QoS based Light path Provisioning and Performance Analysis in WDM Network

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***Abstract*—In this paper, we explore the issue of connection provisioning and performance analysis in WDM network by ensuring the QoS requirement of the connection requests from the client in the network. Each connection request can be specified with a Q-Factor, which is defined in terms of bandwidth and delay associated with the light path. The paper discuss the improvement in blocking probably for incoming requests while performing routing by our proposed algorithm and the traditional shortest path algorithm.**

***Index Terms*—WDM, light path, disjoint path, blocking probability.**

I. Introduction

Due to the large bandwidth offered by the optical fibre, the optical network is becoming a unique candidate for the future internet transport infrastructure. Wavelength division multiplexing (WDM) in optical fibre network has been rapidly gaining acceptance as a means to handle the ever increasing bandwidth demands of network users [1]. The WDM routed networks provides an optical connection layer which consists of several light paths. A light path is defined as an optical connection from the source to destination node, traversing several intermediate optical wavelength routing nodes [2]. In WDM network, the most important issue is routing and wavelength assignment for connections with an optimized blocking probability by considering the network cost of the tree which is defined as the sum of cost of all the links in the tree.

The recent researches in WDM network mainly focussed on routing techniques which guarantee a minimum number of connection drop offs. Due to the tremendous increase in the internet traffic now a days most of the network services are specified in terms of strict QoS parameters. This work concentrated on QoS satisfied light path routing and wavelength assignment algorithm which provides better results in blocking probability. In this paper most of the attention devoted to such networks operating under wavelength continuity constraint, in which light paths are set up for connection requests between node pair and a single light path must occupy the same wavelength on all of the links that it spans [3].

The concept of QoS in communication system closely related to the network performance of the underlying routing system. Quality of Service can be defined as the collective effect of service performance which determines the degree of satisfaction of user of the service [4]. The network is defined in terms of the QoS metrics or cost metrics. While routing, the provisioning is done in such a way that the selected route should satisfy the QoS requirement of the client. The identification of QoS characteristics and their characterization is determinant to the conception of QoS aware routing. The QoS characteristics used to support routing in optical network include bandwidth, delay, jitter and loss rate. Here we consider QoS metric in terms of bandwidth and delay. The two parameters described in term of Quality Factor (QF) which is defined as network cost. For each light path in the network QF is defined in terms of the bandwidth and delay associated with the fibre in the path. The bandwidth mainly depends on length of the link and dispersion effect in the fibre link. And delay depends on the wavelength assigned for the light path. The computation of QoS aware path for connection request requires the information regarding the current state of the network and the client requirement for the connection request. After selecting a route which satisfies the QoS requirement, the wavelength availability has to be checked. In this work, an adaptive routing, the selection of route from a source node to a destination node is performed dynamically on the basis of network state. Similar works has been reported in [5, 6, 7, 8, 9, 10]. The paper [6] suggest a multicast optical level switched path (OLSP) establishment mechanism for supporting high bandwidth multicast services in WDM. The papers [5, 7, 8] studied on the effect of polarization mode dispersion at high speed optical fibre channels. Another issue reported in [9], which says how Bandwidth broker works centrally and provides QoS to the clients. The paper [10] says about traffic based guaranteed QoS which is fully wavelength and number of applicant dependent. None of this paper concentrated on the bandwidth and delay based Q-Factor calculation and the light path connection provisioning mechanism based on the Q-Factor requirement of client. This paper develops a new QoS guaranteed routing algorithm that ensures better performance. Simulation is done for various networks with different number of nodes and links and compared the results with the existing algorithm.

II. QoS BASED ROUTING MECHANISM

A. Network model

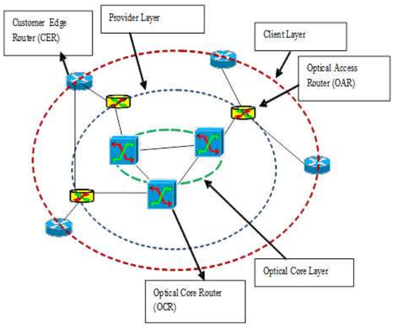


Fig. 1. WDM network architecture

The network model under study is an optical WDM network consists of multiple nodes connected by optical fibre in mesh topology as shown in Fig 1. The wavelength routed optical network consists of optical cross connects (OXCs), optical Add and Drop multiplexers (OADM) which are connected through WDM links. The OXCs have no wavelength conversion capability, which means a wavelength in an input fibre can be switched to any output optical fibre, but must be on the same wavelength. The edge equipments connected to the optical network can communicate each other only through all optical path (light path) established dynamically.

B. problem formulation

1) computation of Q Factor metric for light paths: Here we consider the Q Factor in terms of bandwidth and delay associated with the optical fibre link. Consider an optical link source destination node *(i, j)*. If *DS(i, j)* is the dispersion of the fiber and *L(i, j)* is the length of the fiber link pair *(i, j)* in kilometers, the bandwidth matrix can be defined as [10]

$$B(i,j) = \frac{\sigma}{DS(i,j) \times \sqrt{L(i,j)}} \tag{1}$$

Where σ represents the pulse broadening factor should typically be less than 10% of a bit time slot for which polarization mode dispersion can be tolerated. As per the network condition if *D(i, j)* is the link pair delay, then the end-to-end delay is the sum of link delays suffered by a connection at all routers along with the light path *p(s, d)* and given as [11]

$$D(i,j) = a + b\lambda_{i,j}^2 + c\lambda_{i,j}^{-2} \tag{2}$$

where a, b, c are material dependent fitting parameters and λ is the wavelength assigned for the link *(i, j)*. We defined the link cost as the ratio of bandwidth and delay, which is termed as Q-Factor and will be represented as below

$$QF(i,j) = \frac{B(i,j)}{DS(i,j)} \tag{3}$$

If *p(s, d)* is the light path connection for a source(s) and destination(d) pair, then computed Q-Factor can be formulated as follows

$$QF_c(s,d) = Min\{QF(i,j)\}, \forall (i,j) \in p(s,d) \tag{4}$$

2) computation of blocking probability: Assume *TNCR(s, d)* is the total number of connection requested for a source (s) and destination (d), *TNCB(s, d)* is the total number of connection blocked, then the blocking probability *BP(s, d)* can be defined [12] as follows

$$BP(s,d) = \frac{TNCB(s,d)}{TNCR(s,d)} \times 100 \tag{5}$$

C. Algorithm for Routing and light path assignment

In this work the light path selection is established by considering both the required Q-Factor of client and the computed Q-Factor metric for all paths in the network. If the required Q-Factor is satisfied by one of the computed connections, then that connection is selected for a client, and then the checking for the availability of wavelength is performed. Assume *QFr(s, d)* is the required Q-Factor for a connection request for a source destination pair *(s, d)* and *QFc(s, d)* is the computed Q-Factor, which are explained in previous section, then, the condition for light path provisioning is explained as follows

$$QF_r(s,d) \leq QF_c(s,d) \tag{6}$$

Here we consider two routing algorithms for finding light path in WDM network. I. Shortest path algorithm II. Disjoint path algorithm

1) The mechanism of routing : In Shortest path algorithm, while performing routing, among all possible paths only the shortest path is taken into consideration. But in the proposed algorithm all disjoint paths are considered for routing. The important steps in routing is given below

STEP 1: Find all possible light path connections for a connection request.

STEP 2: Find Shortest light path (For shortest path algorithm) /all Disjoint paths (for Disjoint path algorithm) from all possible light path connections and compute their Q-Factor metric for all wavelength used.

STEP 3: Arrange all the disjoint light path connections in incremental order of Q-Factor. Let p is the total no of disjoint light path connections.

STEP 4: Compare the required Q-Factor value for a connection request with the Q-Factor values of all the connections arranged in STEP 3 one by one.

STEP 5: If it is satisfied then go to STEP 6, otherwise go to STEP 7.

STEP 6: Check whether the selected light path is busy or not. If busy the call will be blocked. Go to STEP 1 for next connection request, otherwise go to STEP 8.

STEP 7: Assign the selected light path for the requested connection. Go to STEP 1 for next connection request.

STEP 8: Calculate blocking probability using equation 5. The algorithm can be explained with the help of Flowchart (refer Fig 2)

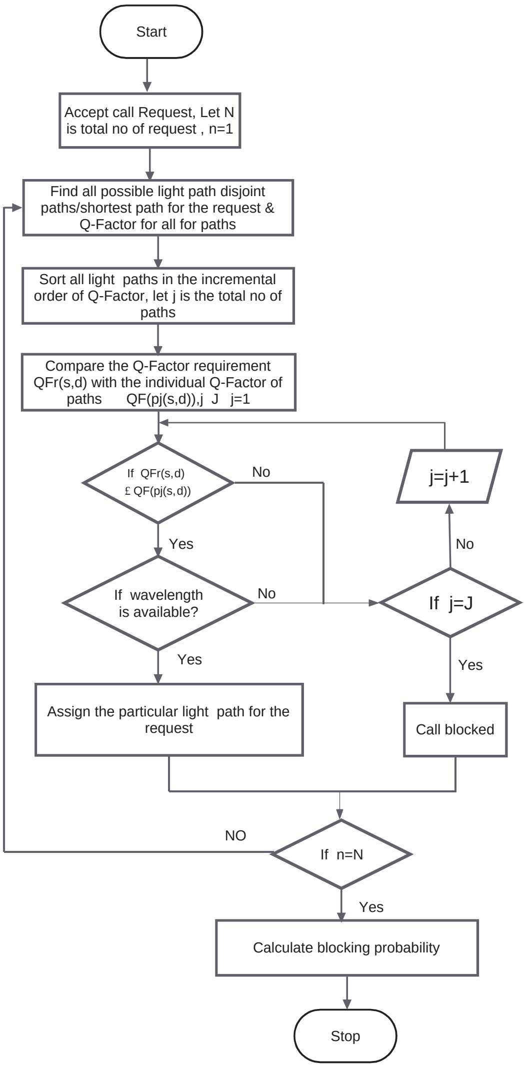
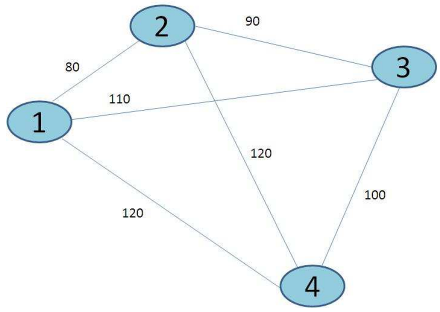
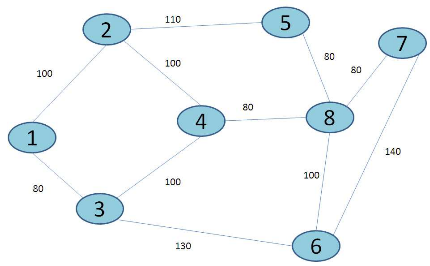


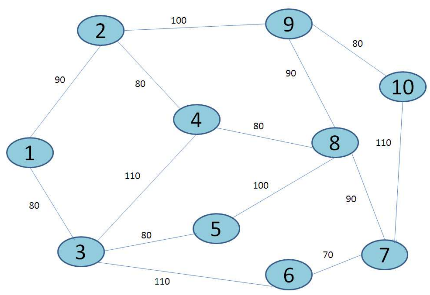
Fig. 2. Flowchart decribing routing algorithm



(a)



(b)



(c)

Fig. 3. Simulation model(a)nodes=4,links=6(b)nodes=8,links=11(c)nodes=10,links=14

III. Performance Analyses

A. Simulation model

Simulation is performed for various WDM network with different number of nodes and links. The basic topologies used for simulation are shown in Fig 3(a), 3(b) and 3(c). Routing is done for various number of connection requests for each of the three network using shortest path algorithm and Disjoint path algorithm and performance analysis is done in terms of number of calls blocked.

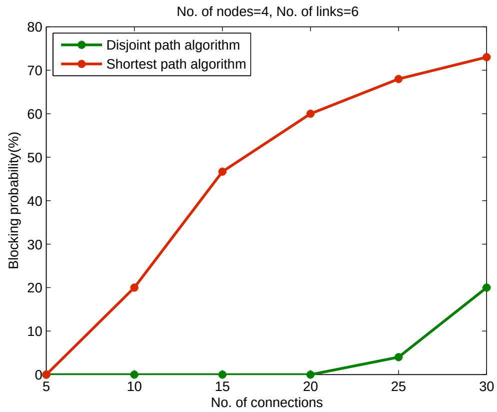
B. Simulation Results

Fig 3(a) shows a network with 4 nodes and 6 links. The light path provisioning is done for this network for various numbers of connection requests and the blocking probability is computed in each case. The result is shown in Fig 4. From the plot it is clear that more number of calls can be established by using disjoint path algorithm compared to shortest path algorithm. Blocking probability increases with the increase in the number of connections. Simulation is repeated for network shown in Fig 3(b) and Fig 3(c). From plot (Fig 4(a), 4(b) and 4(c)) it is clear that blocking probability depends only on the number of connections that has to be provisioned and the Q-Factor requirement of that connection request and not on the number of nodes in the network.

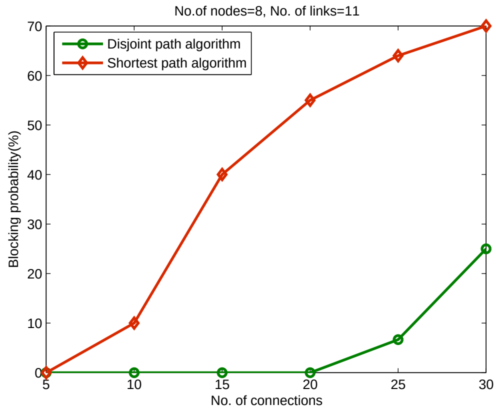
Simulation for light path provisioning done by varying the number of wavelengths (2, 4, 5, 7, 8) used in the network with 10 number of nodes and 14 number of links. The blocking probability for different network load is plotted as shown in Fig 5. The result shows that by increasing the number of wavelength in the network, the blocking probability can be reduced.

IV. Conclusions

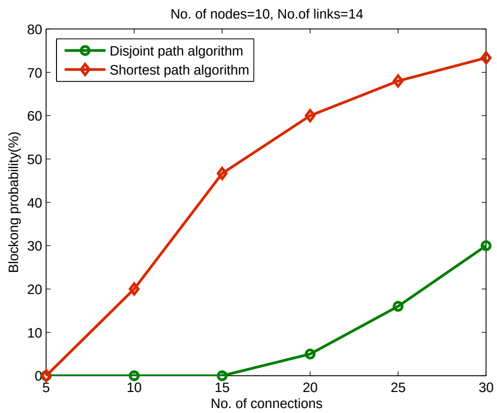
In this paper we have studied the QoS guaranteed routing problem for optimized connection drop offs. We have proposed



(a)



(b)



(c)

Fig. 4. Comparison of Blocking Probability using Shortest Path and Disjoint Path algorithm(a)Network with nodes=4, links=6(b)Network with nodes=8, links=11(c)Network with nodes=10, links=14

QoS based disjoint path algorithm for dynamic routing in WDM networks. In this work the QoS parameter is described in terms of bandwidth and delay associated with the light path. Routing is performed by considering the Q-Factor requirement of the client and availability of wavelength in the network. The performance is analysed for various network by calculating the blocking probability for different number of connection requests. From the results we conclude that compared to traditional shortest path algorithm, the proposed disjoint path algorithm gives improved blocking probability performance.

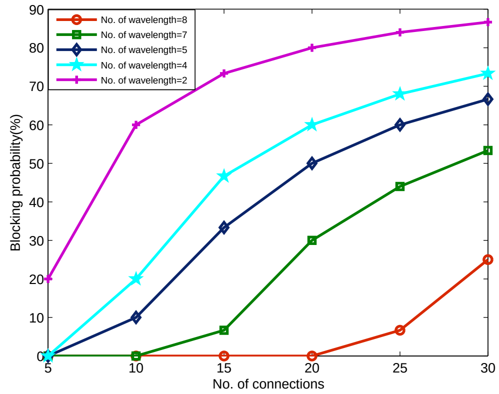


Fig. 5. Comparison of Blocking Probability using Shortest Path and Disjoint Path algorithma for different number of wavelengths

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