

Impact of RTS/CTS Handshake on the Optical Packet Switched Local Area Network Performance

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If you didn't complete the entire work by yourself, you have to include the 2nd authors in the paper.

Abstract A centralized media access control protocol is designed to run optical packet switched traffic in local area networks. The design of the network concept was inspired by the IEEE802.11 wireless LAN protocol, although it has its own outstanding characteristics. The successful exchange of RTS and CTS messages reserves the network resources in advance so that the network ensures collision-free packet switching. The designated scheduling system enables low-cost and efficient transport networking functions. Modelling and simulations through OPNET modeller have been done to evaluate the network performance with TCP/IP traffic.

Sometime Keywords are requested here.

Introduction

For many years people have been studying optical local area networks (LAN), driven by the rapidly growing demand for capacity and speed. Optical LANs show appealing merits by permitting end users to access the network via the entire optical data paths. OPS (Optical Packet Switching) technology utilizes the tremendous capabilities of optical network for flexible, fast and bandwidth-efficient data transmission purpose [1]. Most researches towards applying OPS into local area networks are based on DWDM (Dense Wavelength Division Multiplexing) which involves issues like expensive and complex devices (i.e. AWG, couplers, etc), split loss, constraint of limited number of wavelength etc [2, 3]. Currently packet switching is not well matched with state-of-the-art optical technology, mainly due to the lack of optical memories and optical processing technique. To avoid the problems just mentioned and aim to realize optical networking with the components that can be available in the short term, we combine the optics and electronics to design a centralized control protocol for optical packets transmission in the data link layer, which requires no header-reading and eliminates the needs for optical buffer. Unlike DWDM techniques where individual wavelength works as a channel or path to transport data, we stripe every data packet across the entire bandwidth.

The protocol design takes advantage of the concept of IEEE 802.11 scheme [4], but also differs from it in a few aspects. Both of them employ RTS (Request-to-Send) and CTS (Clear-to-Send) control messages to reserve the network resource in advance. End nodes need to send RTS messages before transmitting data packets and the reception of CTS messages are the acknowledgements for them to send the actual data. The differences are, in IEEE802.11 wireless LAN protocol, as the control messages and data share the same transmission media, broadcast is

necessary which we do not use in our case. We use a separate wavelength for the control messages and the rest waveband for the data. Besides, instead of sending only one RTS every time, we allow end stations to send more at a time which composes a ReQ (Request Queue) message. The corresponding CTS messages will be sent back one by one to the end stations after the successful resource reservation for each request. Moreover, no segmentation takes place in our protocol. The data packets delivered from network layer to the MAC layer remain various sizes to be transmitted. With network resource reserved ahead of time, the network offers collision-free packet switching.

System Design

We deploy a star topology LAN where all the end stations are connected to a central hub via edge interfaces (see Fig. 1). The hub is a black-box switch controlled by an arbiter. The edge interface with embedded protocol can be integrated as line cards to the end stations. The control plane lies upon the edge interface and the arbiter. The structure of the hub is a ring topology with interconnected 2×2 switches. Each 2×2 switch has seven possible states that can be indicated by three binary digits.

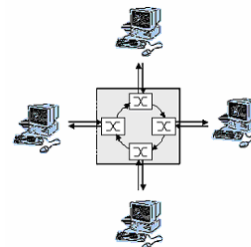


Fig. 1 Network scenario

Like what happens in IEEE 802.11, when new packets arrive, each station sends a RTS message to the central network controller, and waits for CTS from the hub's arbiter before transmitting each data

Introduction can tell the reader what this paper is all about. Or sometime, people include the critical review of background review in this section.

packet. In our network, rather than sending only one request to the hub at once, each end node may send several if more than one packet arrives at once, forming a ReQ message. The hub knows everything about the status of each node, and deals with those requests one by one after receiving the ReQ messages. Upon receiving a response (i.e. CTS message), the end node will transmit the packet at the head of its queue. The data packets are converted into optical slots after the scheduling and before they are transmitted in the network. Upon the successful exchange of RTS and CTS messages, the data are transmitted in the network which composes slotted traffic stream (Fig. 2).

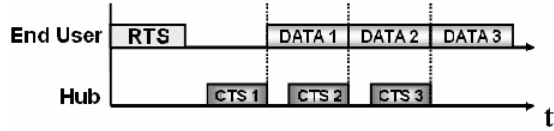


Fig. 2 Traffic stream (RTS, CTS and Data)

New arriving source data are stored in the electronic buffers inside the interfaces until related CTS messages are received. Then they will be converted into optical packets and get transmitted into the network. All the ReQs that arrive at the arbiter comprises a matrix called Request Array (RA). Assume the ReQ length is R and the number of nodes is N . Fig. 3 shows an example of RA for a LAN with four nodes (A, B, C, and D). Each row of RA stands for the requests from one node, which lists the destination addresses. In this case, each node can send up to five requests at a time. If there are less than five requests during the period, the remaining fields of RA will be filled with zero.

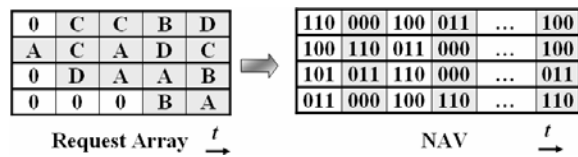


Fig. 3 Request Array and NAV ($R=5$, $N=4$)

There is a NAV (Network Allocation Vectors) inside the hub which contains the state codes of all the switches, and is updated by the arbiter based on RA. The NAV columns correspond to the requests in the time order of being served. The arbiter has an internal cycling timer, based on which it periodically performs the request-serving procedure, including extracting the information from NAV, sending out CTS messages, and signalling each switch the respective state codes, so that all the switches will be configured properly to form a clear end-to-end path when the data packet arrives. Based on the principle of this centralized control protocol, there are three

parameters that may affect the network performance for the same type of LAN, i.e. ReQ length (R), arbiter timer granularity, and edge buffer length.

Performance Evaluation

We simulate a 100m four-nodes LAN with OPNET. Fixed traffic profile for FTP over TCP application is being used to evaluate how the network parameters affect the performance. The application inter-request time is uniform (0, 0.005), and the file size is set to be constantly 50k bytes for simplicity purpose. In order to have a reasonable threshold, we create a reference model with the same network topology and scale, which works in the IP-like interrupt mode but utilizes the optical capacity. In the reality this reference model does not exist, as issues like optical buffering, O-E-O conversion or optical processing are neglected. In the following diagrams, the red lines which stand for the reference model statistics will imply what would be the ideal performance for the network. This threshold will give us a better vision to evaluate the designated protocol.

In the results section, you need to describe the configurations of your practical work environment.

Efficiency is defined as the ratio of successfully delivered traffic to the offered traffic. From Fig. 4 we can see that, RTS/CTS handshake imposes large overhead for data transmission. So the network is not efficient enough with less than four requests allowed at one time. Increasing ReQ length can enhance the performance under certain circumstances.

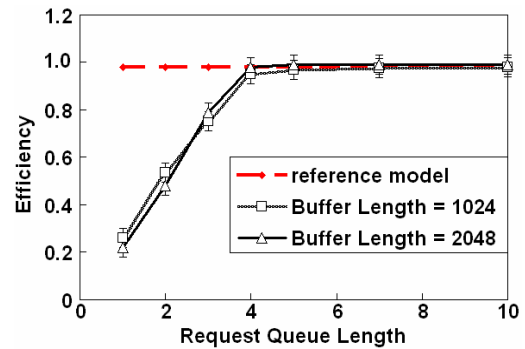


Fig. 4 Network Efficiency vs. ReQ Length

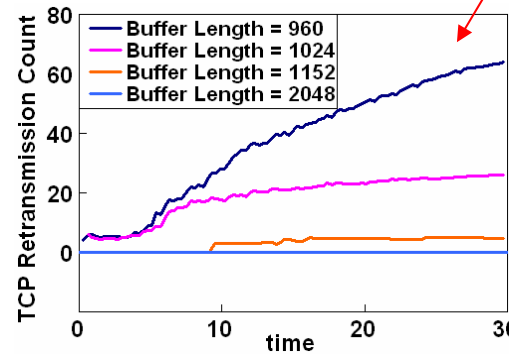


Fig. 5 TCP Retransmission Count

In TCP mechanism, the retransmission is triggered by the lost segments. In this collision-free switching

Only publish coloured diagrams if you are sure that they are readable by the third party. If necessary, replace coloured lines with patterned lines.

Having results isn't enough. You need to discuss them in two ways:

- Validate them to see if they are expected.
- Explain why you are getting such results

network, the only place for packet loss is the edge buffer. Fig. 5 shows the TCP retransmission count in a period of network simulation with different lengths of edge buffers. We can conclude that, with same traffic intensity, bigger buffer can accommodate more packets to be scheduled, so there will be less packet loss, hence fewer retransmissions happen. However on the other hand, longer buffer causes longer queuing delay; we will see this in Fig. 6. TCP segment delay is the end-to-end delay of segments received by the TCP layer across all nodes. Fig. 6 shows the average TCP segment delay with the growing of the ReQ length and with different buffer lengths. Longer ReQ length leads to better efficiency, hence the delay is less. The increase of edge buffer causes extra network delay.

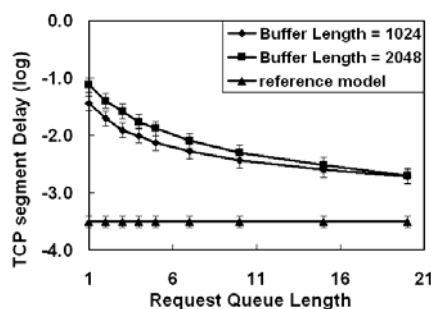


Fig. 6 Average TCP Segment Delay vs. ReQ Length

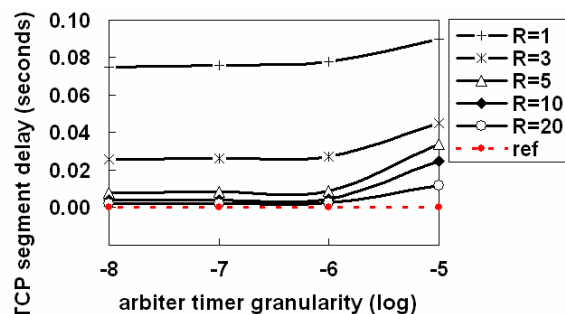


Fig. 7 Average TCP Segment Delay vs. Arbiter Timer

Fig. 7 demonstrates the impact of the arbiter timer interval as well as the ReQ length on the TCP segment delay. The result indicates steady network

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performance when the arbiter interval granularity ranges under 10^{-6} seconds. Any variation that is beyond this number will lead to visible performance change. Fig. 7 also validates another point made by Fig. 4. The network resource is under utilized with ReQ length less than four to deliver reasonable performance.

More than just a summary.

What have you gained so far?

Conclusions

A centralized data transmission control protocol has been designed to run OPS traffic in the local area network. Successful exchange of RTS and CTS messages guarantees collision-free packet switching. Simulation results indicate that the concept of using out-of-band controlling together with the combination of electronic and optics, offers pleasant prospects for optical networking to be implemented in the short term with low cost, simplicity, and fine performance. Network modelling and simulations are done to evaluate the network performance under the impact of different parameters, e.g. request queue length, edge buffer length, network arbiter timer interval, etc. The reference model delivers a perfect threshold to compare the designated protocol performance. The simulation results are all as expected, analyzing the network from different aspects, meanwhile indicating a steady network.

References

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Mandatory parts for every paper:

- Abstract
- Introduction
- Conclusion
- References

Anything between Introduction and Conclusion vary.