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A Simulation Study of TCP/IP over ATM on Interactive Environment

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1 Introduction

Performance of TCP connections in high-speed ATM networks is of great importance due to the widespread use of the TCP/IP protocol and the increasing deployment of ATM networks. In this paper , the performance of TCP/IP over ATM backbone network is evaluated under the interactive environment, based on client-server aspect, by using the method of computer simulation. The effect of ATM-leveled VC bandwidth allocation and TCP congestion control mechanism on the average response time are studied.

2 Image Server Model

The simulation model demonstrates image retrieval from a remote server by application processes running TCP/IP over a backbone ATM network. This network model shows 5 clients connected to single server (Fig.1). Each of the client is trying to "get" an imagery data file from the server. The different clients are connected to the server via three different ATM switches.

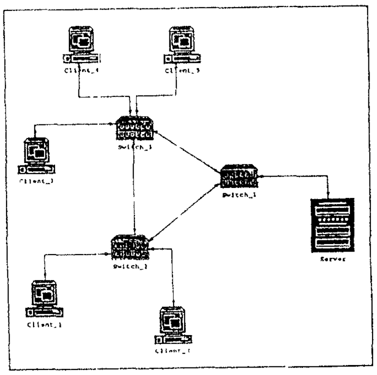

Figure 1: Image client-server model

Each client application sends request packets which have a constant length of 10 bytes. The delay between packets being sent is selected as exponential distribution with an average delay of 5 seconds.

At the server side, we assigned the processing rate of 10,000,000 bytes/sec. This parameter is to ensure for very small processing delay at the server. When the server receives a request packet, it will send one response packet. Response packets are subjected to the same processing delay as received packets. However, these response packets will be processed before any more received packets. In this simulation, the server will send one response packet upon reception with the constant size of 1,000,000 byte.

Simulation parameter	Value
TCP window size	64 Kbytes
MSS	536 bytes
BER per link	0
propagation delay per link	10E-5
Imagery data size	1,000,000 bytes
Server processing rate	10,000,000 bytes/sec
IP processing rate	5,000 pkts/sec
VP bandwidth	155.52 Mbps
simulation time	50 sec.

Figure 2: Run-time Simulation Parameters

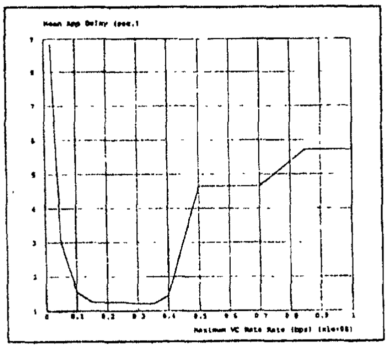

Figure 3: Response time vs. Maximum allocated VC data rate

3 The effect of VC allocation on Response time

At first, we will consider the effect of the maximum virtual circuit allocated to each connection. The simulation parameters are shown in Fig.2. Recall that the virtual path is statically assigned to the data rate of 155.52 Mbps.

At each client application module, we calculate the end to end delays local to this node. This is round trip time delay for the clients to start dumping their data on to the server to the time when they receive the imageral data from the server. Fig.3 demonstrates the mean application end to end delay while the VC bandwidth of each connections are variably set from 2 Mbps. to 100 Mbps. We can notice that when the maximum VC data rate of each connection is allocated below 10 Mbps, by the limitation of the avaliable VC bandwidth, the mean application delay (mean response time) becomes very high. When all five clients request 10-30 Mbit VC allocation, The bandwidth of each link in the network is 155.52 Mbps. Thus all the clients have VC assignments for them at any link irrespective of the number of clients requesting (since their sum total bandwidth will always be less than 155.52 minus the overhead associated with the signaling VP required for the connections). That is why the response time is reasonably low. The response time, however, becomes higher when VC data rate allocation is between 50 Mbps to 70 Mbps. This is because only two or three AAL connections are established in one time due to the 155 Mbps-limitted VP link on all links. Morever, increasing higher VC data rate more than 80 Mbps make the overall mean application delay higher because more request packets have to wait at the TCP sender buffer for lower AAL connection.

4 The effect of TCP congestion control mechanism on Response time

Next, we will study how TCP mechanism affect the client-server system over ATM backbone network. From the graph in Fig.3, 20 Mbps VC bandwidth allocation will be chosen for each connection in order that the limitation of VP link has no effects on the response time. The advertised window size is altered from 64Kbyte to 1 Mbyte and mean application delay of all clients are collected in Fig.4. Note that IP processing rate is set to 5000 pks/sec. which is big enough to process the incoming datagram. As the result in the graph indicate, TCP with larger window size reduces the average time until each client can obtain imageral data from the image server since it start sending a request packet. Under this condition, the window size extension option is theoretically very helpful.

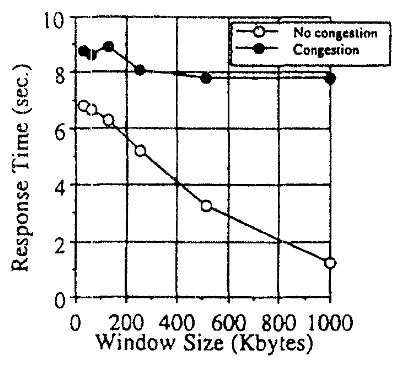

Figure 4: Response time vs Window size

We subsequently use the same network model but the packet processing power at the IP router of the server side is reduced from 5000 pks/sec. to 1000 pks/sec. at the interval of 15-20 sec. and 35-40 sec. Fig.5 illustrates one example of the delay that IP datagrams must be queued before entering the routing process, which is collected by probe tool. Again, the average response time is plotted in Fig.4 for different TCP window sizes.

Eventhough we open the advertised window size larger, the response time cannot be reduced as expected. This is due to the slow-start congestion window's mechanism. When TCP sender acknowledges that congestion has occured, it will grow its congestion window exponentially up to one-half the previous window and then grow linearly toward the bandwidth of the link. Unfortunately, linear growth takes a long time, the window size will not reach the size appropriate for high speed. Morever, in this simulation, more than one congested periods disturb the flow of imagery data. This make it more difficult to grow up the congestion window that it takes more than 40 seconds for the congestion window to grow up to around 70 Kbytes.

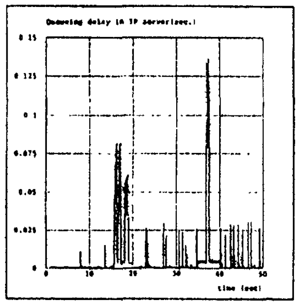

Figure 5: Delay characteristics in IP queue when WS = 256Kbytes

5 Conclusion

We have studied the client-server application process running TCP/IP over a backbone ATM network. First, it is shown that the maximum allocated VC data rate have an influence on the image server's response time because of the limitation of resource bandwidth. The next simulation indicated that TCP with larger advertised window size cannot always reduce the average response time in all cases. This is due to TCP's slow start mechanism when the congestion occurs at some places in the network.

Recall that ATM traffic control function are modeled for constant bit rate (CBR) traffic control only. This make it difficult to study the dynamic behavior of the system. Therefore, it is necessary to implement the new available bit rate (ABR) traffic control scheme and include it into the simulation model. Morever, some problems concerning TCP performance over ABR service should be examined. This is left for further study.

References

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