1553B, and STANAG

3910, be duplex, allow all the connected LRI/LRUs to act, at different times (half duplex), as transmitters and receivers of data.

History

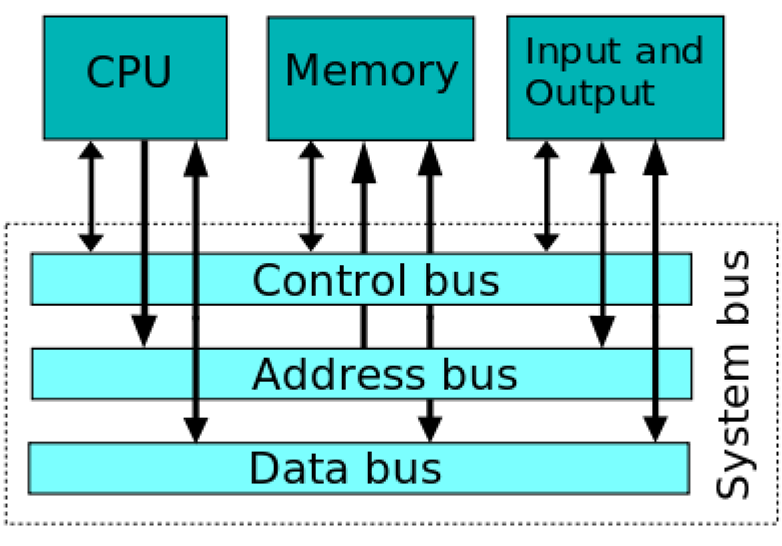
Over time, several groups of people worked on various computer bus standards, including the IEEE Bus Architecture Standards Committee (BASC), the IEEE "Superbus" study group, the open microprocessor initiative (OMI), the open microsystems initiative (OMI), the "Gang of Nine" that developed EISA, etc.

First generation

Early computer buses were bundles of wire that attached computer memory and peripherals. Anecdotally termed the "digit trunk", they were named after electrical power buses, or busbars. Almost always, there was one bus for memory, and one or more separate buses for peripherals. These were accessed by separate instructions, with completely different timings and protocols.

One of the first complications was the use of interrupts. Early computer programs performed I/O by waiting in a loop for the peripheral to become ready. This was a waste of time for programs that had other tasks to do. Also, if the program attempted to perform those other tasks, it might take too long for the program to check again, resulting in loss of data. Engineers thus arranged for the peripherals to interrupt the CPU. The interrupts had to be prioritized, because the CPU can only execute code for one peripheral at a time, and some devices are more time-critical than others.

High-end systems introduced the idea of channel controllers, which were essentially small computers dedicated to handling the input and output of a given bus. IBM introduced these on the IBM 709 in 1958, and they became a common feature of their platforms. Other high-performance vendors like Control Data Corporation implemented similar designs. Generally, the channel controllers would do their best to run all of the bus operations internally, moving data when the CPU was known to be busy elsewhere if possible, and only using interrupts when necessary. This greatly reduced CPU load, and provided better overall system performance.



Single system bus

To provide modularity, memory and I/O buses can be combined into a unified system bus. In this case, a single mechanical and electrical system can be used to connect together many of the system components, or in some cases, all of them.

Later computer programs began to share memory common to several CPUs. Access to this memory bus had to be prioritized, as well. The simple way to prioritize interrupts or bus access was with a daisy chain.

In this case signals will naturally flow through the bus in physical or logical order, eliminating the need for complex scheduling.

Minis and micros

Digital Equipment Corporation (DEC) further reduced cost for mass-produced minicomputers, and mapped peripherals into the memory bus, so that the input and output devices appeared to be memory locations. This was implemented in the Unibus of the PDP-11 around 1969.

Early microcomputer bus systems were essentially a passive backplane connected directly or through buffer amplifiers to the pins of the CPU. Memory and other devices would be added to the bus using the same address and data pins as the CPU itself used, connected in parallel. Communication was controlled by the CPU, which had read and written data from the devices as if they are blocks of memory, using the same instructions, all timed by a central clock controlling the speed of the CPU. Still, devices interrupted the CPU by signaling on separate CPU pins. For instance, a disk drive controller would signal the CPU that new data was ready to be read, at which point the CPU would move the data by reading the "memory location" that corresponded to the disk drive. Almost all early microcomputers were built in this fashion, starting with the S-100 bus in the Altair 8800 computer system.

In some instances, most notably in the IBM PC, although similar physical architecture can be employed, instructions to access peripherals (in and out) and memory (mov and others) have not been made uniform at all, and still generate distinct CPU signals, that could be used to implement a separate I/O bus.

These simple bus systems had a serious drawback when used for general-purpose computers. All the equipment on the bus had to talk at the same speed, as it shared a single clock.

Increasing the speed of the CPU becomes harder, because the speed of all the devices must increase as well. When it is not practical or economical to have all devices as fast as the CPU, the CPU must either enter a wait state, or work at a slower clock frequency temporarily, to talk to other devices in the computer. While acceptable in embedded systems, this problem was not tolerated for long in general-purpose, user-expandable computers.

Such bus systems are also difficult to configure when constructed from common off-the-shelf equipment. Typically each added expansion card requires many jumpers in order to set memory addresses, I/O addresses, interrupt priorities, and interrupt numbers.

Second generation

"Second generation" bus systems like NuBus addressed some of these problems. They typically separated the computer into two "worlds", the CPU and memory on one side, and the various devices on the other. A bus controller accepted data from the CPU side to be moved to the peripherals side, thus shifting the communications protocol burden from the CPU itself. This allowed the CPU and memory side to evolve separately from the device bus, or just "bus". Devices on the bus could talk to each other with no CPU intervention. This led to much better "real world" performance, but also required the cards to be much more complex. These buses also often addressed speed issues by being "bigger" in terms of the size of the data path, moving from 8-bit parallel buses in the first generation, to 16 or 32-bit in the second, as well as adding software setup (now standardized as Plug-n-play) to supplant or replace the jumpers.

However these newer systems shared one quality with their earlier cousins, in that everyone on the bus had to talk at the same speed. While the CPU was now isolated and could increase speed, CPUs and memory continued to increase in speed much faster than the buses they talked to. The result was that the bus speeds were now very much slower than what a modern system needed, and the machines were left starved for data. A particularly common example of this problem was that video cards quickly outran even the newer bus systems like PCI, and computers began to include AGP just to drive the video card. By 2004 AGP was outgrown again by high-end video cards and other peripherals and has been replaced by the new PCI Express bus.

An increasing number of external devices started employing their own bus systems as well. When disk drives were first introduced, they would be added to the machine with a card plugged into the bus, which is why computers have so many slots on the bus. But through the 1980s and 1990s, new systems like SCSI and IDE were introduced to serve this need, leaving most slots in modern systems empty. Today there are likely to be about five different buses in the typical machine, supporting various devices.

Third generation

"Third generation" buses have been emerging into the market since about 2001, including HyperTransport and InfiniBand. They also tend to be very flexible in terms of their physical connections, allowing them to be used both as internal buses, as well as connecting different machines together. This can lead to complex problems when trying to service different requests, so much of the work on these systems concerns software design, as opposed to the hardware itself. In general, these third generation buses tend to look more like a network than the original concept of a bus, with a higher protocol overhead needed than early systems, while also allowing multiple devices to use the bus at once.

Buses such as Wishbone have been developed by the open source hardware movement in an attempt to further remove legal and patent constraints from computer design.

Examples of internal computer buses

Parallel

ASUS Media Bus proprietary, used on some ASUS Socket 7 motherboards

Computer Automated Measurement and Control (CAMAC) for instrumentation systems

Extended ISA or EISA

Industry Standard Architecture or ISA

Low Pin Count or LPC

MBus

MicroChannel or MCA

Multibus for industrial systems

NuBus or IEEE 1196

OPTi local bus used on early Intel 80486 motherboards.

Conventional PCI

Parallel ATA (also known as Advanced Technology Attachment, ATA, PATA, IDE, EIDE, ATAPI, etc.) disk/tape peripheral attachment bus

S-100 bus or IEEE 696, used in the Altair and similar microcomputers

SBus or IEEE 1496

SS-50 Bus

Runway bus, a proprietary front side CPU bus developed by Hewlett-Packard for use by its PA-RISC microprocessor family

GSC/HSC, a proprietary peripheral bus developed by Hewlett-Packard for use by its PA-RISC microprocessor family

Precision Bus, a proprietary bus developed by Hewlett-Packard for use by its HP3000 computer family

STEbus

STD Bus (for STD-80 [8-bit] and STD32 [16-/32-bit]), FAQ

Unibus, a proprietary bus developed by Digital Equipment Corporation for their PDP-11 and early VAX computers.

Q-Bus, a proprietary bus developed by Digital Equipment Corporation for their PDP and later VAX computers.

VESA Local Bus or VLB or VL-bus

VMEbus, the VERSAmodule Eurocard bus

PC/104, PC/104 Plus, PC/104 Express, PCI-104, PCIe-104

Zorro II and Zorro III, used in Amiga computer systems

Serial

1-Wire

HyperTransport

I²C

PCI Express or PCIe

Serial ATA (SATA)

Serial Peripheral Interface Bus or SPI bus

UNI/O

SMBus

Examples of external computer buses

Parallel

HIPPI High Performance Parallel Interface

IEEE-488 (also known as GPIB, General-Purpose Interface Bus, and HPIB, Hewlett-Packard Instrumentation Bus)

PC Card, previously known as PCMCIA, much used in laptop computers and other portables, but fading with the introduction of USB and built-in network and modem connections

Serial

Controller area network ("CAN bus")

eSATA

ExpressCard

Fieldbus

IEEE 1394 interface (FireWire)

Lightning

RS-232

RS-485

Thunderbolt (interface)

USB Universal Serial Bus, used for a variety of external devices

Examples of internal/external computer buses

Futurebus

InfiniBand

PCI Express External Cabling

QuickRing

Scalable Coherent Interface (SCI)

SCSI Small Computer System Interface, disk/tape peripheral attachment bus

Serial Attached SCSI (SAS) and other serial SCSI buses

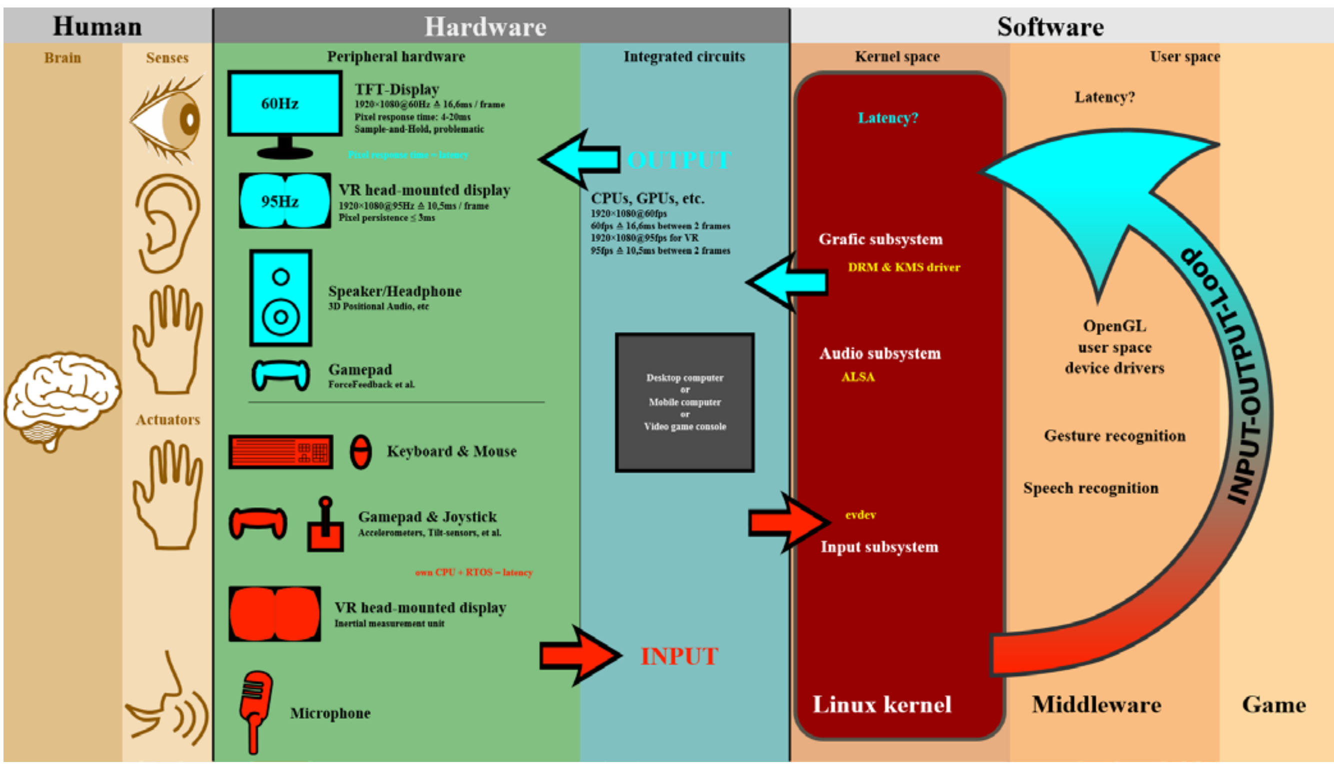
Thunderbolt

Yapbus, a proprietary bus developed for the Pixar Image Computer

Peripheral Device Definition

A peripheral is a "device that is used to put information into or get information out of the computer."

There are two different types of peripherals: input devices, which interact with or send data to the computer (mouse, keyboards, etc.), and output devices, which provide output to the user from the computer (monitors, printers, etc.). Some peripherals, such as touchscreens, may combine different devices into a single hardware component that can be used both as an input and output device.



A peripheral device is generally defined as any auxiliary device such as a computer mouse or keyboard that connects to and works with the computer in some way. Other examples of peripherals are image scanners, tape drives, microphones, loudspeakers, webcams, and digital cameras. Many modern devices, such as digital watches, smartphones and tablet computers, have interfaces that allow them to be used as a peripheral by desktop computers, although they are not host-dependent in the same way as other peripheral devices.

Common input peripherals include keyboards, computer mice, graphic tablets, touchscreens, barcode readers, image scanners, microphones, webcams, game controllers, light pens, and digital cameras. Common output peripherals include computer displays, printers, projectors, and computer speakers.

A peripheral device connects to a computer system to add functionality. Examples are a mouse, keyboard, monitor, printer and scanner. Learn about the different types of peripheral devices and how they allow you to do more with your computer.

A computer peripheral is a device that is connected to a computer but is not part of the core computer architecture. The core elements of a computer are the central processing unit, power supply, motherboard and the computer case that contains those three components. Technically speaking, everything else is considered a peripheral device. However, this is a somewhat narrow view, since various other elements are required for a computer to actually function, such as a hard drive and random-access memory (or RAM).

Most people use the term peripheral more loosely to refer to a device external to the computer case. You connect the device to the computer to expand the functionality of the system. For example, consider a printer. Once the printer is connected to a computer, you can print out documents. Another way to look at peripheral devices is that they are dependent on the computer system. For example, most printers can't do much on their own, and they only become functional when connected to a computer system.

Types of Peripheral Devices

There are many different peripheral devices, but they fall into three general categories:

- **Input** devices, such as a mouse and a keyboard
- **Output** devices, such as a monitor and a printer
- **Storage** devices, such as a hard drive or flash drive

Some devices fall into more than one category. Consider a CD-ROM drive; you can use it to read data or music (input), and you can use it to write data to a CD (output).

Peripheral devices can be external or internal. For example, a printer is an external device that you connect using a cable, while an optical disc drive is typically located inside the computer case. Internal peripheral devices are also referred to as integrated peripherals. When most people refer to peripherals, they typically mean external ones.

The concept of what exactly is 'peripheral' is therefore somewhat fluid. For a desktop computer, a keyboard and a monitor are considered peripherals - you can easily connect and disconnect them and replace them if needed. For a laptop computer, these components are built into the computer system and can't be easily removed.

The term 'peripheral' also does not mean it is not essential for the function of the computer. Some devices, such as a printer, can be disconnected and the computer will keep on working just fine. However, remove the monitor of a desktop computer and it becomes pretty much useless.

Examples of Peripheral Devices

Here you can see a typical desktop computer system with a number of common peripheral devices. The central processing unit (#2), motherboard (#8) and power supply are the core computer system. Expansion slots (#4) on the motherboard make it possible to connect internal peripherals, such as a video card or sound card (not shown). Other internal peripherals shown are a hard disk drive (#7) and an optical disc drive (#6). External input peripherals are a scanner (#1), display monitor (#10), keyboard (#13) and mouse (#14). External output peripherals are a set of speakers (#9) and a printer (#16). Note that labels 11 and 12 in the figure refer to software and are not peripherals.

A computer peripheral, or peripheral device, is an external object that provides input and output for the computer. Some common input devices include: keyboard, mouse, touchscreen, pen tablet. Joystick, MIDI keyboard, scanner, digital camera, video camera, microphone

Some common output devices include: monitor, projector, TV screen, printer, plotter, speakers.

There are also devices that function as both input and output devices, such as: external hard drives, media card readers, digital camcorders, digital mixers, MIDI equipment, touchscreens.

While these are some of the more common peripherals, there are many other kinds as well. Just remember that any external device that provides input to the computer or receives output from the computer is considered a peripheral.

Introduction

A peripheral is a piece of computer hardware that is added to a computer in order to expand its abilities. The term peripheral is used to describe those devices that are optional in nature, as opposed to hardware that is either demanded or always required in principle. There are all different kinds of peripherals you can add your computer. The main distinction among peripherals is the way they are connected to your computer. They can be connected internally or externally.

Buses

A bus is a subsystem that transfers data between computer components inside a computer or between computers. Unlike a point-to-point connection, a bus can logically connect several peripherals over the same set of wires. Each bus defines its set of connectors to physically plug devices, cards or cables together. There are two types of buses: internal and external. Internal buses are connections to various internal components. External buses are connections to various external components. There are different kinds of slots that internal and external devices can connect to.

Internal Types of Slots

There are many different kinds of internal buses, but only a handful of popular ones. Different computers come with different kinds and number of slots. It is important to know what kind and number of slots you have on your computer before you go out and by a card that matches up to a slot you don’t have.

PCI

PCI (Peripheral Component Interconnect) is common in modern PCs. This kind of bus is being succeeded by PCI Express. Typical PCI cards used in PCs include: network cards, sound cards, modems, extra ports such as USB or serial, TV tuner cards and disk controllers. Video cards have outgrown the capabilities of PCI because of their higher bandwidth requirements.

PCI Express

PCI Express was introduced by Intel in 2004. It was designed to replace the general-purpose PCI expansion bus and the AGP graphics card interface. PCI express is not a bus but instead a point-to-point connection of serial links called lanes. PCI Express cards have faster bandwidth then PCI cards which make them more ideal for high-end video cards.

PCMCIA

PCMCIA (also referred to as PC Card) is the type of bus used for laptop computers. The name PCMCIA comes from the group who developed the standard: Personal Computer Memory Card International Association. PCMCIA was originally designed for computer memory expansion, but the existence of a usable general standard for notebook peripherals led to many kinds of devices being made available in this form. Typical devices include network cards, modems, and hard disks.

AGP

AGP (Accelerated Graphics Port) is a high-speed point-to-point channel for attaching a graphics card to a computer’s motherboard, primarily to assist in the acceleration of 3D computer graphics. AGP has been replaced over the past couple years by PCI Express. AGP cards and motherboards are still available to buy, but they are becoming less common.

Types Of Cards

Video Card

A video card (also known as graphics card) is an expansion card whose function is to generate and output images to a display. Some video cards offer added functions, such as video capture, TV tuner adapter, ability to connect multiple monitors, and others. Most video cards all share similar components.

They include a graphics processing unit (GPU) which is a dedicated microprocessor optimized for 3D graphics rendering. It also includes a video BIOS that contains the basic program that governs the video card's operations and provides the instructions that allow the computer and software to interface with the card. If the video card is integrated in the motherboard, it may use the computer RAM memory. If it is not it will have its own video memory called Video RAM. This kind of memory can range from 128MB to 2GB. A video card also has a RAMDAC (Random Access Memory Digital-to-Analog Converter) which takes responsibility for turning the digital signals produced by the computer processor into an analog signal which can be understood by the computer display. Lastly, they all have outputs such as an HD-15 connector (standard monitor cable), DVI connector, S-Video, composite video or component video.

Sound Card

A sound card is an expansion card that facilitates the input and output of audio signals to/from a computer under control of computer programs. Typical uses for sound cards include providing the audio component for multimedia applications such as music composition, editing video or audio, presentation/education, and entertainment. Many computers have sound capabilities built in,, while others require additional expansion cards to provide for audio capability.

Network Card

A network card is an expansion card that allows computers to communicate over a computer network. It allows users to connect to each other either by using cables or wirelessly. Although other network technologies exist, Ethernet has achieved near-ubiquity for a while now. Every Ethernet network card has a unique 48-bit serial number called a MAC address, which is stored in ROM carried on the card. You can learn more about networking in the introduction to networking lesson.

External Types of Connections

USB

USB (Universal Serial Bus) is a serial bus standard to interface devices. USB was designed to allow many peripherals to be connected using a single standardized interface socket and to improve the plug-and-play capabilities by allowing devices to be connected and disconnected without rebooting the computer. Other convenient features include providing power to low-consumption devices without the need for an external power supply and allowing many devices to be used without requiring manufacturer specific, individual device drivers to be installed. USB is by far the dominating bus for connecting external devices to your computer.

Firewire

Firewire (technically known as IEEE 1394 and also known as i.LINK for Sony) is a serial bus interface standard for high-speed communications and isochronous real-time data transfer, frequently used in a personal computer. Firewire has replaced Parallel ports in many applications. It has been adopted as the High Definition Audio-Video Network Alliance (HANA) standard connection interface for A/V (audio/visual) component communication and control. Almost all modern digital camcorders have included this connection.

PS/2

The PS/2 connector is used for connecting some keyboards and mice to a PC compatible computer system. The keyboard and mouse interfaces are electrically similar with the main difference being that open collector outputs are required on both ends of the keyboard interface to allow bidirectional communication. If a PS/2 mouse is connected to a PS/2 keyboard port, the mouse may not be recognized by the computer depending on configuration.

Devices

Removable Storage

The same kinds of CD and DVD drives that could come built-in on your computer can also be attached externally. You might only have a CD-ROM drive built-in to your computer but you need a CD writer to burn CDs. You can buy an external CD writer that connects to your USB port and acts the same way as if it was built-in to your computer. The same is true for DVD writers, Blu-ray drives, and floppy drives. Flash drives have become very popular forms of removable storage especially as the price of flash drives decreases and the possible size for them increases. Flash drives are usually USB ones either in the form USB sticks or very small, portable devices. USB flash drives are small, fast, removable, rewritable, and long-lasting. Storage capacities range from 64MB to 32GB or more. A flash drive does not have any mechanically driven parts so as opposed to a hard drive which makes it more durable and smaller usually.

Non-removable Storage

Non-removable storage can be a hard drive that is connected externally. External hard drives have become very popular for backups, shared drives among many computers, and simply expanding the amount of hard drive space you have from your internal hard drive. External hard drives come in many shapes and sizes like flash drives do. An external hard drive is usually connected by USB but you can also have a networked hard drive which will connect to your network which allows all computers on that network to access that hard drive.

Input

Input devices are absolutely crucial to computers. The most common input devices are mice and keyboards which barely every computer has. A new popular pointing device that may eventually replace the mouse is touch screen which you can get on some tablet notebooks. Other popular input devices include microphones, webcams, and fingerprint readers which can also be built in to modern laptops and desktops. A scanner is another popular input device that might be built-in to your printer.

Output

There are lots of different kinds of output devices that you can get for your computer. The absolute most common external output device is a monitor. Other very popular output devices are printers and speakers. There are lots of different kinds of printers and different sizes of speakers for your computer. Monitors are connected usually through the HD-15 connector on your video card. Printers are usually connected through a USB port. Speakers have their own audio out port built-in to the sound card.

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