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(3) Abstract：

As the Internet continues to evolve, the traffic carried by LANs, MANs, and WANs is not only increasing in volume, but is also experiencing a change in pattern. Current MAN based on SONET/WDM ring architecture is not flexible enough to adapt to this sudden increase in MAN traffic, and network resources are not used efficiently. HORNET is designed to address the inefficiencies of SONET and meet the needs of future MANs. This paper will study the performance of HORNET under different selecting strategies to decide which queue should be served first.

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(6) Keywords：Selecting Strategy, HORNET, and WDM

Performance of Queue Selecting Strategies for HORNET

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Abstract – As the Internet continues to evolve, the traffic carried by LANs, MANs, and WANs is not only increasing in volume, but is also experiencing a change in pattern. Current MAN based on SONET/WDM ring architecture is not flexible enough to adapt to this sudden increase in MAN traffic, and network resources are not used efficiently. HORNET is designed to address the inefficiencies of SONET and meet the needs of future MANs. This paper will study the performance of HORNET under different selecting strategies to decide which queue should be served first.

Keywords: Selecting Strategy, HORNET, and WDM

I. INTRODUCTION

As the Internet continues to evolve, the traffic carried by LANs, MANs, and WANs is not only increasing in volume, but is also experiencing a change in pattern. In old traffic model, the role of the MAN was mainly to connect the clients on the LANs to the WAN. The rapid growth is expected to continue in the future [1].

Current MANs based on SONET/WDM ring architecture [2] are not flexible enough to adapt to this sudden increase in MAN traffic. SONET nodes encapsulate IP/ATM traffic received from LANs into frames and transport them to the Point of Presence (POP). The POP houses a high capacity SONET switch and an IP router or ATM switch to route the traffic either to the WAN, or back to the MAN to connect nodes on different add/drop wavelengths. As the internode traffic increases on the MAN, this architecture scales poorly. The POP, being the central switch gets heavily loaded, increases the packet latency. Second, network resources are not used efficiently [3].

Moreover, Internet data traffic grows exponentially as opposed to the slow growth in voice traffic. With the emergence of voice over IP, an increasing percentage of voice traffic will be carried in packet form. But SONET is not optimized for packet data transport. SONET is a circuit switched protocol; this circuit occupies a fixed bandwidth, regardless of whether or not there are packets to be transmitted. Additionally, current MANs run IP over ATM over SONET over WDM (IP/ATM/SONET/WDM) or IP over SONET over WDM (IP/SONET/WDM). This extended network stack results in high overhead, complicates the system infrastructure, and increases cost [4].

HORNET (Hybrid Optoelectronic Ring NETwork), a joint effort between the Optical Communications Research Laboratory at Stanford University and Sprint Advanced Technology Laboratories, is designed to address the inefficiencies of SONET and meet the needs of future MANs. HORNET transports IP packets/ATM cells directly over WDM (no SONET). HORNET nodes, called Access Points (APs), drop a fixed WDM channel and use a fast tunable laser transmitter to transmit packets on any wavelength. The network uses a novel Media Access Control (MAC) protocol, which is implemented at each AP independently (without any centralized control), to govern access to all network wavelengths. The APs are not synchronized with each other, unlike a SONET network, and are equipped to transmit/receive back-to-back packets to/from different APs [5]. HONET classifies IP packets into different queues according to their destination address. However, it did not describe how to make a decision to select which queue will be served first.

This paper shows the performance of three selecting strategies (Random Strategy, Round-Robin Strategy, and Longest Queue Length First Strategy) in HORNET; these strategies are used to pick packet from multiple queues to transmit for nodes. In HORNET, each node equips with a passed-queue and many transmit-queues. The function of passed-queue is to buffer the upstream packet arrived. The function of transmit-queues is to buffer the packets arrived from LAN. The number of transmitting queues in a node is the same as the number of channels in a fiber. In this paper, the simulation model of HONET will be introduced, and the simulation language SIMSCRIPT is used to understand the system performance.

Section 2 reviews the HORNET network and the CSMA/CA protocol, and the queue selecting strategies will be introduced in Section 3. The simulation model is proposed and some simulations are produced in Section 4. Finally, a conclusion is given.

II. HORNET NETWORK

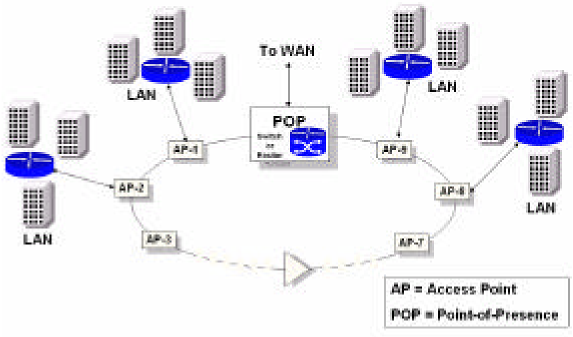

Figure 1. HORNET topology

HORNET is a packet-over-WDM MAN on a single-mode fiber ring. The HORNET topology is depicted in Fig. 1. Each AP has a fixed, single wavelength optical drop and a fast wavelength-tunable transmitter that can transmit on any of the wavelengths in the network. The network can be designed to have the number of wavelengths be more than, less than, or equal to the number of APs. In most cases it is desirable for the number of wavelengths to equal the number of nodes. However, the possibility of using fewer wavelengths is left open because using a smaller number of wavelengths (i.e., a multi-hop ring architecture) allows less expensive optical amplifiers to be used, and also allows the bandwidth to be better statistically shared by nodes. Having more wavelengths than APs is left open because it may be necessary for a network to scale its bandwidth by adding wavelengths without adding more APs.

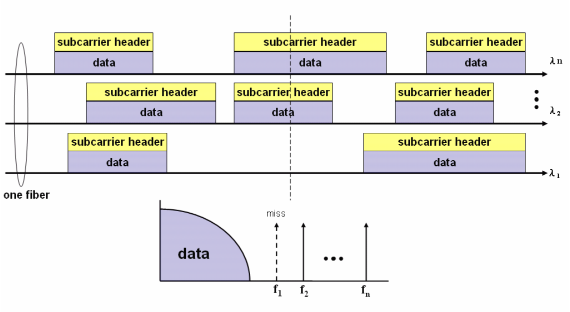

Figure 2. CSMA/CA Protocol

Since all APs are able to transmit on any network wavelength, a MAC protocol must be used that governs access to the wavelengths. The OCRL has developed a novel protocol for HORNET called CSMA/CA (Carrier Sense Multiple Access with Carrier Avoidance) in which an AP monitors all network wavelengths as the traffic passes by. The AP is sensing when there is an opening for a packet on a wavelength. Once an opening is found, the AP sends a packet into the network. The CSMA/CA protocol is implemented using subcarrier multiplexed (SCM) headers. Each wavelength in the network has a unique subcarrier frequency associated with it. When an AP transmits a packet on a particular wavelength, it multiplexes the wavelength's corresponding subcarrier tone onto the packet. As packets travel around the ring, they carry with their SCM header, which indicates the presence of a packet on the wavelength at that instant. Each AP taps a small amount of optical power from the ring and detects the subcarrier tones. The presence of a subcarrier at a particular frequency tells the AP that the corresponding wavelength is currently unavailable. The transmitter uses the wavelength availability information to determine when to send packets.

The scalability of network architecture is crucial. For the most part, the HORNET architecture scales easily. To add more bandwidth or more nodes to the network, more wavelengths are provisioned. This does not cause a problem for the tunable transmitter because the commercial tunable lasers available now or in the near future are tunable over nearly the entire 1550 C and L bands. Also, adding a wavelength to the network does not cause a problem for the receiver since a single wavelength drop is used in each AP. In networks in which a full multiplexer/demultiplexer is used, adding wavelengths is a problem because the multiplexers/demultiplexers need to be upgraded.

III. QUEUE SELECTING STRATEGIES

The queue selection strategy is a key factor of system performance in the network with only one tuning transmitter. For example, a strategy always picks packet from the queue 1 first, then select the queue 2, and so on. It implies the packets of queue 1 will always get the highest priority. That will no only make a fairness problem, but also raises the performance puzzle.

The HORNET queues can be divided into two types; one is used to buffer the packets arrived from upstream nodes, and is named passed-queue. The other queue type is used to buffer the packets sent from LAN, and is named transmitting queue. In order to reduce the delay of the propagated packets, the priority of passed-queue has to be greater than the priority of other queues.

There are two decisions should be made in a node. One is to select a candidate from all transmitting queues, and the other is to choice the queue type (passed queue or transmitting queue). The following proposes three queue selecting strategies in HORNET to study this issue.

1) Random Strategy:

Node selects a candidate from queues to transmit in two steps both all according to the random process. To reduce the processing delay, the process is pre-worked before any channel is available. After a specified period the candidate may be replaced by another candidate from a new selection processing, if it can wait any channel available. The replaced candidate cannot join to the new selection process for fairness.

2) Round-Robin Strategy:

Node selects a candidate according to a nature sequence; all queues are selected in the rotation manner. There are two rounds in a node, one for transmitting queues and the other for different queue type. Any candidate can keep a specified period to wait for transmission. The replaced candidate cannot join to the new selection process for fairness.

3) Longest Queue Length First Strategy:

Node always selects the longest queue length. There are two rounds in a node, one for transmitting queues and the other for different queue type. Any candidate can keep a specified period to wait for transmission. The replaced candidate cannot join to the new selection process for fairness.

IV. SIMULATION RESULTS

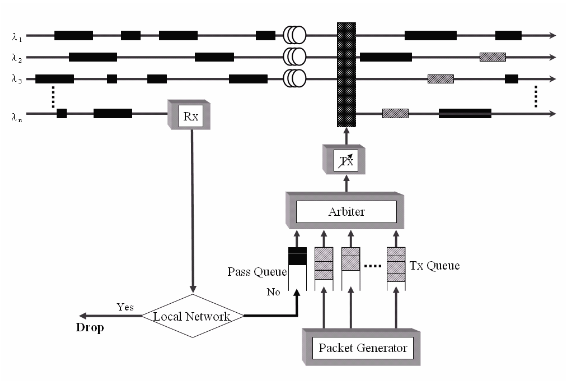

Figure 3. The Simulation Model

SIMSCRIPT II.5 programs were written to test these three queue selecting strategy in HORNET network. The simulation model of node is shown as in Fig. 3. In the model, each simulation packet has a destination address, a source address, and a packet generation time. The packets are shifted a simulation unit time in the simulation process. Each receive checks the destination address of the packet on its drop channel. If the destination address matches the node address, the packet is dropped, and the latency of the packet is calculated. If the destination address does not match the node address, the packet is restored into the passed-queue of the node. Packets are generated

Number of nodes	16
IP packet size	Min: 40 byte Max: 1500 byte Average: 512 bytes
Delay line length	80 ns
AP to AP distance	50 km
Channel rate	OC-192 (10G bps)
Packet generator	Poisson distribution

Table 1. Network Parameters

using a Poisson random process. Once a packet is generated at a node, it is placed in the transmitting queue. A packet departs from the passed-queue or the transmitting queues.

To evaluate the performance of the network, some assumptions for the simulation parameters have shown in Table 1.

In Fig. 4, there are only 2 channels in a fiber. We find the Round-Robin Strategy has the worst performance and the Longest Queue Length First Strategy has the best performance. The curve line of Random Strategy is similar and close to Round-Robin Strategy. The turning point is close to 1.75.

In Fig. 5, there are 4 channels in a fiber. Similarly, the Round-Robin Strategy has the worst performance and the Longest Queue Length First Strategy has the best performance. The curve line of Random Strategy is located at the middle between Round-Robin Strategy and the Longest Queue Length First Strategy. However, the pattern is similar to Fig. 4, the performance has improved much because the turning point become 2.5G between 3.0G.

In Fig. 6, there are 8 channels in a fiber. The performance of Random Strategy will be similar to Longest Queue Length First Strategy. However, it is not too good. The turning point has become 4.0G between 4.5G.

In Fig. 7, there are 16 channels in a fiber. The performance of Random Strategy is better then Longest Queue Length First Strategy. The turning point is at 6.0G around.

By the above figures, a inference can be given: the Round-Robin Strategy always gets the worst performance than the Longest Queue Length First Strategy regardless of the number of channels in a fiber, and the Random Strategy has better performance when the number of network channels increases.

V. CONCLUSION

This paper studies the performance of three selecting strategies (Random Strategy, Round-robin Strategy, and Longest Queue Length First Strategy) to pick packets from multiple queues of node in HORNET network for transmission. A simulation model is built and many simulations are done, from the simulation results can infer the Round-Robin Strategy always get poorer performance than that of the Longest Queue Length First Strategy. In additional, the Random Strategy has better performance when the number of network channels increases.

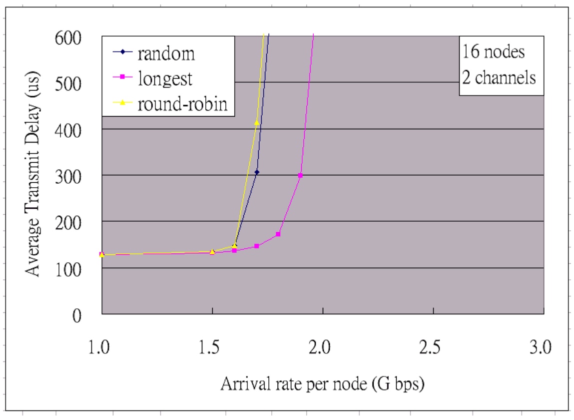

Figure 4. Two channels in a fiber

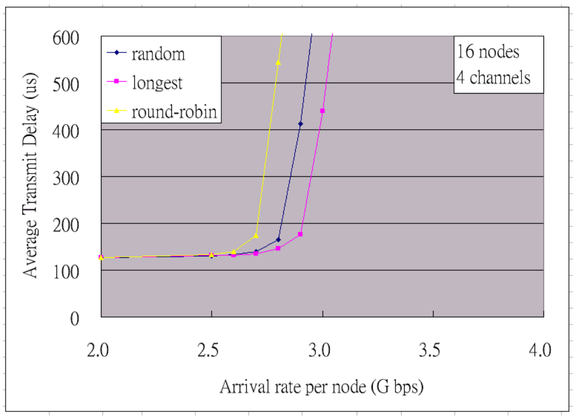

Figure 5. Four channels in a fiber

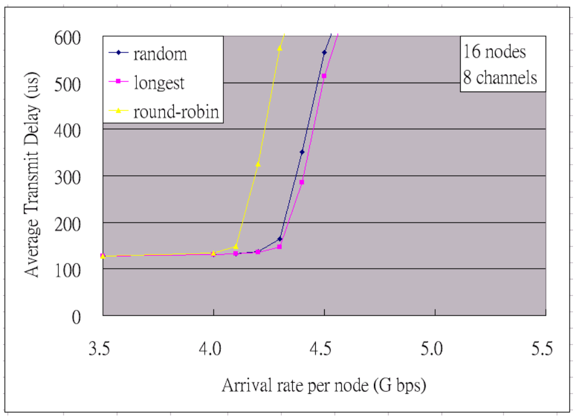

Figure 6. Eight channels in a fiber

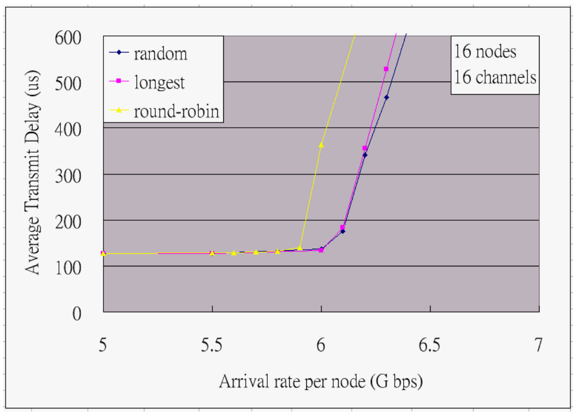

Figure 7. Sixteen channels in a fiber

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