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White Paper

Delivering Optimal Quality of Experience (QoE) for IPTV Success

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Introduction

Telecommunications service providers around the world are in a race to deploy new, revenue generating services to offset the accelerating, and inexorable, decline in voice revenues that they are currently experiencing. New competition, from wireless providers to upstart, cable modem-enabled VoIP services, is successfully chipping away at these revenues, and threatens to completely undermine the traditional telco business model where voice is viewed as the cash cow. According to the market research firm The Yankee Group, global residential access line revenues will decline 8% between 2002 and 2008. At the same time however, it is forecast that consumer voice revenue will decline 16%, while U.S. – based providers face an astounding 34% decline in voice-related revenue.

In order to stem this debilitating erosion of their business, telcos have embraced the concept of the triple-play service bundle – the delivery of voice, video and data services provided on a common network infrastructure. In an effort to catch up to the cable MSOs and their current triple-play offerings, telcos have started to deploy new, carrier-grade IP-based technology. This IP-based infrastructure is contributing to a major shift in the way providers are designing their networks in order to provide new video and enhanced telephony services, and enables an array of enhanced applications and services, including IPTV, video telephony, VoIP and Video on Demand (VoD).

As telcos rush to deploy this new infrastructure and launch new video services, they are faced with a unique set of challenges. First and foremost, they must deliver optimal quality of experience (QoE) to their new and existing subscribers – if they don't, they risk mass defection to their competition. It is essential, then, that telcos employ a comprehensive video and IPTV testing solution that ensures quality of service not only at each element in the network, but end-to-end in the network as well. Such service assurance initiatives must effectively deal with transport and signaling issues, employ the most relevant and accurate method of measuring customer quality of experience, and provide ongoing monitoring and management of the live network.

This white paper addresses the current benefits and opportunities for telcos entering the video market, the challenges of developing the network infrastructure required to deliver the highest IPTV QoE, the best method for assessing subscriber QoE, and key requirements for IPTV testing and network assurance.

The Market for IPTV: Benefits and Opportunities

It is clear from numerous industry reports and service provider announcements that telcos around the world are now solidly resolved on the importance of offering IPTV either by itself or as part of a bundled service package. Little wonder: in North America, telcos are battling cable modem offerings, which are not only impacting their broadband data revenues, but traditional voice revenues as well. In Western Europe and Asia, alternative DSL and fiber service providers are putting the screws

to traditional phone companies. In short, all regions of the world are experiencing a new wave of communications competition. The provider with the best combination of services – including broadband Internet, wireline and wireless voice, and video and next-generation multimedia applications – will likely win the current battle for the hearts, minds and wallets of prospective customers.

As a result, telcos race to deliver video services. The question is no longer "how do we make IPTV possible," but rather, "how do we ensure the highest quality picture delivery." While data and voice are table stakes, increasingly video and IPTV are driving the overall bundle. In order to create strong customer loyalty and prevent damaging churn, it is critical that the subscriber quality of experience (QoE) be equal to or better than competitive offerings from the first day of video delivery.

Indeed, the stakes couldn't be any bigger. With their traditional voice business under siege, telcos are being forced to transform their businesses to include video and IPTV in order to compete and protect their existing customer base. For telcos that successfully enter the video market with the right network access and service delivery strategies, the payoff can be significant.

The benefits of offering a high-quality IPTV service include:

Dramatically reduced churn: A service bundle that includes video service can significantly reduce customer churn. According to The Yankee Group, churn for standalone services can be as high as 40% a year, while triple-play churn with a video offering is one-quarter of that, in the 10% range.

Increased annual revenue per user (ARPU): With the addition of video service, a telco can double the revenue per subscriber on an annual basis.

The ability to grow market share: With a competitive offering, telcos take the dominant position and take business away from the cable and satellite operators that serve their region.

Leapfrogging the cable MSOs with a better bundle: Many large telecommunications service providers own their own wireless operations, which when integrated into their service bundle can enable them to …

Creating a more stable business model: By being less dependent on voice revenue, telcos will be in a better position to withstand disruptive market forces.

IPTV Deployment and Service Assurance Challenges

While the benefits of deploying IPTV are clear, telcos do face a number of challenges as they rush headlong into building their new, converged IP-based network infrastructures. Once the strategic decision is made to offer IP video, a number of challenges and questions immediately come to the surface.

For example, there are a number of different plans for triple-play infrastructure, each with their own set of deployment challenges. Today, there is no common approach to defining network requirements, or agreement regarding the appropriate level of service for voice vs. data vs. video, including the need to determine the proper access technology for video. Should existing copper or a new fiber infrastructure be used in the all-important last mile?

If fiber is used, which fiber technology is best? If copper/xDSL is used, should ADSL or VDSL be employed? In addition, many service providers, in order to shorten the time to market, are beginning deployment of IPTV without first getting real-world, practical QoS experience of how the infrastructure, triple-play applications and the delivered services will work as an integrated triple play solution.

A key benefit to performing comprehensive IPTV testing is that it provides valuable measurements that illustrate how good or bad the user experience will be, in the form of packet loss, jitter, and channel zapping time.

If proper testing is not performed to uncover potential QoE issues, a number of service impairments can rear their ugly heads. From the user's perspective, such impairments can manifest themselves as grainy pictures, blurred images, banding across the screen, frozen frames, and painfully show channel change times. Worst-case user scenarios can involve situations where channel change requests are not performed at all to completely blank screens.

The ability of the telco to deliver high-quality IPTV service over its network can be broken down into these basic areas:

- Ensuring effective transport of the service
- Verification and monitoring of IPTV service-related signaling
- Measuring the quality of the video signal received
- Ensuring adequate scalability in the network infrastructure
- Maintaining security while ensuring service quality
- Effectively delivering IPTV as an integral part of the triple play service bundle

Ensuring Effective Transport of the Service

Regardless of the medium used for the transport of the data, it is important to realize that an IP network is basically designed for the transport of data from Point A to Point B, and not for real-time services such as IPTV. In order to enable real-time transport on an IP network, a protocol such as MPLS must be utilized in order to provide the ability to conduct traffic engineering. In addition, a variety of QoS metrics must be added to the mix.

With these capabilities, it becomes possible to test for and measure a number of service impairments that can negatively impact video service quality, including packet loss and jitter. Another factor that can affect video quality is insufficient available bandwidth on the network to ensure that video packets arrive in the correct order and within the allocated jitter-buffer time. Since the transport of MPEG-4 video signals require bandwidth of approximately 2 Mbps for standard definition channels and 9 Mbps for high-definition channels, it is critical that the required bandwidth be available at the time the IP video stream is viewed. In order to guarantee this, it is vital that the telco be able to measure the bandwidth utilization on the network as well as at the subscriber level.

Another transport-related challenge surrounds the use of multicast protocols – such as PIM, or Protocol Independent Multicast, used in the routed (Layer 3) portion of the network, and IGMP, or Internet Group Management Protocol, used in the switched (Layer 2) portion of the network. With these protocols, telcos can effectively reduce the amount of traffic on the backbone network by limiting the video on the network to what subscribers are actually watching or what channels they request, and by replicating a single video signal across multiple interfaces, rather than sending every household an individual IP video stream.

The challenge with multicast-related network information is that while it can show what users and devices are joined to a multicast group, and present other metrics such as channel change requests, it does not by itself guarantee that IPTV is actually being transmitted to an individual user. A mechanism must be in place that shows the data being sent, and either where it is coming from or the type of data being received, in order to verify that the user is receiving the IPTV signal.

Verification and Monitoring of IPTV Service-Related Signaling

In an IPTV deployment, there are three primary types of signaling used: subscriber to provider, provider to subscriber, and internal network to provider. For example, the most common signaling function from subscriber to provider is the request to change the channel. Another important subscriber-to-provider signaling function involves a request for a specific Video on Demand.

Provider-to-subscriber signaling is primarily confined to the delivery of the actual video content to the set top box. Other such signal functions include the delivery of the channel guide.

Internal provider signaling involves various authorization and authentication functions, such as whether a subscriber is allowed to access requested premium channels or order Videos on Demand. Other signals control the flow of the data, such as from a unicast to a multicast stream (for some of the IPTV transport technologies), and provide information about where video content is being transmitted.

The signaling-related challenges for the telco surround the need of the provider to be able to verify the signals sent over the network in order to ensure the proper operation of the service. Such a system must monitor signals for channel changes or VoD content, and verify that the transition between a unicast and multicast transmission is made. If such signals are not passed properly, the user either will not see his show or too much network bandwidth will be consumed.

Other vital measurements include the ability to measure the channel change times. From a competitive standpoint, the channel change time must be as quick as it is with today's digital cable service. Actual performance, however, will depend on the ability of the telco to effectively develop, manage, and maintain the network elements for optimal performance during periods of a large number of concurrent channel requests (such as during the Super Bowl or the final episode of the latest *American Idol*).

Measuring the Quality of the Video Signal Received

In practical terms, the quality of the video signal delivered to a subscriber's shiny new HDTV is really where "the rubber meets the road," and will determine whether the user will become a loyal, lifetime customer or bolt to the nearest competitor. Indeed, the quality of the video signal received in large part determines the overall Quality of Experience a telco's IPTV customers will have.

Video quality impairments can be grouped into three major categories:

- **Perceptual:** These impairments can manifest as block distortions, image blurring and jerkiness.
- **Spatiotemporal:** These impairments occur as repeated frames and energy differences.
- **Fidelity:** These impairments consist of color problems and signal-to-noise issues.

As with Voice over IP (VoIP), it is vital for a telco to be able to measure the quality of the video signal – and the presence of impairments – in order to ensure optimal QoE. The standards for measuring video quality fall into three primary models: **Full Reference, Reduced Reference,** and **No Reference.**

The Full Reference model takes samples of the full video signal near the network source and destination (the subscriber's set-top box). The samples are compared, and the result is measured at a range from 1 to 5. The Full Reference model, as described, involves a large file capture, and is generally considered to be the most accurate method.

The Reduced Reference Model also takes a sample near the source and destination, but with this model a smaller reference sample is required – as little as 10Kbits using low bandwidth features. Again, results are measured in a range of 1 to 5. This model is considered by many to be at least as accurate as the full reference model.

A No Reference model uses only the video stream at the destination for measuring the video quality. And since the model does not require any transfer, alignment or comparison of signals, the calculations can be performed in near real time. However, because the No Reference model does not compare source video data, it is not considered to be as accurate as the first two models.

Ensuring Adequate Scalability in the Network Infrastructure

The reality of IP networks is that they are extremely dynamic environments, meaning that as more people come on the network to use a variety of applications, service is inevitably affected. As video services, and especially IPTV, are added to the network, the dynamic nature of the network is increased exponentially. Just consider the effects of the Super Bowl or a current event that captures the attention of an entire nation's population, and the strain this can cause a network.

Therefore, it is essential that service providers fully understand how the network infrastructure – and especially various switch and router equipment – will perform under a full service load. Testing the scalability of this equipment is not only vital in terms of delivering the highest quality service, but is also critical with respect to the right-sizing of the equipment investment required to provide optimal service. If the network infrastructure is not up to snuff, then not only will service suffer, but deployment costs will mushroom as additional equipment must be purchased and installed.

By testing the network infrastructure to ensure that it can deliver optimal performance, providers can ensure that services will perform flawlessly under the heaviest loads. Areas of testing include throughput capability and bandwidth utilization, packet loss and measurements of latency created by each piece of equipment. Also vital are tests to ensure that all the required protocol stacks and video coding algorithms employed by the equipment are operating correctly, and that the specific interfaces are working as expected.

Maintaining Security while Ensuring Service Quality

The security issues associated with packet telephony networks are numerous and can be quite complicated, and the deployment of an IP-centric network infrastructure for IPTV and triple play service provision may also require that service providers overhaul their network security measures.

Service providers must consider the impact of new security apparatus on their network and with their new video services. In fact, many security measures can seriously affect the quality of video traffic by introducing additional jitter and other impairments to the network, and in some cases can cause total service failure.

While a provider may be able to identify potential problems before they roll out their network and establish solutions for dealing with them, there is no way to accurately guess which security problems will affect their particular network configuration. The

only sensible way to identify these issues is to perform comprehensive testing in the lab or in pre-deployment testing to simulate real-world traffic on the network and analyze how it interoperates with the installed security solutions. Indeed, failure to test the impact of security equipment and processes can result in serious quality degradation for video service. Comprehensive testing in the lab with respect to existing and additional security measures can avoid such a scenario in the deployed network, and help ensure that both effective security and optimal service delivery are being provided.

Effectively Delivering IPTV as an Integral Part of the Triple Play Service Bundle

With IPTV the centerpiece of a telco's triple play strategy, it is important to remember that there are other services that make up the triple play bundle, such as voice, video telephony and broadband Internet access. These services all have to contend for network bandwidth, multiple protocols and QoS processes may run on the same control and QoS planes, and the services will often interact with each other, oftentimes in unforeseen and unintended ways.

Therefore, it is essential that telcos gain actionable, real-world QoS experience about how the triple-play network infrastructure, services and applications will perform as an integrated solution. In this way, service providers can ensure that not only will IPTV service perform optimally under heavy load, but that the other services will also perform as expected.

Employing MPQM and V-Factor for Delivering Accurate IPTV QoE Metrics

In general, quality of service metrics measure the performance of various network elements and the overall performance of services across the network, and help ensure that equipment, protocols and software, and related services operate as expected. Quality of Experience, however, relates to the quality of the experience of a user of a particular service, and attempts to measure the relative satisfaction of that user.

When it comes to IPTV service, user satisfaction can be considered the ultimate metric of performance, and therefore a method to accurately measure the level of user satisfaction is required. The challenges of such a method require that it rises above mere subjective psychological measurements and produces an objective system that can provide reproducible and practical results.

One of the most commonly used metrics to measure video quality is called PSNR, or Perceived Signal to Noise Ratio, which has been shown to be poorly correlated with human perception and is therefore not optimal for measuring QoE. Another metric, the Media Delivery Index, or MDI, is being developed as an easily deployable diagnostic method that can assess network performance with respect to real-time delivery of video. However, MDI has also been shown to be correlated very loosely

with user-oriented video assessment, and is thus more appropriate for use as a network evaluation tool rather than a tool to measure IPTV QoE.

MPQM and V-Factor, on the other hand, are objective models based on the specific properties of human vision that can accurately reproduce the subjective experience of a user, and they have been shown in studies to be superior to both PSNR and MDI for purposes of video quality assessment. In fact, these are emerging as methods of choice for measuring IPTV QoE. MPQM offers a quality rating scaled from 1 to 5, where "Excellent" is rated a 5, "Good" a 4, "Fair" a 3, "Poor" a 2 and "Bad" a 1, and an "Impairment being Imperceptible" is rated 5, "Perceptible" a 4, "Slightly Annoying" a 3, "Annoying" a 2, and "Very Annoying" a 1.

Testing with G.1050 Impairments

By introducing IPTV, service providers are creating new testing challenges caused by a variety of IP network impairments. Unlike legacy multiplexing methods of service delivery, where bandwidth is always available, IP-based triple play solutions subject video to the same impairments experienced by data, which can vary greatly over time as network conditions change. Further complicating the situation, equipment vendors are creating new products and new features to support the rush to offer triple play and IPTV service, and include new media gateways, media servers, video gatekeepers, application servers, edge routers, set top boxes and IP phones.

The introduction of such new equipment and devices, and the migration of video to an IP network, highlight the need to be able to reproduce network impairments during testing in order to build solutions that can offer the highest quality QoE for the user. This state of affairs, in fact, required the development of a new network model for IP impairments.

Developed by the TIA (Telecommunications Industry Association) and adopted by the ITU (the International Telecommunications Union), G.1050 is a recommended model that provides a common reference for emulating the effects of live networks in the lab. G.1050 specifies over 100 end-to-end network configurations with eight degrees of quality ranging from well managed to unmanaged networks. Testing against G.1050 allows network designers to evaluate the ability of their solutions to compensate for the impairments they will encounter on an IP network. It also removes the guesswork from configuring impairment scenarios such as testing IPTV media quality, QoS, network equipment, roll-out testing, monitoring live network performance and trouble-shooting live network problems.

Key Requirements for IPTV Testing and Network Assurance

Complicating the complexity of rolling out IPTV and triple play services is the fact that the new set of services requires extensive upgrades to current access networks. In order to offer service, providers are investing in the next generation of broadband remote access server (B-RAS), also referred to as broadband network gateway (BBNG). Plans for implementation of ADSL2+, VDSL, FTTX, and Ethernet access require enhanced functionality on B-RAS platforms and many other network elements, including DSLAMs, next generation DLCs, Ethernet aggregation routers and others.

Service providers must deliver optimal quality of experience (QoE) to their new and existing subscribers in order to minimize turnover. It is essential, then, that they employ a comprehensive video and IPTV testing solution that ensures quality of service not only at each element in the network, but end-to-end in the network as well. Key testing requirements include the ability to test new metrics related to IP multicast such as leave-join intervals and the scalability of the overall service, commonly referred to as "maximum zapping rate" (channel changes per unit time).

To ensure that the combination of network elements including B-RAS, EAR and DSLAMs can perform in a manner that provides optimal QoS and performance for delivery of IPTV services, testing must be conducted that addresses each of the following areas:

- Scalability and throughput
- Rate of session termination
- Number of subscribers supported with QoS enabled
- QoS across multiple network elements
- Support for hierarchical traffic management
- Multicast performance
- Number of simultaneous multicast streams (video channels) the network can accept without frame loss

Key areas to test include:

- Bandwidth – Is the infrastructure able to handle hundreds of channels?
- Channel zapping – How rapidly can set top boxes change channels?
- Channel validation – Is the correct information being received?
- Benchmarking – How do real servers compare to the lab environment?
- Triple play – What is the effect on voice and data?

Key tests to perform include:

- Join latency – Time from when a join is sent until first multicast packet arrives•
- Leave latency – Time from when a leave is sent until the last multicast packet arrives
- Interchannel latency – Time it takes to complete an entire channel
- Stream integrity – Lost or mis-inserted packets in the multicast stream
- Measuring the channel surfing (zap rate) capacity of the DSLAM

IPTV Testing Solutions from Spirent Communications

Spirent Communications (http://www.spirentcom.com) is a leading provider of converged network testing and quality assurance solutions for advanced, massively-scaled service provider networks. The company has developed a complete suite of IPTV and integrated triple-play infrastructure, application, and QoE/service assurance testing solutions for both the lab and the deployed network.

In the lab, Spirent is differentiated in the market by its ability to test video quality with both Full and No Reference methods, and its ability to achieve high MOS correlations by using the V-Factor and MPQM methods. In addition, Spirent also provides ITU-T G.1050 impairment testing with its Converged Network Impairment Emulator.

Spirent IPTV test solutions, including the IPMax and qScope products, provide comprehensive infrastructure and service quality testing. This enables network equipment manufacturers and service providers to test each network component individually, as well as test service quality in the network end-to-end in order to verify service quality and accurately anticipate the subscriber's experience early in the development cycle. Ultimately Spirent solutions reduce testing cycles with easy-to-use user interfaces and flexible testing architectures. Spirent proves that the right testing strategy can speed time to revenue from new services.

For further information on triple play testing powered by Spirent Communications technology, contact your Spirent representative or visit www.spirentcom.com/go/tripleplay

About the Author

Robins Consulting Group (RCG) is a leading marketing communications consultancy providing an array of marketing and other services to the IP communications industry. Marc Robins, an internationally recognized authority in the field of IP telephony and emerging new communications technologies, founded RCG in 2003. Prior to RCG, Mr. Robins served as vice president of publications and trade shows, associate group publisher and group editorial director at TMC, publisher of the trade magazine *Internet Telephony* and producer of the *Internet Telephony Conference & EXPO* trade shows, for which he also served as chief architect and conference co-chairman. For more information about Robins Consulting Group services, call 718-548-7245 or e-mail robinsconsult@optonline.net. This white paper was commissioned by Spirent Communications.


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