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LIGHT CONVERSATION

By Charlie Richmond

Now that computers universally occupy our desktops, the hot topic in office automation is *networking*: getting these "productivity enhancers" to communicate with each other. The same concern applies in the theatre, since so many technical areas are now computerized. The major difference between the office and theatre environments, however, is that theatre systems must operate in real time and must therefore be more responsive to the immediate needs of the show. It is unacceptable to have one system held up because of the lack of proper information from another. In practice, these systems have only begun to talk to each other electronically, but we can often see a similar problem when technical rehearsals are delayed because of a lack of inter-operator communication.

Office networking solutions basically comprise two elements: physical interconnection and a software "shell" designed to manage the transfer of data from one terminal to another. Some standard assumptions made in this environment are:

(1) data transfer will be made on an "as available" (or priority) basis (i.e. Not necessarily real time), and
(2) data being transferred is in "standard file format" (i.e. ASCII data strings which are destined for a printer, a similar applications program running on another computer, or for interim or permanent storage in a disk or tape data storage/retrieval system).

Both the physical interconnection and networking software are designed to support data transfer specifically under these assumptions.

But communication between computerized systems in the theatre has not been similarly implemented, nor, at the moment, can it be. Not only do the lighting, sound, and rigging computers not know how to talk with each other, their programs do not know how to exchange meaningful data. In truth, the Musical Instrument Digital Interface (MIDI) is used in some theatre sound applications, and some low-cost lighting controllers embrace this protocol. This allows rudimentary two-way communication, but it hardly qualifies as a network. What we need now is a theatre network standard providing the stage manager with a single terminal that communicates with the sound, lighting, rigging, cueing, front-of-house, and all other theatre systems in real time without delay.

The USITT Control Communications Standards Committee has been studying the applicability to theatre of a new broadcast/video control communications protocol called the ES-BUS. This protocol seems to embrace all our requirements, but, because it requires a separate time code reference and is well known to have substantial delays in communication, it is fatally flawed for theatrical applications. Interestingly, the ES-BUS was specifically designed out of a need for a fast, universal, fault-tolerant control communication standard and, despite criticisms, is already becoming well accepted. But real-time applications were not considered during its development, and so the ES-BUS will never be what we need, although its comprehensive capabilities will help us define our own network requirements.

The development of computer networking solutions has been one of the most diverse and hotly debated areas of modern technology. Current network and pseudo-network designs have accomplished everything from low-cost multi-computer/ terminal hardware communication to high-speed, high-performance supercomputer intercommunication. Even in the areas of commercial, industrial, and concert sound, networks of varying capabilities have been developed with proprietary characteristics and varying performance capabilities. This means that, although electrical connections may follow prescribed standards, one manufacturer's equipment cannot talk with another's.

A committee of the Audio Engineering Society has been formed recently to attempt to define a standard for control communication in the commercial/industrial sound environment. The criteria for this standard does not specifically include the needs of live theatre, but, as a member of the committee, I will be pressing strongly for comprehensive real-time system response. It is much too early to predict whether or not we will be successful in defining a communication standard acceptable to theatre.

FIBER-DISTRIBUTED DATA INTERFACE

With this introduction, I would now like to present an emerging standard which promises to be everything we need and more: FDDI, or Fiber-Distributed Data Interface. This new protocol defines botht he physical connection and the data transmission characteristics so precisely that any FDDI equipment which is integrated with an FDDI system, even while it is operating, will immediately and automatically process, correct, and re-transmit all system messages. This standard has been under development by a subcommittee of the American National Standards Institute (ANSI) for more than four years and is both the most advanced and the most comprehensively defined network standard yet.

It offers all the advantages of fiber-optic technology together with a highly advanced communication protocol. Data transmission rate is ten times that of the fastest traditional high-performance networks, and the installed cost of fiber-optic cable is actually lower than thick coaxial cable. Transmission distances are much longer in FDDI, with several kilometers possible between stations using single-mode, low-dispersion, low-attenuation glass fibers. This thin cable is easier to handle and occupies less space than copper conductor cables, and even less expensive fiber may be used for shorter distances. Finally, fiber-optic cable is completely immune to electrical interference of all types and produces none of its own, eliminating the need for certification of systems with the FCC or similar regulatory agencies.

In its fullest implementation, FDDI transmits messages from any station or node to any other via a multi-token ring system, which allows virtually any number of tokens to be passed simultaneously and provides for many levels of priority to be assigned to both the nodes and the message packets. There are two concenttric and redundant rings, both of which normally carry the same messages and are compared by each node to aid in error correction and system analysis. Each nybble (half a data byte) is sent in a coded parity bit error-correcting format so that ring redundancy is not required.

The system is designed to be so thoroughly fail-safe that if one of the redundant rings is unreliable or even severed completely, no data is lost or affected and the system automatically reports the location of the fault! Even if a particular node becomes faulty or loses operating power, an optical bypass automatically diverts both incoming light signals directly to their respective outputs, and the lack of communication with that node is reported. Whenever new nodes are added, an automatic interrogation procedure fully integrates them into the system.

But what about using such a powerful network in the theatre? How difficult is it going to be for system designers to give their communication interfaces the comprehensive capabilities required? Actually, it turns out that it will be very easy. Major component manufacturers are already manufacturing modular FDDI connectors, compatible cable, and, most importantly, complete integrated chip sets, making the addition of an FDDI communications port potentially as easy as adding a hard disk drive.

Communication cards are now being designed using a five-chip integrated circuit set which automatically performs encoding, decoding, error correction, ring-integrity checking, redundancy, token-passing, priority arbitration, timing correction, fault detection, node-address generation, message-packet data storage and retrieval, local multi-port buffer memory management, and local processor communications management.

These chips are brand new and not particularly cheap, but, as integrated circuit prices decrease, this will soon be the most cost-effective way to create any type of networking capability. Even in the short term, I believe that whatever costs might be saved by using lower-cost non-FDDI hardware, much more than that will be spent in software development simply to create a system that only approaches FDDI's sophistication.

Once FDDI becomes our standard, we can then define standard theatre network messages, assign dedicated node addresses, and generally become part of the expanding FDDI standard. The same FDDI fiber optic backbone of our technical theatre systems can also provide communication between front-of-house and backstage, box office and accounting, production and management, design department and scene shop, payroll and personnel. It can be an electronic mail and messaging system and can be used for virtually any other communications purpose in the foreseeable future. It can do all this and at the same time fulfil our requirements for a comprehensive real-time control system. A 100-megabit per second (100 000 000b/s) data communication rate with over 2(48) (256 000 000 000 000) node addresses available ensures non-obsolescence for a long time.

THE FUTURE

So, if all this is possible now, what will the future hold and how does FDDI fit in? In fact, FDDI II is close to being a standard of its own; completely compatible with FDDI and possessing the same physical interface, it adds a number of enhancements. The major feature of FDDI II is a time-division multiplexed mode provding individual routes within the network with a variety of guaranteed data transfer rates. This allows the system to automatically divide itself into high priority time-sensitive sections as well as lower-priority sections. The high priority sections (indeed, the entire network) can then operate in a synchronous mode providing optimum data transmission speed between any two nodes.

What speeds are we talking about? Enough to transmit 24 channels of digital audio or a fully digitized high-definition video picture all in real time. In addition, the network can redefine itself at any time to perform real-time control functions again. And, with FDDI's current transmission rates, the potential of fiber optics is only being partially utilized. These cables are capable of 10 to 100 times these speeds, depending on the distance involved, and can be increased to that level when transmitter and receiver technology is developed.

When these data rates are available, our existing FDDI system can still utilize the same fiber-optic cables along with the newer high-speed equipment. The new system will handle its own data as well as identify FDDI data and pass it on our “old” system. Although the current FDDI node hardware is unable to handle such extremely high speeds, future hardware will easily accommodate our needs as a simple subset of its local communication options. Or it may be more cost-effective to simply replace all FDDI nodes with new ones that do everything the old ones did, but at a faster clip.

Yet another suggestion for increasing fiber-optic transmission density is to use different wavelengths of light to transmit different channels of data on the same fiber. In effect, a different color of light can be used for each channel and the different colors can be both merged for transmission into the fiber and split upon reception via prismatic refraction. When we count the number of ways in which we can foresee increasing the already enormous capabilities of fiber optics, the future for this communications medium seems virtually unlimited.

As usual, the needs of the theatre will play an insignificant role in the ultimate development of these standards since they are really driven by users with much larger budgets. What remains a great satisfaction to me in this age of high technology is the knowledge that the theatre will continue to use man's most advanced achievements to communicate his most fundamental emotions.
