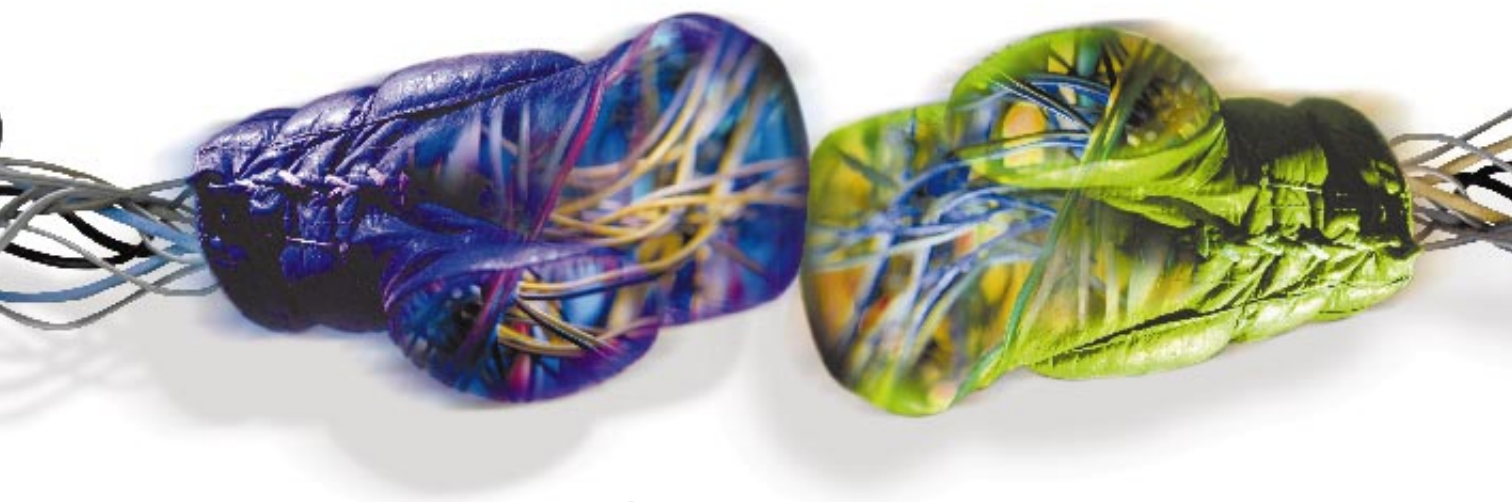
 By Greg Vrana, Technical Editor



Two PC buses go for round two

USB AND 1394 ARE VYING FOR "PORT SPACE" ON YOUR PC AND PERIPHERALS.

Last year, the USB-IF (USB Implementers Forum) announced an improved USB standard. USB 2.0 supports a top data rate of 480 Mbps, slighting edging out the current IEEE 1394 S400 speed. Not to be outdone, the IEEE 1394 committee plans to announce its own revved-up spec this year. The new IEEE 1394b standard will support speeds greater than 1Gbps. All this extra speed doesn't come free. Trade-offs are the rule in engineering, and these two revised bus standards will require engineers to add complexity to their designs in return for that extra bandwidth. Each bus has its own advantages and disadvantages. Here are some of the features of the new specs and issues to consider in your next design.

USB 2.0 MEANS A 40-FOLD SPEED-UP

Last April, the USB-IF released Version 2.0 of the USB specification, replacing the previous Version 1.1. The big news, as most know by now, is the 40-fold increase in speed. The previous 1.1 spec defined two speeds. Low-end devices, such as mice and keyboards, could operate in low-speed mode, or 1.5 Mbps. Full speed, for higher end devices, defined a data rate of 12 Mbps. USB 2.0 now adds a high-speed mode with a data rate of 480 Mbps. This higher speed opens new possibilities for USB peripherals and puts it on par with the current version of the IEEE 1394 bus.

Applications for USB 1.1 currently in-

clude most of the devices you might expect, such as keyboards, mice, external floppy drives, and videoconferencing cameras (see **sidebar** "Some USB background"). However, with 60 Mbytes/sec to play with, peripheral makers now can consider high-bandwidth devices that have been previously impractical. Better videoconferencing cameras, high-resolution scanners and printers, and high-density storage devices are some good candidates for the upgraded bus. Not unintentionally for the USB consortium, devices that made sense only when connected to your PC via a 1394 cable should start appearing this year with USB 2.0 support as well.

AT A GLANCE

- USB-IF last April announced USB 2.0, which defines a new high speed of 480 Mbps.
- All USB 1.1 peripherals will work with the new 2.0 host controllers and hubs.
- USB 2.0 chips are already appearing on the market.
- Expect adoption this year of the new IEEE 1394b specification, which will support speeds as high as 1600 Mbps.

FROM 1.1 TO 2.0

The good news is that most of the features in the 1.1 specifications haven't changed. The bus topology is still a tiered-star arrangement, which in theory supports 127 devices (**Figure 1**). The host is still in charge, allowing peripherals to remain simpler and less expensive. The basic protocol- and device-descriptor framework is also the same. As for software, the specifications will require some new development for host-controller and hub drivers. These drivers must be able to detect high-speed devices and switch between full and high speed as required. However, 2.0 can use USB 1.1's device application and driver.

Power distribution and management have not changed either. There is still 500 mA available for bus-powered devices after configuration and100 mA before configuration. And the suspend/resume model for power management is the same as in the 1.1 spec.

WHAT'S THE DIFFERENCE?

For consumers, the difference between USB 1.1 and 2.0 is more bandwidth. But to realize that gain, they will have to buy new USB 2.0 host (usually the PC itself) and peripherals. Their 1.1 devices will still work on a 2.0 host/hub but not at the new high speed. One other consideration for users is that they cannot use the older low-speed, unshielded cables with the 2.0 bus. But USB 1.1 cables and connectors will work fine.

Obviously, things aren't so simple for the designer of high-speed-capable devices. For one, the much higher data rate requires new transceivers. At boot-up or when a device is connected to the bus, the device must first communicate with its upstream host or hub in full-speed mode and then switch to high speed. New 2.0 devices must also meet tightened full-speed electrical specifications. And high-speed devices are required *not* to support low-speed mode.

Hubs and host controllers are more complicated. With USB 2.0, they must support low-speed, full-speed, and high-speed modes for all downstream ports. Upstream ports need to support full-speed and high-speed modes. Hubs and host controllers must also work within tighter electrical specifications for low- and full-speed modes. An added complexity for hubs is that they must implement a transaction translator to match the speed of any downstream low- or full-speed device. Because data comes to the hub from the (2.0) host at high speed, the hub will likely require a larger buffer than its 1.1-compliant predecessor.

Another thing to keep in mind is that for designs operating at 480 Mbps, board layout and packaging are much more important than at USB 1.1 speeds. If you've worked with 1394, that design experience will come in handy.

WHO'S IN THE CHIPS?

A number of vendors offer chips to help you with your USB 2.0 design. Agere Systems (formerly, Lucent Technologies) and NEC Electronics expect to soon be shipping USB 2.0 host-controller chips. Both devices have a PCI 2.2 interface and integrate a serial-interface engine and transceiver into one chip. Agere's USS-2000 has four downstream

SOME USB BACKGROUND

In January 1993, representatives from Compaq, Intel, Microsoft, and NEC identified requirements for a new peripheral bus to make it easier to connect devices, such as printers, scanners, keyboards, and telephones to PCs. A second goal was to provide more ports to which you could connect peripherals, beyond the two serial ports and one parallel port common on most PCs. Two years later, the consortium released Version 1.0 of the spec. Now, virtually every PC supports USB. We may not all be integrating our phones with our PCs as the originators of USB envisioned, but a USB port is as much a part of a PC today as the on/off switch.

Cahners In-Stat Group predicts that, by 2004, 750 million USB-equipped desktop and notebook PCs will be in use. Because most PCs come with more than one USB port, this figure translates into more than 1 billion USB devices in use. Selling a billion of anything—except maybe McDonald's Big Macs—is big news. In-Stat also predicts that USB peripheral shipments will grow 55% per year through the same period. USB has significant market share in external floppy drives, PC video cameras, flash-memory readers, scanners, ink-jet printers, joysticks, and keyboards.

Another goal of USB is to save users the anxiety and uncertainty of adding a peripheral to a PC. For example, most people don't want—and shouldn't have—to open up their computers to add high-speed backup devices. (Ironically, if they want USB 2.0 support in their current PC they *will* have to open it.) They also shouldn't have to worry about device conflicts if they decide to use that unused serial port on the back of their PC. USB also is hot-pluggable, so you don't have to shut down your PC and restart it whenever you add or remove a peripheral. The USB 2.0 spec is available on the USB-IF Web site.

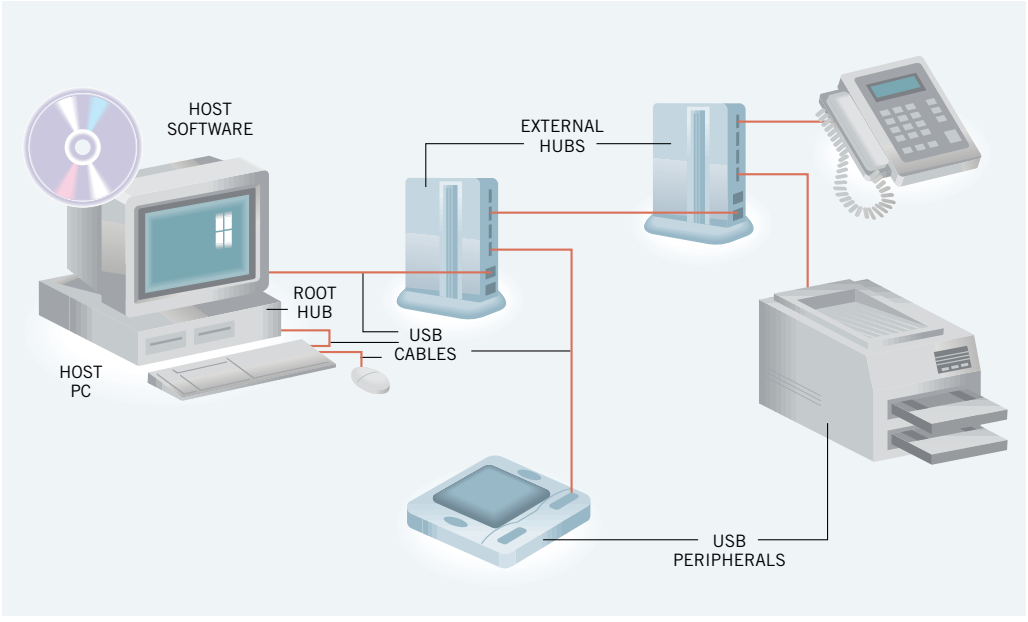


Figure 1
USB devices are connected in a tiered-star arrangement.

ports and comes with an evaluation kit. NEC's μPD720100 comes with one 2.0 and two 1.1 host controllers and five downstream ports. Meanwhile, Cahners In-Stat Group does not expect Intel to integrate 2.0 host controllers into core-logic chip sets until the third quarter of this year.

For 2.0 hubs, NEC has its μPD720110 hub controller. The chip has four downstream ports that support a split-transaction scheme. The split transaction scheme allows 1.1 and 2.0 devices to operate at optimum speeds even though they are connected to the same hub. TI plans to make its own hub controller, the TUSB4030, available for sampling in August.

Even more companies are getting into the USB peripheral-controller market. NEC's μPD720121 ATA/ATAPI bridge chip for external storage devices should soon be available. Also available is NetChip's Net2290 USB 2.0 general-purpose device controller, which interfaces to most 16/32-bit CPUs. The Net2290 targets imaging and storage applications. Standard Microsystems has demonstrated a prototype of its USB97C200 AT-API/ATA/FDC adapter chip, which it schedules for sampling in the first quarter. In July, TI will make available for sampling its TUSB6250 USB 2.0-to-AT-API bridge chip, the TUSB6250. TI is also expected to have a USB desktop-video-conferencing-camera-engine chip available for sampling in October. Kawasaki LSI has also announced plans for three USB 2.0-peripheral chips. These include a general-purpose peripheral controller with a 16-bit processor, a USB-to-100BaseT-interface chip, and a HomePNA network-interface chip.

For those of you who want to roll your own logic and just need the USB 2.0

SOME 1394 BACKGROUND

The names "1394," "FireWire," and "i.Link" are all terms for the same bus. The latest version is officially the IEEE Standard 1394a-2000 High Performance Serial Bus, but most people call it 1394a for short. Apple Computer (www.apple.com) developed the bus in 1986 and named it FireWire. In 1990, Apple offered the FireWire spec as a serial-bus standard to the IEEE Microcomputer Standards Committee. The IEEE adopted the bus in December 1995 and called it IEEE 1394-1995. The IEEE this year adopted the current version, 1394a, which clarifies and standardizes parts of the 1995 specification. The folks at Apple and the IEEE tried to create an inexpensive means of connecting computers, peripherals, and other digital devices with a simple, high-speed bus. The 1394 spec defines 100-, 200-, and 400-Mbps data-transfer rates. The "recommended" maximum cable length is 4.5m using twisted copper pairs. Like USB, 1394 is a hot-pluggable bus.

Probably because it was the first high-speed bus that was also easy to use, 1394 seems to be finding a home in living rooms. Most pieces of consumer-digital-video equipment today have a 1394 port, as does the new Sony Playstation 2 game console. The bus isn't catching on so quickly, however, in the PC market. And, even though Apple invented the technology, it doesn't put 1394 ports in all its iMac models. Instead, every iMac comes standard with two USB ports.

It's hard to say what the future of the 1394 bus will be. Some believe it depends on how well USB 2.0 succeeds in the coming year, implying that it will be either one or the other. One of the goals of 1394b is to tip the scales in its favor. You can review a draft of the proposed standard on Zayante's Web site. After the spec gets approval, you can purchase the final spec from the IEEE. You can find additional information at the 1394 Trade Association Web site.

physical layer, several of these companies are offering PHY (physical-layer-device) chips. NEC's μPD720120 with a serial-interface engine and transceiver and Agere's USS2X1 with an 8/16-bit interface are available. TI plans to make its TUSB4800 PHY chip available for sampling in March. Kawasaki has also announced a PHY chip.

The people behind USB 2.0 don't just want your product to be *compatible* with the USB spec; they want it to be in *compliance*. Compliance means that a USB-IF certified lab must test your product and verify that it's worthy of the USB 2.0 logo. Having a certified lab test your product will help ensure that it will work with other USB products, which should make your customers happy. These labs will also help you debug your design if any problems arise. So far, the list of certified labs includes MCCI, NSTL, NTS/XXCAL, and Professional Multimedia Testing Centre. Contech Research, ETC, or National Technical Systems will certify your products for cable and connector vendors.

The 1394 spec currently supports a maximum speed of 400 Mbps. At this speed, the maximum "recommended" cable length is 4.5m. Last March, the IEEE P1394b Working Group released a draft for the IEEE 1394b High Performance Serial Bus standard. The IEEE Microprocessor and Microcomputer Standards Committee expects the IEEE to adopt the draft this year. When it does, 1394b will make a quantum leap ahead of USB 2.0 in two respects. The new spec will define not only faster modes, but also greater maximum cable lengths. The spec will add 800- and 1600-Mbps speeds and "architectural support" for a 3200-Mbps speed.

Depending on the type of cable it uses, 1394b will support "long-haul" cable runs as long as 100m (see **Table 1**). The draft of the 1394b spec describes shielded-twisted-pair cable; unshielded-twisted-pair, or Category5 cable; plastic optical fiber; hard polymer-clad fiber; and multimode fiber-optic glass. Although the standard does not define runs longer than those listed in **Table 1**, users can in

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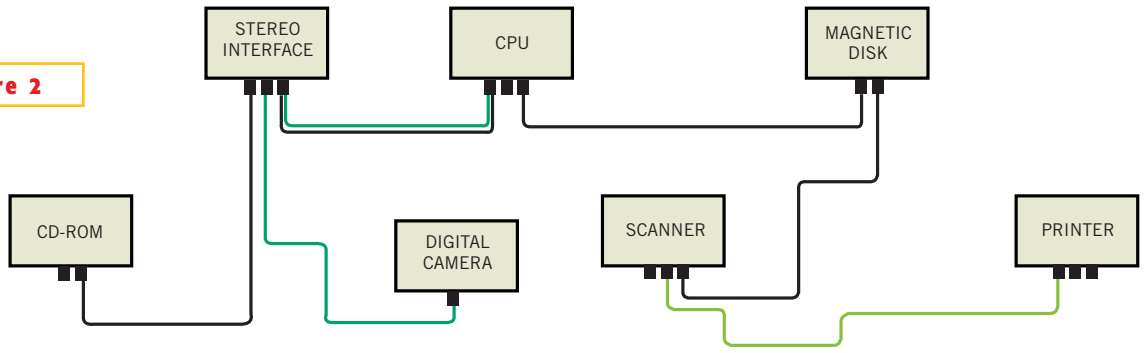
Figure 2



You can connect 1394 devices directly to one another in a peer-to-peer arrangement.

practice achieve longer runs. For example, by using 24 AWG copper wires in standard 1394 cables, you can achieve a 10m cable run at 400 Mbps. For longer hauls, engineers have demonstrated a 500m cable run at 400 Mbps on glass fiber-optic cables.

Another promise of the upcoming spec is more efficient bus arbitration. But all these goodies come at a cost because 1394b is more than an improved spec. It's a new protocol that need not be compatible with 1394a devices. Vendors can choose to make "bilingual" devices that are compatible with both the a and b specs, or they can choose to build devices that support only one of these specs. This feature sounds nice for 1394 manufacturers. However, consumers may be less than thrilled when they buy a 1394b-only digital video recorder and find out later it won't work with the digital videocamera they bought last year.

Most people associate 1394 with consumer-electronic devices, such as DVD players, digital cameras, and camcorders. External storage devices also are available that connect to your PC using 1394. With more than 1 Gbps of bandwidth, 1394b should allow you not only to implement devices that transfer data faster, but also to connect more of these devices to create a truly integrated home-entertainment network. In addition, the longer cable spans enable you to transfer video from the PC in your home office to the digital TV in your living room across a high-speed home network. You can also use 1394b for video/audio editing and management.

Because the 1394b standard has not yet become final, chip vendors have not yet announced any 1394b parts. Some of them are saying that they have prototypes working in the lab that conform to the draft standard. Most of these companies, including Agere, Innovative Semiconductors, Philips, TI, Via, and Zayante, are those currently selling 1394a chips or intellectual-property cores.

Once you have your own prototype working, you need to verify that it conforms to the 1394b spec. Several companies, including 3A International, CATC, Data Transit, and Kenwood, currently offer bus analyzers and testers for 1394a and will probably announce products for 1394b this year. Zayante also offers testing services for 1394 (see **sidebar** "Some 1394 background").

SO WHICH WILL IT BE?

Until the 480-Mbps USB 2.0 standard came along, some argued that USB and 1394 don't really compete because one is slow, and the other is fast. That argument doesn't hold much water because some companies offer a choice of a USB 1.1 or a 1394 interface on identical products. However, clear choices may exist at either end of the bandwidth spectrum. If you're building an inexpensive device, such as a mouse or keyboard, that doesn't require quickly moving a lot of data, then USB is probably the answer. (A PS/2 or serial interface would also work well.) At the other end, if your bandwidth requirements are on the order of hundreds of megabytes per second, then you should choose 1394b. However, when USB and 1394 speeds are comparable—around 400 Mbps—then you must consider other attributes of each bus to decide.

One of the first features to look at is how devices on each bus "talk" to one another. USB uses a host/slave protocol, meaning that a host, usually a PC, must be a part of the USB for a slave device to do anything useful. On the other hand, the 1394 bus has peer-to-peer architecture (**Figure 2**). This scenario means that a PC is not required to initiate transactions between devices. In fact, a PC or host is not required at all. For example, a digital camera could send an image directly to a printer on a 1394 bus. With USB, you must have a PC first download an image file from the camera and then have the PC send the file to the printer.

Both buses define isochronous trans-

TABLE 1–MAXIMUM CABLE LENGTHS FOR 1394B DEVICES

Cable media	Distance (m)	100 Mbps	200 Mbps	400 Mbps	800 Mbps	1600 Mbps
Unshielded twisted pair 5	100	X				
Plastic optical fiber	50	X	X			
Hard polymer-clad fiber	100	X	X			
Multimode fiber-optic glass	100			X	X	X
Shielded twisted pair	4.5			X	X	X

actions, which are used when data must be delivered within a certain time regardless of any errors. It can be argued that the 1394 bus is better at this type of transfer since the data can be sent directly to the receiving device. An isochronous transfer on a USB bus must first send a data packet to the host PC, which then forwards it to the final destination. For this reason, some consider the 1394 bus to have real-time characteristics.

If the distance between devices is important, then consider that 1394 defines cable lengths of 4.5 to 100m. The USB spec doesn't define a maximum cable length; instead, it defines a maximum propagation delay between connectors. Based on what cable vendors are offering, the maximum length is about 10m.

Software support is always a consideration in choosing a technology. Microsoft supports USB 2.0 and 1394a in Windows 2000. Later this year, Microsoft plans to have USB 2.0 support available for Windows 98SE and Windows ME, and both already support 1394a. As for 1394b, Microsoft is on record as planning to support it. Outside the desktop arena, check with your embedded-OS vendor to determine whether and when it will support either of the new standards. Finally, silicon costs will probably not be a huge factor. Chip vendors say that price differences between USB 2.0 and 1394b parts will be small. As more USB 2.0 and the first 1394b chips appear, we'll see whether that's true.□

CHIP VENDORS SAY THAT PRICE DIFFERENCES BETWEEN USB 2.0 AND 1394B PARTS WILL BE SMALL.

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