WDM Local Network에서 예약슬롯을 이용한 가변길이 메시지 지원 프로토콜

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Protocol supporting Variable-length Message using Reservation Slots in WDM Local Network

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이 논문은 2001년도 한국과학재단의 우수연구센타(OIRC) 연구비를 지원받았음.

요 약

본 논문에서는 WDM 기반의 Local Network에서 가변길이 메시지를 수용하기 위한 스케줄링 프로토콜을 제안하였다. 제안된 프로토콜은 제어채널을 예약슬롯과 제어슬롯으로 나누어 제어패킷의 충돌로 인한 액세스 지연시간을 최소화하였다. 즉, 전송할 메시지가 있는 노드는 빈 제어슬롯이 있으면 제어패킷을 제어슬롯에 전송하고 메시지를 전송한다. 그리고 메시지의 전송이 완료될 때까지 주기적으로 제어패킷을 전송하여 가변길이의 메시지를 전송할 수 있도록 하였다. 또한 빈 제어슬롯이 없는 경우에는 예약슬롯을 이용하여 가장 가까운 시간에 메시지를 전송하기 위한 데이터 슬롯을 미리 예약하여 제어패킷의 충돌로 인한 재전송 횟수를 감소시켰다. 제안된 알고리즘은 기존 프로토콜의 문제점을 해결하였으며 성능향상과 액세스지연시간의 감소 효과를 보였다.

ABSTRACT

A new WDM-based protocol for scheduling a variable-length message is proposed in this paper. Two control channels, reservation slot and control slot, are used to coordinate transmission and diminish the collisions of packet to minimize the access delay. When an idle control slot is available, control packet is transmitted on that slot and message is transferred. And the node continues to transmit its control packet through the corresponding slot every cycle, until the message is completely transmitted. If any control slot is not available, the node schedules the transmission time of message in earliest available time using reservation slots. The proposed scheduling algorithm shows better performance and lower access delay.

키워드

WDM, Scheduling Algorithm, Variable Length Message, Local Network, Reservation

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접수일자 : 2001년 6월 13일

Ⅰ. Introduction

Wavelength-division multiplexing(WDM) is an approach that can exploit the huge opto-electronic bandwidth mismatch by requiring that each end-users equipment operate only at electronic rate, but multiple WDM channels from different end-users may be multiplexed on the same fiber[1]. Under WDM, the optical transmission spectrum is carved up into a number of non-overlapping wavelength bands, with each wavelength supporting a single communication channel operating at Gbps[1].

WDM network architectures can be classified into two broad categories: broadcast and select architecture and wavelength routing architecture[2]. In a broadcast and select WDM network, a passive device in the middle of the network broadcasts messages to all the nodes. In this case, the device is a passive optical star coupler. The coupler combines the signals from all the nodes and delivers a fraction of the power from each signal on to each output port. Each node employs a tunable filter to select the desired wavelength for reception. And the nodes in the wavelength routing network are capable of routing different wavelengths at an input port to different output ports. This enables us to set up many simultaneous lightpaths using the same wavelength in the network; that is, the capacity can be reused spatially[3].

The nodes in such a network can transmit and receive messages on any of the available channels using on or more tunable transmitter(s) and/or tunable receiver(s). Several topologies have proposed for WDM networks, a popular one being the single-hop, passive star-coupled topology.

To use the WDM channels more sophisticated in single-hop WDM passive star networks, efficient access protocols and scheduling algorithms are needed to allocate and coordinate system resources optimally, while satisfying message and system constraints. Most of these protocols and algorithms can be divided into two main classes, namely preallocation-based and reservation-based techniques.

Preallocation-based techniques use all channels of fiber to transmit messages. These techniques assign transmission rights to different nodes in a static and predetermined manner. Reservation-based techniques allocate a channel as the control channel, to transmit global information about messages to all nodes in the system. Once such information is received, all nodes invoke the same scheduling algorithm to determine when to transmit/receive a message and on which data channel. Reservation-based techniques have a more dynamic nature and assign transmission rights based on the run-time requirements of the nodes in the network[1].

In this paper, the reservation-based scheduling algorithms in broadcast and select WDM network are mainly concerned. Most of such protocols are based on the transmission of fixed-sized data packets. However, when there is a need to accommodate circuit switched traffic or traffic with long holding times(e.g. file transfer service), it is necessary for a protocol to efficiently support such variable-sized messages.

For supporting variable-length messages, [4] proposed various reservation aloha protocol. Even though these protocols are simple, their throughputs are near the conventional aloha protocol due to the contention in the control and data channels, And sinse large population systems were assumed, the destination conflict effect was ignored. And [5, 6] proposed distributed scheduling algorithms to determine data channels and time slots. In these protocols, each node transmits the reservation packet before transmitting data packet. Only when the reservation has been successfully done, the data packet can be transmitted. However, in these protocols, each node has to maintain reservation histories from the time of network initialization called the global information. The need of such global information has a serious burden in the network scalability for adding or deleting nodes.

In this paper, a new scheduling algorithm is proposed. The new algorithm can support variable-sized messages without requiring global information and network re-initialization. Moreover, the access delay is reduced comparing to existing method.

This paper is organized as follows. In section 2, the details of new scheduling algorithm is described and the performance results are shown in section 3. Finally, the conclusions are shown in section 4.

II. Proposed Algorithm

1. Channel Structure

As shown in figure 1, both control and data channels are slotted using the same time reference. This we call as one cycle. The duration of a cycle equals the fixed-length data packet. The control channel is further divided into 2N minislots, where N is the number of channels(wavelength). Due to the fixed assignment of a control slot for each data channel, if a control packet is successful in a control channel then the corresponding data message will be successfully transmitted. The first N minislots is control slots and the second is reservation slots. Reservation slots are used for reservation when all the control slots are busy. And control slots transmits control packet to reserve the data channel.

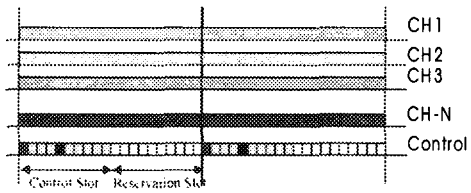


그림 1. 채널구조
Figure 1. Channel Structure

2. Scheduling Algorithm

The existing protocol[4, 5, 6] retransmits the control packet continuously in each cycle until the reservation of data channel is successful. Therefore the access delay of data channel is incremented in the heavy offered load environments. In order to reduce the access delay of data channel, the proposed algorithm uses the reservation mechanism shown in figure 2.

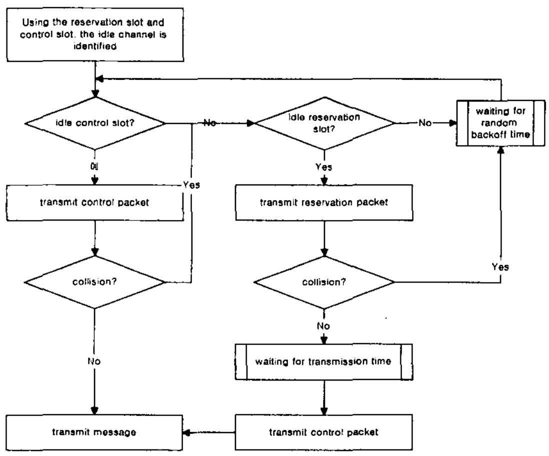


그림 2. 제안된 알고리즘
Figure 2. Proposed Algorithm

When a data message arrives at a network node, the node selects a control minislot using the information collected on the previous cycle. If there is an available control minislot, the node transmit a control packet consisted of destination node and message length. And next cycle, the node observes the collision of control packet or destination conflict. If any collisions are not occurred, message transmission is proceeded and until the completion of message the control packet is transmitted on the reserved minislots.

However when there is no available control minislots or some collisions are occurred in control packet transmitted, the reservation processing is operated. If there exists an available reservation minislot, the reservation control packet is transmitted. The control packet of reservation is composed of destination address and busy time that is calculated using the information collected in previous cycle. The busy time is selected the soonest value among the message length of control packet in control and reservation minislot. When no collision is occurred in control packet of reservation on next cycle, the control packet is transmitted continuously until the busy time become zero. After completion of busy time, the message and control packet are transmitted.

III. Performance Analysis

In order to analyze the performance of proposed algorithm, we follow the following notations:

N	number of data channels
M	number of nodes
V	average length of a message
G	average number of control packets transmitted per slot on a control channel
R	average number of retransmission
Tr	average length of a retransmission period
Dw	average time a packet has to wait from the time it is generated till the beginning of the next cycle
Dr	average total retransmission delay
Dt	average time to transmit a message

We assume G packets/slot is offered for each minislot in every cycle. Usually, the traffic is assumed to be Poisson with parameter G. If any particular data channel is observed in the system, idle periods are embedded between the busy periods on this channel.

The busy period is equal to the message length, then

$$E[t_{busy}] = V$$

Successful message transmission is the one which message either transmits on the control slot or transmits on the reservation slot. To simplify analysis of proposed algorithm, we assume that probability of successful transmission on the both minislots is equal. Therefore, the probability that data slot is idle = 1-S where S is the successful transmission on the control slot(S = 2G(N/M)e^{G}).

Idle period distribution is given by;

$$P[t_{idle} = k\ cycles] = (1-S)^k S\ (where\ k = 0,1,2\ \ldots)$$

$$E[t_{idle}] = \frac{1}{S} - 1$$

Therefore, the throughput U is given by;

$$U = \frac{E[t_{busy}]}{E[t_{idle}] + E[t_{busy}]} = \frac{V}{(\frac{1}{S} - 1) + V} = \frac{SV}{1 + S(V-1)}$$

Following figure shows the throughput of proposed algorithm compared with reservation aloha protocol. Figure 3 is depicted with parameter M(=30) and N(=20). As shown in figure 3, the throughput of proposed method is better than reservation aloha protocol.

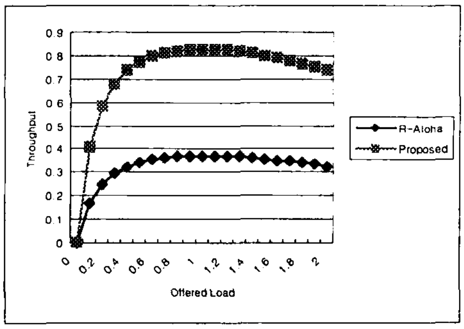


그림 3. 부하에 따른 성능
Figure 3. Throughput versus offered load

Let Ps be the probability of success of acquiring a channel for each packet offered on a control slot. Since V is the average load each packet brings in to the channel and G is the traffic offered to the channel per slot, we have G×V×Ps=U. From this we get Ps as;

$$P_S = \frac{e^{-G}}{1+S(V-1)}$$

And R is 1/Ps. Therefore the access delay is calculated Dw+Dr+Dt; where Dt = T/2, Dt = VT and Dr is

$$D_r = (R-1)(\frac{T}{2} + T_r)$$

$$\text{Access Delay} = \frac{T}{2} + VT + (R-1)(\frac{T}{2} + T_r)$$

Figure 4 describes the access delay of proposed algorithm compared with reservation-aloha protocol. The proposed method shows lower access delay time than reservation aloha protocol.

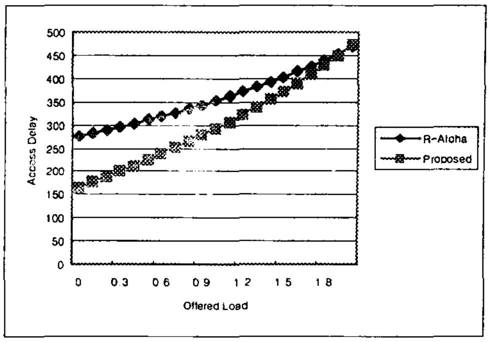


그림 4. 부하에 따른 액세스 지연시간
Figure 4. Access Delay versus offered load

VI. Conclusions

The existing scheduling algorithms for supporting variable-length messages in the WDM network have several serious problems; network re-initialization, global information kept in each node, occurrence of destination conflict and long access delay. Therefore, in this paper, we propose a new scheduling algorithm supporting variable-length messages. The algorithm especially uses the reservation minislots as well as control minislot like other protocols. Using the reservation minislot, the collided control packets can be recovered and when no idle control minislots are existed, the reservation of data channel can be processed early. The performance of proposed method is analyzed, and shows reasonal performance and smaller access delay.

References

[1] B. Mukherjee, *Optical Communication Networks*, McGraw-Hill Series on Computer Communications, 1997

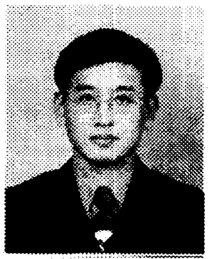
[2] R. Ramaswami, K. M. Sivarajan, *Optical Networks, A Practical Perspective*, Morgan Kaufmann, 1998

[3] R. Ramaswami, "Multiwavelength Lightwave Networks for Computer Communication," IEEE Communications Magazine, pp78-88, Feb., 1993

[4] Ganti N. M. Sudhakar, N. D. Georganas, M. Kavehrad, "Slotted Aloha and Reservation Aloha Protocols for Very High-Speed Optical Fiber Local Area Networks Using Passive Star Topology," Journal of Lightwave Technology, Vol. 9, No. 10, pp1411-1422, Oct., 1991

[5] F. Jia, B. Mukherjee, J. Iness, S. Ojha, "Variable-Length Message Scheduling Algorithms for A WDM-Based Local Lightwave Network," Proc. of INFOCOM 94, pp1362-1369, 1994

[6] J. H. Lee, C. K. Un, "Synchronous Reservation Protocol for Variable-sized Messages in WDM Network," Proceedings of GLOBECOM95, pp2210-2214, 1995



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