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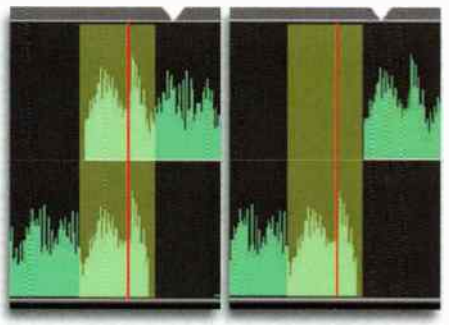

How easy? Just mark to highlight what you want to edit and push a couple buttons. Instantly, one channel of audio is shifted and ready to air.

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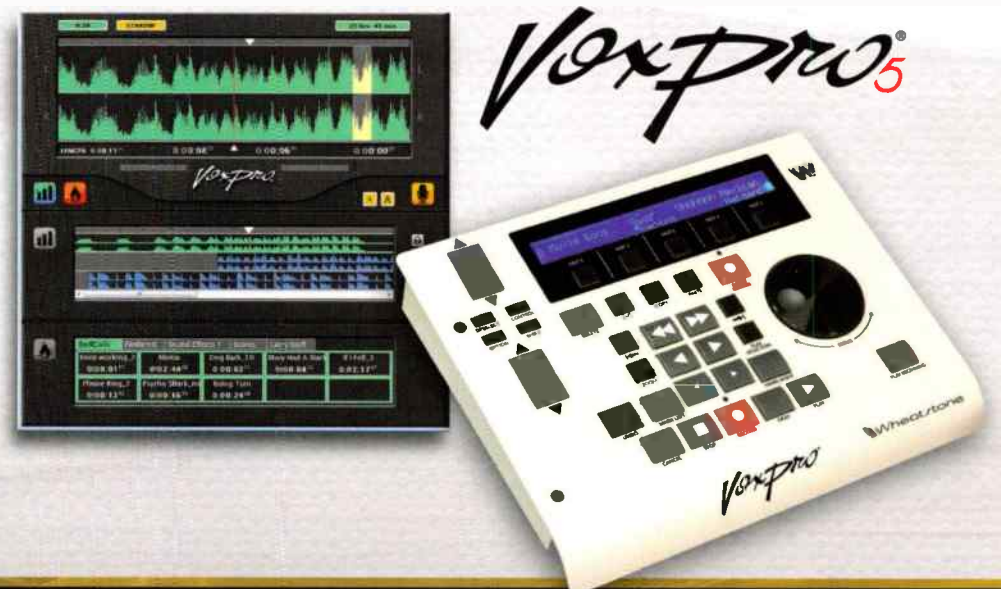

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Studio networks have a way of expanding, and those so-called islands of reliability could now be one large landmass the size of Australia. If one studio goes down, they all will...

For the entire story... INN29.wheatstone.com

Standing Beneath the Big Tower

90 Years of WSM

By Scott Johnson

From three miles north on I-65, I see it, rising from the trees like a steeple. And for radio engineers and country music fans alike, it does mark a place of great reverence. It is the 808-foot tower of radio station WSM-AM, and this day marks an important date in that station's storied history. 90 years ago on this date, WSM first signed on.

As I drive up and am directed to parking in a corner of the vast field, along with a hundred or more other guests, both the scale of the place and the weight of the experience sink in. I'm here for WSM's 90th anniversary celebration, an open-house at one of the nation's most famous transmitter sites.

For the entire story... INN29.wheatstone.com

Kim Komando's New Studios @ Corner of IT and Radio

Oh, the irony.

Kim Komando's talk show about gadgets and computer technology was turned down by two broadcast networks in 1994 because they said computers and the Internet were a passing fad.

Of course we now know that IP is here to stay. And the irony? The Kim Komando Show, produced by WestStar, is now viewed on her television network streamed over the Internet, and it's being distributed to 450 radio stations from a new studio facility that is – you guessed it – IP based.

For the entire story... INN29.wheatstone.com

Processing Tip From the Field

Mike Erickson reports in with this audio processing tip:

Clip restoration processors can make great additions to the production studio but we don't recommend them for the air chain, where they can play tricks on otherwise great sounding audio.

These algorithms seem to work on overly clipped audio but can be unpredictable on audio that doesn't need to be restored.

For the entire story... INN29.wheatstone.com

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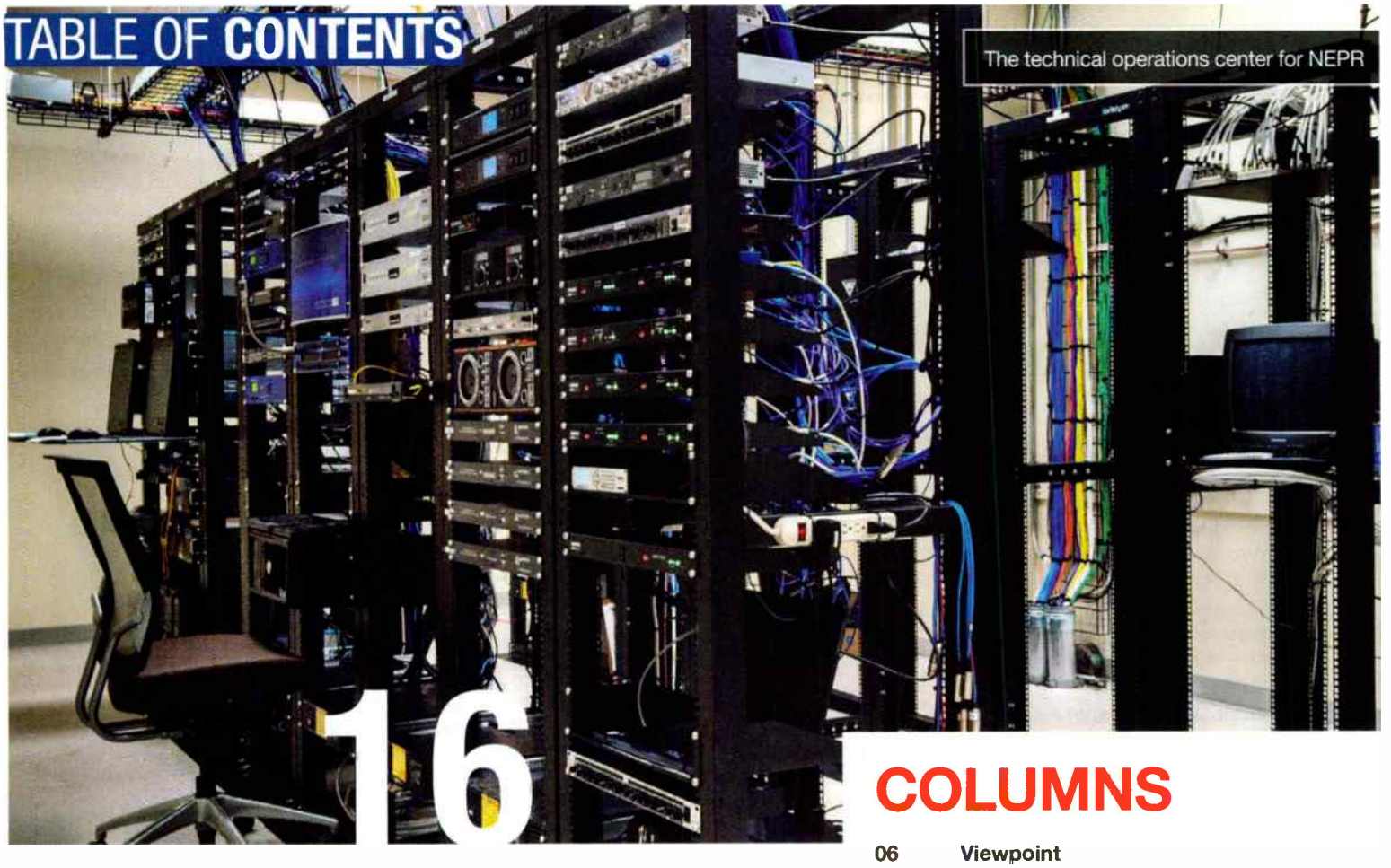

The technical operations center for NEPR

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On the cover: NEPR Studio B: SAS Flush Mounted Cabinet with clock, hp amp and mic control with SAS two-panel guest positions. Torpey Time CLK-20C clock on improvised M!ka monitor stand, M!ka Mic arms, Adam A5X monitors, Neumnann U-87 and BCM-104 mics.

Photo credit: Joyce Skawyra, NEPR

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VIEWPOINT

The Rules Remain (Mostly) the Same

I've been in broadcasting for many years, and I find myself wondering if I'll be able to remain employed until such time as I retire. For years we've heard about the demise of radio; yet here we still are as the calendar turns to 2016.

If we look back, will 2015 be seen as an inflection point for the fortunes of radio? I have heard, and seen, much of what I would consider to be good news this year. Radio is now known to be the top "reach" media, for example. The return on investment for radio advertisers has been shown to be very good. Live reads are turning into what is now called "native advertising."

It's very important to us who work in commercial radio that the medium remains viable for advertisers. Radio has embraced programmatic ad buying, and "advanced advertising" is coming soon.

NextRadio continues to make good headway in the U.S., and RadioDNS is another hybrid radio system gaining acceptance throughout Europe. Both systems are showing that, while Internet connectivity is very important, the ubiquitous nature of over-the-air radio still fulfills a vital function. Nick Piggott, the chair of RadioDNS, has contributed an article to this issue that explains just what RadioDNS is and how it works. I believe the hybrid systems are vital to the future of our industry.

Lee Petro discusses the potential changes to the commission's rules with respect to foreign ownership, which is an evolutionary change, and the result of the fact that radio is simply one medium amongst many today. There is no longer a reason to believe a company can have too much power and influence, just by means of radio, not in this day and age.

We're reviewing the latest in audio over IP technology this month — addressing the transition from ISDN to IP.

Chris Cottingham is back, sharing more of his knowledge and experience with remote access to your radio station's LAN. Wouldn't it be great if you could solve issues from home, such as changing configurations with IP codecs? Well, in case you didn't know, you can do those things already.

Our facility showcase features New England Public Radio's new studio in Springfield, Mass. Its new location in a turn-of-the-century former bank building presented design challenges; but as so often happens, unique challenges result in wonderful outcomes.

As much as we like to discuss changes in technology, we haven't forgotten about the day-to-day job. In fact, I've started a series about rehabilitating old transmitters. Will the application of some TLC turn that old rig into a lifesaver one day? I've seen it happen.

Inside the back cover is the spot we reserve for the Wandering Engineer — who seems to be on a tangent about the new ATSC 3.0 standard for TV. How does that relate to radio? Well, turns out that the new TV standards have similarities to what we're discussing with hybrid radio — combining over-the-air reception of programming with features accessible via IP.

We all know how IP has changed the playing field; but it looks like many of the rules, and the outcome, will remain the same. And that makes me feel pretty good about this vocation.

Doug Irwin, CPBE AMD DRB | Technical Editor

Radio
THE RADIO TECHNOLOGY LEADER

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Firewalls and Remote Access, Part II

by Chris Cottingham

The first installment of this article appeared in the October issue of Radio.

The first remote access solution that I would like to discuss is the virtual private network. A VPN access solution is like none other; it creates a tunnel over the Internet through which all of your data travels. This tunnel is encrypted from end to end and is considered to be the most secure remote access method.

After this tunnel is created and you are connected to it, the computer you are using remotely acts like it is directly connected to the remote network. Likewise, to the remote network, your computer appears to be just like the others on the local area network.

Cisco VPN Client

This kind of remote access solution is the best one, in my opinion. The ports do not need to be forwarded to any specific computer on the local network. This is due to the fact that the firewall or router is handing all the remote network access requests. Certain ports need to be open on a firewall for VPN to work properly, of course.

FOR INSTANCE

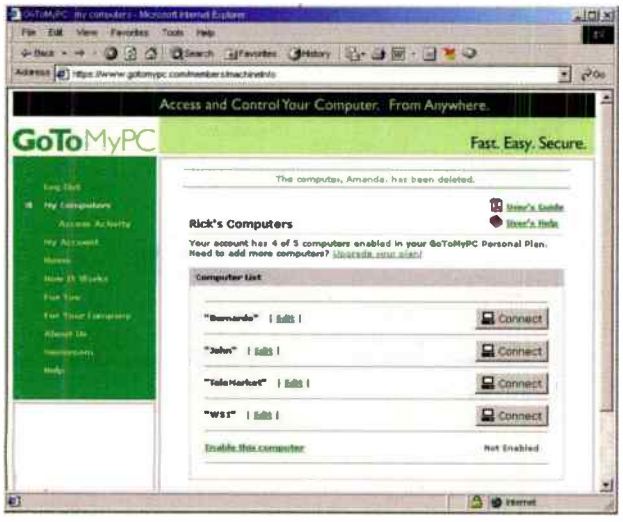
Let me give an example of VPN usage.

Say I want to access the Web portal on my AoIP nodes to manipulate some audio changes remotely. With some other remote access methods, I would need to have a computer setup on my engineering network that I can remotely jump into; from that computer I can access the Web portal and make my changes. If that computer is shut off or reboots I cannot access my engineering network remotely. With a VPN solution, that's not an issue. I do not need to "jump" into another computer to do what I need to do; I can do it right from the desktop of the computer I am on because I appear to be on the local network.

I would be completely lost without the ability to access my engineering network remotely.

VPN solutions require the use of specialized hardware and software. Most Cisco routers can be set up to allow VPN tunneling without additional licensing. Some of the less expensive solutions from Linksys or Netgear also have the ability to set up VPN tunnels. You might already have gear on hand that you can utilize for a VPN solution.

Once you have the VPN solution set up, you will need to configure your remote host computer to be a client of your VPN router. Windows 7 (and newer versions) have the ability to connect to certain VPN tunnels



GoToMyPC

without the need to purchase or add additional software. Certain VPN solutions from Cisco, SonicWall and Watchguard require specialized software to access their VPN solutions.

The need for specialized software varies with each VPN implementation; check with the manufacturer of your equipment to find out if you require specialized software.

All of the other remote access solutions I will mention require a computer to be online at all times on your local engineering network. Some of these solutions require a port forward on the firewall; others do not. The remote access software you choose will determine the cost.

VNC

VNC is a remote access solution that has been around since the late 1990s. There are various versions of VNC; some are free, some require a license. Of all the remote access solutions this one is the least secure because it uses simple passwords and runs on Java. On the other hand, it is also the simplest one to set up and run.

VNC requires a port forward on the firewall if you wish to access it remotely; it runs on a local computer and allows you remote access of the keyboard, mouse and video.

VNC uses a combination of ports to allow access: Client viewing software uses port 5900, and port 5800 is used for remote access via a Web browser running Java. The features you get with VNC are dependent upon the version you use; a variant of VNC called uVNC has file transfer and other capabilities that regular VNC does not.

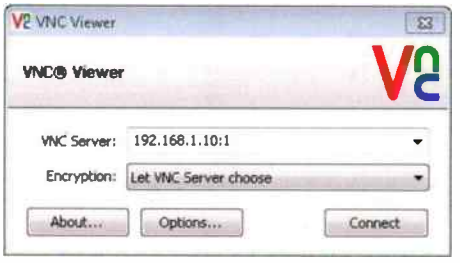
I do not recommend having VNC open to the Internet due to the insecure nature of its codebase; it runs on Java, which is inherently insecure. I use VNC regularly in conjunction with VPN tunnels; once I get on the network with a VPN connection, I then access all of my engineering computers via VNC.

TEAMVIEWER

Teamviewer is a cost-based remote access solution; there is a free version for non-commercial and home use.

It requires a computer to be online at all times, and it works by creating a connection back to the Teamviewer servers, which reside on the Internet. Once it makes that connection, it presents the user with an ID and password to use for remote access. The computer you wish to use to access your engineering computer remotely will also need to have a copy of Teamviewer installed.

All Teamviewer does is create a portal so that you can access the remote PC as though you are sitting in front of it. Teamviewer does not require ports to be opened on the firewall, thus it is considered more secure than VNC. Teamviewer also changes the default passcode each time it is restarted. This code is needed to access the computer remotely. A static or set password can be entered that will not change, if so desired.



VNC Viewer

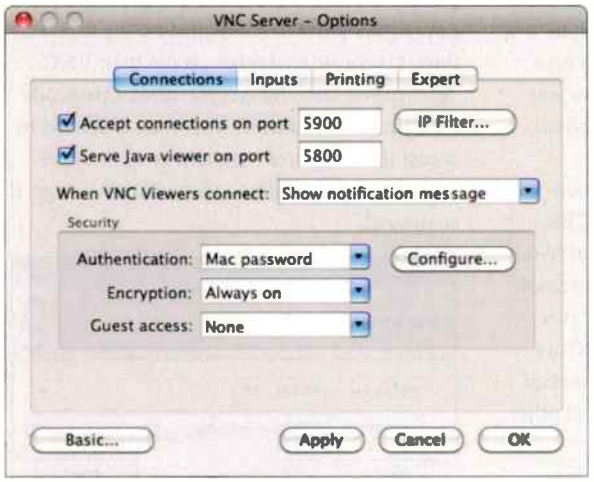
The end user is also allowed to set up an account with which they can associate all of their Teamviewer enabled computers. This works great as a simple monitoring tool: I can tell at a glance if my remote computers are online. If they are not, then I can take steps to determine why.

The insecure side of Teamviewer stems from the fact that it needs to make an outgoing connection to a third-party server to work. For security professionals this creates a question: How secure is the third-party server? If someone were to crack this

third-party server, could they access your computers with impunity? This is a valid question — but as long as your static or set passwords are complex it really does not present any more of a security risk than a VPN tunnel.

Teamviewer has a steep cost associated with it. There are three tiers of licensing, and the lowest one costs around $749. This license needs to be updated as newer versions of Teamviewer come out; as of this writing the upgrade cost to the latest version of Teamviewer from the $749 license is $199.99.

If Teamviewer is used in an unlicensed mode, it will limit connectivity time to your remote computer to five minutes and display a warning about commercial use without a license.



VNC server properties

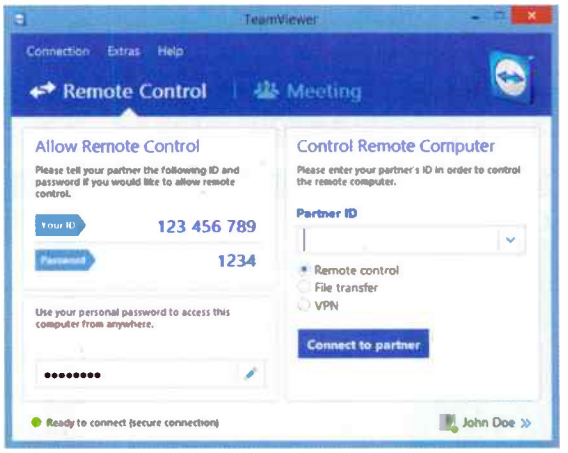
GOTOMYPC

GoToMyPC is another remote access solution that functions similarly to Teamviewer. It is also a cost-based solution for businesses and has no free version for non-commercial or home use. However, it is free to try for 30 days; thereafter you must buy a license.

In order to use this solution you must register with a website and install software on the remote PC and the controlling PC. Much like Teamviewer, it does not require ports to be open on the firewall; but unlike Teamviewer, you can access your remote access PC via a Web browser. It requires a PC to be on at all times for remote access.

GoToMyPC has the same security concerns as Teamviewer: It creates a connection back to the primary GoToMyPC servers and bypasses all of the firewall security measures.

The remote access methods I have mentioned here are some of most common ones; there are many more on the Internet that offer different features and cost advantages.



TeamViewer

There is no reason in today's technologically advanced society that we should cling to the idea that every problem that we face needs to be dealt with in person. We have tools to allow us to work efficiently and to minimize our downtime, and you should take advantage of them.

I would be completely lost without the ability to access my engineering network remotely. I, like most of you, have been at dinner and had the phone ring. It is so convenient and wonderful to be able to fix an issue with my phone in five minutes and get back to dinner rather than having to jump up and drive into the station, and I know that my GM is happy about how quickly issues get resolved.

Remote access to your engineering network, however you may accomplish it, is a necessity in today's work environment. 0

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New Foreign Ownership Rules Proposed

by Lee G. Petro

In October, the FCC released a Notice of Proposed Rulemaking that called for comments on the relaxation of the foreign ownership rules for the broadcast service. The FCC is considering bringing the broadcast foreign ownership rules in line with the rules for other services regulated by the FCC, which have been revised in recent rules.

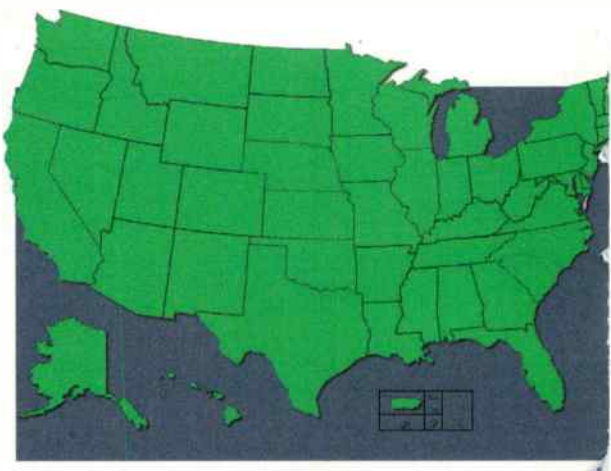
Regulation over foreign ownership of the broadcast service dates back to the dawn of AM radio. The precursor to the Communications Act, the Radio Act of 1927, incorporated regulations on limiting foreign investment to ensure that foreign countries would not gain control of the broadcast stations in time of war. When the Communications Act was passed in 1934, the current foreign ownership cap was established, preventing foreign investment above 25 percent of broadcast licensee and a direct foreign ownership interest of more than 20 percent.

Over the years, the FCC has relaxed the foreign ownership cap in connection with non-broadcast services. During the 1990s, the FCC adopted rules and policies to permit foreign ownership stakes above 25 percent, if the investor was from a World Trade Organization member country —and if the FCC determined such stake was in the public interest. In May 2013, the FCC extended this policy to non-WTO member countries.

Following this action, the FCC took the first step to bring the broadcast service in line with other industries in November 2013 by indicating that investments above the caps would be reviewed under the FCC's public interest standard on a case-by-case basis.

However, this approach came under fire when the FCC held up the acquisition of an FM station by Pandora because the publicly traded company could not establish that it was under the ownership caps. (Read more about the Pandora case in our June 2015 issue.)

In light of the Pandora case, the FCC is proposing to adopt rules that would limit the number of public interest reviews required for foreign investment in broadcast licensees. For example, the FCC is proposing to permit a foreign investor to seek authorization to have up to and including 100 percent foreign investment.



Specifically, the FCC proposes to permit an entity that has already gone through the public interest review and has been approved to make an initial investment of less than 100 percent controlling interest to increase its stake up to 100 percent without seeking a new public interest review. Similar rules would apply to non-controlling interests, with an entity that has already received prior approval to increase its non-controlling stake up to 49.99 percent.

The FCC believes that the proposed rules will spur investment in the broadcast industry, while reducing regulatory uncertainty and delay in obtaining authorization for investments.

Further, the FCC is proposing to eliminate the need for entities to identify foreign equity holders that have 5 percent or lower voting interest (10 percent or less for certain foreign institutional investors). This proposal would eliminate the situation in Pandora in which the publicly traded company could not confirm the identities of its investors because much of the widely held stock is held in the "street name" of brokers, rather than the individual interest holders. The FCC has historically taken the "worst-case" approach to the identification of investors, with a presumption of foreign interest unless the licensee could confirm non-foreign status. As a result, Pandora was required to adopt a detailed reporting regime to obtain FCC authority to acquire the FM station in Box Elder, S.D., as a result.

The FCC believes that the proposed rules will spur investment in the broadcast industry, while reducing regulatory uncertainty and delay in obtaining authorization for investments. The proposed rules would be applied prospectively only, so that any entity that had previously gone through the public interest review will be required to comply with the conditions imposed at the time. Such entities can seek application of the new rules, but the FCC proposes the requirement that they seek review under the proposed standard.

Petro is of counsel at Drinker Biddle & Reath LLP. Email: lee.petro@dbr.com.

DATELINE

Dec. 21, 2015 – Comments in Broadcast Foreign Ownership rulemaking due.

Jan. 10, 2016 – Issues/Program lists must be placed in stations' public inspection files.

Feb. 1, 2016 – Webcasters must submit forms to SoundExchange.

Tear It Down, Scrub It Up, Rebuild It and Then Test It

by Doug Irwin, CPBE AMD DRB

In last month's column, I reviewed how to decide if an old transmitter was worth fixing. I'll assume you've decided the transmitter is worth the time and effort; so let's get started.

Since we're discussing an "old" transmitter, my assumption is that it's a tube-type and like any other transmitter, it has three main systems:

- The power supply — tube transmitters require at least two, and often three, separate power supplies, in addition to filament (or heater) voltage.
- The control logic — the control logic is used to operate the tube in a fashion consistent with the tube designer's intentions. Operator safety factors are included.
- Power Amplifier — the main considerations here are the input and output RF circuits.

Old transmitters, like the Gates or Harris ones shown in the middle above, can serve for years when some TLC is applied.

We're going to work our way from the bottom up in this series of articles.

THE POWER SUPPLY

Due to the inherently dangerous nature of high-voltage power supplies, I want to state unequivocally: Do not work on high-voltage power supplies when you are alone or tired. It's simply too easy to make a mistake. Take every precaution you can think of, and do it twice (or more).

Several things happen to high-voltage power supplies as they age:

- They get very dirty, at the very least, by attracting and accumulating fine particulate matter on high-voltage wiring and insulators.
- High-voltage filter capacitors can fail because of internal short circuits, which are often not detectable except by the application of high-voltage.

- Transformers and chokes can sometimes fail, either by winding-to-frame shorts, or winding-to-winding shorts. Often these shorts are not detectable except by the application of high-voltage.

Several decades ago, I rebuilt an old RCA 1 kW FM transmitter (even then it was old), which had been inhabited by rodents for quite some time. To say this transmitter was filthy is an understatement; but I grabbed rubber gloves and completely disassembled the power supply deck, all the way down to the plate that held the components in the bottom. Every component of the supply was thoroughly scrubbed.

When I reassembled the power supply section, I was naturally faced with the requirement to test it. Did I want to just re-connect the AC power going in (240 VAC single-phase) to see what would happen? Well, no.

I decided to test it out in the following manner:

The power supply deck was completely reassembled in the bottom of the transmitter cabinet.

The load side was left safely disconnected — in other words, the HV lead to the tube deck was not reconnected.

With an ohmmeter I tested for obvious short-circuits. There were none.

I obtained a variac and connected it between a 120 VAC feed, and the input to the power supply (downstream from the HV contactor and right into the plate transformer primary).

I then ran the input voltage up from zero to 120 V to see if the supply generated DC high-voltage, which it did. I used its plate voltage meter as an indicator.

Even though the initial test was only at half of the normal input voltage, the fact that I easily generated 1100 VDC convinced me that I re-assembled everything correctly. The next step was to go back to the 240 VAC feed and the power supply was fine at that voltage as well.

You could do this same thing with a three-phase power supply. Again, use an ohmmeter to test for obvious shorts first. Before you go on to the variac test, make sure you've fused its output at a safe level — so that any arcing encountered will blow the fuse. Also, safely isolate the plate transformer leads that are not under test — they'll still be energized.

My point here is that when you've torn a power supply deck all the way down and then reassembled it, it pays to test your work in a manner that will discover errors without blowing the circuit breaker off of the wall.

Next time: the control logic.

Irwin is RF engineer/project manager for Clear Channel Los Angeles. Contact him at doug@dougirwin.net.

WE WANT YOUR TIPS

Tech tips may be suitable to earn SBE recertification credits. Send your tips to radio@RadioMagOnline.com.

NEPR Transitions From a Bucolic Campus To Life in the Big City

The building's exterior shows the station's new downtown location in a turn-of-the century edifice.

by Chuck Dubé

New England Public Radio is the umbrella organization for Class B FM station WFCR, Amherst, Mass., (and WFCR HD1 and 2); Class A FMs WNNI North Adams, WNNU Great Barrington and WNNZ(FM) in Deerfield.; 50 kW WNNZ(AM) in Westfield; and five WFCR translators in an area of Massachusetts commonly referred to as "The Berkshires."

All stations are owned and operated by the New England Public Radio Foundation, with the exception of the flagship station WFCR, which is licensed to the University of Massachusetts. NEPR also has an agreement with Amherst College's WAMH, providing programming during non-student hours. In addition to the over-the-air signals, NEPR streams its WFCR, WNNZ News Network and WFCR-HD2 programming online at *www.nepr.net*.

NEPR's move to its new urban environment is part of the University of Massachusetts' initiative to play an active role in the city, something that is embraced by and incorporated within the city's own economic development, along with an expansion of its educational purpose.

NEPR will also maintain a satellite studio facility in its old location in Amherst, allowing easy access for educators, authors and professors for interviews, and for students to intern and to be instructed in a local, professional broadcasting environment.

The new NEPR Springfield headquarters includes four control rooms, three studios, two announce booths and two interview booths. One control room and its associated studio and announce booth make up the primary on-air suite, and the three other control rooms, with their two studios and announce booth, are used for production. The interview booths are primarily used for phone interviews, but can also handle "one-on-ones." A Sierra Automated Systems console system shares resources throughout the facility.

Credit: Joyce Sawyer, NEPR

The front reception area is furnished in a modern style, but the original columns are also incorporated.

The vault is a prominent reminder of the studio's past life as a bank.

RETROFIT PLANS

The New England Public Radio facility was designed within the first floor, along with a portion of the basement, of a late 19th century building. Because of this, Amherst-based architectural firm of Kuhn Riddle Architects' Jonathan Salvon and interior designer Sarah Nolan encountered a considerable challenge in finding an acceptable arrangement of studios and offices, as well as the support spaces such as conference rooms, bathrooms, a kitchen area, etc.

The architect submitted several designs before one was found workable. When demolition began portions of the floor plan had to be revisited because of the discovery of load-bearing structures in key areas. Construction work was accomplished by Adams and Ruxton Construction of West Springfield, Mass. The primary owners of the building, The Dennis Group, provided electrical, structural and HVAC engineering. Acousticians from Cavanaugh-Tocci worked with the architects on the studio and control room designs.

There was NEPR staff involvement, primarily from Executive Director of Broadcasting Richard Malawista with assistance from Chief Engineer Chuck Dubé. Both were on hand almost daily once construction began to ensure that the radio-centric aspects of the project were incorporated properly.

Early in the design phase suggestions from air staff as well as the news department were incorporated, especially in regards to studio furniture design. Each department was consulted in the planning of their space, and this information was compiled and presented to the architects. It was the first time the architects had worked on a studio facility, and they were keen to get it right.

TECH SPECS

In a previous project, NEPR had chosen the SAS Rubicon SL system for a news gathering facility in Springfield. The staff seemed to

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take to the Rubicon console, as its layout and functionality were clean and familiar. It was a natural choice for NEPR to outfit our new facility with an expanded version of this same system.

This time around, the new SAS system is built around the 32 KD Router along with 16 slot frames for consoles and a complement of smaller turrets for booths and studios. The 32KD router frame supports five I/O modules (one for each RIO Link located in each control room plus a news area), five DSP Output modules, and four analog input modules (because of cost, primarily in workstations and automation, it was decided early on that this would be primarily an analog plant). Control room console frames support the needed input modules, control room functions (monitors, etc.) as well as a Rubicon meter bridge.

Each channel sports a router feature allowing any channel to access sources throughout the plant. Associated studio turrets allow for the standard mic control, headphones and talkback at each position.

Credit: Joyce Skowyra, NEPR

SAS Flush Mounted Cabinet with clock, hp amp and line inputs, Comrex DH20 Hybrid, Neumann BCM-104 mics, M!ka mic arms, Genelec 8010A monitor.

FURNITURE

In the past we had a great experience with Kennett Square, Pa.-based Studio Technology, and we brought them immediately on board to help design and execute the furniture for the studios and control rooms. Vince Fiola worked closely with us, taking into consideration surface areas, wiring needs, lines of sight, ADA requirements and equipment locations, as well as keeping us grounded with important structural necessities. Aesthetics, of course, played a large part as we wanted furniture that would fit well both the staff's comfort and the styles of the rooms themselves.

Studio Technology provided not only the basic furniture but several custom enhancements such as supply cabinets, copy stands, roll-around and counter top racks, and even a special rack to meet the needs of a space-challenged voicing booth.

STUDIO-TO-TRANSMITTER LINK

When NEPR began to explore the move to an urban location far from its existing transmitter, and knowing that we would be reusing some of our original studio location, we decided to reuse our old digital STL in place (a four-channel Moseley Starlink system).

To get audio to the RF STL, we incorporated a pair of Comrex BRIC-Links operating in linear mode. In Springfield, analog audio enters the codecs, which send the packets to their mates via a dedicated fiber and campus enterprise LAN to our old facility at Amherst. The fiber is part of the University of Massachusetts "backbone" that exists between the city and campus. Once on campus, the AES3 outputs of the BRIC Links are passively split and sent to AES3 inputs on the main and backup STL transmitters. From there it's digital RF up to the mountain.

With the disappearance of Verizon's telco radio loops in the commonwealth, a small army of Comrex BRIC-Links have been deployed to provide connectivity to several NEPR News Network stations. Although DSL infrastructure is far from perfect, it makes the difference between having connectivity or not at all in a given region due to a lack of other available means.

An exception to this is the station in North Adams where, conveniently located within the same building, is an ISP node for AccessPlus Communications of Byfield, Mass. They also

Credit: Vince Fiola, Studio Technology

NEPR Chief Engineer Chuck Dubé gives a tour of Control Room B.

support our fiber IP connectivity to our 50 kW AM station in Westfield.

FINANCIAL ROOTS

Our new facility required remodeling of the floor that once housed everything from a clothier, various retail stores, a bar, a restaurant, and for many years, a bank.

The parts that were once bank space are still in evidence — the elephant in the room is one of three very large bank vaults in the building. Another reminder of those fiduciary years is the mahogany veneered room that, just after the turn of the 20th century, served as the portion of the bank especially designed for women — a rather progressive thing for the time. Today the windows that once looked out onto a grassy courtyard are sealed over, but the marble that decorates the fireplace still dominates the space, which is now used as a conference and meeting room. Kuhn-Riddle was able to retain much of its former elegance. Revealed columns, once enclosed in plaster or wood, echo the austere past as they line the main entrance way by the offices, and areas of exposed 19th-century brick that were at one time outer walls also speak of the great changes made to the building over time.

Although one is often mindful of the past walking about this facility, it is for an auspicious future of New England Public Radio that this was designed; a space where it can burgeon, fulfilling its mission to broaden its local programming and news without compromising the bedrock of its core musical expeditions in classical and jazz. **0**

Make the Switch From ISDN to AoIP Codecs

by Doug Irwin, CPBE AMD DRB

While the end of ISDN may not be as certain as death or taxes, it is coming eventually. There are places around the U.S. where you can no longer order ISDN, and places where you still can (such as from AT&T here on the West Coast).

But we must consider two very practical issues.

First, the obsolescence of the central office switches. I found this little gem online from the University of Missouri: "The University's ISDN switch is now obsolete, cannot be placed under vendor warranty or maintenance, spare parts are not available, and no spare units are in stock. If the device should fail again, it cannot be repaired."

How many CO switches around the country are in the exact same shape?

Second, even if the CO switches could go forever, who would know how to configure or fix them? From the Comrex white paper "Making the Transition From ISDN to IP" comes the following truism: "Troubleshooting ISDN circuits is a difficult task and many experienced ISDN technicians have retired."

In spite of the fact that use of ISDN for remote broadcasts is still very commonplace (using existing circuits), it's time to look at alternative ways to carry out this function, which is crucial to so many stations around the country.

The time has come to transition from ISDN to AoIP codecs.

COMMON AOIP FEATURES

Let's first consider features that are common to nearly all audio over Internet protocol codecs.

Full duplex. One of the best features of ISDN codecs and their AoIP successors is their full-duplex nature. Older analog loop circuits don't provide this, of course, and RPU links don't either. Long gone is the need for a POTS line, or even a cellphone, for cuing.

Dual channels. Again, like ISDN codecs before them, the majority of the AoIP codecs are dual-channel. This is very convenient for cuing and/or talkback purposes and provides a great way to send a PA feed to the remote.

Audio bandwidth. While ISDN codecs usually sounded very good, AoIP codecs, using a (reliable) high-speed IP connection can sound remarkably good — almost "too good," as if you were not really at a remote at all. This is the kind of problem that's good to have.

Remote controls. Most of the codecs we'll talk about provide some means to send (and receive) contact closures to and from the remote site. Of course, since IP communication is obviously in use, many remote users rely on a computer on the far end to provide remote control of, for example, an automation system. Similarly, most of the codecs provide a means to send serial data, as well.

Use the stylus to configure and utilize the Comrex Access 2USB conveniently.

Field configuration. The setting-up of a remote AoIP codec will often require the user to configure the Ethernet and IP settings (unless they are known ahead of time). The three basic settings (IP

address, subnet mask and gateway) can be done from the front panel in most devices. DHCP is an option in most, if not all of the codecs; however, reliance strictly upon that method isn't recommended. Your user needs a minimum amount of training in the use of the device.

For the sake of expense, some manufacturers have gotten rid of front-panel controls; in that case, you'll need a computer placed on the same network for configuration.

COMMON IP PROBLEMS

While the evolution of IP technology has provided many benefits, there are issues associated with its use as well.

AEQ's Alio was designed with remotes in mind.

The primary advantage of ISDN is that the circuit is "nailed up" inside the PSTN system and the channel bandwidth (i.e., two DS0s) is for your exclusive use for the duration of the call. The nature of IP communications is radically different; the Internet is a big, shared system—and the problems one will eventually encounter all stem from that. IP is the most brilliant means of communication yet devised—but it's not perfect. The AoIP codec manufacturers have all addressed the packet delay/loss issues associated with IP transmission in their own ways.

Most of the AoIP codecs we're going to talk about in this article are rack-mount devices, meant to communicate with similar devices on the far end.

An exception is the Comrex Access 2USB, a portable AoIP codec mean to live out in the field. (Its complement in the rack room is the Access rack.) Access 2USB's physical size and form factor allow it to sit on a table top, to be strapped to your belt or held in one hand as the user walks around. The device is powered with its own internal, rechargeable battery or a DC-adaptor. It has a switchable mic/line level input via XLR, and stereo line-level inputs with an integrated mixer; stereo lineouts and the stereo headphone out are both available via 1/8-inch mini-jacks. Communication can be done

via the single RJ-45 Ethernet connector, or via one of the two native USB ports, using Wi-Fi or POTS modems, or via an optional 3G/4G modem. Separate DIN connectors are used for both serial data and contact closure transmission. Configuration of the device can be done via the front-panel LCD display and a stylus, or by way of Comrex BRIC Device Manager, a free Windows app that allows for configuration (via IP) of Access codecs as well as firmware and license updates.

Genie Distribution is able to accommodate up to six simultaneous mono remotes.

Comrex BRIC Technology is a suite of tools that includes Dynamic Jitter Buffer Management and error correction. They've developed what they call "BRUTE" — BRIC UDP Transmission Enhancement — to help maintain stable and reliable transmission on marginal networks. UDP Reliability and Congestion Avoidance modes in BRIC are intended to provide extra error protection with a minimal increase in latency. Algorithms include BRIC HQ, along with AAC, AAC-LD (low delay), HE-AAC (high efficiency), HE-AACv2 and AAC-ELD.

Like all of the manufacturers mentioned in this article, **Tieline** has a line of codecs designed for AoIP usage.

Genie Distribution supports transmission of audio over IP, and optionally, POTS and ISDN — making it a possibility for your ISDN-to-IP transition period. The device is called Genie Distribution because it is capable of sending multiple algorithms simultaneously at different sample rates and bit-rates over a range of network transports. Genie Distribution is a single-RU, full-duplex codec, capable of handling up to six channels of audio, the first two of which are available via XLR connectors and the final four of which are available via a db25 connector (24-bit word and up to 96 KHz sample rate). The device features two independent Ethernet connections, and supports RS-232 and GPIO via separate D connectors.

Configuration can be done from the front panel or via the embedded Web server. Algorithms include E-apt-X, linear PCM, LC-AAC, HE-AAC v1 and v2, AAC-LD, AAC-ELDv1 and v2, Opus, MPEG Layer II, Tieline Music and MusicPLUS, G.722 and G.711. The user will be able to connect over IP with any SIP-enabled IP codec brand that supports the EBU N/ACIP EBU tech 3326 standard.

Genie Distribution includes SmartStream, which is Tieline's suite of features used to mitigate potential IP network problems. Automated Jitter Buffer management, Forward Error Correction and error concealment dynamically respond to the variable conditions that can be encountered so that streaming quality is maximized. The device can support up to 50 unicast connections and an unlimited number of end-points via multicast (with a network supporting IP multicast).

The Telos Z/IP One is another single RU AoIP codec designed and built for remote broadcasts. It features two channels in, and two channels out, via XLR connectors, and configurable levels, with 24-bit A/D and D/A converters. (AES i/o is optional.) Z/IP One is N/ACIP conforming and supports AAC-ELD, AAC-HE, AAC-LD, MPEG Layer-2, MPEG-4 AAC-LC, MPEG-2 AAC-LC, G.711, G.722 and linear PCM (Enhanced aptX coding optional). It features two Ethernet ports, one of which can be used for control, and the other for the streaming functionality, including Livewire+ (audio and control). It also has time-aligned RS-232 serial throughput for remote control, and transmission of metadata.

The Exstreamer 500 is a full-duplex codec.

The Z/IP One gives backwards compatibility with the Zephyr Express and access to a Livewire+ network.

Configuration of Z/IP One can be done via the embedded Web browser, but there are also front-panel headphone controls, a direct-dialing keypad, quick-connect keys and an OLED display giving the user access to common functions and the system set-up.

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Telos' proprietary technology for dealing with the inevitable network problems is called Agile Connection Technology; it automatically senses network conditions and adapts the codec parameters to best suit the reliable transportation of audio.

Since we are on the topic of the transition from ISDN to IP, it's important to note that Z/IP One is backward compatible with Zephyr Xstreams.

APT (from Worldcast) offers a wide line of devices to move audio over IP, including the IP Codec (formerly known as the Horizon NextGen). It's a single RU, dual-channel codec, featuring analog inputs and outputs via XLR connectors, as well as digital ins/outs via AES-3 (24-bit word length, 32, 44.1, 48 kHz sample rate; 192 kHz sample rate optional). IP Codec has two Ethernet ports. Serial data is supported via RS-232 (9-pin D connector) and GPIO is provided via a 15-pin D connector. Standard encoding options are apt-X (16 or 24-bit); Linear PCM (16 or 24-bit); MPEG 1/2 layer 2; MPEG4: AAC-LC/LD/ELD; and, MPEG 2/4: HE-AAC versions 1 and 2. With no front-panel controls, IP Codec would have to be configured in the field by use of a computer (or configured ahead of time).

Streaming modes for IP Codec are unicast, multiple unicast, multicast and multiple-multicast using RTP/UDP or RTCP. Other IP protocols supported for management purposes include dynamic DNS, ICMP, IGMP, UPnP, NTP, SNMP, SMTP and HTTP. IP Codec is configured by way of the APT network management system UI.

To mitigate transmission problems associated with the use of IP, IP Codec includes several features: Buffer depth is adjustable, between 5 and 5000 milliseconds, and the device has automatic packet re-sequencing. IP Codec also features the APT Surestream, a means by which the device sends two independent streams, meant for different transmission paths, to the receive end. The key idea behind Surestream is that packets lost on one path can be recovered by using those received on the other path.

Another European company that deserves a look is **AEQ**. They produce an extensive line of IP codecs, including one device specifically meant for remotes—the Phoenix Alio. A few of its more important features are four XLR mic-level inputs; two XLR line-level inputs; two XLR line level outputs, and two 1/4-inch TRS headphone outs. Alio is meant to communicate via IP and has a single RJ-45 connector. Interestingly (with a second channel option installed) Alio will support two simultaneous IP connections. You could potentially be supporting your audio connection for the remote and an additional audio session for cuing or other technical/production purposes.

APT IP Codec counts Surestream among its features.

Coding algorithms include OPUS (48 kHz SR, data rate between 12 and 256 kpbs); G.711 (u-law or a-law); G.722; MPEG layers 1 and 2; and PCM (32 or 48 KHz sample rate, 12, 16, 20 or 24-bit word length).

Phoenix Alio is N/ACIP compliant, and therefore it can connect to other manufacturers' devices, at least via G.722 or MPEG layers 1 and 2; however, if you wanted an AEQ system on both ends, you could select Phoenix Studio, Venus, Mercury or Stratos. Control-Phoenix is remote control software that allows the user to configure and adjust Alio in real time, even down to trimming the audio levels on the far end.

Barix is a Swiss company known for a family of products used to transport audio via IP. They became familiar to the broadcasting community after the introduction of the Instreamer (the encoder) and the Exstreamer (the decoder). The Exstreamer 500 is a codec though — a pair of these units makes up a full-duplex system. The 500 features two channels of balanced line-level audio (in and out) available on removable connectors; RS-232 and RS-485 for serial data; and four relay inputs/outputs. Configuration is done via built-in Web browser. The 500 supports a stereo codec for MPEG1&2 Layer3 (MP3, 30-192 kbps variable bit rate), PCM linear, a-law and u-law, from 8-48 kHz sample rates. The decoder also supports AAC+ (AAC-LC, HE-AAC, HE-AAC v2). A USB flash interface allows use of external memory to store audio files that the 500 will play out as necessary. Streaming methods include TCP, UDP, RTP and multicast.

Remote broadcasts, whether for high-school football, or college basketball, or the obligatory Saturday afternoon car dealer remote, are one thing that is practically unique to radio. The technology for carrying them out has, fortunately, gotten better, and remotes are far easier than they used to be. They're also a great way to show listeners and advertisers what radio can really accomplish as a medium; for that reason, you should take it upon yourself to see that they deliver as promised, in a professional manner.

RadioDNS: Making Broadcast Valuable in an IP World

by Nick Piggott, Chair, RadioDNS Project

There are many pressures pushing radio toward an all-IP world. Connectivity appears to be on the path to ubiquity, and smartphones are now the most universal personal device (displacing the radio set). Apps can be functional, attractive and measureable. Traditional radio seems to have reached the limits of its flexibility, whereas IP appears to have limitless opportunities.

Broadcast technology has an image problem. If it were to be invented today by Apple or Google, broadcast might be called "a wide-area, highly scalable, reliable, economic multimedia distribution platform." It might even make use of technology like eMBMS, which is intended to support live media over mobile networks, by using spare spectrum to create weak broadcast signals from expensive cellular infrastructure.

The broadcasting aspect is what makes radio big. It's really that simple. If your ambition is to run a big radio station, broadcast has been and will always be an appropriate technology. It uses little power on the receiver, has reliable coverage and uses no mobile data. It is intrinsically more cost-effective than trying to achieve the same coverage using densely populated cell towers.

Hybrid radio is about preserving the core value of our legacy broadcast technology, and modernizing it so it fits in our new IP-centric world. Hybrid radio has all the benefits of IP — metrics, personalization, on-demand, visuals, metadata — while preserving the strategic strengths of broadcast — reliability, low cost, ubiquity. There are no gatekeepers on broadcast radio, controlling which stations get shown to listeners or not.

One of the most important functions of the RadioDNS system is this: If the quality of the broadcast signal degrades (from driving out of the service area or driving into an underground parking lot, for example), the receiver can switch automatically to the stream, and switch back again when the broadcast signal recovers. This means that the single station preset will always find the same station, removing the need for the listener to switch contexts between broadcast and Internet radio.

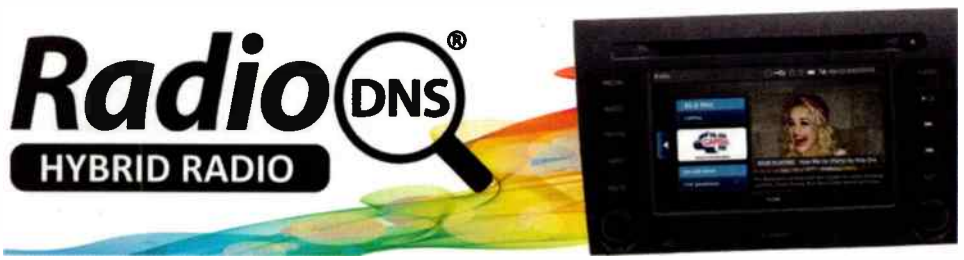
RadioDNS is the international not-for-profit organization that coordinates hybrid radio. Founded in 2010, we create open technical standards, so that broadcasters and manufacturers can be certain that the whole system will interoperate globally, just as radio always has done. We run a DNS root server, which enables the association between a radio station's broadcasts and their IP presence. We work with broadcasters and manufacturers globally to make hybrid a central part of radio's digital future — in the home, hand and car.

RadioDNS has no visibility for the connections between listeners and the radio stations. As a not-for-profit, we won't get involved in new business models (we support commercial and non-commercial broadcasters equally), and we don't have a motive to make money out of radio. Unfortunately, it also means we can't subsidize

broadcasters or manufacturers or provide free turnkey solutions directly. Our model is to grow organically and to create a sustainable open infrastructure for hybrid radio that mirrors the freedom that IP offers to developers to create new ideas quickly and cheaply.

HOW IT WORKS

Technically, RadioDNS takes a simple but very robust approach to making radio hybrid. Almost all broadcast systems either have (or can have) a unique identifier assigned to each transmission; for example in FM, this is the RDS PI code. HD Radio has a similar identifier, and AM transmissions can be adapted to support AMSS, a variant of RDS for AM radio. (The same concept also applies to the DAB digital radio platform.) Together with some coarse location information it allows each transmission to be globally uniquely identified.



DNS is the fundamental technology that translates addresses into IP addresses and locates services on the Internet. DNS is hugely scalable and robust; without it, most of the Internet doesn't work. We leverage these qualities of DNS to reference the unique code in a transmission back to the originating radio station's presence on the Internet.

RadioDNS uses existing identifiers because they are already critical to successful broadcast operation, are supported by all systems now and can be acquired very quickly after tuning in.

It might be possible to create new identifiers, or even transmit specific domain or URL information (for example, in new RDS ODAs), but the acquisition time would be longer and it would use additional data space in some already crowded capacity. It would also require updates to the encoders in the broadcast infrastructure.

By using existing identifiers and existing DNS capabilities, we have a system that is already global and reliable. The RadioDNS Core Lookup (ETSI standard TS 103 270 v1.0) explains how we adapt the broadcast identifiers to be compatible with DNS and return the originating broadcast's domain.

When a RadioDNS Hybrid Radio-compliant device tunes into a radio broadcast, it carries out these steps:

1. Acquire the unique identifier from the broadcast — e.g. C379
2. Combine this with the currently tuned in frequency (101.1MHz) and coarse location information (United States) to create a pseudo-domain — a string in a format that DNS can recognize: 10110.c379.ca0.fm.radiodns.org
3. Send this query to the nearest DNS server (which in turn will refer it to peers until it acquires a canonical answer)
4. Receive back the answer rdns.xyzfm.com
5. Open an IP connection directly to *rdns.xyzfm.com*
6. Start exchanging data according to one of RadioDNS' standardized applications

As the acquisition time of an RDS PI code is less than 100 ms, and DNS lookups are similarly fast, it's possible to get to Step 6 in less than 300 ms. Certainly the RadioDNS Hybrid Radio devices on the market today can do the DNS lookup process, retrieve an image and get it up on the screen in less than half a second.

This principle has been tested in many countries (including the U.S.) and on different broadcast systems. Prototypes have been tested on smartphones, connected car radio head-units and tabletop radios. It's proven to be a reliable method of merging broadcast and IP together entirely seamlessly for the listener. Of course, if the IP connection is unavailable or congested, the reception of audio isn't affected at all.

This standard for creating an IP connection can be used by any broadcaster, for any application. RadioDNS doesn't impose any restrictions on broadcasters or manufacturers. However, we have standardized some common applications, so that there can be widely implemented with confidence that they'll work globally.

RadioDNS Hybrid Radio can be interactive, visual, personalized and can switch fluidly between live and on-demand. We achieve that with three standardized applications: Visual Slideshow for radio; Service and Program information; and RadioTag.

VISUAL SLIDESHOW

Visual Slideshow for Radio (ETSI TS 101 499 v3.1.1) adds a dynamic visual accompaniment to radio.

A signalling channel pushes messages to all connected clients, either over HTTP (COMET) or using Simple Messaging Protocol. The client responds by retrieving an image (JPG, PNG or APNG) using HTTP, providing information about its screen size and pixel density (a technique recently added to Google Chrome). This allows the broadcaster to provide an image that meets the size of the target screen; it's possible to use responsive HTML design and tools like PhantomJS to create the slides on-the-fly, meaning any general Web developer can create the visuals. The support for Animated PNG makes short animation or looping video clips possible, which is timely given the current surge in popularity of animated GIFs on the Internet. All the assets can be served from a standard Web server (or CDN).

SERVICE AND PROGRAM INFORMATION

Service and Program Information (ETSI TS 102 818 v3.1.1) adds metadata related to the current radio services, and other radio/audio services from the same provider. A wide range of metadata can be added to each service: names; description; logos; genres; program schedules (which allow scroll back access to on-demand content); additional streaming services; and links to the streamed version of that broadcast.

Stations can add art and metadata for their broadcasts as part of RadioDNS' Visual Slideshow for Radio.

The links to streaming versions of an audio service enable a valuable function of hybrid radio: If the quality of the broadcast signal degrades for any reason the receiver can switch automatically to the stream, and switch back again when the broadcast signal recovers. This means that a single station preset will always find the same station, removing the need for the listener to switch contexts between broadcast and Internet radio.

The function to include links to associated streams also allows station to provide information on streaming-only services they provide. If widely adopted, this could displace the need for Internet radio apps to be so prominent in the dashboard.

The stream definitions also include hints on how delayed the streams are relative to the broadcast signals, allowing receivers to use various techniques (such as time stretching and waveform alignment) to blend seamlessly between broadcast and IP (although audio processing may mean they sound different). We recommend that broadcasters try to minimize the delay on streams because buffering capacity on head-units is limited.

Service and Program information is encapsulated in a XML file format and retrieved using HTTP from a standard Web server or CDN. There's an online tool that allows you to explore and create SPI information at *http://si.radiodns.org*.

RADIOTAG

Our latest standard, RadioTAG, answers a basic listener use case: The ability to push one button while they're walking or driving and bookmark interesting things, so they can come back to them later. The listener associates their radio device with their personal identity (using a process called Cross Platform Authentication), which provides insight into individual behaviors and also allows personalization and targeting of the responses to TAG requests.

The button push creates a simple JSON request over HTTP to a TAG receiver, which returns a basic confirmation and summary of the current event(s), which can be stored on the receiver. The listener can then see their entire TAG list online or on an app and choose to explore each TAG further. The broadcaster can choose what their TAGs do; in one experiment, the BBC demonstrated pressing TAG on a kitchen radio before leaving the house, and then being able to pick up the same program at the same point in time on a smartphone.

TAGs don't need to be submitted in real

time — in the case of a disconnected car, the TAGs could be stored on a smartcard or memory stick or synced to the network over home Wi-Fi in the garage. TAGs can also cover overlapping or recent events, meaning that the listener doesn't have to hit the button at exactly the right time. The radio station can create a big data view of listener engagement and interaction, and track conversion in a similar way to Web traffic.

All our standard applications (visuals, service and program information and TAG) are located using DNS SRV records, meaning broadcasters can choose which of them to implement.

READ BEFORE IMPLEMENTATION

If the thought of reading standards documents to implement these applications feels overwhelming, RadioDNS has some help at hand. On our website are links to open-source implementations of most of these applications, and summarized "how to" documents for the most common uses. We have service providers who can provide turn-key solutions, and the EBU (European Broadcasting Union) has recently open-sourced their entire RadioDNS Hybrid Radio publishing platform, which you can install and run locally. It all uses standard Web technologies, most of which are used in even the most simple websites.

It's important that broadcasters take first simple steps to start RadioDNS Hybrid Radio services, so that manufacturers have the confidence their RadioDNS Hybrid Radio enabled devices will work properly.

Project LOGO is our plan for 2016 to help broadcasters get underway painlessly with hybrid radio, and give manufacturers confidence to implement RadioDNS Hybrid Radio in more smartphones and connected cars. Project LOGO is the most basic set of hybrid radio metadata, which almost every broadcaster can create, yet it makes a dramatic difference to the listener. You can get more details on Project LOGO on the RadioDNS website. We expect more than 60 percent of radio listening in the major European countries to have accompanying RadioDNS Hybrid Radio services during 2016; the UK will reach 92 percent by the end of this year, and Germany will start 2016 at 70 percent.

RadioDNS is making progress with broadcasters and manufacturers. Our technology standards are being adopted by broadcasters worldwide, and RadioDNS is live in many European countries. Samsung has implemented RadioDNS (alongside FM radio) in their Android handsets outside of the U.S., and we have major automotive OEMs such as Audi, Visteon and Alpine actively involved with the project. Our standards work alongside FM, HD, DAB, AM and DRM. Everything we do is open-source and free to implement.

As an organization, we're committed to making radio more valuable in the future by making broadcast an integral and unique part of radio's digital strategy.

GALLERY

Advanced Advertising for Radio

by The Wandering Engineer

Can radio cash in on "advanced" advertising? I wonder if what is now going on in television will impact radio soon.

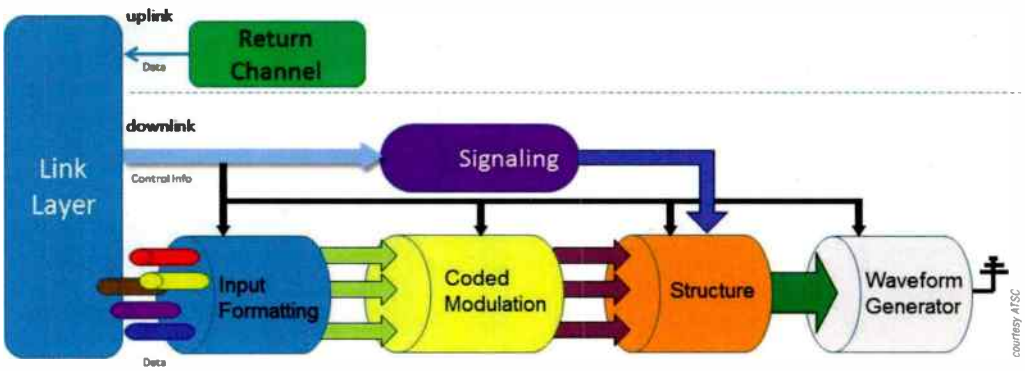
The Advanced Television Systems Committee is rapidly cranking out candidate standards. The physical layer (the "PHY" to TV engineers), or what we'd call modulation for the most part, probably has little to offer radio. Interestingly, ATSC 3.0 may very well end up using FM-IBOC's video features. But the rest is a bit scary.

ATSC 3.0, the new standard replacing ATSC 1.0 that brought digital to television, improves a lot of what has proven to be outdated in TV. More efficient encoding, support for higher resolution and the introduction of immersive sound are all worthy objectives, but the real deal is the shift from lining up and clocking out fixed packets of audio, video and data to physical layer pipes.... pipelines of Internet protocol data.

ATSC 3.0 is more about the Internet than TV. The desired receiver is a new IP gateway in the home or a wireless device with Internet access. In the home, the coax from the antenna doesn't go to the TV sets anymore — it goes to the household's "gateway router" where the over-the-air TV content combines with the Internet service provider's connection. From there, this bundle of content and connections can be shared with every Ethernet-wired and Wi-Fi-receptive device in the home.

Some of this is about cool tricks like using a smartphone or tablet to control the TVs, DVRs or other devices in the home. But most of this is about the many limitations of the Internet when it comes to delivering video, in particular live video.

The Internet struggles with buffering and access times (think channel change), and it breaks under the stress of supplying the same program to very large numbers of users. It's an unimaginable task for the Internet to provide the kind of quality of service and capacity to rival broadcast TV's offerings.



ATSC 3.0 puts a high-capacity, low-latency, high-quality-of-service IP delivery path right to mobile devices and the household router/TV receiver by way of an over-the-air TV transmitter. Hopefully, broadcasters will continue to put attractive programming on this new platform, and naturally, they'll continue to sell eyeballs to sponsors.

ATSC 3.0 is more about the Internet than TV.

Internet advertising is unbelievably complex and efficient; Internet advertising is targeted. It's no coincidence that you get banner ads and pop-ups that somehow seem to read your mind. Imagine the power of Internet targeted ("advanced") advertising if it were applied to TV.

For some of us, there is a creepy side. I'm learning to live with the idea that everything I do on the Internet, everything I buy with a loyalty or credit card, everywhere I go that my license plate can be read, is swept up into the "big data" cloud. From there, messaging is tailored to me, first for the few minutes a day I spend on the Web, and soon on the TV I watch for a third of my waking hours. No longer will I watch ads for things I will never buy or political ads that aren't aware of my biases and beliefs. But I'll see many ads for things my profiles indicate I have a weakness for ... now in my living and bedroom as I passively watch.

Can broadcast radio cash in on "advanced" advertising? Will the next generation of radio evolve into pipes of universally useful IP the way TV is currently transitioning? If so, my "smart" radio will likely have cookies and ad selection engines picking the spots I hear and tracking each impression, dutifully reporting the results back to the mother ship. If that's what it takes to keep radio around, then so be it.

The Wandering Engineer is an industry stalwart who has been in broadcasting since the days of Marconi and Tesla. He gives his thoughts on the current state of broadcast engineering and the broadcast engineer.

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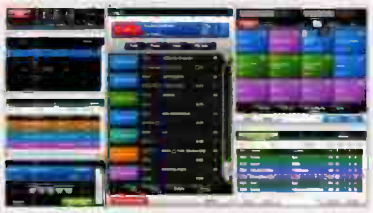

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