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Performance Metrics of ATM & IP Network for Multiple Profiles with 99% Background Utilization of Link

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Abstract – **This paper investigates the performance metrics end-to-end delay and response time for pure ATM, pure IP networking technologies for multiple profiles with 99 percent background utilization of link. To study the said metrics a university network of size 1000 km X 2000 km geographical area has been considered with University and four zones in the top most layer with varying distances of 20 kms, 800 kms, 900 kms and 1000 kms respectively followed by college layer comprising of distance 10 kms and 250 kms and bottommost layer, department layer consisting of three departments represented typically by Dept_EC, Dept_CS and Dept_CV. Each department is capable of handling the multimedia traffic for multiple profiles. The model has been built andsimulated using OPNET IT Guru Academic Edition 9.1, to study the performance metrics for data rate, OC3 (149Mbps) for ATM network and 100 Mbps for IP network. A G711 and G723.1 encoder scheme has been used for voice, low and high resolution for video and low and high load has been used for FTP and EMAIL.**

The results of simulation indicate that pure ATM has better performance compared to pure IP network with respect to voice and video due to prior path establishment feature in ATM. The large delay offset included in ATM is for the reservation of network resources to assure quality of voice and video information. The response time of pure ATM network is better compared to pure IP network due to random path detection in IP networks.

Keywords – **ATM, Link Utilization, OPNET.**

I. Introduction

Networking technologies play important role in our lives. It is undisputed that Internet has become an integral part of Education, Business, Industry, Economy as well as residential world of our society. Performance based network infrastructure and bounded end-to-end delays is the need of ever growing Internet and distributed real-time applications. Networking technologies like ATM and IP that offer packet routing services are prominent in present day's ever growing real time traffic. The vital role in a network is its enhancement of real time traffic which is sensitive to end-to-end delay. Voice and Video traffic of multimedia are delay sensitive and require extra care to provide quality of service [8]. ATM and IP have special features to support multimedia. ATM technology has an enormous impact on future distributed systems because of its attractive features[1][6].The core features of ATM include high speed, cell switching, virtual networking and scalable technology. ATM has an inherent mechanism for Quality of Service (QoS)[2][3][10]. IP technology requires a protocol to specify delay limits in the form of Resource reSerVation Protocol (RSVP). These two technologies are considered to be backbone of a network in terms of their routing capabilities[7][12].

II. Building the Network and Simulation

The real-time distributed system is modeled as a Network for University(NU)with anarea of 1000Km X2000 Km. Network for University has 3 layers. Layer1 has university and four zones, Zone_20, Zone _800, Zone_900,and Zone_1000.The numeral in Zone indicates the distance in kilometers between Zone and University. Layer 2 has two Colleges, College_10and College_250, which represent the colleges under that Zone located at a distance of 10and 250 kilometers respectively. Layer 3 has three departments in college, Dept_EC, Dept_CS and Dept_CV with C10_EC_Voice_src1, C10_EC_Video_ src1, C10_EC_data1 as user voice source, user video source and user data source. The University, different zones and different colleges under a zone are knit by Public Network whereas the departments of a college use a Private Network. Each department is facilitated with bidirectional multimedia communication over a single network. OPNET IT Guru Academic Edition 9.1, 2003, simulation tool is used for modeling NU system[5][13].

The layered architecture enable the setting up of NU system in top-down approach in steps of increasing complexity, thus ensuring its completeness and validity at each layer. The Application Config object in the project workspace named as Applications is configured for Voice, Video, FTP and EMAIL. Profile_1 node is used to create user profiles for NU system as FTP_P, EMAIL_P, Voice_P1 and Video_P1. The applications defined are used by Profile_1 to configure profiles. This Profile_1 will cause the Voice and Video application to run every 300s.Similarly multiple profiles Pro1, Pro5, Pro10, Pro15 and Pro20 also configured.

A. Configuration of Subnet Dept_EC

The communication nodes in the subnet Dept_EC, C10_EC_data1,C10_EC_Voice_src1,EC10_EC_Video_sr c1 are dedicated to FTP and EMAIL, Voice and Video applications respectively. The C10_EC_Server is configured for data transfer application. The application nodes C10_EC_Voice_src1,C10_EC_Video_src1 and C10_EC_data1 are configured for CBR, RT_VBR and UBR respectively in ATM Application parameters for with QoS scenarios. The transport protocol desired for Voice and Video application is AAL2 and that for data application is AAL5. The configured subnet Dept_EC is as shown in Fig. 1. The information is transferred to respective communication nodes Uni_data1, Uni_Voice_src1 and Uni_Video_src1 of University campus.

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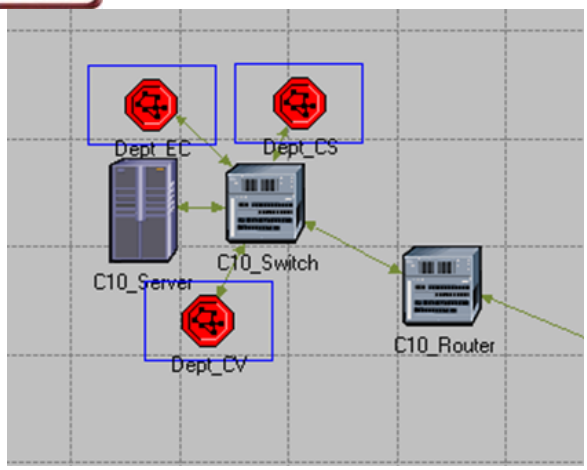

Fig.1. SubnetDept_EC

B. Configuration of other subnets

The other subnets Dept_CS and Dept_CVare built and configured similar to subnet Dept_EC. The department subnets along with server are connected to C10_Switch which is linked to C10_Router. The department together with server, switch and router forms college_10 subnet as shown in Fig. 2. Similarly other college subnets are created and configured.

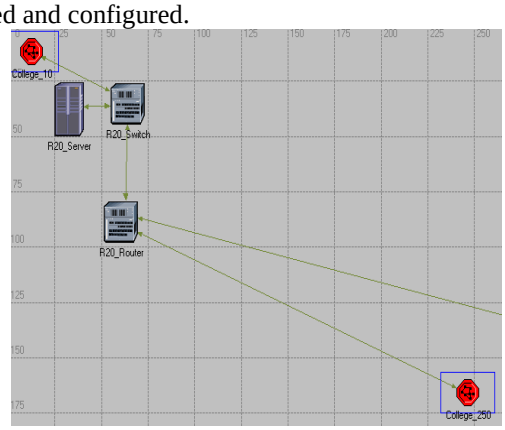

Fig.2. Subnet of College_10

The subnet Zone_20 encapsulates the College_10 and College_250 along R20_Server, R20_Switch and R20_Router as shown in Fig. 3.

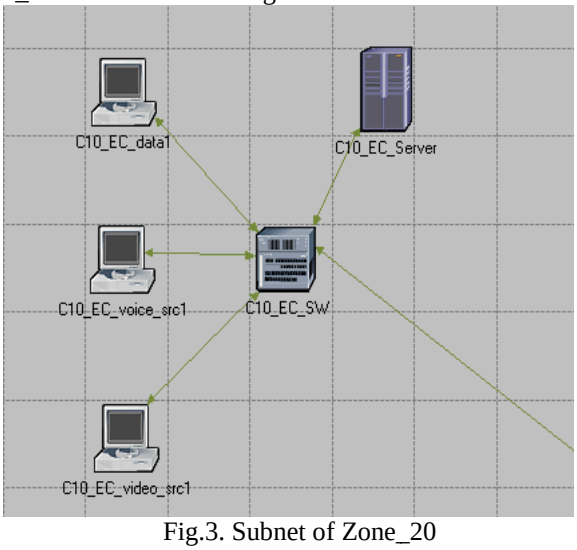

Fig.3. Subnet of Zone_20

This process is repeated for other Zone_800, Zone_900, Zone_1000 and University. All Zones are linked to University by bidirectional links. The complete NU system is as shown in Fig. 4.

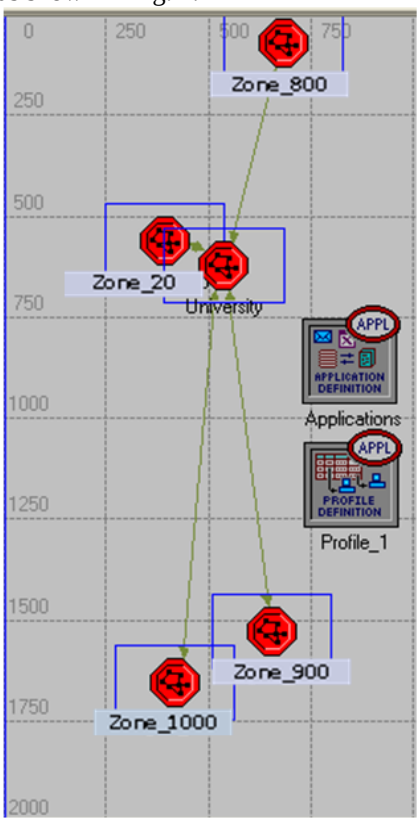

Fig.4. NU System

The configuration of QoS in ATM is inherent and set for default settings and in IP configured using RSVP.

The different statistics that are collected for ATM and IP network are:

- Voice: Packet End-to-End Delay (s)
- Video Conferencing: Packet End-to-End Delay (s)
- FTP: Download Response Time (s)
- EMAIL: Download Response Time (s)
- Link Statistics: Point-to-point Utilization collected between Regions and University only.

Scenarios of the remaining zones with low and high loads, with and without QoS are created by duplication and suitable modification of the base scenario built. The different projects are created for ATM and IP networks and are simulated.

III. Results and Conclusions

The NU system is modeled for ATM and IP networks. NU system is simulated for different scenario to compare the performance of ATM and IP networks. The different applications considered for model NU system are Voice, Video, FTP and Email. The ATM uses atm_adv link with data rate of 149 Mbps for OC3 and IP uses BaseX_link with data rate of 100Mbps. Bck99 represents the average 99% background utilization of the link. This section discusses, infers results obtained from simulation scenarios.

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C. *Voice Application*

TheDelay for G723.1 and G711 multiple profileswith data rate of OC3 for ATM[4] and 100 Mbps for IP network for without QoS and with QoS / without RSVP and with RSVP are tabulated as shown in Table 1,Table2 and corresponding graph isas shown in Fig.5 and Fig. 6 respectively.

Table I: G723.1 Delay for Multiple Profiles with bck99(ms)

Zones		Number of Profiles									
		ATM					IP				
		1	5	10	15	20	1	5	10	15	20
Zone_20	With out	1.7742	1.8347	1.8572	1.8634	1.9028	22.0945	21.2426	16.7639	13.2897	11.2868
	With	0.0217	0.0217	0.0217	0.0217	0.0217	13.0532	13.0808	13.0348	12.9873	12.9969
Zone_800	With out	1.7763	1.8441	1.8694	1.8739	1.9030	23.8147	23.7665	20.9848	18.8602	15.3065
	With	0.0227	0.0227	0.0227	0.0227	0.0227	13.8415	13.0841	13.1972	12.6193	12.6012
Zone_900	With out	1.7767	1.8764	1.8733	1.8847	1.9039	23.9529	23.7564	20.3644	18.4602	15.8589
	With	0.0233	0.0233	0.0233	0.0233	0.0233	13.8716	13.0694	13.1281	12.6938	12.6809
Zone_1000	With out	1.7793	1.8872	1.8972	1.8979	1.9042	23.9481	23.7530	20.4769	18.7436	15.8533
	With	0.0237	0.0237	0.0237	0.0237	0.0237	20.7791	20.0057	19.9907	19.2600	19.2109

Table II: G711 Delay for Multiple Profiles with bck99 (ms)

Zones		Number of Profiles									
		ATM					IP				
		1	5	10	15	20	1	5	10	15	20
Zone_20	With out	2.0727	2.0686	2.0554	2.0135	2.0093	27.2762	14.5537	7.9454	7.2203	6.1501
	With	0.0065	0.0065	0.0065	0.0065	0.0065	21.8419	21.7124	21.4346	21.6444	21.3484
Zone_800	With out	2.0993	2.0985	2.0970	2.0653	2.0095	27.5182	14.5844	8.5396	8.7543	6.9054
	With	0.0076	0.0076	0.0076	0.0076	0.0076	22.0386	21.8361	21.8261	21.7339	21.4904
Zone_900	With out	2.1681	2.1418	2.0995	2.0954	2.0137	27.8895	18.367	13.1780	10.2697	7.4309
	With	0.0086	0.0086	0.0086	0.0086	0.0086	22.3036	21.8177	21.6974	21.6954	21.6430
Zone_1000	With out	2.2677	2.2419	2.1396	2.1249	2.0163	28.0100	18.5665	13.2452	10.826	9.4887
	With	0.0146	0.0146	0.0158	0.0158	0.0168	25.9775	25.966	25.8143	25.6816	25.5938

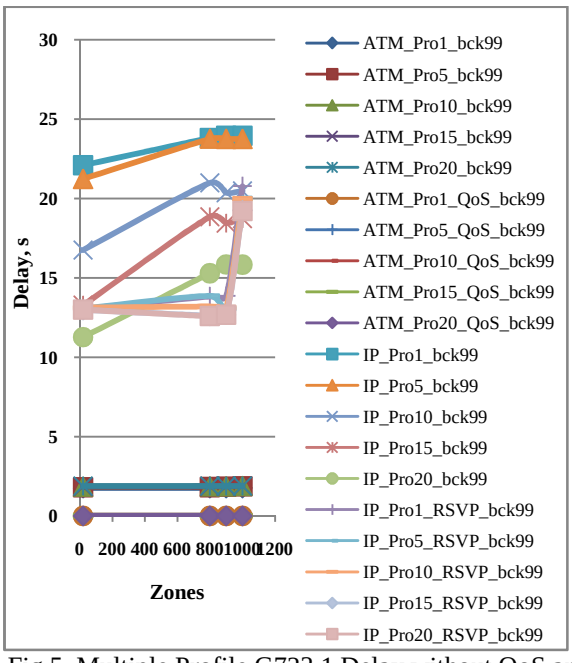

Fig.5. Multiple Profile G723.1 Delay without QoS and with QoS/without RSVP and with RSVP with bck99 (ms)

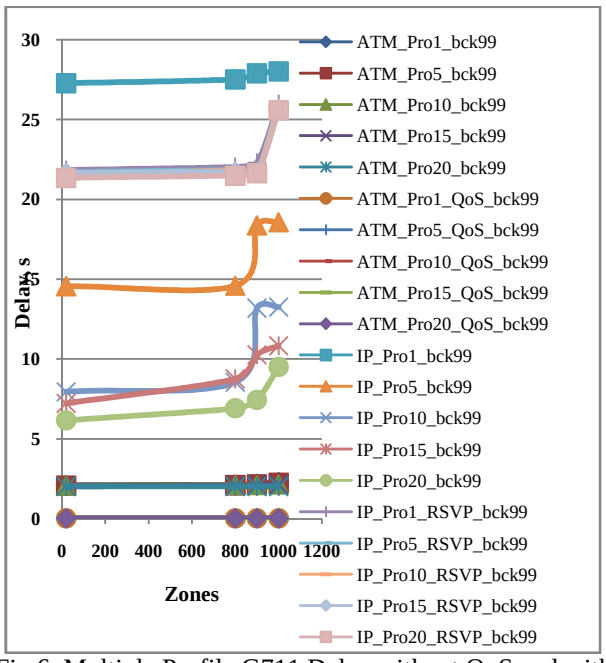

Fig.6. Multiple Profile G711 Delay without QoS and with QoS / without RSVP and with RSVP with bck99 (ms)

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The difference in delay for multiple profiles for G723.1 without and with QoS in ATM network is attributed to the inherent difference in the service category used. The difference in delay for IP network is attributed to best effort service and RSVP used in without and with RSVP respectively.

For multiple profiles without RSVP there is an increase in delay with RSVP because reservations are made at intermediate switches, which act as shared pipe whose capacity is the largest of resource requests for that link from all receivers.

The delay in IP is doubled as compared to ATM for without QoS/RSVP for increasing number of profiles.

The delay in ATM is fairly constant in milliseconds for increase in number of profiles due to prior connection establishment and its inherent QoS.

D. Video Conferencing Application

The Delay for Low and High Resolution Video for multiple profiles with data rate of OC3 for ATM and 100 Mbps for IP network for without QoS and with QoS / without RSVP and with RSVP aretabulated as in Table 3,Table 4 and corresponding graph is as shown in Fig.7 and Fig.8 respectively.

Table III: Low Resolution Video Delay for Multiple Profiles with bck99 (ms)

Zones		Number of Profiles									
		ATM					IP				
		1	5	10	15	20	1	5	10	15	20
Zone_20	Without	2.2496	2.2498	2.2520	2.2532	2.2530	27.1016	28.5674	20.8298	16.4384	13.6804
	With	0.0217	0.0217	0.0217	0.0217	0.0217	14.6789	14.5896	14.6200	14.5044	14.3479
Zone_800	Without	2.2518	2.2490	2.2481	2.2480	2.2489	28.0610	28.6653	26.8970	24.0830	19.6079
	With	0.0228	0.0228	0.0228	0.0228	0.0228	14.3383	14.2227	14.6510	14.5916	14.5934
Zone_900	Without	2.2525	2.2476	2.2445	2.2435	2.2434	28.2806	28.5636	26.3583	23.6384	20.0593
	With	0.0233	0.0233	0.0233	0.0233	0.0233	14.4301	14.4832	14.6290	14.6786	14.6548
Zone_1000	Without	2.2547	2.2535	2.2540	2.2521	2.2537	28.2969	26.3958	18.0487	15.9185	13.3925
	With	0.0238	0.0238	0.0238	0.0238	0.0238	22.5412	22.1733	22.5389	22.6263	22.5754

Table IV: High Resolution Video Delay for Multiple Profiles with bck99 (ms)

Zones		Number of Profiles									
		ATM					IP				
		1	5	10	15	20	1	5	10	15	20
Zone_20	Without	2.5645	2.6134	2.3604	2.4960	2.3165	33.8666	17.2120	9.0340	7.9289	6.5724
	With	0.0217	0.0217	0.0217	0.0217	0.0217	25.8833	25.8838	25.3747	25.7765	25.6145
Zone_800	Without	2.5648	2.6067	2.4461	2.4921	2.3144	33.6312	17.1398	9.7866	9.3364	6.5543
	With	0.0228	0.0228	0.0228	0.0228	0.0228	25.6590	25.6366	25.7069	25.9070	25.7070
Zone_900	Without	2.5617	2.6076	2.4451	2.4898	2.3224	33.8798	22.0601	15.7620	11.7424	8.3042
	With	0.0233	0.0233	0.0233	0.0233	0.0233	25.8786	25.5579	25.8880	25.8581	25.8003
Zone_1000	Without	2.5625	2.6088	2.4440	2.4951	2.3187	34.0337	22.2823	15.6451	12.4377	10.5709
	With	0.0238	0.0238	0.0238	0.0238	0.0238	28.7333	29.0153	29.2344	29.4280	29.3860

Low Resolution Video show similar trend as that of G723.1 with respect to the delay metrics for with and without QoS in ATM network as well as for with and without RSVP in IP network.

The delay in High resolution Video with QoS is larger than without QoS for ATM network. The delay in High resolution Video with RSVP is larger than without RSVP for IP network.

High Resolution Video show similar trend to G711 with respect to the delay metrics for with and without QoS in ATM network as well as for with and without RSVP in IP network.

E. FTP Application

The Response Time for FTP Low Load multiple profileswith data rate of OC3 for ATM and 100 Mbps for IP network for without QoS and with QoS / without RSVP and with RSVP aretabulated as in Table 5,Table 6 and corresponding graph are as shown in Fig.9 and Fig.10 respectively.

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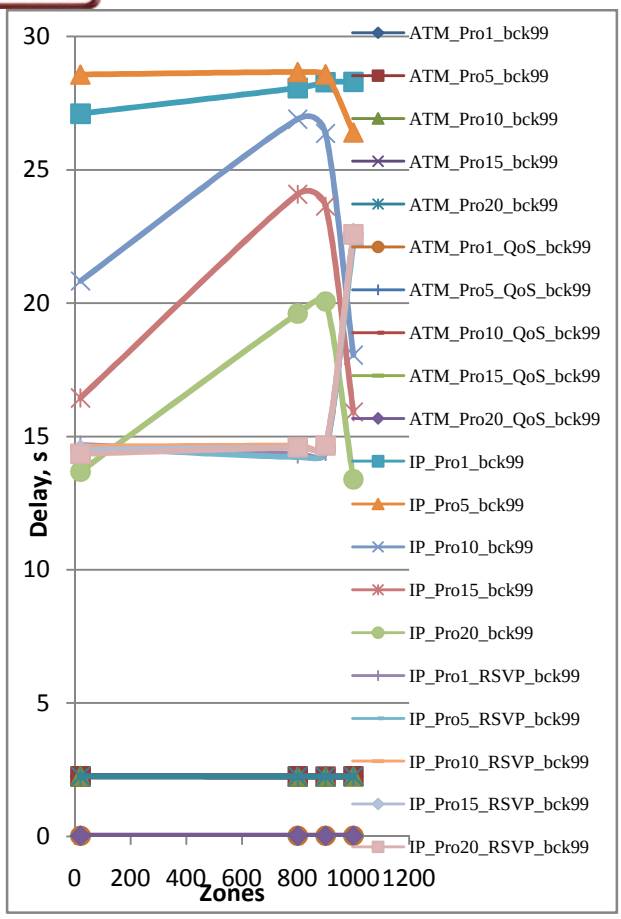

Fig.7. Multiple Profile Low Resolution Video Delay without QoS and with QoS/without RSVP and with RSVP with bck99 (ms)

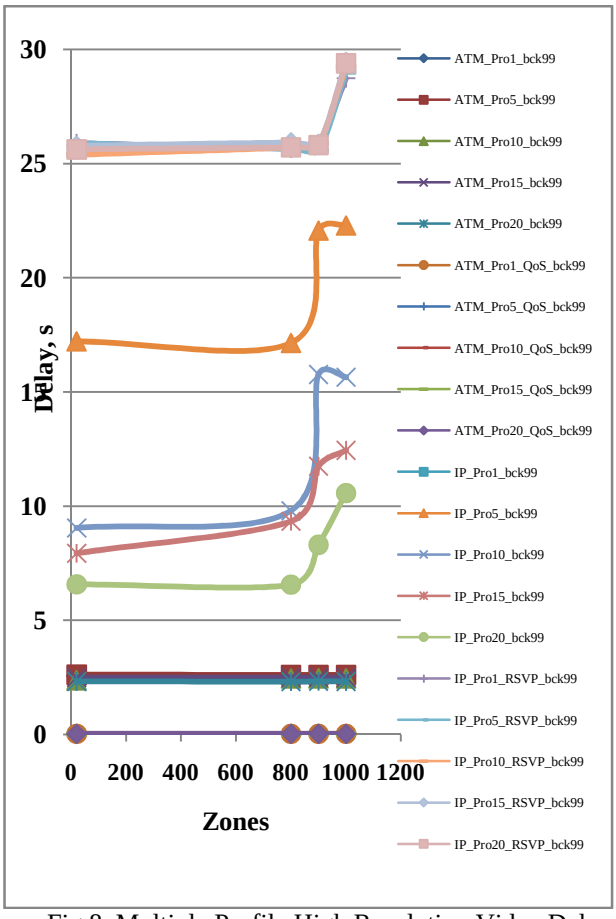

Fig.8. Multiple Profile High Resolution Video Delay without QoS and with QoS/without RSVP and with RSVP with bck99 (ms)

Table V: FTP Low Load Response Time for Multiple Profiles with bck99 (ms)

Zones		Number of Profiles									
		ATM					IP				
		1	5	10	15	20	1	5	10	15	20
Zone_20	Without	65.9368	67.9267	69.2675	73.2532	74.2532	96.9617	66.9617	17.3837	11.3837	4.8907
	With	33.4521	17.1270	15.8156	15.3139	17.3633	89.7098	93.6808	113.3430	178.9753	192.0044
Zone_800	Without	77.3808	78.4704	76.9737	81.0482	82.3762	144.2982	138.8277	70.4303	13.5123	7.5381
	With	26.4947	25.4286	26.0694	27.0304	25.1506	111.5129	118.4921	124.5197	125.9064	129.4152
Zone_900	Without	78.4863	79.7692	79.7950	82.3894	83.1984	146.1599	142.7321	88.9397	14.1212	8.0605
	With	44.4513	29.6190	30.2570	31.2194	29.3321	156.5374	223.0028	252.8695	258.7362	268.0508
Zone_1000	Without	81.6750	82.5906	82.7989	83.3480	84.1788	177.3193	166.1542	116.1542	86.8397	17.1982
	With	34.2593	33.4250	34.6219	34.6110	34.1239	410.8374	427.1407	435.3490	473.1793	483.4667

Table VI: FTP High Load Response Time for Multiple Profiles with bck99 (ms)

Zones		Number of Profiles									
		ATM					IP				
		1	*5*	*10*	*15*	*20*	*1*	*5*	*10*	*15*	*20*
Zone_20	Without	551.7777	561.1787	521.1787	437.1937	417.1937	321.5061	278.3006	256.3519	242.3143	212.3142
	With	408.6249	100.0158	69.1046	67.1034	111.6464	323.1334	313.8093	305.2351	293.3371	273.3371
Zone_800	Without	561.0018	564.7977	542.4736	504.9627	495.7758	393.1769	368.3696	288.3696	265.4375	225.4374

	With	423.6518	184.6447	120.3561	142.4581	122.2564	329.3464	312.7293	302.7293	294.4044	280.7386
Zone_900	With out	562.2000	569.7692	529.0840	510.0646	500.0816	400.8162	356.7517	286.7517	273.6252	260.6252
	With	427.3310	198.8323	124.5347	146.6253	126.4441	338.4642	318.4642	319.5277	293.5277	292.9942
Zone_1000	With out	568.5023	564.7570	473.7867	439.0099	397.8943	410.8182	381.6721	328.1062	289.1061	271.2324
	With	432.4961	244.6927	147.2987	147.3096	127.3623	358.4642	338.4642	329.5277	308.0891	306.7892

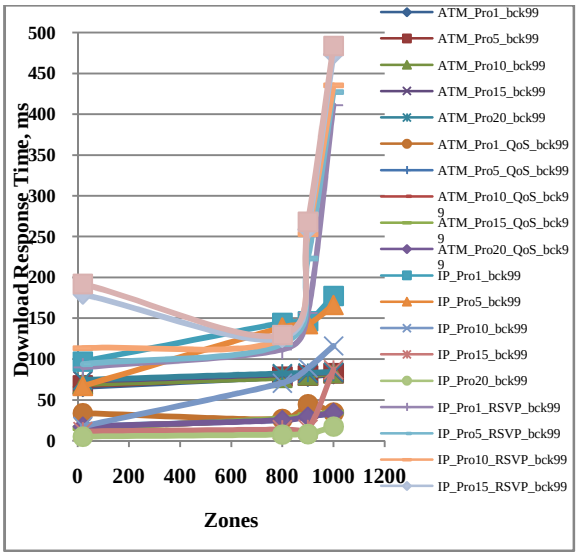

Fig.9. Multiple Profile FTP Low Load Response Time without QoS and with QoS/without RSVP and with RSVP with bck99 (ms)

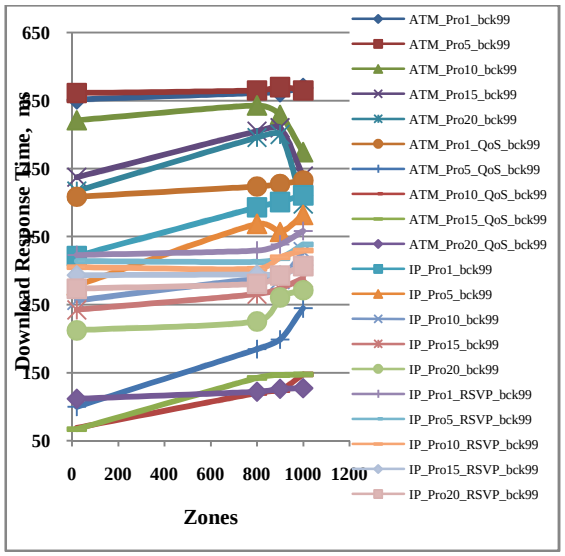

Fig.10. Multiple Profile FTP High Load Response Time without QoS and with QoS / without RSVP and with RSVP with bck99 (ms)

Low Load download response time remains almost same for ATM networks for without and with QoS due to configuration of UBR service category which provides the best effort service.

High Low download response time has similar trend of Low Load download response time for ATM networks for without and with QoS due to configuration of UBR service category which provides the best effort service.

F. EMail Application

The Download Response Time for EMAIL Low Load multiple profileswith data rate of OC3 for ATM and 100 Mbps for IP networkfor without QoS and with QoS / without RSVP and with RSVP are tabulated as in Table 7,Table 8 and the corresponding graph isas shown in Fig.11 and Fig.12 respectively.

Table VII: EMAIL Low Load Response Time for Multiple Profiles with bck99 (ms)

Zones		Number of Profiles									
		ATM					IP				
		1	5	10	15	20	1	5	10	15	20
Zone_20	With out	73.3728	75.9656	76.6969	76.0247	80.6172	11.2709	16.4484	21.8674	22.6676	23.0899
	With	36.5045	18.2993	18.3529	18.5147	18.4638	407.3625	248.9198	183.3955	311.2303	164.7888
Zone_800	With out	80.8389	82.8124	84.6263	86.3987	89.9815	11.3591	27.2762	65.3318	84.1070	94.1570
	With	27.4044	27.0054	27.1681	27.5052	27.4816	326.0453	169.0639	139.8366	308.7755	178.0532
Zone_900	With out	84.6284	85.3411	87.3807	87.3212	90.4885	11.4172	39.4514	68.4971	94.8624	109.9642
	With	47.2695	51.6317	31.3557	31.1931	31.5920	347.5592	175.8551	161.6606	317.1590	194.9345
Zone_1000	With out	88.0833	89.4780	90.5665	91.4469	93.7462	11.6031	78.1501	85.4924	101.3364	180.2816
	With	35.2462	34.7637	34.7873	35.0808	35.0753	477.2449	655.9372	450.0294	564.7509	847.7296

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Table IX: Low Load Link Utilization for Multiple Profiles with bck99 (ms)

Zones		Number of Profiles									
		ATM					IP				
		1	*5*	*10*	*15*	*20*	*1*	*5*	*10*	*15*	*20*
Zone_20	Without	99.6991	99.7003	99.7357	99.7143	99.7294	99.9554	99.9452	99.9311	99.9206	99.8858
	With	2.1014	2.1814	2.2137	2.2240	2.5584	99.8733	99.8761	99.8709	99.8701	99.8733
Zone_800	Without	99.7471	99.7037	99.7178	99.7377	99.7403	99.9449	99.9497	99.9482	99.9393	99.9260
	With	2.1072	2.2072	2.2495	2.2894	2.3270	99.8738	99.8787	99.8762	99.8725	99.8703
Zone_900	Without	99.7467	99.7040	99.7142	99.7381	99.7429	99.9496	99.9500	99.9487	99.9394	99.9262
	With	2.1072	2.2072	2.2494	2.2893	2.3268	99.8736	99.8788	99.8766	99.8727	99.8704
Zone_1000	Without	99.7454	99.7044	99.7149	99.7173	99.7425	99.9522	99.9463	99.9485	99.9184	99.9059
	With	2.1013	2.1813	2.2135	2.2238	2.2557	99.8713	99.8789	99.8767	99.8729	99.8704

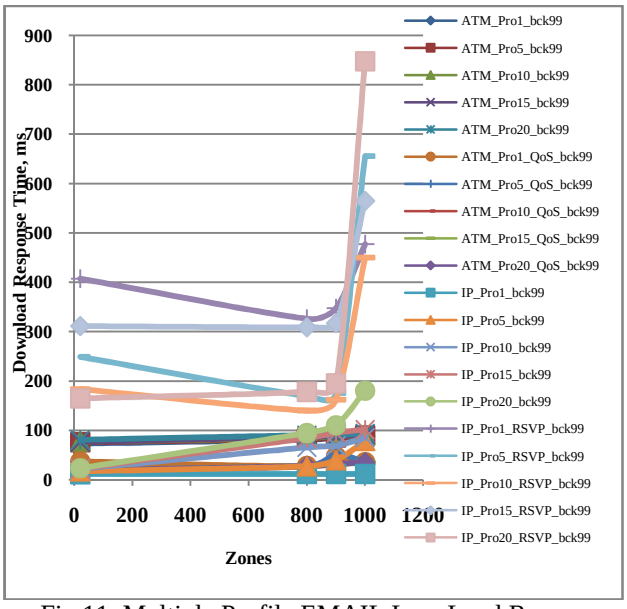

Fig.11. Multiple Profile EMAIL Low Load Response Time without QoS and with QoS / without RSVP and with RSVP with bck99 (ms)

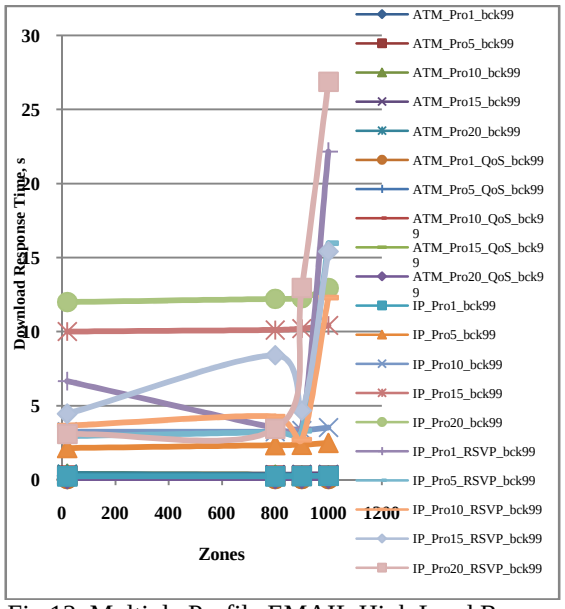

Fig.12. Multiple Profile EMAIL High Load Response Time without QoS and with QoS / without RSVP and with RSVP with bck99 (ms)

Table X: High Load Link Utilization for Multiple Profiles with bck99 (ms)

Zones		Number of Profiles									
		ATM					IP				
		1	**5**	**10**	**15**	**20**	**1**	**5**	**10**	**15**	**20**
Zone_20	Without	99.4648	99.4715	99.4790	99.4795	99.4805	99.9101	99.8034	99.6870	99.6805	99.5727
	With	4.1555	4.2555	4.2752	4.2842	4.3970	99.9101	99.8034	99.6870	99.6805	99.5727
Zone_800	Without	99.5484	99.4843	99.4889	99.5300	99.5100	99.9086	99.8604	99.8113	99.7273	99.6987
	With	4.1553	4.2533	4.2663	4.2693	4.3770	99.9086	99.8604	99.8113	99.7273	99.6987
Zone_900	Without	99.5470	99.4844	99.4826	99.5302	99.5131	99.9096	99.8603	99.8113	99.7397	99.7464
	With	4.1553	4.2532	4.2652	4.2691	4.3765	99.9096	99.8603	99.8113	99.7397	99.7464
Zone_1000	Without	99.5467	99.4841	99.4823	99.4889	99.5130	99.9085	99.8214	99.6938	99.6308	99.6496
	With	4.1553	4.2532	4.2536	4.2625	4.3765	99.9085	99.8214	99.6938	99.6308	99.6496

Email Download response time has same trend as that of FTP download response time for both low and high load. It is observed that the download response time for ATM networks is lesser as compared with IP networks.

G. Link Utilization

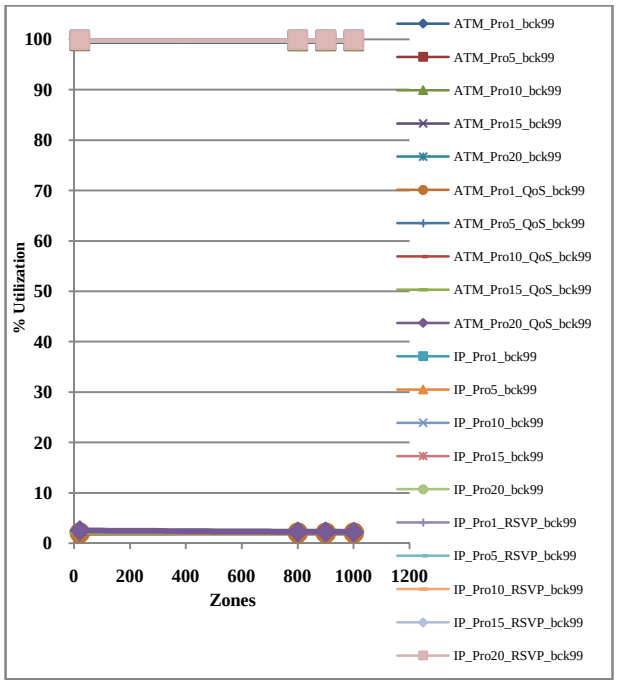

Fig.13. Multiple Profile bck99 Low Load Utilization without QoS and with QoS / without RSVP and with RSVP (s)

It is observed that utilization of link is almost independent of distance in ATM. For bck99 without QoS/RSVP both the networks utilize maximum resource about 98%, but with QoS/RSVP utilization of ATM is 2% when compared to IP which is 99%.

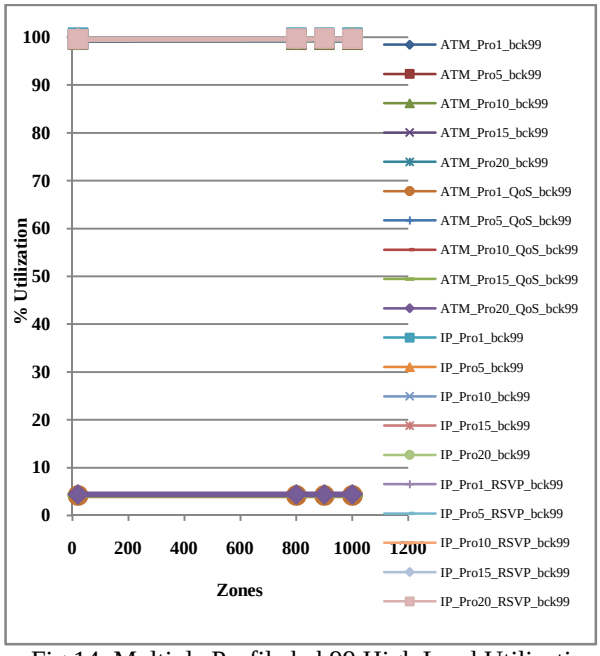

Fig.14. Multiple Profile bck99 High Load Utilization without QoS and with QoS / without RSVP and with RSVP (s)

For multiple profiles, it is observed that utilization of link is independent of distance in ATM. For bck99 without QoS/RSVP both the networks utilize maximum resource, but with QoS/RSVP utilization of ATM is 4% when compared to IP which is 99%. IP utilizes more resources because number of packet is large in case of IP and predicts the best available path when compared to ATM. Relatively less utilization of ATM does not mean inefficiency. However, it will be benefitted at the time of congestion.

IV. Conclusions

With increasing number of profiles, variation in end-to-end delay is almost constant since jitter is in nanoseconds and milliseconds for ATM and IP network respectively.

The larger response time is due to the fact that FTP and Email uses UBR service category in ATM network which is given the least priority amongst multimedia. The response time decreases for IP with increasing number of profiles due to connectionless nature.

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