IP STREAMING AND BROADBAND, TOGETHER ON THE ROAD TO THE TWO-WAY IP HIGHWAY?

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Abstract

*Today's broadcast transport mechanisms limit the services that can be offered to subscribers***.** *The content itself must be manipulated (encrypted, multiplexed, modulated) in many stages before being sent down the cable. At the end of the cable, the set-top box needs special capabilities to make that content usable to the subscriber. All this is done using costly, time-consuming proprietary techniques. Enter IP (Internet Protocol): an open standard transport mechanism that allows operators to deliver existing program content with little or no manipulation. In addition, IP streaming allows operators to offer new and enhanced value-added services to subscribers, such as photo galleries, home movies, audio jukebox, email, advanced personal video recording (PVR), Web access, chat, gaming, Web-enabled programs, e-commerce/t-commerce, video on demand (VOD), subscription video on demand (SVOD), voice over IP (VoIP), and streaming media over home networking.*

Attendees will learn the following from this session:

- *Why is IP streaming a better alternative?*
- *What will it take from a technology and business standpoint to move toward IP?*
- *What can be done with IP streaming that can't be done today?*
- *Benefits to operators.*
- *Benefits to consumers/subscribers.*
- *Deployment challenges.*

> *"Much the way the Compact Disc and Internet has changed this planet forever, so will IP Streaming." C. Dinallo*

IP STREAMING CRITICS

Sure some will say that they have no use for Internet Protocol (IP) Streaming (also commonly referred to as Streaming Media) because broadcast technologies can do everything they need. Plus, who's to argue providers have been delivering content to millions of users for over 50 years. Much the way the LP has been surpassed by the CD, IP Streaming will too have its day. To understand why, one has to look deep into the characteristics that cause a new technology to succeed. The CD didn't put the LP out to pasture just because it eliminated the poor quality of pops and hisses. It offered much more. Value-adds like durability, portability, enhanced content (text & graphics), and yes good quality sound. Vinyl LP records just couldn't possibly compete with this new paradigm shift in listening technology. To understand if and how IP Streaming can flourish, let's explore beyond the surface of all the benefits of what it brings. And to do justice for those hard-liners still listening to their LPs, we'll discuss the costs and challenges associated with this technology that the network operators have to deal with regardless if they are cable, satellite, terrestrial, or DSL providers. The focus of this paper will be on cable since it has the most investment in legacy transport networks.

WHY SWITCH TO ANOTHER TRANSPORT MECHANISM?

Today's broadcast transport mechanisms constrain the services that can be offered to the subscribers by virtue of being mostly a one-way pipe of information. Audio and video content flows downstream from the head-ends to all set-top receivers. It's an all or none condition where each set-top receives the same data flow and is very restricted in how it can communicate back to the head-ends. In addition, the content itself must be manipulated (encrypted, multiplexed, modulated) in many stages before being sent downstream. Similarly, once downstream the cable the set-top receiver needs special capabilities to make that content usable to the subscriber. This is done using proprietary techniques. And although this works fine for broadcast services it does not address how to get custom services to *specific* set-top receivers. Nor does it leverage open standards such as Internet-Protocol (IP) in which the large development community could be leveraged to develop more enhanced services in a timely fashion. What we're getting to is how IP Streaming can be utilized to achieve the vital two-way interaction between the provider and a *specific* subscriber.

It is this two-way interaction that is driving providers to get excited about IP Streaming. For it enables the additional revenue they can create from their subscriber base. It allows for new services to be deployed that have never been possible before. Services like; sharing your digital photos and home movies over the broadband network. These are value-adds that are new, novel, and provide a value to the subscriber. Yet, cool new concepts don't always succeed in the market without the proper business model to carry them forward.

Such enhanced value services are best introduced to market utilizing a bundled approach. Where the "bundle" is comprised of familiar needed services combined with the new enhanced services. To do this, the provider creates a "bundled service" in which many of the provider's standalone features are combined into a package and offered to the subscriber at a cheaper rate than if the subscriber bought the same services individually. Bundled services are a proven mechanism that achieves greater value across many industries. Telephone Local Exchange Carriers (LECs) have been doing it with great results for years. For example, some LECs offer "premium" packages that include: Call Waiting, Caller ID, Caller ID w/ Name, Call Block, 3-Way Calling, Call Return, and Call Transfer. It not only provides a great value to the subscriber, but produces a substantial deterministic repeating revenue stream for the provider, sometimes as much as 50% of the basic service.

Providers want to leverage this same mechanism, albeit using services tailored to their industry: Photo Galleries, Email, Web Access, Chat, Web Enabled Programs, SVOD (Subscription Video on Demand), VoIP (Voice over IP), and yes, IP Streaming Media. IP can and has served all of these capabilities. Whether or not it makes fiscal sense to have streaming media over the cable plant is yet to be determined. In addition, because the Internet has become ubiquitous, it makes good business sense to leverage that infrastructure as a transport mechanism for content delivery.

Even as one decides IP Streaming is the right thing to do, there is still the question of how to do it and what transport to use. The obvious choice would be to encapsulate the IP data packets into the MPEG-2 payloads for broadcast (known as IP over MPEG-2), but doing so would not unleash the full potential that IP Streaming can offer. To merely broadcast IP data packets to all set-top receivers does not help enhanced services that need to target specific set-tops. What's needed is a mechanism for direct point-casting. Furthermore, MPEG-2 transport does not offer a return communication path. Here again, enhanced services do not gain any advantage over legacy mechanisms for fast two-way interaction. Thus, two criterias become apparent: (1) point-cast for direct addressing as opposed to broadcast transmission and (2) two-way communication for interaction. Given this, a better approach is to use the IP over DOCSIS transport layer. For DOCSIS addresses these two criterias and much more. Refer to sidebar on *IP Streaming over DOCSIS* to gain more insight into two-way communication.

To understand what IP Streaming can offer, let's briefly discuss how it came about and then we can explore how it enables the advantages of two-way interaction.

INTERNET PROTOCOL – IP

The Internet was created by U.S. defense and academic institutions to facilitate the sharing of data. It was conceived as a computer-based system in the data communication domain. Since then it has evolved tremendously to affect everyone.
The evolution was started by the Internet Engineering Task Force (IETF), an Internet standards group responsible for the design and upgrade of all Internet communication protocols, Internet Protocol (IP) standards were designed to solve the issues of communications between computers across heterogeneous networks. These standards deal primarily with issues such as networking, routing, and congestion control and do so by specifying a means fordata to be converted into smaller manageable sized data packets. IP is also a layered architecture. Residing on top of IP, many other powerful standards were created. These standards were used in developing applications like the World Wide Web, File Transfer Protocol (FTP), Usenet, and e-mail. These applications implement one standard IP transmission type named unicast. Unicast is the method used for two distinct endpoints to communicate directly (i.e., point-to-point). As IP routers became more powerful, multicast transmission came into existence, which offered more efficient use of the shared bandwidth across the network (i.e., point-to-multipoint). Multicast enables a single endpoint to communicate with many endpoints in one transmission session. This is much the same as the way broadcast TV or radio arrives at everyone's home or car within the network's geographic area, yet in a digital medium. Applying this technique of multicast to transporting multimedia data (audio, video, graphics, text, & data) now has the added benefit of reaching many subscribers while not overloading the digital bandwidth available in the network. Providers, especially cable operators, have a huge pipe to deliver multimedia data. Furthermore, since their network topology was designed as an 'edge' network, IP transmission gives them an advantage to efficiently transport their services to millions of subscribers in a dynamic and interactive fashion.

IP also has two transport delivery methods that reside on top of the layered IP architecture. The first is *Transmission Control Protocol* (TCP). TCP is connection-based where the data packets are transported using guaranteed delivery approaches that have automatic retries. Providers can use this for situations where data corruption or total loss is not tolerated. TCP does have associated overhead with it, so nothing is for free. The second transport method is *User Datagram Protocol* (UDP), which is connection-less. UDP is a highly efficient transfer mechanism of data packets that actually contain and can distinguish between multiple destination addresses. Unlike TCP, there is no receipt acknowledgment of delivery thus making UDP an “unreliable” protocol. Some networks choose UDP over TCP is because of the packet overhead savings by not opting for guaranteed deliveries. This is the automatic retryof retransmitting data packets if the sender does not receive an acknowledgement. Hence, the trade-off is delivery reliability vs. bandwidth. Many providers today choose UDP because it more closely emulates the efficiency of broadcasting.

Despite IP Streaming’s benefits, there are still critics in the broadcast industry. Some view IP Streaming as both an encroachment and redundancy of how content is delivered to the subscriber today. On the surface, these criticisms are valid because IP streaming does what their broadcast technologies have done for quite some time. However, drilling down one sees that IP streaming can enable new capabilities to many devices and is not just limited to televisions. Any device that can obtain connectivity to the network whether it be wired or wireless can become an IP Streaming client. All this is accomplished in an open more efficient environment which, at the end of the day, drives better viewing experiences, faster, and more accessible flow of information of all types that yield associated increased revenue opportunities for the providers.

One might question what an open environment offers to typically closed networks such as the ones that cable operators in North America have built. In relation to IP Streaming, open standards are the preferred approach for it allows more choices for the operators, faster development times, interoperability across heterogeneous networks, and cost benefits from having more open competitive supply vendors.

IP Streaming over DOCSIS:
If the goal is to have an open standard that promotes two-way communication over broadband networks then the standard bodies unanimously agree that Data Over Cable Service Interface Specification (DOCSIS) is the preferred cable modem implementation over proprietary techniques. DOCSIS provides a high-speed, two-way communication path between the set-top receiver and the head-end plant. Although now the head-end equipment will consist of an additional piece of hardware called a Cable Modem Termination System (CMTS). The CMTS has the role of back hauling transmit and receive requests across the network. It performs this role in a IP-centric fashion including direct addressing to a specific set-top. It’s this direct addressing that unleashes the power for IP Streaming to capitalize on and providers to offer new services. Hence, with DOCSIS, the broadband network is transitioned into a two-way high capacity data independent carrier that goes beyond the reach of traditional broadcast television while still preserving the QAM infrastructure the provider has invested in over the years. Pace was the first and still the leader in DOCSIS deployments with over 2 million digital set-tops with integrated DOCSIS modems in the field.

As broadcasters solidify around a single approach, whether it is MPEG-4 and its multifaceted parameters or the more straightforward MPEG-2, IP Streaming will become more ubiquitous.

COMPRESSION ALGORITHMS

The whole concept behind streaming media is focused on compressing data (all types) into efficient packet sizes that minimize bandwidth, yet still preserve data integrity. The encoding side is only half of the challenge. The other half deals with ensuring that the receiving edge device can decode the encoded streams thus reconstructing back to the originals. It's this reconstruction process that drives the need for open standards and its interoperability goals.

Today, MPEG-2 dominates the industry with nearly all streaming media being comprised in some form of MPEG-2. There is a strong need among cable operators to achieve high quality video at significantly less than 1MB per second data rates. In fact, deployed schemes today are merely at data rates of 384KB/sec, 15 frames per second, 32bit color, and ¼ screen resolution. Clearly, not premium quality that subscribers demand. To address this quality deficiency while still preserving bandwidth capacity there are some techniques emerging that claim to have high quality MPEG-2 at 1MB/sec data rate.

In addition to emerging MPEG-2 techniques, of late, MPEG-4 is the successor of MPEG-2 that has been getting many headlines. MPEG-4 was created to address better quality at less bandwidth consumption of its predecessor along with adding enhanced features like non-rectangular objects known as sprites and animation. However, with these enhancements come complexities such as: file and transport formats, and control protocol. Unfortunately, it's these flexibilities that permit various streaming media implementations to have interoperability issues.

Once broadcasters and providers can adopt common formats within the MPEG parameters, the IP Streaming adoption rates will dramatically increase. These same issues also exist for the computing environment. To better predict where the entertainment market will go with respect to IP Streaming, one needs to see who the players are today.

Interoperability is key to driving this technology.

TECHNOLOGY DRIVERS

Today, the major technology movers in IP Streaming are Microsoft, Real Networks, and Apple Computer. There are others with products in market niches, like Video on Demand (VOD) that offer streaming solutions tailored to their environments. Yet, they all have one thing in common, each has adopted a proprietary version of the MPEG-2 standard. Given the benefits of open standards one may wonder why a proprietary standard is being used. That doesn't sound like it's in the best interest of moving a technology forward. This single reason alone could cause a slow adoption rate of this technology all because these companies have each adopted proprietary encoding schemes and associated streaming clients. Interoperability becomes non-existent.

There is also a trend to support MPEG-4. Microsoft's streaming solution actually uses an MPEG-4 compliant algorithm, however, its file format and multiplexing technique known as Advanced Streaming Format (ASF), is not compliant to MPEG-4. In contrast to Apple's Quicktime format, which follows the MPEG-4 format more exactly.

Some vendors are exploiting embedding techniques for MPEG-2 content that mimics capability designed into MPEG-4. It is called SMIL (Synchronized Multimedia Integration Language). SMIL is a text based markup language (really XML based) that allows a given stream to embed and/or link in other streams. The concept is not new and commonly referred to as metafiles (describes files that tie sets of other files together). The W3 Consortium has recently proposed a recommendation for SMIL 2.0 Animation. Techniques such as these that support metafiles are gaining momentum.

Of the top 3 vendors previously mentioned, the following tags identify their file and metafile formats:

- `Microsoft's WindowsMedia player - .ASF and .ASX for metafiles`
- `Real's Realplayer - .RM and .RAM & .SMI for metafiles`
- `Apple's Quicktime player - .MOV`

Yet, with MPEG-2, MPEG-4, and SMIL standards actual implementations today have inter-operatorability issues.

> *Web content drives enhanced services. Enhanced services drives revenue.*

ENHANCED SERVICES

Let's be clear about one thing, enhanced service revenue generation is the overwhelming factor why providers make the investments they do.

For IP Streaming to become pervasive, providers must find value-add in doing what previously could not have been done or done easily and cost effectively. One approach is to evolve current services into rich enhanced services of all types. For example, VoD, VoIP, Audio Jukebox, Home Movies, and Photo Galleries are all types of enhanced services that can both benefit from IP Streaming while building on proven business models that subscribers will and (currently) do pay for.

Given this, let's explore how we get to the money. What are the benefits and costs to the providers. Does the subscriber really gain value-add from this enhanced service enabling technology?

> *Reaching outside the TV box!*

BENEFITS TO PROVIDERS

First and foremost, providers benefit economies of scale of infrastructure by adopting an open transport model, i.e. Internet Protocol. Proprietary infrastructure delivery systems don't interoperate with other systems. And as such, providers are locked into specific technologies, costs, timeframes, and capabilities. Furthermore, some providers have many different "closed" systems in geographically isolated networks rendering it impossible to obtain economies of scale. In this situation, everything is different from unique equipment to back-office billing and support tools, right to and including the set-tops!

Another benefit of IP Streaming is the demand it drives for high-speed access. This is directly related to increased revenue opportunity. IP Streaming also allows for more dynamic and tighter Web content integration. This reduces costs by both equipment and manpower overseeing the content delivery operations. Less content data manipulation is another benefit. This comes into play with add insertions and utilizing off-the-shelf web servers which boils down to less specialty proprietary equipment needed.

Yet, one of the biggest benefits of all is expanding the provider's customer base. This is realized because content delivery can now be to any IP connected device and no longer dependent on TVs only.

BENEFITS TO SUBSCRIBERS

From a subscriber's perspective, they will need to see the benefits of IP Streaming in order to justify the possible rate increase associated with the new IP services. The proponents of IP Streaming believe the viewing experience will be more enriched because the providers can enhance the IP streams very easily. By using techniques like metafile support the content is much more dynamic. The provider can also choose to cache the streaming media content locally on hard drives within a set-top receiver, thus tremendous amounts of information are literally in the hands of subscribers. This cache can also be tailored to each subscriber's preference. Imagine having the data you want a mere push-button away without the time-consuming web surfing. This is definitely an enhanced service worth paying for.

CHALLENGES TO PROVIDERS

Where's the downside? IP Streaming still has it challenges. In North America, cable operators are still faced with deploying DOCSIS. There is still a large challenge in implementing Quality of Service (QoS), although this is getting resolved with IETF technologies focused on traffic management such as MultiProtocol Label Switching (MPLS) , Resource Reservation Protocol (RSVP) , and policy management like the Common Open Policy (COPS) protocol. COPS and RSVP work together in managing intelligent routing of network traffic based on priorities, traffic type, and user subscription level. This allows for tiered level services such as basic and premium. MPLS comes into play by allowing these route decisions to happen very quickly. In essence, MPLS acts as a lookahead on each packet to determine the fastest way to route it to its destination. It does this by integrating the data link layer and network layer. The integration point inserts a small "label" in the packet header that instructs the MPLS-enabled switches/routers how best to route to the destination address. As these technologies gain more deployment, the QoS issue becomes a non-issue.

Other areas of the technology have to do with security. Providers must make their infrastructure more secure by adding proper firewalls and other techniques that combat against denial of service attacks. There is also the much-debated topic of Digital Rights Management (DRM) techniques. All parties must be protected from pirating abuse. This topic is highly controversial and is beyond the scope of this discussion. A good starting reference is Linden deCarmo's article on DRM (see http://www.zdnet.com/products/stories/reviews/0,4161,2766381,00.html).

Lastly, providers need a common IP Streaming format and edge device client that can interoperate seamlessly. If this is made a priority, then the differentiating factors would merely be thin vs. thick clients and not the format of the content.

COSTS TO PROVIDERS

All of these challenges do come at a cost to the provider. This is why the business model must be right for IP Streaming to take-off. Here's a high level view of what kind of costs, both capital and personnel, providers can expect in this transition to IP.

- IP proficient technical personnel
- They should plan on consolidating network operations & platforms in order to reduce complexity of managing the NOC (Network Operations Center). This will entail forklifting legacy equipment out and putting in more data centric equipment.
- Revamping their IP network to employ a highly reliable network topology: including making it highly available to a minimum of 4-9s of availability (99.99% min. uptime), fault tolerant schemes, redundancy, failover, and load balancing.
- Investing in enhanced security techniques and equipment.

Yet, there is good news here for the cable operators. Besides having having done a great job of upgrading their Hybrid Fiber Coax (HFC) network to give them unsurpassed 24x7 high-speed bandwidth directly into the subscriber's home they have built up much of the needed infrastructure and expertise to deploy IP Streaming. And like their HFC upgrade, IP networks will take time and come on-line in increments. And rightly it should, because there is a ton of legacy equipment that still has return on investment life. IP and broadcast QAM technologies will co-exist for many years. Yet, now is the time to initiate the rollout of IP Streaming Media services.

IP HIGHWAY

As one can see, there are some hurdles along the IP highway to reach a solid business model in which both providers and subscribers benefit. However, the benefits listed above outweigh the hurdles. In fact, the outlook appears good from what the market researchers are forecasting. The prediction is for the streaming media market to skyrocket as compression algorithms improve and high-speed access gains momentum. Forrester Researchers predict that by 2003, 33 percent of all households will have broadband access. More specifically, according to DFC Intelligence, a research firm for interactive and digital entertainment, video streaming on the Internet grew 215% in 2000 to over 900 million total streams accessed. This includes broadband streams, which made up almost 29% of total accesses. As broadband moves toward ubiquity, operators are uniquely positioned to make streaming media what it's meant to be – a viable, revenue-generating business.

And rest assured that during the co-existence period of IP and Broadcast technologies Pace has products available today to meet the needs whether they are an incremental approach to IP utilizing our DOCSIS set-top technology as in our Di4000 and 700 series set-tops or a pure IP solution such as the DSL4000 and IP500 digital gateways.

Chris Dinallo, Chief Technologist

Mr. Dinallo's responsibilities for Pace focus on US Cable and include digital set-top box development, future technological directions, participation in standard bodies such as Cable Labs, SCTE, and TV Linux Alliance. Chris brings 17 years' experience developing innovative solutions in software and firmware. Since 1989, his expertise has been in the discipline of multimedia technologies. Prior to joining Pace, Dinallo has held engineering director positions in DVD and Voice over IP companies. In the (VoIP) telephony solution space, Dinallo's team architected next generation networks with a focus on enhanced services for telecom and cable service providers utilizing open standards and leading internet technologies.

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