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Rotation Time Optimization of FDDI Networks

Harsimranjot jassal[1,*], Hardeep Singh Saini[2], Amit Wason[3]

[1]Singhania University, Jhunjhunu, Rajasthan, India
[2]Indo Global College of Engineering, Mohali, Punjab, India
[3]Hindustan Institute of Technology &Management, Ambala, Haryana, India
*Corresponding author: jotharsimran@gmail.com

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Abstract The Fiber Distributed Data Interface can be implemented as a higher speed version of a token ring and is designed to work over fiber. This standard is also designed primarily for peer-to-peer communications but can certainly be used for the polled traffic modem. In this paper, the techniques and the rules which should be followed so as to optimize the performance of the FDDI networks have been discussed. The response time of the FDDI systems is dependent upon the transition delay and propagation delay. The transition delay can be decreased by increasing the bandwidth and propagation delay can be decreased by increasing the group velocity.

Keywords: *efficiency, frame time, ring latency, token time, TTRT value*

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1. Introduction

The Fiber Distributed Data Interface (FDDI) is a newly proposed standard for fiber-based computer network. It is designed for a 100Mbit/s local area network (LAN) using fiber optics as the transmission medium [1,2]. FDDI, a token passing ring based on fiber optic technology, is versatile, high performance networking standard and its operation is similar to IEEE 802.5 token ring standard [3,4]. FDDI uses a dual ring topology and some other mechanisms, such as station bypass, to enhance fault tolerance, share the network bandwidth in an orderly and efficient manner.

Token rings were originally developed to avoid the situation of data collisions. Essentially, a special code is passed from one node to the next, giving the node that has received this special code (token) permission to transmit data. The node removes the token from the data path, inserts its address and the address of the node where it would like to send its data, followed by the data it wants to send.

This data packet is re-transmitted around the ring and each node along the line checks to see if it is the receiving node or the transmitting node. If it is the receiving node, it copies the packet to the node to which it is connected, adds an acknowledgement that it has received the data and re-transmits the data to the next node. When the data packet has made its way back to the transmitting node, this node removes the packet from the ring and passes the token to the next node in line. One of the primary differences between the token ring (IEEE 802.5) and FDDI is that FDDI passes the token to the next node immediately following the transmission of its packet as opposed to waiting for the packet to make it way around ring before releasing the token. This can make poll time of FDDI much quicker, if the remote node has a response ready as soon as it is queried. This transmission scheme has some latency associated with it because each node must read enough of the data to determine if it was the sender of the data before it re-transmits the data to the next node downstream [6].

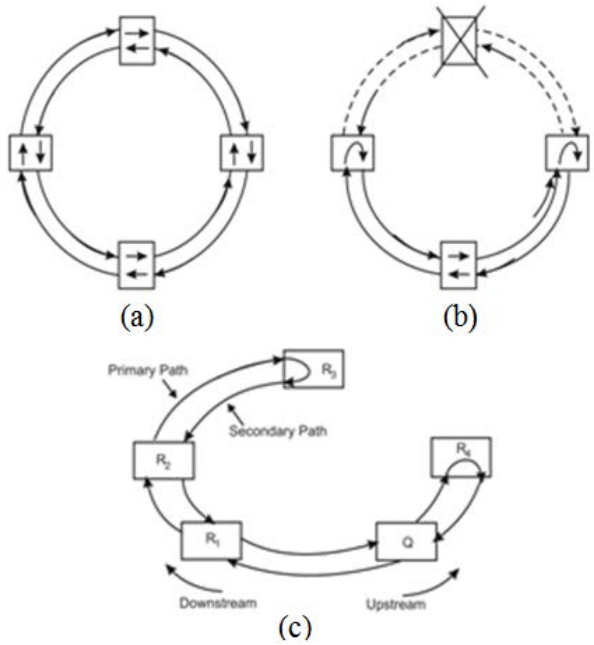

Figure 1. (a, b and c): Dual Token Ring

For the token ring to work in a fault tolerant mode, it must know whether it is physically connected to its neighbor [6], and the sender must examine the acknowledgement bit added by the receiver before it removes the packet from the ring [7]. If a node is not connected to its neighbor, it re-transmits the token it just received back in the direction from which it came, and the packet travels around the ring in the opposite direction shown in Figure 1. The cable break may occur in such a location that the packet must travel through the master node again before it reaches the receiver node; thus the master must examine the acknowledgment bit before removing the packet from the ring and passing the token to the next node. If a node does not receive a token within some maximally specified time, it generates a token claim algorithm whereby a special frame is generated and passed around the ring. If this special frame makes its way back to the originating node, that node now has the token. This makes the token ring useful even if more than one cable break occurs in the ring because each of the subsections can still pass data between the connected nodes.

1.1. Parameters of Time Token Protocol

(a) TRT (Token Rotation Time): It is the time taken for a token to go around or it is a time of last rotation of token or is the time interval between two successive receptions of the token by a station [10].

$$TRT \le ActiveNodes \times THT + RingLatency \qquad (1)$$

(b) TTRT (Target Token Rotation Time): It indicates the expected time of each token rotation [9]. The value of TTRT is negotiated during initialization and set to the maximum desired rotation time.

For ***asynchronous traffic*** i.e. Computer Data. Applications that do not have time constraints use the asynchronous mode [10].

$If TRT > TTRT\left(token is late\right)$: No Transmission;

$If TRT < TTRT\left(token is early\right)$:Transmission limited to $THT = TTRT - TRT$

For ***synchronous traffic*** i.e. Voice Data:

Transmission, but THT is small and fixed so: worst case $TRT < 2TTRT$

Synchronous frames are given higher priority over asynchronous frames [9].

(c) THT (Token Holding Time): It is a maximum time a station may hold a token.

(d) Station Delay: It is time needed for a station to read and regenerate.

$$Station\ Delay \le THT$$

(e) Ring Latency: It is time taken by bit to go around. It is combination of total propagation delay and sum of station delays.

The performance of an FDDI LAN depends upon configuration and workload parameters such as the extent of the ring, the number of stations on the ring, the number of stations that are waiting to transmit, and the frame size. In addition, one key parameter that network managers can control to improve performance is the target token rotation time (TTRT). Setting the TTRT at 8 milliseconds (ms) provides good performance over a wide range of configurations and workloads [5]. Fuzzy FDDI approach proposed by Kirov [8] can be implemented into each network node to control the access delay, THT, throughput and thus improving the network performance. Cobb and Lin [9] introduced a modified timed-token FDDI protocol. Both approaches can slightly improve the network performance however; they cannot achieve multi Gb/s throughput and full utilization of the bandwidth of the optical fiber.

2. Optimization of TTRT in FDDI Networks

For optimization of the performance of FDDI networks, specified setting the TTRT value should be taken into consideration. First of all, the token rotation time is calculated which can be as long as two times the target. Thus, a synchronous station may not see the token for $2 \times T$. Therefore synchronous stations should request a TTRT value of one half the required service intervals. TTRT should allow at least one maximum size frame along with the synchronous time allocation, if any which can be shown by the equation (2).

$$\begin{aligned} TTRT &\ge RingLatency + TokenTime \\ &+ Max.Frametime + Synchronousallocation \end{aligned} \qquad (2)$$

The equation-(2) states that minimum value of the TTRT is explained by equation (3)

$$\begin{aligned} TTRT &= RingLatency + TokenTime \\ &+ Max.Frametime + Synchronousallocation \end{aligned} \qquad (3)$$

The maximum size frame on FDDI is 4500 bytes (0.360 ms), the maximum ring latency is 1.773 ms and the token time is 0.00088 ms. This rule, therefore, prohibits setting the TTRT at less than 2.13ms plus the synchronous allocation. Over allocating the synchronous bandwidth, in contradiction to this rule for requisite frame size, results in unfairness. Also, no station should request a TTRT less than T_{min}, which is a station parameter. The default maximum value of T_{min} is 4 ms. Assuming that there is at least one station with T_{min}=4 ms, the TTRT on a ring should not be less than 4 ms. Another parameter to be considered is that, no station should request a TTRT more than T_{max}. The default minimum value of T_{max} is 165 ms. If there is at least one station with T_{max}=165 ms, the TTRT on a ring cannot be more than this value. In addition to these rules, the TTRT values should be chosen to allow high-performance operation of the ring [11].

3. Simulation and Results

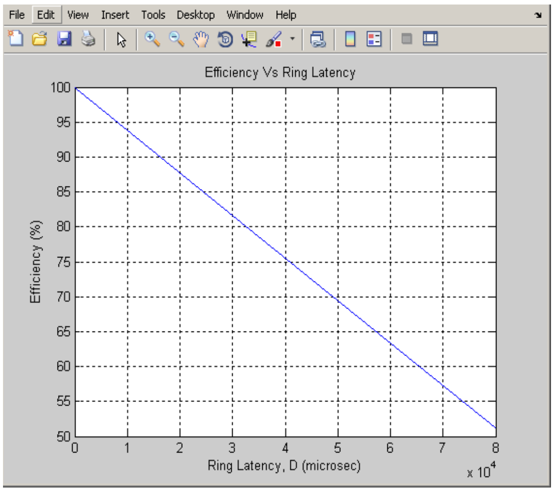

Figure 3.1. Efficiency vs Ring Latency for T=165ms and D=80ms

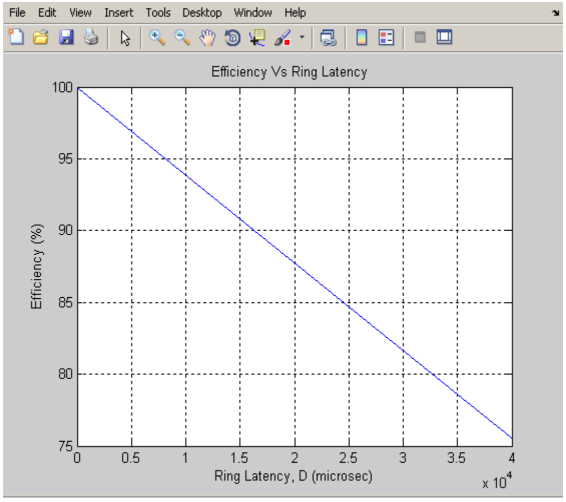

Figure 3.2. Efficiency vs Ring Latency for T=165ms and D=40ms

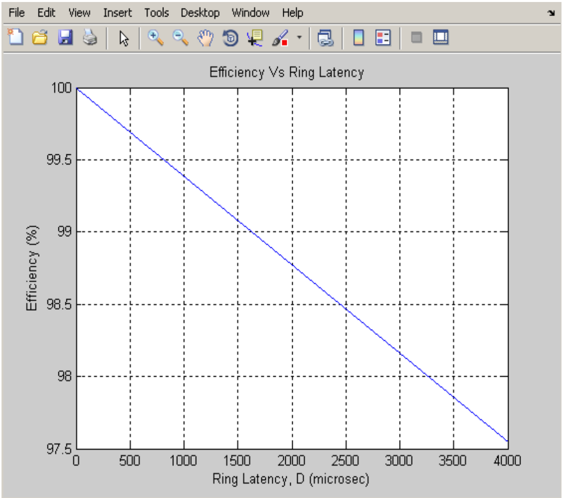

Figure 3.3. Efficiency vs Ring Latency for T=165ms and D=4ms

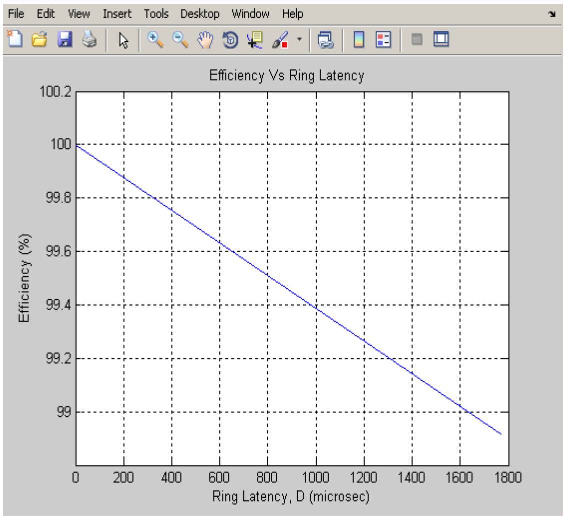

Figure 3.4. Efficiency vs Ring latency for T=165ms and for optimized latency

Keeping the above point into consideration we have calculated some results shown in Figure 3.1-3.12 on software MATLAB 7B of Mathworks. Initially we have fixed the value of maximum value TTRT to165; number of stations is fixed to 100 and the ring latency of the system is varied as 80, 60, 40, 20, 4, 1.773 ms. These results show the optimized results for the efficiency when the TTRT value is 165 ms and the ring latency (D) is fixed to 1.773ms. Thus we can optimize the FDDI network by fixing the value of TTRT value to be equal to 165 ms and reducing the ring delay or ring latency to as low as 1.773ms.

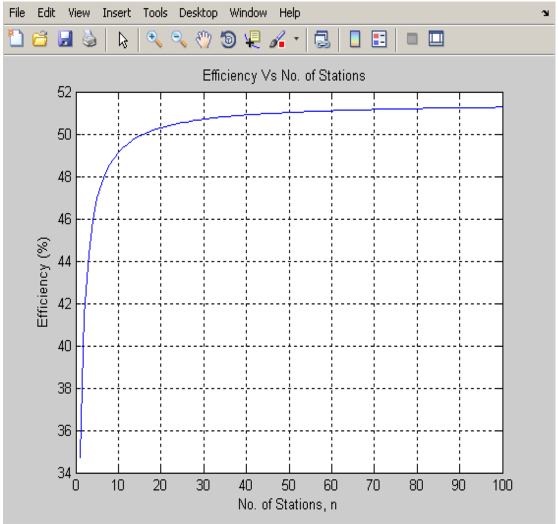

Figure 3.5. Efficiency vs No. of Station for D=80ms and T=165ms

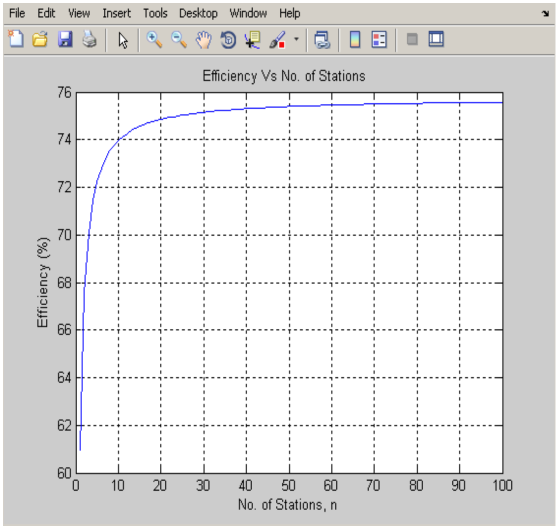

Figure 3.6. Efficiency vs No. of Station for D=40ms and T=165ms

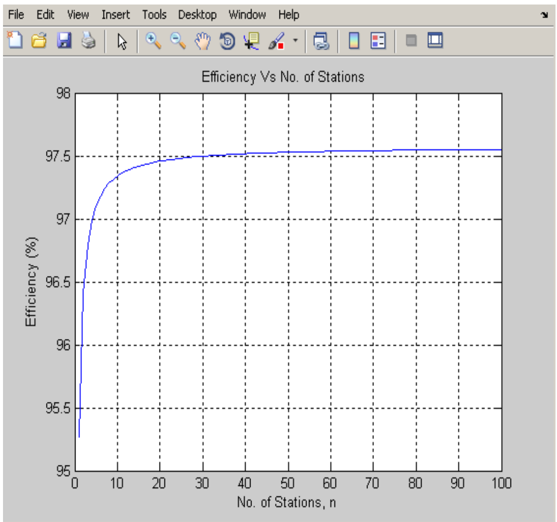

Figure 3.7. Efficiency vs No. of Station for D=4ms and T=165ms

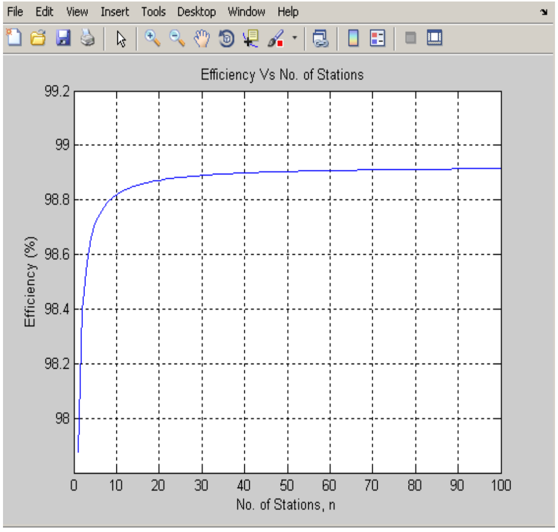

Figure 3.8. Efficiency vs No. of Stations for T=165ms and for optimized latency

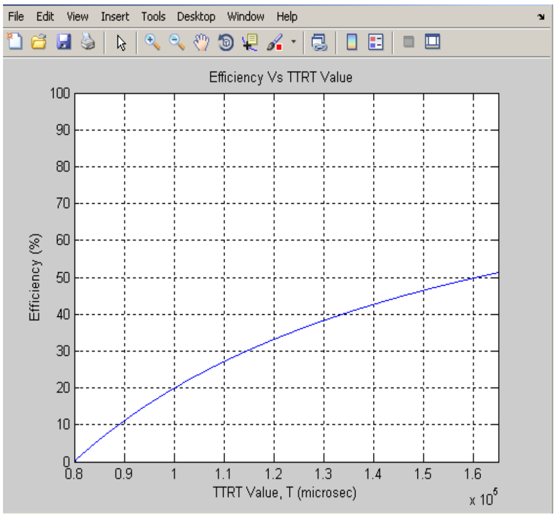

Figure 3.9. Efficiency vs TTRT Value for D=80ms and T=165ms

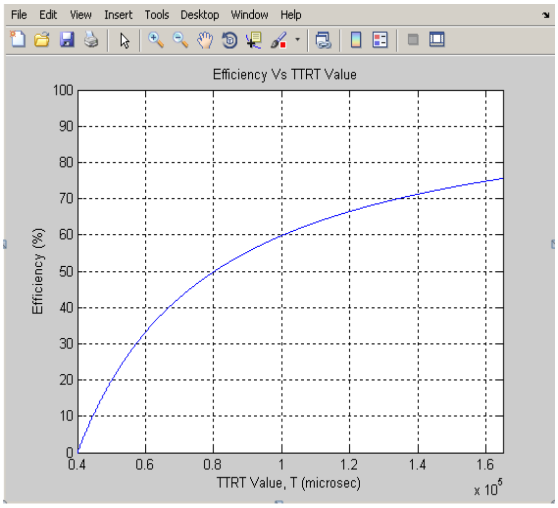

Figure 3.10. Efficiency vs TTRT Value for D=40ms and T=165ms

The results in Figure 3.1-3.12 show the relationship of the efficiency with ring latency, TTRT value and number of stations. We have fixed the value of TTRT to its maximum value which is optimized to 165ms and varied the value of ring latency and reduced its value from 80ms to 4ms and then 1.773 ms which is the optimized value of ring latency. The combination of maximum value of TTRT value (i.e. 165ms) and optimized value of ring latency (1.773ms) has optimized the results to produce the high efficiency of FDDI networks. With these optimized results the value of Efficiency was produced to be 98.9%. In this way we have optimized the performance of FDDI network by optimizing the value of efficiency with TTRT value and latency. This optimization technique results in improved performance of the FDDI Networks. Some of the optimization steps include the adjustment of TTRT value and ring latency. The synchronous stations should request a TTRT value of one half the required service intervals. TTRT should allow at least one maximum size frame along with the synchronous time allocation, if any. The maximum size frame on FDDI is 4500 bytes (0.360 ms). The maximum ring latency is 1.773 ms and token time is 0.00088 ms.

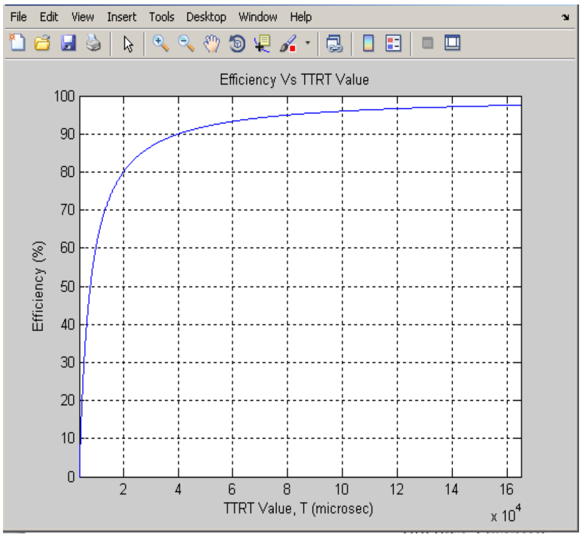

Figure 3.11. Efficiency vs TTRT Value for D=4ms and T=165ms

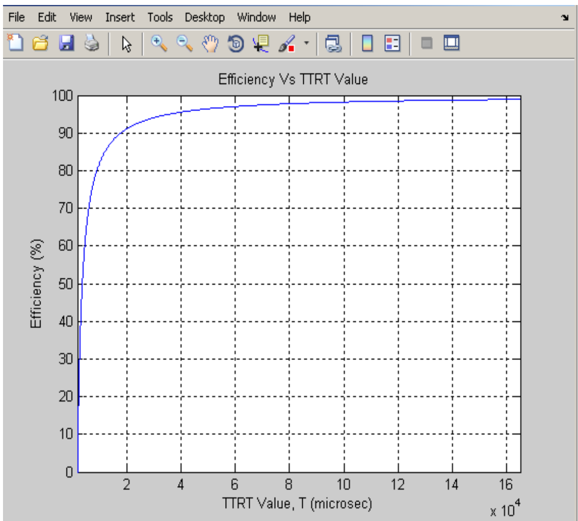

Figure 3.12. Efficiency vs TTRT for T=165m sand for optimized latency

4. Conclusions

The performance of FDDI network can be increased by controlling the ring latency and by minimizing it. The response time can be improved by decreasing the transition delay and propagation delay. The combination of maximum value of TTRT value and optimized value of ring latency has optimized the results to produce the high efficiency of FDDI networks. The results have proved that the efficiency of the networks can be improved by following rules which have been suggested in this paper. The efficiency of the FDDI networks has been improved from 50% to 99%.

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