



WAN CLOUD ACCESS LINK UTILIZATIONS FOR COMPRESSED VIDEO

¹P.Nageswararao, ²Dr.I.Ramesh Babu, ³K.Gouthami

¹Professor, NIET, Guntur, INIDA

²Professor, ANU, Guntur, INDIA

³Asso.professor, NIET, Guntur, INDIA

E-mail: pnrao33@yahoo.com, gowtami_paruchuri@yahoo.com

ABSTRACT

There are a number of different video compression standards. Most of them are variations of the work of two different committees. The International Telephony Union's Specialist Group on Coding for Visual Telephony and the International Standards Organization's motion picture expert group, known as MPEG. The most popular standards are the ISO's MPEG-2 and the ITU's H.261. MPEG-2 has been chosen to simulate video application. We study link utilization, WAN clouds, and message sources for compressed data and uncompressed data. The study includes Video application. The bandwidth used for simulation runs depends on the type of application under study. The bandwidth is divided into five percentages, 50%, 60%, 70%, 80%, and 90% (traffic intensity) for the purpose of study.

Keywords: *Wan clouds, MPEG2, Link Utilizations,*

1. HISTORICAL VIEW

WAN Cloud is available in COMNET III for modeling WAN services in terms of Access Links and Virtual Circuits (VCs). WAN Clouds are used to model frame relay, cell relay, and packet switching services. WAN Cloud behaves similarly to the link objects in that it delivers frames and models a delay of these frames across the network. The cloud's internal structure is defined using Access Links and VCs. VCs are abstract models of sets of switches and links and connect to Access Links only. The Access Link is a special case of a Point-To-Point link that works with the WAN Cloud. They provide the point-of-presence to the WAN cloud. Outside the WAN Cloud (backbone) the connection between a processing node and the WAN Cloud is through an Access Point. An Access Point represents an Access Link in the cloud.

2. WAN CLOUDS

We have three types in WAN clouds:

(1) **Frame Delay by VC;** (2) **Frame Counts by VC;** and (3) **Access Link Statistics at Entry and Exit.**

Access Link Statistics

The access link statistics are data/statistics for each access link in a WAN cloud. Each access link has two rows: the first

is for the entry (source) link and the second is for exit (destination) link. No buffer is modeled for the entry link. Hence, those values are N/A.

Access Link

Is the name of the access link in the WAN cloud. Each access link has entry and exit rows.

- **Frames Accepted**

The number of frames accepted by the entry and exit access link of the WAN cloud. For entry link, this count reflects the frames that found a path to the required destination. If a frame arrives that must go to a destination for which no virtual circuit is defined and the cloud does not allow transmission through non-VCs, then that frame will count as being dropped by the entry access link even though that frame's transmission will have utilized the link.

- **Frames Dropped**

The number of frames dropped by the entry and exit access links of the WAN cloud. For exit links, the count reflects the number of frames accepted or blocked by the exit buffer.

- **Utilization %**

The entry and exit access link utilization in terms of percentage. The utilization is time-averaged over the replication, where at each event, the utilization is the number of busy



circuits divided by the total number of circuits.

We have three categories in links: (1) **Channel Utilization**; (2) **Utilization by Application**; and (3) **Utilization by Protocol**.
Channel Utilization

The channel utilization provides the breakdown of the utilization rates for links used to carry connectionless and VC messages. It presents the number of link layer frames delivered and resent due to error (rst/err), and transmission delays and link utilization.

We have three categories in sources: (1) **Message Delay**; (2) **Messages Delivered**; and (3) **Packet Delay**.

Packet Delay

The Packet Delay data are a summary of the number of packets created, delivered, resent, or dropped for each message and response source. It also provides the average and maximum packet delay. Packet Delay is the time between creating a packet on the originating node and the time of receiving the packet at the destination node.

- **Packets Created:** The number of packets created to send to the destinations listed in the message sources.
- **Packets Delivered:** the number of packets received at the destination. This may differ from the number of packets created by the number of packets that are in transit at the instant the report is written.
- **Packets Dropped:** The number of packets dropped, when a node or link fails.

3. WAN Clouds: Access Link Statistics Analysis

Tables 1,2,3, and **4** present statistics for compressed and uncompressed data for 7 access links: (1) Calcutta-Hyderabad (2) Calcutta-Mumbai, (3) Calcutta-Bangalore (4) Calcutta-Jaypur, (5) Hyderabad-Delhi (6) Calcutta-Delhi and (7) Hyderabad-Mumbai. Only three links are chosen for analysis to demonstrate the pattern of variation over access links.

• **Compressed Data**

The numbers of frames accepted by Calcutta-Hyderabad access link are 15991, 19597, 20839, 26006, and 26068 at 50%, 60%, 70%, 80%, and 90% bandwidths, as shown in **Figure 1**. The number of dropped frames at each bandwidth percentage is 1868 at 50%, 2082 at 60%, 2421 at 70%, 2818 at 80% and 2835 at

90%, as shown in **Figure 2**. The numbers of frames accepted and dropped by the link show that the increase from one bandwidth to another is upward and the slope is positive. The drop rate is 12%, 11%, 12%, 11%, and 11% for all five different bandwidth simulation runs, respectively Calcutta-Jaypur access link accepted 13451 frames at 50% and 19391 frames at 60%, and 26330 frames at 70% bandwidths. At 80% the number of frames accepted by the link went down to 20722, a decrease of 21%. The number of frames accepted at 90% went up to 27893, an increase of 35%. The number of dropped frames at each bandwidth percentage is 1509 at 50%, 2261 at 60%, 2952 at 70%, 2300 at 80% and 3146 at 90%. The drop rate is 11%, 12%, 11%, 11%, and 11% for all five different bandwidth simulation runs, respectively.

The numbers of frames accepted by Hyderabad-Mumbai access link for compressed data at different bandwidth simulation runs are 17664, 21076, 25852, 22544, and 23406. The number of accepted frames decreases at 80% by nearly 13% and again increases at 90% by 4%. The number of dropped frames at each bandwidth percentage is 2047 at 50%, 2436 at 60%, 2896 at 70%, 2540 at 80% and 2624 at 90%. The drop rate ranges from 11% to 12%.

• **Uncompressed Data**

The number of frames accepted by Calcutta-Hyderabad link is 20839, 26006, 29989, 31754, and 30578, as presented in **Table 3**. From 50% to 80% bandwidths, the numbers indicate that the increase is linear. However, at 90% the number of frames accepted by the link goes down to 30578, a decrease of 4%. The number of dropped frames at each bandwidth percentage is 2421 at 50%, 2818 at 60%, 3350 at 70%, 3408 at 80% and 3385 at 90%. At 90% the number of frames dropped decreases by 0.7%. The drop rate is 12%, 11%, 11%, 11%, and 11% for all five different bandwidth simulation runs, respectively. **Figures 1** and **2** depict the number of frames accepted and dropped, respectively.

The numbers of frames accepted by Calcutta-Jaypur access link are 26330, 20722, 27937, 30265, and 32306 at 50%, 60%, 70%, 80%, and 90% bandwidth simulation runs, respectively. These numbers indicate that at 60% the number of frames accepted by the link decreases by 21%. From 70% to 90% the increase is upward. The number of dropped frames at each bandwidth percentage is 2952 at 50%, 2300 at 60%, 3105 at 70%, 3397 at 80%



and 3540 at 90%. At 60% the number of frames dropped by the link decreases by 22%. The drop rate is 11% for all five different bandwidth simulation runs.

The numbers of frames accepted by Hyderabad -Mumbai access link for uncompressed data at different bandwidth simulation runs are 25852, 22544, 20389, 32888, and 30344. We observe that at 60% and 70% the number of frames accepted by the link decreases by approximately 13% and 10%, respectively. At 80% there is an increase of 61% and a decrease of 8% at 90%. The number of dropped frames at each bandwidth percentage is 2896 at 50%, 2540 at 60%, 2266 at 70%, 3687 at 80% and 3471 at 90%. The decrease is 12% and 11% at 60% and 70% bandwidths, respectively. The drop rate is 11% for all five different bandwidth simulation runs.

4. Comparison of Frames-Dropped

The drop rate of compressed and uncompressed data and their differences are shown in **Table 5**. Also shown in the table is the comparison of the link utilization rate for both data types.

The drop rate of Calcutta-Hyderabad access link at 50% bandwidth for compressed data is equal to that of uncompressed data, 12%. Similarly, the drop rates are equal for the remaining bandwidth percentages, 60%-90%. The link utilization rate for compressed data for all bandwidths is less than for uncompressed data.

The drop rate of Calcutta-Jaypur access link at 50%, 70%-90% bandwidths for compressed and uncompressed data is 11%. The difference between the two is 0. At 60% bandwidth the difference is 1%. These differences are well within the margin of error, $\pm 5\%$. The link utilization rate for compressed data is 32.50%, 46.87%, 63.60%, 50.01% and 67.42% at 50%-90% bandwidths. The link utilization for uncompressed data is 63.60%, 50.01%, 67.43%, 73.11% and 77.85% at 50%-90% bandwidths. We note that the link utilization rate of uncompressed data at 50% and 60% bandwidths is equal to that of compressed data at 70% and 80% bandwidths, respectively. Clearly, the link utilization rate for compressed data is less than for uncompressed data.

The drop rate of Hyderabad-Mumbai access link of compressed and uncompressed data is approximately 11%. The link utilization rate overall for compressed data is less than that of uncompressed data with one exception- at 70% bandwidth This demonstrates that while the drop rate is more or less the same for both compressed and uncompressed data, compressing data has a clear and substantive advantage in terms of the link utilization rate. Thus, data compression allows for transmission of substantially larger volume of data in shorter intervals.

Uncompressed Data

Calcutta-Mumbai, origin node, created 19980, 29100, 35100, 33600, and 41280 to send to Calcutta-Delhi, destination node, at 50%, 60%, 70%, 80%, and 90% bandwidth, respectively. The number of packets created increases from 50% to 70% bandwidths linearly, decreases at 80% by 4%, and at 90% bandwidth increases by 23%. The number of packets delivered at the destination is 6572, 6095, 8910, 6306, and 7488 at the five simulation runs, respectively. These numbers show a decrease from 6572 packets delivered at 50% to 6095 packets delivered at 60%, a decrease of 7%. This shows that the number of packets delivered oscillates over the range of the bandwidths. And the number of packets dropped is 2648, 5263, 8200, 7680, and 10575 at 50%, 60%, 70%, 80%, and 90% bandwidths, respectively. The average packet delay (in milliseconds) increases from 50% bandwidth to 70% bandwidth, decreases at 80%, and again increases at 90%.

5. Comparison of Compressed and Uncompressed Data

The number of packets created for compressed data is nearly 3% more at 50% bandwidth (20580/19980) than that of uncompressed data and less for the rest of the simulation runs, as shown in **Table 6**. The number of packets delivered also is about 2% more at 50% (8382/6572) and 1% more at 60% (6162/6095) bandwidths. And at 70%-90% bandwidths the number of packets delivered is less (6572/8910, 6095/6306, 5385/7488). The number of packets dropped is more at 50% and less for 60%-90% simulation runs. The ratio of packets dropped over packets delivered (packets dropped/packets delivered) is 37% (3061/8382), 42% (2583/6162), 40% (2648/6572), 86% (5263/6095), and 87% (4690/5385) for compressed data and it is 40% (2648/6572), 86%



(5263/6095), 92% (8200/8910), 122% (7680/6306), and 141% (7488/10575) for uncompressed data. We see high percentages at 60%-90% bandwidths for uncompressed data. This can be attributed to network saturation. The average packet delay (in milliseconds) for compressed data is less than for uncompressed data for all 5 bandwidth simulation runs.

Compressed Data

Delhi-Hyderabad, origin node, created packets 15000, 24180, 24120, 20820, and 36540 to send to Hyderabad-Mumbai, destination node, at 50%, 60%, 70%, 80%, and 90% bandwidths, respectively. The number of packets delivered at the destination is 5290, 7339, 5859, 5591, and 5199 at the five simulation runs, respectively. And the number of packets dropped similarly is 2096, 5070, 3391, 3019, and 10755. The number of packets created decreases at 70% and 80% bandwidths and increases at 90%. But, the number of packets delivered decreases linearly from 60% to 90% bandwidths. The number of packets dropped by the network decreases at 70% and 80% bandwidths and increases at 90%. The average packet delay (in milliseconds) increases linearly from 50% to 70%, decreases at 80%, and again increases at 90% bandwidths

Uncompressed Data

Delhi-Hyderabad, origin node, created 24120, 20820, 25980, 34440, and 39060 to send to Hyderabad-Mumbai, destination node, at 50%, 60%, 70%, 80%, and 90% bandwidths, respectively. The number of packets delivered at the destination is 5859, 5591, 4981, 4806, and 6078 at the five simulation runs, respectively. And the number of packets dropped similarly is 3391, 3019, 4544, 5449, and 8019. The number of packets created by the origin node decreases at 60% bandwidth and increases linearly from 60% to 90% bandwidths. The ratio of packets dropped over packets delivered is 58% (3391/5859), 54% (3019/5591), 91% (4544/4981), 113% (5449/4806), and 132% (8019/6078) at 50%-90% bandwidths. The average packet delay (in milliseconds) decreases linearly from 50% to 80% and increases at 90% bandwidth.

6. CONCLUSION

The number of packets created for compressed data is more than for uncompressed

data at 60% bandwidth (24180/20820) and less for the rest of the simulation runs than for uncompressed data. However, for compressed data the number packets delivered is more for 60%-80% bandwidths (7339/5591, 5859/4981 and 5591/4806). The number of packets dropped for compressed data is more than for uncompressed data at 60% and 90% bandwidths (5070/3019, 10755/8019) and less for the rest of the simulation runs. The ratio of packets dropped over packets delivered (packets dropped/packets delivered) is 40%, 69%, 58%, 54%, and 207% for compressed data and for uncompressed data it is 58%, 54%, 91%, 113%, and 132%. We observe that the ratio of packets dropped over packets delivered is more at 60% and 90% bandwidths for compressed data than for uncompressed data.

REFERENCES

- [1] Ahamed, Syed V. and Lawrence, Victor B (1997). **Intelligent Broadband Multimedia Networks**. Norwell MA, Kluwer Academic Pub.
- [2] Cooperman, Michael, Paige, A., and Sieber Richard W. (1989). **"Broadband Video Switching."** IEEE Communications, vol.27, no.12, pp.26-30.
- [3] Cutler, C.C. **Differential Quantization for Television Signals**. U.S. Patent 2.605.361 July 29, 1952.
- [4] Falkner, Matt (1984). **Modeling ATM Networks with COMNET III**. Version, 1.0, August 30, 1996, CACI.
- [5] Garzia (1999). **Network Modeling Simulation & Analysis**. Electrical Engineering & Electronics Series, vol.61.
- [6] Gibson, Jerry D. [et al.] (1998). **Digital Compression for Multimedia: Principles and Standards**. San Francisco, CA, Morgan Kaufmann Pub
- [7] Held, Gilbert (1983). **Data Compression**. New York, John Wiley & Sons.
- [8] Huffman, D.A. (1983). **A Method for the Construction of Minimum Redundancy Codes**, Proceedings of the IRE, 40:1098-1101, 1951.
- [9] Jahne, Bernd (1993). **Digital Image Processing: Concepts, Algorithms and Scientific Applications**. 2nd ed. New York, Springer-Verlag.



- [10] Kohli, Jagdish (1989). **“Medical Imaging Applications of Emerging Broadband Networks.”** IEEE Communications, vol.27, no.12, pp.8-16.
- [11] Kou, Weidong (2001). **Digital Image Compression: Algorithms and Standards.** Norwell, MA, Kluwer Academic Pub.
- [12] Law, A.M. and Kelton, W.D. (1982). **Simulation Modeling and Analysis.** New York, McGraw-Hill.
- [13] Lelewer, D.A. and Hirschberg, D.S. (1987). **Data Compression.** ACM Computing Surveys, 19:261-296, September 1987.
- [14] Miano, John (1999). **Compressed Image File Formats: JPEG, PNG, GIF, XMB, BMP.** New York, ACM Press.
- [15] Sayood, Khalid (1996). **Introduction to Data Compression.** San Francisco, CA, Morgan Kaufmann Pub.
- [16] Watkinson, John (1999) **MPEG-2.** Boston, MA, Focal Press.
- [17] Ziv, J. & Lempel, A. (1977). **A Universal Algorithm for Data Compression,** IEEE Transactions on Information Theory, IT-23(3): 337-343, May. 1977.

Compressed Data Access Link	Frames Accepted				
	50%	60%	70%	80%	90%
Calcutta-Hyderabad	15991	19597	20839	26006	26068
Calcutta-Mumbai	18087	16232	17445	24557	21890
Calcutta-Bangalore	15997	18008	21389	22348	24771
Calcutta-Jaypur	13451	19319	26330	20722	27893
Hyderabad-Delhi	13645	19896	21419	19019	26403
Calcutta-Delhi	13742	21568	24325	24139	25574
Hyderabad-Mumbai	17664	21076	25852	22544	23406

Table 1: Video - WAN Cloud Access Link Statistics: Frames Accepted (Compressed Data)

Compressed Data Access Link	Frames Dropped				
	50%	60%	70%	80%	90%
Calcutta-Hyderabad	1868	2082	2421	2818	2835
Calcutta-Mumbai	2097	1905	1939	2816	2311
Calcutta-Bangalore	1763	2052	2430	2530	2733
Calcutta-Jaypur	1509	2261	2952	2300	3146
Hyderabad-Delhi	1498	2282	2380	2164	3092
Calcutta-Delhi	1490	2334	2673	2693	2854
Hyderabad-Mumbai	2047	2436	2896	2540	2624

Table 2: Video - WAN Cloud Access Link Statistics: Frames Dropped



(Compressed Data)

Uncompressed Data Access Link	Frames Accepted				
	50%	60%	70%	80%	90%
Calcutta-Hyderabad	20839	26006	29989	31754	30578
Calcutta-Mumbai	17445	24557	27570	26608	31898
Calcutta-Bangalore	21389	22348	26344	28334	28380
Calcutta-Jaypur	26330	20722	27937	30265	32306
Hyderabad-Delhi	21419	19019	21968	28808	31785
Calcutta-Delhi	24325	24139	29207	30481	34164
Hyderabad-Mumbai	25852	22544	20389	32888	30344

Table 3: Video - WAN Cloud Access Link Statistics: Frames Accepted (Uncompressed Data)

Uncompressed Data Access Link	Frames Dropped				
	50%	60%	70%	80%	90%
Calcutta-Hyderabad	2421	2818	3350	3408	3385
Calcutta-Mumbai	1939	2816	3170	3030	3500
Calcutta-Bangalore	2430	2530	2880	3190	3052
Calcutta-Jaypur	2952	2300	3105	3397	3540
Hyderabad-Delhi	2380	2164	2492	3246	3514
Calcutta-Delhi	2673	2693	3261	3400	3896
Hyderabad-Mumbai	2896	2540	2266	3687	3471

Table 4: Video - WAN Cloud Access Link Statistics: Frames Dropped (Uncompressed Data)

Figure 1: Video- Selected Access Link: Calcutta-Hyderabad (Frames Accepted)

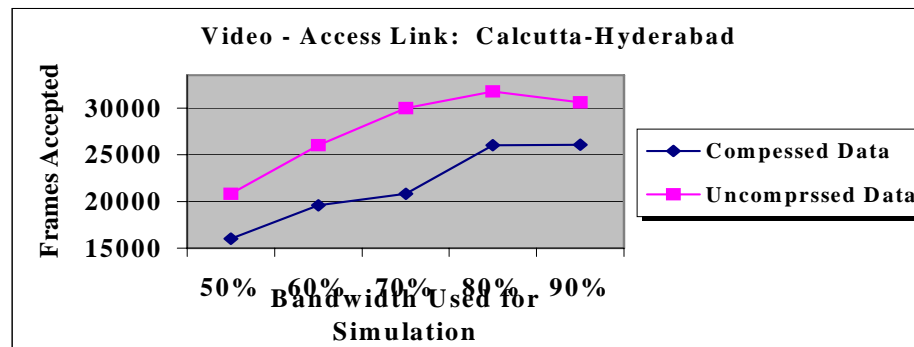
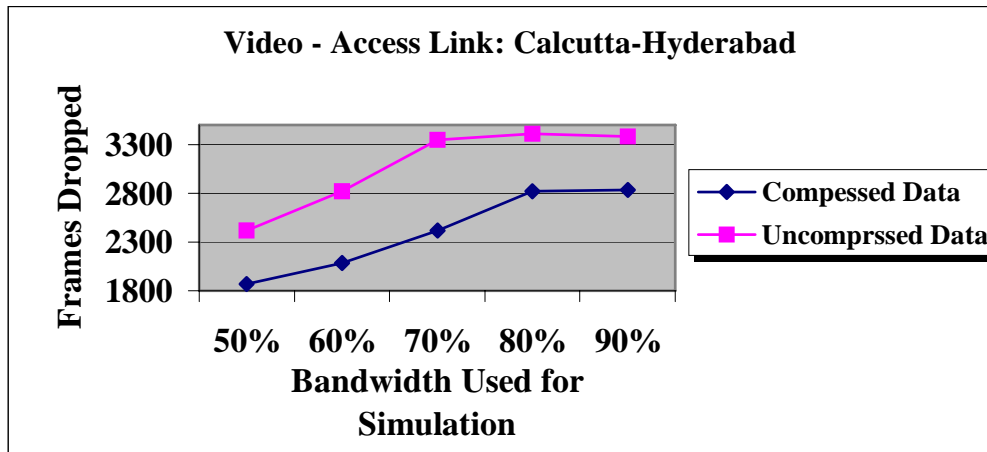




Figure 1: Video– Selected Access Link: Calcutta-Hyderabad (Frames Dropped)



Video (OC-9)	WAN CLOUDS: ACCESS LINK STATS (ENTRY)									
MPEG-2(30%)	Comparison of Compressed & Uncompressed Video Data									
Message Size: 3.8MB	Frames Accepted/Dropped/Utilization									
Cloud: Access Link	Cmp 50%	Uncmp 50%	Cmp 60%	Uncmp 60%	Cmp 70%	Uncmp 70%	Cmp 80%	Uncmp 80%	Cmp 90%	Uncmp 90%
Calcutta-Hyderabad										
Frames Accepted	15991	20839	19597	26006	20839	29989	26006	31754	26068	30578
Frames Dropped	1868	2421	2082	2818	2421	3350	2818	3408	2835	3385
Drop Rate	0.1168	0.11617	0.1062	0.10835	0.1161	0.11170	0.1083	0.10732	0.1087	0.11070
Drop Rate (%)	12%	12%	11%	11%	12%	11%	11%	11%	11%	11%
Difference	0%		-0%		0%		0%		-0%	
Link Utilization (%)	38.80	50.52	47.10	62.61	50.52	72.42	62.61	76.36	62.78	73.76
Calcutta-Mumbai										
Frames Accepted	18087	17445	16232	24557	17445	27570	24557	26608	21890	31898
Frames Dropped	2097	1939	1905	2816	1939	3170	2816	3030	2311	3500
Drop Rate	0.1159	0.11114	0.1173	0.11467	0.1111	0.11498	0.1146	0.11387	0.1055	0.10972
Drop Rate (%)	12%	11%	12%	11%	11%	11%	11%	11%	11%	11%
Difference	0%		0%		-0%		0%		-0%	
Link Utilization (%)	43.85	42.11	39.40	59.46	42.11	66.76	59.46	64.37	52.57	76.89
Video (OC-9)	Frames Accepted/Dropped/Utilization (Cont'd.)									
Cloud: Access Link	Cmp 50%	Uncmp 50%	Cmp 60%	Uncmp 60%	Cmp 70%	Uncmp 70%	Cmp 80%	Uncmp 80%	Cmp 90%	Uncmp 90%
Calcutta-Bangalore										
Frames Accepted	15997	21389	18008	22348	21389	26344	22348	28334	24771	28380
Frames Dropped	1763	2430	2052	2530	2430	2880	2530	3190	2733	3052



Drop Rate	0.1102	0.11360	0.1139	0.11320	0.1136	0.10932	0.1132	0.11258	0.1103	0.10754
Drop Rate (%)	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
Difference	-0%		0%		0%		0%		0%	
Link Utilization (%)	38.58	51.74	43.57	54.04	51.74	63.47	54.04	68.47	59.74	68.27
Calcutta-Jaypur										
Frames Accepted	13451	26330	19319	20722	26330	27937	20722	30265	27893	32306
Frames Dropped	1509	2952	2261	2300	2952	3105	2300	3397	3146	3540
Drop Rate	0.1121	0.11211	0.1170	0.11099	0.1121	0.11114	0.1109	0.11224	0.1127	0.10957
Drop Rate (%)	11%	11%	12%	11%	11%	11%	11%	11%	11%	11%
Difference	0%		1%		0%		-0%		0%	
Link Utilization (%)	32.50	63.60	46.87	50.01	63.60	67.43	50.01	73.11	67.42	77.85
Hyderabad-Delhi										
Frames Accepted	13645	21419	19896	19019	21419	21968	19019	28808	26403	31785
Frames Dropped	1498	2380	2282	2164	2380	2492	2164	3246	3092	3514
Drop Rate	0.1097	0.11111	0.1146	0.11378	0.1111	0.11343	0.1137	0.11267	0.1171	0.11055
Drop Rate (%)	11%	11%	11%	11%	11%	11%	11%	11%	12%	11%
Difference	-0%		0%		-0%		0%		1%	
Link Utilization (%)	32.89	51.70	48.17	46.01	51.70	53.13	46.01	69.63	64.07	76.67
Video (OC-9)										
Frames Accepted/Dropped/Utilization (Cont'd.)										
Cloud: Access Link	Cmp 50%	Uncmp 50%	Cmp 60%	Uncmp 60%	Cmp 70%	Uncmp 70%	Cmp 80%	Uncmp 80%	Cmp 90%	Uncmp 90%
Calcutta-Delhi										
Frames Accepted	13742	24325	21568	24139	24325	29207	24139	30481	25574	34164
Frames Dropped	1490	2673	2334	2693	2673	3261	2693	3400	2854	3896
Drop Rate	0.1084	0.10988	0.1082	0.11156	0.1098	0.11165	0.1115	0.11154	0.1115	0.11403
Drop Rate (%)	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
Difference	-0%		-0%		-0%		0%		-0%	
Link Utilization (%)	33.09	58.64	51.92	58.28	58.64	70.52	58.28	73.59	61.75	82.66
Hyderabad -Mumbai										
Frames Accepted	17664	25852	21076	22544	25852	20389	22544	32888	23406	30344
Frames Dropped	2047	2896	2436	2540	2896	2266	2540	3687	2624	3471
Drop Rate	0.1158	0.11202	0.1155	0.11266	0.1120	0.11113	0.1126	0.11210	0.1121	0.11438
Drop Rate (%)	12%	11%	12%	11%	11%	11%	11%	11%	11%	11%
Difference	0%		0%		0%		0%		-0%	
Link Utilization (%)	42.81	62.41	51.08	54.48	62.41	49.21	54.48	79.38	56.55	73.41

Table 5: Video - WAN Cloud: Access Link Statistics- Frames Accepted, Frames Dropped & Link Utilization



Message & Response Sources: Packets Delivered/Packet Delay										
Video (OC-9)	Compressed Data					Uncompressed Data				
MPEG-2 (30%)	Bandwidth Used For Simulation									
Origin/Destination	50%	60%	70%	80%	90%	50%	60%	70%	80%	90%
Calcutta-Mumbai/ Calcutta-Delhi										
Packets Created	20580	18060	19980	29100	26040	19980	29100	35100	33600	41280
Packets Delivered	8382	6162	6572	6095	5385	6572	6095	8910	6306	7488
Packets Dropped	3061	2583	2648	5263	4690	2648	5263	8200	7680	10575
Dropped/Created	15%	14%	13%	18%	18%	13%	18%	23%	23%	26%
Dropped/Delivered	37%	42%	40%	86%	87%	40%	86%	92%	122%	141%
Packet Delay (MS)										
Average	21545.220	23800.986	23152.951	24430.271	24285.0 17	23152.951	24430.271	26853. 650	26317. 635	27174.64 2
Maximum	35761.646	39753.589	38442.972	41754.478	15937.6 52	38442.972	41754.478	43751. 467	46754. 748	45997.23 1
Hyderabad-Delhi/ Hyderabad-Mumbai										
Packets Created	15000	24180	24120	20820	36540	24120	20820	25980	34440	39060
Packets Delivered	5290	7339	5859	5591	5199	5859	5591	4981	4806	6078
Packets Dropped	2096	5070	3391	3019	10755	3391	3019	4544	5449	8019
Dropped/Created	14%	21%	14%	15%	29%	14%	15%	17%	16%	21%
Dropped/Delivered	40%	69%	58%	54%	207%	58%	54%	91%	113%	132%
Packet Delay (MS)										
Average	18937.367	24205.829	24237.068	24170.535	25957.6 09	24237.068	24170.535	24086. 892	23164. 516	29016.78 8
Maximum	34686.021	39251.421	37752.701	41923.018	45998.4 79	37752.701	41923.018	42185. 979	45995. 462	46195.85 8

Message & Response Sources: Packets Delivered/Packet Delay (Cont'd.)										
Video (OC-9)	Compressed Data					Uncompressed Data				
MPEG-2 (30%)	Bandwidth Used For Simulation									
Origin/Destination	50%	60%	70%	80%	90%	50%	60%	70%	80%	90%
Calcutta-Bangalore/ Bangalore-Jaypure										
Packets Created	18660	19680	25260	24600	31680	25260	24600	33420	40020	35880
Packets Delivered	4710	5234	5443	5940	7801	5443	5940	3940	4608	5985
Packets Dropped	3190	2661	4471	3607	8108	4471	3607	7526	11571	8189
Dropped/Created	17%	14%	18%	15%	26%	18%	15%	23%	29%	23%
Dropped/Delivered	68%	51%	82%	61%	104%	82%	61%	191%	251%	137%
Packet Delay (MS)										



Average	18316.892	22700.776	21987.922	22305.040	27316.763	21987.922	22305.040	27282.640	27406.769	25983.689
Maximum	34815.675	38995.320	37999.714	41998.341	44995.186	37999.714	41998.341	42999.850	45999.167	45915.336
Calcutta-Jaypur/ Bangalore-Jaypur										
Packets Created	15060	21900	30060	26460	33360	30060	26460	34320	39840	45780
Packets Delivered	4782	4719	6200	6663	5494	6200	6663	5142	5790	5873
Packets Dropped	2034	3125	4476	6490	6439	4476	6490	6549	10872	13719
Dropped/Created	14%	14%	15%	25%	19%	15%	25%	19%	27%	30%
Dropped/Delivered	43%	66%	72%	97%	117%	72%	97%	127%	188%	234%
Packet Delay (MS)										
Average	22132.069	23018.402	23614.416	24479.970	28458.794	23614.416	24479.970	25639.160	27681.452	26808.653
Maximum	33390.164	38994.223	37864.572	40783.982	43289.376	37864.572	40783.982	42996.558	45989.974	44777.672

Message & Response Sources: Packets Delivered/Packet Delay (Cont'd.)										
Video (OC-9)	Compressed Data					Uncompressed Data				
MPEG-2 (30%)	Bandwidth Used For Simulation									
Origin/Destination	50%	60%	70%	80%	90%	50%	60%	70%	80%	90%
Calcutta-Hyderabad/ Hyderabad-Bangalor										
Packets Created	17940	22200	26160	32820	31020	26160	32820	35580	42240	39300
Packets Delivered	6662	3941	5134	5138	6174	5134	5138	6252	6315	4684
Packets Dropped	2578	2551	5883	7380	5012	5883	7380	5673	11238	9232
Dropped/Created	14%	11%	22%	22%	16%	22%	22%	16%	27%	23%
Dropped/Delivered	39%	65%	115%	144%	81%	115%	144%	91%	178%	197%
Packet Delay (MS)										
Average	19406.890	20115.726	18922.891	22990.946	27608.174	18922.891	22990.946	27288.050	28376.281	27056.934
Maximum	35180.295	38503.759	35627.469	41999.439	44995.872	35627.469	41999.439	42992.167	46997.383	45999.851
Calcutta-Delhi/ Hyderabad-Delhi										
Packets Created	15180	26040	27600	28500	31140	27600	28500	39300	40320	50520
Packets Delivered	4643	7026	6277	5270	4508	6277	5270	6610	6924	7160
Packets Dropped	1994	5261	3902	4755	6001	3902	4755	10272	10711	16368
Dropped/Created	13%	20%	14%	17%	19%	14%	17%	26%	27%	32%
Dropped/Delivered	43%	75%	62%	90%	133%	62%	90%	155%	155%	229%
Packet Delay (MS)										
Average	20435.045	27705.592	21806.770	24620.266	23439.293	21806.770	24620.266	23334.466	26711.550	28540.180
Maximum	35148.382	39613.026	38147.012	41295.547	42565.315	38147.012	41295.547	43147.148	46133.979	46994.363

Table 6: Video - Message & Response Sources: Packets Delivered/Dropped/Delay