Performance Evaluation of FDDI, ATM, and Gigabit Ethernet as Backbone Technologies Using Simulation

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Abstract

As the proliferation of distributed environments continues, the design and architecture of LANs becomes more important. In today's environment a LAN must be both reliable and fast. Bandwidth intensive distributed applications are becoming available every day. Network designers have been moving towards network mediums, protocols, and architectures that can handle the higher bandwidth requirements of today. One of the network architectures currently in use is the backbone LAN. There are several technologies today that can provide this backbone service for interconnecting LANs. A few of these are FDDI, ATM, and Gigabit Ethernet. Each of these different technologies differs in terms of maximum throughput, scalability, quality of service, and migration path. Using simulation software the performance of the different backbone LAN architectures is measured under varying traffic load levels. Comparisons of the results of the simulations are used to evaluate the different backbone technologies. The results obtained allow network designers to gain insight into the performance aspects of ATM, FDDI, and Gigabit Ethernet technologies as backbones for LANs.

Keywords: Gigabit, Ethernet, FDDI, ATM, Performance evaluation, backbone, LAN.

1. Introduction

Local Area Networks today are facing higher demands in terms of both capacity and throughput due to an ever increasing number of devices connected to the network, client/server computing, and the increased speed of client workstations is resulting in the creation of powerful applications in the areas of multimedia and computer graphics that generate a lot of traffic. [4] To combat this problem the backbone LAN architecture has become prominent. In this system, workstations are divided into small LANs that are interconnected via a high-speed connection also known as a backbone. This allows all devices on each of the small networks to communicate with every other device, but increases performance by limiting the number of devices competing for bandwidth on a given LAN. Servers that receive a lot of traffic are also often located directly on the backbone to provide high performance for all users on the LAN. This is the basic architecture that is currently used by the Computer Science Building at the University of North Florida. The LAN of this building was modeled in the simulation software as closely as possible, providing a realistic scenario on which this paper is based. Simulations were run changing the backbone between ATM, Gigabit and FDDI. The traffic run in the simulation is modeled to provide various levels of traffic both on the LANs and across the backbone to a network server. The University does not currently use real-time traffic and the simulation software is not capable of modeling this type of traffic, so this was omitted from the simulation. However, the capability of each architecture to provide this service to workstations will be addressed in the conclusion.

2. Backbone LAN technologies

2.1 FDDI

Fiber Distributed Data Interface (FDDI) is a fiber optic token ring LAN that runs at 100Mbps over distances ranging up to 200km. FDDI consist of two multimode fiber rings. One of the rings transmits data clockwise, the other counterclockwise. This provides redundancy in the event of a break the ring can close and become one large ring [1]. FDDI is based on a token passing scheme similar to token ring (802.5), although FDDI has changes to the scheme that accommodate the 100 Mbps data rate. FDDI defines two types of traffic synchronous and asynchronous. Each station on the FDDI network can be allocated a portion of the total capacity, this is designed to allow for real-time transmission of data. This type of traffic is referred to as synchronous. In addition to this allocated portion stations may transmit data if time allows, this is referred to as asynchronous traffic. Stations may further prioritize the asynchronous traffic into eight levels [2].

2.2 ATM-LANE

Asynchronous Transfer Mode (ATM) is a connection oriented, cell based technology. ATM is designed to meet the following criteria: configurable quality of service, scalability at both the individual host and in terms number of high performance hosts connected, and to facilitate the internetworking of LAN and WAN technologies [2].

LANE provides LAN Emulation for networks that are interconnected via ATM. The purpose of LANE is to convert traffic from the LAN into the ATM protocols and vice versa. Machines connected directly to the ATM network do not require this service. This creates overhead , particularly when communicating across the backbone between two Ethernet machines. An Ethernet frame must be broken up into multiple cells and delivered to the proper network where it is reassembled.

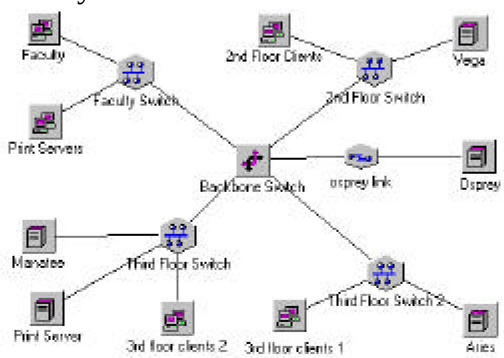
2.3 Gigabit Ethernet

Gigabit Ethernet is designed to provide a smooth migration path for users of Ethernet technologies. All Gigabit products in the marketplace today use a switching technique to control access to the medium. As a result of this the CSMA/CD protocol is not used. Gigabit uses the same frame format as its predecessors. As such it is compatible with both 100BASE-T and 10BASE-T networks. Gigabit Ethernet can run on Category 5 unshielded twisted pair up to distances of 100 meters. For longer runs a fiber optic cable is needed, these runs may be as long as 5km using a single mode fiber [2].

The ability to reuse existing wiring and using the same frame formats allows for a smooth migration path for users currently using other Ethernet technologies.

3. Results

The topology for the simulation was modeled after a building containing machines divided into four LANs. One LAN connects machines in classrooms, a second contains the machines located in faculty offices, and two LANs are student labs. Each of these 4 LANs is interconnected via a high-speed backbone and contains between 12 and 25 workstations and a server. In addition to the LANs, a server that receives a lot of traffic from all machines in the topology is connected directly to the backbone.



The traffic was modeled using bursty data applications commonly used on networks namely FTP, HTTP, and SMTP. Under all network load conditions each of the stations is equally likely to transmit requests to a server. To vary the load on the network, the average size of messages being transmitted was increased. This is shown in Table1.

Table 1 – Traffic load

	Light	Medium	Heavy
HTTP Response Size	1 Mb	2Mb	3Mb
FTP Response Size	100 Kb	1 Mb	2 Mb

A majority of the traffic generated by the workstations is directed toward the server connected to the backbone. A portion of the traffic on each small LAN is directed to the server(s) within the small LAN. This adds realism to the simulation in that all traffic is not transmitted across the backbone, some is local to each LAN. In addition the two LANs labeled third floor in the diagram transmit request across the backbone to servers connected on the other LAN. Overall the traffic model is designed to effectively simulate local traffic moving across the backbone both to request data from a server connected directly to the backbone as well as between machines located on different LANs.

The performance of the backbones was evaluated based on two main criteria: link utilization and average message delay as measured by clients accessing the server on the backbone. The link utilization is measured to determine how the network is handling the load and to give an estimate of growth potential in terms of both traffic and connected workstations.

Figure 1 - Link Utilization

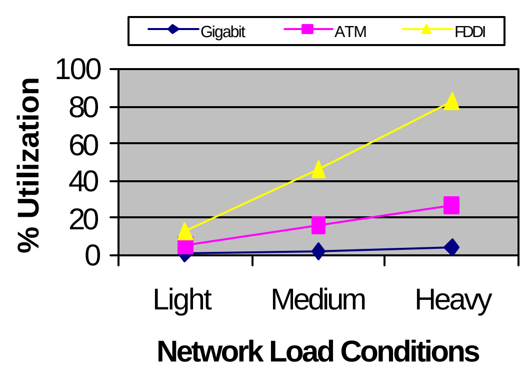


Figure 1 shows the link utilization for each technology under each network load condition. Gigabit Ethernet performed exceptionally well in this area. Under the extreme conditions of the heavy load it utilizing less than 5% of the available capacity. FDDI performed well under the light load, however as the traffic increased the performance of FDDI decreased quickly. Under the heavy load FDDI was operating at slightly over 80% utilization. ATM provided a low level of utilization under all loads and the performance didn't decrease as rapidly as FDDI as the traffic increased. This shows that ATM will scale better than FDDI as the network grows in terms of traffic. The ATM link used to connect the server to the switch was a 155Mbps link, this can be upgraded to 2.5Gbps to increase the capacity of the link.

Figure 2 - Average Message Delay

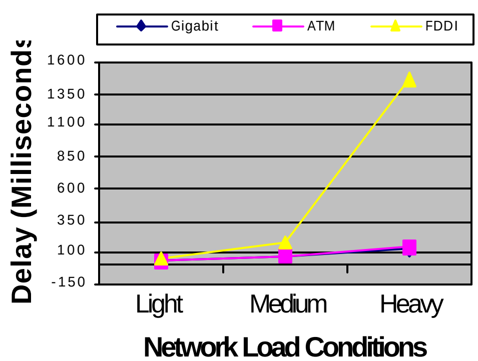


Figure 2 shows the average message delay for message sent to the server on the backbone under each of the load conditions. Under this test ATM and Gigabit Ethernet provide fast message response times. Gigabit Ethernet was marginally faster across all load conditions. FDDI message response times were between 2 and 8 times Gigabit Ethernet depending on the load. As FDDI became saturated with traffic the response times became unacceptable.

On interesting result in response times was between ATM and Gigabit. The difference in response times for large and small messages was approximately the same under each load condition. This is interesting in that it suggests that the overhead of establishing an ATM connection is costly. So Gigabit excels over ATM in terms of large amounts of small messages, however the advantage decreases as the size of the messages being transmitted increases.

FDDI is the most expensive in terms of hardware and implementation costs and the performance was the worst across the board for the simulations. ATM and Gigabit hardware costs are about the same, however ATM experts are more expensive.

4. Conclusion

A main strength of FDDI is its ability to deliver real-time traffic, which was not simulated. This was part of the reason why FDDI did not stack up as well as it may have. The other reason is that FDDI only provides for 100Mbps across the backbone. For the backbones of today and tomorrow it is necessary to provide higher data transfer rates than the networks being connected. The poor performance of FDDI, along with the high cost of the technology does not bode well for the future FDDI in the future in the LAN backbone arena.

ATM has the ability to deliver voice, data, and video. In the future of LAN backbones this will become increasingly important. In terms of performance of bursty data transfers, ATM performed well in the simulation. ATM has another advantage in its domination of the WAN arena. For large organization using ATM to interconnect buildings, issues with training will not be an issue as this cost has already been absorbed. However for small organizations looking only to interconnect LANs in a single building the cost of ATM is a downside.

Gigabit Ethernet has a clear advantage of the other technologies in terms of installed user base and transfer of bursty data traffic [3]. In the simulation its performance was superior across the board to the other technologies. Gigabit does not provide any facilities at the MAC layer for real-time traffic. This would have to be provided in a protocol running at a higher layer if that type of service is required.

When choosing a backbone technology for an organization, the decision between ATM and Gigabit Ethernet, or perhaps another up and coming technology, will need to be based on the current and future needs of the organization, available funds, and technology team expertise.

Any organization looking to provide real-time traffic will want to consider ATM as it is designed to be able to carry voice as well as video. The ability to scale the technology to meet the needs of the organization in the future is especially important in this area.

If cost or raw performance for bursty data traffic applications is the main factor for an organization, then Gigabit Ethernet is the best choice as it provides the best performance at the lowest cost. Gigabit Ethernet will be widespread and will be scalable with the needs of the organization.

For a large organization with an existing WAN using ATM or planning on implementing a WAN in the future, it will more than likely make sense to use ATM as a backbone on the LANs. This configuration provides a smooth integration between each LAN and the WAN at each location.

Unfortunately there is no clear-cut choice for all organizations. With 10Gbps Ethernet on the horizon and ATM able to run at speeds of 2.5Gbps it seems clear that end users will be the ultimate benefactors of these high speed backbones as applications will be able to rely on high speed connections that have not existed in the past. New applications will provide users with real-time video conferencing, voice communications, high resolution imaging all connected real-time to the users desktop.

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[1] Tanenbaum, A., "Computer Networks", Prentice Hall, 1996, pp. 319-322.

[2] Stallings, W., "Local and Metropolitan Area Networks", Prentice Hall, 2000.

[3] Clark, D., "Are ATM, Gigabit Ethernet Ready for Prime Time?", *Computer*, May 1998.