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How to Design and Build an Audio Network with Products that Utilize CobraNet Technology

Kevin Gross and Richard Zwiebel

Sound & Video Contractor, Dec 1, 1997


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Audio Networks have been a very hot topic lately. Several manufacturers have either announced, or introduced networkable audio products. Specifications are on the streets specifying audio networks, several major projects have been installed utilizing the technology, and there have been many recent articles on the subject. The incorporation of CobraNet technology into the products of at least six professional audio manufacturers (Crown, EAW, L.C.S., Peavey, QSC, and Rane) as the multichannel digital audio and control interface certainly sends a strong message to the industry that audio networking has arrived. In the October issue of Sound and Video Contractor Magazine the authors wrote an article which explained what CobraNet technology is.

So now you are ready to design or install your first CobraNet networked audio system and you need to know how to start. The purpose of this article is to explain the real world "hands on" information of how to design and install a CobraNet audio/control network.

Overview of CobraNet Technology CobraNet is a data transportation system. It carries multiple channels of digital audio, along with control data over standard 100MB Ethernet networks. Ethernet is a very well established "standard" for computer networks, with over 50 million nodes installed worldwide. Products are offered by numerous vendors, and since it is driven by the huge computer industry, the cost of the parts and equipment keep dropping. A 100 MB hub that cost about \$2000 one year ago, sells for about \$189 today.

How does it work? CobraNet delivers the audio and control data from all input devices to all output devices. Each output device has a unique address, each data stream being transmitted by an input device is directed to one or more output devices through this addressing scheme. All audio and control data reaches all devices. Each device "picks off" only the data that is addressed to it. This means that when you are designing your network, you need to be concerned with good network design practices, rather than which audio is going to which node on the network. This is quite different from traditional analog audio system design. This also allows for a great deal of flexibility and future changes or upgrades, since these changes will not require physical wiring changes, only address changes

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Advantages of the Networked Approach There are several key advantages to using CobraNet for audio distribution. CobraNet offers an entirely digital solution. This, of course, affords superior sound quality but also offers a number of less obvious benefits. A digital data stream offers more immunity to electrical interference. A data stream delivered via optical fiber offers complete noise and lightening immunity for the harshest environments. Even when only copper cabling is used, ground loop issues are handily eliminated by the mandatory transformer isolation and electrical robustness of Ethernet. Datacomm networks are designed to carry multiple non-interfering traffic streams. The recent 10 and 100 fold improvements in Ethernet bandwidth allows CobraNet to deliver at least 64 channels of audio over a single category 5 unshielded twisted pair cable or a pair of optical fibers. The capacity of CobraNet over such commodity cabling results in a significant reduction in cabling and infrastructure cost and complexity. Data communications networks also offer almost limitless flexibility with regards to routing of data on the network. This flexibility also carries over to a CobraNet network. An audio channel sourced onto the network is simultaneously available at any other point or points at any time. There is no need for rewiring or even re-patching to make those inevitable unforeseen audio connections. In this regards we see CobraNet as the audio distribution sister to field configurable audio processing systems such as Peavey's MediaMatrix. CobraNet's flexibility allows unforeseen or overlooked system requirements to be accommodated in the field - even at the last minute. Like the configurable processing systems, the operation of a CobraNet network can be reconfigured for special events and the network may be economically expanded at any time. Other advantages of the networked approach include the ability to centrally monitor the entire network from a central point or points. And, since CobraNet does not disable any of the standard data communications capabilities of the Ethernet network, control data may be carried over the same cables as the audio, eliminating yet another infrastructure expense and complication.

Designing an Ethernet Network What are the steps I need to take in designing the network? 1. Determine where the audio network nodes need to be located, and how many nodes there will be.

2. Select the audio products that best suit the needs for each location. Products that include CobraNet I/O, can connect directly to the audio/control network. Products that do not offer CobraNet I/O can be connected to the network via an interface product such as the RAVE units manufactured by QSC.

3. Determine how many channels of audio need to be transmitted over the network. Also, determine if the network needs to be one large network, or multiple smaller networks. To do this, first determine if there are certain audio/control data sources that will never go to certain locations. An example of this might be in a theme park where each attraction has audio and control data being transmitted bidirectionally between the attraction and a central equipment room. The audio data from one attraction will never go to another attraction, therefore these can be separate networks. The next step is to examine the distances and locations, as well as the channel counts for each node. In the theme park example, if the two attractions were located close together, while the central equipment room was located far away, it might make sense, from a cabling perspective, to put the two attractions on the same network. One must also examine the total number of audio channels. If there are less than 64 total audio channels, one network may be the best choice.

A stadium can be a good example of an application where separate networks are not a good idea. In the stadium, any audio source may want to be outputted at any node on the network. And the audio routing may change from one day to the next. As an example, it may

be desirable to have a radio feed come out of the speakers that cover the concession areas during a baseball game, but have an announcer come out of the same speakers during a tractor pull. One network allows all inputs to reach all outputs.

A hybrid example might occur in the above stadium, where perhaps, there are two meeting room areas that simply need to be tied together in a point to point manner. In this case, the bulk of the stadium would be on the primary audio network, while the two meeting rooms would be on a separate, dedicated CobraNet network

4. Lay out the network design, this includes reviewing the distance rules, selecting the cable type, selecting the network products such as hubs, and locating the devices and cable run locations. You may have many options and this is explained with numerous examples in the remainder of this article.

Ethernet Overview A CobraNet network is an Ethernet network except that instead of connecting computers and other data terminal equipment to the network, audio I/O devices are connected. We'll start this overview by showing how modern Ethernet networks are constructed. While many may be familiar with the original Ethernet networks run over gregarious 5mm or fragile 2mm coax cable, this type of Ethernet has fallen largely out of favor in the data communications industry. The coax has been replaced with cheaper and more reliable unshielded twisted pair cabling. As we'll see shortly, the vulnerable daisy chained topology of these coaxial networks has given way to a robust star topology. Twisted pair Ethernet is known as 10BASE-T for 10Mbit operation and 100BASE-TX at the 100Mbit rate. Since the older 10Mbit Ethernet does not provide adequate bandwidth for most audio applications (and is not supported by CobraNet), we will concentrate exclusively on the 100Mbit Ethernet for the remainder of this article. The simplest possible Ethernet network is shown in Figure 1. This network allows only two devices up to 100 meters apart. While Ethernet patch cables are generally wired straight pin-to-pin, this network requires a special "crossover cable" wiring - essentially the equivalent of a "null modem" cable for Ethernet. If the 100 meter maximum distance is a problem or if EMI or lightning isolation are desired, the data can be carried over optical fiber (allowing distances of up to 2 km) as shown in Figure 2. Just as with the twisted pair implementation, 100Mbit Ethernet over multimode fiber has been standardized by the IEEE. The multimode fiber incarnation is called 100BASE-FX. Both of the "networks" shown thus far may be populated with no more than two devices. In order to build more realistic networks, a centrally located hub as demonstrated in Figure 3 is employed. A hub is a simple device that combines the data signals from numerous network devices and routes them back to all other connected devices. Hubs usually display an array of "idiot lights" which aid in diagnosing network problems including bad or disconnected cables. Ethernet hubs are commodity products available from many manufacturers, distributors and catalogs. 100Mbit Ethernet hubs are available with 4 to 24 or more ports each and run as cheap as \$25 per port. The network shown in Figure 3 could be implemented with a three port hub if such a thing existed. A four or eight port device would probably be specified depending on whether future expansion is foreseen for the network. Swapping out hubs for larger ones is not the only way to expand an Ethernet network. Hubs from many vendors are "stackable" meaning that, for instance, a sixteen port hub may be constructed by stacking two eight port devices and attaching a proprietary interconnect cable between them. Hubs may also be cascaded as shown in Figure 4. Any of the techniques described thus far for expanding networks can be combined to build even larger site-specific solutions. An example of such a solution is shown in Figure 5.

Distance Limitations In designing an Ethernet network you must take care not to exceed the capabilities of the technology. 100Mbit Ethernet

requires category 5 cabling. The category 5 rating applies not only to the cable itself but also to the installation and termination thereof. Some care must be taken in these matters - especially for the longer runs. Hand held Ethernet cable testers are available to measure characteristics and length of installed cables. Ethernet has specific distance limitations. 100Mbit Ethernet can go no further than 100 meters over category 5 cabling. The signal becomes too degraded and weak over longer distances. Ethernet hubs regenerate the data signals so a 200 meter run can be achieved if a hub is inserted in the middle. A far better approach as demonstrated in Figure 2 is to jump to fiber. Signal degradation is much less pronounced over fiber allowing for uninterrupted runs of up to 2 kilometers. Fiber installation is not the pricey rocket science it once was. Fiber optics represents the future (if not the present) in infrastructure for large facilities.

Distance limitations due to signal degradation are but one of two types of distance limitation imposed on Ethernet installations. The other distance limitation arises due to timing issues on the network. As a network becomes larger, it takes more time for a signal (moving almost the speed of light) to travel from the originator to all points on the network. According to operating principles of Ethernet, it is a requirement that all devices on the network receive the signal within a certain interval. This timing requirement has the effect of limiting the maximum diameter of a network. The diameter is essentially the cable distance between the two most remote devices on the network. If you have two remote equipment rooms with CobraNet DTE devices connected to a hub in a central control room and each remote equipment room is 500 meters from the central equipment room, the network diameter is 1000 meters. By keeping the network diameter less than 2km for either category 5 cable or fiber optic cable, you do not need to be concerned about network timing issues. If you must have a network diameter that is larger than this, you must go through the calculations. Details on accurately computing a network diameter can be found at <http://www.peakaudio.com/CobraNet> - look for "Network Configuration Guidelines." By the book, 100Mbit Ethernet allows a network diameter of just over 200 meters. Due to the way CobraNet uses an Ethernet network a CobraNet network may be over 2 kilometers in diameter.

CobraNet Devices Now that we know how to build 100Mbit Ethernet (and thus CobraNet) networks, we'll have a look at the devices with which a CobraNet network is populated. In the previous figures, these devices have been labeled "CobraNet DTE". DTE or Data Terminal Equipment is a networking term for any device attached to the network. In the case of CobraNet, these devices transmit and receive digital audio data on the network. Any audio devices such as a preamplifier, audio processor, mixer, or amplifier that inputs and/or outputs audio data in the CobraNet format is a DTE.

A key point to understand with CobraNet is that all "CobraNet compliant devices" have been tested for compliance and will seamlessly interface with all other "CobraNet compliant devices" on the network, regardless of manufacturer.

CobraNet Capacity A single CobraNet network has a capacity of 64 audio channels. Unconnected audio inputs will consume audio channels on the network. If the design exceeds CobraNet's capacity, you'll first want to check your design to see whether you are efficiently using the network. As an example, you may be sending the same 8 signals to two or more different speaker clusters. Although you're going to two or more different destination locations, this should only consume 8 channels on the network. If you have a multi-use facility, try to identify mutually exclusive audio sources. An audio source can be shut down when not in use, saving network channels for other uses. If the system still exceeds CobraNet's capacity you may wish to consider installing multiple CobraNet networks. You lose some flexibility in that you will

not be able to readily exchange audio between the networks, but there is usually little difference in cost between building one large network and building two or three smaller ones.

Operating Parameters The CobraNet protocol for distribution of audio over a dedicated Ethernet network is currently at revision level 1.0. Audio distribution at either 16 or 20 bit resolution is supported. 48Khz sample rate is supported exclusively. Because data must be arranged into packets for transmission onto the network, there is a data buffering delay of 5-1/3ms across the network. This delay is constant from any source to any destination on the network. A version 2.0 of the protocol is expected to be released in n1998. This enhancement will allow for more flexibility in the designation of channel block sizes, will likely introduce a 24 bit audio format and should allow for configuration of the network for shorter delays at the expense of channel capacity, or greater channel capacity with greater delay. Support for datacomm industry standard Simple Network Management Protocol (SNMP) and switched Ethernet networks are additional enhancements on the CobraNet horizon.

Control Data Many professional audio manufacturers have products that can be remotely controlled. The products of several of the manufacturer's of CobraNet products provide (or will in the near future) control data that can be transported via Ethernet. By introducing this control data via a host port on a CobraNet product, the data will be sent over the network in a manner that prevents it from causing collisions with the audio data. Since each Ethernet packet provides both source and destination information, there is no possibility of the control data that is being transmitted accidentally effecting any product, regardless of manufacturer, that has not been specifically addressed.

CobraNet provides an easily implemented, cost effective method of networking audio products from many manufacturers together in the digital domain. By learning and applying the basics of network design, the systems contractor can optimize his or her designs.

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