DYNAMIC ROUTING SCHEME IN ALL-OPTICAL NETWORK USING RESOURCE ADAPTIVE ROUTING SCHEME

S. Suryanarayana[1], K.Ravindra[2], K. Chennakesava Reddy[3]
[1] Dept. of ECE, CMR Institute of Technology, JNT University Hyderabad, India
[2] Dept. of ECE, Mallareddy Institute of Tech & Science, JNT University Hyderabad, India
[3] Dept. of EEE, TKR College of Engg &Tech, JNT University Hyderabad, India

ABSTRACT

With the increasing demand for high data transfer rate, the communication is getting new developments. For progressive data transfer at high data rate services, the means of communication has now taken high offering bandwidth architecture such as optical networks. In optical networks the mode of communication is completely an optical medium and data are transferred from various nodes to reach to the destination via optical routers. Though these networks have high bandwidth compatibility they offer heavy traffic congestion due to non-linear traffics resulting in degraded quality services. In this paper we present an adaptive methodology towards developing routing scheme in optical network based on queue based mechanism at wavelength router for comparatively higher offering quality of services.

KEYWORD: *All-optical network, resource adaptive routing, dynamic routing scheme, throughput, overhead*

I. INTRODUCTION

From the past ten to twenty years the usage of internet services are drastically increasing year by year. So we have to develop our communication systems to meet the demand for the data transfer. So to incorporate the quality of service for high data rate services, optical networks are the upcoming solution. Optical wavelength-division-multiplexing networks provide large bandwidth and are promising networks for the future Internet. Wavelength routed WDM systems that utilize optical cross connect are capable of switching data in the optical domain. In such systems, end-to-end all-optical light paths can be established and no optical-to electronic and electronic-to-optical conversions are necessary at intermediate nodes. Such networks are referred to as all-optical networks. Wavelength routed networks without wavelength conversion are also known as wavelength-selective (WS) networks [11]. In such a network, a connection can only be established if the same wavelength is available on all links between the source and the destination. This is the wavelength-continuity constraint. Wavelength routed networks with wavelength conversion are also known as wavelength-interchangeable (WI) networks [11]. In such a system, each router is equipped with wavelength converters so that a light path can be setup with different wavelengths on different links along the path. To establish a light path in a WDM network, it is necessary to determine the route over which the light path should be established and the wavelength to be used on all the links along the route. This problem is called the routing and wavelength assignment (RWA) problem. Routing and wavelength assignment requires that no two light paths on a given link may share the same wavelength. In addition, in WS networks, light paths must satisfy the wavelength continuity constraint, that is, the same wavelength must be used on all the links along the path. The RWA problem can be classified into two types: the static RWA problem and the dynamic RWA Problem.

In the static RWA problem, the set of connections is known in advance, the problem is to set up light paths for the connections while minimizing network resources such as the number of wavelengths and

the number of fibers. Alternatively, one may attempt to set up as many light paths as possible for a given number of wavelengths.
Dynamic RWA tries to perform routing and wavelength assignment for connections that arrive dynamically. The objective of dynamic RWA is to minimize the blocking probability. The routing and wavelength assignment problem has been studied extensively.
A summary of the research in this area can be found in [16]. This problem is typically partitioned into two sub-problems: the routing sub-problem and the wavelength selection sub-problem [2, 3, 5, 6, 7, 10, 14]. For the routing sub-problem, there are basically three approaches, fixed routing [6], alternate routing [6, 7, 14], and dynamic adaptive routing [9, 10]. Among the routing schemes, dynamic adaptive routing, which is studied in this paper, offers the best performance. A large number of wavelength selection schemes have been proposed: random-fit [5], first-fit [5], least-used[15], most-used[15], min-product[8], least-loaded [11], max-sum[2, 15], and relative capacity loss[17].
The schemes can roughly be classified to three types. The first type, including random-fit and least-used, tries to balance the load among different wavelengths. The schemes in this category usually perform poorly in comparison to other types of RWA schemes. The second type, including first-fit, most-used, min-product, and least-loaded, tries to pack the wavelength usage. These schemes are simple and effective when the network state information is precise. The third type, including max-sum and relative capacity loss, considers the RWA problem from a global point of view. These schemes deliver better performance and are more computational intensive than the other types of schemes. In this study, we investigate the impact of route overhead information on the performance of the routing wavelength algorithms.

II. DYNAMIC ROUTING SCHEME

In this paper we outline the approach of providing quality of service based on route queue mechanism for higher quality of service. It is observed that the congestion probabilities at the link points are very heavy and a large computation is carried out at each router to provide an optimal routing. As the overhead in the route is basically due to packet blockage and queuing it is prime requirement to reduce this overhead to achieve high quality services. To achieve this objective in this paper we propose a markovian approach for a distributed optical network.
A queuing system consists of one or more routers that provide service of some sort to arriving node. Node who arrives to find all routers busy generally join one or more queues (lines) in front of the routers, hence the name queuing systems. There are several everyday examples that can be described as queuing systems [7], such as bank-teller service, computer systems, manufacturing systems, maintenance systems, communications systems and so on. Components of a Queuing System: A queuing system is characterized by three components: Arrival process - Service mechanism - Queue discipline.

2.1. Arrival Process

Arrivals may originate from one or several sources referred to as the calling population. The calling population can be limited or 'unlimited'. An example of a limited calling population may be that of a fixed number of machines that fail randomly. The arrival process consists of describing how node arrives to the system. If A_i is the inter-arrival time between the arrivals of the $(i-1)^{th}$ and i^{th} node, we shall denote the mean (or expected) inter-arrival time by E(A) and call it

$(\lambda) = 1/(E(A)$ the arrival frequency.

2.2. Service Mechanism

The service mechanism of a queuing system is specified by the number of routers (denoted by s), each server having its own queue or a common queue and the probability distribution of customer's service time. Let S_i be the service time of the ith customer, we shall denote the mean service time of a customer by E(S) and $\boldsymbol{\mu} = 1/(E(S)$ the service rate of a server.

2.3. Queue Discipline

Discipline of a queuing system means the rule that a server uses to choose the next customer from the queue (if any) when the server completes the service of the current customer. Commonly used queue disciplines are:

FIFO - Node are served on a first-in first-out basis. LIFO - Node are served in a last-in first-out manner. Priority - Node are served in order of their importance on the basis of their service requirements.

2.4. Measures of Performance for Queuing Systems:

There are many possible measures of performance for queuing systems. Only some of these will be discussed here.

Let, D_i be the delay in queue of the ith customer W_i be the waiting time in the system of the ith customer = $D_i + S_i$ Q(t) be the number of node in queue at time t L(t) be the number of node in the system at time t = Q(t) + No. of node being served at t

Then the measures,

$$d = \lim_{L \to \infty} \frac{\sum_{L=1}^{L=2} D_L}{n}$$

$$w = \lim_{L \to \infty} \frac{\sum_{L=1}^{L=2} W_L}{n} \qquad \text{------- (1)}$$

(if they exist) are called the steady state average delay and the steady state average waiting time in the system. Similarly, the measures,

$$Q = \lim_{T \to \infty} \frac{1}{T} \int_0^T Q(t).dt$$

$$L = \lim_{T \to \infty} \frac{1}{T} \int_0^T L(t).dt \qquad \text{-------- (2)}$$

(if they exist) are called the steady state time average number in queue and the steady state time average number in the system. Among the most general and useful results of a queuing system are the conservation equations:

$$Q = (\lambda)\, d \text{ and } L = (\lambda)\, w \qquad \text{-------- (3)}$$

These equations hold for every queuing system for which d and w exist. Another equation of considerable practical value is given by,

$$w = d + E(S) \qquad \text{--------- (4)}$$

Other performance measures are:

the probability that any delay will occur. - the probability that the total delay will be greater than some pre-determined value - that probability that all service facilities will be idle. - the expected idle time of the total facility. - the probability of turn-always, due to insufficient waiting accommodation.

2.5. Notation for Queues.

Since all queues are characterized by arrival, service and queue and its discipline, the queue system is usually described in shorten form by using these characteristics. The general notation is:

[A/B/s]:{d/e/f}

Where,
A = Probability distribution of the arrivals
B = Probability distribution of the departures
s = Number of routers (channels)
d = The capacity of the queue(s)
e = The size of the calling population
f = Queue ranking rule (Ordering of the queue)

There are some special notation that has been developed for various probability distributions describing the arrivals and departures. Some examples are,

M = Arrival or departure distribution that is a Poisson process
E = Erlang distribution
G = General distribution
GI = General independent distribution

Thus for example, the [M/M/1]:{infinity/infinity/FCFS} system is one where the arrivals and departures are a Poisson distribution with a single server, infinite queue length, calling population infinite and the queue discipline is FCFS. This is the simplest queue system that can be studied mathematically. This queue system is also simply referred to as the M/M/1 queue.

III. SYSTEM DESIGN

The common characteristic of all markovian systems is that all interesting distributions, namely the distribution of the interarrival times and the distribution of the service times are exponential distributions and thus exhibit the markov (memoryless) property. From this property we have two important conclusions:

1. State of the system can be summarized in a single variable, namely the number of node in the system. (If the service time distribution is not memoryless, this is not longer true, since not only the number of node in the system is needed, but also the remaining service time of the customer in service.)
2. Markovian systems can be directly mapped to a *continuous time markov chain* (CTMC) which can then be solved.

3.1. The M/M/1-Queue

The M/M/1 Queue has iid interarrival times, which are exponentially distributed with specified parameters and also iid service times with exponential distribution. The system has only a single server and uses the FIFO service discipline. The waiting line is of infinite size. It is easy to find the underlying markov chain. As the system state we use the number of node in the system. The M/M/1 system is a pure birth-/death system, where at any point in time at most one event occurs, with an event either being the arrival of a new customer or the completion of a customer's service. What makes the M/M/1 system really simple is that the arrival rate and the service rate are not state-dependent.

Steady-State Probabilities:

We denote the steady state probability that the system is in state k(k€N) by pk, which is defined by

$$p_k := \lim_{t\to\infty} P_k(t) \qquad \text{----------- (5)}$$

Pk(t) Where pk(t)) denotes the (time-dependent) probability that there are 'k' node in the system at time t. The steady state probability p_k does not dependent on t. We focus on a fixed state k and look at the *flows* into the state and out of the state. The state k can be reached from state k-1 and from state k+1with the respective rates $\lambda P_{k-1}(t)$ (the system is with probability $P_{k-1}(t)$ (t) in the state k-1 at time t and goes with the rate from the predecessor state k-1 to state k) and $\mu P_{k+1}(t)$ (the same from state k+1). The total flow into the state k is then simply $\lambda P_{k-1}(t)+\mu P_{k+1}(t)$. The State k is left with the rate $\lambda P_k(t)$) to the state k+1 and with the rate $\mu P_k(t)$ to the state k-1 (for k=0 there is only a flow coming from or going to state 1). The total flow out of that state is then given by $\lambda P_k(t)+\mu P_k(t)$. The total rate of change of the flow into state k is then given by the difference of the flow into that state and the flow out of that state:

$$\frac{dP_k(t)}{dt} = (\lambda P_{k-1}(t) + \mu P_{k+1}(t)) - (\lambda P_k(t) + \mu P_k(t)) \qquad \text{-------- (6)}$$

Furthermore, since the pk are probabilities, the *normalization condition*

$$\sum_{k=0}^{\infty} p_k = 1 \qquad \text{----------- (7)}$$

3.2. M/M/m-Queue

The M/M/m-Queue (m > 1) has the same interarrival time and service time distributions as the M/M/1 queue, however, there are m routers in the system and the waiting line is infinitely long. As in the M/M/1 case a complete description of the system state is given by the number of node in the system (due to the memoryless property). The M/M/m system is also a pure birth-death system.

3.3. M/M/1/K-Queue

The M/M/1/K-Queue has exponential inter arrival time and service time distributions, each with the respective parameters λ and μ. The nodes are served in FIFO-Order; there is a single server but the system can only hold up to K node. If a new customer arrives and there are already K nodes in the system the new customer is considered lost, i.e. it drops from the system and never comes back. This is often referred to as *blocking*. This behavior is necessary, since otherwise (e.g. when the customer is waiting outside until there is a free place) the arrival process will be no longer markovian. As in the M/M/1 case a complete description of the system state is given by the number of node in the system (due to the memoryless property). The M/M/1/K system is also a pure birth-death system. This system is better suited to approximate "real systems" (like e.g. routers) since buffer space is always finite.

IV. RESULT OBSERVATION

For the evaluation of the suggested approach a distributed optical network environment is been developed.

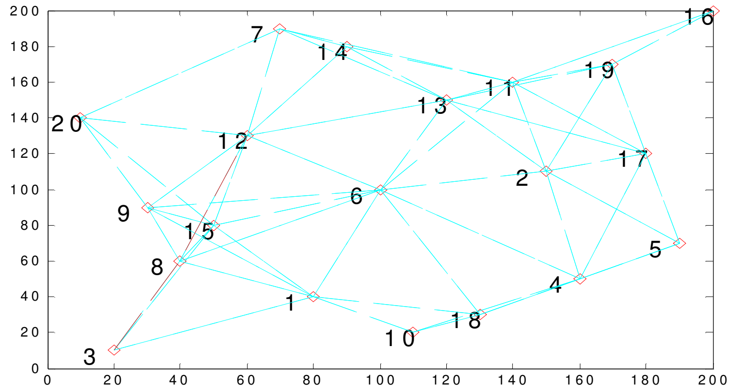

Fig 1: optical network architecture considered

The above figure illustrates about how the assigned nodes are established as a network. By applying the routing method we have got all the possible links in between the nodes. Whenever a node has to deliver packets to the destination from the source it has to follow the shortest path and reliable path to travel. This is done by the routing methodology. It is observed from the above figure that the reliable path is chosen and the data is passed through that path. It is represented by red dotted lines. After calculation of reliable path the data packets has to travel to destination in communication phase. The setup phase finds out which are all the possible paths shown in above figure.
The figure 2 plot is between number of data packets and data queue. It's been observed that delay performance is better in proposed system when compared to conventional systems. In proposed model we are using queuing methods to overcome the delay. It's clearly observed that as the number of data packets is increasing the queue management is good in the proposed work.

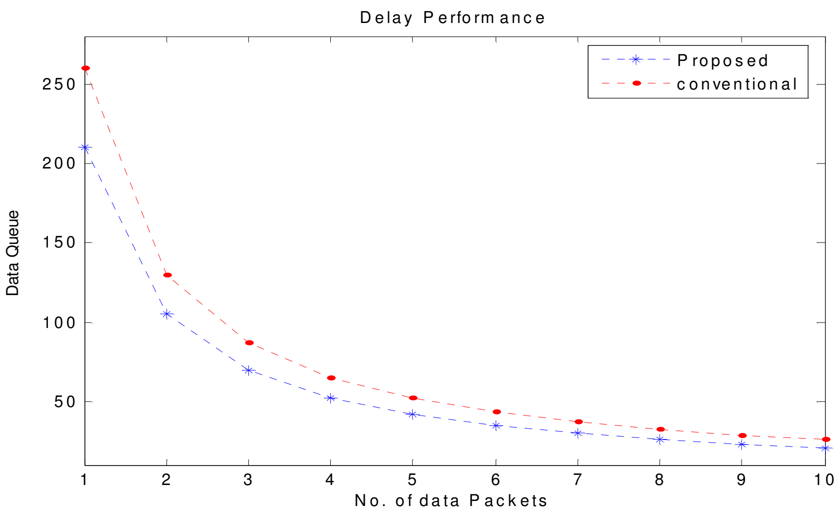

Fig 2: Delay Performance

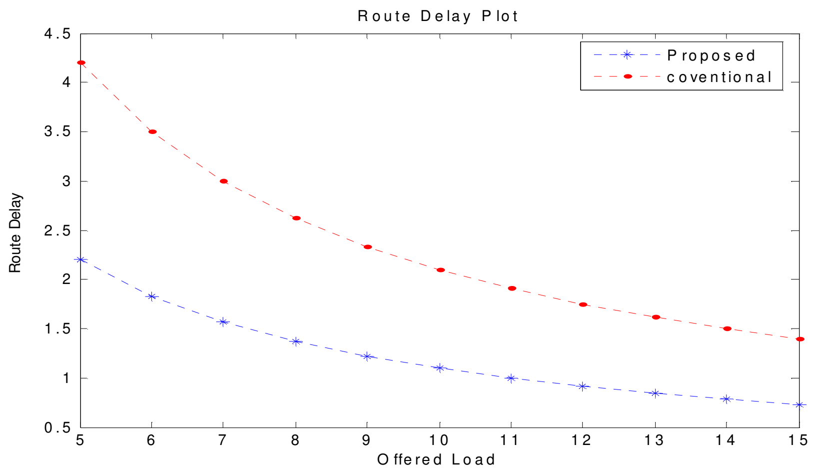

Fig 3: Route Delay Plot

Usually when the offered load is more the route delay will be there. The load is more means obviously the traffic and due to traffic congestion also will be more. In order to overcome the congestion in the network due to heavy traffic queuing models are used. The above plot mentions how the route delay varies when the offered load is increased. For the proposed method route delay is less when compared to the convention method.

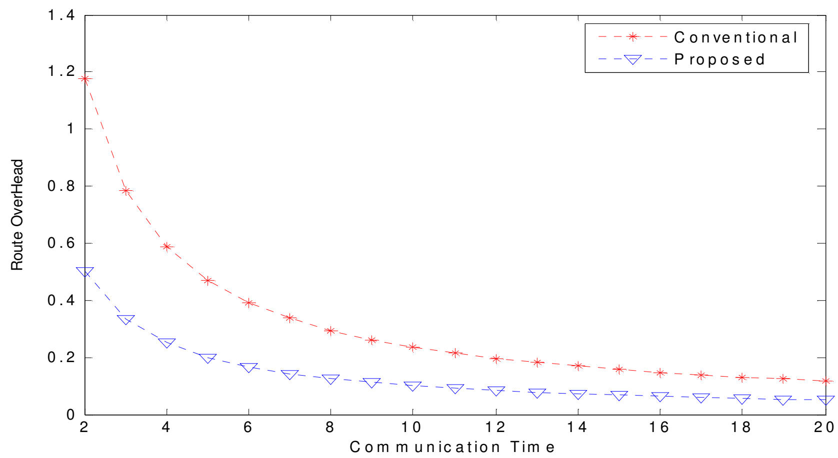

Fig 4: Route Overhead

Due to route delay the route overhead will increase. It leads to failure in data packets arrival. Chance of data packet loss will be there. Hence by applying queing model the problem is clearly solved. It's observed that even increase in communication time the route overhead is less in proposed methodology when compared to conventional method.

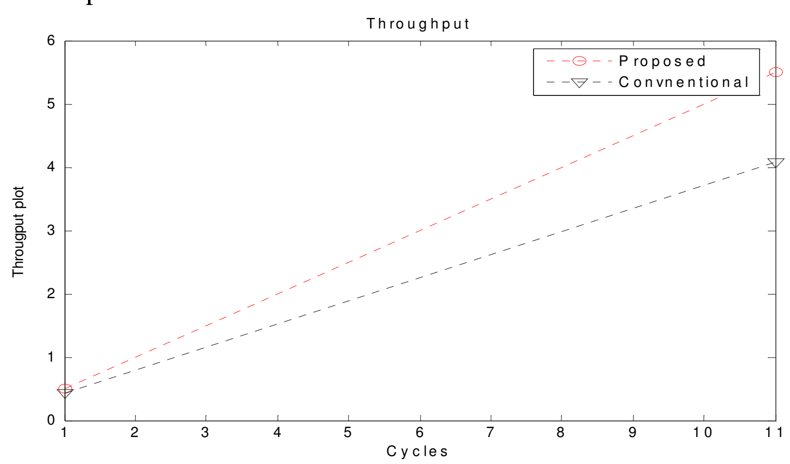

Fig 5: Throughput Plot

For any system throughput is the main parameter to be concentrated on. The above plot gives idea that the routing system which is used without any queing model has got less throughput when compared to the reliable model which we have proposed. The throughput is comparatively high when compared to the conventional method. Under a similar observation for different topology of network is simulated and observed as,

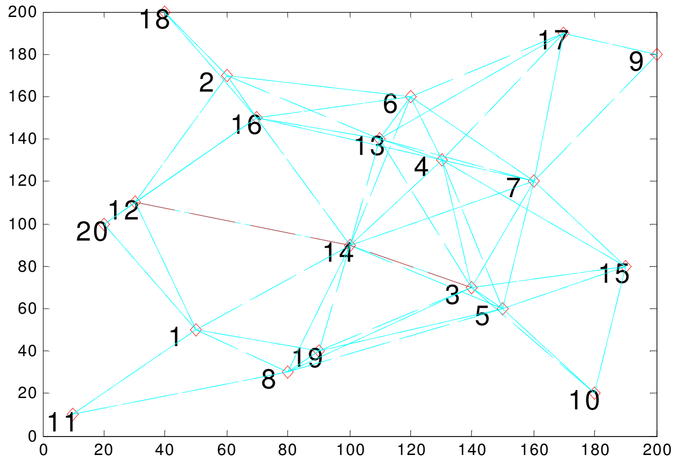

Fig 6: Link Probability

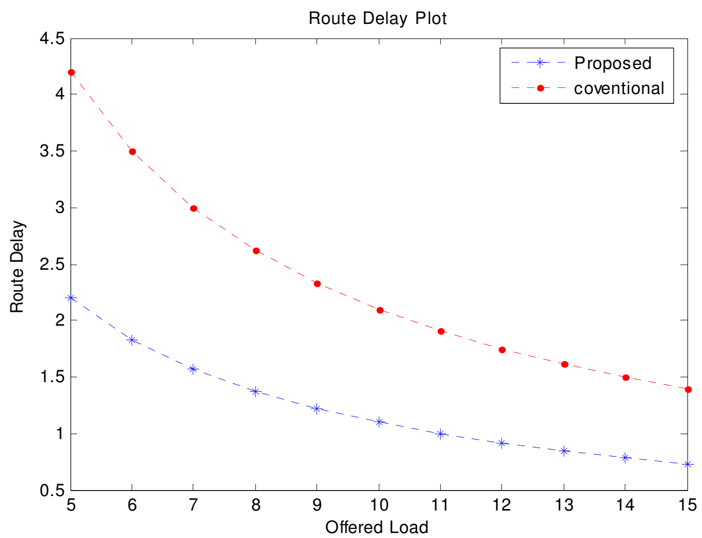

Fig 7: Route Delay Plot

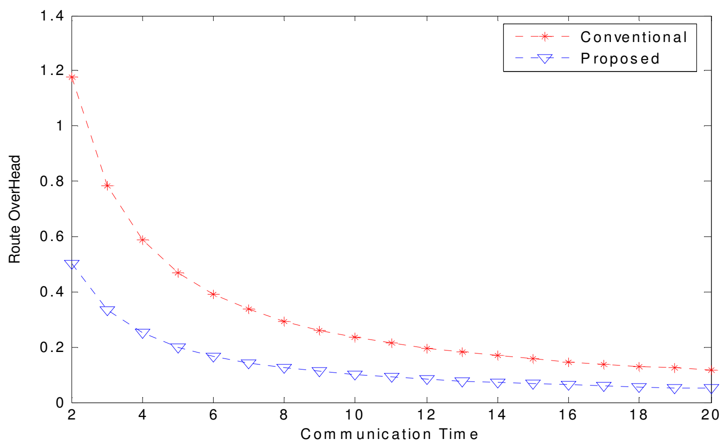

Fig 8: Route overhead

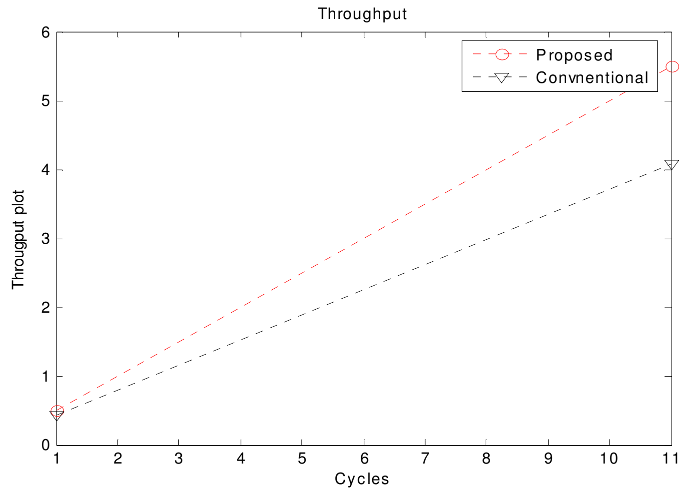

Fig 9: Throughput Plot

V. CONCLUSION

In this paper authors give importance of communication system and based on its increasing usages, need for developments in communication area. In this paper authors identified some problems in optical networks and proposed a new methodology towards developing routing scheme in optical network. So this paper gives a clear idea about a different approach to improve the quality parameters based on adaptive routing mechanism. The concept of route overhead due to queue at the link points is considered. They developed a new model called markoivan model, to obtain an optimal routing in optical network so as to achieve the quality service in distributed optical network. The quality metrics developed for the proposed approach is observed to be higher in quality as compared to the conventional approach of routing scheme and finally they explained all these improvements with the simulation results

REFERENCES

[1]. G. Apostolopoulos, R. Guerin, S. Kamat, and S. Tripathi, "Improving QoS Routing Performance Under Inaccurate Link State Information." Proceedings of the 16th International Tele traffic Congress, June 7-11, 1999.
[2]. R. A. Barry and S. Subramaniam, "The MAX-SUM Wavelength Assignment Algorithm for WDM Ring Networks,", OFC'97, 1997.
[3]. K. Chan and T.P. Yun, "Analysis of Least Congested Path Routing in WDM Light wave Networks," IEEE INFOCOM'94, vol. 2, pages 962-969, 1994.
[4]. C. Chen and S. Banerjee, "A New Model for Optimal Routing and Wavelength assignment in Wavelength Division Multiplexed Optical Networks." In Proc. IEEE INFOCOM'96, 1996, pages 164–171.
[5]. I. Chlamtac, A. Ganz, and G. Karmi, "Purely Optical Networks for Terabit Communication," IEEE INFOCOM'89, pages 887-896, 1989.
[6]. A. Girard, Routing and dimensioning in circuits witched networks. Addison-Wesley, 1990.
[7]. H. Harai, M. Murata, and H. Miyahara, "Performance of Alternate Routing Methods in All-Optical Switching Networks," IEEE INFOCOM'97, vol. 2, pages 516-524, 1997.
[8]. G. Jeong and E. Ayanoglu, "Effects of Wavelength-Interchanging and Wavelength Selective Cross-Connects in Multiwavelength All-Optical Networks," IEEE INFOCOM'96, vol. 1, pages 156-163, March 1996.
[9]. J. P. Jue and G. Xiao, "An Adaptive Light path Establishment Scheme for Wavelength-Routed Optical Networks", IEEE ICCCN, 2000.
[10]. L. Li and A. K. Somani, "Dynamic Wavelength routing Using Congestion and Neighborhood Information," IEEE/ACM Transactions on Networking, 1999.
[11]. E. Karasan and E. Ayanoglu, "Effects of Wavelength Routing and Selection Algorithms on Wavelength Conversion Gain in WDM Optical Networks," IEEE/ACM Transactions on Networking, vol. 6, no. 2, pages 186-196, April 1998.

[12]. Urmila Bhanja,Sudipta mahapatra, Rajashri Roy, "A novel solution to the dynamic routing and wavelength assignment problem in transparent optical networks", "International Journal of computer networks & communication, Vol.2, No.2, March 2010.
[13]. Virendra Singh Shekhawat, Dinesh Kumar Tyagi, V.K. Chaubey, "Weight Based Edge Disjoint Path Routing and Wavelength Assignment (WEDP-RWA) Algorithm for WDM Networks", IEEE,2008.
[14]. S. Ramamurthy and B. Mukherjee, "Fixed-Alternate Routing and Wavelength Conversion in Wavelength-Routed Optical Networks," IEEE GLOBECOM'98,vol. 4, pages 2295-2302, 1998.
[15]. S. Subramaniam and R. A. Barry, "Wavelength Assignment in Fixed Routing WDM Networks," IEEE ICC'97, pages 406-410, June 1997.
[16]. H. Zang, J. P. Jue, B. Mukherjee, "A Review of Routing and Wavelength Assignment Approaches for Wavelength- Routed Optical WDM Networks", Optical Networks Magazine, Vol. 1, No. 1, January 2000.pp 47-60.
[17]. X. Zhang and C. Qiao, "Wavelength Assignment for Dynamic Traffic in Multi-fiber WDM Networks," IEEE ICCCN, pages 479-485, Oct. 1998.
[18]. Chan, K. and Yum, T.P., "Analysis of least congested path routing in WDM lightwave networks." INFOCOM '94. Networking for Global Communications, 13^{th} Proceedings IEEE, 1994. pp. 962-969.
[19]. Banerjee, D. and Mukherjee, B. "A Practical Approach for Routing and Wavelength Assignment in Large Wavelength-Routed Optical Networks." IEEE Journal on Selec. Areas in Comm., vol 14, No. 5, June 1996.
[20]. Dorigo, M. and Gambardella, L.M., "Ant-Colony System: A Cooperative Learning Approach to the Travelling Salesman Problem." IEEE Transactions on Evolutionary Computation, pp. 53-66.
[21]. Dijkstra, E. "A note on two problems in connexion with graphs." Numerische Mathematik, 1959. vol. 1, pp. 269-271.
[22]. Karasan, E. and Ayanoglu E., "Effects of Wavelength Routing and Selection Algorithms on Wavelength Conversion Gain in WDM Optical Networks." IEEE Trans. Networking, vol 6, pp. 186-196, April 1998. Dutton, H.J., Understanding Optical Communications, Prentice Hall, 1999.
[23]. Hui, Z., Jue, J., and Mukherjee, B. "A Review of Routing and Wavelength Assignment Approaches for Wavelength- Routed Optical WDM Networks," Optical Networks, January 2000.
[24]. Zhang, X. and Qiao, C."Wavelength Assignment for Dynamic Traffic in Multi-fiber WDM Networks," ICCCN '98, pp. 479-585, 1998.
[25]. Stern, T.E. and Bala, K., "Multiwavelength Optical Networks." Addison-Wesley, 1999.

Authors Biography

S. SURYANARAYANA is working as Professor, ECE Department, CMR Institute of Technology, Hyderabad, Andhra Pradesh, INDIA. He received the Bachelors degree in Electronics & communication engineering from JNTU College of Engg in 1991 and M.E(Microwaves) from Birla Institute of Technology (BIT), Ranchi. He is pursuing Ph.D (Optical Communications) under the guidance of Dr. K. Ravindra and Dr. K. Chenna Kesava Reddy. His research interests are Optical Communication, Networking, Switching & Routing and Electromagnetic waves. He has published 12 papers in International/National Journals and Conferences. He is an IEEE Member and life member of ISTE.

K. RAVINDRA currently working as a principal in Mallareddy Institute of Tech & Science, Secunderabad. He received his B.Tech. degree in Electronics and Communication Engineering from Andhra University, M.E. with Honors from University of Roorkee (Presently IIT, Roorkee) and Ph.D. in the field of Mobile Communications from Osmania University. He is a recipient of GOLD MEDAL from Roorkee University for standing first in Masters Degree. He has Engineering teaching experience of over 25 years in various capacities. Dr. Ravindra served as Senior Scientist in the "Research and Training Unit for Navigational Electronics" Osmania University from December 2000 to December 2002. He is presently working as PRINCIPAL in Malla Reddy Institute of Technology & Science, Hyderabad.

Ravindra has 36 technical papers to his credit published in various International, National Journals and Conferences. He co-authored 2 technical reports in the field of GPS. He is the resource person for video lectures produced by SONET, Andhra Pradesh. He is presently guiding 4 research scholars in the fields of Optical & Mobile Communications, Cellular and Next generation networks etc. He is life member of ISTE, IETE and SEMCE(I).

K. CHENNA KESAVA REDDY currently is working as a principal in TKR College of Engg & Tech, Hyderabad. He received his B.E. (Electrical Engineering) in 1973, and M.Tech. (Electronic Instrumentation), from Regional Engineering College, Warangal, 1976. He obtained Ph.D. (Power Electronics), from JNT University, Hyderabad in 2001. He has guided many numbers of graduate and post graduate projects. He has worked in various capacities in JNTU.