MTR: A MODIFIED TOKEN RING PROTOCOL AND ITS PERFORMANCE

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Abstract

Devising efficient and high performance communication protocols for Computer networks is a challenging issue. This paper presents a new Modified Token Ring protocol (MTR) for token ring LANs. The idea behind proposing this protocol is to improve the performance of the *Standard (Traditional)* Token Ring protocol (STR). The advantage of the MTR protocol over the STR protocol is its capability of bypassing idle stations in the ring. This is achieved by utilizing two of the reserved bits *in* the Frame Status (FS) field. The utilized bits are called Transmission Reservation bits (TR-bits). The TR-bits operate as an implicit token while they are circulating around the ring with their associated packet. Our simulation experiments show that the MTR protocol has higher ring throughput and lower packet delay than that of the STR protocol. For high traffic conditions the MTR protocol has shortened the packet delay down to 45% as compared to the STR protocol. Throughput improvement provided by the MTR can reach about 6% as compared to the STR protocol. The MTR protocol is characterized by its fairness, simplicity and cost-effectiveness.

Index Terms : Token Ring, LAN, Protocol, Performance Evaluation, MTR, Delay.

I. Introduction

There has been a great deal of interest in Local Area Networks (LANs) due to their attractive cost/performance ratio, multiuser capabilities, and common resource sharing capabilities [1]. LAN networks differ from Wide Area Networks (WANs) in their high channel bandwidth and short packet delay [2]. LANs can be broadly classified based on geometry into two basic types: Broadcasting networks such as CSMA/CD and Ring networks [1], [3], [4]. Ring networks are attractive for many applications and have some advantages over bus structures networks such as higher channel utilization and bounded packet delay [5], [6], [1].

A token ring network has the basic structure of all rings. Stations in ring networks are connected together by point-to-point links in a circular fashion. IEEE standard committee developed the Token Ring standard protocol and published it as ANSI/IEEE standard 802.5 [7]. In the standard token ring protocol, a free token is passed from station to another whenever all stations are idle. When a station wants to transmit a packet, it is required to seize the free token and remove it from the ring before transmitting. Hence, one station can initiate transmission at a given instant. A packet transmitted by a station is relayed single-directionally from station to station until it reaches its destination. The destination station copies the packet, marks it "received", and continues to relay it down the ring. This packet is removed out of the ring network when it circulates back to the sender station. Then a free token is regenerated and passed to the next station.

As can be seen from the operation of the IEEE standard protocol the token spends most of its time idly circulating around the ring when traffic is light. Moreover, a station that wants to transmit must wait for a free token to start transmitting. Passing a free token between idle stations would degrade the performance of the ring network. Qu et al in [8] have tried to alleviate this degradation by allowing a station to transmit if it receives either a free token or a data packet destined to it. Their protocol provided performance improvement over the standard token ring protocol, however, the implementation of their model requires extra hardware such as input and output buffers which would affect the cost/performance ratio.

In this paper we present a new Modified Token Ring (MTR) protocol for token ring network. The idea behind this protocol is to improve the performance of the standard ring networks. In the MTR protocol the problem of passing a free token between idle stations is optimized. The MTR protocol is simple, fair, requires no extra hardware and has better performance than the standard protocol. In section II the protocol operation is described. Section III presents the model assumptions and parameters. The results are discussed in section IV. Finally, section V has the conclusion.

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II. Protocol Description

In the IEEE 802.5 token ring standard protocol passing a free token to idle stations degrades the performance of the ring network. Our goal in presenting the new MTR protocol is to minimize this degradation by

SD	AC	ED

(a) IEEE 802.5 and MTR Token Format.

SD	AC	FC	DA	SA	INFO	FCS	ED	FS

(b) Frame Format for IEEE 802.5 (STR) and MTR Protocols.

A	C	R	R	A	C	R	R

(C) IEEE 802.5 Frame Status (FS) Format (8 bits).

A	C	TR	R	A	C	TR	R

(d) MTR Frame Status (FS) Format (8 bits).

SD = Starting Delimiter	ED = Ending Delimiter
AC = Access Control	FS = Frame Status
FC = Frame Control	A = Address Recognized Bit
SA = Source Address	C = Frame Copied Bit
INFO = Information	R = Reserved Bit
FCS = Frame Check Sum	TR = Transmission Reservation Bit

Figure 1: Data Packet and Token Format.

skipping the idle stations. Hence, shorten the packet delay and enhance the utilization of the ring channel. To achieve this goal we utilize two bits of the reserved bits in the Frame Status (FS) field of the data packet. We call these bits the **TRANSMISSION RESERVATION BITS (TR-BITS)** as shown in Figure 1. Any station transmits a data packet initializes the associated TR-bit with "0" value. While the packet circulating around the ring, each station has a data to transmit checks the associated TR-bit and modifies it to "1" if non of the previous stations already modified it. Then the station that sets the TR-bit can transmit its own data packet. More details and illustrations are described in the following steps:

1• When a station transmits its own data packet, it sets the associated TR-bit to " 0 ".

2• A free token is circulating around the ring when all stations are idle.

3• When a station receives a free token, it transmits its own packet if it has a ready packet to transmit. If the station does not have data to transmit, it just passes the token to the next station on the ring.

4• If a station receives a packet not addressed to it, the station directly forwards the received packet on the ring. If the associated TR-bit=0 and the station has a ready packet to transmit, it modifies the associated TR-bit to "1" and starts transmitting its own packet.

5• When a station receives a data packet addressed to it, it copies the received packet while forwarding the packet on the ring and checks the associated TR-bit if it has a ready packet to transmit. If the associated TR-bit=0 the station modifies the TR-bit to "1" and transmits the ready packet.

6• The sender station removes its transmitted data packet after it loops back and at the same time checks the associated TR-bit.
- If the associated TR-bit=0 and the station has a ready packet to transmit, it starts transmitting its own packet.
- If the associated TR-bit=0 and the station has nothing to transmit, it generates a free token and passes it to the next station.
- If the associated TR-bit=1 the station recognizes that another transmission is initiated by another station on the ring and no need to perform any action.

From the above steps, The MTR protocol gives a station a chance to transmit when a free token is received or when a data packet with an associated TR-bit=0 passes through its interface. Using the TR-bit in each data packet gives the MTR protocol the ability to skip the idle stations. The first station, relative to the last sender, that has a ready packet to transmit always takes the next turn to transmit. This definitely would decrease the waiting time at each station. As can be seen from the description of the protocol operation, passing a free token to the idle stations is minimized such that it may completely eliminated if the network is heavily loaded. Hence, packet delay is shortened.

III. Model Assumptions and Parameters

To evaluate the performance of computer systems and networks three techniques are often used. Namely, simulation, analytical, and measurement techniques [9-12]. Token ring networks have been analyzed in many papers [13-16]. In these papers packet delay expressions are derived under various approximations. In this paper we evaluate the performance of the MTR protocol using the simulation technique. In this section we describe the assumptions and the parameters used in the simulation models which is developed by using SIMSCRIPT II.5 simulation language.

In this model we assume that the number of stations on the ring is fixed for all simulation experiments we have conducted. The stations are spaced on unidirectional ring so that the distances between any two consecutive stations are equal. The ring length is considered 1000 meters with a bandwidth of a 5 Mbit/sec. The propagation signal speed is assumed to be 200 meters/micro second. Each station offers a station latency of 1 bit delay. The arrival process to each station is poisson with average arrival rate λ packets/sec. The inputs to the ring network is balanced such that arrivals are equally likely at any station. The packet length is assumed to be exponentially distributed with a mean of L bits. Each station has an infinite buffer size and services packets at its queue using First Come-First Served discipline. Non-exhaustive service policy is assumed so that a station is allowed to transmit one packet when it has a permission to transmit.

The input parameters to the model are: number of stations N, average arrival rate λ packets/second, and the mean packet length L bits. While the performance measures include packet waiting time in the queue, total packet delay, and throughput of the ring network.

IV. Results and Discussion

Various simulation experiments have been performed to evaluate the performance of the proposed protocol. The results obtained for the MTR protocol and Standard Token Ring protocol (STR) are compared and discussed in this section. In this work, we consider the throughput, average packet waiting time, and average packet delay time as performance measures. Throughput of the ring network is defined as the total number of transmitted data per one second. We define the mean waiting time of a packet as the time that the packet spent in a queue waiting for service. While the average packet delay is measured from the arrival time of the a packet until the time it is completely transmitted to its destination. The average packet delay includes the average waiting time plus the service time. The performance of the MTR protocol has been evaluated for different number of stations (N) and different packet lengths (L) as shown in Figures 2 through 12.

Delay performance of the MTR and STR networks are shown in Figures 2 through 7. In Figure 2 we show the average packet delay against the mean arrival rate λ for packet length L=256 bits. The Figure shows that the MTR protocol has shorter average packet delay for various number of stations (N=5,10, and 20) as compared to the STR protocol. As the arrival rate λ increases the difference in average packet delay between both protocols increases. The average packet delay in both protocols increases with the increase of the number of stations in the networks.

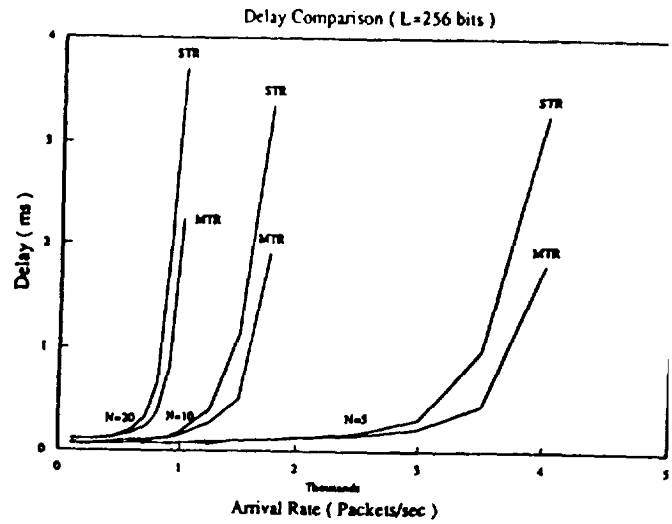

Figure 2: Average Delay Comparison for L=256 bits and Various Number of Station.

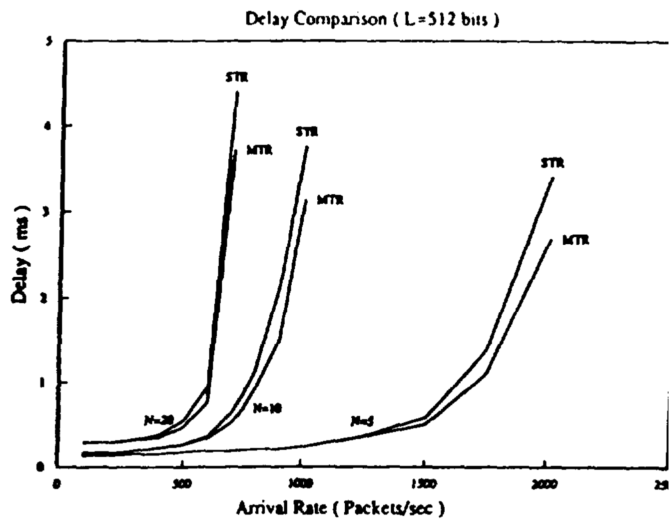

Figure 3: Average Delay Comparison for L=512 bits and Various Number of Stations.

Figures 3 and 4 depict the average packet delay comparison for average packet length L=512 and 1024 bits respectively. We notice from the figures that the average delay of the MTR protocol is shorter than that of the STR protocol especially for high values of arrival rate λ. However, the average delay of the MTR matches that of the STR when the traffic load is light. The results shows that the percentage reduction in average packet delay provided by the MTR protocol over the STR protocol vary between 0 to 44.8%.

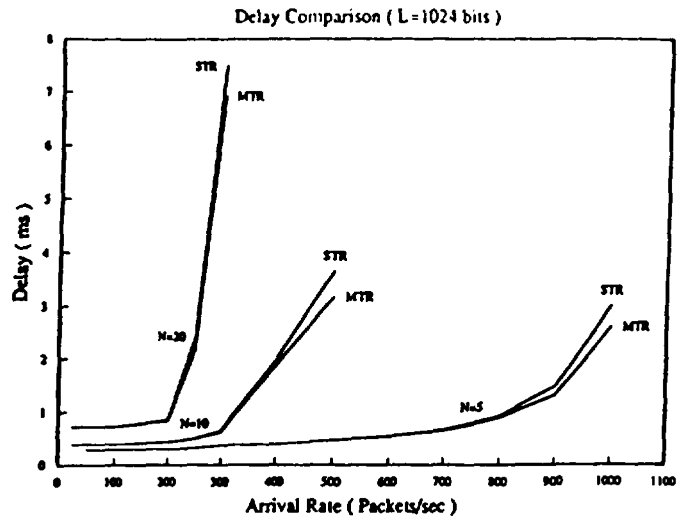

Figure 4: Average Delay Comparison for L=1024 bits and Various Number of Stations.

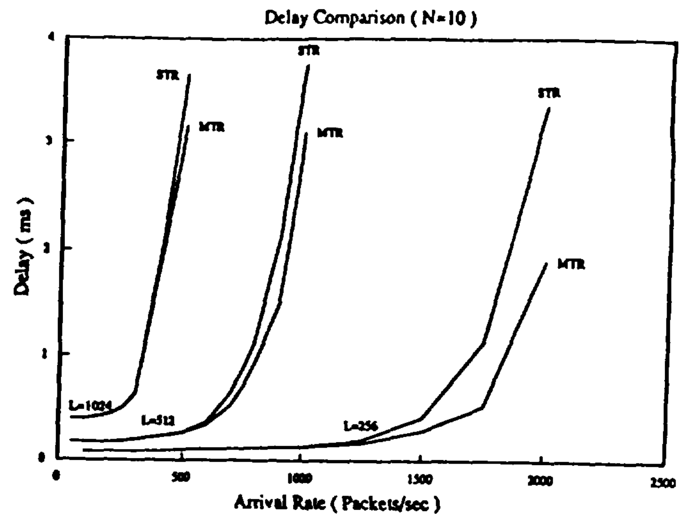

Figure 6: Average Delay Comparison for N=10 and Different Values of Packet Lengths.

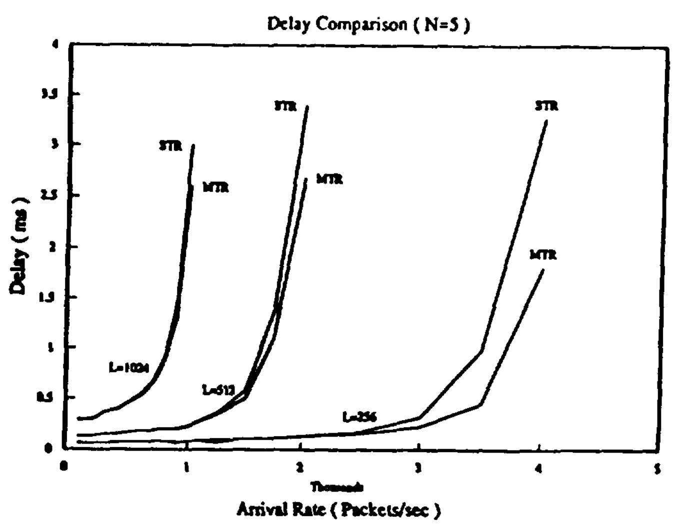

Figure 5: Average Delay Comparison for N=5 and Different Values of Packet Lengths.

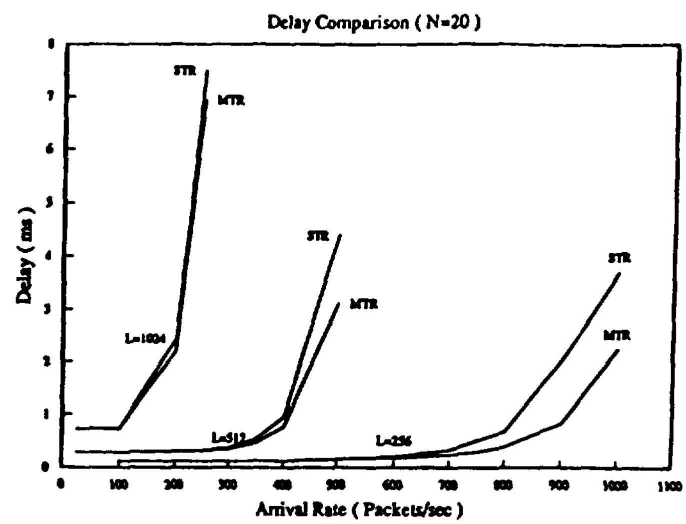

Figure 7: Average Delay Comparison for N=20 and Different Values of Packet Lengths.

The effect of the varying the packet length is shown in Figures 5 through 7. In Figure 5 we fix the number of stations (N=5) and vary the average packet length. Again the MTR protocol shows better delay performance over the STR protocol. Both protocols provide shorter average packet delay for shorter packet length. The difference in average packet delay decreases as the average packet length increases as shown in the figure. The delay comparisons for 10 and 20 stations are shown in Figures 6 and 7 respectively. The MTR protocol shows shorter average packet delay for all cases.

Figure 8 depicts the average waiting time (queuing time) of a packet against the arrival rate λ for average packet length L=512 bits and various values of N. The Figure shows that the MTR protocol has shorter average packet waiting time than that of the STR protocol. As the arrival rate increases a packet spends more time in a queue and the difference in average waiting time between both protocols increases. This result is also shown in Figure 9 which shows the comparison of average waiting times for L=1024 bits.

The throughput of both protocols are compared in Figures 10 through 12. Figure 10 compares throughput of both MTR and STR protocols for 20 stations and different average packet lengths. As in the delay performance measure case, the MTR has improved the ring throughput

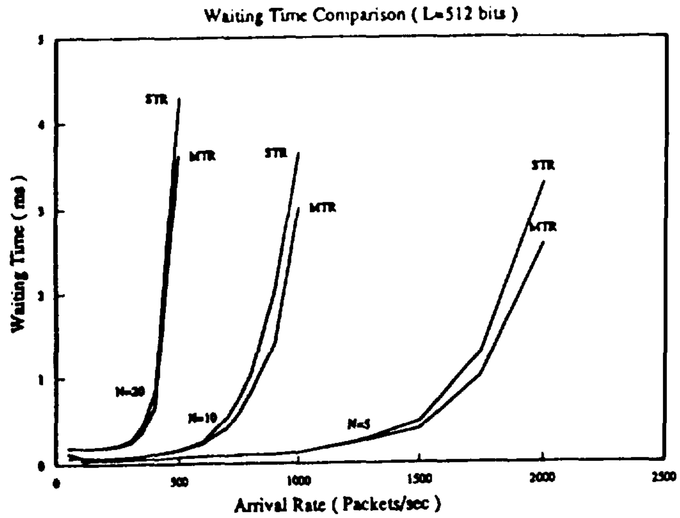

Figure 8: Average Waiting Time Comparison for L=512 bits and Various Number of Stations.

as compared to the STR protocol. The improvement increases with the increase of the arrival rate λ. This is also shown in Figures 11 and 12. The percentage improvement in throughput provided by the MTR over the STR protocol vary from 0% in low traffic load to 5.97% at high traffic load conditions.

As shown from the simulation results the MTR protocol provides shorter delay performance and better throughput as compared to that of the STR protocol in most cases. Since the TR-bit presents in data packets the MTR protocol shows better performance when the traffic load is high. For low traffic load the performance of the MTR protocol is slightly higher than the performance of the STR protocol.

V. Concluding Remarks

A Modified Token Ring (MTR) protocol for token ring LANs is presented in this paper. The performance of the MTR protocol has been studied, analyzed, and compared with the performance of the standard IEEE 802.5 protocol (STR) using SIMSCRIPT II.5 simulation language. By using the TR-bit in the data packet the MTR protocol has minimized passing a free token between idle stations in a ring network. The simulation results show that the MTR protocol has shorter average packet delay than that of the STR protocol especially when the ring network is heavily loaded. The maximum reduction in the average delay that has been provided by the MTR protocol over the STR protocol reaches 45%. Moreover, the MTR protocol has provided better ring throughput as compared to the STR protocol. A throughput improvement of 6% is achieved by the MTR protocol over the STR protocol in its best case. In addition to its good performance, the MTR protocol is simple, does not require any extra hardware, and has fair characteristics.

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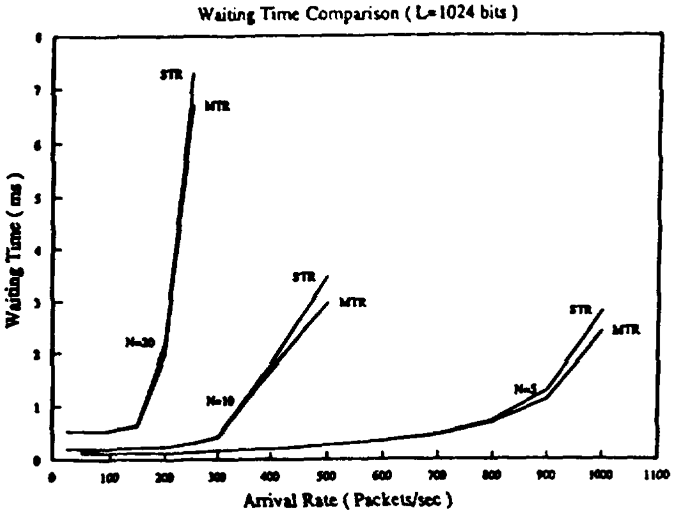

Figure 9: Average Waiting Time Comparison for L=1024 bits and Various Number of Stations.

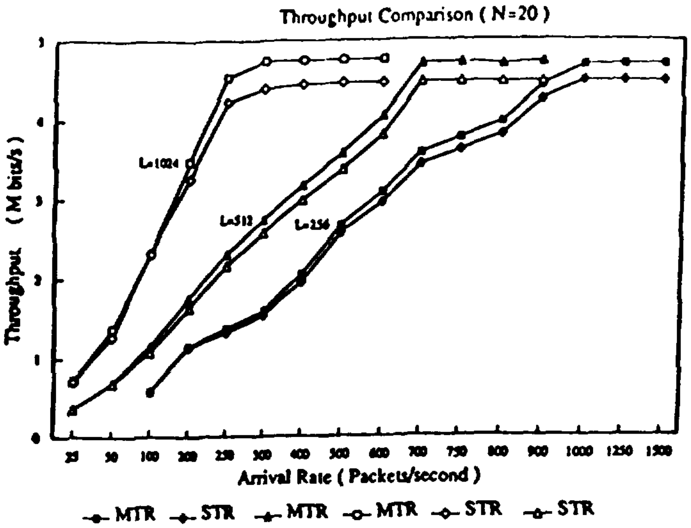

Figure 10: Throughput Comparison for N=20 and Different Values of Packet lengths.

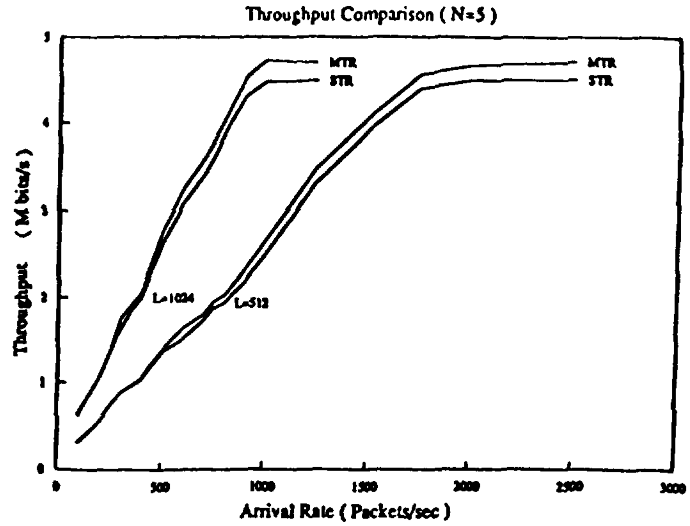

Figure 11: Throughput Comparison for N=5 and Different Values of Packet lengths.

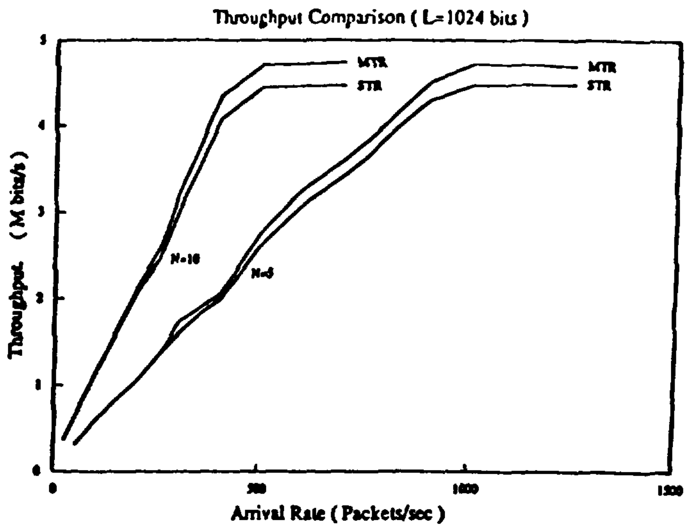

Figure 12: Throughput Comparison for L=1024 bits and Various Number of Stations.