CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction.

This chapter provides in detail about the multiple access technologies and the OCDMA system. It starts with a discussion on various existing multiple-access techniques, comparison of multiple access schemes, the OCDMA system and the advantages of OCDMA system.

2.2 Multiple Access Schemes

Optical fibers provide excess bandwidth for multiple access operations, permitting many users to simultaneously communicate over the same medium by partitioning and allocating time, bandwidth, or some other features of the transmitted signal. A multiple access is required for combining and separating traffics on a shared physical medium when the users are not at the same place.

There are three major multiple access schemes available, Time Division Multiple Access (TDMA), Wavelength Division Multiple Access (WDMA) and Code Division Multiple Access (CDMA). Traditionally, fiber optic communication systems use either TDMA or WDMA schemes to allocate bandwidth among multiple users. In a TDMA system, each channel occupies a time slot, which interleaves with time slots of other channels. In a WDMA system, each channel occupies a narrow bandwidth around a center wavelength or frequency. In optical CDMA, each user is identified by different codes or addresses. In a particular technique, a CDMA user inserts its code or address in each data bit and asynchronously initiates transmission. In Optical CDMA, the field of the optical signal carrying the data exhibits a set of signal processing operation. This modifies it's time and/or frequency appearance, in a way recognizable only by the intended receiver. Otherwise, only noise-like bursts are observed. The advantages of CDMA include the flexibility in the allocation of channels, the ability to operate asynchronously, enhanced privacy, and increased capacity in bursty-nature networks. The advantages and disadvantages of these three schemes are summarized in Table 2.1.

Table 2.1: Comparison of Common Optical Multiple Access Schemes

Multiple Access Schemes	Advantages	Disadvantages
TDMA	a. Dedicated channels provided b. High throughput c. Deterministic access	a. Accurate synchronization needed b. Not efficient in bursty traffic c. Bandwidth wasted d. Channel not efficiently used e. Performance degrades with the number of simultaneous users
CDMA	a. Simultaneous users allowed b. Asynchronous access c. No delay or scheduling d. High bandwidth efficiency e. Efficient for bursty traffic. f. Dedicated channels provided	a. Performance degrades with the number of simultaneous users
WDMA	a. Dedicated channels provided b. Simultaneous users allowed c. High bandwidth efficiency d. Simultaneous users allowed e. High bandwidth efficiency	a. Channel crosstalk b. Channel idle most of the time c. Non-linear effects

2.3 Optical Code Division Multiple Access (OCDMA)

In long haul optical fiber transmission links and networks, the information consists of a multiplexed aggregate data stream originating from many individual subscribers and normally is sent in a well-timed synchronous format. The design goal of the Time Division Multiplexing (TDM) process is to make maximum use of the available optical fiber bandwidth for information transmission, since the multiplexed information stream requires very high-capacity links. To increase the capacity even further, Wavelength Division Multiplexing (WDM) techniques that make use of the wide spectral transmission window in optical fibers are employed. As an alternative to these techniques in a local area network (LAN), Optical Code Division Multiple Access (OCDMA) has been examined. This scheme can provide multiple access to a network without employing very high speed electronic data processing devices as are needed in TDM networks. In the simplest configuration, CDMA achieves multiple access b assigning a unique code to each user. To communicate with another node, users imprint their agreed-upon code onto the data. The receiver can then decode the bit stream by locking onto the same code sequence.

The principle of OCDMA is based on spread-spectrum techniques, which have been widely used in mobile-satellite and digital-cellular communication systems. The concept is to spread the energy of the optical signal over a frequency band that is much wider than the minimum bandwidth required to send the information. For example, a signal that conveys 10^3 b/s may be spread over a 1 MHz bandwidth. This spreading is done by a code that is independent of the signal itself. Thus, an optical encoder is used to map each bit of information into a high rate (longer code length) optical sequence.

The symbols in the spreading code are called chips, and the energy density of the transmitted waveform is distributed more or less uniformly over the entire spread spectrum bandwidth. The set of optical sequences becomes a set of unique address codes or signature sequences for the individual network users. In this addressing scheme, each 1 data bit is encoded into a waveform or signature sequence s(n) consisting of N chips, which represents the destination address of that bit. The 0 bits are not encoded. Ideally, all of the signature sequences would be mutually orthogonal, and each receiver would process only the address signals intended for it. However, in practice, “nearly orthogonal” is the best that has been accomplished. Consequently, there is some amount of cross correlation between the various addresses.

The unique address-encoding scheme can be considered analogous to having numerous pairs of people, in the same room, talking simultaneously using different languages. Ideally, each communicating pair will understand only their own language, so that interference generated by other speakers in minimal. Thus, time-domain OCDMA allows a number of users to access a network simultaneously through the use of a common wavelength. This is particularly useful in ultrahigh-speed LANs where bit rates of more than 100 Gb/s will be utilized. A basic limitation of OCDMA using a coded sequence of pulses is that as the number of users’ increases, the code length has to be increased in order to maintain the same performance. Since this leads to shorter and shorter pulses, various ideas for mitigating this effect have been proposed. Alternatively, frequency-domain methods based on spectral encoding of broadband incoherent sources (e.g., LEDs or Fabry-Perot lasers) have been proposed.

Both asynchronous and synchronous OCDMA techniques have been examined. Each of these has its strengths and limitations. In general, since synchronous accessing schemes follow rigorous transmission schedules, they produce more successful transmissions (higher throughputs) than asynchronous methods where network access is random and collisions between users can occur. In applications that require real-time transmission, such as voice or interactive video, synchronous accessing techniques are most efficient. When the traffic tends to be bursty in nature or when real-time communication requirements are relaxed, such as in data transmission or file transfers, asynchronous multiplexing schemes are more efficient than synchronous multiplexing.

2.4 The Advantages of OCDMA Architecture

The basic spectral OCDMA architecture naturally possesses a number of desirable advantageous features:

a. The all-optical multiplexing results in a protocol agnostic system in which channels can be carried at any combination of data rates and formats in an independent, unsynchronized fashion.

b. Since there is no need for TDM or temporal encoding, each channel operates at its native data rate. Since there is no need for repetitive optical-to-electrical-to-optical conversion at each node, there is no accumulation of temporal jitter, and electronic regeneration is unnecessary.

c. The use of incoherent sources and the spreading of each channel over multiple wavelengths affords spectral OCDMA an inherent tolerance to a variety of imperfections in optical components and the transmission medium such as center wavelength shifts, slow drop offs at the edges of filters, polarization dependent loss and fiber nonlinearities.

d. Sophisticated encryption is not required because OCDMA is already encoded and does not suffer from the same type of adjacent-channel crosstalk as DWDM: that is, center wavelength shifts in filters do not result in the accidental reception of someone else's signal. Similarly, OCDMA cannot result in the accidental reception of an unwanted channel as could occur with errors in synchronization in TDM.

e. The flexibility afforded by the tap-and-insert nature of the optical bus combined with the programmability of the transceivers enables the assignment of bandwidth and logical connections where they are needed.

f. Multiple logical topologies can be supported simultaneously on the same physical network. For example, a physical ring could be implemented for optical layer protection on top of which virtual rings, meshes, stars, and trees can also exist.

g. The broadcast nature of the system also lends itself to video distribution in a point-to-multipoint configuration.