Simulations for WDM Mesh Networks with Visual Basic

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***Abstract*-Fully optical fiber networks that transmit large quantities of information due to multiple applications or because they serve large urban areas (big and small local telephone exchanges), need to be maintained fault-free at all times of their operation. The protection and restoration strategies are critical. In this paper the modeling method and simulation tool are described that have been used for the analysis of the WDM mesh networks, their protection and their restoration when a fault occurs. The network is modeled by Microsoft Visual Basic. So this paper emphasizes the simulation capability and in the results of the simulation.**

Key words: Planning, designing, WDM, mesh, protection, restoration, simulation

I. INTRODUCTION

Fully optical fiber WDM (Wavelength Division Multiplex) mesh networks are high capacity networks (potentially tens of Terabits per second) that transmit large quantities of information due to multiple applications or because they serve large urban areas (big and small local telephone exchanges), need to be maintained fault-free at all times of their operation. A simulation tool is necessary to study the protection and the restoration of the network. So service providers and end-users can study their network protection and restoration with a more effective way [1], [2], [3] and [14]. To ensure service continuity, service providers plan and design suitable solutions to alleviate such disruptions. Planning depends on the demands or needs that the network satisfies as well as on the percentage of protection and fulfillment of the network systems. The protection is provided on optical fiber layer or on wavelength layer or combining both of them.

The term "protection" is usually defined as the method by which backup capacity on the link or path is statically reserved during connection setup. Protection is usually the first mechanism to deal with a failure. It needs to be fast and protection routes are preplanned so that traffic can switch immediately from the failed working routes to the protection routes. Protection schemes use 100 percent excess bandwidth in the network or more. The term "restoration" is usually defined as the method by which backup or spare capacity for the connection is dynamically discovered after connection has failed due to a link or node failure. Restoration is not the primary mechanism to deal with a failure. Instead, it is used to provide either more efficient routes and additional resilience against further failures before the first failure is fixed. As a result, it provides a slower alternative to protection. Complex algorithms can be used to reduce the excess bandwidth required.

Manuscript received May 9, 2011.

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Protection is limited to simple topologies and relies on the hardware; it is preplanned and faster than restoration. Protection schemes operate either on the multiplex optical WDM signal layer or on the individual optical path layer [4], [5], [6], [7], [8], [9], [10], [11].

A protection scheme with separate protection resources for every working connection is called a dedicated protection scheme while a protection scheme for multiple working connections is called a shared protection scheme or common protection scheme.

The mesh network has the best and fastest protection technique for every lightpath because there are more than one back-up paths for each main one. When a failure occurs, a backup path is activated through the network. Each backup lightpath is shared by many working lightpaths. In [12] and [13] the authors describe and modeling methods and simulation tools we have used for analysis of a new integrated restoration scheme operating at multiple layers/networks.

An own simulation tool is developed using Visual Basic to study the network several cases as unprotected paths, 1+1 dedicated optical path protection, 1:1 shared optical path protection, restoration by both modes of the cut link on optical path layer and restoration by source and destination nodes ignoring the cut links on optical path layer. It notes that path restoration is more efficient than line restoration. It is assumed that all protection and restoration paths are preplanned. So the restoration is not dynamical but preplanned.

The network topology and other parameters are known as WDM and optical fiber capacity, one optical fiber per link with an extension to a 1+1 fiber protection system. So this network is characterized by one working fiber per link, edges of two links, links of two optical fibers, one for working and one for protection .In this paper we are usually referred at the working optical fiber. The connections are lightpaths originating in the source nodes and terminating at the destination nodes proceeding from preplanned optical working paths. Additionally, the same number of optical paths is preselected for the preplanned fully disjoint backup paths (1+1 dedicated protection connection). It is also the same number of optical paths is preselected for the preplanned fully disjoint backup paths (1:1 shared protection connection) and a number of wavelengths reserved for it. Thus the connections that have been set up are protected. When working optical paths are unprotected and a failure occurs the traffic is lost during the failure. When each working optical path has a dedicated protection and a failure occurs the traffic is routed by the protection optical path. The same happens for the shared protection method. The protection optical paths must be full disjoint with the working ones. The restoration methods are done by preplanned restoration paths. The connections of the same node pair by same preplanned optical paths form a connection group along the network. The nodes have wavelength conversion capability .The problem solution is to calculate the final available capacity of the network for a given traffic table for the studied cases a)Unprotected paths b)Dedicated protection paths c)Shared protection paths d)Restoration by both nodes of the cut link and e)Restoration by source-destination nodes ignoring the cut link. The traffic table contains a number of the node pairs, the node pairs and their working and protection paths that are preplanned.

This paper is broken down in the following sections: Section II describes the problem and provides a solution, Visual Basic simulator, Formulation, General description of algorithms, an example and a discussion; Section III draws conclusions and finally ends with the references.

II. THE PROBLEM AND ITS SOLUTION

A. The problem

The following problem is solved. The network topology and other parameters are known as WDM and optical fiber capacity, one optical fiber per link with an extension to a 1+1 fiber protection system. So this network is characterized by one working fiber per link, edges of two links, links of two optical fibers, one for working and one for protection .In this paper we are usually referred at the working optical fiber. The connections are lightpaths originating in the source nodes and terminating at the destination nodes proceeding from preplanned optical working paths. Additionally, the same number of optical paths is preselected for the preplanned fully disjoint backup paths (1+1 dedicated protection connection). It is also the same number of optical paths is preselected for the preplanned fully disjoint backup paths (1:1 shared protection connection) and a number of wavelengths reserved for it. Thus the connections that have been set up are protected. When working optical paths are unprotected and a failure occurs the traffic is lost during the failure. When each working optical path has a dedicated protection and a failure occurs the traffic is routed by the protection optical path. The same happens for the shared protection method. The protection optical paths must be full disjoint with the working ones. The restoration methods are done by preplanned restoration paths. The connections of the same node pair by same preplanned optical paths form a connection group along the network. The nodes have wavelength conversion capability. The problem solution is to calculate the final available capacity of the network for a given traffic table for the studied cases a)Unprotected paths b)Dedicated protection paths c)Shared protection paths d)Restoration by both nodes of the cut link and e)Restoration by source-destination nodes ignoring the cut link. The traffic table contains a number of the node pairs, the node pairs and their working and protection paths that are preplanned.

The network is a circuit switched one with identical nodes. On the network nodes are installed the OXCs (Optical Cross Connects) (WDM-OXCs). WDM-OXC does the switching and the routing on the path layer. The WDM-OXC has multiplex and demultiplex systems that convert the aggregated optical signal to simple optical signals and vice versa. A lightpath is an optical channel from source to destination to provide a circuit switched connection between these nodes. An optical channel passing through a cross-connect node may be routed from an input fiber to an output fiber with undergoing optical-electronic-optical (O-E-O) conversions. It is assumed that different wavelengths are assigned on all links along the route because nodes have wavelength conversion capabilities.

B. The Visual Basic Simulator

The Visual Basic was chosen because its object oriented-event driven functionalities and containment relationship make it suitable for straightforward ward modeling of networks of any type (links within edges, etc). It collaborates with the Windows operating system and has built in functionality to create forms, buttons, textboxes, labels, lines and so on for input and for output. The user can design its input/output interface to analyze the network as he would like. For example, running the simulator for unprotected paths case you see if any link is cut reading the suitable text boxes. When you are clicking on the edge of this link, you are taking the two opposite links and from their color you see immediately the cut link and its status which is off. Clicking on a link without failure you see the link status which is on, the number of working WDM and fiber systems, the number of protection WDM and fiber systems, the WDM capacity and its demands. You can also see a command button and when you are clicking, you are taking, each WDM and optical fiber, working or protection. Clicking on the working fiber system, you can see the busy and the free wavelengths as well as the optical working (and protection paths) which pass through. If you are clicking on a node, you can see the node status that it is on when there is not any fault in it and off in other case. You can also see the incoming links and the outgoing ones as well as the local drop out links and the local added in ones. Clicking more, you see the optical paths that have source or destination this node and so on. The cut link is done either setting in the procedure read adjacent matrix the neighboring vertexes in the value of 10000 or by setting one by one node separately in the begin of each case. The Menu Tool bar has three choices (menu items), a) utils, b) design and protection and c) design and restoration. The *(a)* choice (menu item) has one subchoice (submenu) which is quit. The *(b)* choice (menu item) has three subchoices (submenu items) which are unprotected paths, dedicated protection paths and shared protection paths. The *(c)* choice has two subchoices (submenu items), the restoration by both nodes of the cut link and the restoration by source destination of a cut link. The choice is done clicking on every choice.

C. The formulation

The solution of the planning and designing problem is based on the following equations.

$$Yw = Aw * Xn \qquad (1)$$

It means that the knowledge of each node pair demands which are its requests for connection and their preplanned working lightpaths create the necessary wavelengths for their satisfaction for each link. The total working wavelengths of each link are

$$Yw,i = \sum^{n(i)} Aw\, i,j * Xj \qquad (2)$$

$j=1$

The knowledge of each node pair demands which are its requests for connection and their preplanned full disjoint dedicated protection lightpaths create the necessary wavelengths for their satisfaction for each link.

$$Ydp= Adp * Xn \qquad (3)$$

The total dedicated protection wavelengths of each link are

$$Y_{dp,i} = \sum_{j=1}^{n(i)} A_{dp\ i,j} * X_j \qquad (4)$$

For the matrix the following equation is valid

$$A=AwUAdp \qquad (5)$$

The total wavelengths for dedicated protection the following

$$Y=Yw + Ydp \qquad (6)$$

The total wavelengths for the corresponded shared protection are the following

$$Y=Yw+Ysp \qquad (7)$$

Ysp contains the total wavelengths that are reserved for sharing protection of working lightpaths.

$$T=W+P \qquad (8)$$

The protection ratios for dedicated and shared protection are more analytical written below

$$PRd=\frac{\sum_{i=1}^{2p} Y_{dp,i}}{\sum_{i=1}^{2p} Y_{w,i}} \qquad (9)$$

$$PRs=\frac{\sum_{i=1}^{2p} Y_{sp,i}}{\sum_{i=1}^{2p} Y_{w,i}} \qquad (10)$$

$Y_{w,i}$, $Y_{dp,i}$, $Y_{sp,i}$ the elements of the corresponded matrixes.

Optical fiber spare capacity for connection protection $Y_{sp,i}$ is calculated assuming that a sub-network protects each optical fiber. For the unptotected paths the protection ratio is zero because there are not protection paths.

When there are not protections WDM and fiber systems the equation (8) is transformed to

$$T=W \qquad (11)$$

The protection ratios for the restoration cases are more analytical written below

$$PRrbn=\frac{\sum_{i=1}^{2p} Y_{rbn,i}}{\sum_{i=1}^{2p} Y_{w,i}} \qquad (12)$$

$$PRrsd=\frac{\sum_{i=1}^{2p} Y_{rsd,i}}{\sum_{i=1}^{2p} Y_{w,i}} \qquad (13)$$

TABLE 1.THE SYMBOLS OF THIS PAPER

S/N	Symbol	Comments
1	q	The node number
2	p	The edge number
3	G(V,E)	The network graph
4	V(G)	The network node set
5	E(G)	The network edge set
6	2p	The number of working and backup fiber for 1+1 line protection
7	n	The number of source – destination nodes pairs of the network
8	Xn	A column matrix (nx1) with elements the connection group size of the corresponding source-destination node pairs and corresponds to the successful requests for connection.
9	n(i)	The total number of the connection groups that passes through the fiber (i) and means that each fiber has different number of connection groups pass through it
10	K	The number of the wavelengths channels on each fiber that is the WDM system capacity
11	Y	The column matrixes (2px1) with the total wavelength demands of network links.
12	Yw	The column matrixes (2px1) with the working wavelength demands of network links.
13	Ydp	The column matrixes (2px1) with the dedicated protection wavelength demands of network links.
14	Ysp	The column matrixes (2px1) with the shared wavelength demands of network links.
15	Yrbn	The column matrixes (2px1) with the extra wavelength demands of network links for restoration by both nodes of a cut link.
16	Yrsd	The column matrixes (2px1) with the extra wavelength demands of network links for restoration by source destination nodes of a cut link.
17	W	The column matrix (2px1) with elements the working WDM and optical fiber systems per link.
18	P	The column matrix (2px1) with elements the protection WDM and optical fiber systems per link.
19	T	The column matrix (2px1) with elements the total WDM and optical fiber systems per link.
20	A	The matrix (2p x n) that present the network active links that pass the total connections before a link cuts.
21	Aw	The matrix (2p x n) that present the network active links that pass the working connections before a link cuts.
22	Adp	The matrix (2p x n) that present the network active links that pass the dedicated protection connections before a link cuts.

$Y_{rbn,i}$ and $Y_{rsd,i}$ are the maximum extra wavelengths for each link that are used in the restoration. The total busy wavelengths of each case are the sum of the wavelengths of the numerator and the denominator of the protection ratios. The available capacity is the installed capacity minus the busy capacity.

D. The General Description algorithm

Our methods describe the operation of the WDM optical fiber mesh network. Simulation language is critical to the economic feasibility of the entire investigation and VISUAL BASIC is used to program the model (See Visual Basic

Simulator). All cases of this paper have two parts. The first part or the planning and designing part is network without failure part and the second part or network with failure part.

First step, Network parameters

Initially the following data are known network topology, node number, edge number, link number and wavelength number per WDM and fiber system. This information allows the computer to draw a graph with Fiber and WDM OXCs are on the vertex of the graph. Each edge corresponds to two links with opposite direction to each other. The computer reads the adjacency matrix and is informed about the network topology.

Second step, Connection selections

In this step, the connection node pair number and the connection node pair selection for connections are done. The connection group of each node pair reads its size. It may constant or it is taken by a random number generator. The command (REM) is used to change.The code for this is written below.

```
For i=1 to np
  REM z(i)=int(rnd*max)+1
   Z(i)=c
Next i
```

Np, represent the node pair number, z(i) the connection node pair size, rnd is the function that gives a random number in the interval [0,1), max the maximum value of the int(rnd*max).The constant (c) takes integer values.

Failure-free Network Phase

Third step, Wavelength allocation

In this step, wavelength allocation is initiated. A working connection starts from the source node and progresses through the network occupying a wavelength on each optical fiber and switch to another fiber on the same or other wavelength by OXC, according to its preplanned working optical path up to arrive at the destination node. Then for the suitable case (for unprotected and the restoration cases these are aborted), the protection lightpath of the connection starts from the source node and progresses through the network occupying a wavelength on each optical fiber and switch to another fiber on the same or other wavelength by OXC, so another full disjoint protection optical path is obtained. So there is full dedicated protection for this connection. The same procedure is repeated for the shared protection but each wavelength is reserved to share by others connections. The number of connections of each node pair is equal to its connection group size. After a connection (working as well as protection) has been established, the available capacity is also calculated under both protection methods. Thus the available capacity of the one method is compared to available capacity of the other method for one connection.

Forth step. Results

Having the connection group size the total results are computed. After the wavelength allocation has been completed, the wavelengths that each link needs for the full satisfaction of network demands are known and WDM and optical fiber system calculation starts with all fibers have the same wavelength number. The working WDM and fiber system calculation per link is implemented using the WDM capacity as well as the total network working WDM and fiber systems. The protection WDM and fiber systems are equals to the working. At the end, the number of WDM and fiber system per link and the total network WDM and fiber systems are calculated. If there is no failure, the method is terminated. This network have been planned and designed so that all requests for connection have been satisfied and formed connections. So there is not any connection blocking.

Network with failure Phase

When a failure occurs a link is cut. The working and protection optical fibers of this link are also cut and the network topology changes. The connection groups that passed through the cut link are also cut. The computer is informed of the cut link and modifies suitably the network parameters. The cut optical fibers sets their wavelengths to zero, the connection groups that passing through the cut link are noted and set their using wavelengths to zero and through the others to free, the adjacent matrix changes as well as the number of the group size that passing through fibers. Protection paths pass the traffic. In the cases of the restoration, it is done by the suitable nodes according the preplanned paths. The restoration by both nodes of the cut link starts from the one node and progresses through the network occupying a wavelength on each optical fiber and switch to another fiber on the same or other wavelength by OXC, according to its preplanned working optical path up to arrive at the other node. The restoration by source and destination nodes ignoring the cut link starts from the source node and progresses through the network occupying a wavelength on each optical fiber and switch to another fiber on the same or other wavelength by OXC, according to its preplanned working optical path up to arrive at the destination node.

Its worst case time complexity depends of the network topology and the total number of connections. It is $O(t*q^2)$ where t the total number of the connections.

E. Example

For the best presentation of the simulation of these approaches the network here below is studied.

The node number can be increased easily with some changes to about forty. When the display size increases then the node number also increases. It is assumed that the topology of the network is presented by the graph G(V,E). This mesh topology is used because it is a simple, palpable and it is easy to expand to any mesh topology. The vertex set has q=12 elements which are $V=\{v_1, v_2, v_3, v_4, v_5, v_6, v_7, v_8, v_9, v_{10}, v_{11}, v_{12}\}$ and the edge set has p=15 elements which are $E=\{e_1, e_2, e_3, \ldots, e_{11}, e_{12}, e_{13}, e_{14}, e_{15}\}$. Each edge has two optical links of opposite directions with their fibers for each

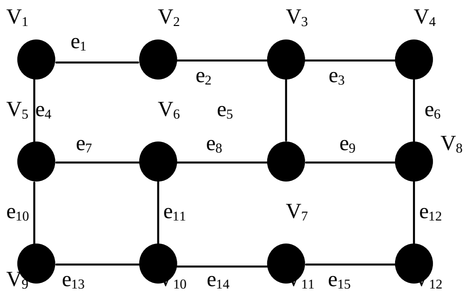


Figure 1.The mesh topology of the network.

direction. The connections of each node pair form connection groups according to its preplanned path and transverse the network. Figure 1 presents the mesh topology which is displayed in a form with the title “Network Topology”.

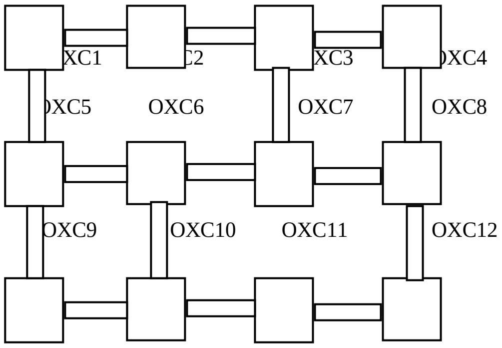


Figure 2.The logical network.

TABLE 2.THE MENU TOOL BAR WITH SUBMENUS

Utils	Design and Protection	Design and Restoration
Quit	Unprotected paths	Restoration by both nodes of cut link
	Dedicated Protection paths	Restoration by Source-Destination nodes
	Shared Protection paths	

In the Visual Basic simulation environment, when an edge has not a cut link, its color is green otherwise its color is red. When a node has any problem its color is red otherwise is green. In the table 2 the Menu Tool bar is showed with the submenus. You choice from the above tool bar to design a network with unprotected paths pass through clicking the proper submenu item. So it is done. There is not a cut link. When you are clicking on the edge of this link, you are taking the two opposite links and their color green say to you immediately that there is no cut link and their status which is on. When any link of this edge is cut then its color is red and their status is off. The edge1 means edge number 1 and it is written in the caption of the form. The links are text boxes and the V1-→V2 and V1←-V2 are written in the caption of the text boxes. The symbol (->) shows the transmission direction.

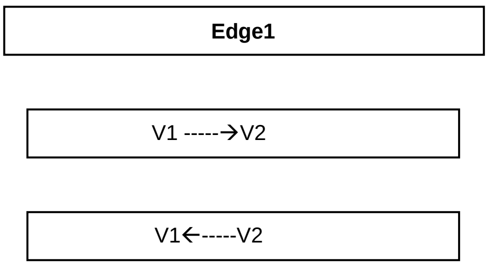


Figure 3.The window opens clicking on an edge1.

Clicking on the link V1-→V2 without failure that its color is green, you see the link status which is on, the number of working WDM and fiber systems, the number of protection WDM and fiber systems, the WDM capacity and its demands. You can also see a command button writing on “Click this button for more” and when you are clicking, you see more for each WDM and optical fiber, working or protection.
These are showed in the figure 4.

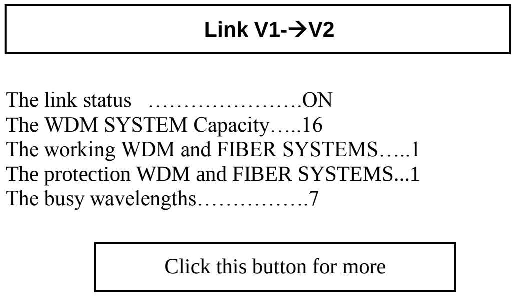


Figure 4.The link window.

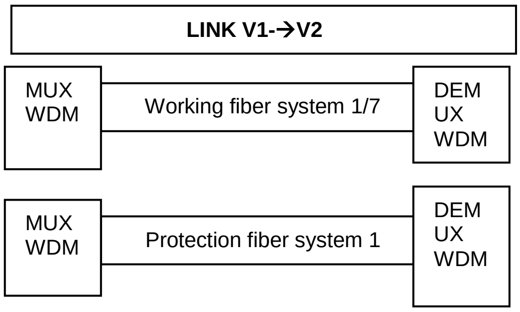


Figure 5.The more analytical WDM and fiber systems window.

There are labels and text boxes with exception the last which is a command button. When the link is not cut, the window color is green other wise is red. When you are clicking the command button, you are taking, a more detail window. The protection switching is done on line layer but the protection fiber has its own MUX/DEMUX system to be used as occasional carrying low priority traffic and equipment protection. Clicking on the working fiber system, you can see the busy and the free wavelengths as well as the optical working (and protection paths) which pass through.

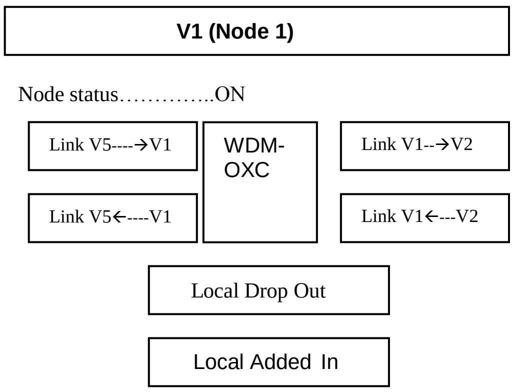


Figure 6.The node window.

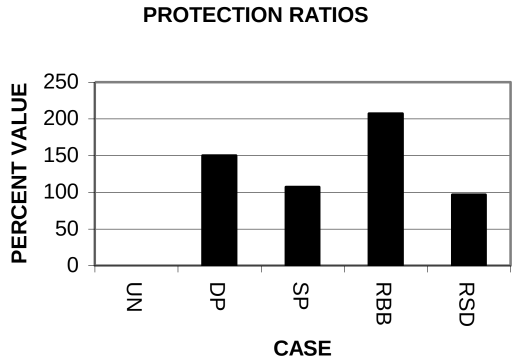
If you are clicking on a node, you can see the node status that it is on when there is not any fault in it and off in other case. You can also see the incoming links and the outgoing ones as well as the local drop out links and the local added in ones. The WDM-OXC works on a group of wavelengths within a single or multiple fibers to extract and route the individual wavelengths to the appropriate destination. Some or all wavelengths may require wavelength conversion from external transponders. Clicking on the links you go to the previous windows. Clicking on local drop out, you see the optical paths that have destination this node. Clicking on local added in, you see the optical paths that have source this node. In this example none path has destination this node. In this example, the connections have not protection so the working optical paths are green and the protection optical paths are red. There are two paths have this node as input node. These are the node pairs [V_1, V_4] and [V_1, V_8] with demands 4 and 3 respectively. The symbolized V_1->V_2-w->V_3->V_4 shows the path from source node, intermediate node to node up to destination node. The symbol (->V_2->) shows the switching direction, it means that the traffic on the node V_2 is switched from one wavelength input (input port) of the corresponded fiber to the same or another wavelength output (output port) of the corresponded fiber. The symbol *(/4)* means the wavelength demands (needs) of optical path. These are marked with the letter (w) that means working paths. For the protection paths, the letter (p) is used. In the figure 1, there is a small matrix with labels which write, Total Installed wavelengths, Total busy wavelengths Total available wavelengths and the corresponded text boxes.

The problem is solved for *n=9 of 132 possible* connection groups. These have their order for each source-destination node pair, their working paths and their protection paths as shown in *table 3*. The restoration is done by preplanned paths and there a lot of restoration path tables for each case so they are omitted. The size is one (1) so that there are not blockings. The percent protection ratios for each case are showed in the next figure. It is obvious that the dedicated path protection mechanisms use more than 100% redundant capacity because their lengths are longer than their working paths. The protection ratio of unptotected paths is zero and the corresponded values of the restoration methods are low.

TABLE 3.ORDER, WORKING PATH, PROTECTION PATH OF EACH NODE PAIR

Node Pair [Si, Di]	Node pair [v_i, v_j]	Working Path	Protection Path
[S_1, D_1]	[v_1, v_4]	v_1, v_2, v_3, v_4	$v_1, v_5, v_6, v_7, v_8, v_4$
[S_2, D_2]	[v_2, v_6]	v_2, v_1, v_5, v_6	v_2, v_3, v_7, v_6
[S_3, D_3]	[v_1, v_8]	v_1, v_2, v_3, v_4, v_8	v_1, v_5, v_6, v_7, v_8
[S_4, D_4]	[v_3, v_{12}]	v_3, v_4, v_8, v_{12}	$v_3, v_7, v_6, v_{10}, v_{11}, v_{12}$
[S_5, D_5]	[v_7, v_9]	v_7, v_6, v_5, v_9	$v_7, v_8, v_{12}, v_{11}, v_{10}, v_9$
[S_6, D_6]	[v_5, v_{11}]	v_5, v_9, v_{10}, v_{11}	$v_5, v_6, v_7, v_8, v_{12}, v_{11}$
[S_7, D_7]	[v_{12}, v_9]	$v_{12}, v_{11}, v_{10}, v_9$	$v_{12}, v_8, v_7, v_6, v_5, v_9$
[S_8, D_8]	[v_2, v_9]	v_2, v_1, v_5, v_9	$v_2, v_3, v_7, v_6, v_{10}, v_9$
[S_9, D_9]	[v_9, v_7]	v_9, v_5, v_6, v_7	$v_9, v_{10}, v_{11}, v_{12}, v_8, v_7$

The symbols UN(UNprotected), DP(Dedicated Protection), SP(Shared Protection), RBB(Restoration By Both nodes), RSD(Restoration by Source Destination nodes) mean unprotected network, dedicated protection optical path network, shared protection optical path network, the restoration by both node of cut link on optical path layer and the restoration from source and destination nodes respectively. They are for the restoration length with the maximum number of hop-wavelengths because there are restoration paths with different lengths for each cut link. These are showed in the figure 7. The capacity of WDM and fiber systems is 16 wavelengths and the installed capacity is constant 30*16=480.



7.The protection ratios for each case.

It is assumed that all connection group sizes are the same and their maximum values are different for each study case. These maximum values are limited by the WDM and fiber system capacity. They are showed in the figure 8. The protection ratios of these cases are the same of the figure 7.

The symbols UN, DP, SP, RBB<1,2>, RSD<1,2> mean unprotected network, dedicated protection optical path network, shared protection optical path network, the restoration by both node of cut link <1,2> on optical path layer and the restoration from source and destination nodes respectively. The available capacity for each case is presented in figure 9 and the symbols are the same as previously.

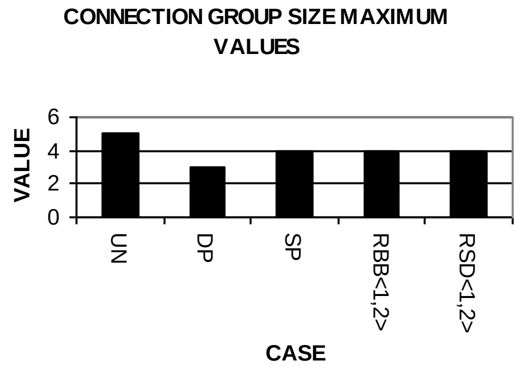


Figure 8.The maximum value for each case.

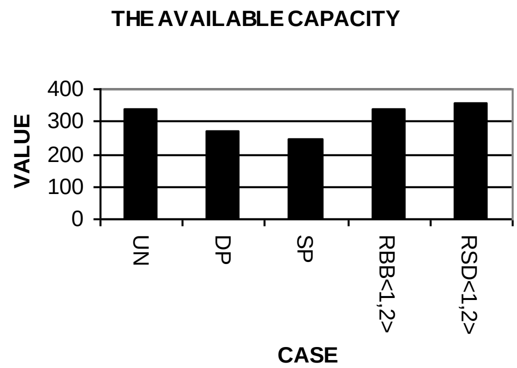


Figure 9.The available capacity for each case.

F. Discussion and Proposals

Today installation of WDM networks is based on mesh topologies but the latter are essentially formed by a set of point-to-point links between nodes. Network survivability is an inherent part of the mesh topology because there are usually at least two paths between end nodes. Thus, a network that uses a mesh topology can survive after a single failure. In communications, network survivability defined as the capability of a communication network to resist any link or node interruption or disturbance of service, particularly by warfare, fire, earthquake, harmful radiation or other physical or natural catastrophes.

When the network is planned and designed to satisfy all its needs with protection path means that no blocking probabilities should be calculated. The rerouting paths for demand restoration use a preplanned method. The preplanned method requires that each local OXC controller carry all, or a majority of rerouting information related to the network restructuring for all preplanned failure scenarios. The disadvantages of the preplanned method are first the higher memory requirement and second may have more difficulty adapting to rapid network changes. However, the preplanned method has faster restoration capability and lower system complexity. The preplanned method may also have lower network reliability than the dynamic rerouting method (shortest path algorithm) because it is difficult to implement all possible scenarios in the preplanned method. It means that preplanned method can not restore all demands but the dynamic can do it. The protection time is very small comparing with restoration time. In the case of the protection, provide fast (millisecond) rerouting when a failure occurs such that there is no effect. The restoration time depends primarily of the connections quantity and secondary of the restoration rerouting hops and the fiber-cut position (within a matter of seconds or minutes).

The Visual Basic capability is showed to simulate all type network designs with or without physical or logical protection. Microsoft Visual Basic consist an intelligent innovation for everybody who writes applications for windows. Its mechanism is event driven, easy and new drawing tools, gives the capability to exploit completely the graphics environment of windows to develop fast power applications while keeps Basic heritage.

III. CONCLUSIONS

In this paper Visual Basic is used to model the WDM mesh network. The Visual Basic capable to simulate all type network designs with or without physical or logical protection. When the GUI in which the network is displayed is larger then it is capable to support the visualization and analyze the topology and its changes more.

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