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A Review of Data Transport Employing Wavelength Division Multiplexed (WDM) Transmission

Savita Itkarkar[1]*, Dr. D. S. Bhangari[2]

[1] Research Scholar, Shridhar University, Pillani, Rajasthan, India

Email: savitatul20@gmail.com

[2] Professor, Shridhar University, Pillani, Rajasthan, India

Abstract- The term "high performance networks" describes optical networks. Through optical networks, massive amounts of data may be delivered at incredible speeds. Electromagnetic interference and other forms of outside impact do not affect optical networks. For a variety of uses, optical systems provide increased information transmission capacity at reduced cost. There is hope for the realisation of optical networks with unparalleled bandwidth capacity due to the success of recent trials in data transport employing Wavelength Division Multiplexed (WDM) transmission. WDM based on wavelength routing has become the standard in both metro-area & wide-area networks. Information routing & allocation of wavelength resources across links are essential components of all optical WDM networks, which maintain network connections from source to destination in the optical domain.

Keywords- WDM, Transmission, Network, Routing, Optical

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INTRODUCTION

The term "computer network" refers to a system of linked, independent computers (Andrew S. Tanenbaum 2001). When two computers can transfer data to one another, we say that they are interconnected. Fibre optics, microwaves, & communication satellites are alternative to copper wires that can be utilised for the connection. According to the technology used at the physical level, there are three distinct generations of networks (Biswanath Mukherjee 1992). Before fibre optic technology emerged, networks were constructed using the first generation. Copper wire or radio waves via microwaves form the basis of these networks. Among these, you can find examples such as ARPANET, IEEE 802.5 token ring, IEEE 802.4 token bus, Digital Network Architecture (DNA) from IBM, and Cambridge ring from Digital. One example of this generation is the transition from copper or microwave radio to fibre connections for long haul trunks in a WAN.

The massive opto-electronic bandwidth mismatch is something that third-generation networks do their best to take advantage of through WDM. Through the utilisation of the fiber's transmission capacity, WDM facilitates the realisation of Tb/s networks. To the extent that data may stay in the optical domain during its journey from source to destination, third-generation networks are essentially optical in character. Data transferred via optical networks, which use photons as their unit of measurement and send them over fibre, is far quicker than data transferred via more conventional networks.

WAVELENGTH DIVISION MULTIPLEXING

In order to implement Tb/s networks, WDM is the method of choice. Higher data rate transmission over a single fibre is far more cost-effective than lower data rate transmission over numerous fibres, which is why multiplexing is necessary. Increasing a fiber's transmission capacity can be done in two main methods. One option is to raise the bit rate. One way to accomplish this is by utilising optical time division multiplexing (OTDM) or electronic time division multiplexing (TDM). WDM is another method for increasing a fiber's transmission capacity. WDM refers to a technique that uses an optical fiber's core to transmit multiple light beams of varying wavelengths all at once.

Using WDM and TDM, network topologies and protocols can take advantage of the fiber's massive bandwidth by allowing numerous user transmissions to run concurrently. One further way to add concurrency to optical communication networks is with Optical Code Division Multiplexing (OCDM). By merging numerous data streams with different speeds into one faster stream, electronic TDM raises the bit rate. Electronic TDM can't compete with the data rates that OTDM can achieve. When using OTDM, the optical domain is where the multiplexing & demultiplexing operations are carried out. The networking interface of the end user's device needs to be significantly quicker than the processing speed of the electronic device in order to accommodate the significantly higher data rates and chip rates used by OTDM & OCDM. Because of this, WDM is preferable to OTDM & OCDM. Optical communication networks currently use WDM as their chosen multiplexing technology for long-haul communications (Biswanath Mukherjee 2000). The reason behind this is that the bit rate of a WDM channel can be freely chosen—for example, the peak electronic processing speed—and all end user equipment is confined to working at this rate. The common term for second-generation optical networks is WDM. In Figure 1, we can see the WDM principle in action.

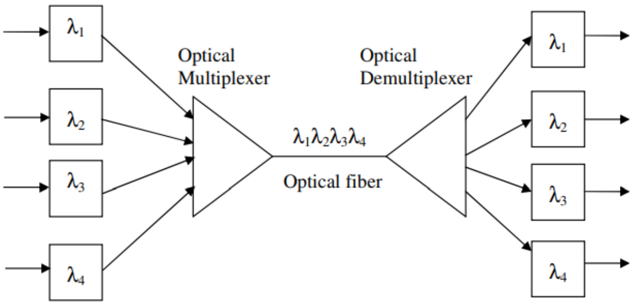


Figure 1 Wavelength Division Multiplexing

By modulating optical signals at different wavelengths, the information signals that correspond to an end user working at electronic speed can be mixed & delivered simultaneously over the same optical fibre. In contrast to electrical Frequency Division Multiplexing (FDM), a WDM optical system that makes use of a diffraction grating is entirely passive, making it incredibly dependable. Additionally, each WDM optical channel has a carrier wave that is one million times more powerful than an FDM channel. A single WDM channel's bandwidth can be split into many radio frequency channels with different operating frequencies utilising FDM. The term for this is subcarrier multiplexing. With WDM, the optical transmission spectrum—which spans 1.55 microns—is divided into numerous nonoverlapping wavelength channels that share a single fibre and enable individual communication channels operating at electronic speeds, thus resolving the optical-electronic bandwidth mismatch. The ability to significantly increase available bandwidth without incurring the exorbitant expenditure of laying down additional fibre is one attractive feature of WDM.

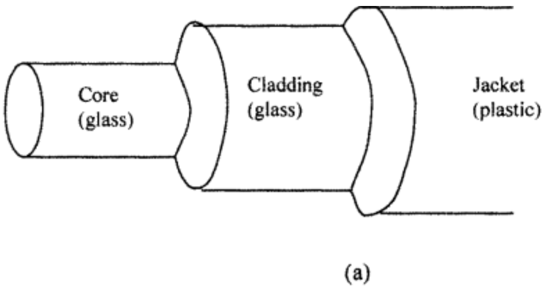
OPTICAL NETWORKS

The reason optical networks are faster than traditional networks is that photons weigh less than electrons and do not interact with each other or stray photons outside the fibre because they have no electric charge. There are more "bits" of information that can be contained in a length of fibre than in the same length of copper since light has higher frequencies and shorter wavelengths.

At the turn of the 20th century, endoscopes were equipped with optical glass fibres that were based on the then-popular principle of total internal reflection. In 1966, Kao and Hockham were the first to suggest using fibre glass as a medium of communication. To replace copper wire with optical fibre and achieve faster speeds, several optical networks emerged in the late 1980s and early 1990s. For linking computers to other computers or peripheral systems, computer interconnects like ESCON, Fibre Channel, & HiPPI use low-rate optical components, which are quite affordable. For data transfer rates of 100–200 Mb/s between computers, FDDI (Fibre Distributed Data Interface) makes use of two fibre optic token rings. SDH (Synchronous Digital Hierarchy) in Europe and Asia and SONET (Synchronous Optical Network) in North America enable fibres to seamlessly interoperate up to an OC-192 rate of approximately 10 Gb/s, making it one of the most successful standards in the entire networking industry & foundation for modern high-speed backbone networks. OC-48 and OC-192 correspond to about 2.5 Gb/s and 10 Gb/s, respectively, based on the specifications provided by (OC-n (Optical Carrier-/?) for an electronic data rate of n x 51.84 Mb/s. The next benchmark for the fastest achievable electronic communication speed is OC-768, which comes in at 40 Gb/s.

Optical Fiber Principles

The core of an optical fibre is a tiny cylinder of glass that allows light to pass through. As depicted in Figure 2(a), the core is encased in a thin plastic jacket and encircled by a concentric layer of glass, also known as cladding. The index of refraction is somewhat greater in the core compared to the cladding. A critical angle, θc, is defined by the ratio of the cladding & core indices of refraction. When a light beam from the core hits the surface of the core-cladding at an angle smaller than θc, it is entirely reflected back into the core, which is the mechanism that makes fibre optics function (see to Fig. 2(b)).



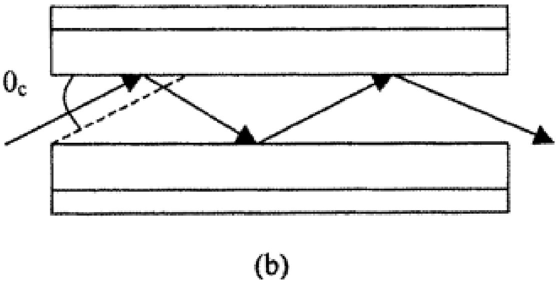


Figure 2. (a) Optical fiber (b) Reflection in fiber

A multitude of light rays emanating from the core will be reflecting at various angles due to the fact that every light beam that hits the core cladding at an angle below the critical angle (θc) is reflected internally. A multimode fibre is one that exhibits this quality; in this case, each ray is said to have a separate mode (see Fig. 3(a)). Because the rays interact with each other when sent through a multimode fibre, the highest bit rates that may be achieved are limited. The core's tiny diameter allows the fibre to function as a waveguide, allowing light to move in a straight line down the fiber's centre axis. See Figure 3(b) for an illustration of what this quality means for fibres: single-mode fibres. To transfer data at many gigabits per second over hundreds of kilometres, one must use the more expensive single-mode fibres. The core diameter of single-mode fibres is 8 to 10 microns, but that of multimode fibres is 50 microns (1 micron = 106 meter).

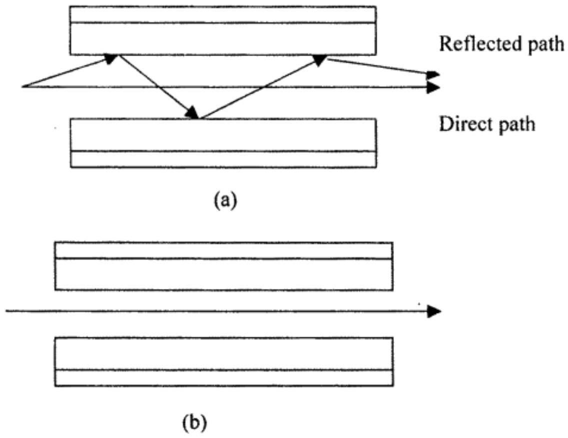


Figure 3(a) Multimode fiber (multiple rays follow different paths). (b) Single-mode fiber (only direct path propagates in fiber)

Optical Transmission System

The three main parts of an optical transmission system are the transmitter, the medium of transmission, and the receiver, as illustrated in Figure 4. An electrical input signal modulates a light source, such as a laser or light-emitting diode, to create a beam of light that is sent into the transmission medium, an optical fibre. This light source is the transmitter. It is common practice to transform the binary data sequence into a series of pulses of light that can be turned on and off before sending them over the optical fibre. An optical detector at the receiver turns the on/off light pulses back into an electrical signal. In this way, we have a system that can only transmit in one direction—a unidirectional transmission system—that takes an electrical signal, changes it into light pulses, sends them via a medium, and then, at the receiving end, changes them back into an electrical signal.

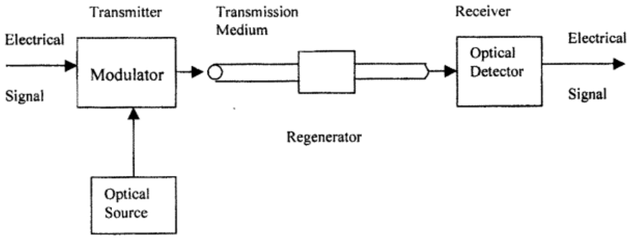


Figure 4. Optical transmission system

Signal power decreases due to attenuation in fibre as it travels over a certain distance. The original attenuation loss of optical fibre was 20 dB/km when it was invented in 1970, but fibres with a loss of just 0.2 dB/km were available within a decade. Using the formula 10 log(transmitted power/received power), we can find the attenuation in decibels. Light attenuation through fibre is wavelength dependent. The attenuation, measured in decibels per linear kilometre of fibre, is illustrated in Figure 4. This picture clearly shows three bands of low-loss data, with centres at 0.85, 1.30, and 1.55 microns. Using cheap LEDs as its light source, early optical fibre transmission systems (from the 1970s) worked in the first, 0.85-micron band, and achieved data rates in the tens of megabits per second (3). Their current iterations reach gigabits per second through the utilisation of laser sources and operation in the 1.30 and 1.55 micron bands. Rayleigh scattering in the fiver glass are the main sources of attenuation. Interconnecting fibre sections with electronic regenerations (also termed repeaters) allows for the restoration of a degraded signal, allowing for continuing transmission despite attenuation (see Fig. 5).

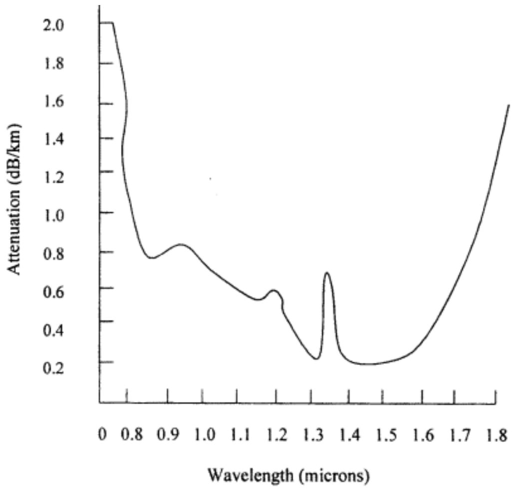


Figure 5. Attenuation versus wavelength for optical fiber

The dispersion of the light pulses causes their duration to increase as they travel through the fibre. The quantity of this dispersion, which is a term for this spreading, varies with wavelength. Bit rates are constrained by dispersion, which reduces the minimum time gap between successive pulses due to interference with light pulses ahead and behind. In a fibre, there are essentially two dispersive effects. Both chromatic and intermodal dispersion are involved. In multimode fibres, intermodal dispersion happens when a pulse gets smeared after travelling a certain distance because the energy in the pulse travels in various modes, each with its own velocity. various wavelengths move at various rates, causing chromatic dispersion. This is because the transmitting laser can't send all the photons at the same wavelength. An unusual pulse shape known as a soliton can be identified; this shape is able to maintain its original form even as it travels through the fibre. Therefore, the dispersion problem can be solved using solitons. Soliton speeds of 80 Gb/s over 10,000 km have been demonstrated experimentally.

ROUTING AND WAVELENGTH ASSIGNMENT

In wavelength-routed WDM networks, lightpaths allow for connectivity. Every link in the network must have its own distinct path and maintain a steady wavelength throughout. There must be a way to connect the two nodes that is continuous over a whole wavelength. If the nodes in the network can convert wavelengths, then wavelength continuity in the routes is not necessary. By integrating route selection with wavelength assignment, the RWA algorithm can be used to find lightpaths. Subproblems of RWA are prevalent in optical networks that use wavelength routing. Use effective RWA algorithms for optimal lightpath establishment. The capacity to allocate particular wavelengths distinguishes wavelength-routed networks from conventional networks.

Tang et al. (2001) and Gerstel (1997) both state that there are three distinct kinds of connection requests, sometimes known as traffic demand: static, incremental, & dynamic. All of the connections are known in advance while dealing with static traffic. Pairs of sources & destinations can be used to describe the traffic demand. A prediction of the node pairs' long-term traffic needs is used to choose these pairs. The goal is to minimise the number of wavelengths required by assigning routes and wavelengths to all the requests. Maximising the number of demands served with a given number of wavelengths is the dual problem of assigning routes & wavelengths. An acronym for "Static Lightpath Establishment," the RWA issue is specifically for static traffic. Lightpaths are created for each connection in the incremental traffic scenario, and they stay in the network forever. In this model, connection requests come in a sequential order.

Each connection request in the dynamic traffic scenario triggers the establishment of a lightpath, which is then released after a certain amount of time. Qin et al. (2003) defined dynamic RWA as a RWA problem in which connection requests come and go at random. The goal of the dynamic traffic scenario is to maximise the number of lightpaths established while efficiently using network resources by assigning wavelengths to connections and selecting routes. As described by Zhang et al. (2001), this issue is known as the Dynamic Lightpath Establishment (DLE) problem. A mixed integer linear programme is one way to express the SLE problem (Rajiv Ramaswamy 1995, Pallavi Manohar et al 2002). The routing subproblem & wavelength assignment subproblem are two ways to break down SLE into manageable chunks. You can solve each subproblem on its own. To address the SLE issues with big networks, Banarjee (1996) put forward viable approximation techniques. Heuristics are typically used since the DLE problem is more complex to solve. For the routing subproblem as well as the wavelength assignment subproblem, heuristics are available. According to many sources (Chan 1994, Harai et al 1997, Li and Somani 1999, Lang et al 2001, and Ramu Ramamurthy 1996), the routing subproblem can be approached in three main ways: FAR, AR, and FR. in the year 2002. Of these methods, AR produces the highest quality results while FR is the easiest to implement. A compromise between complexity and performance is provided by FAR. The subproblem of wavelength assignment has multiple proposed heuristics. Consider these heuristics: RN for Random Wavelength Assignment, FF for First-Fit Wavelength Assignment, LU for Least-Used, MU for Most-Used, MP for Min-Product, LL for Least-Loaded, Rsv for Wavelength Reservation, or Thr for Protection Threshold.

Routing

In this section, various approaches to routing the connection requests are discussed.

Fixed Routing

Each source-destination pair in FR uses the identical fixed-route. Fixed shortest path routing is one method that uses this strategy. Offline, using shortest path algorithms like Dijkstra's or the Bellman Ford's, we identify the shortest route for each source-destination pair, and then we use that route to connect any two nodes that we provide. The shortest route between two specified points is determined using Dijikstra's technique in this study.

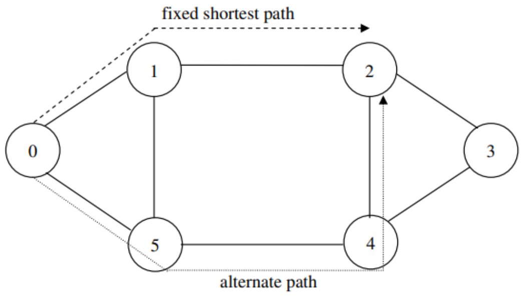


Figure 6: Dijikstra's technique

Fixed-Alternate Routing

According to Ramu Ramamurthy (2002), FAR statically calculates a list of routes that should be utilised between each pair of source & destination locations. There can be no edges connecting the paths in this set. The reason for selecting edge-disjoint routes is to improve fault tolerance (Li and Somani 1999 and Lee et al 2004). If a route cannot be used due to a link failure, then an alternate route is available. This alternate route has no link in common with the failed route as these routes are edge-disjoint.

Adaptive Routing

In AR, the path from one node to another is determined on the fly based on the current status of the network. The collection of all active connections defines the network state. According to Mokhtar and Azizoglu (1998), AR takes network state information into account while making a routing decision & evaluates all possible paths between a source-destination pair. Compared to FR and FAR, AR has the benefit of causing less connection blocking. Each source-destination pair follows a predetermined sequence of routes in Least Congested Path (LCP) routing, as described by Chan and Yum in 1994. As soon as a connection request comes in, the least crowded route out of the ones that were already chosen is used.

Wavelength Assignment

Static wavelength assignment is the process of assigning a unique wavelength to each lightpath in a collection of lightpaths and their routes in order to ensure that no two lightpaths on a particular fibre link share the same wavelength (Zang et al 2000). The graph colouring algorithm is one possible solution to this issue. Heuristic approaches are required to assign wavelengths to lightpaths in the scenario where they arrive sequentially, such as in incremental or dynamic traffic demand. In the dynamic problem, we want to minimise the call blocking probability for a specific number of wavelengths rather than trying to minimise the number of wavelengths, as in the static situation. A number of heuristics for determining the chosen route's wavelength have been put forward in the literature.

Random Wavelength Assignment

The RN scheme is able to find all the wavelengths that are available on the needed path by searching the space of wavelengths. A random wavelength is selected from the available options.

First-Fit Wavelength Assignment

The wavelengths are searched in a set order by this approach. We search all the wavelengths in the order they appear in the index. This search order is used to choose the first free wavelength that is found. No global information is needed by this technique. Since the full wavelength space does not have to be searched for each route, the computing cost of this technique is lower than random wavelength assignment. The basic premise of this plan is to cluster all the currently-used wavelengths closer to the bottom of the spectrum, increasing the likelihood that the higher spectrum will be available for longer, continuous pathways.

LU Wavelength Assignment

LU aims to distribute the load evenly among all wavelengths by picking the one that isn't used too often in the network. Not only does LU incur extra communication cost, but its performance is also lower than random assignment.

MU Wavelength Assignment

The heuristic prioritises the wavelength that is utilised by the majority of the network's links. According to Subramaniam and Barry (1997), it has far better performance than LU. By conserving the spare capacity of less used wavelengths and doing a better job of putting connections onto fewer of them, MU slightly surpasses FF. Costs for storage, computation, and transmission are comparable to LU.

Min-Product Wavelength Assignment

Ayonoglu and Jeong (1996) state that MP is utilised in multifiber networks. As FF in a single-fiber network, it fits the bill. The idea behind multiplexing is to reduce the number of fibres needed for a network by packing wavelengths into them.

Least-Loaded Wavelength Assignment

According to Karasan and Ayanoglu (1998), this is also suggested for networks that use several fibres. Using the route's most heavily loaded connection as a proxy, this heuristic chooses a wavelength with the highest residual capacity.

Wavelength Reservation

Wavelength reservation involves assigning a certain wavelength or wavelengths to a traffic stream on each link in a longer hop route in order to reduce the likelihood of blocking that stream. Fairness is enhanced by this strategy. The worldwide network's performance drops as a result of a drop in wavelength utilisation caused by the exclusive reserve of wavelengths for certain connections. The shorter hop connections are likewise penalised by this strategy.

Protection Threshold

This technique only uses shorter hop connections to assign an idle wavelength when the link's idle wavelength count reaches a certain threshold. Because of this, longer hop connections are able to use part of the available wavelengths on the network. This approach is thus a way to increase fairness.

Centralized and Distributed Control

According to Rajiv Ramaswami and Segall (1997), WDM networks can establish lightpaths utilising either centralised or distributed control. The presence of a central controller in the network is presumed in centralised control. The establishment and release of connections are coordinated by it. The health of the entire network is monitored by it. The controller keeps track of the load on each connection in the network as it pertains to different wavelengths. The information regarding the current lightpaths is likewise preserved by it.

CONVERTING WAVELENGTHS IN WAVELENGTH-ROUTERED OPTICAL NETWORKS

To establish a lightpath, choose a path that is continuous throughout all wavelengths. Since the risk of connection blocking is increased by the wavelength continuity constraint, network performance is negatively affected. Connection performance degrades more noticeably with increasing hop count in relation to blocking probability as opposed to connection performance degradation with decreasing hop count. When two calls with the same wavelength are supposed to go over the same network connection, it can potentially block one of them. One solution to these issues is wavelength conversion, also known as wavelength translation. (Frey, Michael 2001)

In order to establish a call, wavelength conversion is required. This is because each link in the call path must have access to a common wavelength. At nodes in a network, there are devices called wavelength converters that allow lightpaths to change wavelengths as they travel from source to destination. A semilightpath is a transmission path that uses a converting node between any two lightpaths in a consecutive sequence. An example of a semi-lightpath that does not include any nodes that transform light into visible light is a lightpath. According to Ramamurthy (1998), optical networks that may change their wavelength are called wavelength-convertible networks. By easing the requirement for continuous wavelengths, wavelength converters are crucial nodes in WDM networks. Which means that wavelength-convertible networks have the capacity to take on additional connections.

To change the wavelength of an incoming signal, one can use a device known as a wavelength converter. A node with wavelength conversion capabilities can change the data coming in from one wavelength to another through its output ports. The term "wavelength converter node" describes this type of node. Full conversion capacity is achieved when such a node can convert any wavelength to any other wavelength. According to Yates et al. (1996) and Harai et al. (1998), a node is considered to have limited conversion capability when it can only convert incoming wavelengths to a subset of available wavelengths. The analogy to a circuit switched telephone network is apt when discussing wavelength-convertible networks that provide complete wavelength conversion capacity at every node. When this occurs, wavelength assignment becomes irrelevant; the sole concern becomes fixing the routing problem. The high cost of fully capable wavelength converters means that not all nodes in the network can afford to have them. Therefore, it is more practical for a network to have some important nodes that can convert wavelengths fully. A sparse wavelength conversion network is the name given to this type of network.

CONCLUSION

Optical Networks are faster than traditional networks because photons weigh less than electrons, and further, unlike electrons, photons do not affect one another when they move in a fiber (because they have no electric charge) and are not affected by stray photons outside the fiber. Light has higher frequencies and hence shorter wavelengths, and therefore more “bits” of information can be contained in a length of fiber versus the same length of copper. WDM optical networking is enabled by a range of technologies. At the foundation is the extremely high-bandwidth (25-THz), low-attenuation-loss (0.2-dB/km in the 1.55-micron low-attenuation band) single-mode optical fiber allowing long-distance transmission. Today’s widely installed WDM optical networks are opaque (optical electrical-optical) path (connection) between any two end nodes or users in these networks is not totally optical. This means the path involves optical electronic-optical conversion operations at intermediate nodes and these conversion operations affect the network speeds or bit rates.

REFERENCES

1. Aravindh, S., and Michael, G., (2012), “Hybrid of Ant Colony Optimization and Genetic Algorithm for Shortest Path in Wireless Mesh Networks,” Journal of Global Research in Computer Science, 3(1), pp. 31-34.

2. Arci, D., Maier, G., and Pattavina, A., Petecchi, D. and Tornatore, M., (2003), “Availability Models for Protection Techniques in WDM Networks,” Proc. 4th International Workshop on Design of Reliable Communication Networks (DRCN 2003), pp.158-166.

3. B.Mukherjee, “WDM Optical Communication Networks: Progress and Challenges,” IEEE Journal of Selected Areas in Communications, Voi.18, No. 10, pp. 1810-1824, October 2000.

4. Dutta, R., and Rouskas, G. N., (2002), “Traffic Grooming in WDM networks: Past

and Future," IEEE Network, 16(6), pp. 46-56.

5. Guo, L., Yu, H., Li, L., (2005), "Dynamic Survivable Algorithm for Meshed WDM Optical Networks," Journal of Network and Computer Applications, 30(1), pp. 282–295.

6. Huang, S., and Dutta, R., (2004), "Research problems in dynamic traffic grooming in optical networks," Proc. Workshop on Traffic Grooming in WDM Networks, (BROADNETS 2004),

7. I.Chlamtac, A. Ganz, and G.Karmi, "Lightpath Communications: An Approach to High Bandwidth Optical WANs," IEEE Transactions on Communications, voi.40, No.7, pp.l 171-1182, July 1992.

8. K. Chan and T. Yum, "Analysis of least congested path routing WDM Lightwave networks," in in: Proc. IEEE INFOCOMM 94, April 1994.

9. Luo, Y & Ansari, N 2004, 'A Computational Model for Estimating Blocking Probabilities of Multifiber WDM Optical Networks', IEEE Communication Letters, vol. 8, no.1, pp. 60-62

10. Mukherjee, B 2000, 'WDM Optical Communication Networks: Progress and Challenges', IEEE J. on Selected Areas in Communications, vol. 18, no. 10, pp. 1810-1824

11. Osama Awwad, Ala, I, Al-Fuqaha & Mohsen Guizani 2006, 'Genetic Approach for Traffic Grooming, Routing, and Wavelength Assignment in WDM Optical Networks with Sparse Grooming Resources', IEEE ICC 2006 Proceedings, pp. 2447-2452.

12. Osama Awwad, Ala, I, Al-Fuqaha & Mohsen Guizani 2006, 'Genetic Approach for Traffic Grooming, Routing, and Wavelength Assignment in WDM Optical Networks with Sparse Grooming Resources', IEEE ICC 2006 Proceedings, pp. 2447-2452.

13. Passakon Prathombutr, Jerry Stach & Park, EK 2003, 'An Algorithm for Traffic Grooming in WDM Optical Mesh Networks with Multiple Objectives', This paper is reprinted from a paper published in ICCCN 2003. Proceedings of the 12th International Conference on Computer Communications and Networks, pp. 405–411.

14. Randhawa, R., Kaler, R. S., and Singal, A., (2013), "Performance Evaluation of Algorithms for Wavelength Assignment in Optical Ring Network," Journal for Light and Electron Optics, 124, pp. 78-81.

15. Wang, J., Qi, X., and Chen, B., (2006), "Wavelength Assignment for Multicast in AllOptical WDM Networks With Splitting Constraints," Proc. IEEE/ACM Transactions on Networking, 14(1), pp. 169-182.

16. Yonggang Li & Longjiang Lication 2012, 'Static Traffic Grooming in WDM Network Using Artificial Immune Algorithm', Photonics and Optoelectronics, pp. 1-4

17. Zang, H, Jue, JP & Mukherjee, B 2000, 'A Review of Routing and Wavelength Assignment Approaches for Wavelength Routed Optical WDM Networks', Optical Networks Magazine, vol. 1, no. 1, pp. 47-60.

Corresponding Author

Savita Itkarkar*

Research Scholar, Shridhar University, Pillani, Rajasthan, India

Email: savitatul20@gmail.com