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Optical Networking – A Study

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Abstract— This paper throws light on what Optical Networks are really capable of and what developments have been made in terms of the higher bandwidth provided by them in an adaptive way, whenever and wherever required. How optical fibres have been extensively implemented now days in all types of communication networks. Multiple ways of increasing the capacity by using the WDM (Wavelength Division Multiplexing) technique. A brief survey on the recent developments on 'flexible' optical networking. This paper deals with the evaluation of the performance of WDM networks.

Keywords— optical networks, WDM, flexible optical networking, ONN, NAS.

I. INTRODUCTION

Optical Network is a telecommunication network with transmission links such as optical fibres, with an architecture designed to exploit the unique features of fibres. It is a high performance light wave network which involves complex combination of both optical and electronic devices. The key features that hold together the optical networks are:

- **O**ptical **N**etwork **N**odes (ONN) - connects the fibres within the network.
- **N**etwork **A**ccess **S**tations (NAS) - interfaces user terminals and other non- optical end systems to the network.

The critical role played by the Optical Networks basically relies on reducing the communications costs, promoting competition among carriers & service providers and increasing the demand for new services.

II. LAYERED VIEW OF OPTICAL NETWORKS

Physical Layer

- Contains optical components executing linear operations on optical signal.
- Provides basic communication services to a number of independent logical networks (LNs).

Logical Layer

- Contains electronic components executing nonlinear operations on electrical signal.

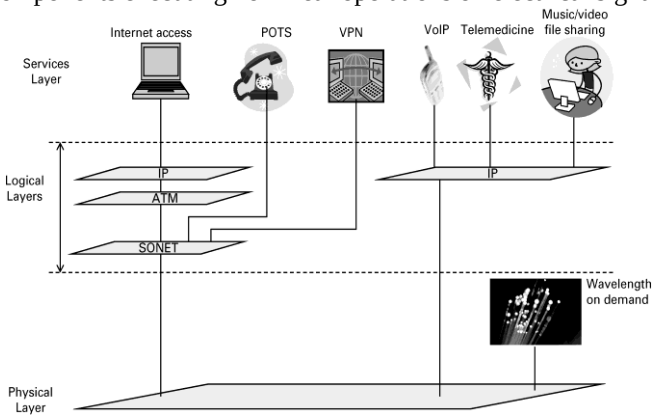

Fig.1. Layered View of the Optical Network

III. WDM OPTICAL NETWORKS

Important advantages of WDM Optical Networks are:

- Low signal attenuation.
- Low signal distortion.
- Low power requirement.
- Low material usage.
- Small space requirements.
- Low cost.

Broadcasting Networks and Wavelength-Routed Networks

In a *wavelength-routed network*, the wavelength of the optical signal and the fibre it is using determine the subsequent path used (hence the name wavelength-routed) by the signal. Since each optical signal is sent along a specified path and not broadcast to all nodes in the network, the power requirement of such a network is lower than that of a broadcast-and-select network. This type of network may contain a large number of end nodes but is more complex and expensive than a broadcast-and-select network.

In a *broadcast-and-select network* for unicast communication, the source end node selects an appropriate wavelength λp and broadcasts the data to be transmitted to all end nodes in the network using the wavelength λp. The receiver at the destination end node must be tuned to the wavelength λp while the receivers at all other end nodes are tuned to wavelengths different from λp. The net result is that the data is detected and processed only at the destination node.

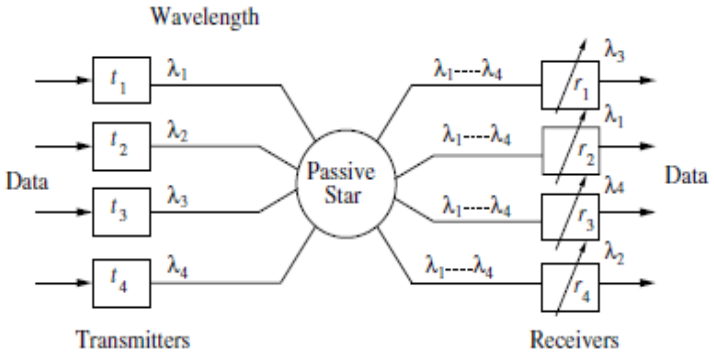

Fig. 2. A broadcast-and-select network

Static and Dynamic Lightpath Allocation

There are two approaches for deciding a strategy for data communication in a wavelength-routed network. The more standard approach is to set up lightpaths on a semi-permanent basis so that, once the lightpaths are set up to handle the expected volume of data between the ordered pairs of end nodes, the lightpaths will continue to exist for a relatively long period of time (weeks or months). This approach is called *static lightpath allocation*. When the communication pattern changes sufficiently, the existing lightpaths will be taken down and new lightpaths will be set up to handle the changes in traffic.

In the second approach, called *dynamic lightpath allocation*, lightpaths are set up on demand and, when a communication is over, the corresponding lightpath is taken down.

Single Hop and Multi-Hop WDM Networks

In order to make the most economical use of a network, maximizing the throughput of the network is important. The cost of devices for optoelectronic conversion is high, and the speed of processing in electronic circuits is much less than the speed at which optical signals propagate through fibers. Minimizing the number of stages of electronic processing of data in WDM networks is therefore a crucial objective. It is highly desirable that the data be kept in optical form from the time it leaves the source end node until it reaches its destination end node. In a *single-hop* network, all data communication involves a path length of one logical edge. In other words, exactly one lightpath is involved in each communication. Single-hop networks are also called *all-optical networks*, since the communication is always in the optical domain.

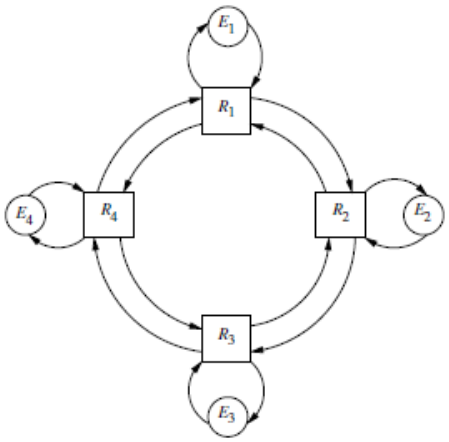

Fig. 3. The physical topology of a typical WDM network with four end nodes E1… E4 and four routers R1… R4

In a *multi-hop* network, some data communication involves more than one lightpath. In the network shown in Fig. 3, with lightpaths shown in Fig. 4, the communication from end node *E*1 to end node *E*4 involves two lightpaths (either *L*3 and *L*2 or *L*1 and *L*4). The network is therefore a multi-hop network. If in the network shown in Fig. 3, there were lightpaths between every ordered pair of end nodes, then it would become a single-hop network.

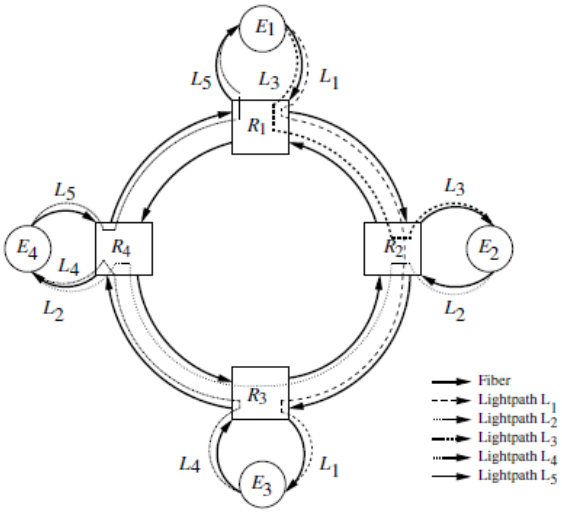

Fig. 4. Some lightpaths on the physical topology shown in Fig. 3

IV. PROBLEMS IN WDM NETWORKS & THEIR SOLUTIONS

Important problems in the area of WDM network design that have been are as follows:

- How to set up a lightpath, or a set of lightpaths, to make optimum use of the network resources.
- How to best define the logical topology of a multi-hop network.
- Given a logical topology, what is the optimum strategy to handle all the requests for data communication in the network.
- How to handle faults in the network.

The problems mentioned above are optimization problems and are often tackled using *linear program* formulations or using *combinatorial optimization*. The idea of a *linear program* (LP) is to optimize some objective function, subject to linear constraints of a number of decision variables appearing in the problem formulation. If, in a problem formulation, some of the variables are constrained to have non-negative integer values and the others are *continuous* variables, each capable of having any nonnegative value, the formulation is called a *mixed integer linear program* (MILP).

V. CONCLUSIONS

As optical networks continue to develop and emerge, WDM network systems will evolve from static point-to-point links to optically switched wavelength-routed networks. The establishment of lightpaths in such networks requires the implementation of control and management protocols to perform routing and wavelength assignment functions.

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