Optical transmission and optical switching

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Abstract. This paper deals with optical networks and basic components in this network – optical fibers, optical sources and optical receivers. One of the most common devices is optical switching, too. We know – wavelength convertor, wavelength Add/Drop multiplexer, optical cross connect and optical gateway.

Keywords. Optical network and crossconnector, switching, MEMS, MPLS.

1. Introduction

Optical fiber communication is now ubiquitous in the telecommunications infrastructure. The optical network use for transmission two variants of fibers – single-mode and multimode. The early fibers were the so-called **multimode** fibers. Multimode fibers have core diameters of about 50 to 85 mm. This diameter is large compared to the operating wavelength of the light signal and therefore multimode fiber supports multiple propagation nodes, each mode traveling at a slightly different speed through the fiber.

The other devices needed for optical fiber transmission are light sources and receivers. Compact semiconductor lasers and light-emitting diodes (LEDs) provided practical light sources. Semiconductor photodetectors enabled the conversion of the light signal back into the electrical domain.

The next generation used **single-mode** fiber. Single-mode fiber has a relatively small core diameter of about 8 to 10 µm, which is a small multiple of the operating wavelength range of the light signal. This forces all the energy in a light signal to travel in the form of a single mode. Using single-mode fiber effectively eliminated intermodal dispersion and enabled a dramatic increase in the bit rates and distances possible between regenerators [1].

Generally, the current telecom infrastructure is a mix, with fiber optic cables and copper wire. Grail in telecommunications and networking today is the 'all-optical network', where every communication would remain an optical transmission from start to finish. The speed and capacity of such a network would be practically limitless. Solution is in the DWDM and optical Switching.

2. DWDM

Dense Wavelength Division Multiplexing (DWDM) is a fiber-optic transmission technique. DWDM works by transmitting different signals over a fiber-optic cable through different wavelengths of light. The main difference between DWDM and WDM is that DWDM is more condensed and, thus, able to transmit more wavelengths of light [2].

3. Optical switching

Most networking equipment today is still based on electronic-signals, meaning that the optical signals have to be converted to electrical ones, to be amplified, regenerated or switched, and then reconverted to optical signals. This is generally referred to as an 'optical-to-electronic-to-optical' (OEO) conversion. Optical switching should be cheaper, as there is no need for lots of expensive high-speed electronics.

One of the most common techniques using the tiny moveable mirrors is known as micro-electro-mechanical systems (MEMS) [3].

4. Optical MEMS

The technology that allows high-port-count data-rate-independent switches is micro-electro-mechanical-systems (MEMS). These are silicon micromachines built just the same way as a silicon integrated circuit. VLSI fabrication techniques also allow designers to integrate micromechanical, analog, and digital microelectronic devices on the same chip, producing mutifunctional integrated systems [4].

MEMS consist of mirrors no larger in diameter than a human hair that are arranged on special pivots so that they can be moved in three dimensions as Fig. 1 and Fig.2. Several hundred such mirrors can be placed together on mirror arrays no larger than a few centimeters square. Light from an input fiber is aimed at a mirror, which is directed to move the light to another mirror on a facing array. This mirror then reflects the light down towards the desired output optical fiber.

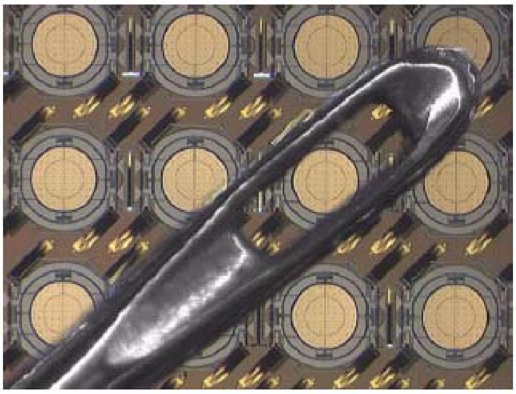

Figure 1. MEMs [5]

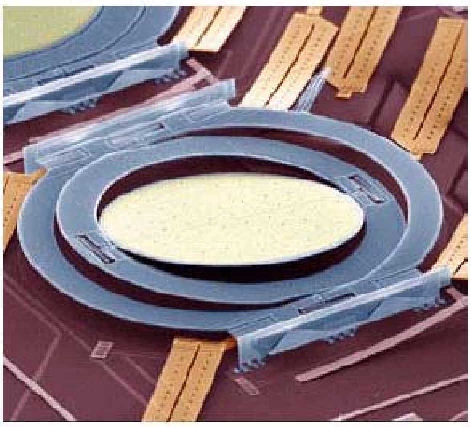

Figure 2. Single MEMs for OCX [6]

5. Basic switching components in optical network are:

- wavelength converters
- wavelength Add/Drop multiplexer
- optical cross connects
- optical gateway

5.1. Wavelength converter

A wavelength converter's function is to convert data on an input wavelength onto a possibly different output wavelength within the operation bandwidth of the system as Fig. 3. This component is used in the routing devices when the wavelength is to be changed. An ideal wavelength converter should be transparent to bit-rates and signal formats. Wavelength converter is an important component in all-optical networks, since the wavelength of the incoming signal may already be in use by another information channel residing on the destined outgoing path.

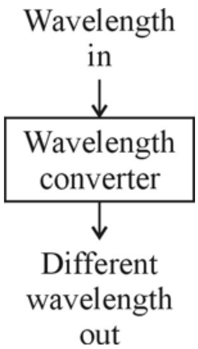

Figure 3. Wavelength converter

Wavelength converter can be Optoelectronic (O/E/O) converter or all optical converters. All optical converters devide to:

a) XGM Cross-gain modulation in as Fig.4.
b) SOA (Semiconductor amplifier) as Fig.5. XPM Cross-phase modulation in SOA
c) FWM Four wave mixing as Fig. 6.
d) DFG Different frequency generation

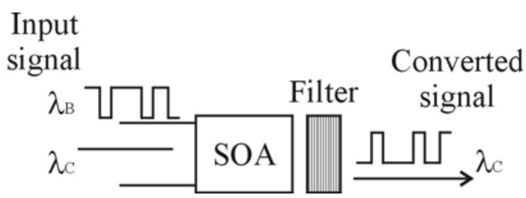

Figure 4. Gross gain modulation

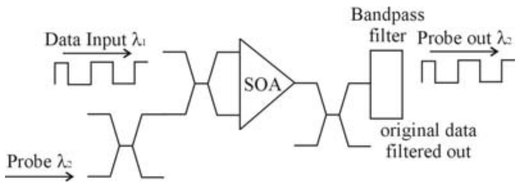

Figure 5. Cross phase modulation

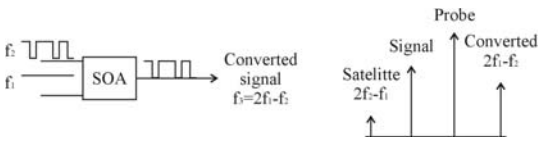

Figure 6. Four wave mixing [8]

5.2. Optical add-drop multiplexing

Optical add-drop multiplexers are used to add and drop specific wavelengths from multi-wavelength signals, to avoid electronic processing as Fig. 7. For this application, wavelength selective switches are required. Switching times in the ms range are adequate.

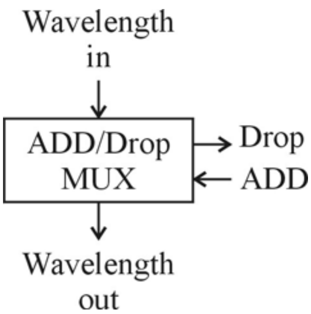

Figure 7. Add/Drop multiplexer

5.3. Optical cross conect

Cross-connection in optical domain is much more difficult task than in electrical world. It may be accomplished converting optical data streams into electronic data, using electronic cross-connection technology, and then converting electronic data streams into optical as Fig.8. This is known as the hybrid, or opaque OXC. Another way is to cross-connect optical channels directly in the photonic domain with all-optical (transparent) OXC.

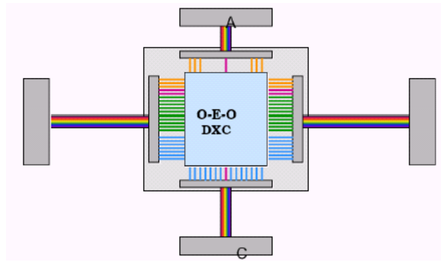

Figure 8. Hybrid cross connect [6]

5.3.1. All optical OXC

All optical, or photonic OXCs, as the name indicates, don't need expensive Optical – Electrical – Optical (OEO) conversion, but the signal stays in photonic domain through the switching. This is the first requirement for transparent operation. As Fig. 9.

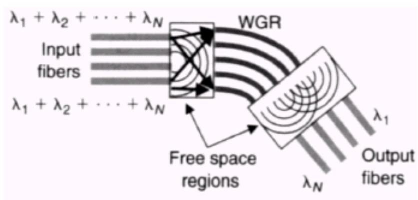

Figure. 9. All optical cross connector [6]

5.4. Optical Gateways

The optical gateway is a common transport structure that must groom and provision traffic entering the optical layer.

By providing a link between the variety of electrical protocols and allowing flexible deployment of any mix of them, optical gateways provide networks the maximum benefits of optical networks.

6. Definition MPLS

Multiprotocol label switching (MPLS) is a versatile solution for network—that is speed, scalability, quality-of-service (QoS) management, and traffic engineering. MPLS has emerged as an elegant solution to meet the bandwidth-management and service requirements for next-generation Internet protocol (IP)–based backbone networks. MPLS play an important role in the routing, switching and forwarding of packets througt the next-generation network in order to meet the service demands of the networkl users.

MPLS is an integration of Layer 2 and Layer 3 technologies. By making traditional Layer 2 features available to Layer 3, MPLS enables traffic engineering. Thus, you can offer in a one-tier network what now can by achieved only by overlaying a Layer 3 network on a Layer 2 network.

Combination multiprotocol switching and utilization wave multiplex WDM or DWDM genesis technics multiprotocol switching by means of wave length of optical level and a type "L" in short MPLS is possible accept that "Lambda" switching too [9].

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