A Special Technology Report
Using Internet Protocol for Audio & Broadcast
An IP Guidebook for Radio

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Welcome to IP

This Special Technology Report on Using the Internet Protocol for Audio and Broadcast is intended as an IP guidebook for radio broadcasters, and aims to provide an introduction to the basic concepts and applications of a new technology that should prove to be exceptionally important as it is integrated into radio facilities in the coming years.

The common data platform of IP, already well-established in the computer networking environment, is now beginning to open doors for the cost-effective transfer of digital audio and program-associated data in the professional production space, providing universal connectivity between many different types of products in the broadcast signal chain and throughout the installed base of IP networks.

As a result of IP technology growth, an entirely new way of studio planning, design and system integration is developing. Like most new technologies, there are concerns among industry professionals about its widespread deployment and acceptance. The pages that follow will explore these issues and the many values of current and proposed future usage of IP technology in the broadcast environment.

“Of special interest to broadcasters are IPv6’s improvements in multicast functionality and its support for real-time data flow, host mobility and security.”

The editors of Radio World, recognizing the significance of this developing trend, have devoted this entire publication to the subject of IP Audio. It’s written by Skip Pizzi, a Contributing Editor to Radio World, who has built a career on working at the leading edge of audio and broadcast technology. His years of experience in the world of digital media standards, PC software and the Internet make him an eminently qualified guide for your tour of this emerging paradigm for audio distribution.

We hope you find this guidebook a useful and informative presentation of a technology that many feel will have the biggest impact on the radio facility since the introduction of the PC.

The ABCs of IP

Like the acronym “CD,” which has two distinct and equally popular meanings — one from the music world and one from the financial — the term “IP” is ambiguous and necessarily defined by its context. Even then it sometimes is unclear, given the high-tech world’s overlapping interest in Intellectual Property and Internet Protocol. In this case, we are concerned with the latter.

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The Internet Protocol specifies these functions as it defines the format of packets of data used on IP networks (called datagrams), and the scheme used for their addressing. The latter function defines the IP address assigned to any device on a network using IP (such as a LAN or the Internet), and is specified as a 32-bit numeric address, written in the form of four decimal-format numbers separated by periods. Each of the four numbers can range from zero to 255, such as 155.80.220.1 or 16.199.1.255.

IP is combined with a higher-level protocol called Transmission Control Protocol (TCP), which is used to initiate a connection between devices on the network. While TCP establishes a path from a source to one or more destinations on a network, IP addresses and packages the data that flows on the path.

Although the TCP/IP pairing is common, IP data can be used with other transmission protocols such as the User Datagram Protocol (UDP). In contrast to TCP/IP, a UDP/IP approach provides fewer

In contrast to the familiar OSI model that divides the network stack into seven layers, the IP approach defines only four, as shown on the left. At right are examples of typical protocols or functions used in each layer. (ICMP = Internet Control Message Protocol; IGMP = Internet Group Management Protocol)
IP Audio in the Radio Facility

In the beginning there was analog, and it was good. Then came digital audio, and it was better (after a little tweaking). Next followed data compression, and it was, well, controversial, yet enabling. Now comes the next stage, IP audio distribution. It is widely considered a significant move forward. Here's why.

THE FUTURE

The current version of IP is called IPv4. The successor system, now beginning deployment, is called IPv6. The core set of IPv6 protocols became an Internet Engineering Task Force draft standard in August 1998. (The IETF is the technical standards body for the Internet.)

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It may be hard to believe, but IPv4 has been in use for nearly 20 years. Although it has served remarkably well over that period (if six months is an "Internet decade," IPv4 has lasted four Internet centuries!), it is showing signs of aging. Like the telephone system, its success and popularity have forced it to grow beyond initial design expectations. The most fundamental problem with IPv4 is the limitation of its addressing scheme. As more and more devices connect to the Internet, a shortage of IPv4 addresses is occurring.

IPv6 will allow more unique addresses in a hierarchical fashion, providing substantially improved scalability for the Internet. This will become increasingly important with the expected growth in mobile devices and the use of the Internet for entertainment content distribution to multiple devices in a user's domain.

The new system also improves routing and network auto-configuration. IPv6 is designed to coexist and interoperate with IPv4, allowing a long and gradual transition period, which has begun. This evolutionary design is a fundamental premise of IPv6, not an afterthought.

IPv6 also envisions more multimedia usage of the Internet. Of special interest to broadcasters are IPv6's improvements in multicast functionality, along with its support for real-time data flow, host mobility and end-to-end security. Broadcast customers will enjoy IPv6 "plug-and-play" installation of local network devices and easy selection of service from multiple ISPs.

As useful as IP is today for broadcasters, it will only get better as the migration to IPv6 continues.
signal transport that was regarded warily by audio pros to a highly favored approach. These LANs are used for the transport of all sorts of computer data. At radio stations this often includes audio files, although generally in the form of file transfers of completed, stored programs between PC hard drives.

"The IP Audio network can be extended from LAN to WAN applications among facilities around the city, region or world."

In addition, the growth of online media applications has given rise to systems specializing in streaming and the file-transfer of audio in the TCP/IP data format used on the Internet.

All of these processes have created an environment that allows for the substantial streamlining of computer-based digital audio in the broadcast facility and a move to the next level: real-time signal routing using IP networks.

**LEVERAGING BENEFITS**

Putting these elements together provides a favorable arrangement of technologies for today's radio studios.

Given the maturity of current-generation PCs and networks, much of the discrete and traditional circuit-switched approaches used in radio now can be replaced by a more modern, packet-switched interface style without sacrificing quality, reliability or user friendliness.

In this brave new world, audio still typically makes its initial entrance into the computer environment through a sound card; but once in that “PC domain,” it now can stay there much longer as it courses through the radio station's regular processes.

Instead of coming back out of each PC used in the broadcast facility as an audio signal of some type — analog, AES3, S/PDIF, MPEG Layer II, etc. — and being routed through mixing consoles, processors, routing switchers and other storage devices in that form, the data can be transported through these chains in IP format via LAN-type connections.

Alternatively, new terminal devices can eliminate the need for a PC and sound card at any audio I/O point on the IP network. These small, inexpensive units look and act like modems, converting one or more sets of analog or digital audio input(s) and/or output(s), on XLR or other typical audio connectors, to IP Audio on Ethernet via an RJ-45 connector.

Today's computer hardware and LANs — and an increasing amount of professional digital audio and broadcast equipment — now allow this without compromise to the robust, real-time processes that radio facilities demand.

Moreover, they can accomplish this at a substantially lower cost than the dedicated devices traditionally used for these processes. Just as broadcasters harnessed the considerable processing power and economics of scale of the PC for audio storage, production and automation, now the same kind of value can be applied to the end-to-end signal path in the radio station.

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The Belden DataTwist CAT-6 cable is simple and cheap.

The greatest savings come in the wiring and routing systems of the station.

Instead of requiring specialized analog audio or AES3 crosspoint switchers, signal destinations are simply given unique IP addresses, and audio files or real-time signals are routed as packets on the audio LAN. Signal routing and switching can be managed by relatively inexpensive Ethernet routers or hubs. Ethernet switchers allow each link to own its entire theoretical bandwidth, and full-duplex operation is now routine. System expansion also is simple and cheap.

Intermediate processing and other station devices also can do without expensive audio I/Os and ADCs/DACs stages, using an Ethernet port instead. A single RJ-45 jack can replace many XLR connectors on these devices, further reducing the physical size and cost of the hardware as well.

Using IP data for audio transport also allows users to employ the connectivity that already exists in a private corporate environment, or readily available systems in the public switched environment. This can provide lower cost alternatives to dedicated audio circuits, or allow connectivity where dedicated paths cannot be provided.

Another advantage of IP that may become
more important over time is its inherent ability to mix various media types in a synchronous manner on the same link. An example of this could be the integration of program audio streams with visual auxiliary data envisioned for future digital radio transmission, or for advanced Web services. These applications need not be constrained to the physical facility.

"Much of the discrete and traditional circuit-switched approaches used in radio can now be replaced by a more modern, packet-switched interface style."

The IP Audio network can be extended from LAN to WAN (wide-area network) applications among facilities around the city, region or world. Products taking this approach are beginning to hit the market, and all indications point to this becoming a mainstream trend in the radio studio audio environment soon.

Adapters that take program audio and convert it to/from IP packets for transmission already are available. These can be used in local or global contexts, across any kind of link supporting IP transport. This implies that their application can range far beyond the studio environment to interfacility links using the public Internet, virtual private networks, ATM or Frame Relay connections, packet switched networks or even DSL and cable modem systems.

This provides extensive flexibility and cost-effectiveness in setting up permanent or temporary point-to-point or point-to-multipoint, multichannel STLs or remote backhaul systems using IP transport for audio signals.

CHALLENGES, COMPARISONS

One of the early criticisms leveled against IP for professional use was that it was a packet-switched system not well-suit for robust, continuous, synchronous connections at constant bit rates required in a radio environment.

Moreover, IP networks often are “best-effort” systems, meaning that there is no guarantee of continuity or specified error rate, nor is there any quality-of-service (QoS) functionality that would allow tradeoffs between payload capacity and robustness, as offered on some other digital paths and networks. The dropouts, delay or impaired audio fidelity that would result were considered unacceptable in earlier times.

Various coding techniques were developed to manage these issues. Some used redundant coding, in which data was transmitted multiple times. This reduced the effective payload bandwidth available, but added significant reliability. Other systems took a nonredundant approach, in which sophisticated receive-end processing was used to compensate for lost bits. These were the basis for the first streaming audio systems developed in the mid-1990s.

More recently, QoS support has emerged in the IP world; the Resource Reservation Protocol (RSVP) is a prime example. This work has occurred primarily in the telephony space, where service robustness is highly valued, as in the broadcast world. In fact, much of the funding and development of the advances in IP now trickling into the pro audio environment has come from telecom.

As a result of these advances, and the more localized scope of application, IP-based systems intended for professional broadcast use today need not exhibit any of the artifacts typically ascribed to streaming audio on the public Internet, where high latency and signal losses or impairments remain common.

"It is expected that the technology eventually will become the dominant mode of audio transport in broadcast facilities."

The power and advantage of IP Audio broadly deployed in the radio space presents a scenario in which content can flow in nearly unlimited fashion, and at substantially lower cost and higher quality than that of earlier processes. The change is profound and worthwhile.
What’s Next for IP?

The current level of development in radio stations toward IP Audio over Ethernet for primary, real-time audio distribution looks like it may be the vanguard of a trend that will take hold and become universally adopted in short order.

Like the CD format in the 1980s, the new technology may hit a few potholes on its road toward acceptance, and the trip may be uphill in some more traditional circles; but it appears likely to succeed eventually.

A number of manufacturers have incorporated this technology into their products to significant advantage for their customers (see Vendor Guide, p. 14). As a result, these companies probably have the best view on where development of this technology is headed.

For example, Steve Church, president of Telos Systems, is bullish on IP Audio’s prospects.

AES3, the current standard for professional digital audio interconnection, is “looking ready for retirement,” he said. “It was designed in the dark ages before PCs and data networks were everywhere.” He pointed out that formats’ shortcomings: “It only has a two-channel, unidirectional capability. It can pass data only in a primitive and slow fashion. It usually uses soldered-on and bulky XLR connectors. It cannot leverage components from the high-volume computer network world.”

Weighing this against the alternatives, he concluded, “Ethernet is better on every count.”

Dan Braverman, president of Radio Systems, agrees — not surprisingly; his company has been one of the first and foremost backers of IP Audio for radio facility infrastructure.

“I think that the heavy dose of IP in every broadcast facility is rushing this technology on us all,” he said.

Braverman feels a sense of urgency in this transition: “Digital routers and consoles, digital delivery systems, ISDN phone interfaces, codecs, TCP/IP-based remote control and even the GM’s PC are forcing all of us to learn, confront and integrate this technology. In other words, we can’t ignore it.

The biggest challenge we face with the new technology is keeping personnel trained and capable of using the new features.”

“Stations should always use corporate security. That’s why developments in those fields are significant to our future.”

He added, “It is interesting that AT&T was one of the co-inventors of ATM, but apparently will not use it for their next network phase.”

He mentioned other leading manufacturers that are moving accordingly: “Cisco has been giving high-profile demonstrations for a few years of their routers running high-quality IP Audio and video alongside data traffic. VoIP telephony has moved from the experimental phase, with 3Com, Nortel, Avaya, Siemens and most of the other telecom gear heavyweights offering and promoting real IP-based products now.”

COORDINATING EFFORTS

As the IP Audio revolution moves into the radio environment, some manufacturers feel that a coordinated, radio-specific approach should be taken. For example, Church says that IP Audio over Ethernet can help stem the tide of multiplying formats in the radio station.

“Most radio facilities have at least four networks in place: an Ethernet for the computers, a proprietary PBX for the office phones, dedicated on-air telephone system wiring and traditional audio wiring. The last is the least modern and most difficult to install and maintain, with its thick multiconductor wires, punch blocks, soldered-on plugs from the ‘50s and ad-hoc mixture of digital and analog in both pro and consumer forms. Ethernet gets us past all this.”

With all the advantages they bring, IP-based systems are also exposed to new threats and vulnerabilities. SCMS’s Central Regional Sales Manager Bernie O’Brien thinks the biggest problem stations face in this area are hackers and viruses.

“Stations should always use corporate virus subscriptions that automatically update, since most others are not updated properly or regularly,” he recom...
Some industry vets question the value of an IP-based approach to audio transport, or feel that the technology is not yet mature enough for deployment. According to Chris Crump, Director of Sales and Marketing for Klotz Digital America, “There are some problems with the current iteration of Internet Protocol that limit the reliability of the medium.” Crump believes that the real value of this approach will not take hold until there is broader deployment of IPv6 and related, next-generation systems. “It will probably require the very expensive and extensive rollout of the much-talked-about ‘Internet II’ and a fully-fibered network infrastructure to really make this a viable medium for large-scale content delivery,” says Crump.

He also notes that, while most manufacturers are moving beyond AES3 for digital audio routing within the studio, some prefer a proprietary approach instead of a fully IP-based solution today. These manufacturers are likely to offer full, end-to-end systems so they can provide a complete package, while others have chosen to use an optimized IP-based solution.

Crump says that Klotz remains open to the idea of using an IP approach for inter-facility audio distribution, noting that, “We'd be interested to see if there is truly a need for secure media transfer utilizing Internet technology.”

Meanwhile, Bill Gould, the Broadcast Products Manager for Intraplex Products at Harris Broadcast Communications, thinks that answer is already known. He feels that IP Audio transport provides added flexibility and cost-effectiveness to broadcasters today, using existing LAN/WAN infrastructures, DSL or cable modems. “These facilities exist many times and in many places where dedicated copper does not,” says Gould. “Using managed packet-switched networks like ATM, Frame Relay and corporate intranets, and even the Internet, will dramatically cut inter-facility communications costs,” he adds.

Gould also thinks the continuing deployment of IPv6 and other service improvements make future prospects bright for this technology. “Rapid improvements in the quality of service in packet-switched networks will make them increasingly desirable for professional audio applications,” he says. He expects particular interest in the short run from station groups who have (or have plans to) install robust inter-facility 10/100Base-T networks.

Longer-term, Gould is optimistic in his forecast for IP Audio distribution. “Imagine the station of the future with all consoles, storage devices and even audio processing and transmitters sitting on a LAN with integrated audio distribution and distributed control over a single CAT-5 wire,” he muses.

Mike Uhl, director of sales for Sierra Automated Systems, thinks that movement in this direction, at whatever pace feels right, is inevitable. “Taking advantage of computer-based technology is a sensible macroeconomic solution. Utilizing affordable technology for professional purposes is the way to go, if it can be done without sacrificing quality,” he said.

To this end, SAS uses IP for control, while keeping program audio in the analog or AES3 environments. “Using IP for control allows the router to talk to other devices like digital consoles, and this provides a seamless and welcome integration of functions for the operator.” SAS plans more in this direction, with a current project developing control panels that can interconnect to the router via the regular station LAN.

There are some problems with the current iteration of Internet Protocol that limit the reliability of the medium. - Chris Crump, Klotz Digital

HYBRID PATHS
Some manufacturers are taking a step-by-step approach to IP Audio.

Mike Uhl, director of sales for Sierra Automated Systems, thinks that movement in this direction, at whatever pace feels right, while some companies do not yet transport program audio via IP, they have adopted the multiplexed digital approach over CAT-5 cable, using RJ-45 connectors, so a single cable type can be used for all digital signals. Cost savings on installation labor for such a system can be substantial.

For example, on one such system, a single RJ-45-terminated CAT-5 line can replace up to 96 individually shielded twisted-pair lines. Uhl does the math and concludes, “That’s almost 300 wires to deal with at each end, terminating in separate connectors or punching down onto blocks. Even if you have to pull new CAT-5 and fit on a couple of RJ-45 connectors, which would you rather install?”

This scaled, proprietary approach does have a downside. Although several manufacturers use CAT-5 cables with RJ-45 connectors, divergent signal formats and wiring conventions are used. This has motivated continued on pg. 8
Dan Braverman of Radio Systems to call for standardization in this area. “This is an opportunity for broadcast manufacturers to adopt pin-out, level and protocol interface standards,” he said. Braverman advocates industry standardization. “Broadcast manufacturers need to cooperate now to implement a much higher level of compatibility for IP. Our clients would be much better served if we communicated at least as much as we compete.”

Manufacturers also are allowing a wide range of possibilities so broadcasters can decide for themselves when and how to implement these new technologies. Philippe Generali, president of RCS, is a major supporter of the use of IP-based systems for many radio applications. One advantage he cites as a prime example is increased flexibility for off-site voice tracking. “Talent can now interact with a radio station’s automation system from great distances to be on the air, thanks to IP configurations,” said Generali, whose firm has patented its application for voice tracking via the Internet.

Generali’s comments mirror much of the industry’s hopes for the ultimate incarnation of the technology at the radio station. The advantages are myriad, the downsides dwindling and the conversion costs relatively low. It is likely that this paradigm shift will happen quickly and quietly, but have no less of an impact than the conversion from traditional analog to digital audio and PC-based production had on the industry.

IP Audio distribution is clearly the next logical step in the digital conversion of radio. Like many successful conversions in the past, it has all the ingredients for rapid adoption: It provides clear and immediate benefits (including reduced cost, so return on investment is easily and quickly demonstrated), it employs well-established and highly favored technology and it leverages already deployed hardware and systems. Within a very few years, the radio industry will likely look back on traditional audio distribution techniques and consider them as quaint as the diamond stylus.

### VENDOR GUIDE

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**Comparing “spins” on three stations using RCS Selector Enterprise IP technology for cooperative data and audio sharing**