2009 International Conference on Communication Software and Networks

Analysis of Real-time Multimedia Transmission over PR-SCTP with Failover Detection Delay and Reliability Level Differential

Changqiao Xu[1, 2, 3] Enda Fallon[1] Yuansong Qiao[1, 2]
[1]Software Research Centre, Athlone Institute of Technology Athlone, Ireland
[2]Institute of Software Chinese Academy of Sciences Beijing, China
[3]Graduate University Chinese Academy of Sciences Beijing, China

Gabriel-Miro Muntean
School of Electronic Engineering Dublin City University Dublin, Ireland

Xiaoguang Li Austin Hanley
Software Research Centre, Athlone Institute of Technology Athlone, Ireland

Abstract—**The growing availability of different wireless access technologies provides the opportunity for real-time distribution of multimedia content using multi-homing technology. Investigating the behaviors and quality of such applications under heavy network load is necessary. This paper studies the effect of path failure detection threshold and reliability level on Stream Control Transmission Protocol Partial Reliability Extension (PR-SCTP) performance in symmetric and asymmetric path conditions respectively with different path loss rates. The platform Evalvid-SCTP implemented in the University of Delaware's SCTP ns-2 module performs the emulation experiment.**

Keywords-Real-time; PR-SCTP; Evalvid-SCTP

I. INTRODUCTION

The growing availability of different wireless access technologies, such as GPRS, 3G, WiFi, WiMax, etc., provide the opportunity for real time distribution of multimedia content. The characteristics of mobile environments, with the possibility of frequent disconnections and fluctuating bandwidth, pose significant issues for mobile application developers and therefore the path redundancy offered by multi-homing protocols has a clear attraction. The multi-homing features of the Stream Control Transmission Protocol (SCTP) [1] [2] appear to be key enablers for improving mobile communications [3] [4]. Multi-homing technologies, where a host can be addressed by multiple IP addresses, achieves definite improvements when link/path failures occur or temporary loss is experienced.

The Partial-Reliable SCTP (PR-SCTP) [5] is an unreliable data mode extension of SCTP, PR-SCTP allows an SCTP sender to assign different levels of reliability to data so that lost data can be retransmitted until a predefined reliability threshold is reached. When the reliability threshold is reached for unacknowledged data, the sender abandons that retransmission of the data and notifies the receiver (with Forward TSNs) to neglect the outstanding data and move the cumulative ACK point forward.

As unreliable application data such as multimedia is usually associated with time sensitive (real-time) applications, consideration of end-to-end delay and jitter becomes a major issue when using the transport protocol. This paper study the performance on real-time multimedia transmission over PR-SCTP with different failover detection delay and reliability level of PR-SCTP

II. PATH FAILURE DETECTION AND HANDOVER ALGORITHMS

SCTP is designed to tolerate network failure and therefore provides a mechanism to detect path failure. The path failure detection time is determined by SCTP parameters Path.Max.Retrans (PMR) and Retransmission Timeout (RTO). For an idle destination address, the sender periodically sends a heartbeat chunk to that address to detect if it is reachable and update the path Round Trip Time (RTT). The heartbeat chunk is sent per path RTO plus SCTP parameter HB.interval with jittering of +/- 50% of the path RTO. The default value of HB.interval is 30s. RTO is calculated from RTT which is measured from non-retransmitted data chunks or heartbeat chunks. For a path with data transmission, it can be determined if it is reachable by detecting data chunks and their SACKs. When the acknowledgement for a data chunk or for a heartbeat chunk is not received within a RTO, the path RTO is doubled and the error counter of that path is incremented. For a data chunk timeout, the sender retransmits data chunks through the timeout retransmission algorithm. For a heartbeat chunk timeout, the sender sends a new heartbeat chunk immediately. When the path error counter exceeds PMR, the destination address is marked as inactive and the sender sends a new heartbeat chunk immediately to probe the destination address. After this, the sender will continuously send heartbeat chunks per RTO to the address but the error counter will not be incremented. When an acknowledgement for an outstanding data chunk or a heartbeat chunk sent to the destination address is received, the path error counter is cleared and the path is marked as active. If the primary path

978-0-7695-3522-7/09 $25.00 © 2009 IEEE
DOI 10.1109/ICCSN.2009.14

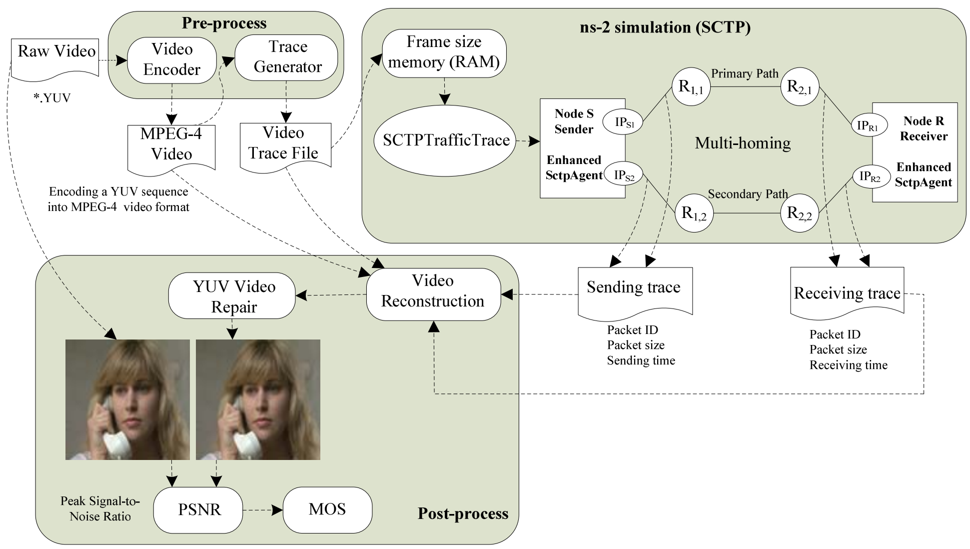


Figure 1. Evalvid-SCTP framework

is marked as inactive, the sender will select an alternate path to transmit data. When the primary path becomes active, the sender will switch back to the primary path to transmit data. The default PMR value in SCTP is 5, which means that SCTP needs 6 consecutive transmission timeouts to detect path failure. RTO will be doubled for each transmission timeout and ranges between the SCTP parameters RTO.Min and RTO.Max. The default values for RTO.Min and RTO.Max are 1s and 60s respectively. If RTO is 1s (RTO.Min) in the case of a path failure, the minimum time for detecting path failure is 1+2+4+8+16+32=63s. However, the initial RTO could be 60s (RTO.Max). Therefore, the maximum path failure detection time is 6*60=360s.

In paper [6] [7], the authors studied the performance of different PMR settings. The results show that PMR=0 can achieve best throughput in various path failure or non-failure situations. The authors of [8] proposed an analytical model for evaluating the performance of SCTP multi-homing. The authors of [9] investigate SCTP's throughput performance in different path scenarios and proposed a change to the protocol's heartbeat mechanism to improve the performance. The effect of path delay on SCTP performance was studied in [10]. [11] indicates that retransmission of all data on the same path with the path failure detection threshold set to one or zero gives the most stable performance in all path configurations.

However, all of above researches focus on the performance of "FTP over SCTP". This paper will focus on real-time multimedia transmission performance over SCTP.

III. EVALVID-SCTP

With the increasing deployment of real-time applications over wireless networks, end-to-end delay and packet loss are vital QoS requirements for these applications. In order to investigate the behavior and quality of such applications under heavy network load, it is therefore necessary to create genuine traffic patterns, both at network/transport layer and application. To setup true multimedia test networks is very expensive and of little flexibility. Thus, networking simulations, using tools like the ns-2 seem tempting. A local simulation environment enables the researcher to build customized effective networks at a low cost.

In recent years, papers have been published on the topic of the simulation of multimedia. In paper [12], MPEG-4 trace files are used to calibrate a TES (Transform Expand Sample) mathematical model, and rate adaptation is incorporated by adjusting the frame size output by a scalar (from rate-distortion curve). H.263 video trace files are used in [13], and the sending rate is controlled by DCCP TCP-like. In [14] models are derived for pre-recorded media streaming over TFRC and compared to simulations. The models focus on the impact of the TFRC rate changes to the probability of rebuffering events, i.e. events where the receive buffer is emptied.

In our previous work [15], we designed a platform called Evalvid-SCTP. It gives a good solution for MPEG-4 video transmission simulation over SCTP in ns-2, it based on the modifications of Evalvid [16] and Delaware University's SCTP module [17] for ns-2 [18][19]. As figure 1 shows, the framework of Evalvid-SCTP has three processes namely, pre-process, ns-2 simulation and post-process. In pre-process, the original YUV format video is compressed into MPEG-4 format video, and a MPEG-4 video trace file is generated which includes information about each frame (I-frame, P-frame, B-frame) in the video. In the ns-2 simulation, the Agent SCTPTrafficeTrace which we designed sends data to SCTP network following the video trace file; the enhanced SctpAgent produces the sending trace file including sending time, packet type, packet id, size. It also produces the receiving trace file including receiving time, packet type, packet id and size. With those information, in the post-process phase, the target video is reconstructed and converted in to raw video (YUV), then the video quality evaluation can be given by the calculation of PSNR or MOS. Please see [14] for more detail.

IV. Simulation-based Assessment

A. Simulation Setup

The simulations in this section consider different network path conditions. The simulation topology is shown in figure 2 and includes node S and node R which are the SCTP sender and receiver respectively. Both SCTP endpoints have two addresses. $R_{1,1}$, $R_{1,2}$, $R_{2,1}$ and $R_{2,2}$ are routers. The implementation is configured with no overlap between the two paths. The MTU (Maximum Transmission Unit) of each path is 1500B. The queue length of bottleneck links in both paths is 50 packets. The queue length of other links is set to 10000 packets.

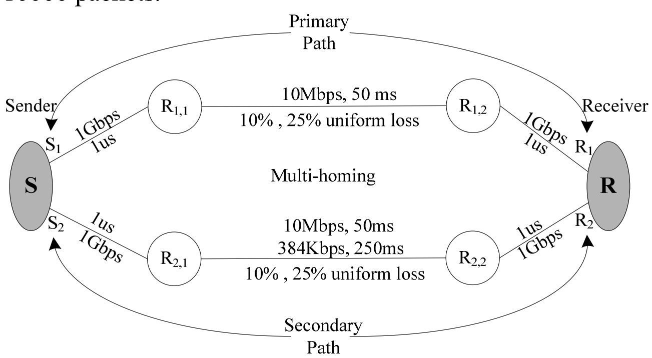


Figure 2. Simulation network topology

The SCTP parameters are the default ones [1]. The initial slow start threshold is set large enough to ensure that the full primary path bandwidth is used. SCTP is set as PR-SCTP, only one SCTP stream is used and the data is delivered to the upper layer in order. For simulations with an infinite receive buffer, the receiver window (rwnd) is set to 100 MB as this size is larger than the data size transmitted by the sender. Based on the work of [11], we set the retransmission of all data on the same path as the default retransmission policy when the level of reliability is more than 0. Network congestion is simulated by varying the path loss rate.

A YUV video sequence is used with a QCIF format (resolution 176x144 pixels) and 2000 frames. After pre-processing in Evalvid-SCTP, a MPEG-4 video trace file is produced. In ns-2 node S sends data following this video trace file at 30 frames/sec to node R. The simulation stops after S finishes sending frames. 10 random seeds are used for simulation and testing results are calculated by averaging the results of 10 runs.

B. Symmetric Path Conditions

This section studies the performance of PMR settings and reliability level in symmetric path conditions. In the simulations, wireless link parameters are used as the references for network configurations. A computing node has two WiFi connections and an infinite buffer. The bandwidth of both bottleneck links is set as 10Mbps. The delays on the primary and secondary path are 50ms, and the paths loss rates are set to 20%, 25%. Aggressive failover settings (PMR=0) and less aggressive failover settings (PMR=1) are set respectively. The results for PMR=2, 3, 4, 5 are not shown in this paper. One reason for this omission is that the path failure detection time is long, another reason is that the data transmission time for PMR>0 is similar.

Table I, II, III show the comparison results of average PSNR (dB) values and the numbers of different dropped frames (I-frame/P-frame/B-frame), which employed different level of reliability with path failure detection threshold set to 0 and 1 respectively. As the table show, with the increasing path loss rate the average PSNR decreases and the number of dropped frames increase in all cases. Figure 3 shows the corresponding PSNR values frame-by-frame (only the last 1500 frames are shown). As the tables and figures illustrate that in most cases, with both of path failure detection threshold setting to zero and reliability level setting to smaller value gives better performance. With increasing reliability level, it runs more unstably, such as the quality of the case with setting PMR=1, loss rate=20%, reliability level=2 becomes to be very bad suddenly after the frame around 1250.

TABLE I. Reliability level=0

PMR	Path loss rate	Average PSNR (dB)	Dropped frames		
			I	*P*	*B*
0	20%	35.24	8	15	44
1	20%	33.59	32	63	188
0	25%	32.43	49	98	292
1	25%	31.68	61	123	366

TABLE II. Reliability level=1

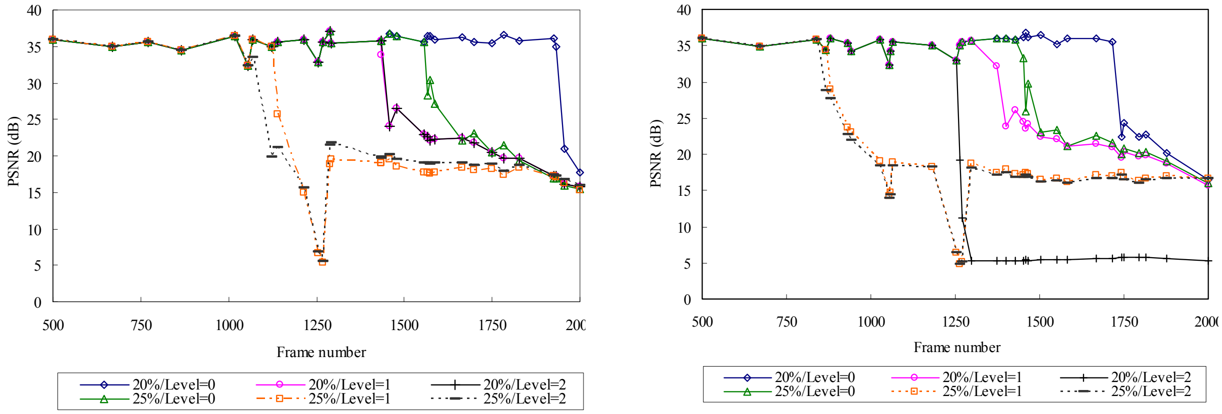
PMR	Path loss rate	Average PSNR (dB)	Dropped frames		
			I	*P*	*B*
0	20%	31.60	63	123	376
1	20%	31.08	70	139	418
0	25%	27.97	97	194	581
1	25%	25.63	125	249	746

TABLE III. Reliability level=2

PMR	Path loss rate	Average PSNR (dB)	Dropped frames		
			I	*P*	*B*
0	20%	31.60	63	125	374
1	20%	24.61	126	253	757
0	25%	27.83	82	164	490
1	25%	25.34	104	207	621

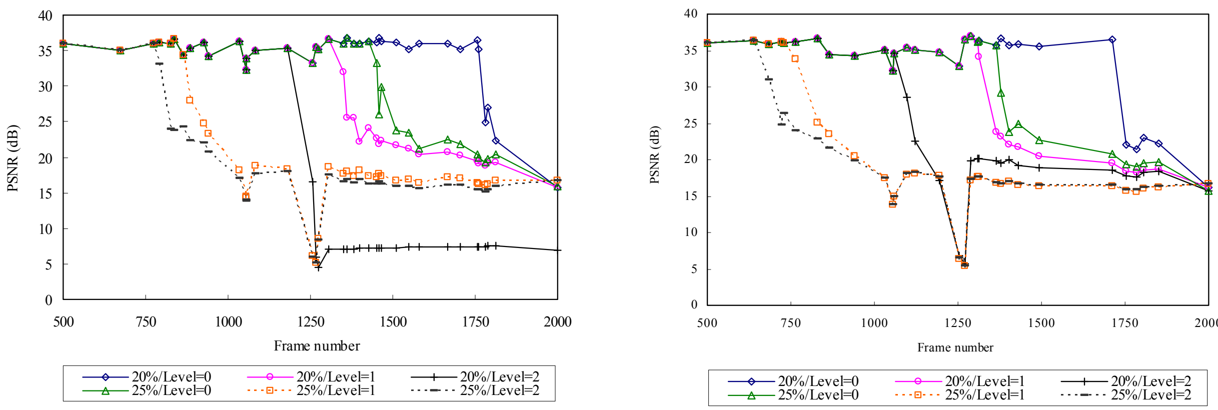
C. Asymmetric Path Conditions

This section studies the performance of PMR settings and reliability level in asymmetric path conditions. A computing



(a) PMR=0 (b) PMR=1

Figure 3. PSNR (dB) for symmetric path conditions (primary path: 10Mbps & 50ms; secondary path: 10Mbps & 50ms; paths loss rate change with 20%, 25%)



(a) PMR=0 (b) PMR=1

Figure 4. PSNR (dB) for asymmetric path conditions (primary path: 10Mbps & 50ms; secondary path: 384Kbps & 250ms; paths loss rate change with 20%, 25%)

node has a hybrid of WiFi, 3G connections and an infinite buffer. The primary path bandwidth is 10Mbps and the secondary path bandwidth is 384Kbps. The delay on the primary path is 50ms, the delay of secondary path is 250ms, and the loss rates of both paths are set to 20%, 25% respectively. Other settings are the same as for previous tests.

Table IV, V, VI illustrate the comparison results for average PSNR (dB) values as well as dropped frames (I-frame/P-frame/B-frame), for different level of reliability with PMR 0, 1 respectively. Figure 4 shows the corresponding PSNR values frame-by-frame (only the last 1500 frames are shown). As the tables and figures show, with the increasing of path loss rate the PSNR decreases and the number of dropped frames increase in all the cases. The total average video quality degrades compared with symmetric path conditions. In most cases however, it has the same results with the first scenario that with path failure detection threshold setting to zero and reliability level setting to smaller value performs better than other configurations.

TABLE IV. RELIABILITY LEVEL=0

PMR	Path loss rate	Average PSNR (dB)	Dropped frames		
			I	*P*	*B*
0	20%	33.83	27	53	158
1	20%	33.55	32	65	192
0	25%	31.68	61	123	366
1	25%	30.92	71	142	424

TABLE V. RELIABILITY LEVEL=1

PMR	Path loss rate	Average PSNR (dB)	Dropped frames		
			I	*P*	*B*
0	20%	30.71	72	145	432
1	20%	30.27	77	153	458
0	25%	25.71	124	248	742
1	25%	24.67	138	275	842

TABLE VI. RELIABILITY LEVEL=2

PMR	Path loss rate	Average PSNR (dB)	Dropped frames		
			I	*P*	*B*
0	20%	25.11	83	166	496
1	20%	27.83	101	201	602
0	25%	24.70	135	269	806
1	25%	24.08	146	293	877

D. Analysis of the Results

The test results illustrate that in most cases, with both of path failure detection threshold setting to zero and reliability level setting to smaller value performs better in the two scenarios. As we know, less aggressive failover (PMR = 1) cause a sender to wait longer before sending new data to the primary destination, however, the underlying advantage of aggressive failover (PMR=0) is that handover occurs with less time blocked during failure detection. With PMR=0, a single timeout migrate new data transmission to the alternate path quickly while the primary destination is probed with heartbeats. The primary destination may respond on the first probe, or it may not respond for a long time. In either case, data transmission continues on the alternate path. Though aggressive failover setting could increase the possibility of spurious failover where a small number of lost packets are interpreted to mean that the destination address is no longer reachable and sender mistakenly concludes a failure has occurred, the alternate path conditions are not bad in the two scenarios, which avoid negative impacts by unnecessary failovers. So the two scenarios with PMR=0 are actually concurrent multi-path transmissions, then they achieve better performance. The results show that with increasing level of reliability, in most cases, the video quality degrades and is unstable. It is because with higher partial reliability thresholds, the number of consecutive timeouts would be high via the timeout retransmission, then the excessive reliability of the retransmission of missing data could be the bottleneck for the guarantee of a desired frame rate. For real-time video, sometimes it is necessary to drop a few missing packets, instead of waiting for them to be retransmitted, because they are no longer needed for the stream.

V. CONCLUSIONS

The growing availability of different wireless access technologies provides the opportunity for real-time distribution of multimedia content using multi-homing technology. In this paper, we analyse the real-time multimedia transmission performance over multi-homing transport protocols utilizing network failure tolerant mechanisms. In particular, we focus on the extension of SCTP, Partial Reliable Stream Control Transmission Protocol (PR-SCTP). Different reliability level was evaluated using a number of path failure detection threshold values in symmetric and asymmetric path conditions respectively. Uniform loss is used to simulate network congestion. The simulation results indicate that with path failure detection threshold setting to zero and PR-SCTP's reliability level setting to smaller value performs better for real-time video transfer.

REFERENCES

[1] R. Stewart, Q. Xie, K. Morneault, C. Sharp, H. Schwarzbauer, T.Taylor, "Stream Control Transmission Protocol," IETF RFC 2960, October 2000.

[2] R. Stewart, Q. Xie, M. Tuexen, S. Maruyama, M. Kozuka, "Stream Control Transmission Protocol (SCTP) Dynamic Address Reconfiguration," IETF draft, April 2007, draft-ietft-tsvwg-addip-sctp-20.txt, draft-ietf-tsvwg-addip-sctp-15.txt.

[3] M. Riegel, M. Tuexen, "Mobile SCTP," IETF Draft, July 2005, draft-riegel-tuexen-mobile-sctp-05.txt.

[4] A. Dutta, S. Das, D. Famolari, Y.Ohba, K. Taniuchi, T. Kodama, H. Schulzrinne, "Seamless Handoff across Heterogeneous Networks - An 802.21 Centric Approach," Proc. of IEEE WPMC 2005, Aalborg Denmark, September 2005.

[5] R. Stewart, M. Ramalho, Q. Xie, M. Tuexen, and P. Conrad, "Stream Control Transmission Protocol (SCTP) Partial Reliability Extension," IETF RFC 3758, May 2004.

[6] A. Caro, P. Amer, R. Stewart, "Retransmission Policies for Multihomed Transport Protocols," Computer Communications, June 2006, 29, (10), pp. 1798–1810.

[7] A. Caro, P. Amer, R. Stewart, "Rethinking End-to-End Failover with Transport Layer Multihoming," Annals of Telecommunications, 2006, 61, (1-2), pp 92-114.

[8] S. J. Fu, M. Atiquzzaman, "Performance modeling of SCTP multihoming," Proc. of IEEE GLOBECOM '05, Nov. 2005.

[9] race, K.H., Pecelli, D., Amelia, J.D.: Improving Multi-homed SCTP Mobile Communication Performance. Technical Papers, The MITRE Corporation, 2006.

[10] Y. Qiao, E. Fallon, L. Murphy, J. Murphy, A. Hanley, X. Zhu, A. Matthews, A. Conway, "SCTP Performance Issue on Path Delay Differential," Proc. of WWIC 2007, LNCS 4517, Coimbra Portugal, May 2007, pp 43-54.

[11] Y. Qiao, E. Fallon, L. Murphy, J. Murphy, A. Hanley, X. Zhu, A. Matthews, A. Conway, "Performance Analysis of Multi-homed Transport Protocols with Network Failure Tolerance," IET Communications, 5(2), 336–345, 2007

[12] C. H. Liew, C. Kodikara, A. M. Kondoz, "Modelling of MPEG-4 Encoded VBR Video Traffic," IEE Electronic Letters, vol. 40, no. 5, March 2004.

[13] C. Xu, J. Liu, and C. Zhao, "Performance analysis of transmitting H.263 over DCCP," Proc. of IEEE Int. Workshop VLSI Design and Video Technology, May 2005.

[14] L. Xu and J. Helzer, "Media Streaming via TFRC: An Analytical Study of the Impact of TFRC on User-Perceived Media Quality," Proc. of IEEE Infocom, March 2006.

[15] C. Xu, Y. Q, E. Fallon, G.-M. Muntean, P. Jacob, A. Hanley, "Comparative Study of Real-Time Multimedia Transmission over Multihoming Transport Protocols," Proc. of 11th IFIP/IEEE International Conference on Management of Multimedia and Mobile Networks and Services (MMNS), Springer LNCS, September 2008: 64-76.

[16] J. Klaue, B. Rathke, A. Wolisz, "Evalvid - A Framework for Video Transmission and Quality Evaluation," Proc. of the 13th International Conference on Modelling Techniques and Tools for Computer Performance Evaluation, Urbana, Illinois, USA, Sept. 2003.

[17] A. Caro, J. Iyengar, "ns-2 SCTP module," Version 3.5, http://www.armandocaro.net/ software/ns2sctp/.

[18] UC Berkeley, LBL, USC/ISI, and Xerox Parc, "ns-2 documentation and software," Version 2.29, October 2005, http://www.isi.edu/nsnam/ns.

[19] Ke, C.H.: How to evaluate MPEG video transmission using the NS2 simulator. [Online], http://hpds.ee.ncku.edu.tw/smallko/ns2/Evalvid in NS2.htm