SPIRENT Communications

Inspired Innovation

Application Note

Spirent GEM Network and Impairment Emulators

IP Video

Streaming Video • IPTV • VoD • Multicasting

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Spirent GEM Network and Impairment Emulators

IP Video

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Overview

The delivery of video over an Internet Protocol (IP) network provides new avenues for development and growth for service providers of every description. As an evolutionary step in service delivery, use of the IP network infrastructure to deliver video enables more intelligent services, from simultaneous viewing/recording of multiple programs to targeted advertising and content control.

However, new opportunities bring new challenges. Delivering video over an IP network requires time-sensitive content to be transported over a network that may introduce packet delay, loss and reordering with limited available bandwidth. A successful IP video solution must provide quality of experience for the viewer by compensating for negative conditions that occur in IP networks. Spirent's GEM Network and Impairment Emulators allow test engineers to introduce those conditions in a controlled and repeatable fashion to predict quality of experience in actual networks.

The Technology

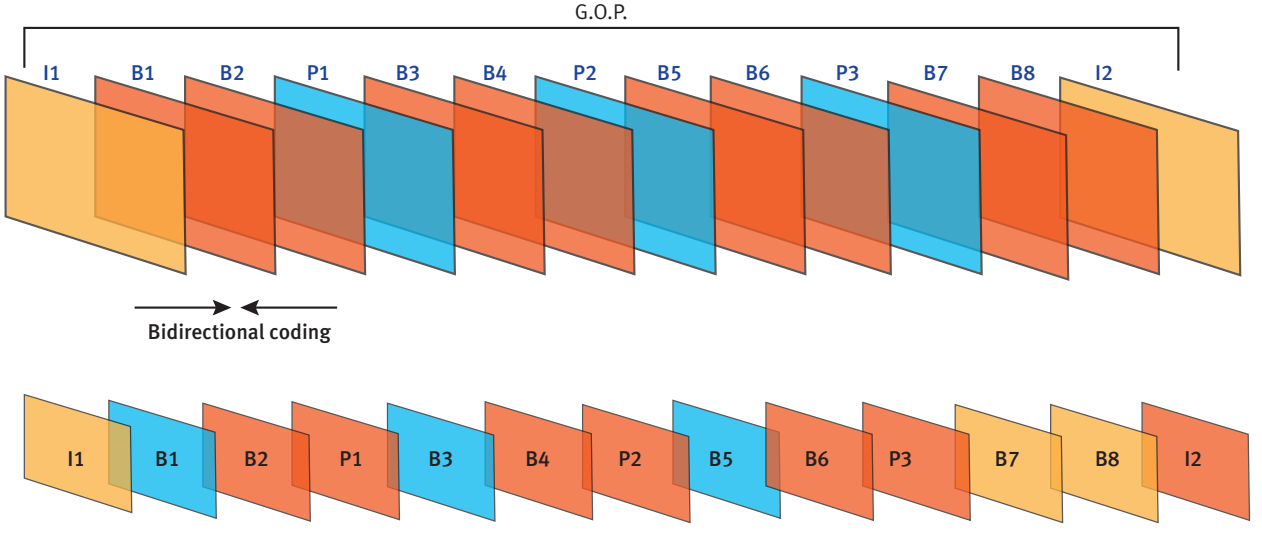
IP Video typically uses MPEG-2 encapsulated in Real Time Streaming Protocol (RTSP) and IP. Video is a set of individual frames played at a rate sufficient to be perceived as smooth motion, typically 30-frames per second. However, transmitting 30 full frames per second requires more bandwidth than is practical on IP networks. The Moving Pictures Experts Group (MPEG) developed methods of reducing the required bandwidth by reducing the amount of information required to display the next frame in a sequence.

MPEG compression divides video into a set of frames called a group of pictures (GOP). A GOP comprises three types of frames: I-frame (intra-frame), P-frame (predictive frame) and B-frame (bi-directional frame). An I-frame contains all the information required to display a frame. A P-frame contains only changes from the preceding I-frame – information on the parts of the picture in motion, but no information on the parts of the picture that is static. The information contained in a P-frame is not sufficient to display a full image.

It must be preceded by an I-frame. A B-frame is similar to a P-frame, but contains information that has changed from the preceding frame or will change in the following frame.

In a GOP, I-frames are followed by P-frames and B-frames. The more I-frames, the better the video quality. I-frames are two or three times larger and require more bandwidth.

MPEG Frames



Transmission Order

A typical GOP will contain seven to ten frames in the pattern IBBPBBPBBP, although the order of the B and P frames may be adjusted before transmission. A GOP is encapsulated into one IP packet.

Testing Considerations

IP Video is a complex application that requires the seamless operation of many functions. The transport must have the capability of delivering the required bandwidth at the appropriate service level. Signaling is required to select channels and Video on Demand programming. The system must be scalable to accommodate a sustainable customer base and the associated stress of channel zapping during peak times. Most importantly, the system must be able to deliver high video quality over the deployed infrastructure. And, if converged services are offered, all of this must be delivered in the presence of voice and data traffic as well.

In a Perfect World: The Performance Baseline

The first step in testing an IP Video solution is to evaluate it in a test lab under optimum conditions. The infrastructure of the test lab should provide an environment with no packet loss, no packet reorder and minimal delay. As all aspects of the solution are tested, such as signaling, channel zapping, video quality, QoS schemes and scalability, the maximum performance limits of the system are determined. These limits establish the baseline, which will be used for comparison against the results of tests in a more realistic environment.

Real-World Testing: The Reality Check

IP Video services are not delivered on an ideal network. They run in combination with other traffic through multiple devices and across infrastructure that spans significant distances. The result is an environment that presents some level of delay, impairment and bandwidth limitation, the severity of which depends on how well the network is engineered.

To deliver IP Video with confidence, test and debugging iterations must be performed under the conditions in which the solution will actually be deployed, and also under worse conditions to account for equipment failure and disaster conditions. Rather than test on a live network, which is expensive, impractical and not repeatable, real-world testing is achieved by using network emulation in the test lab.

Each of the tests performed during baselining are performed again with Spirent's GEM Network and Network Emulators creating impairments such as packet loss, delay, bit errors, sequence errors or duplication in a controlled fashion. The emulator can also model the effects of high traffic load by constraining available bandwidth. The actual delay, impairment and bandwidth values used are determined by various methods.

Table 1. Determining Network Emulation Parameters

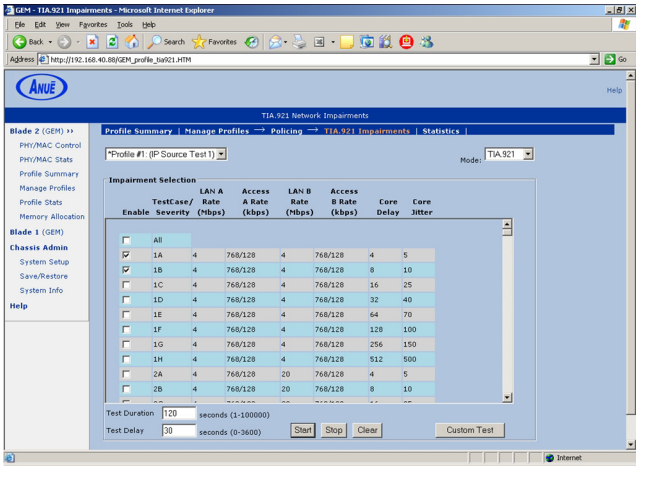
Educated Guess Trial and Error	Values known to affect the service can be tweaked to determine quality-of-experience thresholds. For example, MDI and V-Factor use jitter, sequence errors and packet loss, among other metrics, to measure video quality. Values for these impairments can be ramped up, both individually and jointly, to determine the breaking point for video quality scores. Results can be used to characterize the limits of a device or service. **Pros:** Granular control over specific impairment metrics, goal-seeking of performance thresholds. **Cons:** Can be time-consuming if not automated; combinations tested may not reflect real-world conditions.
Network Management System or Protocol Analyzer	A network management system or protocol analyzer can be used to determine the performance of the live network on which the solution will be deployed. Measured values for packet loss, delay, duplication and sequence errors can be used to configure the emulator during testing. **Pros:** Test conditions reflect the actual conditions measured on the production network. **Cons:** Conditions in IP networks are not static. They vary over time as events such as traffic congestion, router flaps and topology changes occur. Testing with a single value averaged over time will not produce an accurate reflection of actual performance. Realistic testing requires impairments that change dynamically over time. Taking thousands of measurements over short intervals and automating the changes in configuration of the network emulator can accomplish this, but it can be complex and time consuming.
Standards-Based Model	A standard network model for IP network impairment can be used. TIA-921 and ITU-T G.1050 describe a Network Model for Evaluating Multimedia Transmission Performance over Internet Protocol based on actual network data provided by anonymous IP service providers and IP network equipment manufacturers. An algorithm uses typical LAN, access and core network characteristics as in-put and produces as output dynamic values for end-to-end packet delay, loss and reorder that vary over time in the same manner as conditions in deployed networks. **Pros:** The model more accurately reflects the way actual IP networks behave than other methods of testing. **Cons:** Since the impairments are changing dynamically, in the case of failure of a test case, the impairment that caused the failure may not be immediately clear. Further troubleshooting may be required.

Before and After

Features that are susceptible to specific impairments should be baselined and then tested in the presence of the impairments known to affect them. As issues are revealed, troubleshooting uncovers root causes and facilitates the debugging of applications or tuning of network parameters. This iterative process is required to assure robust solutions and minimize support costs.

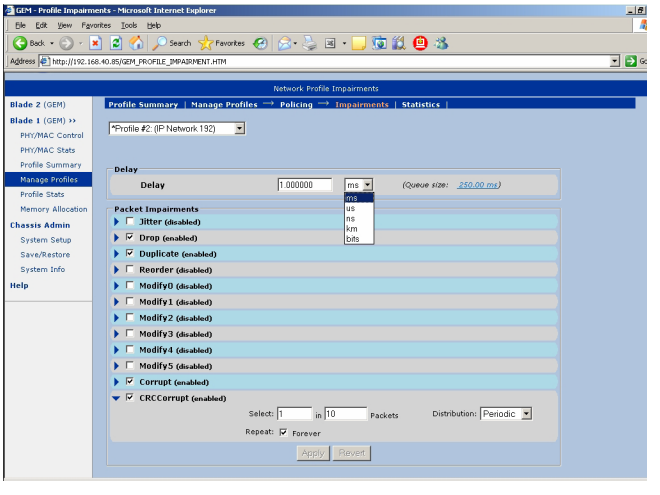
Quality of Service

Video is highly sensitive to packet loss. The dropping of a single MPEG I-frame is noticeable. QoS is employed to guarantee delivery of video traffic with minimum latency. Different schemes may be used depending on the implementation. Video priority queues must be able to deliver packets without loss, even in the presence of other, lower priority traffic. Bandwidth oversubscription should be tested to verify that lower priority traffic is dropped to accommodate video traffic. Impairment profiles can be configured based on where the QoS is implemented, such as in the experimental bits in the MPLS header (core network traffic engineering), the DSCP/ToS bits in the IP header (aggregation-level QoS) or the 802.1p-bits in the VLAN tag (DSLAM or PON QoS).



Video Quality

Measures of quality of experience for IP video can be categorized into those that measure network statistics and those that measure the content itself. Media Delivery Index (MDI), specified in IETF RFC 4445, predicts the quality of packet video by measuring network statistics such as packet jitter, loss and sequence errors. V-Factor assesses the quality of packet video by inspecting the content of the MPEG frames themselves. Both scores will be affected by emulation of network jitter, sequence errors, jitter discards (frames discarded due to arriving too late) and packet loss. However, MDI will not detect corruption of video content if that corruption doesn't result in a discarded packet. Using V-Factor with an impairment emulator that can modify payloads with checksum correction or drop specific frames, such as I-Frames, can test for this kind of scenario.



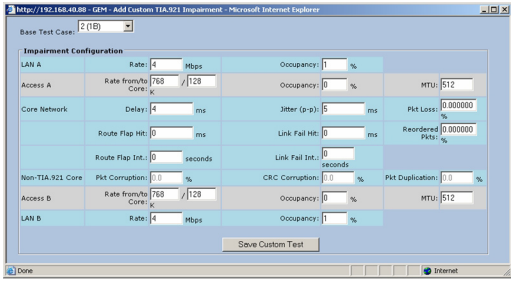
Channel Changing

IP Video uses IGMP and multicast to efficiently transmit channels to multiple destinations. If Join/Leave requests are corrupted or dropped, it will affect channel zapping as requests are re-transmitted. Spirent's GEM Network and Impairment Emulators can be used to target IGMP requests to measure the effect of dropped requests.

Performance Thresholds

When baselining performance, packet loss and sequence errors caused by the system under test may increase as thresholds are reached. When testing with impairments, the amount of impairment injected should be compared to the impairment measured by the analyzer to compare performance thresholds to the baseline thresholds.

In addition, performance thresholds under realistic conditions are used to determine the service level parameters required for a sustainable implementation. Testing with network emulation is used to right size the engineering of a production network, avoiding the needless expense of over-engineering, or the revenue-threatening consequences of under-engineering, the network.



Conclusion

A successful IP video solution requires testing under real-world conditions to guarantee that it can provide quality of experience for the viewer by compensating for conditions that occur in IP networks. Using the Spirent GEM Network and Impairment Emulators enables engineers to predict application performance, thereby reducing risk, accelerating time to market, and allowing deployment with fewer problems and greater confidence that the solution will perform as expected .

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