Delivering High-Quality Video over IP

Why Your Digital Video Service Must Be Monitored

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Executive Summary

For years, network and service monitoring tools have been providing operations engineers with invaluable information for troubleshooting, diagnosis, and problem resolution. With the introduction of new, high-bandwidth, real-time video services that stress Internet protocol (IP), network infrastructure-monitoring solutions become even more critical. Escalated end-user expectations for video quality—especially for high definition (HD)—combined with the negative business impacts of delivering a poor quality of service (QoS) are driving demand for higher quality and new video-focused monitoring solutions.

Impairments to video services can come from a wide variety of sources. Having not been designed for large volumes of real-time video traffic, best-effort IP networks do not meet the quality requirements of today's digital video services. In addition, video architectures are becoming more complex, and constant content manipulation from the content owner down to the end user also adds additional corruption risk—encoding/transcoding, digital ad insertion, splicing, statistical multiplexing, and up/down conversions are examples of such manipulations.

With the wide range of complex video equipment and aggressive compression goals to ensure lowest bandwidth and network impacts, providers face challenges to ensure video-service quality meets the growing end-user quality expectations or face high operations costs, high customer churn, and slower service deployment.

Ensuring high-quality video is a critical component of any successful IP–based video offering and, based on their proven ability to affect bottom-line business metrics (e.g., lower churn, lower operations costs, faster growth), monitoring solutions bring significant value to IP video services. Monitoring is an essential activity that time and time again more than justifies its return on investment, drastically improving IP video service offerings and enabling rapid growth in overarching business and service objectives.

The Current IP Video Business Environment

In short, this is a great time to be in the video business. Video on the Internet is more popular than ever—it is responsible for driving huge traffic levels along with large subscription and advertising revenue. Companies across the board, including telcos and multiservice operators (MSOs), stand to benefit a great deal from including IP video in their offerings. IP video creates new, more attractive service offerings, lowers delivery cost for end-to-end content management, enables expanded catalogs of long-tail niche content, delivers higher performance, and enables more targeted and more effective advertising models.

There is, however, a catch. While video represents a great opportunity and traffic is growing by leaps and bounds, IP networks fundamentally were not designed for such large quantities of real-time sensitive video content. The following explores some of these challenges in more detail.

Video Delivery Challenges

There are four key inherent aspects of video responsible for a large number of today's video-quality challenges.

Demanding Traffic Profiles

Video traffic is real-time with strict delay, delay variation, and loss requirements. High-bandwidth streams (2–3 Mbps standard definition [SD], 6–12 Mbps HD) further stress the network's ability to deliver video in high quality. As an example, 10M viewers of some particular video content at 6 Mbps per stream results in 60 Tbps of total traffic. Even the largest providers would struggle to deliver 60 Tbps—especially at the quality needed for video. Most important, this example is only for one video and does not count other video, voice, and data services that need to be delivered.

High End-User Expectations

Not only is video traffic stretching the envelope, but also, end users are more sensitive to errors with video. This of course is based on years of history and experience watching TV. Problems are not tolerated at all and users get frustrated and complain. This becomes especially true when talking about HD services, as improved quality is the primary driver for these offerings. High user expectation for video quality is a major point fueling the drive behind the need for video monitoring.

IP Network Effects

Internet protocols, having been built primarily with scalabil-

ity, ubiquity, and fairness in mind, do not perform well with large volumes of real-time video traffic and have traditionally been considered best-effort networks. Packet loss, designed into IP networks to maintain overall performance objectives, has adverse effects on video.

Having been constructed under strict economic constraints, IP networks are bandwidth-limited environments resulting in packet loss episodes, which can adversely affect video. In addition, the drive toward higher compression ratios, in an effort to lower bandwidths and reduce costs, can have unfavorable effects on video quality—especially for action-based video content.

When it comes to bursty loss, video reacts very differently than other services. For instance, 10 ms of loss for a data service (e.g., e-mail, browsing) is undetectable. For VoIP, 10 ms of loss is about 80 bytes, which is well inside the 50 ms failover standards and is very tolerable from the end-user perspective. But for HD video, 10 ms is about 10,000 bytes, and when that is lost, it can be extremely noticeable. Operators putting video on their IP networks (which were previously carrying voice and data services) often discover fundamental problems they never knew existed.

New Network Architectures

State-of-the-art video architectures contain new video equipment such as encoders, middleware, servers, and management systems. The introduction of these new elements has not been a seamless process, and some investment of time and operational effort will continue to be necessary to stabilize these devices.

These combined factors make video an extremely challenging service, especially at the quality levels required from today's very demanding subscribers.

Key Operations Challenges

Understanding What Is Going On

Service providers face challenges in understanding their actual video quality as perceived by end users. Because little information is available about what is happening with the video service, it becomes unclear how the service is actually performing at the end-user terminal. As a result, too often the end user becomes the monitoring system, putting operators in "reactive mode" and often resulting in very angry customers. *Figure 1*, taken from Symmetricom's 2007 Operator Video Quality Study, confirms the primary method for issue identification is via customer calls.

Some providers have resorted to doing things such as offline surveys to determine end-user experience, but this is clearly not real-time and does not provide operators with timely information needed for network and service maintenance. Unless operators can gain better understanding of their services and prevent the customer from becoming the monitoring tool, they will continue to struggle with how to lower churn and operations costs.

Unable to Improve Service or Fix Issues

Moreover, because of lack of information, operators cannot fix quality problems in a timely manner. Operators often spend hours of valuable time attempting to gather relevant metrics about issues and, with little meaningful data, extended periods are spent debugging and troubleshooting. In addition, longer outages lead to more frequent and longer-lasting customer complaints, and ultimately more customer churn.

Being equipped with very little timely and relevant data, operators are unable to improve service levels, diagnose problems, and discover solutions to video quality–related problems.

Digital Video Monitoring

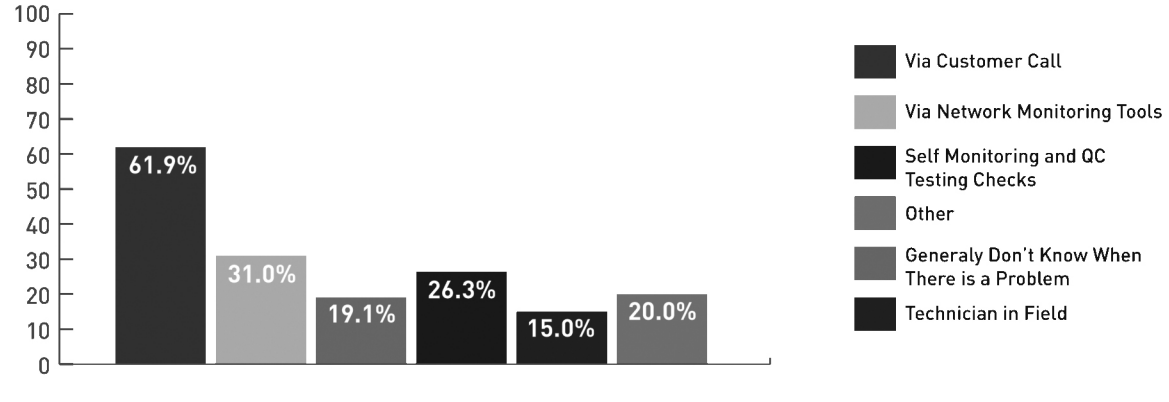
History and Background

Since the early days of networking, operators have used monitoring tools to help them understand problems with their system. In these early days, continuing through today, operators have relied on invaluable data provided by monitoring systems to understand their networks and services, and rapidly diagnose, troubleshoot, and resolve issues.

Network monitoring tools were focused on network quality of service (QoS), represented by four QoS metrics: loss, delay, jitter, and bandwidth. For services such as video streaming, however, requirements for the monitoring tools have evolved to monitor QoS from a customer, and content, per-

FIGURE 1

Video Quality Problem Reporting—Average Percentage per Source. The Customer Is the Monitoring System.



spective—an idea that has been termed quality of experience (QoE) monitoring. QoE monitoring focuses on the quality of the (video) content, not just the network parameters.

The complexity of video delivery systems today has also made it necessary to monitor not just the network, but also all the components of the system from end to end. This includes the source content, the devices used for processing it (e.g., encoders, transcoders, splicers, multiplexers, streamers), and the equipment at the customer premises (e.g., set-top boxes [STBs], home networks). End-to-end monitoring is considered essential to identify causes and locate problematic components in an IP video system.

Despite the evolution of IP services, the requirement to obtain real-time, accurate information remains and fuels the need for today's state-of-the-art monitoring approaches.

Benefits of Digital Video Monitoring

Monitoring is important for the fundamental reason that managers need information to run their businesses. Video-quality monitoring solutions allow operators to determine where issues are coming from and how service issues are impacting the business. Bottom-line business objectives, including improving and growing the service, lowering operations costs, and reducing customer churn, are achieved through implementing a monitoring solution. The importance of monitoring is further evidenced in *Figures 2* and *3*, from Symmetricom's 2007 Video Quality Study.

The availability of timely and accurate video-service–quality information can radically improve bottom-line business metrics. The previous data, gathered from cable operators, outlines the top business benefits of video monitoring.

Reduction of Operating Expenses

Maintaining and managing a video service offering is a key expense that needs to be controlled. Support calls generally cost a minimum of $30 per call, while truck rolls can run upward of $800 per instance. Support costs for video services have been steadily growing, and poor video quality is a key reason for this, as shown in *Figure 4*.

FIGURE 2

Centrality of Video Quality Monitoring to Video Initiative. Monitoring Video Is Extremely Important.

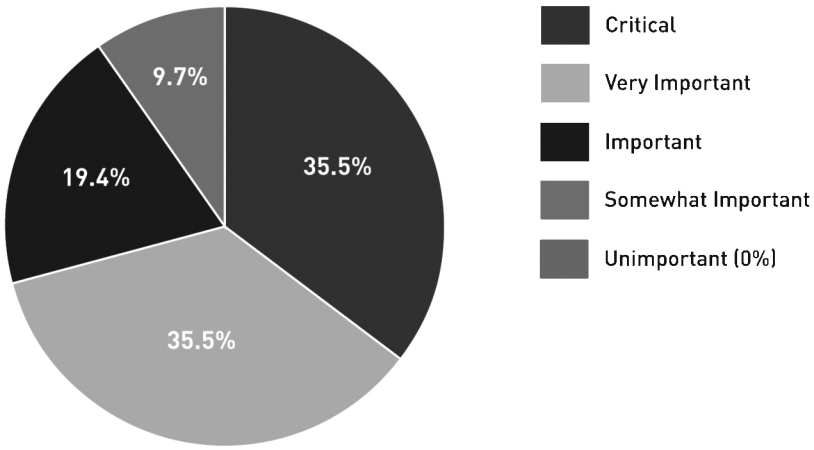


FIGURE 3

Business Benefits of Monitoring.

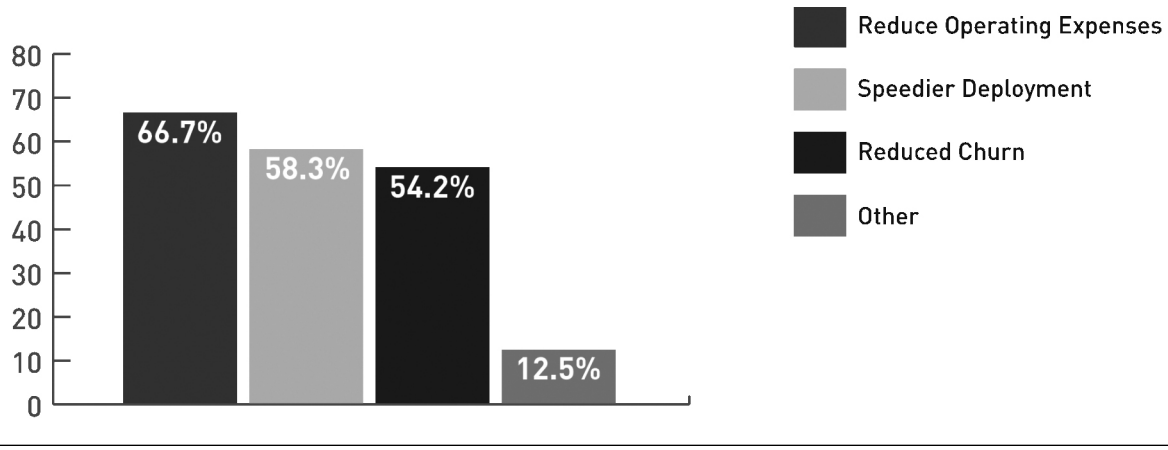
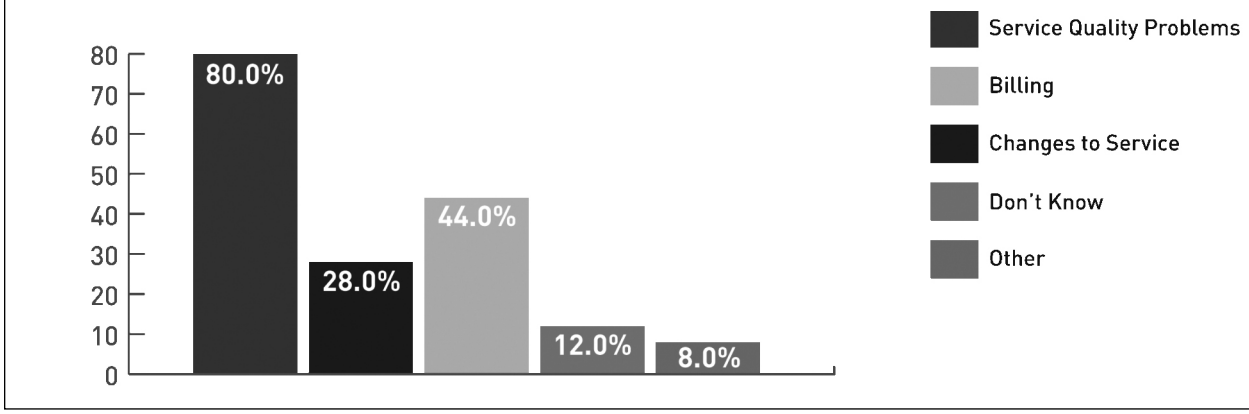


FIGURE 4

Key Reasons for High Support-Call Volumes.



These costs need to be controlled if operators are to deliver profitable video services.

Reduced Churn

Lost customers are a key metric to measure IP video service success, and unfortunately, poor video service quality is a key driver of churn. The high cost of new customer acquisition makes losing customers even more painful. Because of negative impacts on churn, it is extremely important to deliver high-quality video and measure this quality to ensure ongoing video performance.

Without the right monitoring tools, the following may be a typical scenario:

- A customer calls complaining of poor video quality.
- In response, service providers send a truck, make a test, and determine video is good. In an effort to ensure the customer is satisfied, the set-top box is replaced and tested by the manufacturer.
- The same customer calls a few days later with the same issue.
- Due to frustration, the customer moves to a competitive digital video service.

Such a scenario represents a lost revenue stream of nearly $100 per month. What is worse is customer acquisition costs, often upward of $250 per customer, need to be expended to replace this lost revenue stream. All these factors quickly escalate the total cost of rolling out a poor-quality video service and rationalize video-monitoring solutions.

Speedier Deployments

Because of high-quality video's central importance to IP video services and the adverse effects of poor quality, operators need to ensure service performance before customers are turned up. On the other hand, extreme pressure exists to turn up large numbers of video customers to meet overall business objectives. Deploying monitoring tools that validate video quality speeds up deployments and is key to faster service monetization.

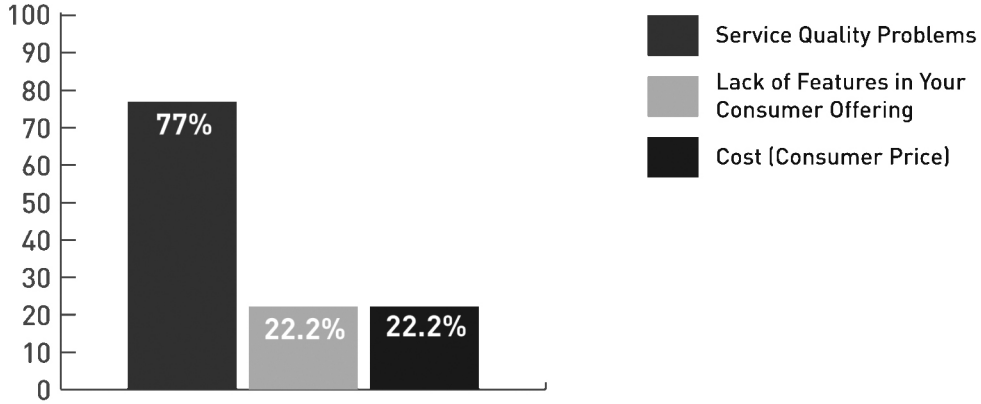
Common Objections to Monitoring

Monitoring Is Too Costly

True, deploying monitoring solutions requires capital investment in hardware and software components, along with training and other upfront operations costs. Despite

FIGURE 5

Primary Reasons for Customer Churn.



this, based on current deployments, monitoring solutions generally cost less than $1 per IPTV subscriber and, based on these figures, get a return on capital investment of two to five months depending on deployment and architecture. When you consider costs of not monitoring outlined previously, the investment in monitoring technology is generally a very smart choice.

Network Repair-Only Solutions Are Sufficient
Packet loss recovery approaches such as forward-error correction (FEC) and packet re-transmission techniques such as reliable UDP (RUDP) can overcome a large percentage of packet loss in some network scenarios. These solutions can be helpful in mitigating impact on video quality from packet loss in network elements. These approaches, however, are not sufficient as their "static" nature (they are tuned for specific cases) often only protects against predetermined loss probabilities; there are theoretical and practical limitations to their effectiveness. In addition, being a real-time service, video cannot often "wait" for retransmission to occur, and service quality can suffer with delays and overhead resulting from retransmission.

Furthermore, FEC and RUDP are network-centric solutions designed to recover from packet loss. Impairments come from other places besides the IP network, making these FEC and retransmit approaches insufficient to recover from all problems. As packet loss is only one source of video quality issues (others are poor source quality, encoder/transcoder artifacts, ad-insertion issues, and a host of other content-related issues), video quality problems still exist even if these approaches are deployed. Moreover, ensuring quality in each network demarcation (e.g., head end, VSO, CPE, etc.) is essential to daily operations activities, including troubleshooting and diagnosis, and requires monitoring devices specially designed for the specific challenges of each of these demarcations.

While such repair-only solutions can help make video delivery more robust, operators will still require monitoring tools to understand and improve the quality of their video service.

Overhead
A general misconception about monitoring solutions is that they add extra processing, bandwidth, reliability, and complexity overhead to IP video systems. Because the vast majority of monitoring activity is "passive," where streams are "tapped" and a copy of the streams is analyzed, monitoring does not impact video performance. While there are some "active" monitoring approaches (which involve setting up connections to servers to simulate end users and test performance), these are generally for temporary troubleshooting and diagnosis.

Conclusion

For years, network and service monitoring tools have been providing operations engineers with invaluable information for troubleshooting, diagnosis, and problem resolution. With the introduction of new, high-bandwidth, real-time video services that stress IP network infrastructure, monitoring solutions become even more critical. High end-user expectations for video quality—especially for HD—combined with the negative business impacts of delivering a poor quality service are driving demand for higher quality and new video-focused monitoring solutions.

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