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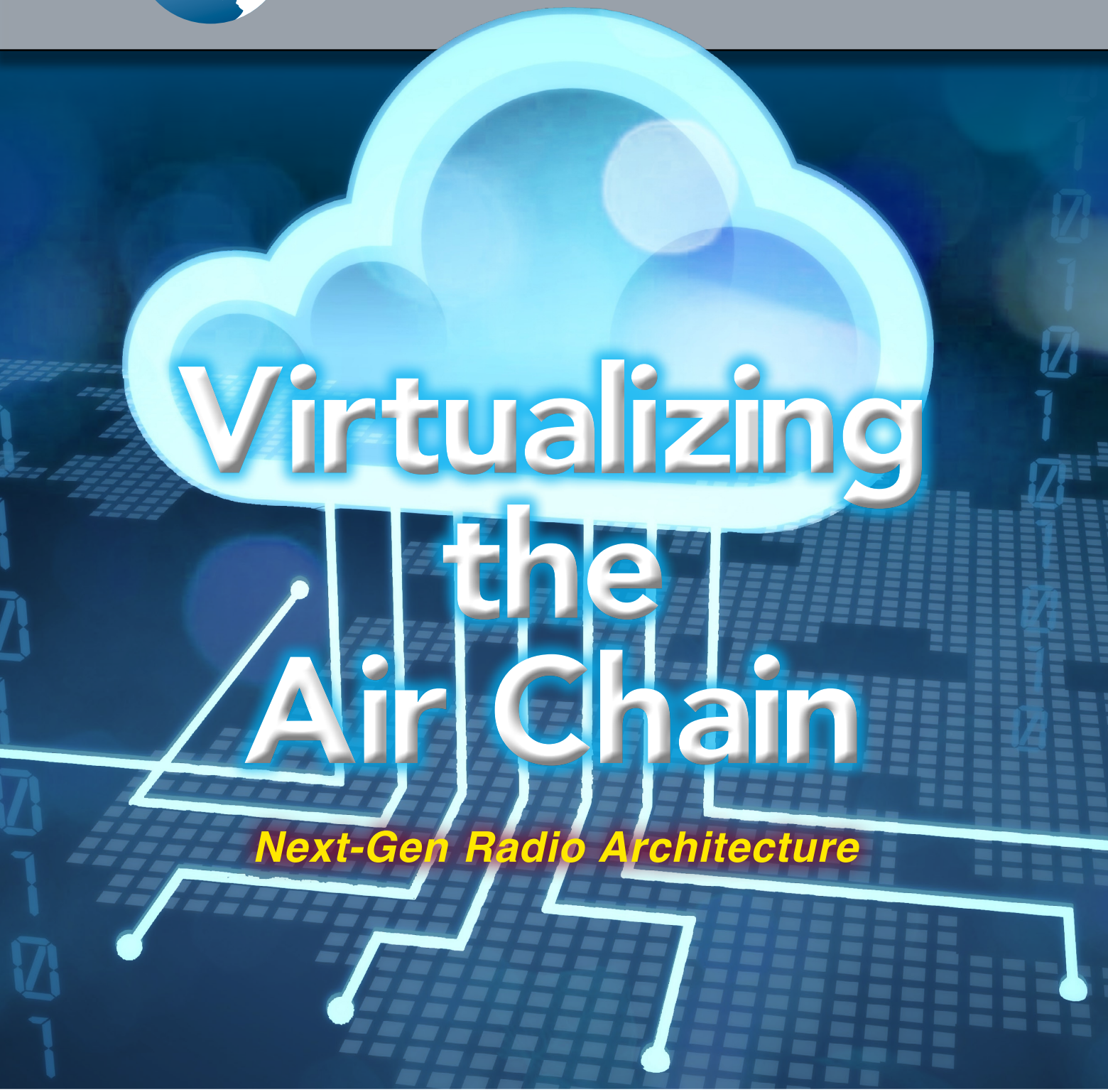

Virtualizing the Air Chain

Next-Gen Radio Architecture

September 2020

From the Publishers of Radio World

FUTURE

Virtualize. The. Radio. Air Chain.

Michael LeClair

Just what are we getting ourselves into?

In this ebook we bring together a group of industry experts to discuss virtualization as it is developing. We speak to people who are working to come up with a standard for how to virtualize the elements of the radio air chain, and to experienced radio engineers who know the ins and outs of what is required by modern radio.

This future is already coming into view on the road ahead of us. It's radio adopting new technologies and practices from the information technology industry for its own success.

Such changes have already taken place in the back office for most of us; but now we're talking about core technical systems that help define the radio medium itself.

This is a concept that inspires both excitement and not a little apprehension among experienced radio engineers. It also leads to many questions.

Why is this important? How do we go about this? What is virtualization, anyway?

To start with the last one first: Virtualization is a process where the execution of tasks that previously used purpose-built hardware is converted into software. The concept is as old as computing software itself, although the complexity of virtualized systems has grown steadily over many years.

In radio engineering, a perfect example is the modern audio processor for FM radio. It was proven in the 1970s that one could model complex physical effects such as filtering, gain control and limiting with digital signal processing techniques. This opened the gate to using virtual processes — software — to achieve what had previously been accomplished with discrete electronic components such as transistor switches, capacitors and inductors.

DSP simply treats the electronic effects of these physical components as mathematical operations on a signal that can be combined, recombined and modified in the computer domain. The operations themselves are virtual.

Essentially, a modern processor is a computer in a box with a custom interface that allows us to control these mathematical operations as needed to provide the desired customization of audio content. Specific to the radio industry are input and output formats that correspond to the other physical devices in a radio air chain, such as the digital AES serial stream for stereo signals and, perhaps, a composite output complete with 19 kHz pilot to drive an FM exciter.

Finally, the box provides various kinds of graphical displays and a user interface like a multipurpose knob to allow people to adjust it according to the sound concepts that are desired. It's a virtual system in a box that comes with the necessary external connections to be combined with other islands of virtual operations.

THE STREAM AS A VIRTUAL SIGNAL

It is a only a short step from there to utilize the other key concept of modern digital audio systems, the stream, to begin a conversation about radio air chains going fully virtual.

Streams came about when it became clear that it was both economically beneficial and simple to combine more than just a couple of audio channels for stereo into a single signal stream. In fact, modern transport systems like a backbone Ethernet switch moving packetized audio can combine literally thousands of streams onto the same cable with the appropriate management to share the physical wiring or optical medium for transport.

Similarly, a modern multi-core central processor can manage many streams simultaneously, allowing powerful computers to be built that have the capacity to manage multiple signals and their processing all at the same time.

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When we combine these concepts — using software running on computers to process our audio signals, complete now with custom metadata for users, and then transporting that complete signal as a stream that never leaves the digital domain — we're already creating a virtualized radio station.

As I said, the future is coming into view. Right now.

WHAT ABOUT THOSE OTHER TWO QUESTIONS?

If what the radio industry is doing now is sufficient, why do we want to move toward all this change that we're calling virtualization?

A short and simplified answer: As we look to other industries and businesses, many of them are already transforming their processes into virtual systems and realizing competitive advantages in terms of cost and reliability.

Radio is no different in wanting those results, so it stands to reason it could reap similar advantages. In fact, as a communications business, radio may be more easily virtualized than many others.

Which raises that third question, one that is critical to radio's future: How do we make the last set of steps to transform ourselves into a virtual air chain? The answer is: very carefully.

Just what are we getting ourselves into? Let's explore the why, the what and the how of virtualization of the radio air chain.

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Next-Gen Radio Architecture and You

We asked five technologists to talk about virtualization. We got an earful.

What could be more interesting than the technical future of broadcast engineering? Relatively new technologies like digital radio and enhanced content metadata for graphics are intended to help radio survive in a rapidly changing communications environment. At the same time, infrastructures that support our industry have been undergoing significant technological changes, before and during the pandemic.

Have you wondered where this is heading? Does radio need to get ready for a fundamental change in its approach to technology?

If so, you are in for a real treat in this ebook. We brought together five thinkers and doers who are investigating the concept of virtualization and how the future air chain will look — exploring how we could transform our technical systems into building blocks based on software that could be centrally supported and placed anywhere.

Roz Clark
Cox Media Group

"When you ask, 'Is the industry ready for this,' the answer from a business case is 'absolutely.' Cheaper, better, faster."

Roz Clark is senior director, radio engineering for Cox Media and chair of the Next Generation Architecture working group of the NAB Radio Technology Committee. He also chaired of the HD Time Alignment Working Group that published the document that the National Radio Systems Committee adopted related to HD/FM time alignment.

Shane Toven is senior broadcast engineer, Educational Media Foundation and a national director of the Society of Broadcast Engineers.

Alan Jurison is senior operations engineer, iHeartMedia Centralized Technical Operations, and the chair of the Metadata Usage Working Group within the National Radio Systems Committee.

Philipp Schmid is chief technology officer of Nautel. Greg Shay is chief technology officer of Telos Alliance. The conversation was moderated by Michael LeClair, chief engineer of WBUR in Boston.

Their freewheeling conversation explores the challenges and benefits of such a conversion for broadcasters, and how to be prepared for it.

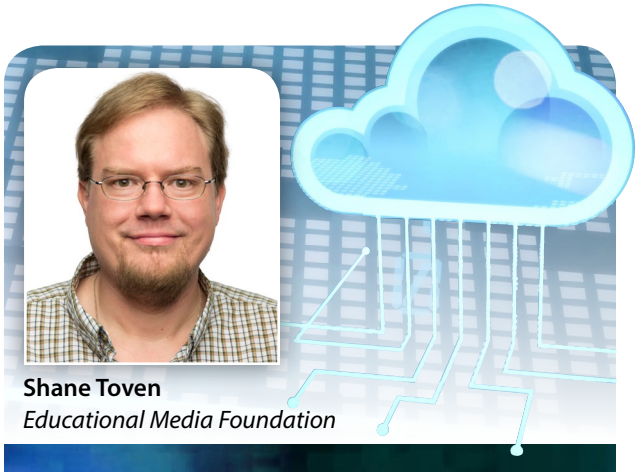
THE NATURAL PROGRESSION OF VIRTUALIZATION

Michael LeClair: *What does virtualization of the air chain mean to you?*

Roz Clark: I think it's a natural progression of our business, as we look at the technologies that surround it and how we can use those technologies.

Once we can get a process into the world of software and it can be networked and connected together, it lends itself to, "Okay, where is this software? Where does it live? Does it live in a purpose-built box or does it live in a server amongst other instances of the software?" And once it's into that "virtual environment," the location of it becomes optional, depending on available networking.

There's this building block approach. Things like



Shane Toven
Educational Media Foundation

"We have this really nasty habit as broadcasters of dragging our feet … there is a time when technology does need to shift and adapt and adopt, otherwise you end up dying on the vine."

dependencies, networking and business criticality, how much do you really want to go and touch that box that it lives in, all become considerations.

We're doing a tremendous amount of it on the business side but less on the broadcast side at the moment, mainly because of the networking and perceived reliability requirements.

Shane Toven: We've been living in a software-based world now for quite a number of years. Every box that you have, at some level or another, likely has some software driving it in the back end.

So it really doesn't matter whether that software lives in a dedicated purpose-built box or elsewhere in your environment.

In our particular case, again, we have a lot of virtualization going on in the business side of the house. We're just starting to dip our toes into it in the broadcasting side of the house. I've been doing some projects to investigate that, and look at what it would take to basically create a virtual air chain, so to speak.

In our case, a lot of the challenge is around connectivity. We have a number of remote mountaintop sites with limited bandwidth to them; so I think the real limiting factor would be being able to get reliable connectivity to those sites. But, if we could get a couple of forms of connectivity, say something like the combination of a Starlink [microwave link] and LTE [4G wireless data] to the site, that would be a very robust solution for connecting a lot of these sites.

Philipp Schmid: At Nautel, whether it's virtual or whether it's a software-only system running on physical hardware, it doesn't make that much of a difference. Our goal is to come up with a transmitter design where essentially you just have an Ethernet jack and it takes care of everything. Really simplify the transmitter site. That's where we want to get to.

We're definitely not there today, in today's architecture. Our hope is that this virtualization approach will reduce complexity. And perhaps, it may not necessarily eliminate all the complexity, but by moving it into a virtual site, Nautel can come along and help with customized solutions.

Now that it's no longer at a remote transmitter site, if it's not a purpose-built box with a very rigid set of firmware that has a very specific purpose, and it's a more flexible virtual system, Nautel can come along and help the broadcaster tailor the solution to best integrate with the rest of the broadcast plant.

I'm not going to lie; particularly with HD Radio, there will still be a lot of complexity. But maybe we can shoulder some of that.

In particular, for broadcasters that don't necessarily have all of the technical know-how to deal with the finer details of HD, perhaps we can provide the technical support in a virtual environment.

So, I believe virtualization will lead more into customized solutions. We're moving away from products that have very rigid specifications to a more agile type of environment where a set of standard building blocks can be used. The way they're put together as a system will be customized.

HD is here to stay, but it has a lot of complexity, and we've noticed that even though there is a significant build-up in side channels, the overall station conversion has somewhat plateaued over the last five to eight years. Everybody is planning for HD, but there are a lot of broadcasters that have not pulled the trigger because there is significant complexity, cost and a requirement for technical specialists.

We're hoping to make it easier for people to get into HD.

Greg Shay: Of course, at Telos Alliance we make studio broadcast equipment as well as interconnectivity over long distances.

Virtualization, to us, is really about intentionally taking advantage of the latest technologies from the IT world. Full stop. We believe that by intentionally following the best practices of the IT industry, you end up in a place where you actually have the best possible performance.

Your Guide on the Road to Virtualization

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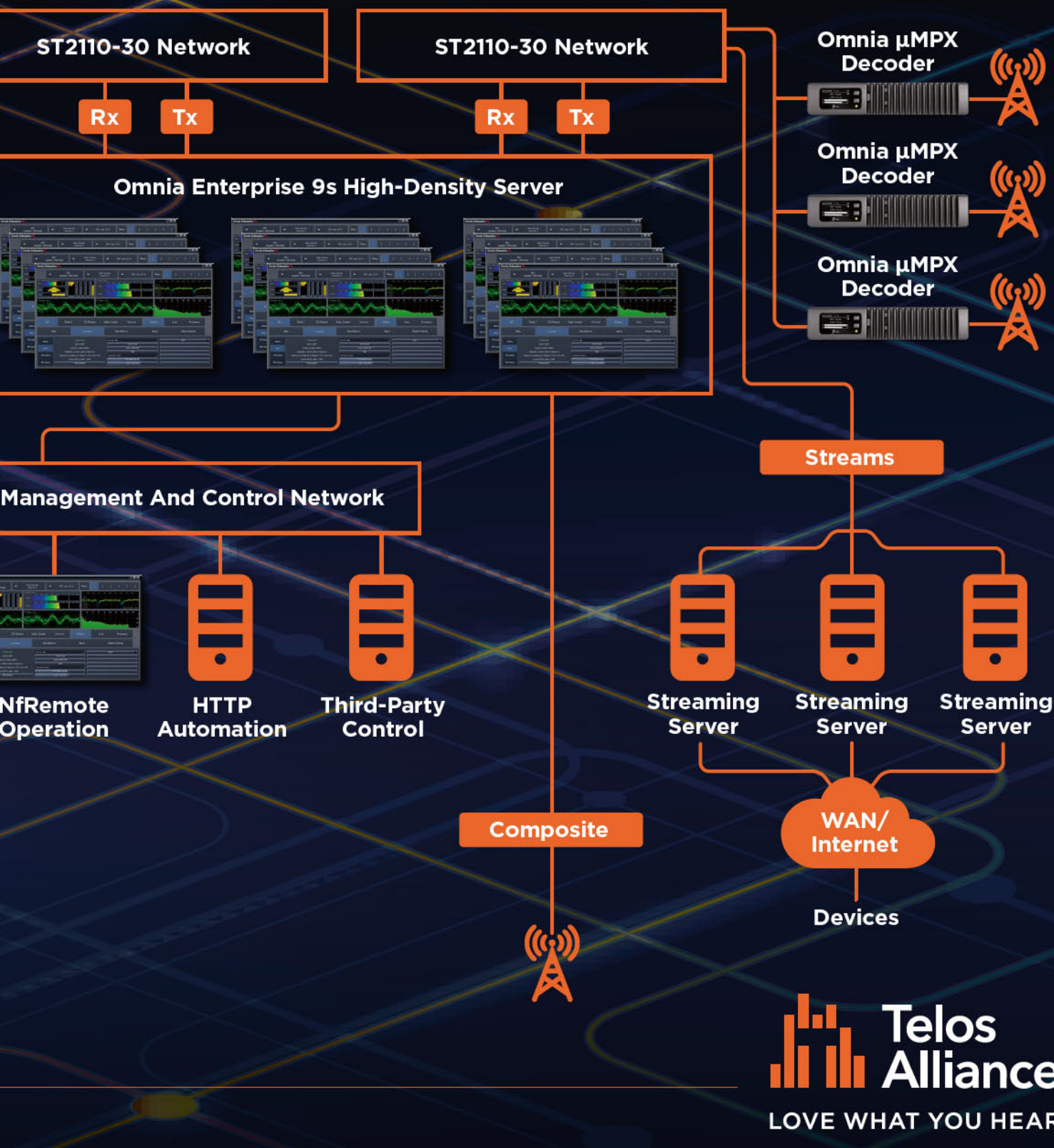

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In the same way that 20 years ago when we first figured out how to do audio over IP, it was an intentional choice to leverage standard networking equipment, here we are again: an intentional choice to take advantage of the best server technology, which is virtualization.

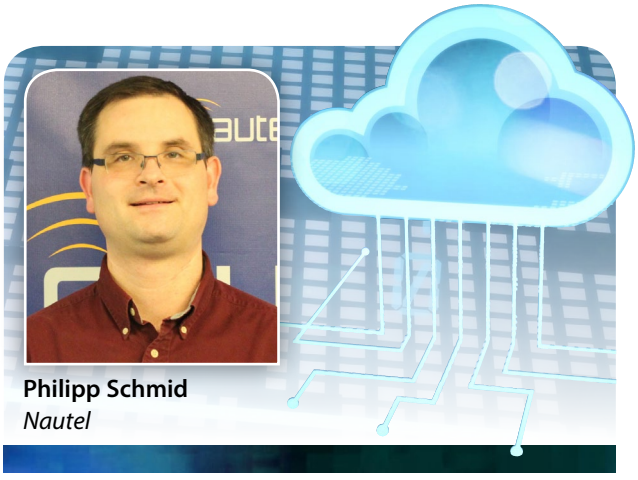
Alan Jurison: [Virtualization] is really consolidating all the broadcast functions into either a software environment, or single-purpose hardware and facility functions at the transmitter site. That's our focus on it.

There are big challenges with virtualizing something as critical as broadcast. Putting parts of your air chain right now into the cloud, you are going to need that "last-mile" connectivity to the site, and at this point, there's just not a universal solution for getting stations connected at the level of reliability to run air chains completely virtually.

We're able to do parts of it now. As virtualization increases in other businesses, the infrastructure becomes more available.

As broadcast companies — manufacturers, software providers and broadcasting companies — come together and work through some of those things, I think within a matter of a few years we'll see increased options for connectivity. We have been seeing the overall rollout of 4G LTE, and now soon we'll be on 5G wireless connectivity. With new and different satellite networks that will have much more robust connectivity in the next few years, we can start planning now to harness that.

This isn't something that everyone is jumping into today, but it's a topic the industry is starting to delve into. It's good to see companies look at the challenges of how do we make something live and robust for broadcast stations and systems.



Philipp Schmid
Nautel

"Our goal is to come up with a transmitter design where essentially you just have an Ethernet jack and it takes care of everything. Really simplify the transmitter site. That's where we want to get to."

MICROPHONE TO TRANSMITTER IS GOOD BUSINESS

LeClair: *Alan's comments anticipate my next question. Are we ready, as an industry, to pursue this kind of virtualization from a technical standpoint? Alan was touching on that in terms of the last-mile networking required. And part of that question is: Should we be planning to build out virtualized segments of the broadcast air chain one piece at a time or is it ready for us to think end-to-end at the moment?*

Clark: I wanted to note that we are working on another project in the industry, the NAB Radio Tech Committee's Next Generation Architecture Committee. There's essentially a three-legged stool approach: broadcasters are one leg, equipment manufacturers such as Telos and Nautel are the second, and Xperi as the third leg.

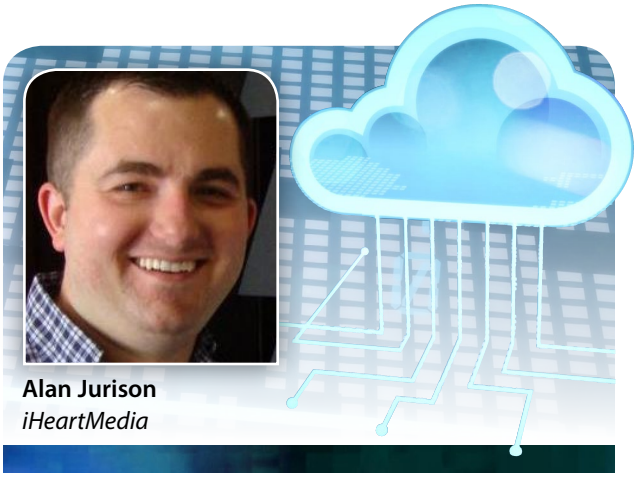
We all need to coordinate so we have standards that can be built towards, and interoperability is baked into it — even though there are unique solutions being developed by extremely intelligent folks across the industry. We want everyone to collaborate so that we have interoperability and the ability to migrate parts of the system towards that eventual goal.

When you ask "Is the industry ready for this?" the answer from a business case is, absolutely. Cheaper, better, faster.

Philipp touched upon the skill sets to support broadcast. Where is that going to come from? And who? Who's going to provide that?

That's an open question, but along the infrastructure path there are certain things that we feel need to be solved for. Folks like Telos and Wheatstone and others have proven that we can run audio in a plant over IP, and we can get content from the field over IP, and we can do all these things moving data and audio around over IP. Been there and done that.

The problem is in the infrastructure. If you look at it from a broadcaster's point of view, even if we



Alan Jurison
iHeartMedia

"There's more content streams than people. To really produce that high-quality broadcast, we need to be able to simplify and structure the broadcast business into a way where it can be easily managed."

have a pure IP plant, we still have to come out of that IP stream and go into things like a PPM encoder, or going into in and out of things like an EAS encoder. They're just part of the requirements of a broadcast plant.

So we have targeted those essential things. For instance, right now, as we're having this conversation, yesterday we qualified the first case of a test of PPM software living in an audio processor, so that it becomes a software solution versus a hardware dependency. That same network path can flow through a piece of software versus having to come out to an XLR AES jack and back in.

EAS is going to probably be a little bit of a heavier lift for the main channel, but Alan can speak to how there is a software solution for the sub-channels that has been developed.

So we're chipping away at the stone here, and I think what Nautel showed yesterday with Telos on their webinar, it is super awesome to be able to test the theory of how you can virtualize these things [see "Nautel and Telos Alliance Explore Cloud-Based Air Chain"].

We still are hamstrung by some hardware dependencies for some of the signal flow. Some of the content that has to be aggregated and put into that pipe is still a challenge.

The industry is ready, from a business case and from a support case, for just how the future has to evolve. As Greg said: Adopting a best practices protocol, we've always done very well as broadcasters. We've stolen the best ideas from telecom, from IT, from networking, everything else. We're very good at that.

But we need to look at some of these broadcast-centric systems and do the same thing with them. And that's sometimes easier said than done.

Toven: The technology is certainly there. The technology for virtualization has been there in the IT industry for a number of years.

But we have this really nasty habit as broadcasters of dragging our feet as we go kicking and screaming into these future type technologies, particularly when it comes to some of the small and medium broadcasters: "We've always done it this way, why change it?"

But there is a time when technology does need to shift and adapt and adopt, otherwise you end up dying on the vine, so to speak.

Having the tools from the IT industry to build on, that gives us about 90% of what we need right there. But the big challenge will be those industry specific components, the things that only broadcasters are hamstrung with, like PPM, like EAS and various other things.

For larger broadcasters and broadcast groups, it won't be so much of a challenge to make this shift, aside from that last-mile connectivity issue. For smaller and medium broadcasters, they're going to find it a little bit more of a challenge to kind of get into this, both from a talent perspective and maybe even just from a financial perspective, depending on how that works out.

This is going to look more like op-ex costs than cap-ex costs as we move forward. It depends on their comfort level of op-ex versus cap-ex, as well.

Overall, from a technology perspective we're ready and moving forward on all of this. But from an industry perspective, I think we still have a little bit of work to do, especially in the scalability down to the smaller and medium-sized levels.

LeClair: *Shane, do you want to elaborate on what you mean about op-ex?*

Toven: In the past you bought a box that was capital expenditure. And that box may have sat in your air chain or in your facility for five, 10, 20 years or whatever the lifetime expectancy of that box was.

As technology has progressed, the lifetimes of

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those boxes has shortened now, just due to the cycle of technology. We know that technological change has really sped up.

But things on the business side are moving away from this model and toward software as a service, where basically you pay an annual subscription fee for products and various components of software packages that you use.

Look at on the business office side. A number of people may be subscribed to something like QuickBooks Online and it becomes a critical piece of their business; but they're paying a monthly fee, or operational expenditure, to actually have that available. They don't actually own that software package.

That means that they are, of course, dependent on that company, and it is an ongoing operational expense for them.

Some companies are more comfortable having ongoing expenditures like this. Some are more comfortable just wanting to buy it and be done, at least until they have to think about it again five, 10, 20 years down the road.

Schmid: As you know, we've done a three-part webinar series on exactly this topic. We felt it was important, given the industry discussions that are going right now, to show a technology direction.

Greg Shay
Telos Alliance

"The broadcasters always are going to have to have somebody whose vested interest is that their signal and their program sounds right. So, it's not completely walking away and saying, 'Oh, the air chain is a 'service,' with people who are going to make sure that happens.'"

We've shown a technology proof of concept that shows you where it goes. We're not at the level yet where we have products, where we can just say, "Here, go with that," but we thought it was very important to work with the initiative that Roz mentioned with NAB RTC, working with other broadcasters, and getting their input at this point rather than just simply forging ahead.

We wanted to throw our suggestion out there. We're not saying that we have all the answers. Far from it. There are still many, many things to look at, but we're adding our two cents of discussion.

We're hoping to work with broadcasters, see how we can address challenges like the last mile and how we can address challenges like providing the expertise to make all this happen.

We're also in the midst of the same transformation. There is this world that Shane was talking about, and it affects us manufacturers equally. It is changing the way we operate, so we need to go through the same transition that you're going through. That is where the industry is going and Nautel is there to support that.

Shay: Is the industry ready? You know, something that we've seen our customers experience through the whole two decades of audio over IP is this transition or the hand-off from the traditional broadcast engineer to the IT engineer. At the beginning it was a big challenge, but we're seeing now, it's not a challenge any more.

Any organization of any size, and especially broadcasters, are pretty seriously invested now in know-how on the IT side. And indeed we see the trends: When they're planning new facilities, it starts with the IT department—their choice, not because of any equipment considerations. So that transition, which at the beginning was more of a problem, I think we're over that hump.

Sitting down with a big corporate customer, I'll ask, "Do you have guys who are familiar with and can handle setting up virtual machines?" "Oh, yeah, sure." "Do you guys know Docker and Docker containers?" Well, sometimes.

I went to Google Next, their developers' conference, two summers ago and really had my head expanded, on how that class of large corporate big facility operates, serving lots of people. The patterns are very similar. When we want to leverage those facilities, like AWS and Google Cloud, they're available to be hired.

You as a broadcaster don't have to create all this from scratch. It's around. It's able to be leveraged.

These are products *available as a service*. Air chain as a service, right? Network technology as a service. Because somebody doesn't have to be physically at your location to manage or set up or configure what you need, it is something that you can then hire out.

But, I will say this: The broadcasters always are going to have to have somebody whose vested interest is that their signal and their program sounds right. It's not completely walking away and saying, "Oh, the air chain is a service, with people who are going to make sure that happens." You're going to have to always have somebody on your side making sure things are done the way that you need them to. It's not a complete wipeout of broadcasters having technical people, but it's like a teaming up. Based on that, I think the industry's ready, they just have to realize it.

Jurison: Business demands are really requiring it. Not only within the broadcast industry but in general business trends altogether.

One of our challenges in the broadcasting industry is the amount of people and technical people that have to service a radio station. Engineers, IT folks and those types of technical people, they're fewer and farther between.

One of the benefits of moving most of our broadcast processes into software and virtualizing them or having them managed services through companies like Nautel or Telos [is that] you can get some expertise that you might not have had in certain locations.

Broadcast stations have always needed to have that wise engineer or wise IT person to assemble the plant and keep things running smoothly day to day. There's just going to be fewer of us, and it's going to be more radio stations, more audio streams, more content, right?

It's how the world is expanding, with additional HD sub-channels and streaming-only channels. There's more content streams than people. To really produce that high-quality broadcast, we need to be able to simplify and structure the broadcast business into a way where it can be easily managed.

Virtualization simplifies a lot of that management and provides expertise that a smaller broadcaster might not be able to afford. Many stations rely on contract engineering and do not have a dedicated support team. Moving much of the operation into the cloud and removing hardware dependencies in the field can get them 24/7/365 monitoring and support. This direction may not be the best fit for every broadcaster but I think it could revolutionize how smaller stations operate and dramatically improve the quality of their terrestrial and streaming broadcasts.

LAST-MILE CHALLENGES

LeClair: *What about the data connections required? It seems to me that one of the technical issues we might run into is that interconnection of networking between locations.*

Toven: It is going to require some robust connectivity, especially if you're doing public cloud type of stuff.

But it's kind of like going back to the old days of AoIP where instantly people might think of the public internet, right? Well, it doesn't have to be. You can do private cloud. You can do on-premises; that's certainly a very valid option.

In fact, there are some people who are absolutely adamant that they do not want that stuff leaving their facility. And that's perfectly fine. You can still do these things and have that connectivity all in-house.

It just depends on what your tolerance for risk is and what the available resources are financially, connectivity-wise and otherwise.

To be sure that we understand: When we're talking about virtualization and the cloud, those are two separate things.

— Greg Shay

Shay: Connectivity up the mountain — and I hope this isn't trivializing the problem — in my mind, some Telco is going to figure out that if they get out the equipment one last time and drag a fiber up that mountain, they've got a real premium niche.

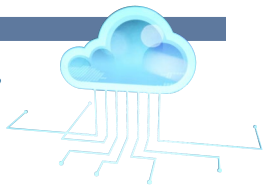
Imagine feeding all of those transmitters. You go to San Francisco and you see the hill. Cleveland has it, too. There are seven towers in this one area. It's an obvious target for a premium service. I think they just need to wake up to that.

To be sure that we understand: When we're talking about virtualization and the cloud, those are two separate things. And that can make a difference in conversation, because as soon as you say the cloud, you

think, "Okay, now I'm totally long distance. I'm here in Cleveland, and AWS is in Virginia, and that's a problem." The cloud providers are recognizing the need for what they call the hybrid cloud, such as [Outposts by AWS or] Microsoft's Azure Stack.

The point is that if you want, they will bring a chunk of their servers on your premises and manage it for you; you'll pay them to manage the physical thing that's on your premises.

Some corporations — hey, we're talking banks and a lot of big corporations or broadcasters are in that class too — may make that choice. And you still gain a lot of these advantages.



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—Shane Toven

As long as there are backhoes, backhoe fade is not going to go away. We just have to be smart about it.

Clark: I've watched connectivity to transmitters evolve pretty rapidly from zero — you have to establish your own point-to-point, whatever that may be — to DSL, to cable, to you-name-it. It's evolving. As far as creativity, there are wireless ISPs, and this, that and the other commercial solutions.

Our goal for that last mile is to have more than one of those service providers — and if possible, one that is over the air. Whether it's our own microwave link, a wireless ISP or 4G, whatever is available, you want this in addition to whatever's buried in the ground — to address Greg's point about backhoe fade.

And then utilize the technology, again from the IT industry, to employ multiple circuits at the same time and automatically build packet level fault tolerance.

It doesn't matter how they got there, but they're getting there, over one path or the other. It takes the stress level down on the broadcast engineer — even though, historically, for that last mile, there's always been this, you know, holding on with bare knuckles: "I must have this one microwave path and that's it."

That attitude is dissolving once people realize and become accustomed to the fact their everyday life is over a packet. They are becoming more comfortable with the idea that, "As long as it's working, and as long as we have fault tolerance baked into it, I'm good." Even the idea that satellites can deliver this in a much better way than back in the day — satellite IP, I think there is a future for any site.

Schmid: One thing to note here is the data capacity and the data rates that we're talking about in the professional audio world, I mean, it fades in comparison to all the backbone traffic from video and Netflix today. We are just a drop in a bucket.

So in terms of connectivity across the globe, finding the network bandwidth is not an issue. But it is that last mile that is going to be the challenge. Getting that fully reliable 24/7 is critical. I agree with suggestions for having multiple service providers, absolutely.

That's the challenge that we want to focus on, that last mile. That's where we really need to put retransmissions in, perhaps Forward Error Correction, perhaps multiple IP connectivity, to establish resiliency into the IP connectivity. Techniques like that are going to be key on that last mile.

We're also following these developments with satellite-based broadbands. That could be a game changer, particularly for those remote mountaintops. Will it be your main way of getting content up the mountain? Probably not initially, but it could certainly be a backup.

They're even talking about moving the whole data center into a satellite to get it closer to the end user. How content could come right from the satellite down to your radio transmitter. So, there's nothing but the last mile now.

But keep in mind it's not just the last mile; it's also the first mile. From your microphone input to the cloud. That's another aspect you need to look at as well.

THE ESSENTIAL BEAUTY OF A SELF-HEALING NETWORK

LeClair: *Your comment Philipp leads to another question that is such a concern for broadcast engineers today. How do you feel about the public internet as one of those transmission paths? I think we've found pretty successful operations for audio, pure audio, but what about the rest of all these pieces that we are now tying in?*

Toven: You know what? I think people fear that a lot more than is really necessary.

To be honest, so many aspects of our lives today

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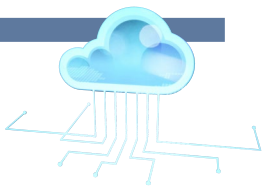
are tied in with internet connectivity, but the out-and-out entire failures of connectivity from multiple providers at the same time are really few and far between. I think I can count maybe two in recent memory; one was a really obscure hardware issue, and the other was just a missed program routing error. Honestly these things can be very, very robust.

If I have LTE from one provider in one hand and I have cable modem in the other hand, I am almost never without connectivity.

People need to realize where we've come from, the days of things like DSL and dialup.

Clark: As a broadcast engineer, it's all about the buffer. You know what I mean? We can build systems to handle outages depending on if it's exactly 100% real-time, or if there's a buffer that we can exploit.

That makes a world of difference in how we move this stuff around. Philipp alluded to this. It's radio, so the bandwidth and the requirements are significantly less than what is available out there. Not too long ago, getting quality audio delivered on that last mile was a challenge. Now that connectivity, whoever is providing it, the bandwidth and capabilities far exceed our demand.



To really produce that high-quality broadcast, we need to be able to simplify and structure the broadcast business into a way where it can be easily managed.

—Alan Jurison

Shay: Think of the difference between MPLS [Multi Protocol Label Switching] and SD-WAN [Software Defined Wide Area Network]. If you want to pay for it, traditionally you get an MPLS connection that is, basically, reserved bandwidth from the Telco operator from point-to-point. It's technically not carried over the public internet. It's kind of alongside the internet and using the same backbone, but it's not subject to the evening Netflix data surge and so forth.

SD-WAN, which is coming on strong, is basically built employing user redundant paths, multiple paths, and basically trying to get the best performance you can out of the internet.

Now, there's a big different in price, and it really comes down to the end customer. Are you willing to pay for that reserved higher class of service? It's there if you need it, if you want it, if you want to pay for it. Or is the SD-WAN, which is a self-correcting layer added to the internet, good enough? Part of the SD-WAN coming on strong is basically that people are voting with their pocketbooks.

Schmid: The public internet is itself self-healing. It is a dynamic structure, and that was demonstrated just last week with the CenturyLink outage that affected a massive amount of the internet's backbone but hardly anybody noticed, because traffic got rerouted, everybody got to work and it was essentially repaired itself.

For the internet globally to go down, I mean, it would have to be a super catastrophe for that to happen. So the public internet in terms of reliability is there.

But there are other challenges, security being a big one. And latency issues.

It's a different set of challenges than what we're used to. But again using standard IT technologies like virtual private networks or other encryption techniques, we can overcome these. I am positive the public internet will play a part, maybe just as a backup way of connecting, but it will play a part in the future.

Jurison: The public internet actually is kind of our primary in a lot of cases because some of those high-availability networks that might be managed like a traditional MPLS circuit are also prone to last-mile failures.

We joke about backhoe fade, but it can be beyond that. In larger markets it can be a problem within a building, like what happened in Chicago with the big flooding earlier this year. The entire basement of the Willis Tower gets flooded and it takes out the Telco facilities for weeks.

You need to think about not only connectivity to diverse ISPs or to diverse connections. We've got to think about how that connection arrives to your transmitter site, and if it all arrives on the same aerial cable coming from a telephone pole, or if it's arriving through basically Telco distribution in a large building or in an office park. You can have all of your connectivity just go away in an instant, even with two or three ISPs.

You might still want that point-to-point shot with IP that we may have established, or you might want to use LTE or a satellite backup.

A big challenge in virtualizing the broadcast environment is the ability to take hardware-dependent devices like EAS and make them software.

— Roz Clark

That's going to be our biggest challenge as we move forward. Connectivity at the transmitter site needs a lot of these fibers. Getting a Telco provider motivation to build fiber to a big facility with 10 radio stations or whatever, TV stations, isn't difficult in an urban environment; but when you get into these towers that are literally miles away from fiber infrastructure, there's really nothing. One customer at the end of a mile or two of fiber is not really a lucrative business for them unless that broadcaster wants to take on the capital cost to extend that network there.

THE VALUE OF CENTRALIZED CONTENT

LeClair: *We mentioned the difficulties of attaching function specific devices such as a Neilsen PPM encoder or an EAS generator to a virtual air chain. Can you comment on some other broadcast-specific functions that currently use hardware specific devices such as RDS, and HD metadata features like dynamic PAD or Artist Experience graphics?*

Clark: The Next Generation Architecture group, one of our sub-committees, is [looking at] the actual network transport concept, and it's a complicated question. I think some of the vendors, Nautel and others, have proposed solutions to that. But you're correct: Getting all of the content, whatever that is, a place on that train, that packet train, is going to be one of the key things.

Shay: It gets a lot easier when all of the information, all the data, all of the streams, are in that central shared place. Then we can put them together into the packets. The single worst thing is to have the one odd box out that is still on premises somewhere and you have to make a complete round trip to loop it in. So people are trying to get everything into the same location for this kind of assembling.

Schmid: If you have everything in one place, that's what we demonstrated yesterday in our webinar, we had all the content originating from one place, and it included RDS, one of the examples that you mentioned. That's probably one of the easier ones to deal with.

We've conceptually demonstrated a whole air chain, without PPM, without EAS, on a system like that. Alan can probably talk to the EAS solution on secondaries, but I think we're working in the right direction to come up with this concept of a central place.

One of the messages we've been developing is to fall back on established made-for-radio protocols to put this pipe together. Rather than coming up with something new, we can look at concepts that already exist, like composite MPX over IP. As Greg said, that puts all of the FM components in one place, plus the RDS and all the PPM stuff that starts to stream from that, so it's already handled bundled together.

In the HD system we have the E2X protocol, that's conceptually the same thing for HD. It bundles and multiplexes all of the side channels, all of the data services in one spot, and it's one pipe.

So all we're saying is to extend this concept and marry the two together, and now we have this single data stream. This may not be the complete solution for all of the problems we're facing, but it is one aspect of it. It doesn't prevent you from using that same link at the transmitter, or at the studio, or in a cloud, but it does mean that you can now have more flexibility as to where you put it.

Looking at the HD side first, those bandwidth requirements are fairly low, and we've been dealing with that for years. As a matter of fact, I believe it goes back to 2006 that iBiquity created a very comprehensive networking guideline, having to deal with both the import traffic and the export traffic, and it's still applicable today because not that much has changed. We're talking between 150 to 200 kilobits per second by that standard. So the existing HD side of things is fairly well taken care of.

One of the arguments for the third-generation HD architecture was that we wanted to move that export function back to the studio, so all of the HDC compression happens in one place. Essentially, the bits get packaged together in the same manner they will be broadcast on air, which is the most efficient way.

Things have changed since and you can follow that in our webinar, but that was the argument back then for this protocol, and it was designed to efficiently handle the last mile.

Now, on the MPX side, for FM, it's a little bit more challenging. The MPX waveform has a higher band-

width than your audio, and we're talking about something like 2.8 Megabits.

Again, compared to video streams, even your YouTube connection, that's probably not that much these days. But still, for the last mile, that is going to be a challenge. One thing that we are discussing with our partners at Telos Alliance is a hard look at microMPX, a codec specifically designed for composite MPX.

MicroMPX is not an audio codec, in the same way we use a perceptual codec applied to your normal left/right audio. It is applied to the composite MPX and it can bring the bandwidth requirements down anywhere between 300 to 600 kilobits. That, I believe, is a technology that's going to be key for this concept.

FINAL QUESTIONS

LeClair: *Final thoughts? Questions for each other, or did one of you hear somebody else say something and go, "Well, that's news to me."*

Shay: I'd like to take this opportunity to ask the same question that I ask customers. Within your organizations, what's the comfort level? Do you have people who are comfortable spinning up and down virtual machines? And what about Docker?

Toven: That's absolutely happening at EMF already on a daily basis. I talk to our media delivery team who are part of our technology team, and, my goodness, some of the things that they're already doing with virtualization is ... Just kind of blows my mind, so they'll absolutely look at these applications and go like, "Ah, no problem."

LeClair: *Are you pursuing on-premises data systems, or in the cloud, so to speak?*

Toven: We kind of have a mix right now. There's a lot of the kind of back-end applications, just the business applications, non-real time type applications that are happening up in the public cloud like up on AWS. But I suspect when it comes to the broadcast end of things that will likely be all on-prem once we get to that point.

Clark: As I said earlier, our business side is very comfortable with virtualization. We have some subject matter experts.

The Cox Media Group has evolved recently, and we all fall under one technology group. It's a whole lot of IT folks there and cloud specialists. I just got a note here saying, "Hey, Roz, just to remind you, this weekend we're moving all of our traffic systems into Amazon ... But you don't have to worry about it, because we've got it all handled and it's all pre-tested, and it won't be a big deal." Okay!

They've migrated a whole bunch of non-real time stuff to Amazon Services, and it's been better performance. We have a part of our automation system, that is not real-time, in Amazon Services. It used to be in our hardcore data center where all these things were going on. So we've got several toes dipped in the water on that.

From my point of view, talking to manufacturers, Greg's question was framed as, "Hey, if we're sitting down talking to a customer," my encouragement would be, keep on doing what you're doing.

What I saw with your presentations with Nautel, you guys are really the tip of the spear in a lot of this stuff, and we are closely watching that.

I'm asked by my boss — who is a technologist, not necessarily a broadcast engineer — about all of the above. "How come we're not doing some of this stuff in the broadcast space?" So we're looking at all of that for business reasons. We are going to implement these things most likely in areas that are less risky to the business, on the broadcast side now, in real-time fashion, and then move into the more critical parts like streaming, sub-channels, and so on.

A big challenge in virtualizing the broadcast environment is the ability to take hardware-dependent devices like EAS and make them software. This step is required to eliminate the need to convert the IP networked content stream into some form of I/O to interface with a piece of hardware before the final transmit destination. EAS for the main channel content channel has specific FCC requirements that need to be approved by government agencies before any manufacturer can provide a completely virtualized solution.

Jurison: We at iHeartMedia are doing a lot of virtualization for business applications like traffic in music scheduling. Our RCS division has an automation system that runs up in the cloud, so we've got our hand in all sorts of this stuff, plus traditional business applications have all moved to the cloud, like e-mail.

There's no real reason, now that you can buy the services, that you have to build these huge data centers, and we're moving towards virtualizing and moving those types of applications that would take

up racks and racks and racks of equipment, with people to maintain them, and kind of handing that off to providers like Amazon and others like AWS.

We're getting back to the root topic here. It's really good that Nautel, Telos and the NAB Technology Committee are figuring out what parts of the broadcast chain we can put up in the cloud. What part belongs in hardware still at the transmitter site? How do we tie together the connectivity? We all have the bits and pieces to work with this, and we're hoping to get the industry together to come up with some common ways and standards for intercompatibility, so that we have a robust set of solutions for different stations in different levels of service.

Toven: I just have one more quick comment regarding the cloud technology and one of the biggest reasons we started migrating to the cloud for some back-end applications here. It was, first, because of multiple geographic locations, and second, improved disaster recovery.

Having a lot of applications based in the cloud environment makes migrating between those locations so much easier, and it makes disaster recovery scenarios so much easier, because suddenly you're not thinking about how to switch between a bunch of servers physically located at one location, versus another. As Nautel showed in their demonstration, they're able to switch on the fly and suddenly it just goes.

Schmid: I just want to caution everybody that we need to keep our eye on the puck, on the goal. This whole technology is very cool; there's a lot of benefits; but we're going to be entering a period where we're going to flush out all the problems. So we're showing a technology direction. We are only just beginning with all of this. There's going to be challenges. We're going to have failures. We're going to have problems, and we're going to solve them.

The word of caution is to not give up when we're in the middle of this, because I think there is a very good goal at the end of this. And coming through this and resolving all the problems and the issues is going to make our industry stronger.

Shay: May I end with a story? This is a historical perspective that I think gives due credit to the broadcast industry, so it might be interesting.

Looking back at the development of technology and asking the question, "Why do we have this distrust of computers? Where does it come from, in the real world today?"

When you think back to the computers of the 1970s and '80s, and even in the '90s, mostly they were a box in the corner of the room. And they often got a black eye because you couldn't get the printer to work half the time. That's our memory of computers.

It's my claim that the modern IT industry has learned from the broadcast industry to regain our trust. If you go way back to the beginning of broadcasting a century ago or half a century ago, it was the broadcast engineers and the broadcasters who knew how to build facilities and systems that would stay up, stay on the air.

The broadcast engineer was the guy that if you were off air, he would jump up in the middle of the night and go fix it. And they started to say, "How can we build things so I don't have to get up in the middle of the night so often?"

We're showing a technology direction. We are only just beginning with all of this. There's going to be challenges.

—Philipp Schmid

Then, when the business world got serious about IT supporting banks, Amazon.com and Google, all of these big infrastructures, they had to figure it out. How do you make computers super reliable?

And so they borrowed all of these techniques and everything that broadcasters always have done. There are DevOps guys at Amazon who, if a chunk goes down, get up in the middle of the night and fire up a redundant system. They jump out of bed. So they're the ones on the hook now.

That transformation has come full circle, and sometimes we don't realize it. I believe there's a foundation, a legacy of broadcast engineering, in the IT world that should give us confidence in relying on them.

LeClair: *Well said. … Gentlemen, thank you. It's a privilege to have you.*

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