USB BASICS

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Imagine a network based on inexpensive, high volume chipsets, with data rates up to 12Mbit/second and a 25 meter distance capacity, designed from the start with "plug and play" in mind. Add 5 Volt power, with up to 500mA current capacity, and compatibility with many consumer products.

What we just described is Universal Serial Bus (USB)—an external-connectivity communications technology for linking peripherals such as mice, keyboards, modems, joysticks, video, etc. to Macintosh and PC computers. It has gained favor commercially and privately since 1996.

It is included with nearly all new PC's, it is quickly replacing PC serial ports, and it's driven by some of the largest manufacturers in the electronics industry, it's inevitable that USB will become a factor in the industrial, retail and data collection worlds too.

Where USB Came From

USB grew from the requirement for a simple, inexpensive expansion bus for PCs. PCI solved many speed and compatibility problems that existed with the ISA bus, but the need to take the cover off the PC to add a peripheral was a real problem. And though PCI made Windows' "Plug-n-Play" possible, we've all experienced the frequent reality of "Plug-n-*Pray*."

USB is serial (less costly than parallel) and permits you to "hot-swap" without rebooting the PC. In USB, the PC is the master of the network and controls all bus traffic. Peripherals are simpler and less costly.

A USB master does not *have* to be a PC, but usually is. All recent versions of Windows and Linux support USB. An embedded device, of course, is a computer that doesn't look like a computer. But only sophisticated embedded devices with full operating systems will be USB masters.

"Can I add USB to a computer that does not have a USB port?"

Most new PC's come with USB ports, often built right into the motherboard. But many computers don't have them. You can add USB by installing a PCI add-in card. (You may need to upgrade the computer's Operating System and BIOS for it to work properly.)

Are you running out of PCI or ISA slots? With USB you can forget about setting COM ports and IRQ's, just plug in a USB to RS-232, RS-422, RS-485 or parallel converter.

USB comes in different variations:

- USB 1.1 (also called USB Basic Speed), the most common version that gives data-transfer rates of 1.5–12 megabits per second (Mbps)
- USB 2.0 (also called USB Hi-Speed), the high-speed version of 1.1 that gives 480 Mbps data-transfer rates
- USB OTG ("on the go"), allows mobile devices to be connected without going through a PC, including laptops

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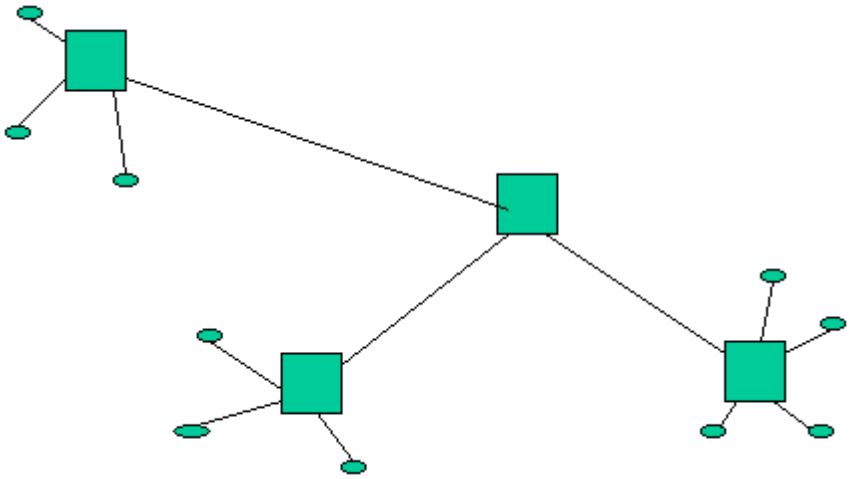
What follows is information on USB 1.1.

USB Network Layout



USB uses a "Star" topology, which means that there is only one device connected at each end of a cable, and multiple devices require a hub to re-distribute the signal.

Highlights

- A single port can connect up to 127 peripheral devices.
- It supports Microsoft's plug-and-play (PnP) specification as well as hot swapping or hot plugging (i.e., you can unplug something and plug in something *on the fly*, which means you don't have to shut down the computer).
- It's auto-configuring, which means the peripheral device and the computer figure out how to communicate without disrupting anything else.
- It's a "cross-platform" standard, which means it will work on either a Macintosh or PC.
- It can support up to 500 milliamp of current to items on the bus.

Technology, Systems Makeup

Three things comprise USB technology:

- Host, which is the master connector or controller—the host computer
- Hub, which is the host's root node that allows multiple USB devices to be connected
- Function, which is the actual USB device (e.g., mouse, keyboard, etc.)

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Three things comprise a USB system:

- Host
- Device
- Physical bus (represented by the cable)

Devices, Data-transfer Methods

Two categories of devices are used with USB devices:

- Low-speed, such as mice, keyboards, joysticks, etc.
- High-speed, such as zip drives, printers, scanners, etc.

Four types of data-transfer methods are involved with USB devices:

- Bulk, used for devices that have large amounts of data to transmit or receive—scanners and printers, for example—and that need guaranteed delivery, but have no particular bandwidth requirements
- Control, bi-directional—at rates of 8, 16, 32, or 64 bytes [note: 1 byte equals 8 bits] depending on device and transfer speed—and used by software to query, configure, and issue generic commands
- Interrupt, used to poll devices—keyboards, mice, and joysticks—that sporadically and unpredictably produce small amounts of data to determine if they have data to transmit
- Isochronous, used for time-critical streaming data or in real-time applications requiring constant data-transfer rates

Interfaces, Endpoints

USB devices have at least one interface, which is the peripheral's physical component.

Each interface has a set of endpoints, which are data producers or consumers. All USB devices have a special endpoint called endpoint 0, which supports generic USB status and configuration protocol.

Device drivers establish logical communication channels, called pipes, which are software associations between the endpoints and driver.

Endpoint characteristics determine pipe characteristics (e.g., communication direction, required bandwidth, etc.).

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More on USB 2.0 and USB OTG

Version 2.0 has backward compatibility with USB 1.1 and also retains the plug-and-play and hot-swapping capabilities of the earlier version.

OTG, which is a supplement to USB 2.0, allows mobile-device interconnectivity when a PC is not available. The first USB OTG version premiered in December 2001.

USB Summary

Origin: USB is a multiple platform serial network standard created by Microsoft, Intel, and various PC vendors for linking low- and medium-speed computer peripherals.

Power: 5V and up to 500 mA for each device or hub on the network.

Nodes: 127 Maximum

Distance: ~4M maximum without the use of a hub; ~25M maximum with use of multiple hubs.

Baud Rate: 1.5 Mbps and 12 Mbps can co-exist on the same bus. (However mixing speeds should be avoided as it substantially slows communication; it's best to split the devices between two host connections.) 1.5 Mbps wiring does not require shielding

Termination: Built in to devices

Wiring: Star topology; multiple devices supported by extending with multi-port hubs. Cables have a two-conductor, twisted-shielded pair of wires for two-directional data, plus two heavier wires for 5V power and ground.

Signal: Low-amplitude signal minimizes EMI/RFI interference: 0.4 volt differential centered at 1.75 volts DC.

Supporting trade organization: USB Implementers Forum, www.usb.org

Common hardware: USB hubs expand networks to accommodate up to 127 devices. ISA and PCI cards for USB are popular, and adapters are also available for converting serial, parallel and Ethernet ports to USB.

Typical Applications: Consumer electronics such as digital cameras, speakers, telephones, storage devices, scanners, printers, keyboards and mice. Also beginning to appear in data acquisition systems as alternative to GPIB (General Purpose Interface Bus) and in configuration ports for embedded devices.

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