"Information Networking toward New Millennium"

PROCEEDINGS

Volume II

The 13th International Conference on Information Networking (ICOIN-13)

Cheju Island, Korea
January 27 - 29, 1999

Sponsored by
Korea Information Science Society(KISS) SIG-IN, Korea

Technically Co-sponsored by
IEEE Communications Society

IEEE IEEE COMMUNICATIONS SOCIETY

(2) **Handoff Procedures in the Base Station for IMT-2000 System**
Dong Myung Lee, Jee Hwan Ahn, Duck Bin Im, ETRI, Korea

(3) **Intelligent Network Call Model and Information Flows to Support IMT-2000 Services**
HanKyung Lee, IlHyeon Hwang, JangMan Bae, Daewoo Telecom, Korea; Myungwhan Choi, Sogang Univ., Korea

(4) **On the Maximum Difference of Path Metrics for Viterbi Decoding of Punctured Code**
Jin-Ho Kim, Myung-Sup Kim, Seong-Pal Lee, ETRI, Korea; Hoon-Bok Lee, Hallym Univ., Korea

Session 8B: CDMA(II)

(1) **Performance Degradation of an MC-CDMA System from Carrier Frequency Offset**
Younsun Kim, Sooyong Choi, Chulwoo You, Kyunbyoung Ko, Daesik Hong, Yonsei Univ., Korea

(2) **Design of Common Data Channel in W-CDMA for ABR Packet Services**
Se-Jong Oh, Seok-Gue Hong, Sung-Soo Kim, Jae-Hong Park, Hyundai Electronics Industries Co., Korea

(3) **Super Algorithm for Clip Probability Reduction of DMT Signals**
M. Zekri, L. Van Biesen, Vrije Univ. Brussels, Belgium

(4) **Call Processing Performance Analysis in CDMA Cellular Systems with Multiple Frequency Channels**
Sookun Kwon, Pyungjoong Songs, Jinkyung Kim, Namhee Lee, ETRI, Korea

Session 8C: WDM(II)

(1) **Optimized Scheme of Dispersion Compensation for 100Gbit/s OTDM Signal Transmission**
Yongwon Lee, Yongbum Kim, Jinwoo Park, Korea Univ., Korea

(2) **Performance Analysis of Optical SCM Transmission Link for CDMA Signal**
Jintae Yu, Youngwoo Choi, Jinwoo Park, Korea Univ., Korea

(3) **Nx1 Optical Packet Multiplexers with Contention Resolution**
Chang-jin Suh, Soongsil Univ., Korea

(4) **A Priority Transmission Protocol on the WDM Slotted Ring Network**
Jun-Yao Wang, Ling-Yang Kung, Ce-Kuen Shieh, Nat'l Cheng Kung Univ., Taiwan; Wen-Shyang Hwang, Nat'l Kaohsiung Inst. of Technology, Taiwan

Session 8D: Security

(1) **An Oblivious Transfer containing Non-Repudiation Capability**
Sang-Choon Kim, ETRI, Korea; Sang-Ho Lee, Chungbuk Nat'l Univ., Korea

(2) **Authentication Scheme for Wireless Mobile Communications**
Jeong-Hyun Park, Sun-Bae Lim, Narm-Hee Lee, ETRI, Korea

(3) **Enhanced Authentication Protocol for TINA-based System**
Jeung-Heon Hahn, Jae-Cheol Ryou, Chungnam Nat'l Univ., Korea; Kyung-Hyu Lee, ETRI, Korea

(4) **A Study on Priority Control of Packet Forwarding by a Router**
Yuzuru Saito, Melco, Japan

Session 9A: ATM(II)

(1) **A Simulation Study on Connectionless Server Buffer Management Schemes in ATM Networks**
Woojin Seok, Haengjin Jang, Okhwan Byeon, Sungyul Park, ETRI, Korea

(2) **ATM/Frame Relay IWF architecture with SVC proxy in an ATM system**
Won-Sik Park, Yoon-Seok Nam, Jung-Sik Kim, Kwon-Chul Park, ETRI, Korea

(3) **Performance Analysis of Switching Path Using Cell Path Test**
Hyunsuk Kim, Gisik Kwon, ETRI, Korea

(4) **Intranet Services Planning and Deployment in ATM Networks**
Rong-Ruey Lee, Chain-Chin Yen, Cheng-Sheng Lin, Yen-Ting Chen, Chun-Hsuing Wang, Ching-Ming Shu,

A Priority Transmission Protocol on the WDM Slotted Ring Network

Jun-Yao Wang* Wen-Shyang Hwang** Ling-Yang Kung* Ce-Kuen Shieh*
* Department of Electrical Engineering,
National Cheng-Kung University
**Department of Electrical
Engineering, National Kaohsiung Institute of Technology

[Abstract]

The paper presents a priority transmission protocol based on the WDM slotted-ring network. In the network, each node is equipped with two fixed-wavelength receivers, one tunable-wavelength transmitter and one fixed-wavelength transmitter. There are many channels for transmitting data and one channel as the control channel in the network. The control channel is used to coordinate all nodes of the network for reserving slots. Here, data packets are separated into normal packets and priority packets, and slots are only reserved by nodes for priority packets. This protocol reduces the packet delay of priority packets in heavy load.

This protocol using slot-reservation scheme does not only provide better bandwidth utilization but also provide a simple method to achieve the priority-transmission function. In this paper, simulation results have used to prove the above descriptions.

Keyword: WDM, slotted Ring, priority protocol, reservation mechanism, multiple channel

1. Introduction

Recent years, the wavelength division multiplexing (WDM)[1] technology is explored and allows the huge bandwidth of fiber being exploited. WDM is normally used to divide the huge bandwidth of fiber into a number of channels which rate matches the speed of electronic interfaces[2].

The WDM network with slotted ring topology, called the WDM slotted ring network, has the simpler architecture, transmission devices and the slot reused property among these protocols exploited WDM technology. These advantages make it being nice method utilizing bandwidth. Two possible node architectures are usually used in the WDM slotted ring networks. First, every node has one tunable transmitter and one fixed receiver. Secondly, every node has one fixed transmitter and one tunable receiver. When the transmitter is tunable and many nodes just communicate with few nodes, channel utilization is worse. With tunable receiver, receiver contention may arise, when two or more packets transmitted on different wavelengths and reach the same destination node at the same time[3]. Because the receiver collision can be avoided, the paper will focus on the first architecture.

Because of the huge-bandwidth requirement of multimedia application, the research about real-time transmission and huge-bandwidth is the hot topic in the research of high-speed network. The paper [2] proposed a solution for the real-time transmission on a WDM slotted ring network. Its proposed protocol, called SR^3 protocol, allows nodes to reserve slots based on SRR (Synchronous Round Robin) and MMR (Multi-MetaRing) fairness schemes proposed by the same authors in the paper [4]. The node in the MMR scheme will reserve the slots by the SAT (Satisfied) message. The method can improve bandwidth utilization and provide the guarantee of QOS (Quality of Service) to support multimedia application, however it needs a very complicated synchronization mechanism to implement.

In this paper, we proposed a simple priority transmission protocol based on the WDM slotted ring network. In this network, every node has a fixed transmitter and a fixed receiver for the control packets, and a tunable transmitter and a fixed receiver for the data packets. A specified channel is used as the control channel to transmit control packets that carry the reserve-slot information for every node. Because of the control packets, the network provides the capability to transmit normal packets and urgent packets. In section 3, we will describe it in detail. The tunable transmitter is used to transmit packets to a data channel. The fixed receiver is used to receive packets from its corresponding channel. In this paper, we separate data packets into normal packets and priority (urgent) packets.

2. Network Architecture

The proposed network architecture is a WDM slotted ring network consisted of M nodes and W+1 channels as shown in figure 1. In the network, every ring is divided into a constant number of fixed length slots which synchronously and circularly flow in one direction in the ring. We assume every ring has k slots, $S_1 \ldots S_k$, and every packet is exactly to fit into the payload of a slot. In the network, one channel is used to coordinate all nodes in the network, called the control channel and other W channels are used to transmit normal and priority packets, called data channels. These packets transmitted on the control channel are called control packets. They broadcast the node reservation information to other nodes in the network.

In the network, every node has one tunable transmitter and one fixed receiver for transmitting and receiving data packets. Every node is assigned a particular channel, called the receiving channel to receive packets.

Every node transmits a packet by tuning its transmitter to the receiving channel of the destination node. The transmitted packet will propagate along the ring until it is extracted from the ring by the receiver of the destination. Figure 2 shows the node structure in the network.

Each node is not only equipped with one tunable transmitter and one fixed receiver, but also one fixed transmitter and receiver. The later is used to transmit and receive control packets. Besides, every node maintains separate queues for different data channels. These queues corresponding to data channels can separate two kinds. The first is called data queues that are used to stores normal packets. Second is the priority queues that are used to store priority packets. In addition to these queues, every node has one *reserved-counter* (RC) for each data channel to record the number of reserved slots in the channel. The *channel controllers* (CCTRs) in the figure 2 are used to select packets from data queues and priority queues to transmit on data channels.

In addition to these queues, every node has a *reservation table*(RT) and a *reservation register*(RR). RT is used to record the information that is which slot is reserved and which node reserved slots in each transmission cycle. RR is used to record which slot time is reserved by the node in a transmission cycle. The transmission cycle is the time that a slot flows through the whole ring once. In section three, the functions of these components will be described in detail.

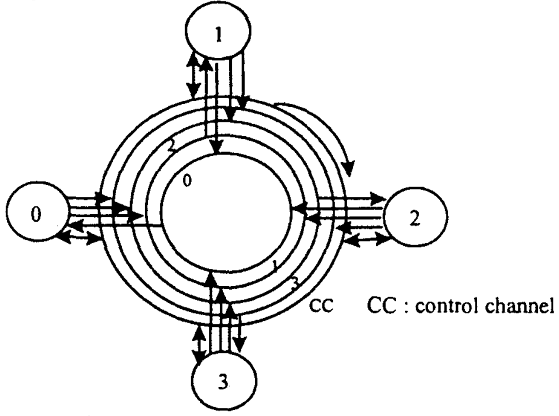


Figure 1. The architecture of WDM slotted ring network with a control channel as W=M=4.

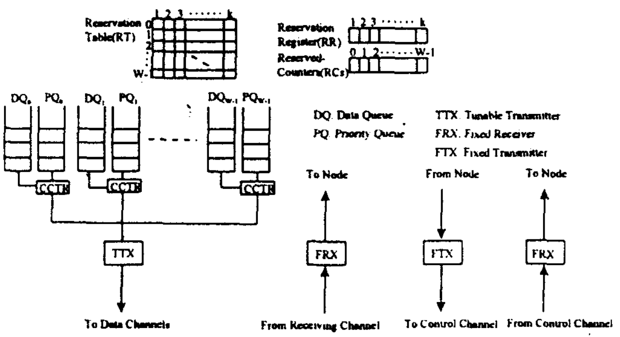


Figure 2. The Node Structure

3. Transmission Protocol

The transmission protocol that we propose is to provide the real-time packet transmission. In the protocol, all nodes are coordinated by control packets. Control packets are circularly transmitted on the control channel. The size of control packet is fixed to one slot, and its format is described as shown in figure 3. Every control packet consists of a preamble field, a parity field and many Slot-Reservation Frames (SRFs). The preamble field is used to represent the beginning of a control packet, and the parity field is used to verify the accuracy of a packet. The SRF consists of a reservation bit (RB) and a source address(SA). Every SRF represents the usage of one slot on data channels. The sequence of SRFs is the slot sequence of channels. For example, the usage of slots of channel 0 is represented first, then the usage of slots of channel 1, and so on. Because there are *k* slots circulate through the ring, the number of SRFs used to represent the usage of all slots of one channel is *k*. So the number of total SRFs used to represent the usage of all slots of the network should be $k \times W$, where *W* is the number of data channels. The number of control packets is the total number of SRFs dividing the number of SRFs in each control packet.

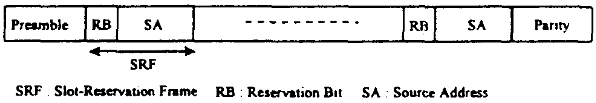
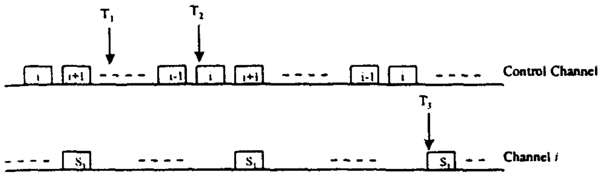


Figure 3. The Format of Control Packet.

Because the SRFs representing each channel are at different position of control packets, a node considers the first slot after the slot that carries the first control packet representing a channel as S_1 of the channel. The slot also is the starting slot of a transmission cycle for the channel. So, the starting slot of a transmission cycle in each channel is different.

When a node attempts to reserve slots on a channel, it must wait till the control packet representing slots of the channel arrivals. Then, it checks serially whether the RB of SRFs is false for S_1 S_k of the channel. If it is false, the node assigns the RB of the selected SRF to true, SA to its node address. If the RB is true, the node check next SRF till all SRFs of the channel have been checked. When a node has reserved a slot for priority packets on a channel, the RC corresponding to the channel increases by one. When the node received the same control packet again, it checks the SRF to ensure that every node knows its reservation, and then set the RB of the SRF to false. Then, the node transmits a priority packet on the reserved slot from the priority queue, and the RC decreased by one. When the destination received the packet on its receiving channel, it removes the packet from the channel and lets the slot become idle. The add/drop multiplexer[5][6] can be used to remove the packet on channels. Figure 4 shows the timing diagram that a priority packet arrives at a node, then the node reserves S_1 of channel i for the packet and transmits the packet on the S_1 of channel i. In the example, the number of data channels is equal to that of nodes. Each control packet just carries SRFs for one data channel.



T_1: The time that a priority packet which destination is node i arrives at a node.

T_2: The time that the priority packet reserves S_1 at control packet i.

T_3: The time that the priority packet is sent on S_1 of channel i.

Figure 4. The timing diagram that a node reserves a slot

Because every node only has one tunable transmitter, it must avoid reserving two slots which arriving itself at same slot time. This requirement can be attained by the RR. The register has k bits and every bit represents a slot time on a transmission cycle. Because control packets are transmitted on fixed slots of the control channel, the relative positions between slots are fixed for all channels. By it, a node can calculate the positions of slots for all channels easily. If one bit of RR is true, it means that the slot time that the bit corresponds to is reserved and the node can not reserve the same slot-time slot of other channels.

Because the control packets are broadcast to all nodes in the network, every node can know when the reserved slots are utilized. By this, when these reserved slots arrive, every node can transmit its packets on these channels without reservation. The method is that if a reserved slot reached the destination of a packet earlier than the node reserving the slot, the node can be attempted to send the packet on the reserved slot.

It is no doubt that a node can transmit its packet on a slot of a channel if the slot was not reserved. Each node can obtain the reservation status of a slot on a channel from its RT that records the reservation status of slots of all channels when control packets pass through the node. So, when a slot is coming in a node, the node can transmit its packet on the slot if the RT indicates that the slot is not reserved.

In this paper, the RND (Random) access protocol proposed in [4] is used when a node transmits its packets on non-reserved slots. In the protocol, on each slot, every node selects one channel by the random-selection method from these channels which slot can be used and the data or priority queues corresponding to them are not empty. For each priority queue, it is not seen as empty only when the number of packets on itself is larger than the RC corresponding to the same channel. If the priority queue of the selected channel is not empty, the node will attempt to send the top packet of the queue on the channel. If the priority queue is empty, the node will attempt to transmit the top of the data queue. Every node executes the random method once a slot. If the slot is idle on the selected channel, the packet will be transmitted successful and removed from the queue. If the slot is busy on the channel, the packet is remained in the queue. When a node received the packet on its receiving channel, it removes the packet from the channel and lets the slot become idle. The signal detection technique can be achieved by subcarrier signaling [3].

4. Simulation Results

In this section, we show the performance of a network with 16 nodes and 16 channels by simulation results. The packet delay is the time spent by a packet in the system, i.e., the difference between the time instant the packet is received at the destination node and the time instant the packet was generated at the source node[7]. The simulation program is written in Simscript language.

To obtain these results, we make the following assumptions: every control packet comprises k SRFs that exactly contain the reservation information of slots of one channel. So, on the control channel, the number of control packets is same as the number of channels. Nodes are equally separated with a propagation delay of 1 slot between neighboring nodes. Every node reserves one slot at most for each channel in every transmission cycle. The buffer size of every queue is infinite. The size of normal and priority packets is same as that of a slot. The data traffic generated by each station is same and with a Poisson distribution that consists of normal packets and priority packets. The traffics generated by nodes are evenly distributed to other nodes.

Figure 5-8 show the packet delay of normal packets and priority packets when the proportion of priority packets, named P, occupies 20%, 40%, 60%, 80% of the load respectively. These figures show that the packet delay grows as the traffic load per channel increases. In light load, the packet delay of priority packets is little higher than normal packets because little priority packets are transmitted on the reserved slots. In heavy load, the packet delay of priority packets is lower than normal packets because most priority packets are transmitted on the reserved slots and the delay of normal packets is increased. The turning points of priority-packet lines of these figures show that the protocol affects the delay of priority packets and makes it shorter.

Figure 9 shows the packet delay of normal packets and priority packets when proportion of priority packets in total packets is 0%, 100%, respectively. When the proportion is 0%, the result is the simulation result of the WDM slotted ring network using the RND protocol. When the proportion is 100%, the result is the simulation result of the network that only transmits priority packets. The result shows that the network transmits priority packets more efficiently than transmitting data packets.

Figure 10 shows the result of channel throughput versus different traffic load per channel. The result shows that the proposed protocol can improve the performance of the WDM ring network in comparison with the network without it. It also could be found that the throughput of the network is better as the proportion of priority packets is higher.

5. Conclusion

In the paper, we propose a new protocol that provides the capability to transmit priority packets. The protocol is based on WDM slotted ring network and utilizes a control channel to coordinate all node for reserving slots. In the network, data packets are transmitted by the RND protocol and priority packets can be transmitted by reserving slots or the RND protocol. Because of that, the proportion that priority packets are transmitted on reserved slots changes when the traffic load of the channel is changed. It makes priority packets transmitted rapidly. The simulation results show the property.

From these simulation results, we can found that the proposed protocol does reduce the delay of priority packets without prolong delay of data packets by comparing with the RND protocol. The proposed protocol also makes the network have better transmission capability.

[Reference]

1. C.A. Bracket, "Dense Wavelength Division Multiplexing Networks: Principles and Applications," IEEE Journal on Selected Areas in Communications, SAC-8(6), pp.948-p964, Aug. 1990
2. M. Ajmone Marsan, A. Bianco, E. Leonardi, A. Morabito, F. Neri, "SR^3: a Bandwidth-Rservation MAC Protocol for Multimedia Applications over All-Optical WDM Multi-Rings", InfoCom'97, 1997
3. Chlamtac, A. Fumagalli, L. G. Kazovsky, P. T. Poggiolini, "A Contention/Collision Free WDM Ring Network for Multi Gigabit Packet Switched Communication," Journal of High Speed Networks 4, 1995, pp.201-219
4. Ajmone Marsan, A. Bianco, E. Leonardi, M. Meo, F. Neri, "On the Capacity of MAC Protocols for All-Optical WDM Multi-Rings with Tunable Transmitters and Fixed Receivers", InfoCom'96, 1996
5. Chawki, V. Tholey, E. Delevaque, S. Boj and E. Gay, "Wavelength reuse scheme in a WDM unidirectional ring network using a proper fibre grating add/drop multiplexer", Electronics Letters, Mar. 1995, vol. 31, No.6, pp.476-477
6. Tholey, M.J. Chawki, L. Berthou, I. Le Gac, E. Gay and A. Poudoulec "Demonstration of WDM survivable unidirectional ring network using tunable channel dropping receivers", Electronics Letters, Aug. 1994, vol. 30, No.16, pp.1323-1324
7. Eric W. M. W., Andrea F. and Imrich C., "Performance Evaluation of CROWNs: WDM Multi-Ring Topologies", ICC'95, pp. 1296-1301

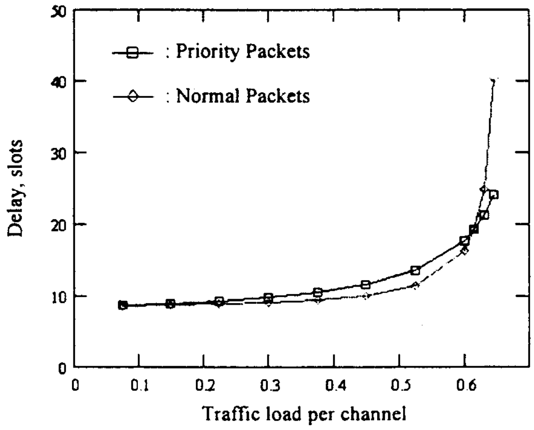


Figure 5. Packet delay versus traffic load per channel as P=20%

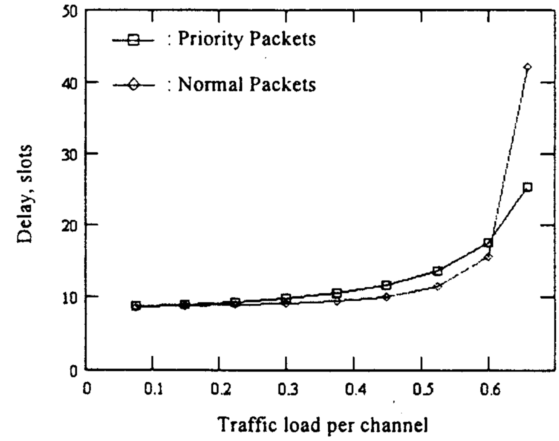


Figure. 6 Packet delay versus traffic load per channel as P =40%