Stochastic Packet Loss Model to Evaluate QoE Impairments

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Abstract. With provisioning of broadband access for mass market—even in wireless and mobile networks—multimedia content, especially real-time streaming of high-quality audio and video, is extensively viewed and exchanged over the Internet. Quality of Experience (QoE) aspects, describing the service quality perceived by the user, is a vital factor in ensuring customer satisfaction in today's communication networks. Frameworks for accessing quality degradations in streamed video currently are investigated as a complex multi-layered research topic, involving network traffic load, codec functions and measures of user perception of video quality.

Based on backbone traffic and DVB-H packet loss traces, stochastic models for the packet loss process are evaluated and discussed. Within this area, we provide a Markovian generator for packet loss pattern for studying the impact of impairments on the Quality of Experience. The main contribution is a new parameter estimation technique for Markovian point processes. Second-order statistics for the distribution of the number of lost packets over multiple time-scales are derived by moment generating functions. Moment matching is used to adapt a Markov process to error pattern observed in multiple time-scales. The second-order statistics in multiple time-scales is equivalent to the autocorrelation function of a process. An explicit analytical expression is derived for the Gilbert-Elliott model to compute the statistics on arbitrary scales based on four model parameters, which gives clear insight for the reverse process of parameter adaptation to observed statistics in relevant time-scales.

The experience in applying the results to to several scenarios in fixed and wireless communication networks suggest that the classical 2-state Gilbert-Elliott model already captures a wide range of observed loss pattern. The proposed approach leads to a closer match in multiple time-scales than classical methods with more flexibility to include information from different time-scales, enabling a simple and useful fit for long traces of traffic and packet loss processes.

The analytical study of loss pattern is supplemented with a qualitative investigation of their effects on QoE metrics for video transmission. In general, impairments of video sequences are sensitive to different assumptions on loss processes yielding different reaction in coding of slices and frames, which stresses the importance of refering to the most relevant pattern. A comparison of 2400 impaired video sequences led to strong evidence that uniform packet losses produce a larger distortion than busty packet losses at the same and sufficiently high loss-rate, since the former affect more frames on the video coding layers. Moreover, the results suggest that impairments at the video layer are affected by the applied parameter estimation technique.

References

1. Oliver Hohlfeld. Statistical error model to impair an H.264 decoder. Master's thesis, TU Darmstadt, March 2008. KOM-D-0310.