A Logical Topology to Find Alternate Routes in WDM Lightwave Network

Santosh Das and Abhijit Makhal

Department of Computer Science
Dream institute of Technology
West Bengal, Kolkata 700104
{das2008.santosh,jontromanab.abhijit}@gmail.com

Abstract. In today's environment, as the need for more bandwidth for intensive networking applications such as data browsing, video conferencing, etc increase, so also does the need for high bandwidth-transport network facilities. Optical WDM networks show great promise in handling such high data volume problems, and it is expected that they will form the backbone of the next generation of high volume light wave networks. Multihop networks show the most promise in that they offer the greatest flexibility of design. This paper describes an approach to modify the routing algorithm for finding out the alternate routes on the occurrence of single node fault in WDM optical network where GEMNET is used as a physical topology and also try to find out the link which carries the maximum number of light paths in the network for randomly generated source-destination pair.

Keywords: Gemnet, optical network, WDM.

1 Introduction

Now a days more bandwidth required for networking applications such as data–browsing , video conferencing etc. are widely used. Optical fiber is used as a communication medium for this type of applications. The technology which is mainly used in optical fiber communication is wavelength division multiplexing(WDM).Optical WDM networks show great promise in handling such high data volume problems, and it is expected that they will form the backbone of the next generation of high volume light wave networks. But in WDM network there is a limitation on the total number of nodes in a column in the network. The limitation is that there is only p^k nodes in any column in the network, where p is the degree of each node in the network and k is the number of column in the network.

But later in GEMNET this limitation is eradicated. GEMNET is a logical topology which is a generalization of the shuffle-exchange connection..In WDM optical network several nodes are communicating via optical fiber . Here several wavelengths of lights are transmitted through a single fiber simultaneously. This provide a great benefit for high volume of data transmission. Another advantage of using GEMNET as a topology is that scalability, that means the addition of new nodes in the network

N. Meghanathan et al. (Eds.): CCSIT 2012, Part I, LNICST 84, pp. 138–145, 2012.

is quiet easy. The flexibility is that there is no restriction of the total number of nodes in the network providing the condition that the total number of nodes are evenly divisible by the total number of columns in the network.

Here we have attempted to modify the routing algorithm for finding out the alternate routes on the occurrence of single node fault in WDM optical network where GEMNET is used as a physical topology and also try to find out the link which carries the maximum number of light paths in the network for randomly generated source- destination pair.

Here the first problem is to find out alternate routes in case of single node fault, to reach the destination from source avoiding the faulty node for randomly generated source- destination pair in WDM optical network.

Another problem is to find out the link which carries maximum number of light paths for randomly generated source destination pair.

2 GEMNET

An attractive approach to interconnect computing equipment(nodes) in a high speed, packet –switched network is to employ a regular interconnection graph. It is desirable that the graph have 1) small nodal degree(for low network cost), 2) simple routing (to allow fast packet processing), 3) small diameter(for short messege delays), and 4) growth capability, viz. the graph should be scalable (so that nodes can be added to it at all times) with a modularity of unity (i.e. it should always be possible to add one node to or delete one node from an existing (regular) graph while maintaining regularity). We examine such a new network structure, called Generalized shuffle-exchange Multihop Network(GEMNET).

GEMNET[1] can serve as a physical, multihop topology for constructing the next generation of lightwave networks using wavelength-division multiplexing(WDM) .Given a low loss optical bandwidth of approximately 30 terabits per second and a peak electronic processing speed of a few gigabits per second, innovative parallelism and concurrency mechanisms are needed to exploit this huge opto-electronic bandwidth mismatch .WDM has emerged as the most promising choice since, unlike other alternatives, it only requires end-user equipment to operate at the bit rate of a WDM channel(peak electronic speed).

Generally a GEMNET has three parameter. They are K,M & P where K represents the number of column ,M represents the number of rows and K*M nodes are arranged in a cylindrical structure and the degree of each node is represented by P. The structure is the generalization of shuffle-exchanged connectivity pattern using directed links.. The generalization allows any number of nodes in a column as opposed to the constraint of P^K nodes in a column.

2.1 Interconnection Pattern of GEMNET

Let N be the number of nodes in the network. If N is evenly divisible by an integer y, there exist a GEMNET with K=y columns.

In the corresponding (K,M,P) GEMNET, the N=K*M nodes are arranged in K columns(K>=1) and M rows (M>=1) with each node having degree P. Node a (a= 0,1,2,…….., N-1) is located at the intersection of column c (c=0,1,2,……, K-1) and row r (r= 0,1,2,…….., M-1), or simply location (c ,r), where c=(a mod K) and r $=\lfloor a/K \rfloor$. The P links emanating out of a node (c, r) is connected to node (c1,r1) , where c1= (c+1) mod K and r1 =((r * P) +i) mod M . and i = 0,1,2,……, P-1).

The largest distance between the two nodes is the diameter of the network. GEMNET's diameter is obtained as follows. Starting at any node, note that each and every node in a particular column can be reached for the first time on the $\lceil \log_P M \rceil$ th hop. This means that there were one or more nodes not covered in the previously visited column. Due to cylindrical nature of GEMNET[1] , the nodes in this column will be finally covered in an additional K-1 hops. Thus , $D = \lceil \log_P M \rceil + K-1$.

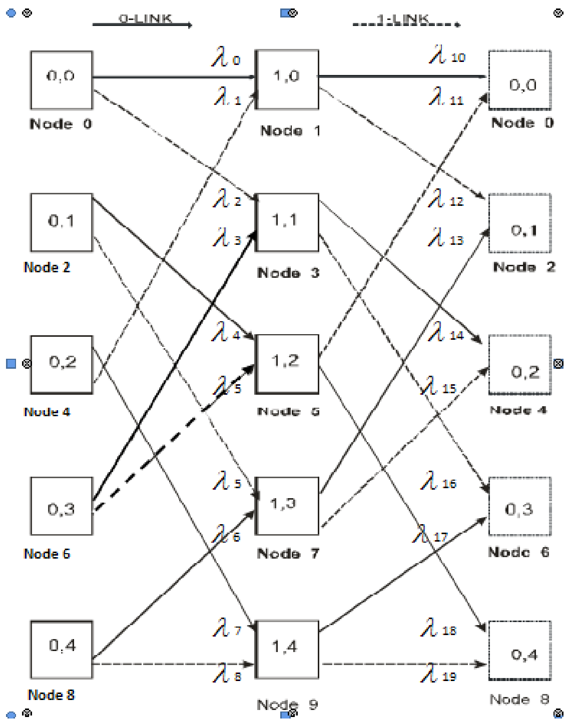

Fig. 1. The interconnection pattern and routing in GEMNET

2.2 The Routing In GEMNET

Let (c_s, r_s) and (c_d , r_d) be the source node and the destination node, respectively.

We define the " column distance " delta as the minimum no of hops required to reach a node in column c_d from a node in column c_s.

c_d represent destination column.

c_s represent source column.

when $c_d > c_s$,then , delta = $c_d - c_s$ because (c_d- c_s) forward hops from any node in column c_s will cover a node in column c_d. When $c_d < c_s$, delta is given by, delta = (c_d+ k) - c_s because, after "sliding "c_d forward by K (i.e. c_d+ K), due to wraparound, the situation becomes the same as when $c_d >= c_s$. Thus delta can be generalized as:

delta =[(K + c_d) – c_s] mod K.

The hop distance from source node (c_s, r_s) to destination node (c_d , r_d) is given by the smallest integer h of the form (delta+ jk) , j=0,1,2,… satisfying the following expression ,

$$R = [M + r_d - (r_s . p^h) \bmod M] \bmod M < P^h$$

where R is called the route code , specifies a shortest route from the source node to the destination node when it is expressed as a sequence of h base P digits.

Often, the p^h nodes covered on the h th hop could be greater than the number of nodes in that column. This means that multiple shortest paths may exist to some nodes in that column. Having calculated R, if (R+ x* M) < P^h for x = 1,2,3,…………., then (R+x*M) is also a routing code with path-length h for any x that satisfies this enequality. Thus , if the shortest path from node a to node b is h hops, the number of shortest paths is given by Y=[(P^h- R)/ M].

Hence , for a given N , the number of alternate shortest paths increases as M decreases. The larger the number of shortest paths, the more opportunity there is to route a packet along a less congested path and the greater is the network's ability to route a packet along a minimum length path when a link or node failure occurs.

3 Results

Here we developed an algorithm for finding out alternate shortest paths avoiding the faulty node on the occurrence of single node fault in the WDM optical network.In the next section we have provided a step-by-step approach for the algorithm to avoid the faulty node.

3.1 Survivable Routing of GEMNET in Presence of Single Node Fault

Survivable routing means the method of finding the alternative shortest paths in WDM optical network if there is an occurrence of single node fault. It can be shown that in case of the occurrence of one node fault in the network alternative paths can route the messege to the destination for randomly generated source-destination pair avoiding the faulty node.

The steps are as follows…

1. At first it should be checked wheather the source node is equal or not with the faulty node.The same method should be applied for destination node. If source or destination node is faulty the connection is discarded.
2. Next the number of multiple shortest paths for same hop count for first source-destination pair has to be found out.
3. Next the first path among the multiple shortest paths of same hop count has to be taken and stored in an array of structure called currentpath. Likewise all other paths of same hop count are stored in the currenpath array of structure for first source- destination pair.
4. Then it is assumed that there is no faulty node in that currentpath array of structure.

5. Next it is checked from very first to the last node of the currentpath, wheather , each node is equal or not with the faulty node. If it is equal then there exist a faulty node in the currentpath & the path is faulty.
6. Next that faulty path is discarded and step 5 is followed for the next path of same hop count of that particular source-destination pair.
7. If any path of that hop count is found where there is no faulty node then that is the desired path and that path is accepted. If it is found that there is a faulty node in each path of same hop count of that particular source-destination pair, then the hop count is increased and the same procedure is repeated from step 2 to 6.
8. After getting the right path for first source-destination pair from the randomly generated request set (source-destination pair) , the same steps from 1 to 7 followed as before for next source destination pair and so on for all source destination pair .

In the image 2 the connectivity of each node with the other nodes are shown on the basis of total number of nodes ,no. of columns, and degree of each node

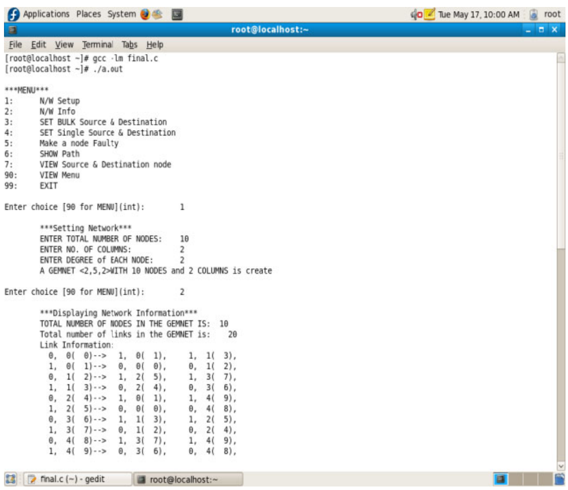

Fig. 2.

In Fig 3 the number of source destination pair,the number of shortest paths between every source –destination and the entire path from source to destination are shown . Starting from a source node it passes through a number of nodes and reach to the destination. Here the total paths are shown and the required number of hops to reach from source to destination are also shown. If there has been multiple shortest path of same hop count is exist then it shows all the paths of same hop count from a source to destination.

If a node will become faulty on the path from a source to destination the algorithm then founds the alternate path, incrementing the hop count avoiding the faulty node. In both the cases the algorithm finds the maximum used link of the network.that means through which link maximum number of light paths are passes.This has been shown in fig 4.

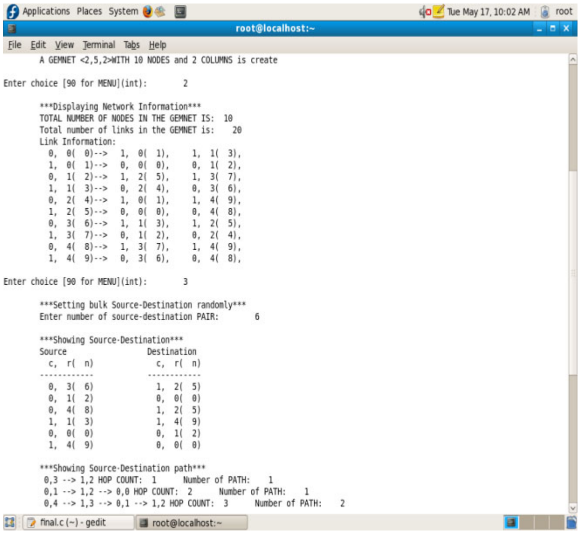
Applications Places System
Tue May 17, 10:02 AM root
root@localhost:~
File Edit View Terminal Tabs Help
A GEMNET <2,5,2>WITH 10 NODES and 2 COLUMNS is create
Enter choice [90 for MENU](int): 2
Displaying Network Information
TOTAL NUMBER OF NODES IN THE GEMNET IS: 10
Total number of links in the GEMNET is: 20
Link Information:
0, 0(0)--> 1, 0(1), 1, 1(3),
1, 0(1)--> 0, 0(0), 0, 1(2),
0, 1(2)--> 1, 2(5), 1, 3(7),
1, 1(3)--> 0, 2(4), 0, 3(6),
0, 2(4)--> 1, 0(1), 1, 4(9),
1, 2(5)--> 0, 0(0), 0, 4(8),
0, 3(6)--> 1, 1(3), 1, 2(5),
1, 3(7)--> 0, 1(2), 0, 2(4),
0, 4(8)--> 1, 3(7), 1, 4(9),
1, 4(9)--> 0, 3(6), 0, 4(8),
Enter choice [90 for MENU](int): 3
Setting bulk Source-Destination randomly
Enter number of source-destination PAIR: 6
Showing Source-Destination
Source Destination
c, r(n) c, r(n)
------------ ------------
0, 3(6) 1, 2(5)
0, 1(2) 0, 0(0)
0, 4(8) 1, 2(5)
1, 1(3) 1, 4(9)
0, 0(0) 0, 1(2)
1, 4(9) 0, 0(0)
Showing Source-Destination path
0,3 --> 1,2 HOP COUNT: 1 Number of PATH: 1
0,1 --> 1,2 --> 0,0 HOP COUNT: 2 Number of PATH: 1
0,4 --> 1,3 --> 0,1 --> 1,2 HOP COUNT: 3 Number of PATH: 2
final.c (~) - gedit
root@localhost:~

Fig. 3.

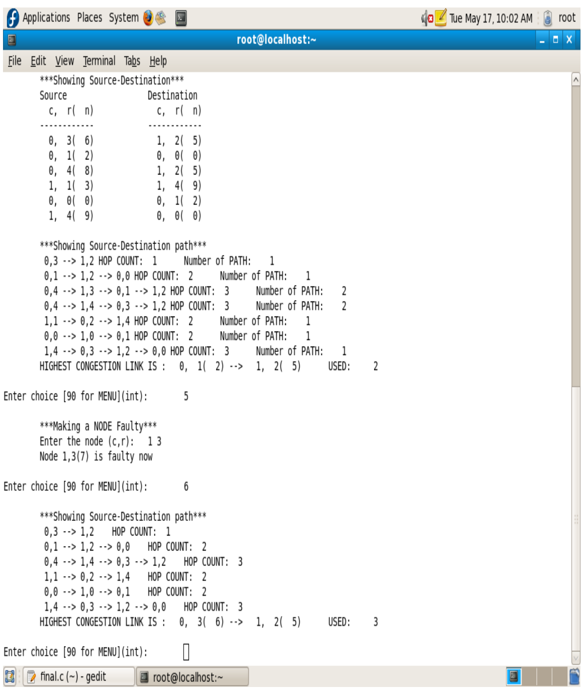
Applications Places System
Tue May 17, 10:02 AM root
root@localhost:~
File Edit View Terminal Tabs Help
Showing Source-Destination
Source Destination
c, r(n) c, r(n)
------------ ------------
0, 3(6) 1, 2(5)
0, 1(2) 0, 0(0)
0, 4(8) 1, 2(5)
1, 1(3) 1, 4(9)
0, 0(0) 0, 1(2)
1, 4(9) 0, 0(0)
Showing Source-Destination path
0,3 --> 1,2 HOP COUNT: 1 Number of PATH: 1
0,1 --> 1,2 --> 0,0 HOP COUNT: 2 Number of PATH: 1
0,4 --> 1,3 --> 0,1 --> 1,2 HOP COUNT: 3 Number of PATH: 2
0,4 --> 1,4 --> 0,3 --> 1,2 HOP COUNT: 3 Number of PATH: 2
1,1 --> 0,2 --> 1,4 HOP COUNT: 2 Number of PATH: 1
0,0 --> 1,0 --> 0,1 HOP COUNT: 2 Number of PATH: 1
1,4 --> 0,3 --> 1,2 --> 0,0 HOP COUNT: 3 Number of PATH: 1
HIGHEST CONGESTION LINK IS : 0, 1(2) --> 1, 2(5) USED: 2
Enter choice [90 for MENU](int): 5
Making a NODE Faulty
Enter the node (c,r): 1 3
Node 1,3(7) is faulty now
Enter choice [90 for MENU](int): 6
Showing Source-Destination path
0,3 --> 1,2 HOP COUNT: 1
0,1 --> 1,2 --> 0,0 HOP COUNT: 2
0,4 --> 1,4 --> 0,3 --> 1,2 HOP COUNT: 3
1,1 --> 0,2 --> 1,4 HOP COUNT: 2
0,0 --> 1,0 --> 0,1 HOP COUNT: 2
1,4 --> 0,3 --> 1,2 --> 0,0 HOP COUNT: 3
HIGHEST CONGESTION LINK IS : 0, 3(6) --> 1, 2(5) USED: 3
Enter choice [90 for MENU](int):
final.c (~) - gedit
root@localhost:~

Fig. 4.

Discussions

In WDM optical network several wave-lengths are transmitted simultaneously through the same optical fiber. So we have to pay special attention during data transmission so that the data packet can reach at the destination safely. If any node is become faulty the data can't travel through that path where that faulty node resides. To reach at the destination it should follow another route avoiding the faulty node. We have also shown the link which carries the maximum number of light paths during data transmission for randomly generated source-destination pair. It is important to know that which link has the maximum traffic, so if the data is transmitted through that link the network become over-crowded .There are several physical topologies in WDM optical network for data transmission but here we deals with the physical topology , GEMNET. The survivable routing algorithm is done on GEMNET, & we can say that this survivable routing algorithm gives a new aspect for data communication in WDM optical network.

Future Work

As the algorithm has been modified deliberately to find the single node fault occurance,it cannot find the alternate paths when more than one node become faulty. Algorithm to find the alternate routes on occurrence of multiple node fault is under processing.

References

[1] Iness, J., Banerjee, S., Mukherjee, B.: GEMNET: a generalized, shuffle-exchange-based, scalable, and modular multihop network based on WDM lightwave technology. IEEE/ACM Transactions on Networking 3, 470–476 (1995)

[2] Chatterjee, M., Karmy, T., Dutt, S., Bhattacharya, S., Bhattacharya, U.: Reconfigurable Logical Topology Design for survivability in WDM networks. Department of computer science and engineering, Asansol engineering college, Asansol, West Bengal, India, Department of computer science and Technology, Bengal engineering and science university, Shibpur, Howrah, West Bengal, India National Institute of Technology, Durgapur, West Bengal, India

[3] Dissemination of Information in Optical Networks from Technology to Algorithms. Spin Springer's internal project number, if known– Monograph. Springer, Heidelberg (April 3, 2007)

[4] Bhattacharya, U., Datta, D., Chowdhury, B., Saha, G.C., Sikdar, B.K.: A congestion controlled logical topology for multihop optical network, Department of Computer Science & Technology, Bengal Engineering College (D.U.), Shibpur, Howrah-711103, West-Bengal, India

[5] Mukherjee, B.: WDM-Based Local Lightwave Networks, Part-II: Multihop Systems- As an alternative to single hop local lightwave networks, multihop systems have their own strength & limitations

[6] Siva Ram Murthy, C., Gurusamy, M.: WDM optical network: Concept, Design and Algorithms. Pearson Education

[7] Tridandapani, S., Mukherjee, B., Hallingstad, G.: Channel Sharing in Multi-Hop WDM Lightwave Networks: Do We Need More Channels? IEEE/ACM Transactions on Networking 5(5), 719–727 (1997)
[8] Borella, M.S., Jue, J.P., Banerjee, D., Ramamurthy, B., Mukherjee, B.: Optical Components for WDM Lightwave Networks, Computer Science Department, University of California, Davis Davis, CA USA
[9] Zhu, K., Mukherjee, B.: A review of traffic grooming in WDM optical networks, architectures and challenges: Computer Science Department, University of California, Davis Davis, CA USA