PERFORMANCE EVOLUTION OF HIGH SPEED NETWORK CARRYING MULTIMEDIA

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ABSTRACT
The performance evolution of a high-speed network, called Fiber Distributed Data Interface (FDDI), carrying video and data traffics is tackled. Also, a proposal aspect to improve the FDDI performance for supporting the asynchronous traffic that suffers low throughput and excessive delay is presented. It is well known that the FDDI network is based on Timed Token Rotation (TTR) protocol for controlling the token rotation time. With TTR protocol, packets are grouped into two classes: synchronous class, which represents video, and asynchronous class, which represents the ordinary data. The study of the performance evolution and the proposal aspect is done by means of computer simulation. The simulation results confirm that the proposal aspect provides FDDI network more powerful for carrying video and data traffics.

KEYWORDS: *FDDI, FDDI`s MAC protocol, video and data traffics.*

I. INTRODUCTION

Many multimedia applications are distributed in nature and involve networking and communications. Examples of such applications are video on demands (VoD) for training and education, conferencing, and computer supported collaborative work. There is a great interest in carrying these distributed multimedia applications over existing network (which have been designed originally to carry conventional data applications, such as database access, file transfer, etc.) [1]. It is a known fact that the real-time (video) communication requires high-speed transmission and performance guarantees, and end-to-end delay to be less than 100-200ms [2,3]. The FDDI high speed network is the suitable for real-time communication because of its high speed transmission and performance guarantees it provides [4-8]. The FDDI is also overcome the bandwidth saturation problem of the 10Mbps Ethernet and the 4 –16 Mbps Token Rings due to its high speed transmission [5]. FDDI is one of the High-Speed Local Area Networks (HS-LANs) standard [9], and provides a data rate of 100Mbps[8]. The basic topology is a dual (counter-rotating) ring consisting of a primary ring for transfer and a secondary ring for redundancy. Access to the ring is by a timed-token mechanism similar to that used for token bus [11].

The Media Access Control (MAC) layer is one of the FDDI`s four layers, defines addressing, scheduling, and routing of data. It is also communicate with higher layer protocols, such as TCP/IP, SNA, IPX, and DECnet. It operates according to the so-called *TTR* Protocol. During ring initialization process, a protocol parameter called Target Token Rotation Time *(TTRT)* is determined, and that indicates the expected target token rotation time. Each station is assigned a fraction of the *TTRT* known as Synchronous Allocation *(SAi),* and that represents the maximum permitted time for a station number *i* to transmit its real-time messages (i.e., digital video) whenever it receives the token. Meanwhile, the Token Rotation Time *(TRT)* controls the transmission of non-real time messages (i.e., data packets) by measuring the time between successive token arrivals at a station. When a station receives the token, the value of *TRT* is copied into Token Holding Time *(THT)*, that is only if the token arrived early, then the station can transmit its non-real time messages until the *THT* expires or all its data packets are transmitted, whichever occurs first [12,13]. As mentioned above, the FDDI network provides both bounded transmission delays and guaranteed bandwidth for real-time traffic. This is because the transmission delay controlled by the ring's *TTRT*, which guarantees each station to have a chance to transmit its real-time messages at least once every *(2*TTRT)* units of time (in the worst case). It also assures the average time between two consecutive token`s visits to a node not to exceed the *TTRT*. The bandwidth of real-time traffic for a station *i* is guaranteed by *SAi*.

II. A RELATED WORK

An extensive research has been conducted on FDDI networks, where the objectives were mainly focused on maximizing the throughput and minimizing the delay to guarantee meeting the individual message deadline. E. A. Khalil in [14] proposed a new protocol of FDDI's MAC to control the maximum *TTRT* in the worst case, the new protocol of FDDI's MAC increasing both the throughput of asynchronous traffic and the capacity of synchronous sources. Wang, and etc. [15,16] proposed a new approach for allocating synchronous bandwidth, which can be easily implemented in practice. A. P. Jayasumana, and etc. [17] presented a model can be used to evaluate the throughput of FDDI networks for different priority threshold values, the model can also be used to determine the control parameters of the priority scheme to meet the throughput requirements of different classes of traffic. Sijing Zhang and etc in [18-27] have done extensive research in which conducted on using the timed token protocol to guarantee timely transmission of messages in a communication environment. In [28] Ching-Chih Han and etc., were formally proven that there did not exist any optimal local Synchronous Bandwidth Allocation (SBA) scheme, they also proposed an optimal global SBA scheme. Daoxu Chen and etc. in [29] first they proposed a new taxonomy of SBA schemes based on the underlying strategy used to partition the synchronous bandwidth, second they presented an analysis of the timing properties of the FDDI-M protocol, using the Worst Case Achievable Utilization (WCAU) as the performance metric. Y Ofek and etc. in [30] described and evaluated a protocol for integrating two types of traffic on the MetaRing architecture, the integration mechanism is functionally equivalent to the timed-token function in FDDI, which is a shared media ring protocol. There are many related works and researches were studied different applications of allocating synchronous and asynchronous bandwidths in FDDI networks, and related researches were confirmed that the *TTRT* is the key network parameter that network manager can use to optimize the performance of the FDDI ring network [31-62].

In this paper the performance characteristics of the FDDI network carrying video and data traffics is studied. The effect of the system parameters such as video packet length, data traffic intensity on the network performance is discussed. The maximum number of real-time traffic the can be carried by the network is also discussed. The proposal aspect for improving service to data traffic is included. The next section describes network architecture. The traffic models and assumptions are discussed in section 3. Section 4, explains the proposal aspects, followed by the simulation results in section 5, finally section 6, and presents the conclusion.

III. NETWORK ARCHITECTURE

3. A. Assumptions

The network is simulated for FDDI ring network with N stations and 92Km length. All stations are uniformly distributed on the ring, i.e., the station to station propagation delay is the same for all station. Each station has a latency of 0.6μs and the latency of the link is the same as the propagation delay of light through the fiber which is 5.085μs/Km [63]. According to the FDDI standard, the channel speed (C) is 100Mbps and the maximum packet size is 4500 bytes including header (28 bytes), and thus, the maximum packet transmission time is (36Kb/100Mbps) 0.36ms [64].

3. B. Network Configuration

The network consists of N nodes connected as point-to-point links forming a ring as shown in Figure 1. A special bit pattern called ***token*** circulates around the ring providing access control among the active nodes. We consider that the ***ring latency*** is *Trig* , which represents the movement time of the token around the ring without any disturbance by any nodes on the network.

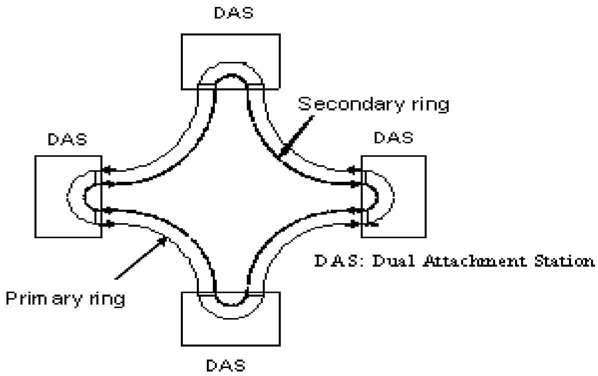

Figure 1 FDDI Network

3.C. FDDI`s Medium Access Control Operation

The FDDI`s *MAC* operates for N stations numbered 1 to N using the *TRT* mechanism. The stations' access to the ring is controlled by the following protocol:

1-With the network`s initialization process, each station is announced a Target Token Rotation Time (TTRT), which equals one half of the request transmission delay (Treq) of its synchronous traffics. The lowest value of (Treq) amog al lstatons is assigned to ring`s TTRT. Then, each station have synchronous traffic should assign a portion of the TTRT to transmit its synchronous packets. The portion of TTRT, denotes bySAi, is greater than or equal to zero.

2- There are two timers at each station namely, Token Rotation Time (TRT), and Token Holding Time (THT). With the first rotation of the token, there is no chance for transmitting any packet. All stations are initialized the following parameters: TRTi = TTRT, THTi = 0, and LCi = 0, (Where i indicaes the station`s 'number, and LC denotes late counter).

3- Both TRTi and THTi counters count down. However, when TRTi reaches zero before the token arrives at station i, the TRT is rest toTTRT and the token is marked as late (i.e., TRTi = TTRT, and LCi = LCi+1). Then the TRTi starts again to count down and LCi begin incremented by one whenever TRTi expires. Noted that, if LCi > 1, the ring should reinitiate its process [12].

4- The station which captures the token is the only sation has the right to transmit its packets. The transmission time of the packet is controlled by the timers, meanwhile the packet in transmission progress will not be interrupted until the transmission of the packet is completed. The response of the station that seize the token depends on the arrival time of the token which may be early or late. It is considered early if LCi = 0, and late if LCi > 0 at the time of its arrival. In case of early arrival, the following actions take place: i) THTi = TRTi; ii) TRTi= TTRTi; iii) For a duration equals to SAi the station i tansmits its synchronous traffics, or upto the transmission of the hole message, whichever occurs first.; and iv) The station i enables its THTi to count down, and begins transmitting asynchronous traffics (if any) until THTi reaches zero or the transmission of the whole packets, whichever occurs first. It is important to mention here that if, there is a bandwidth (SAi) belongs to synchronous traffic not used by the station, that bandwidth can be used to transmit asynchronous traffics, only if the token arrives early. In case of late arrival, the following action take place: i) LCi = 0; ii) TRTi counts down upto expire (it is to be noted here that TRTi not reset as in the case of token arrives early); iii) For a duration equals to SAi the station i trasmts its synchronous traffics (if any) or upto the transmission of the whole packets, whichever occurs first; and iv) The asynchronous traffic will not transmitted.

5- Station i passes the token to the next station (i + 1), and so on.

IV. TRAFFIC MODELS AND ASSUMPTIONS

4.A. Stream Traffic

Figure 2 illustrates the block diagram of a station, which encodes and sends a video stream over a communications network [1,2,65]. A frame is taken in the video camera, and sent as an analog signal into the frame grabber, where it is digitized. Then it is compressed by the encoder. The data produced by the encoder is passed to the station which packetizes the encoded video stream, and sends it over

the network. We consider that video streams are encoded according to a coding standard such as *H.261* [66], or *MPEG* [67]. The encoding rate *(V)* is considered to be *V*= 1.5Mbps for high quality video conferencing.
The sending station uses a fixed video packet length denotes as *Pv* in bits. Consequently the packets are Generated regularly every *Gp* second (where $Gp = Pv/V$ *sec.).*

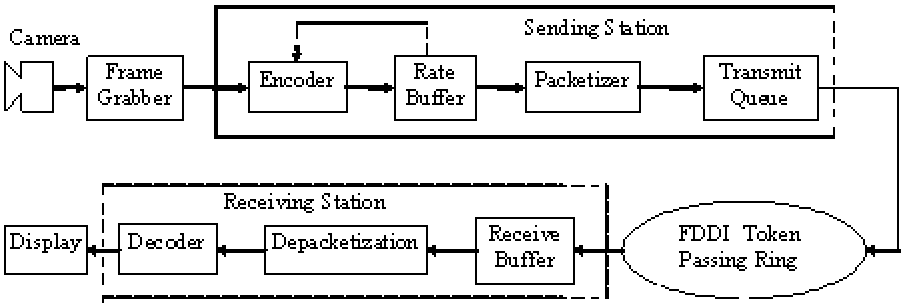

Figure 2 Block Diagram of a Station Which Encodes and Sends a Video Stream

The maximum queuing delay until a video packet reaches the top of its queue is *Qv-max*. The transmission time of a video packet is *Tv* second (where $Tv=(Pv + H)/C$ sec., *H* is the packet header which equals 28bytes, and *C* is the data rate which equals 100Mbps). The maximum transmission delay of a video packet (*Dv-max*) can be given by the following: $Dv\text{-}max = Gp + Qv\text{-}max + Tv + Ds,d$ sec, where *Ds,d* represents the propagation delay between source *(s)* and destination *(d)* stations. Here, it is to be mention that the video packets are required delivery within a bounded delay (*Dbound*). This means that, the video packets that exceeding the bounded delay considered lost. The probability of loss (*Ploss*) of a video packet is given by: $Ploss = prob\ (Dv\text{-}max > Dbound)$.

4.B. Data Traffic

As described in [2,65] a data source is characterized by its message size (*Md*) and its average message interval time (μd). We assume that, a data source generates fixed messages with uniformly distributed interval times. If a message is longer than a maximum data packet size *(Pd)*, it is divided into as many packets as needed. In that case, the packets belonging to the message are placed into the transmit queue as a bulk arrival. The total load of the network can be adjusted by varying the interarrival time (μd). That is, if the total number of data sources is *Nd*, and the arrival rate of data message is λ in message per second (message/sec.), then the total data load (*Td*) over the network can be given by: $Td = \lambda * Nd * Md$ b/s [68,69]. The maximum data packet transmission delay (*Dd-max*) can be given by: $Dd\text{-}max = Qd\text{-}max + Td + Ds,d$ sec. Where *Qd*-max is the maximum queuing delay faced the target data Packet reaches the top of its queue. *Td* is the transmission time of a data packet (where $Td = (Pd+H)/C$ *sec*.). The normalized data throughput (ρd) (data traffic intensity) of the network can given by: $\rho d = Td / C = (\lambda * Nd * Md)/C$.

V. THE PROPOSAL ASPECT

In the proposal aspect, we assume that there are N stations on the ring numbered from 0 to N-1. The token circulates among all the N stations of the ring in a round robin fashion. The stations` access to the ring is then controlled by the following protocol [70]:

1- Each station declares its *TTRT* which equals to *Treq*, instead of one half of it. The smallest value among them is selected as the ring`s *TTRT*. Each station has synchronous traffic is then assigned a portion of *TTRT* to transmit its synchronous messages. Let $SAi \geq 0$ denotes the portion of *TTRT* that assigned to station i to transmit its synchronous messages.

2- Each station has two timers: Token Rotation Timers *(TRT)* and Token Holding Ring *(THT).* During the first token rotation, no packets are allowed to be transmitted and the following parameters are initialized at each stations: $TRTi = TTRT$, $THTi = 0$, and $LCi = 1$. Note that *LCi* is set to 1 in order to ensure that there is no transmission of asynchronous packets during the second token rotation.

3- Set a new parameter called total Asynchronous Time *(Ta*), represents the total time used to service asynchronous packets through a complete cycle of the token to be $Ta \geq \alpha TTRT - Tring$. This can be realized by setting $Ta = TTRT - Ts - Tring$, (where Ts is the bounded time used for transmitting asynchronous packet $Ts = \sum SAi$). If $Ts \leq (1-\alpha)\ TTRT$, otherwise $Ta = \alpha TTRT - Tring$. Where α is a reserved portion of the *TTRT* allowed for transmitting asynchronous packets, in the worst case, plus the time requested to circulate the token around the ring once without transmitting any packet, such that $(Tring/TTRT) \leq \alpha \leq 1/2$.

4- The *TRTi* counter always counts down, meanwhile, the *THTi* counter counts down only when the station i is transmitting or forwarding asynchronous messages. Whenever the *THT* counter of any station reaches zero before the token arrives it, the token is marked as late by incrementing the station`s late counter *(LCi)* by one. Also, whenever the *TRT* counter of any station reaches zero before the token arrives it, the ring recovery process is initialized.

5- Any station which has the token is eligible to transmit its packets. The packet transmission time is controlled by the timer. The station is permitted to transmit a packet only if the transmission can be completed before the timer *(THTi or SAi)* expires. Whenever station i receives the token, its response depends on whether the token is early late. The token is considered to arrive early to station i if its $LCi = 0$, and late if its $LCi > 0$ at the time of its arrival.

A- If the token arrives early, the following status takes place:

i) $TRTi = TTRT$.

ii) If the station has synchronous packets, it transmits them either within a span of time equals to *SAi* , or until all the synchronous packets are transmitted, whichever occurs first.

iii) The station i enables its *THTi* counter (i.e., it starts counting down) and begins transmitting asynchronous packets until *THTi* reaches zero or all its asynchronous packets are transmitted, whichever occurs first. Note that, if a station doesn`t use the guaranteed synchronous bandwidth *(SAi),* the remaining bandwidth can be used to transmit asynchronous packets.

iv) *THTi* is reset to *Ta* in order to compute the total time used to service asynchronous packets during the next rotation up to receive the token.

B- If the token arrives late, the following status takes place:

i) $TRTi = TTRT$.

ii) $LCi = 0$,

iii) The station i can transmit synchronous packets (if any) for either a maximum time *SAi*, or until all the synchronous packets are transmitted, whichever occurs first.

iv) The asynchronous packets will not be transmitted.

v) *THTi* is set to *Ta* (i.e., $THTi = Ta$).

6- The station i passes the token to the next station $(i + 1)$.

VI. SIMULATION RESULTS

An extensive simulation study has been carried out. However, in this paper the focus only on the effects of packet length and number of video sources as parameters on the various network performances. All the measures are for the given values of MPEG (Moving Picture Expert Group) coding rate V=1.5Mbps, maximum bounded delay $Dv\text{-}max$ = 30ms, and audio packet loss probability $Ploss \leq 0.1\%$.

Figure 3 shows the delay versus *Pv* for various ρd. Initially with short *Pv*, the delay is very high this is because the huge number of packets are generated and waiting for transmission with the short packet length. However, as the *Pv* increases the delay decreases upto the minimum delay (which corresponding the optimal packet length) reaches the delay increases as *Pv* increases due to the long delay for the generation of video packet.

Figure 4 indicates *Nv-max* versus *Pv*, for various bounded delays *Dv-max*, and packet loss probability $Ploss \leq 0.01\%$. It is to be mentioning that as the *Dv-max* increases the *Nv-max* is also increase. This is, because high delay resulting from heavy load, so as *Dv-max* increases *Nv-max* is also increase.

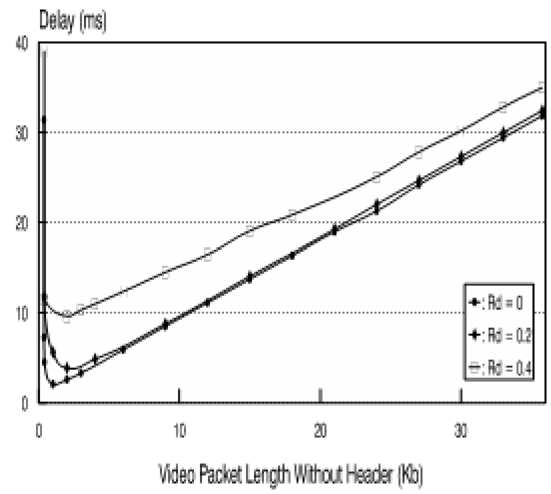

Figure 3 Average Transmission Delays (Nd=20, Nv=40, Md=1KB, Pd=1024B)

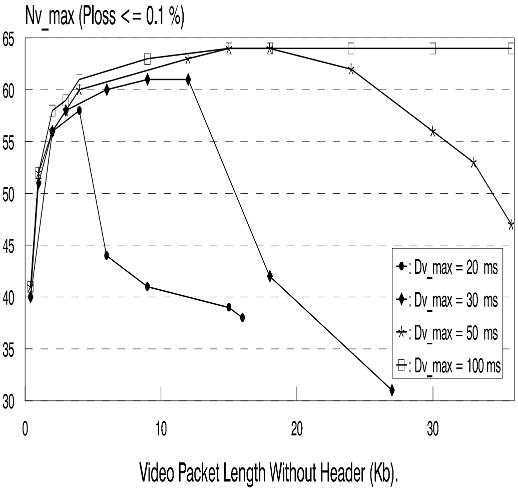

Figure 4 Maximum Number of Video Sources versus Pv.

Figure 5 shows the *Nv-max* versus *Pv* for various ρd (data traffic intensity) and fixed bound delay *Dv-max* = 30ms. *Nv-max* increases as the *Pv* increases upto the saturation limit of the network reaches (depends upon the value of ρd), *Nv-max* decreases with the increase of *Pv*. This is because the optimal packet length has sensitive effect on the maximum network capacity, however, initially with the short *Pv*, *Nv-max* increases upto the optimal packet length reaches (correspond to the saturation limit), after that, *Nv-max* decreases as *Pv* increases. The effect of ρd is very clear as ρd increases *Nv-max* decreases, this is due to the contribute of data traffic with the video traffic. It is to be mention here that, the bounded delay *Dv-max* = 30ms the maximum number of the video sources can be carried by the network reaches to 63-64 audio sources and this compared well with the standard FDDI, which can carried up to 66 video sources (100Mbps/1.5Mbps).

Figure 6 shows the data throughput versus *Nv* for various values of ρd . It is to be noted that as ρd increases the data throughput is also increase. Meanwhile, as *Nv* increases the data throughput decreases this is, because the video traffic has highest priority for transmission than data traffic; and at the ring initialization process, the FDDI guarantees a pre-specified value of *SAi* at each synchronous, however, the total bandwidth for video traffic increases as *Nv* increases, resulting in the bandwidth for data traffic decreases, that problem has been solved by our proposal aspect.

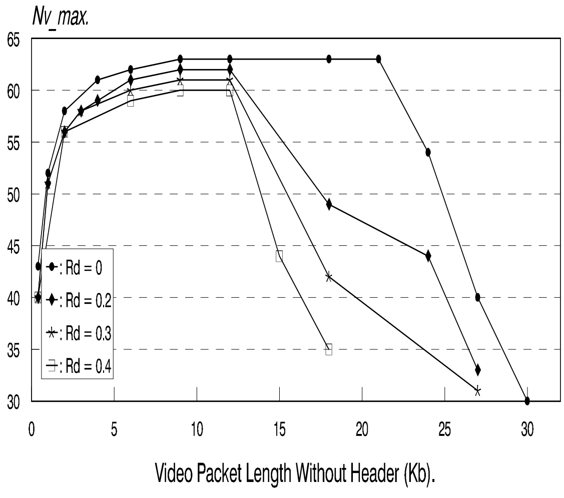

Figure 5 Maximum Number of Video Sources versus Pv for Various ρd

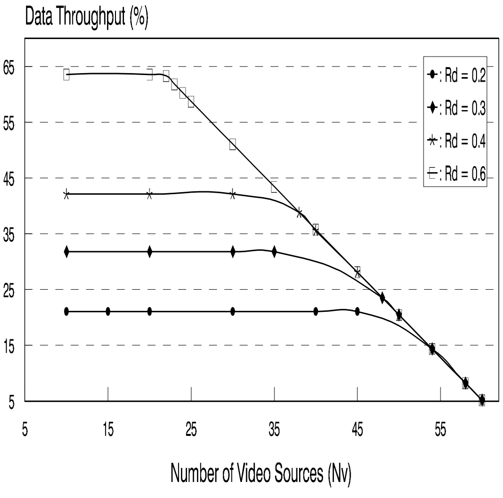

Figure 6 Data Throughput versus Nv for Various Values of ρd

Figure 7 illustrates the throughput characteristics of asynchronous traffic for standard FDDI and our proposal aspect. The Figure shows that the achievable throughput of our proposal aspect is higher than that of the standard protocol. However, with our proposal aspect as α increases, the achievable throughput is also increase. This is because the reserved portion of the *TTRT* for transmitting asynchronous packets increases as α increases. This performance can be seen more clearly in Figure 8, which shows the average token rotation time for the standard FDDI and our proposal aspect under the same conditions of Figure 7. Obviously, the shorter average token rotation time, the longer transmission bandwidth that used for the token passing, resulting in, short bandwidth for asynchronous traffic. The difference between asynchronous throughput is more pronounced with the increasing of the average token rotation time.

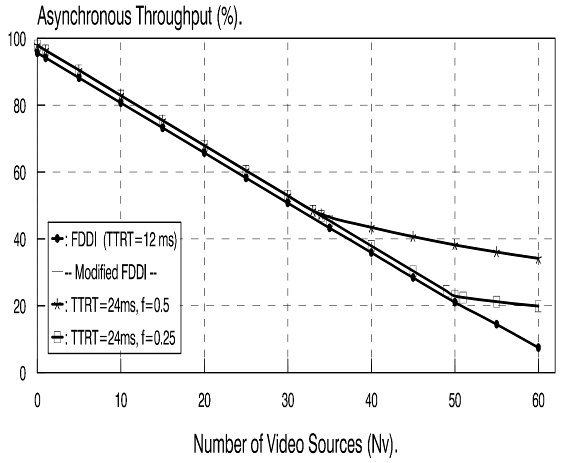

Figure 7 Throughput Characteristics of Asynchronous Traffic for Standard FDDI and Modified FDDI

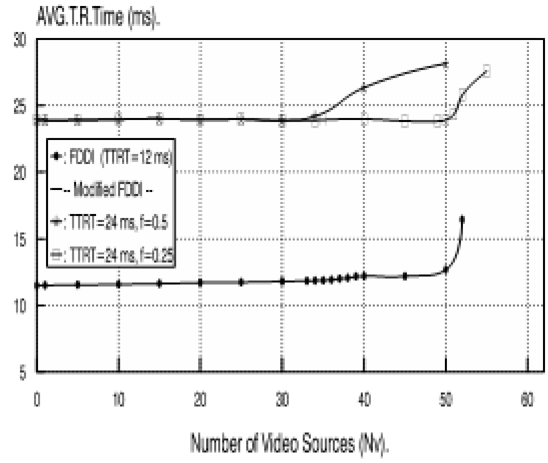

Figure 8 Average Token Rotation Time of Standard FDDI and Modified FDDI Protocol

VII. CONCLUSION

This paper presents the performance evolution of FDDI network carrying video and data traffics. The results compared well with the standard FDDI network, and show that the network parameters such as packet length, tolerable bound delay, data traffic intensity, and loss constraints can be adjusted to increase the FDDI`s network capability for supporting multimedia applications. The simulation results are also confirmed that the FDDI is suitable for synchronous traffic because of high speed and performance guarantees it provides. However these guarantees are achieved at the expense of asynchronous traffic, because synchronous traffics are given higher priority over asynchronous traffics, resulting in excessive delays and low throughput for asynchronous traffics. Our proposal aspect has tackled these problems, and confirms that the FDDI is suitable not only for the synchronous traffics but also for asynchronous traffics. Just looking at the high throughput of asynchronous traffic for confirmation.

REFERENCES

[1] F.A.Tobagi, and I.Dalgic, ``Performance Evaluation of 10Base-T and 100Base-T Ethernets Carrying Multimedia Traffic,`` IEEE J. of SACs, Vol.14, No.7, Sept. 1996.

[2] I.Dalgic, W.Chien, and F.A.Tobagi, ``Evaluation of 10Base and 100Base-T Ethernets Carrying Video, Audio, and Data Traffic,`` IEEE INFOCOM`94 Procs., Toronto, Canada, June 1994.

[3] F.Fluckiger, ``Understanding Networked Multimedia Applications and Technology,`` Prentice Hall, 1995.

[4] M.Hamdaoui, and P.Ramanathn, ``Deferring Real-Time Traffic for Improved Non-Real-Time Communication in FDDI Networks,`` IEEE Trans. on Computers, Vol.44, No.12, Dec. 1995.

[5] K.G.Shin, and Q.Zheng, ``FDDI-M: A Scheme to Double FDDI`s Ability of Supporting Synchronous Traffic,`` IEEE Tran. On Parallel Distributed Systems, Vol.16, No.11, pp.1125-1131, Nov.1995.

[6] A.Shah, and G.Ramakrishnan, ``FDDI: A High Speed Network,`` PTR Prentice Hall, Inc. 1994

[7] M.Yabe, T.Ideguchi, T.Fuji, Y.Koui, Y.Baba, and N.Okazaki, ``Proposal of a Data Transfer Protocol Suitable for Multimedia Communications on Shared Media LAN,`` Procs. APCC/OECC'99, Beijing, Chaina, Oct. 1999.

[8] M.Yabe. T.Fuji, Y.Koui, T. Ideguchi, Y.Baba, and N.Okazaki, ``Proposal of Synchronous Data Transfer Protocol Suitable for FDDI With RSVP Mechanism,`` Procs. IEEE APCC/ICCC`98, Singapore, Nov.1998.

[9] FDDI Token Ring Media Access Control (MAC), ANSI X3T9.5, Doc.X3.139/1987 (ISO 9312-2/ 1989).

[10] H.P.Davids, T.Meuser, and O.Spaiol, ``FDDI: Status and Perspectives,`` Computer Networks and ISDN Systems, Vol.26, No.6-8, March 1994.
[11] H.R.van As, ``Media Access Techniques: The Evolution Towards Terabits/s LANs and MANs,`` Computer Networks and ISDN Systems, Vol.26, No6-8, March 1994.
[12] C.M.Bakes, and F.N.Goldberg, ``Applications of Fibre Optic Networks in High Technology Research,`` Intel. J. of Computer Applications in Technology, Vol.8, No.3-4, 1995.
[13] G.Agrawal, B.Chen, W.Zhao, and S.Davari, ``Guaranteeing Synchronous Messages Deadlines With Timed Token Medium Access Control Protocol,`` IEEE Trans. On Communications, Vol.43, No.3, March 1994.
[14] E. A. Khalil, "High Throughput of Asynchronous Traffic and Maximum Capacity of Synchronous Sources With the New FDDI's MAC Protocol," IJESET, Vol. 1, Issue, 2, pp. 27-36, February, 2012.
[15] Wang, J. Zhang, S. Maple, C. " Guaranteeing the Timely Transmission of Periodic Messages with Arbitrary Deadline Constraints Using the Timed Token Media Access Control Protocol ," In the Communications, IET, Volume: 5 Issue: 4, pp. 519 – 533, March 2011.
[16] Jun Wang, Sijing Zhang, Carsten Maple, Zhengxu Zhao, "Guaranteeing Hard Real-Time Traffic with Legitimately Short Deadlines with the Timed Token Protocol," In the Journal of Computer Standards & Interfaces , Volume 31 Issue 3, March 2009.
[17] A. P. Jayasumana and P. N. Werahera, "Performance of Fibre Distributed Data Interface Network for Multiple Classes of Traffic," IEEE Proc., pt. E, vol. 137, no. 5, pp. 401-408, Sept. 1990.
[18] Sijing Zhang, Alan Burns, Jing Chen, E. Stewart Lee, "Hard Real-Time Communication with the Timed Token Protocol: Current State and Challenging Problems," Published in: · Journal Real-Time Systems, Volume 27 Issue 3, September 2004.
[19] Sijing Zhang, Alan Burns, Tee-Hiang Cheng, "Cycle-Time Properties of the Timed Token Medium Access Control Protocol," Journal IEEE Transactions on Computers, Volume 51 Issue 11, November 2002.
[20] Sijing Zhang, Alan Burns, Ahmed Mehaoua, E. Stewart Lee, Hongji Yang, "Testing the Schedulability of Synchronous Traffic for the Timed Token Medium Access Control Protocol," Journal Real-Time Systems, Volume 22 Issue 3, May 2002.
[21] Sijing Zhang, E. Stewart Lee, " Efficient Global Allocation of Synchronous Bandwidths for Hard Real-Time Communication with the Timed Token MAC Protocol," In the Proceeding of RTCSA '99 Proceedings of the Sixth International Conference on Real-Time Computing Systems and Applications, December 1999.
[22] Sijing Zhang, E. Stewart Lee, " The Worst-Case Scenario for Transmission of Synchronous Traffic in an FDDI Network," In the Proceeding LCN '99 Proceedings of the 24th Annual IEEE Conference on Local Computer Networks, October 1999.
[23] Sijing Zhang, Alan Burns, "Timing Properties of the Timed Token MAC Protocol," In the Proceeding of IC3N '97 Proceedings of the 6th International Conference on Computer Communications and Networks, September 1997, IC3N '97.
[24] Sijing Zhang, Tee-Hiang Cheng, K. R. Subramanian, Liren Zhang, Chee Heng Tan, "Testing the Feasibility of Synchronous Bandwidth Allocation for Time-Critical Communication in FDDI Networks," Proceeding of the IC3N '97 Proceedings of the 6th International Conference on Computer Communications and Networks, September 1997, IC3N '97.
[25] Sijing Zhang, Tee-Hiang Cheng, Hongji Yangt, K.R. Subramanian, Chee Heng Tan and Liren Zhang, "Improving the Normalized Proportional Allocation Scheme for Time-Critical Communication in FDDI Networks," International Conference on Information, Communications and Signal Processing ICICS *'97* Singapore, pp. 1436-1440, 9-12 September 1997.
[26] Sijing Zhang, Alan Burns, Andy Wellings, "An Efficient and Practical Local Synchronous Bandwidth Allocation Scheme for the Timed-Token MAC Protocol," In the Proceeding of the INFOCOM'96 Proc. of the 15th annual joint conference of the IEEE computer and communications societies conference on The conference on computer commun. – Vol. 2, March 1996 INFOCOM'96.
[27] Sijing Zhang and Alan Burns, "An Optimal Synchronous Bandwidth Allocation Scheme for Guaranteeing Synchronous Message Deadlines with the Timed-Token MAC Protocol ," IEEWACM TRANSA~IONS ON NETWORKING, Vol. 3. No. 6 , pp. 729-741, December 1995.
[28] Ching-Chih Han; Shin, K.G.; Chao-Ju Hou, " Synchronous Bandwidth Allocation for Real-Time Communications with the Timed-Token MAC Protocol," IEEE Transactions on Computers, Volume: 50 Issue:5, pp. 414 – 431, May 2001.
[29] D. Chen, V.C.S. Lee, E. Chan, "On the Ability of the FDDI-M Protocol to Support Real-Time Traffic," In the Fifth International Conference on Real-Time Computing Systems and Applications (RTCSA'98), Hiroshima, Japan, Page 51, October 27-29, 1998.
[30] Y Ofek, K Sohraby, Ho-Ting Wu, "Integration of Synchronous and Asynchronous Traffic on the MetaRing and its Performance Study," In IEEEACM Transactions on Networking'97, Vol.5, Issue 1, pp. 111-121, 1997.
[31] Nicholas Malcolm and Wei Zhao, "The Timed-Token Protocol for Real-Time Communications," In the IEEE Computer, pp.35-41, January 1994.

[32] G. Agrawal, B. Chen, B. Chen, S. Davari, "Guaranteeing Synchronous Message Deadlines with the Timed Token Medium Access Control Protocol ," In the IEEE TRANSACTIONS ON COMPUTERS, Vol. 43 No. 3, pp. 327-339, March 1994.

[33] Chug-Ju Chang, AND Hsin-Huei Wu, "Analysis of Synchronous and Asynchronous Traffic in an FDDI Network," TENCON '93. Proceedings. Computer, Communication, Control and Power Engineering.1993 IEEE Region 10 Conference on 19-21 Oct 1993, IEEE TENCON '93 / Beijing, Vol.3, pp. 187-189, China, 1993.

[34] Qin Zheng, Kang G. Shin, "Synchronous Bandwidth Allocation in FDDI Networks," TR93-06 December 1993, MITSUBISHI ELECTRIC RESEARCH LABORATORIES, Cambridge Research Center, http://www.merl.com.

[35] B. Chen, G. Agrawal, and W. Zhao, "Optimal Synchronous Capacity Allocation for Hard Real Time Communications With the Timed Token Protocol," in Proc. Real-Time Systems Symposium. IEEE, Dec. 1992.

[36] G. Agrawal, B. Chen, W. Zhao and S. Davari, "Guaranteeing Synchronous Message Deadlines with Timed Token Medium Access Control Protocol," Tech. Rep. 92-006, Comput. Sci. Dept., Texas A&M Univ., Apr. 1992.

[37] Willebeek-LeMair, M.; Schaffa, F.; Patel, B., " Isochronous versus Synchronous Traffic in FDDI," In the Proc.., of 17th Conference of Local Computer Networks, pp. 100 - 109, 13-16 Sep. 1992.

[38] Raj Jain, "Performance Analysis of FDDI Token Ring Networks: Effects of Parameters and Guidelines for Setting TTRT," In the IEEE, Letter, pp.16-22, May 1991.

[39] M. Tan emann and K. Sauer, "Performance Analysis of the Timed Token Protocol of FDDI and FDDI-II," IEEE Globelcom**,** pp. 271-278, 1991.

[40] **Y.** Y. Yang and R. Sankar, "Maximizing FDDI Network Performance by Parameter Tuning," IlEE Globecom, pp. 1431-1439**,** 1991.

[41] H. Takagi, "Effects of the Target Token Rotation Time on the Performance of a Timed-Token Protocol," in Proc. Performance '90, Edinburgh, Scotland, pp.363-370, Sept. 1990.

[42] Amarvir Singh,"Throughput Analysis of Ethernet and Fiber Distributed Data Interface Using OPNET IT Guru Academic Edition 9.1," Research Cell: An International Journal of Engineering Sciences ISSN: 2229-6913 Issue,Vol. 4. pp.455-461, Sept 2011.

[43] M A Al-Shargabi, A S Ismail, "Utilizing Optical Burst Switching Networks for the Internet Real-Time traffic," 2008 International Symposium on High Capacity Optical Networks and Enabling Technologies, , pp.63-68, HONET 2008 (2008).

[44] Ping Wang, Weihua Zhuang, "A Token-Based Scheduling Scheme for WLANs Supporting Voice/Data Traffic and its Performance Analysis," IEEE Transactions on Wireless Communications (2008) Vol.7, Issue 5, pp.1708-1718, Publisher: IEEE 2008.

[45] J Wyatt, D Habibi, I Ahmad, H Zen, "Providing QoS for Symmetrical Voice/Video Traffic in Wireless Networks ," ICON 2007 Proceedings of the 2007 15th IEEE International Conference on Networks, pp.312-317, (2007).

[46] Ping Du, Shunji Abe, "Burst Assembly Method with Traffic Shaping for the Optical Burst Switching Network ," IEEE Globecom (2006).

[47] Ruyan Wang, Dapeng Wu, Keping Long, Weile Zhu, "A Low-Latency Burst Assembly Technique in Optical Burst Switching Networks," 2006 International Conference on Communications Circuits and Systems (2006) Volume: 00, pp.1865-1868, Publisher: IEEE 2006.

[48] L.Pushparani Devi, S. Birendra Singh and Sanasam Bimol, “A new Analysis of System Utilization Performance for Ethernet Networking System”, IEEE 802.11e EDCA, IEEE Transactions on Comm., 2005.

[49] George N Rouskas Teng Jing, "Traffic Engineering Approach to Path Selection in Optical Burst Switching Networks ," Journal of Optical Networking (2005), Vol.4, Issue 11, pp.759-777, 2005.

[50] Y. Y. Yang and R. Sankar, “Performance Analysis of FDDI”, IEEE Network, September 2004.

[51] William J. Cronin, Jerry D. Hutchison, K.K. Ramakrishnan and Henry Yang, “A comparison of High Speed LANs,” Proc. of IEEE Inte'l Symposium on Network Computing and Applications, 2003.

[52] Jiangtao Luo, Qingji Zeng, Hao Chi, Zhizhong Zhang, Huandong Zhao, "The Impacts of Burst Assembly on the Traffic Properties in Optical Burst Switching Networks," Inte'l Conference on Comm. Technology Proceedings 2003 ICCT'03, Issue 69990540, pp. 521-524, 2003.

[53] S Dharmaraja, A S Alfa,"Performance Analysis of 3G Wireless Networks Supporting Voice, Data and Video Traffic," Proc. of The Inte'l Conference On Wireless Networks 2003, pp.495-498, 2003.

[54] Shriram Patwardhan, “High Speed Optical Networking with Ethernet”, proceedings of 24th conference on Local Computer Networks (LCN’02), 2002.

[55] Timothy J King, **“**The fiber distributed data interface (FDDI) – A New Generation Standard for Local Area Networks**”,** http://www.citeseerx.edu/

[56] Joseph Kee-Yin Ng, Victor Chung-sing Lee, "Performance Evaluation of Transmission Schemes for Real-Time Traffic in a High-Speed Timed-Token MAC Network ," Journal of Systems and Software (2000), Vol. 54, Issue 1, pp.41-60, 2000.
[57] Nazy Alborz, Maryam Keyvani, Milan Nikolic, and Ljiljana Trajkovic, "Simulation of Packet Data Networks Using OPNET", http:// www.citeseerx.edu.
[58] G. Bucci, A. Del Bimbo and S. Santini, "Design and Performance Evaluation of High Throughput Ethernet/FDDI Interconnect", Proceedings of Seventh International Conference on Computer Communications and Networks (ICCCN '98), 1998.
[59] S Kamat, Wei Zhao, "An Efficient Optimal Reconfiguration Algorithm for FDDI-Based Networks, " IEEE Transactions on Parallel and Distributed Systems'96, Vol.7, Issue 4, pp.411-424, Apr 1996.
[60] G Bucci, A Del Bimbo, S Santini, "Performance Analysis of two Different Algorithms for Ethernet-FDDI Interconnection ," IEEE Transactions on Parallel and Distributed Systems (1994), Vol.5, Issue 6, pp.614-629, 1994.
[61] Sanjay Kamat, Nicholas Malcolm, Wei Zhao, "Performance Evaluation of a Bandwidth Allocation Scheme for Guaranteeing Synchronous Messages with Arbitrary Deadlines in an FDDI Network ," IEEE Real-Time Systems Symposium, 1993, pp.34-43, 1993.
[62] Th Welzel, Peter Martini, S Rudloff, "Performance Analysis of FDDI and Multiple Token Ring Backbones in a Mixed Traffic Environment," High Speed Local Area Networks II 1990, pp.53-68, 1990.
[63] B.Albert, and A.P.Jayasumana, ``Performance Analysis of FDDI LANs Using Numerical Methods,`` Procs. Of the 20th Conf. On Local Computer Networks, Minneapolis, MN, USA, 1995.
[64] W.Stallings, ``Networking Standards A Guide to ISDN, LAN, and MAN Standards,`` Addison Wesely Publishing Co. 1993.
[65] I.Dalgic and F.A. Tobagi, ``Constant Quality Video Encoding,`` Procs. Of IEEE ICC`95, Seattle, Washington, June 1995,
[66] ITU/CCITT Rec. H.261, ``Video CODEC For Audiovisual Services ar px64 Kbbits/s,`` Geneva, 1990.
[67] International Organization for Standardization (ISO), ``MPEG: Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to about 1.5Mbps,`` Nov. 1991.
[68] P.Wong, and T.Peter, ``An Integrated Services Token Controlled Ring Network,`` IEEE J. SACs, Vol.7, No.5, June 1989.
[69] T.Suda, and T.T.Bradley, ``Packetized Voice/Data Integrated Transmission On a Token Passing Local Area Network,`` IEEE Trans. On Communications, Vol.37, No.3, March 1989.
[70] E.A.Khalil, and G.M.Ali, ``An Efficient FDDI`s MAC For Increasing The Throughput of Asynchronous Traffic and The Capacity of Synchronous Traffic,`` Accepted For Publication in the Eighth IEEE IC3N`99,Boston, MA, USA, Oct. 1999.

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