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Performace Enhancement of An Optimal Network Protocol for High-Speed Communication

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고속통신을 위한 최적 네트워크프로토콜의 성능 향상

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ABSTRACT

This paper describes an optimal communication protocol for high-speed networks. This scheme can support multimedia services and provide fast data transmission using the distributed gueue scheme and the dynamic bandwidth allocation architecture, based on ATM(Asynchronous Transfer Mode). Performance analyses and simulation results are presented to illustrate the effectiveness of the proposed scheme in a variety of communication environments.

要 約

본 논문에서는 고속통신망에 적합한 통신 프로토콜을 설계하고 그 성능을 분석하였다. 제안된 프로토콜은 ATM 전송방식을 기본으로 하고, 분산큐 방식 및 동적대역폭 할당구조를 사용하여 고속의 전송속도 및 다양한 서비스 지원이 가능하다. 다양한 통신망 환경에 따른 성능분석과 컴퓨터 시뮬레이션 결과를 고찰하여 제안된 구조의 우수성을 입증하였다.

I. Introduction

Recent developments in communication technology have made low cost, distributed network interfaces possible. With these latest increased network capabilities new architectures of the high-speed LANs and MANs(Metropolitan Area Network) have been studied in many laboratories to provide efficient LAN-to-LAN interconnection as well as multimedia communication.[1, 2] The FDDI(Fiber Distributed Data Interface) was adopted as standard by the ANSI (American National Standards Institute) for a 100 Mbps token ring using fiber optic cabling.[3] The IEEE 802.6 DQDB(Distributed Queueing Dual Bus) is also adopted for standard with 150 Mbps counter-flowing unidirectional buses that each station accesses via a global distributed queueing scheme.[4] The ATMR(ATM Ring) protocol proposed from JTC1/SC6 WG 1 is consists of ATM-based slot-

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ted ring scheme.[15] But most of the previous protocols may have some disadvantages in high-speed environmnents, especially under overload traffic condition. Recently, new technologies for high-speed communication with the efficient structure have been required.

Therefore the purpose of this paper is to describe the concept of an optimal network protocol and to show this scheme has the enhanced performance in the end-to-end delay reduction. The protocol adopts the cell reuse mechanism and the bandwidth allocation scheme in order to compensate for the fairness of the network. The Monitor bit is used to recover the transmission errors. Also, it provides connectivity with B-ISDN(ATM network) and an efficient common media access scheme to make best use of network resources.

Ⅱ. The proposed Communication Protocol

A. Network configuration

The proposed CDQR(Cyclic Distributed Queue Ring) network is a multi-access ring system with the distributed stations and a special access control station. These stations are linked by two unidirectional optical ring. This protocol provides connection oriented and connectionless mode services, as well as isochronous mode services.[11] The overall network configuration is shown in fig.1.

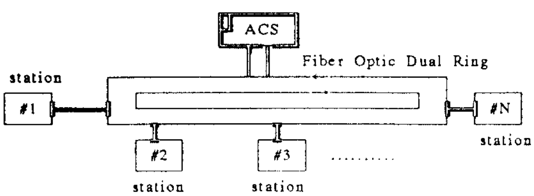

Fig. 1. Overall network configuration

The Acs(access control station) creates and manages frames between 125 μs. The minimum transmission unit is defined as a cell. User frames packets are divided into 53 octets on channel and transmitted to the network. The cell format as shown in fig. 2, is similar to the ATM cell format and the B(busy) bit checks if the cell is empty or full. Before transmission, using the REQ(request) bit, a station makes upstream station know the fact that it has the packets to transmit. The Q and Q′ bits are used to allocate the bandwidth. The R(Reset) bit informs that reset function is needed, and the M(Monitor) bit represents that the cell is monitoring state or not.

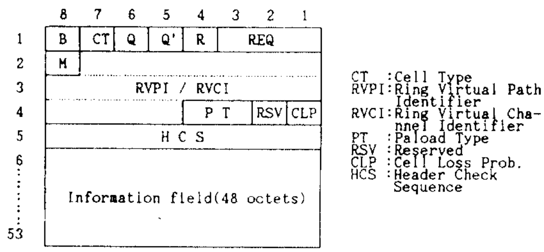

Fig. 2. Cell architectuve

B. Operation of Access Control Station

When the station receives a user cell that was already set Q bit to zero, it sets Q′ bit to one. If it receives a cell with one Q bit, there are at least one or more stations on the ring with the non-zero valued DBAC _ i(Dynamic Bandwidth Allocation Counter with i priority), so, it reset the value of Q′. Therefore, if it receives a cell with zero Q bit and one Q′ bit, it generates reset signal and then REQ bit of each cell will be reset. The ACS consists of five units such as Initialization unit, Bandwidth allocation unit, Monitoring unit, Isochronous unit, and Control unit as shown in fig.3. As the ring is initialized, it checks the data traffic status of each station, and makes the traffic distribution table, the database system including traffic information for all stations. From this table, the maximum value of DBAC _ i for each station can be assigned. When the network is in normal operation, it checks the DBAC and the CDBAC bits(Q and Q′). In monitoring state, assigned a few of bandwidth periodically, it checks and extracts traffic information field of the cell for network and then updates the traffic distribution table. With this table, the DBAC _ i value is set to new current value in cyclic way. The isochronous unit may check the time and make the input cell empty for isochronous servics. These all functions are controlled by Control Unit.

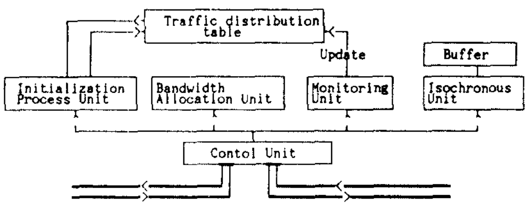

Fig. 3. The Access Control Station structure

C. The operation of a station

The structure of a station is shown in figure 4. The media access layer consists of three units such as Pre-setup unit, Cell processing unit and Ring media access control unit. The Pre-setup unit can be used for isochronous service and the cell processing unit manages request and countdown counters. Both DBAC _ i and CDBAC _ i are managed by ring access control unit.

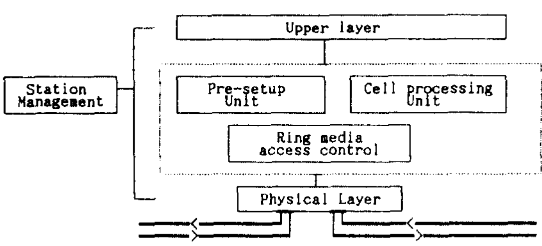

Fig. 4. The structure of a station

According to the queue state and network traffic condition, each station puts the number of transmission cells into DBAC _ i. The station with the transmitting cells transmits them if the value of DBAC _ i is not zero. If DBAC _ i bit is zero, then the station sets the Q bit to notice that it becomes pause state, that is it examines the maximum ring rotation time(RT_{max}) and the value of request counter(V_{req}), and from this value, the CDBAC _ i(Compensatory DBAC _ i) is set to the value of $RT_{max}-V_{req}$ in order to increase ring efficiency. If CDBAC _ i is not zero, then it still has the rights to transmit the packets. When CDBAC _ i becomes zero, the value of CDBAC i reduces by one at every transmission the operation of station stops the transmission when it reaches zero, and then waits until the DBAC _ i is reset. In summary, this process is illustrated in fig. 5.

Though the queue of each station is distributed, each station operates as a single queue because it has the rights to transmit its packets. Operating states of each station depend on the value of DBAC _ i or CDBAC _ i and user packets. If there are no packets, a station has only request counter operation, and two pairs of counters are necessary to control two rings of the network. When user packets for ring A arrived in distributed queue, the reserved bit of cell for ring B will be set to the value of one in order to inform the fact that it has the cells, and countdown counter is set to the value of request counter, and request counter is reset.

If it receives a reserved cell in ring B, it increases REQ _ CTR (REQuest CounTeR) by one. When it catches empty cell for ring A, it decreases CD _ CTR(CountDown CounTeR) by one. If the DBAC _ i or CDBAC _ i is not zero and the CD _ CTR reaches zero, it sends out the packets. Each station checks the destination station address. If it matches its own address, it clear the reserved bit, and then transmit to next station. At the moment state transition occurs, from idle state to transmission one, the reserved bit is set to one. If there are one or more input cells in the queue, the first incoming cell enters distributed queue, and then queue will be changed into

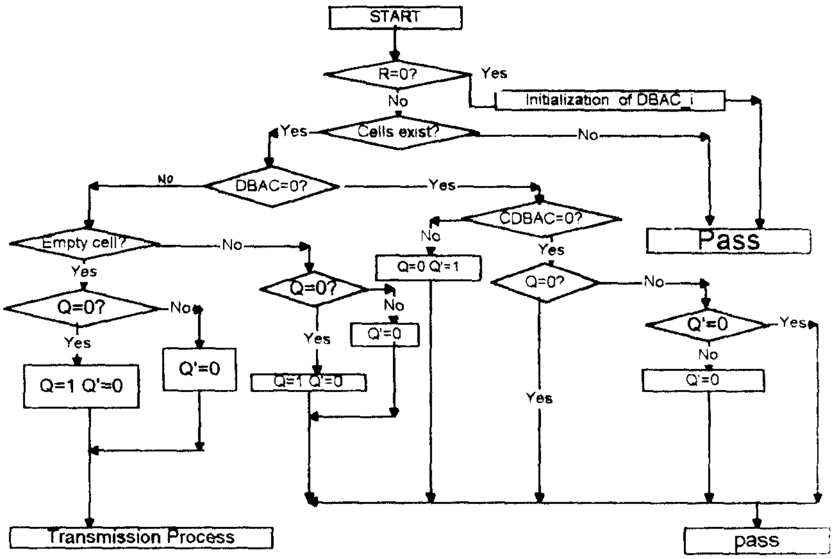

Fig. 5. The operation of each station

transmission state according to priority levels. The ACS manages empty cells periodically to support isorchronous services, that is, it the input cells are empty, it pass over, otherwise, it generates empty cells. The main characteristic of CDQR protocol are distributed fairness control among the stations by using distributed queues mechanism as well as dynamic bandwidth control scheme with a cycle-reset mechanism.

Ⅲ. Modeling and Analysis

To analyze the proposed protocol, let the users be numbered sequentially 0, 1,...M-1. The priority is based on the observation that if the most recent slot the channel was allocated to user i then it must have been the one with the highest priority. Denote by τ the maximum propagation delay and let every slot consist of initial M-1 reservation followed by a packet transmission time of duration T. We get a maximum throughput of [6]

$$S_{max} = \frac{T}{T+M\tau} = \frac{1}{1+M\cdot\tau/T} \quad (1)$$

Let the arrival process of packet at user i be Poission distribution with rate λ_i. Also, let w_i and x_i be the waiting time of a packet at user i, the service time of one, respectively. Denote $\rho_i=\lambda_i x_i$ and $\rho=\sum\rho_i$. Considering a random tagged packet that joins user k's buffer and L_i packets at the user already waiting. Let N_i be the number of packets that arrive at user i during the waiting time of the tagged packet. With the above definitions we have

$$E(w) = w = \left[\sum_{i=1}^{M-1} \rho_i \frac{E[x_i^2]}{2E[x_i]} + (1-\rho)\frac{E[t^2]}{2E[t]}\right] + \left[\sum_{i=0}^{k} E[x_i]E[L_i]\right] + \left[\sum_{i=0}^{k-1} E[x_i]E[N_i]\right] \quad (2)$$

Using Little's formula, we get equation(3) and equation(4).

$$E[L_i] = \lambda_i W_i \quad (3)$$

$$E[N_i] = \lambda_i W_k \quad (4)$$

Therefore, we get

$$W_k = \frac{\left[\sum_{i=1}^{M-1} \rho_i \frac{E[x_i^2]}{2E[x_i]} + (1-\rho) \frac{E[t^2]}{2E[t]} \right]}{(1-\rho^{(k)})(1-\rho^{(k-1)})} \quad (5)$$

where, $\rho^{(k)} = \sum_{i=0}^{k} \rho_i$

For MSAP(Multi-Slotted Alternating Priority) case, as all the x_i are the same and equal to slot size, we note that

$$M\tau + T = T(1+Ma) \quad (6)$$

Finally, the mean packet delay $\overline{T}_d$ is given by

$$\overline{T}_d = \frac{T_d}{T} = (1+Ma)\left[\frac{1}{1+2(1-\rho)}\right] \quad (7)$$

where $a(=\tau/T)$ is a characteristic parameter of the network.

Ⅳ. Simulation Results and discussion

1. Simulation Model

In order to analyze network performance of the proposed protocol, we use simulation model of our system and compare the proposed scheme with DQDB _ FCFS(DQDB not considering distributed queue scheme), DQDB _ NR(DQDB operation of considering distributed queue scheme), DQDB _ BB(DQDB with Bandwidth Balancing operation). Here, the CODR _ NP means proposed scheme without any priority levels and CDQR _ PR1 means the proposed one with priority level 1. CDQR _ PR2 and CDQR _ PR3 represent proposed cases with priority level 2 and priority level 3, respectively. These results are based on the next assumptions.

· The network has an unidirectional single ring strurcture and each buffer of all stations has the infinite capability.

· The arrival rate of each station is Poisson distributuion

· The process delay of each station is considered as zero and propagation delay between each station is same.

For various situation, we also consider some different traffic rate as table 1 : first we assume each station has same traffic and then changed the traffic of station number 3 and 6. Here, the values represents the transmision cell rate versus the total generating cells in 155 Mbps at each station. So overall traffic would be made as over-traffic and under-traffic states. All figures for several protocols are derived from a simulation study. Throughput and delay time are used as the most appropriate comparative measure of system.

Fig.6 shows the mean access delays at each station under the condition that transmission speed is 155 Mbps and load traffic is balanced. We observe that the delays in case of DQDB increase as the station is located farther from the heahend and this effect of DQDB _ BB is slightly relaxed. But the delay for the proposed scheme is fair and short. Note that the results of applying three level priorities show that the delay of the highest priority data is less than one μsec, so it may appropriate for supporting the isochronous data service.

Fig. 7 and Fig. 8 illustrate the mean access del-

Table 1. Load traffic distribution at each station

	Station load traffic								
	ST.1	ST.2	ST.3	ST.4	ST.5	ST.6	ST.7	ST.8	ST.9
CASE1	0.1	0.1	**0.1**	0.1	0.1	**0.1**	0.1	0.1	0.1
CASE2	0.1	0.1	**0.1667**	0.1	0.1	**0.1667**	0.1	0.1	0.1
CASE3	0.1	0.1	**0.0667**	0.1	0.1	**0.0667**	0.1	0.1	0.1

ays at each station under the condition that load traffics have unbalanced distribution(67% or 167% load traffics are applied to both 3rd station and 6th one, respectively). We also observe that the proposed scheme has good performance comparing to others. The comparison of analytical value and simulation result is shown in Figure 9. The graph represents the mean access delays as the transmission speed increase up to 1 Gbps. We can observe that the simulation results approach to analytical ones within 2%. In summary, the proposed model with ring structure and dynamic bandwidth allocation scheme resolves some problems and it is possible to support very high speed communication.

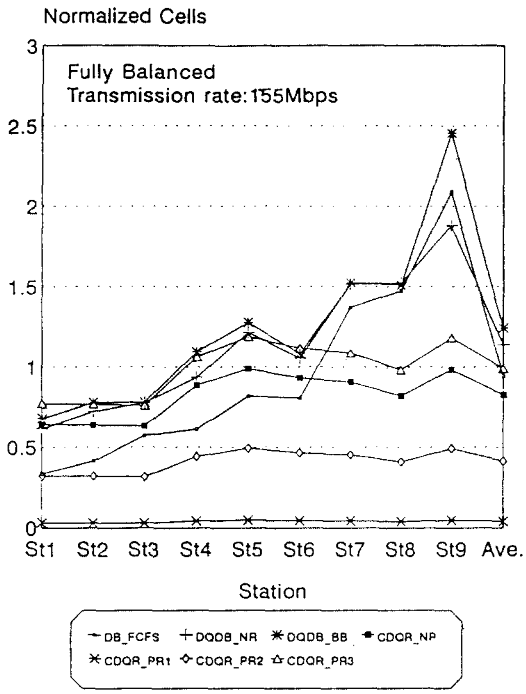

Fig. 6. Average delay time(CASE1)

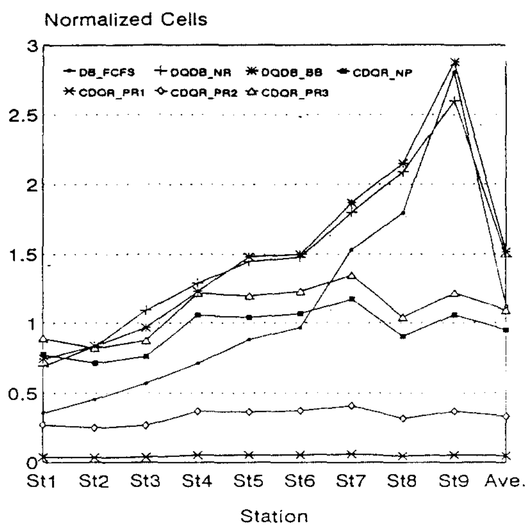

Fig. 7. Average delay time(CASE2)

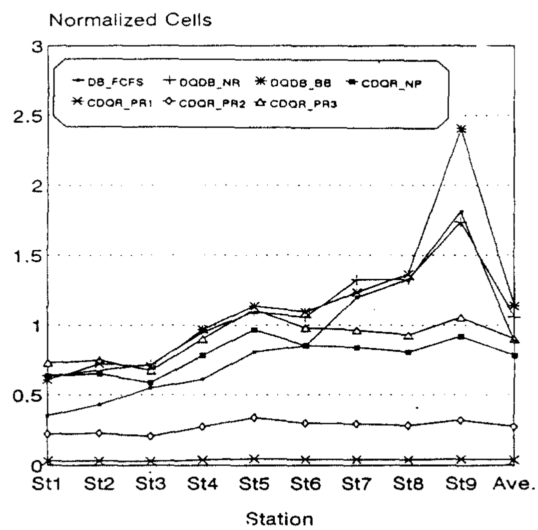

Fig. 8. Average delay time(CASE3)

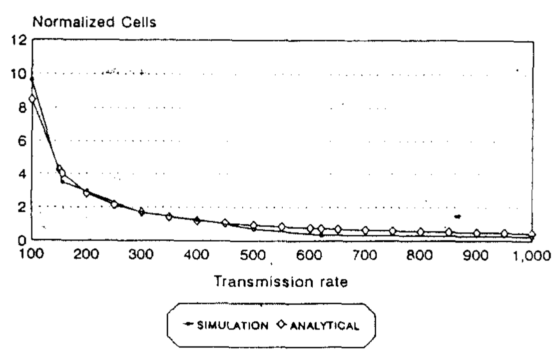

Fig. 9. Average delay time vs transmission rate(CASE1)

V. Conclusion

An optimal communication protocol for high-Speed networks is presented. The dynamic bandwidth allocation scheme makes it possible to operate efficiently according to network traffic conditions as medium access control mechanism. As each station is permitted to send out data packets with efficient way, the proposed scheme has better time delay performance.

The effeciveness of the proposed scheme was shown via a performance comparision to the conventional protocols and simulation results were also presented.

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