Playing with Fire

FireWire and mLAN are music to the ears of studio owners, performers, and desktop musicians. **R** ireWire (like USB) is a bus for connecting digital gear, and it is amazing for the kinds of data that it can carry at one time over a single cable. MIDI data, audio data, video data, control data, computer files; all can travel through the same path (see Fig. 1). What's more, the amount of data

that FireWire can carry is huge, and the amount gets larger as the data rate increases. (Faster data rates are on the horizon.)

FireWire's data is not just limited to the sounds that we know and love. You can hook up diverse equipment such as a synthesizer, a hard drive, and a scanner to a single FireWire setup. All the peripherals coexist without bumping into each other. FireWire cables have an advantage over USB in that FireWire can stretch for long distances. That makes FireWire ideal for wiring up studios and performance spaces (see **Fig. 2**). To better understand how we got where we are today, and to see where FireWire will go from here, let's take a look under the hood. FireWire was originally developed in the 1990s by a team at Apple Computer. The published standard as finally released by the IEEE (Institute of Electrical and

By Mike Overlin and John Strawn

Electronic Engineers) is about an inch thick and is officially known as IEEE 1394-1995. The number 1394 was simply the next

available number chosen by the IEEE in its running list of standards. Originally, the term *FireWire* was owned by Apple Computer. Sony came up with its own term, *i.LINK*. The term FireWire has now been released by Apple for everyone to use; therefore, that's the term that we'll use in this article. (For a list of FireWire resources, see the sidebar "FireWire Sites.")



ued to develop since it was first released. You'll see references to 1394a and 1394b (finalized in 2002). With those standards, faster bus speeds and longer cable lengths became possible.

The chips used to implement FireWire got simpler

to manufacture, and dif-

ferent kinds of cable, such

as fiber optic, were intro-

duced. Most of today's Fire-Wire products conform to

Power line. Like USB,

most FireWire cables (ex-

cept Sony's i.LINK) carry

power. You can therefore

have a small module, such

as a guitar stompbox, powered directly from

the bus without needing a wall wart.

Self-configuration. FireWire supports

plug-and-play and is self-configuring.

In other words, while the bus is up and

running, you can plug in a new device

or unplug something. There are limits

to the way you can connect devices. You

can, for example, connect all the nodes

in a single line or connect the nodes

in a star configuration (see Fig. 3).

There is only one configuration that is

Connectors. As things currently stand, you may encounter up to four

not allowed: a circle.

the 1394b standard.

WHAT FIREWIRE DOES

Like USB, FireWire lets you hook things up to a computer. Drivers are now available for the usual operating systems such as Windows, Macintosh, and Linux. Unlike USB, however, FireWire will run quite happily without a computer. That makes it ideal for situations in which a computer would be unnecessary, such as in permanent audio installations like theaters or churches. It also gives FireWire another advantage, because devices can talk directly to each other without having to go through a computer's operating system.

If you use FireWire in its original form, you can run up to 400 Mbps (megabits per second) over a copper wire. (Apple's new desktop computers now support 800 Mbps FireWire as well.) Each "hop" in the bus can be up to 4.5 meters long. Up to 64 devices (called nodes) can be connected to one bus; all 64 devices, however, must be within 16 hops of each other. With a maximum of 16 hops, a single FireWire bus can handle devices up to 72 meters apart (in the original FireWire spec).

The FireWire specification has contin-



FIG. 1: FireWire is a digital bus that can carry many kinds of data at the same time, including audio, MIDI, and other signals such as digital video and control data.



MIKE OVERLIN

FIG. 2: One or two FireWire cables can replace many audio and MIDI cables. The top photo shows a typical rear panel (the I/O unit for Yamaha's PM1D mixer) without the benefit of FireWire or mLAN. In the bottom photo, the same rear panel is shown reconfigured with FireWire and mLAN.

> kinds of FireWire connectors. The standard FireWire connector goes back to 1995. Sony's i.LINK connector is smaller, has the smallest number of pins, and doesn't carry power. Since 1394b supports faster data rates, two new connectors were developed for it. You can safely connect a 1394b device to any other FireWire device. But if you have several 1394b devices, you may want to connect them together, then connect any older FireWire devices. The reason is that the faster 1394b devices can talk at least to each other at faster data rates. But once the data encounters an older FireWire device, the slower data rates may be imposed.

By the way, there is a fundamental difference between older ways of connecting gear, such as MIDI, and FireWire. A MIDI cable shovels data in just one direction. But with FireWire connectors, there is no "FireWire Out" or "FireWire In" because data travels over the FireWire cable in both directions.

Bus reset. In the original FireWire (1394-1995), a short amount of time (called the bus reset) is required for the bus to configure itself. If you're performing onstage and someone wants to plug in, that could lead to an audible gap in the audio. Fortunately, 1394b introduced a way for the bus to reconfigure itself much more quickly, at least some of



the time. As a result, in many cases you won't even hear a break in sound when you plug in to a bus that's active.

In use. Several popular products currently make good use of FireWire. For example, Mark of the Unicorn's 828 and the more recent 896 offer eight channels of audio at 48 and 96 kHz sampling rates respectively. Euphonix has used FireWire for years for sending control messages. Digidesign's Digi 002 control surface uses FireWire to send control messages, MIDI, and audio back and forth to the control computer running Pro Tools. All of these devices should, in theory, run at the same time on the same FireWire bus without breaking each other or the bus.

In progress. An important new development is still being worked out: 1394.1, which finalizes how to use bridges. A bridge allows you to hook up more than one FireWire bus. You could then have one bus in Studio A, another bus in Studio B, and gear in one studio could "see" and "talk with" gear in the other studio across the bridge. Having separate buses connected by a bridge has one great advantage: when you hot-plug a new device into the bus in Studio A, there is no bus reset for the bus in Studio B. The original FireWire specification lets you connect up to 1,023 buses (each containing up to 64 nodes). The details of how to do so are what will be established in 1394.1.

SAFE AT ANY SPEED?

FireWire connections are classified according to how fast they can work. An S100 cable can carry data at about 100 Mbps. There are higher speeds at multiples of 100: S200, S400, S800, S1600, even S3200. They represent data rates of 200 Mbps, 400 Mbps, and so on. The top two speeds of S1600 and S3200, matching 1.6 Gbps (gigabits per second) and 3.2 Gbps, give rise to the name "gigabit FireWire." An S200 cable connected with today's hardware can carry about 80 channels of 24-bit audio at a 48 kHz sample rate (or correspondingly fewer audio channels at higher sample rates). The same cable can alternatively carry the equivalent of about 100 MIDI cables, or it can carry a mix of the two.

PACKET POWER

FireWire works by sending packets of data over the bus. There are two fundamental kinds of FireWire data: asynchronous, meaning "any ol' time" and isochronous, meaning "same-time." The asynchronous way to transmit data is used for data that needs to be transmitted reliably, but perhaps not very quickly. For example, control information has to be reliable as does the data in a file passed over the bus. About 20 percent of the bus capacity is reserved for asynchronous traffic.

Fortunately for musicians, the Fire-Wire designers put an emphasis on delivering the kind of data that we most often use. When you play a key, hit a drum, or stream a file, you have to know that the musical data arrives in a timely fashion. For that kind of data, isochronous messages are used.

Up to 80 percent of the bus traffic is available to isochronous traffic. When you plug a new device into the bus, the device "asks" the bus for the bandwidth it needs. If the bandwidth is available, it is reserved for the device. In that way, the device doesn't have to worry about whether the bus is overflowing. Because isochronous packets were available, they inspired Sony to adopt FireWire many years ago for its video products. Isochronous packets allowed several companies to develop audio for FireWire, which ultimately led to Yamaha's mLAN.

STANDARD FARE

It would be a good idea here to become familiar with some new terminology because you'll see these words used when referring to audio and music boxes that connect to FireWire.

As we said, it is the FireWire specification that tells how to bundle data into isochronous packets. Yamaha and some other companies have figured out



FIG. 3: When the FireWire bus becomes active, it figures out what devices are connected to it. This diagram shows two of the many ways to connect your gear with FireWire.

how to send audio over FireWire, building on standards set by various groups.

Working separately from the IEEE, the 1394 Trade Association, commonly known as the "T-A," has members from all over the world; many are consumerelectronics manufacturers. The Trade Association has developed standards on top of FireWire, especially for carrying audio and video data (see Fig. 4).

Because the 1394 Trade Association was not yet a formal standards body, it turned to the IEC (International Electrotechnical Commission) to bless the new standards. The IEC has assigned to the standard the basic number 61883, and there are subsets of the 61883 standard numbered 61883-1, 61883-2, and so on. The IEC 61883-1 standard defines a common way to handle audio and video.

The most interesting standard for musicians is 61883-6, which builds on 61883-1 and defines an exact way to handle audio and MIDI in FireWire isochronous packets. The IEC 61883-6 standard has formats for audio samples ranging up to 196 bits, floating-point audio, and MIDI messages. Yamaha made the original proposals for the formats given in 61883-6, which is sometimes also

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known as the Audio and Music Protocol (AMP). Even though Yamaha contributed significant parts of the 61883-6 standard, it is a public standard available for anyone to use.

The MMA (MIDI Manufacturers Association) chimed in also. It became interested because FireWire is capable of carrying MIDI without a MIDI cable. The MMA has now produced guidelines for extending MIDI (RP-027), which ensure compatibility with legacy MIDI devices.

In addition, the 1394 Trade Association has developed a set of standards known as AV/C, the audio/visual control protocol. It allows each device to implement what are effectively plugs—not plugs in the sense of the FireWire connectors, but rather plugs in the sense of, say, inputs and outputs on a mixer. The AV/C protocol also includes commands, such as Start, Stop, and Reverse, that are especially useful for consumer devices. Some networks and buses make you patch in a separate cable to carry a clock signal, such as house sync. That is not required for audio over FireWire. If you adhere to 61883, there is a clever way for a receiver to derive the clock from the data being transmitted.

THE MLAN CONNECTION

In addition to the 61883 standards, Yamaha has developed some improvements known as mLAN (pronounced "em-lan"). The mLAN standard gives FireWire audio and music devices some added capabilities (see Fig. 4).

One of the biggest improvements contributed by mLAN is in connection management. Why is connection management important? As we mentioned earlier, you can plug a new FireWire node into the bus, and the bus configures itself automatically. Then how do you connect the kinds of inputs and outputs that we normally associate with, say, a mixer, to other devices on the bus? Connection management is the answer. For example, a computer connected to the bus runs a connection management program that can talk to



FIG. 4: When you send audio and music over FireWire, you may be using standards from many different sources. For example, Yamaha's mLAN includes the MMA's recommended practice for MIDI, and Yamaha's own connection management and clock management functions were added to earlier FireWire standards.

FIREWIRE SITES

1394 Trade Association www.1394ta.org Apple FireWire www.apple.com/FireWire International Electrotechnical Commission www.iec.ch MIDI Manufacturer's Association www.midi.org Yamaha's mLAN site www.global.yamaha.com/index.html

the "plugs" in each mLAN device. Using a graphical user interface, musicians can connect inputs and outputs just as they've always done it. If you don't have a computer, you can use a user interface on some mLAN devices to do the same thing.

What's more, mLAN remembers a setup even when there's a power failure or the bus is powered down. Suppose you set up your equipment where your band usually rehearses. With mLAN, you can "memorize" whose equipment is connected in which way. When it's time for a live gig, you power down the gear. At the club where you're performing, you reconnect the mLAN gear using FireWire cables. When it's powered up again, the mLAN gear automatically remembers the inputs and outputs, even if you connect the gear differently. That makes setup much easier.

MLAN IN THE MARKET

A computer is often the heart of a studio, and the good news is that Yamaha has released mLAN drivers for OS 9. In a future update of OS X, Apple will release Core Audio mLAN support. That OS X capability was demonstrated at the winter NAMM 2003 convention in the booths of many mLAN licensees. Yamaha has released beta versions of mLAN drivers for Windows XP.

Several music and audio products already support mLAN. For example, Apogee offers an mLAN option for its Big Ben Master Word Clock unit introduced at NAMM 2003. Apogee's AMBus FireWire card supports mLAN and fits into the company's Trak2 microphone

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preamp and A/D converter and its AD-8000 A/D converter. Presonus offers the FireStation, a converter and interface with mLAN built in. The Kurzweil KSP8 signal processor has an mLAN option called the KMLN8.

Tamura's Qolle mixer line includes a 5.1 surround mixer called the izm125 with mLAN built in. The Tamura izm821 controller allows you to synchronize audio and video over mLAN. Korg offers an expansion option called EXB-mLAN for its Triton series. Otari's ND-20 audio distribution unit connects to other audio gear, including more ND-20s over mLAN. The FS96 digitalformat and sampling-rate converter from Otari can be augmented with Otari's I/O Card for mLAN connectivity.

Of course, Yamaha also makes mLAN devices. The mLAN8P lets you connect legacy devices to the FireWire bus. It offers up to eight channels of audio in and out as well as two MIDI connectors. To retrofit the gear you already have, Yamaha offers expansion cards that fit into synthesizers, such as Yamaha's Motif series, A4000 and A5000 samplers, and the S80 and S90. Yamaha has also developed mLAN expansion cards to connect virtually all of its digital mixers to the mLAN network, from the 01V to the PM1D (see Fig. 2).

The mLAN connection management lets you connect inputs and outputs from all of this mLAN gear, even though it comes from so many manufacturers.

WHAT WILL THE FUTURE BRING?

Now that we've been through the world of FireWire, audio, and mLAN, let's take a glance at what is coming down the pike. We've already mentioned that the IEEE is working on 1394.1, which will determine how bridges connect separate buses. In addition, you can expect that gear will become less expensive in the near future. That could happen because companies such as Yamaha, Philips, and Texas Instruments are producing individual chips that combine the functions of two or more other chips.

Given how computer-related technology advances, you can surely expect major advances in FireWire technology. In fact, in the not-too-distant future, you might even be running your Fire-Wire gear over a wireless network.

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