Chapter 2
Optical Networking:
Current Issues and Review

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ABSTRACT

Telecommunication networks based on optical fiber technology have become a major information transmission system with high capacity optical fiber links encircling the globe in both terrestrial and undersea installation. At present there are numerous passive and active optical devices within a light wave link that perform complex networking functions in the optical domain, such as signal restoration, routing, and switching. Along with the need to understand the functions of these devices comes the necessity to measure both components and network performance and to model and simulate the complex behavior of reliable high capacity networks. This chapter presents the fundamental principles for understanding and applying these issues. This chapter is primarily about TCP/IP network protocols and Ethernet network architectures, but also briefly describes other protocol suites, network architectures, and other significant areas of networking. It explains in simple terms the way networks are put together, and how data packages are sent between networks and subnets, along with how data is routed to the Internet.

OPTICAL NETWORKING

Key features of this chapter for accomplishing these issues are as follows: history, types, principle and operation of optical networking; wavelength division multiplexing (WDM) routed optical networks; main characteristics of optical switching; IP over WDM issues: routing problem and routing protocols used in IP network; current typical protocol stacks and classification of routing schemes; topology of optical network: star network, ring network and tree network, et cetera; types of optical networks, and network categories. Hence this chapter treats more complex optical networks that

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can be utilized in local, metropolitan or wide area networks to connect hundreds or thousands of users with a wide range of transmission capacities and speeds (Modiano, 1999).

As the name suggests, optical networks form a class of networks where optical, rather than electronic, components are the building blocks of the network. Compared to metallic cable, fiber optic systems offer greater bandwidths, lower attenuation, and no crosstalk or electrical interference. Those advantages have led to the dramatic growth of fiber optic systems worldwide. This chapter is primarily about TCP/IP network protocols and Ethernet network architectures, but also briefly describes other protocol suites, network architectures, and other significant areas of networking. This chapter is written for all audiences, even those with little or no networking experience. It explains in simple terms the way networks are put together, and how data packages are sent between networks and subnets along with how data is routed to the internet (Gerstel & Ramaswami, 2000; Modiano & Narula Tam, 2002; Manchester et al., 1998).

Today, nearly all long-haul telecommunications depend on the use of optical networks for their large capacity and robust performance.

- The purpose of the management and control systems for optical networks is to provide for the efficient delivery of highly available, highly reliable communication services.
- These services consist of a variety of different types of connections between end users of the optical network.

Standards

Standards for fiber optic cable and other optical components have been developed over the last 20 years primarily by the American National Standards Institute (ANSI) and the International Telecommunications Union (ITU). Standards for fiber optic transmission have been developed initially in North America under the name Synchronous Optical Network (SONET) and later by the ITU using the name Synchronous Digital Hierarchy

Historical Milestones

- **1958:** Discovery of laser
- **Mid-60s:** Demonstration of guided wave optics
- **1970:** Production of low-loss fibers, which made long-distance optical transmission possible
- **1970:** Invention of semiconductor laser diode, which made highly refined optical transceivers possible
- **70s-80s:** Use of fiber in telephony: SONET/SDH standards from ITU
- **Mid-80s:** LANs/MANs: broadcast-and-select architectures
- **1988:** First trans-Atlantic optical fiber laid
- **Late-80s:** Development of EDFA (optical amplifier), which greatly alleviated distance limitations
- **Mid/late-90s:** DWDM systems explode
- **Late-90s:** Intelligent Optical networks
- **20??:** Soliton transmission with optical TDM

Optical Networking: Why

The "traditional" networks consist, for the most part, of a collection of electronic switches interconnected by point-to-point optical fiber links, which can span local, metropolitan, or wide area networks. To accommodate continually increasing demand for bandwidth and flexibility, such networks are being enhanced by adding more fibers and switches, increasing the bit rate per fiber, and upgrading the switches' size, throughput and functionality. Such enhancements eventually lead to very large and complex networks that are difficult and expensive to construct, operate and maintain. Recent and emerging advances in optical technology promise revolutionary all-optical