White Paper

Advanced IP Testing

RTP Loss Distance and Loss Period

By Sascha Chwalek, JDSU

IPTV Networks

Internet Protocol Television (IPTV) ecosystems are mainly based on video distribution over a Motion Picture Experts Group 2 (MPEG-2) Transport Stream, which carries a compressed payload, today typically encoded with MPEG-2 or Group 4 (MPEG-4), and uses a protocol stack similar to the one in Figure 1.

The Transport Stream, established on top of the User Datagram Protocol (UDP) and defined by RFC-768, is an efficient protocol for transmitting real-time data for broadcast or multicast applications such as IPTV. It does not wait for an acknowledgment such as Transmission Control Protocol (TCP), nor does it guarantee the same reliability or ordering as TCP. Datagrams may arrive out of order, appear duplicate, or miss packets without notice.

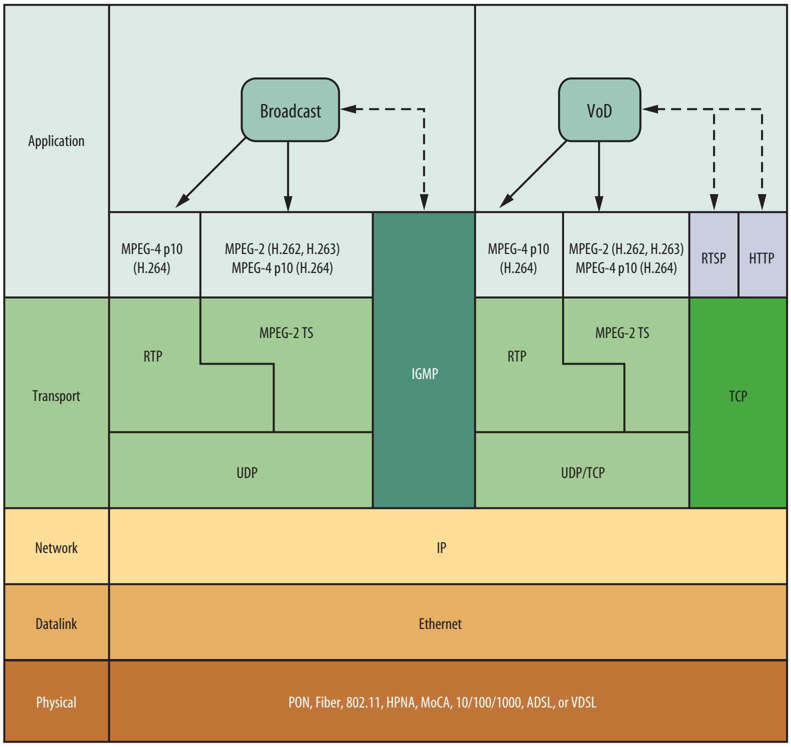

Figure 1 Protocol stack for streaming IPTV

Worldwide IPTV deployments are primarily delivered over an Asymmetric Digital Subscriber Line 2+/ Very High-Speed Digital Subscriber Line 2 (ADSL2+/VDSL2) infrastructure. Field experiences identified impulse noise on the last mile or the in-home environment as a major source for intermittent IPTV impairments. Impulse noise, or short duration energy bursts caused by environmental influences and electromechanical devices, can cause uncorrectable cyclic redundancy check (CRC) errors for ADSL2+/VDSL2. The CRC errors will then cause continuity errors for the IPTV stream and, therefore, directly impact the video stream with pixelization, blurring, or freezing.

To overcome quality issues for IPTV delivery, new systems offered by Microsoft and Cisco have been developed and deployed to allow retransmissions for error recovery in the event of packet loss typically caused by impulse noise or congestion. A fundamental change for these new systems is that they utilize Real-time Protocol (RTP) on top of UDP, as defined by RFC-3550, which adds a sequence number and timestamp to the UDP stream. The sequence number in the RTP stream allows identification of lost and out of order packets. Retransmissions can replace lost packets; however, at the expense of additional bandwidth and hardware requirement.

Forward error correction (FEC) is another recovery method proposed by the Pro-MPEG Forum Code of Practice No. 3.1 (COP No. 3 Release 1, adopted RFC-2733). The FEC mechanism adds redundant packets to the original packet stream, so that lost packets can be restored without delay. A checksum packet per row and Exclusive-OR (XOR) operation can restore any single packet loss. To restore contiguous losses of packets, or burst-drops, requires an interleaving mechanism that groups FEC blocks as introduced by RFC-2733 and results in a matrix with a final checksum row as shown in Figure 2. Further evolutions of FEC methods exist, including proprietary solutions; however, all methods, including basic DSL impulse noise protection (INP), DSL interleaver, RTP FEC or retransmission mechanisms have practical limitations by depth of error recovery versus additional protocol overhead requiring more bandwidth and acceptable delay for real-time applications like IPTV. Managing this issue so as not to over-provision the network and maintain quality of experience (QoE) for the user is an evolving challenge.

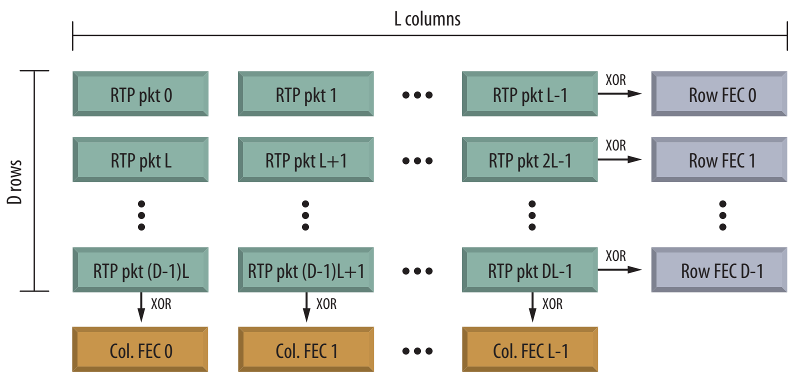

Figure 2 RTP FEC matrix

RTP Loss Distance and Loss Period Testing

As discussed previously, intermittent packet loss caused by impulse noise can be recovered by re-transmission or FEC mechanisms; however, each has its limitations. Analysis of the RTP packet sequence numbers can provide information about the number of consecutive lost packets and the distribution of loss events based on the number of good packets between a loss events. RFC-3357 defines a combination of two metrics that capture one-way loss pattern metrics: Loss Distance and Loss Period.

Loss Period is defined as the length of a single loss event, or the number of lost packets between two successfully received packets. Loss Distance measures the difference in sequence numbers of two loss events establishing the spacing of the loss events.[1] Figure 3 outlines this analysis.

Packets are identified by RTP sequence numbers Pkt2, Pkt5, Pkt6, and Pkt7 as losses. Pkt2 represents the first loss event with a Loss Period of 1, the sequential packets Pkt5, Pkt6, and Pkt7 result in a second loss event. The Loss Distance between the first loss event and the second loss event results in a Loss Distance of 3. The second loss event shows the duration Loss Period of 3.

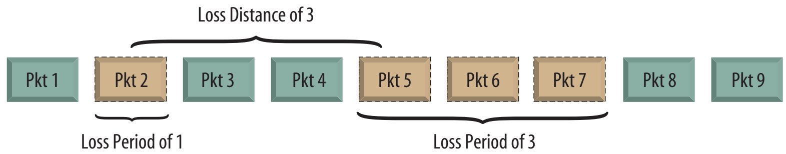

Figure 3 Loss Distance/Loss Period definition

[1]Note: This is a slight deviation to the exact RFC-3357 definition as Loss Distance being “the difference in sequence numbers of two successively lost packets which may or may not be separated by successfully received packets”.

Error recovery mechanisms can deal with some loss events, depending on the number of consecutive lost packets (Loss Period) and spacing of loss events (Loss Distance). As Figure 4 shows, a good constellation of known Loss Period/Loss Distance values can be recovered through the network as well as an obvious bad combination of Loss Distance/Loss Period values, where impairment loss events are so great or they come so frequently that the recovery mechanism cannot keep up with the result that not all lost packets can be recovered. The results are visible to the user through such things as pixelization, frame freezes, or other poor quality events.

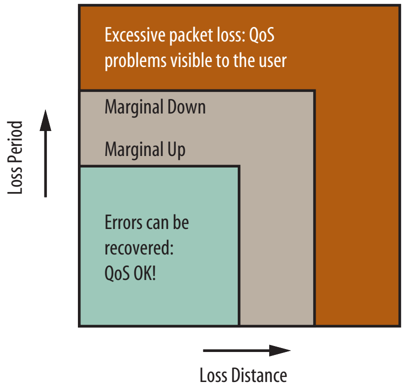

Figure 4 Error Recovery matrix with Loss Distance/Period Limits

The dispersion of Loss Distance and Loss Period values may not be linear between good and bad. Likewise, consecutive lost packets measured by Loss Period may prove more crucial than the Loss Distance between two loss events. As Figure 5 shows, the JDSU HST-3000 Packet Analysis function provides a powerful tool for finding Loss Distance and Loss Period events. Passing critical selectable thresholds for Loss Distance/Period will cause a Distance Error or Period Error and displays the Current, Maximum, and Total number of errors. To provide additional granularity, the HST-3000 measures the Minimum Distance and Maximum Period to illustrate the worst-case scenario.

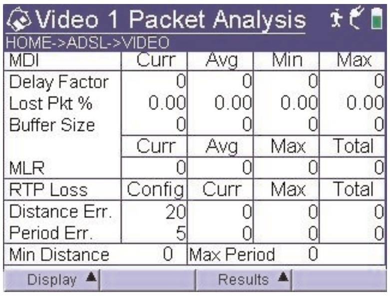

Figure 5 HST-3000 Packet Analysis with Loss Distance/Loss Period

The difficulty for IPTV operators is determining the marginal area or threshold where notification of Distance Errors and Period Errors becomes crucial for delivery of IPTV. The screen in Figure 5 above shows a relatively conservative limit set of Loss Distance <20 and Loss Period >5. New retransmission error recovery mechanisms can tolerate much more aggressive limits, for example 30 packet loss events. Any thresholds selected should be tuned to a given network. A first pass at defining the acceptable thresholds is often performed in a laboratory environment by applying repetitive electrical impulse noise (REIN) to the line under test. As real-world levels differ, JDSU recommends a second step: using the HST-3000 capabilities mentioned in Figure 6 to troubleshoot known problematic lines and establishing revised thresholds based on real network architecture and conditions. In addition, correlating impulse noise levels with packet loss can establish copper analysis thresholds which can then be used to qualify the health of the copper plant. The screens shown in Figure 6 below are examples of such analysis.

- Spectral view up to 30 MHz and specific J-filters for VDSL2 testing
- Impulse noise error count with main and ±3 dB sub-thresholds, including long-term monitoring with associated time stamps
- Impulse capture in the time-domain to determine the characteristics of an impulse event
- Correlating uncorrectable DSL CRC-errors with RTP lost packets, MPEG-2 time stamp continuity errors and Loss Distance/Loss Period events to determine the source of failure and quality impact

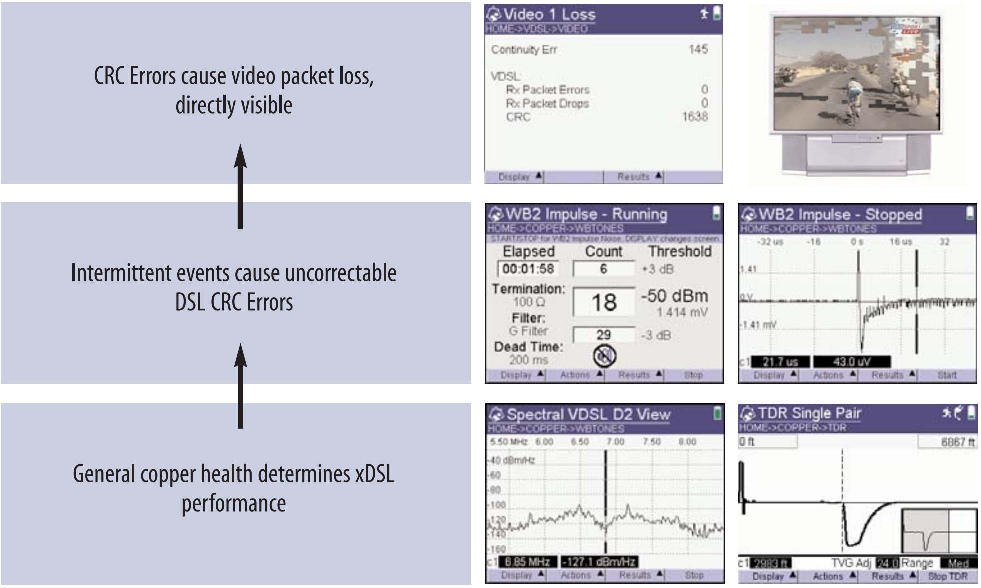

Figure 6 HST-3000 with correlated IPTV troubleshooting from the Physical to the Application layers

Summary

Impulse noise on copper loops has been identified as a significant source of packet loss affecting IPTV QoS failure. IP networks are also prone to congestion, which can cause packet loss. While IPTV systems become more adept at recovering from intermittent packet losses, all error correction or recovery mechanisms have performance limits related to the size of a loss event, and its spacing or frequency. Packet loss that exceeds these limits can be quickly identified using Period and Distance analysis. Impulse noise analysis can be used to measure the health of the plant and performance thresholds set, which will eliminate packet loss at the video packet level. The need for corrective action can be established before service is affected.

Test & Measurement Regional Sales

NORTH AMERICA	LATIN AMERICA	ASIA PACIFIC	EMEA	www.jdsu.com/test
TEL: 1 866 228 3762	TEL: +55 11 5503 3800	TEL: +852 2892 0990	TEL: +49 7121 86 2222	
FAX: +1 301 353 9216	FAX: +55 11 5505 1598	FAX: +852 2892 0770	FAX: +49 7121 86 1222	

 July 2008 30149475 000 0708 ADVANCEDIPTV.WP.ACC.TM.AE