



# RUNAS RADIO



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Richard  
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RunAs Radio is a weekly Internet Audio Talk Show for IT Professionals working with Microsoft products. The full range of IT topics is covered from a Microsoft-centric viewpoint.



Greg  
Hughes

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**John Bocharov Smooths Our Streaming!**  
**February 4, 2009**



[Music]

**Brandon Wenn:** From [runasradio.com](http://runasradio.com), you're listening to RunAs Radio, the Internet audio talk show for IT professionals with Richard Campbell and Greg Hughes. This is Brandon Wenn, announcing show #95, with guest John Bocharov, recorded Thursday, January 15, 2009. RunAs Radio is produced each week by PWOP Productions, providing professional media and podcasting services online at [pwop.com](http://pwop.com). You can follow the boys on Twitter at [twitter.com/runasradio](http://twitter.com/runasradio).

**Richard Campbell:** You're listening to RunAs Radio. I'm your host, Richard Campbell, with me as always my co-host Greg Hughes.

**Greg Hughes:** Hey Richard, how are you today?

**Richard Campbell:** I am fine. First trip of the year already out of the way and looking towards the MVP Summit and the madness. That will be March.

**Greg Hughes:** Very cool.

**Richard Campbell:** It's an endless process but I'm not complaining, lots of good things happening these days.

**Greg Hughes:** Yeah, this is the time of year when I'm sitting around working and you're off traveling. You travel quite a bit more than I do. I travel enough, but you travel a lot.

**Richard Campbell:** I usually get you roped into my things in the fall when we start doing the big shows.

**Greg Hughes:** Yup.

**Richard Campbell:** So let's shift right into the show because I've got a topic we've always wanted talking to John Bocharov from Microsoft. John is the Program Manager for Microsoft's IIS Media team. He focuses primarily on designing and delivering Smooth Streaming and related media server technologies. Welcome, John.

**John Bocharov:** Thank you.

**Greg Hughes:** Hey, John.

**John Bocharov:** Glad to be here.

**Richard Campbell:** We bumped into each other at TechEd EMEA if I remember correctly.

**Greg Hughes:** Yeah.

**John Bocharov:** Yes, that's right, in Barcelona.

**Richard Campbell:** Yeah and oddly enough way back at the beginning of RunAs Radio, one of our topics that people were asking us about was the Streaming Media Technologies that Microsoft has. I mean it's certainly popular. You guys are everywhere but it is very much a specialty, isn't it?

**John Bocharov:** In a way. One of the nice things is that it's a piece of technology that most internet users will be able to relate to and understand, but it takes a very special set of people and it's really interesting to see how often we wind up working with the same groups of people and the same set of experts on creating wave after wave of this technology.

**Richard Campbell:** Right, because you have to have this mindset around the whole concept of Streaming Media or that kind of data. The datasets are large and you're sending huge chunks of data to individual people. It's an interesting problem, different from a lot of other problems.

**John Bocharov:** It is very different from a lot of problems that you solve on the web and I think you've hit the nail right on the head in that you need to send a lot of data and very many of the challenges we try to solve is how do you get people the best experience possible when it's not always easy to send all the data you want to send.

**Greg Hughes:** Yeah.

**John Bocharov:** So you wind up spending a lot of time thinking about, well, how do we compress this information as efficiently as possible, how do we present users with a rich amount of metadata about what it is they're watching and what's the best way to optimize the connection between the client and the server so that the people get the best experience they can. One of the biggest challenges that people have always faced is that there's a broad spectrum of last mile connection speed.

**Richard Campbell:** Right.

**John Bocharov:** So even in an enterprise network, you might have somebody who has a direct link to their corporate network, you might have somebody in a branch office, you might have somebody who is trying to view the content of their wireless router, and so all of those people are going to experience very different characteristics of how they download data.

**Richard Campbell:** This is not just about the bandwidth on your end of the network.



**John Bocharov:** On the end-users end of the network, correct, and once you get into the web space, of course it just completely breaks open in that you have some people who have now, I believe, in the U.S. 20-megabyte DSL and they say, well, I want the best experience now because I'm paying for all of these great bandwidths, and by the same token you have some people on sort of much older generation technologies and of course people roaming with their laptops trying to connect to over wireless networks provided by the carriers and whatever else and once again there's great variability over that last mile between the internet and the user who's trying to watch or listen to this content on this train.

**Greg Hughes:** I remember using Windows Media Technologies to encode content and stream it out. I think the first time I use it, and this would be probably eight years ago, use it in any real business sense was to tie together international offices for the purposes of like an all ends company meeting and trying to get it and going through the intricacies of encoding multiple different bit rates on one stream and what not. I haven't use the current version of Windows Media Technologies to be perfectly honest with you, but I'm really excited and interested to find out what's better and what has changed.

**John Bocharov:** Okay, great. So I can talk to you a little bit about that. Yeah, what you're describing is basically one of the core scenarios of enterprise streaming as trying to bring all these employees together whether there are several thousands of employees at one site or everybody on the company however they happen to be distributed, and one of the big promises of digital media is that enterprises can save a lot of money. Instead of having to shuttle people together and rent these massive spaces every time they need to have abroad meeting, they can basically get a panel together and stream them to everybody's desktop or laptop, whatever they happen to be, so everybody gets the same picture. Now, one of the challenges that you've mentioned of course is having to encode at a variety of different bit rates for a variety of different audiences.

**Greg Hughes:** Right.

**John Bocharov:** So when we talk about how this technology has evolved, Windows Media, of course, is incredibly prevalent in the enterprise today. It has been around for quite a while and the way that people use to do this is create several different versions of the stream so they would say, well, we're going to say that if you want to watch this, you really need 300 kilobytes. So we're going to create 300 kilobytes stream, maybe a 500 kilobytes stream, and 700 kilobytes stream and then in the past the challenge have been that IT Pros have had to put

together basically ways of detecting the right bandwidth for the right users and making sure that people got the right link or sending everybody out links and then pushing that burden to the users who then have to say, well, what kind of bandwidth could I sustain?

**Greg Hughes:** Right.

**John Bocharov:** One of the challenges that have led to us sometimes people would say, "Well, I think I have a very fast connection. I think I can handle a 700-kilobyte version." So they would start that stream and then something would happen to their network in the midst of the operation and network dropout, the buffer would stutter and they would have to restart at a lower version so that they'd have to watch the rest of the steam at a lower version.

**Greg Hughes:** Sure.

**John Bocharov:** There were some painful experiences in the past.

**Greg Hughes:** Yeah, I can remember having to send out multiple different links for different ends. Just as you're saying, people would say, well, but I didn't want to get it in the lower quality, I wanted to get the higher quality and it was a bit of an ongoing battle. People eventually learned, but there's a lot of pain in the process.

**John Bocharov:** Exactly and so that's, from a user's experience standpoint, that's exactly where Smooth Streaming comes in. Smooth Streaming happens to be the way that we do the broader set of technology for this. It's known as Adaptive Streaming and Smooth Streaming is the IIS implementation.

**Greg Hughes:** Okay.

**John Bocharov:** Adaptive Streaming is all about having that set of bit rates throughout your entire content, but instead of you picking a particular bit rate and trying to view a drought, basically you have a feedback mechanism where your client is constantly monitoring what is the bandwidth I can sustain and what is the processing power I have in order to be able to decode and render the video.

**Greg Hughes:** Right.

**John Bocharov:** And then getting the video from the server at the best quality you can actually handle, given your network and local rendering conditions, at any given point in time. So if you start at a very high bandwidth -- and one of the nice things is that it opens up some bandwidths that before were not possible just because just a small fraction of the users could actually sustain it. So now you can start thinking



about having a 1.5-megabit stream, a 2-megabit stream for people who really have fast connections and lots of stream real estate; and the algorithm will basically say, well, right now you've got plenty of network, you've got plenty of rendering power so we're going to go ahead and give you the best stream, and then if some way down the line there's a network glitch or the machine is occupied doing something else so it can't render that really high bit rate, it will very seamlessly and transparently have the user drop down to lower bit rate.

**Greg Hughes:** Shift gears.

**John Bocharov:** And begin to download and decode, and if later those conditions improved it will jump back up.

**Greg Hughes:** Interesting. So in the bad analogy world, it's the transmission, the automatic transmission for streaming if you will. So it will shift gears and make the adjustments for you as you drive along.

**John Bocharov:** I don't think that's a bad analogy at all, actually. I think that's actually, yeah, so all you do is push on the gas, you just keep on driving down the freeway and the transmission takes care of what gear you need to be in.

**Richard Campbell:** And the interesting truth here is that when you get into networking spaces like in -- I think in internal networks sometimes it gets saturated with these sort of things where more and more people in the office start watching that stream and bit by bit you get switches that are overwhelmed and being able to drop everyone down a notch so that everybody can get at least some experiences pretty compelling.

**John Bocharov:** Right, right.

**Greg Hughes:** How does the client know?

**John Bocharov:** How does the client know?

**Greg Hughes:** Is there a network measurement that takes place periodically? What happens on the network side? What resources do I have available on the hardware, I can see where a software client can see that. I can think of several ways to maybe try to look at the network. How does that work?

**John Bocharov:** Really, the concept to use is called Perceived Bandwidth. So we basically are constantly obviously downloading the stream and we don't try to explicitly detect what's going on, we just measure how many bits are we getting.

**Greg Hughes:** Okay.

**John Bocharov:** Based on that, we use that to calculate what the next bit rate should be.

**Richard Campbell:** It's a very empirical measure, it's really how much you've got irrespective of whether the nick was choking or the switch is choking or the internet connection is choking, it doesn't matter. What did you get?

**John Bocharov:** Absolutely and one of the nice things is the self-correcting system in the way you've described. So coming back to your nightmare scenario of everybody starts getting the high bit rate stream, the network gets saturated, the network gets slow, well, the perceived bandwidth and all the clients go down. They say I want one megabyte per second but all that's coming to me is at 600 kilobytes per second for whatever reason.

**Greg Hughes:** Right.

**John Bocharov:** So I'm going to make a decision and start playing the 500 kilobytes stream.

**Richard Campbell:** And just seamlessly drops down. So this is actually part of IIS? Do I have to buy this or is it just part of the package?

**John Bocharov:** This is available as an optional module for IIS, or will be soon.

**Richard Campbell:** IIS 7.0.

**John Bocharov:** IIS 7.0, right. So if you have IIS 7.0 which, of course, comes with Windows Server 2008 any SKU including the web SKU, you can go to [iis.net](http://iis.net) when this technology is available and get a free download that will integrate directly into IIS 7.0 and enable these media experiences.

**Greg Hughes:** It's cool.

**Richard Campbell:** So obviously there's some intelligence here on the client, so what? Clients work with Adaptive Streaming?

**John Bocharov:** Absolutely and that's a great point. What we do is we leverage Silverlight. So Silverlight also has this great ability to have an application package that's built by the user or by a third party. So instead of having to, in a way, lock people into a particular client implementation that might be then really difficult to update, the server can update the client algorithm as often as you need to.

**Richard Campbell:** Right.



**John Bocharov:** So basically what we make available with IIS is a reference implementation that runs within Silverlight and it contains some of the heuristic algorithms that I've described and a whole bunch of other pieces that are just design to make the solution run out of the box. The nice thing is that that application package, you get to download it dynamically. So if ever you decide that maybe the standard heuristics aren't applicable to your network and your version have become available, it's a simple matter of posting a new package and the next time your clients reconnect, they're going to re-download that extra package for Silverlight and these things tend to run in about a hundred kilobytes so the download is very lightweight certainly compared to Streaming Media content and the player in effect instantly updates itself.

**Greg Hughes:** Cool.

**Richard Campbell:** Right, because the alternative will be Windows Media Player and then you need to deploy Windows Media Player updates to all of your users.

**John Bocharov:** That's right, that's right and I can't stress enough how useful it is especially as we're just -- I would say that Adaptive Streaming as a technology is not quite mature and that we haven't tested all the permutations and done all of the Best Practices so we put together a demo deployment with Akamai at the end of October at a site called [smoothhd.com](http://smoothhd.com) and the feedback that has come back and watching what happens when you expose that technology to a broad range of users who are all over the world, they have all sorts of different connections and all sorts of different hardware, the feedback that comes back and allows us to optimize the system even in one month, you know, we've made some pretty useful updates in the past two months based on the feedback we've got from customers, so the ability to update these algorithms for what you actually see in the real world has already proven itself to be immensely useful.

**Richard Campbell:** So I guess the other part of Adaptive Streaming has got to be the feed. Are we only talking about pre-processed video files or can we actually do live stream like I have a camera on the site and I'm able to adapt on the fly? How different is all of that?

**Greg Hughes:** One other way to ask the question is maybe what's the difference between this and using the full-blown Windows Media Services that's available as well?

**John Bocharov:** So Windows Media Services, I would say right now the IIS Media serving capabilities and Windows Media Services are complimentary

technologies in that one of the greatest things, and certainly from an IT perspective for Windows Media Services and we keep getting as much as loud and clear, is its resiliency, it just works and it just runs and, yeah, it's stable and runs like a rock for doing these media scenarios.

**Greg Hughes:** Right.

**John Bocharov:** Now, Windows Media Services today will not do Adaptive Streaming.

**Richard Campbell:** Right. You pick the bandwidth that you're using and that's that.

**John Bocharov:** That's right, that's correct. There was an earlier, you might call it precursor technology called Windows Media MBR, where people would encode the Windows Media multiple bit rates...

**Greg Hughes:** Multiple bit rate, yeah.

**John Bocharov:** Some of the challenges have been in exactly the problem of when do you switch, how do you switch, the switching wasn't very smooth and it was good for downgrading but traditionally we saw this had real challenges in getting new back-up to high quality stream.

**Greg Hughes:** Yeah.

**John Bocharov:** So if customers just need to stream Windows Media and they haven't maybe an existing solution that already solve these battle of detection problems, the Windows Media is there for that and Windows Media Services is great for people who want these new types of experiences for making IIS Media available. A couple of other things that we've done on the IIS Media side is to optimize for progressive download scenarios. So one of the problems of progressive download has been ironically not to access bandwidth so what will happen is that customers, so if let's say that I just start downloading a video that's encoded at 500 kilobytes per second...

**Greg Hughes:** Right.

**John Bocharov:** And you really have a megabyte per second, so you're going to download that video much faster than you need to in order to play it back. The typical pattern that we saw is that people would download the entire thing, puts it back on process in the browser, they wouldn't think about it, they just download but they would only watch 20%. So that other 80% effectively represented wasted bandwidth.

**Greg Hughes:** Right.



**John Bocharov:** So we have developed a feature called Bitrate Traveling and what Bitrate Traveling will do is it will automatically detect, for 11 common media formats, what is the encode bit rate of your video and then give an initial birth to make sure that the client doesn't have to wait to start up as you make the start-up as fast as possible.

**Richard Campbell:** Right.

**John Bocharov:** After you get that initial birth, it will only deliver the bits at the encoded bit rate so that if somebody has really watched only 20% of the video, they've maybe downloaded a little over 20%. That 20% close a faster birth.

**Greg Hughes:** Cool.

**John Bocharov:** So that helps you save bandwidth that helps keep networks unclogged. The progressive download side is another case we get to want to use IIS.

**Richard Campbell:** Sort of a clever way of you really think about what bits do you need and how you lose eyeballs.

**Greg Hughes:** Its good balance between making it really good, get that good birth for the users in the beginning and then keep it reasonable for the provider after that quick birth there.

**John Bocharov:** Yeah, but I want to go back to your question about Live. So we've made this especially with Akamai at the end of October and we've been talking to obviously working on integrating our technology with their network which is always an exciting challenge, but also talking to early adaptors and potential early adaptors, and some of the most immediate feature requests have been this is great, we want it for our live streams. So that's definitely something that we're actively looking at.

**Richard Campbell:** My experience at dealing with folks who are trying to do it with live streams, of course, is that there's no such thing as live streaming. It's some many seconds behind the live experience because you simply have to, you've got the camera receiving the data and then there's a processor there that has to encode it and then pump it out.

**Greg Hughes:** Processing and buffering and you know.

**Richard Campbell:** And it's just a question of what's the number of seconds offset that you've got but the tolerance to failure there is so low and the horsepower that takes to encode, especially when you're coding four, five, six different formats of stream to try and keep all that up, it's arduous.

**John Bocharov:** Absolutely, absolutely and what's really exciting is talking to people who are well along the path of being able to solve that problem, but I absolutely agree with you in that there's a lot of opportunities where the system could fail and designing it in a way that you can correct and recover from those failure anywhere along the line has been one of the most exciting challenges.

**Richard Campbell:** Yeah, without a doubt very challenging.

**John Bocharov:** Yeah.

**Greg Hughes:** What are some examples of where people might see Smooth Streaming and some of the other technologies that you're talking about like in action today like you mentioned the site a few minutes ago?

**John Bocharov:** Yeah, [smoothhd.com](http://smoothhd.com) is the demo site that we set up with Akamai which contains actually pretty good mix of content. So that content is encoded up to two-and-a-half megabyte per second for some of the less motion prone content, the sports content that really high motion content, it's going to go up to 3 megabytes per second for the customers who have those types of connection.

**Greg Hughes:** Okay.

**John Bocharov:** So you can see that basically gets the 720p quality which is HD as the environment.

**Richard Campbell:** Right.

**Greg Hughes:** Right.

**John Bocharov:** So it's really interesting because the four Smooth Streaming, it's been really challenging to be able to deliver HD effectively because such a small slice of the population has been able to support that high bandwidth of a connection and with the network being, you know, they have glitches and maybe you're running a background process that you might not even know about, anything that interrupts that system is going to compromise the experience. So the nice thing about Smooth Streaming is that when you start delivering this HD content, even the customers who have that top bit rate will still benefit from having the ability to go down. If they're decoding horsepower decreases, I mean often people will have a virus scanner or something that will come online and so that doesn't interrupt the screen because once again it just seamlessly downgrades. If they suffer a network glitch, it will just seamlessly downgrade and then when the bandwidth becomes available again it will come back up. I would



say that's the best showcase and the best demo right now.

**Richard Campbell:** You know what, technology, and John, I don't know if you could speak to this necessarily, but multicasting, I mean we always talk about unicast...

**Greg Hughes:** Yeah.

**Richard Campbell:** But multicasting never took off, and in the media space isn't that a huge technology we get massive difference to us?

**John Bocharov:** Multicasting is -- so I would qualify your statement about multicasting never took off. Multicasting never took off on the open web.

**Richard Campbell:** Right, that's true.

**John Bocharov:** Multicasting did take off in the enterprise, and the challenge is that in order to multicast from any point to any other point, every router along the line has to be multicast enabled.

**Richard Campbell:** Right.

**Greg Hughes:** Right.

**John Bocharov:** If you're an enterprise and you control your network, you can do that. On the web, unfortunately there is more than enough weak links where trying to multicast to a broad audience has always been too unreliable to really be worth the effort.

**Richard Campbell:** I wonder when we finally get to IP because, I mean one big problem with multicasting came along after IPV 4.0 and so forth and now with IPV 6.0 I wonder if multicast is finally going to come into its own even though we know that's years in the future.

**John Bocharov:** I'm not entirely sure. There have been many attempts to communicate over other protocols or other channels or other ports and the web keeps coming back to the same answer time and time again. Do HTTP over port 80, that's what's going to get between your servers and your customers.

**Greg Hughes:** Right.

**Richard Campbell:** Right.

**John Bocharov:** So I'm not going to take out any gambles on when other means of communication over the web are going to become as prevalent, as reliable, and as efficient. In a way, the web is optimized for HTTP over port 80.

**Richard Campbell:** Right.

**John Bocharov:** I'm really glad you ask the question because that's actually one of the great things about streaming and one of the things that differentiate it from other solutions. I'm going to steal a quote from a colleague of mine and the way to describe it is in the past we've tried to adapt the web for streaming. With Smooth Streaming, we've adapted streaming for the web.

**Richard Campbell:** Right.

**John Bocharov:** So what we're basically trying to do is we're trying to make the Streaming Technology work with existing HTTP infrastructures, with existing routers and existing caches. What's been really great about multicast and the reason why the people are so excited about it is that you send one copy of the data.

**Richard Campbell:** Right.

**John Bocharov:** If you have one client, you send one copy. If you have a hundred clients, you send one copy. If you have a thousand clients, etc, etc, etc.

**Greg Hughes:** Exactly.

**John Bocharov:** So you needed very few services at the origin of your system in order to serve many clients. With streaming, what we're effectively doing is we're using HTTP and specifically HTTP caching to solve the exact same problem. Before, when you had a streaming protocol, it's usually a one to one communication to the server. The server sends you a packet of information, you decode it, you parse it here under it and then the server sends you another packet and the packets that the server sends you are applicable only to you.

**Richard Campbell:** Right.

**John Bocharov:** What we've done with Smooth Streaming is we basically define a unit of media, a fairly natural unit of media that caches really well. So once you've sent that, once the origin server has sent that unit of media to one client, that answer can be cache and deliver to any other client.

**Greg Hughes:** Still a separate network packet but on the machine it's the same data.

**John Bocharov:** On the machine it comes back at the same data regardless of whether that data came from the origin server, the "streaming server," or whether that data came out of their cache, or whether that data came out of an edge server in a content



delivery network, or an edge server in the enterprise network.

**Greg Hughes:** Got you.

**John Bocharov:** The idea is that once you've requested this piece of the stream, this particular piece of the stream, that answer is consistent and that answer can cache really well.

**Greg Hughes:** Got you.

**John Bocharov:** So specifically, once we start thinking about what streaming means as an enterprise technology; that should really help us a lot with the value proposition and to reduce the total cost of ownership. If you can use your existing HTTP caching proxy appliance to be able to effectively fan out, to be able to distribute that one signal from the server to many, many, many clients that makes that whole solution so much easier to deploy.

**Richard Campbell:** Definitely yeah, it makes things a lot simpler. An interesting thought you had there around multicast which in some ways it offloads the responsibility of the producer to have all the infrastructure to support the load it ultimately get. I mean, if your streaming server only gets one connection in the internet, you only ever need to send one copy of the stream out and ultimately the network is the thing that branches it out to the thousands of users that are out there.

**Greg Hughes:** The big content delivery network, yeah.

**Richard Campbell:** You put the weight on that network, but it's interesting. When you talk about Content Delivery Network, you're not just talking about the Akamai's of the world, right.

**John Bocharov:** Well, when I say Content Delivery Network, that's primarily who I'm talking about.

**Richard Campbell:** Right.

**John Bocharov:** But in many ways you can think of what many enterprises do particularly with branch offices, in setting up caches and proxies in their branch offices as in a way building a mini content delivery network within their enterprise.

**Greg Hughes:** Sure.

**John Bocharov:** And so many of the same considerations apply. It's just a very different relationship. Instead of writing a check to your CDN, it's IT infrastructure.

**Greg Hughes:** Right. If you have a thousand people in an office in the United States and a hundred people over in the UK that need to watch some piece of content all at the same time, for example, then setting up servers on each ends so that there's just actually one stream going over that probably limited connection between the two, that still allowed multiple and multiple of people to occasionally be able to look into those edge servers and see the same content.

**John Bocharov:** That's exactly right and so anything -- you know, CDN makes it their business, Content Delivery Network makes it their business to be able to distribute bits all over the world. Many enterprises want network to just work and that they're as maintainable as possible. So all the considerations of how do you make the solution as easy to deploy as possible, as self-correcting as possible, you know when we talk about not having to implement your own bandwidth detection and the client's algorithms just sort of self-correct, same story comes too when you don't need to, for example, configure a set of proprietary edge servers. How do we allow the existing infrastructure you're going to put in all ready to deliver this video traffic effectively.

**Greg Hughes:** Right. Well, it's clear to me that the technology has come a long way since eight or so years ago when I was first starting to put that together and trying to do these things, kind of cobbling it together. It was great technology then, but clearly it has come a long way since.

**John Bocharov:** Yeah, and that's one of the most exciting things about the space, it's how quickly it evolves.

**Richard Campbell:** Well, I think Silverlight is going to be a piece of that now.

**John Bocharov:** Yes. Silverlight is a huge piece and Silverlight isn't, I'll just be honest, not so the critical enabler in this technology.

**Richard Campbell:** Right.

**Greg Hughes:** Sure.

**Richard Campbell:** So, it's an interesting shift to where we're going. John, where can folks go to get more information to keep an eye out for the Adaptive Streaming product, actually Smooth Streaming, to actually ship and to keep in contact with you as things progress?

**John Bocharov:** Sure. I would check on my blog. It's at [blogs.iis.net/jboch](http://blogs.iis.net/jboch) and there's a post was aligned with the first announcement of the Smooth Streaming technology and I'm going to continue having the conversation there about how the



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technology has evolved and I would certainly be glad to take any feedback or comments or questions or ideas that the viewers have and hopefully address them and incorporate them into future versions of the product.

**Greg Hughes:** That's great.

**John Bocharov:** But also any news will likely be there.

**Richard Campbell:** Awesome John, thanks so much for having you on the show.

**Greg Hughes:** Yeah.

**John Bocharov:** Thank you so much for your time. It's been a pleasure talking to you.

**Richard Campbell:** And we'll talk to you next week on RunAs Radio.