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A performance model for differentiated service over single-hop passive star coupled WDM optical networks

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ABSTRACT

One of the important issues in the design of future generation high-speed networks is to provide differentiated services to different types of traffic with/without various time constraints and priorities. In this paper, we study the problem of providing differentiated services in passive star coupled wavelength division multiplexing (WDM) optical networks. We present a medium access control (MAC) protocol based on a simple static priority based scheduling algorithm combined with channel assignment. We propose an analytical model to evaluate the performance of the differentiated services provided by the MAC protocol which prioritizes message transmissions in single-hop WDM passive star networks. We formulate the analytical model and conducted numerical study to validate the model. The study proves that the proposed analytical model is accurate enough to describe the behaviors of the differentiated service provided by the networks with the MAC protocol.

1. Introduction

Wavelength division multiplexing (WDM) is an effective technique for utilizing the large bandwidth of an optical fiber. By allowing multiple messages to be simultaneously transmitted over a number of optical channels, WDM has the potential to significantly improve the performance of optical networks. A passive star coupler, equipped with tunable transmitters and tunable receivers, can be used to construct a multi-access LAN/MAN using WDM channels. It has the potential of sharing the enormous bandwidth of the optical medium among all the network users. In order to fully exploit the enormous available bandwidth of the optical fiber, efficient medium access control (MAC) protocols are needed to efficiently allocate and coordinate the system resources. Generally, the key requirements and features of MAC protocols for LANs/MANs comprise flexibility in terms of bandwidth allocation and configuration, low cost and compatibility with existing network architectures and protocols.

A major challenge in the design of future generation high-speed networks is the provision of real-time service to time-constraint applications such as video or audio information. It is also demanded that different types of traffic could coexist in one system and share the bandwidth of a few communication channels and other network resources. The networks would have the capacity to provide flexibility and efficiency to allow the coexistence of different types of traffic, such as real-time and multimedia traffic. An integrated traffic stream is composed of real-time traffic streams, in which messages have time constraints, and non-real-time traffic streams without time constraints. The most important aspect of the time-constrained applications is that a message generated at a source station must be received at its destination station within a given period of time. If the delay of a message in the network exceeds its time constraint, the message is considered as late. A scheduling algorithm for a MAC protocol that serves real-time messages is to schedule the transmission of the messages to meet their time constraints as much as possible.

There are many research results published on the real-time scheduling algorithms to provide real-time service in WDM optical networks as well as in some other networks. The proposal in Yan et al. (1996) tries to combine the pre-allocation-based technique with the reservation-based protocol to provide real-time service to the time-constrained messages by using a centralized controller for the message scheduling in optical networks. The scheduling algorithm proposed in Ma et al. (1999) is the first solution to provide real-time services in the single-hop passive star coupled WDM optical networks. The scheduling algorithm is to provide real-time service to the variable-length, burst messages with time constraints. The solution proposed in Huang and Ma (2005) explores the features at the physical layer of the same networks to improve the performance of the real-time service. There are also some research results published on the performance model of the optical networks with single server priority queuing systems. Such models can be found in Mitrani and King (1981), Gail et al. (1988, 1992), Kao and Narayanan (1990), Kao and Wilson (1999),

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