RESEARCH NOTE

PERFORMANCE IMPROVEMENT OF EXPANDED INTEGRATED LOCAL AREA NETWORKS

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Abstract In Local Area Networks (LAN) connected together by bridges, flow control and smooth traffic in the network is very important. However, congestion at bridges can cause intensive loss of received frames. In addition, the received frames are thrown away and have to be retransmitted by the source station, which causes more congestion and massive reduction in the overall network throughput. The network has a series topology in which all the LANs use Token Ring protocol at the presence of voice and data services. In the simulation voice traffic has the priority to access the network over the data traffic. In this paper techniques are introduced to reduce congestion at the bridges and improve the overall performance in the LANs connected through bridges. In the first technique data transmission is allowed during voice transmission by bridges. In the second technique the bridges have higher priority of access. The results show that using these techniques significantly improves network throughput.

Key Words LAN, Bridges, Topology, Transparent, Source Routing

چکیده پدیده ازدحام در شبکه های محلی متصل شده با پلها می تواند باعث تلفات شدید فریمهای دریافتی در پلها شود. در این شرایط؛ حذف فرم های دریافتی در پلها و ارسال مجدد آنها توسط ایستگاهها؛ پدیده ازدحام را تشدید کرده؛ افت کارایی شدیدی را بدنبال دارد. بنابراین کنترل جریان ترافیک و ایجاد ترافیکی روان در سطح شبکه بسیار مورد توجه است. در این مقاله روشهایی برای بهبود کارایی و کاهش تلفات بسته در یک شبکه محلی که توسط پلها به یکدیگر متصل شده اند ارائه گردیده است. شبکه شبیه سازی شده دارای توپولوزی سری است؛ که در آن؛ تمام شبکه های محلی از پروتکل حلقه نشاندار در حضور سرویس داده و صدا استفاده می کنند. در این شبیه سازی ترافیک صدا اولویت بالاتری نسبت به ترافیک صدا در دسترسی به شبکه دارد. دو روش برای بهبود عملکرد شبکه معرفی شده اند. در اولین روش پل می تواند بسته های داده ای را در میان ترافیک صدا ارسال کند. در دومین روش پل دارای اولویت بالایی برای دستیابی به شبکه است. نتایج نشان می دهد که اعمال این روشها بهبود عمده ای بر روی کارایی شبکه ایجاد می کند.

1. INTRODUCTION

The need for higher speed information transmission in small areas such as an office building or a university campus is one of the main reasons for the improvement of Local Area Networks (LAN). However limitations in the number of stations, available bandwidth and physical environment of a LAN, has forced the designers to install few individual LANs and connect them through what is known as "bridges" to cover larger areas and have more stations with higher bandwidth. Bridges act at the second layer of the network and are responsible for passing or discarding the incoming frames. Congestion can occur at the bridges since heavy traffics may be sent to them. Under this condition, discarding the received frames and their retransmission increases the congestion [1,2].

The studies show that under this condition, the network throughput reduces extensively [2]. The evaluation of the expanded LAN behavior is a suitable way to locate the weak points of the network [3].

Few techniques can be employed to smooth the traffic flow at the bridges in order to minimize the delay and packet loss. Some of these techniques are: Dynamic flow control in Token Ring [4], Cut-through bridging for CSMA/CD [5], and High performance MAC protocol for high speed LANs [6].

Bridges introduced so far are: Transparent Bridge (ST) [7], Source Routing Bridge (SR) [8] and Transparent Source Routing Bridge [9]. The ST Bridge has tables for keeping the addresses of all stations and the port number from which the station has been seen. Hence all the routings are done by the bridges. In SR bridges, the routing is done by the stations with transmission of the discovery packets. In TSR bridges, the routing is the same as that of SR but it is done by the bridges themselves. TSR Bridge is a combination of ST and SR bridges and has the advantages of both.

It should be noted that in the presence of integrated traffic (voice and data) in an expanded network, data packets might face large delays. Application of suitable techniques in servicing data packets can significantly reduce packet loss.

In the model presented in this paper three LANs are connected together in cascade and voice and data are being serviced (Figure 1). All LANs are Token Ring LANs and the bridges are of ST types.

The paper includes three parts. The first part explains servicing the packets in an integrated environment. The second part briefly explains the assumptions used in the simulation. And the third part introduces two new techniques and presents the simulation results.

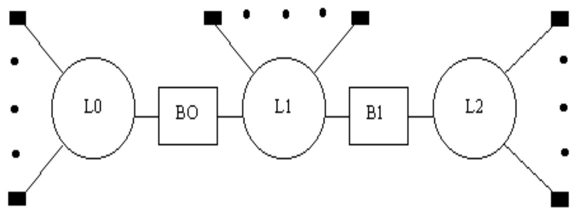


Figure 1. Series topology.

2. INTEGRATED SERVICES

In the Integrated Token Ring protocol, the token moves around the ring and nodes with data packets to transmit the packets in sequence. Since voice traffic is more delay sensitive, it has priority of access over data traffic. This priority is applied in the following manner. If a node has voice packet to transmit and the token is not available, the reservation bit in the passing header is activated. If this bit is already activated, the node cannot make any changes in the reservation bit. When the passing packet reaches its source node, this station is chosen as the controlling station. The controlling station generates a token with its reserve and priority bits activated. Having the reservation bit activated means that stations with voice packets ready for transmission can now transmit their packets upon the receipt of the token and that the ring is in synchronous mode. During this operation no station with data packets is allowed to send its data packets. When the token reaches the station that originally activated the reservation bit, it transmits its packet and inactivates the reservation bit and then passes the token.

This gives the chance to other stations with voice packets to transmit, and to activate the reservation bit. When token reaches the controlling station, it checks the reservation bit, if it is inactivated, then the priority bit is also inactivated and the token is passed. The ring goes into a asynchronous mode and all the stations with data packet can now transmit their data packets on the receipt of the token. The retransmission of data packets restarts from the last node where data transmission stopped. This technique creates a uniform packet transmission among the stations [10].

3. SIMULATION PARAMETERS

All LANs in the network use Token Ring Protocol. Each ring is 1km long and has 5-us/km propagation delays. Every node connected to the ring also causes one bit of delay in the passing frame. Station buffers are considered to be large (120kbytes). Traffic is uniformly distributed on the network. 20% of the generated traffic by each station on a LAN is carried out of that LAN through the bridges, and is called external traffic. The buffer size for each bridge is 25kbytes. A new incoming frame is discarded if the buffer is full. The voice call duration has negative exponential distribution with an average length of 180 seconds [11]. The voice packet length is 128 bits with 80 bits of header added to it. Maximum lifetime of voice packets in the network is 10msec. Packets with life period larger than 10msec are discarded. All the discarded packets are regenerated and retransmitted by their source stations. Data is generated with Poisson distribution and its length has negative exponential distribution, with an average length of 1000 bytes [4]. The bit rate of each LAN is 10Mbps.

Now let us define some expressions:

Throughput: average number of bits transmitted per second divided by the channel bit rate.

Bridge Throughput: the ratio of packets serviced by a bridge to the packets entering it.

Bridge Queuing Delay: the average time a packet remains in the bridge buffer.

Packet Delay: the average period of time a packet stays in the network, i.e., from the time it is generated at the source station to the time it reaches its destination.

The simulation software was developed using C++. In this simulation study, three LANs were connected together in series. This configuration was referred to as the primary network (NET).

4. METHODS

The two techniques presents in this paper for performance improvements are as follows:

Transmission of Data Packets During Voice Traffic by the Bridges According to the integrated Token Ring protocol, if a bridge or any other station has a voice packet to transmit and the token is not available, it activates the reserve bit in the passing frame. Then the ring goes into the synchronous mode of operation and the voice packet is transmitted. Since voice traffic has priority of service, as long as stations have voice packets to send, the ring stays in the synchronous mode. In this case no node is allowed to transmit its data packet. Now a new definition for bridge operation is given in this paper, that is, when the ring is in

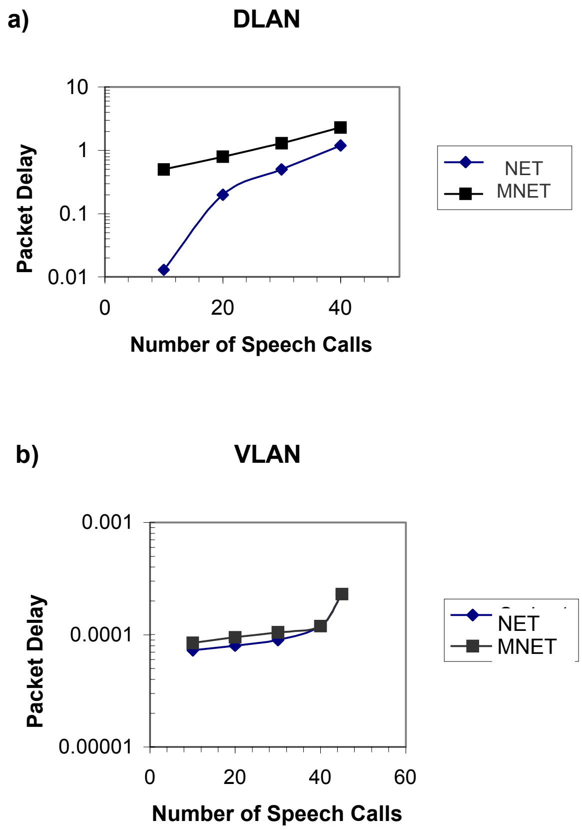


Figure 2. End-to-End delay versus number of speech calls for the two networks in a) Asynchronous mode b) Synchronous mode

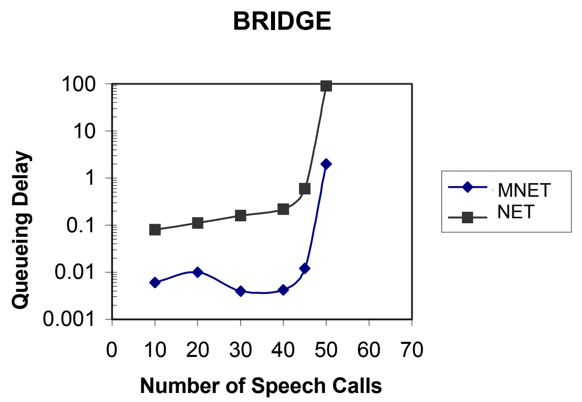


Figure 3. Queueing delay versus number of speech calls for the two networks.

the synchronous mode and the bridge receives the token and it has data packet to transmit, it sends it, otherwise, it is allowed to transmit a data packet during synchronous operation. In this way, during the heavy voice traffic, data traffic flow gets smoother.

This configuration is referred to as Modified NETwork (MNET).

Figure 2a shows the packet delay in the network. Since the number of bridges are much fewer than the number of stations in the network and traffic at the bridge is usually heavy, giving service to data packets in between the voice packets can significantly reduce data queue length and avoid congestion. It also avoids heavy losses of data packets and reduces data packet delay.

Figure 2b shows voice packet delay in the network. When few calls are in progress, voice traffic passing through the bridge is light. Hence bridges have more time to give service to data packets. On the other hand, the number of stations with voice calls in progress are so few that can be made compatible with the number of bridges giving service to voice and data, hence voice packet delay increases slightly. With increased voice traffic, bridges practically spend more time to give service to voice traffic; therefore, in this case voice packets delay in the two networks is almost the same. Voice packet loss is also the same in both NET and MNET. This is because voice packet loss mainly occurs during heavy voice traffic and this is when the voice packet delay is also significant.

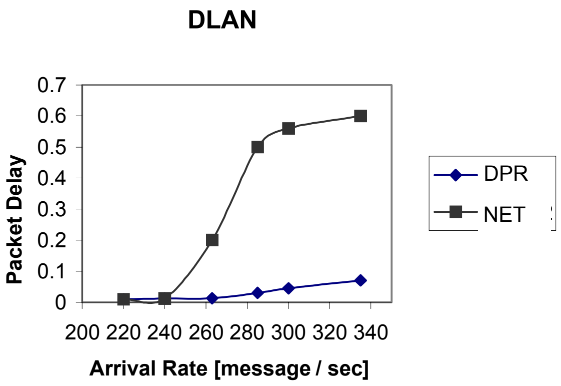
Throughput improvement in LANs is due to smoother traffic flow at bridges. Figure 3 shows the data queuing delay at the bridges of the two networks. With gradual increase in the voice traffic, the data packets queuing delay at the bridges reduces. This is due to the fact that with increase in the voice traffic, the network stays more in the synchronous mode and the bridges have more chance to give service to data traffic. This occurs when voice traffic is not very heavy and the number of voice packets reaching the bridges is few. It should be noted that in this situation only the bridges can send data packets in between voice packets and therefore increase in voice traffic reduces the chance of data packet transmission from stations to bridges. Increase in data packets being serviced by bridges reduces the data queuing delay. When the voice traffic in the network is very heavy, bridges mainly give service to voice traffic and data packet delay increases.

High Priority Bridges The other technique that gives a major improvement in the expanded LANs network performance especially during heavy voice traffic is to give the bridges higher priority in accessing the LANs. Bridges can only use the higher priority for a particular service when a ring is in that mode of transmission. This means that a bridge like other stations can only send voice packets during synchronous transmission and data packets during asynchronous transmission but with higher priority of access with respect to other stations. If a bridge has a packet to transmit and the token is not available, the reserve bit in the control field of the passing frame is activated. After the passing frame reaches its source station, the token is released, and only stations with higher priority are allowed to send their data. Since only bridges have such a priority they can have the free token at their disposal for as long as they have packets in their output queue ready for transmission. At the end, the token is sent back to the station of which the packet transmission was interrupted.

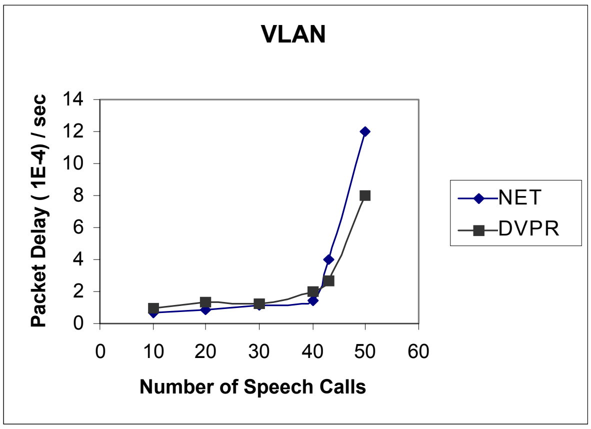
This technique is referred to as Data PRiority (DPR) network. A comparison between the performances of such a network with that of NET is presented below.

Figure 4a shows the data packet delay in DPR. With increase in data traffic, data packet delay also increases, but this increase is less than the increase in NET in which there is no priority of service for bridges. Note that since priority is only for data service, these changes have no negative effect on voice traffic since in integrated token rings; voice service has higher priority than this priority. Throughput and delay for voice service is the same in DPR and NET.

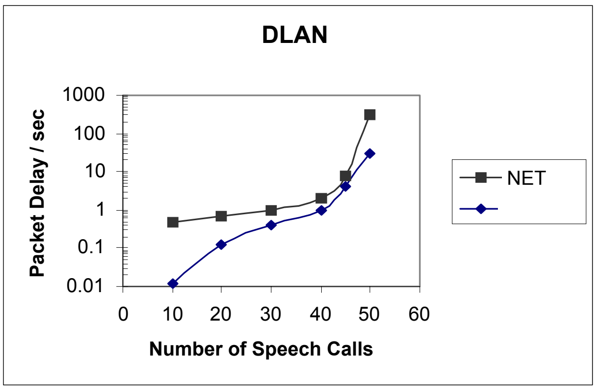
The priority is now applied to both services, i.e., Data and Voice Priority (DVPR). Changes are according to the number of calls in the network. The message arrival rate is assumed to be equal for both networks. Figure 4b demonstrates the voice packet delay for both systems. When the numbers of calls are small, throughput and delay for packets are almost the same. This is because voice packets have high priority, so they are being serviced very quickly and their queue length stays short. But with increase in the number of calls in the networks, external traffic of voice service also increases and the queue length grows and consequently packet loss increases. In this case giving priority to the bridges with respect to other stations reduces the amount of packet loss and hence improves the voice service



(a)



(b)



(c)

Figure 4. End-to-End delay versus arrival rate and number of speech calls for the two networks
(a) Data packet delay for NET and DPR
(b) Voice packet delay for NET and DVPR
(c) Data packet delay for NET and DVPR

throughput. Delay for voice packets is also lower in the second network as compared to the priority network.

Figure 4c shows the changes in the data packet delay with respect to the number of calls in the two networks. Packet delay reduction in the second network is quite significant. It is noticed that giving priority to bridges for their data packet service has no negative effect on voice service because voice service has higher priority. Since bridges act as bottle neck and congestion points of the network during heavy traffic, the priority of service at these points has a major role in reducing the congestion and fewer packets are lost and hence the overall network performance is improved.

5. CONCLUSION

This paper studies the performance of expanded Token Ring LANs in the presence of voice and data. Rings are connected in cascade via bridges and techniques to improve the network throughput and reduce delay are presented.

Bridges are considered as points where congestion occurs. So the aim is to reduce congestion at the bridges and have smoother traffic flow in order to improve the network throughput and to reduce the average delay.

In the first technique, servicing of packets at the bridges is modified. In this case when network is in synchronous mode, if the bridge does not have a voice packet to transmit, it would send its data packet. This is referred to as MNET. The results show that during heavy data traffic and light voice traffic, the network performance improves significantly.

The second technique gives a special priority but lower than that of voice packet transmission to bridges and is referred to as DPR and DVPR. This also reduces congestion at the bridges and smoothes the traffic flow. It also causes significant improvement in the overall network performance.

The above-mentioned changes are only at the bridges and have no effect on the stations. They are easily applicable, and significant network performance improvement is achieved at little overall cost.

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