

WAN/LAN PLANNING AND DESIGN

**COURSE NUMBER 0681-712 G PROJECT
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GRADUATE PROJECT

Objective

In the Caribbean there is a regional force that maintains Law and order, and also track down local and international crime lord. It has been a challenge to ensure effect coordination and communication between the different headquarters which are located in 20 plus Island through the Caribbean. Many Governments in the Caribbean s are coming together to collaborate on an information and communication infrastructure that will improve coordination and communication between Governmental Organization such as police headquarters, hospitals, and educational organizations in the region.

This project will be carried out by Southern Caribbean Fiber Corporation (SCFC), who will design and build the network infrastructure. The corporation will create a fiber backbone which composes of fiber ring network using SONET technology to connect the eleven major Islands. These Islands are:

- Guyana
- Trinidad & Tobago
- Grenada
- St Vincent & the Grenadines
- St Lucia
- Dominica
- Barbados
- Martinique
- St Kitts & Nevis
- Jamaica
- Venezuela

Network architecture

The network will be base marine fiber links that will connect each of the Islands. The map below (**Figure 1**) shows the Caribbean region and the Island that will be part of the network. There will be several rings within the network as part of the redundancy plan.

It is new generation network that employ state-of-the-art technologies such as an IP platform that runs MPLS and QoS with VOIP technologies and other internet tools and application s that are useful for the education sector, health sector among others.



Figure 1

Planning

1. Design the network topology for the Baseline Scenario.
2. Determine which SONET ring topology to used (2F-BLSR or UPSR) base on cost.
3. Scenario 1:
 - i) Obtain traffic matrix for DCL and OCH layers.
 - ii) Route DCL/OCH traffic.
 - iii) Dimension DCL/OCH layer using no protection.
 - iv) Observe rout results.
 - v) Carry out availability and failure analysis on Scenario 1.
 - vi) Obtain the total cost of the network.
 - vii) Observe 20% growth in traffic.
4. Scenario 2:
 - i) Dimension DCL/OCH layer using 1+1 protection.
 - ii) Carry out availability and failure analysis on Scenario 2.
 - iii) Obtain the total cost of the network.
 - iv) Observe 20% growth in traffic.
5. Scenario 3:
 - i) Dimension DCL/OCH layer using shared path protection.

- ii) Carry out availability and failure analysis on Scenario 3.
 - iii) Obtain the total cost of the network.
 - iv) Observe 20% growth in traffic.
6. Scenario 4:
- i) Dimension DCL/OCH layer using link restoration.
 - ii) Carry out availability and failure analysis on Scenario 4.
 - iii) Obtain the total cost of the network.
7. Scenario 5:
- i) Dimension DCL/OCH layer using path restoration.
 - ii) Carry out availability and failure analysis on Scenario 5.
 - iii) Obtain the total cost of the network.
 - iv) Observe 20% growth in traffic.
8. A comparison of the network and a conclusion.

The topology of the network

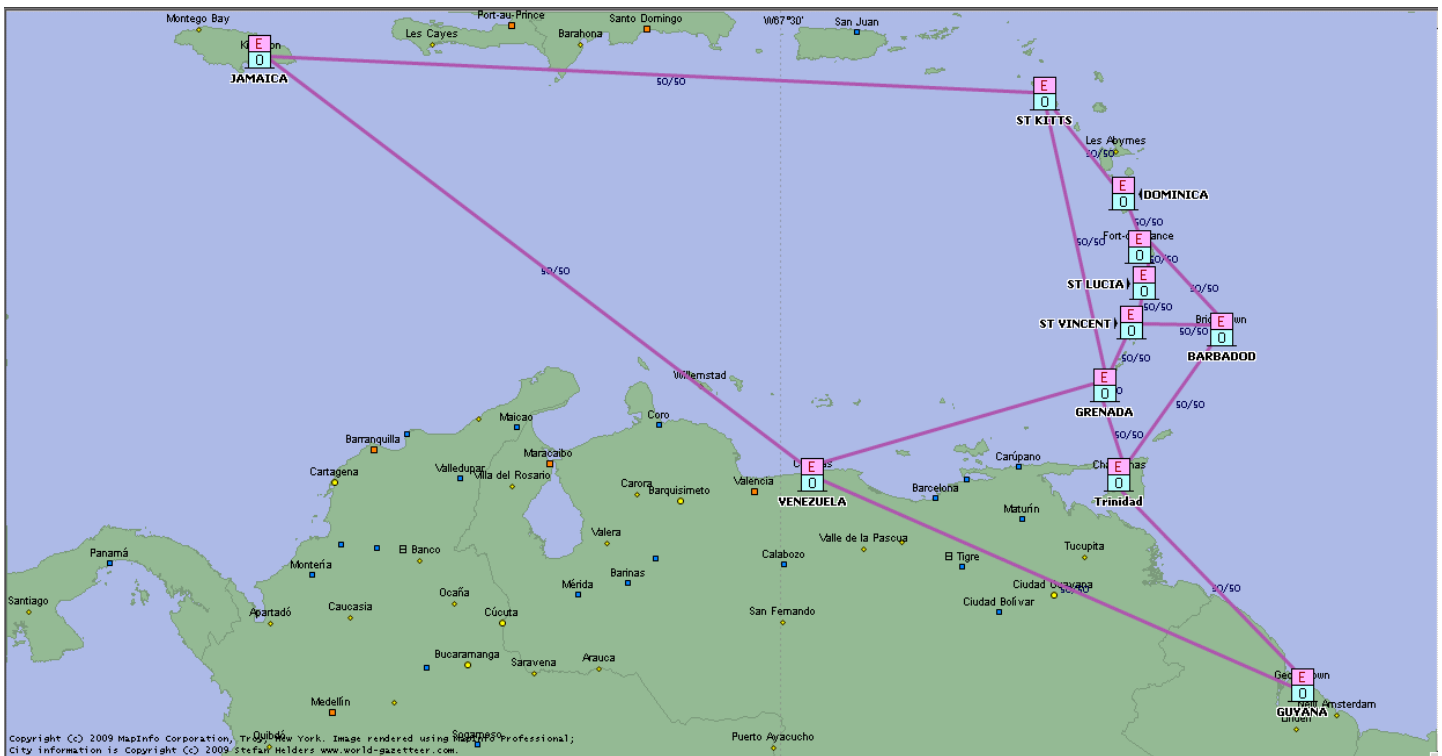


Figure 2

Figure 2 show a physical layout of the network infrastructure. It is not full mesh physical but it is design to achieve 100% in routing the traffic. Several rings are created to provide redundancy, the traffic is routed on the DC and OCH lay to optimize the capacity provide by the infrastructure. On the OCH layer different protecting schemes are used as discuss in scenarios 1-3.The network properties, the traffic matrix are the same for all scenarios.

Network properties

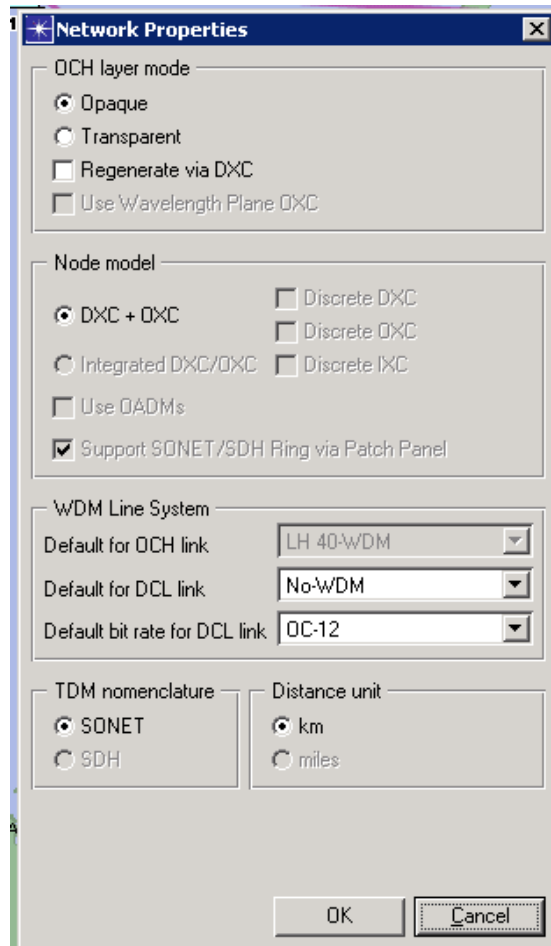


Figure 3

Figure 3 shows the properties of the network. The OCH layer is in opaque mode which means that every channel that passes through the node is regenerated. DXC + OXC are selected as the node model, in which the EOCC node uses a DXC to switch SONET/SDH traffic and a separate OXC to switch wavelengths. The DXC trunk ports connect to the OXC tributary ports so nodes can transport SDH/SONET traffic over WDM wavelengths.

Link design

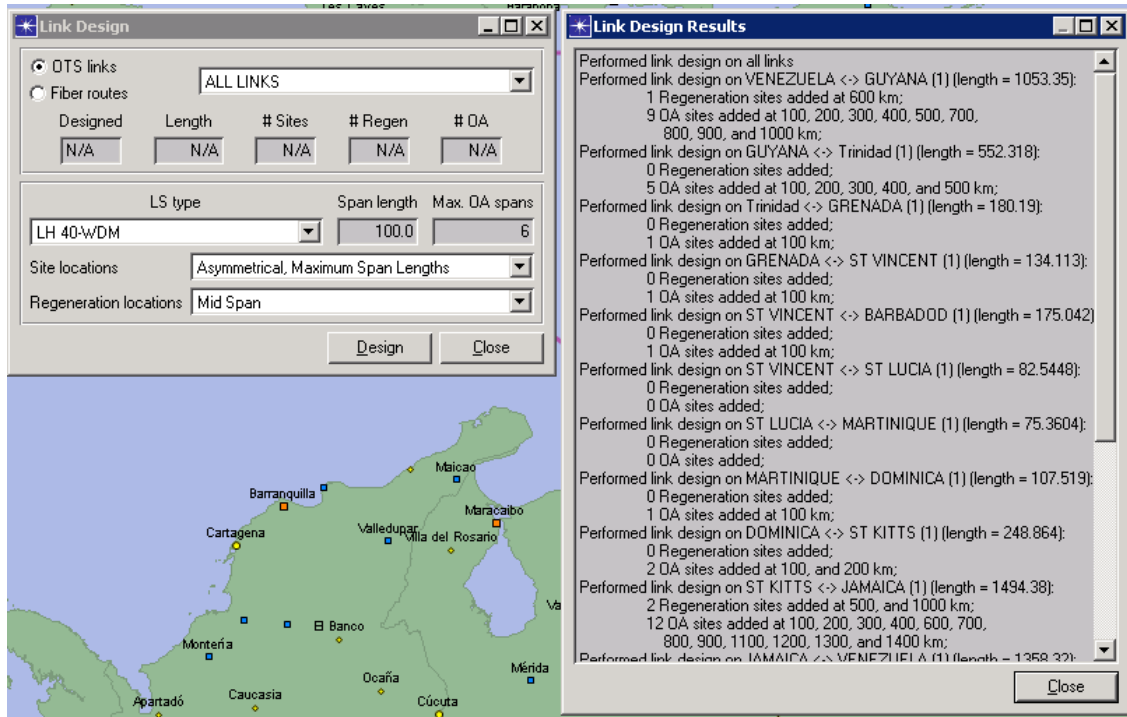


Figure 4

Ring design

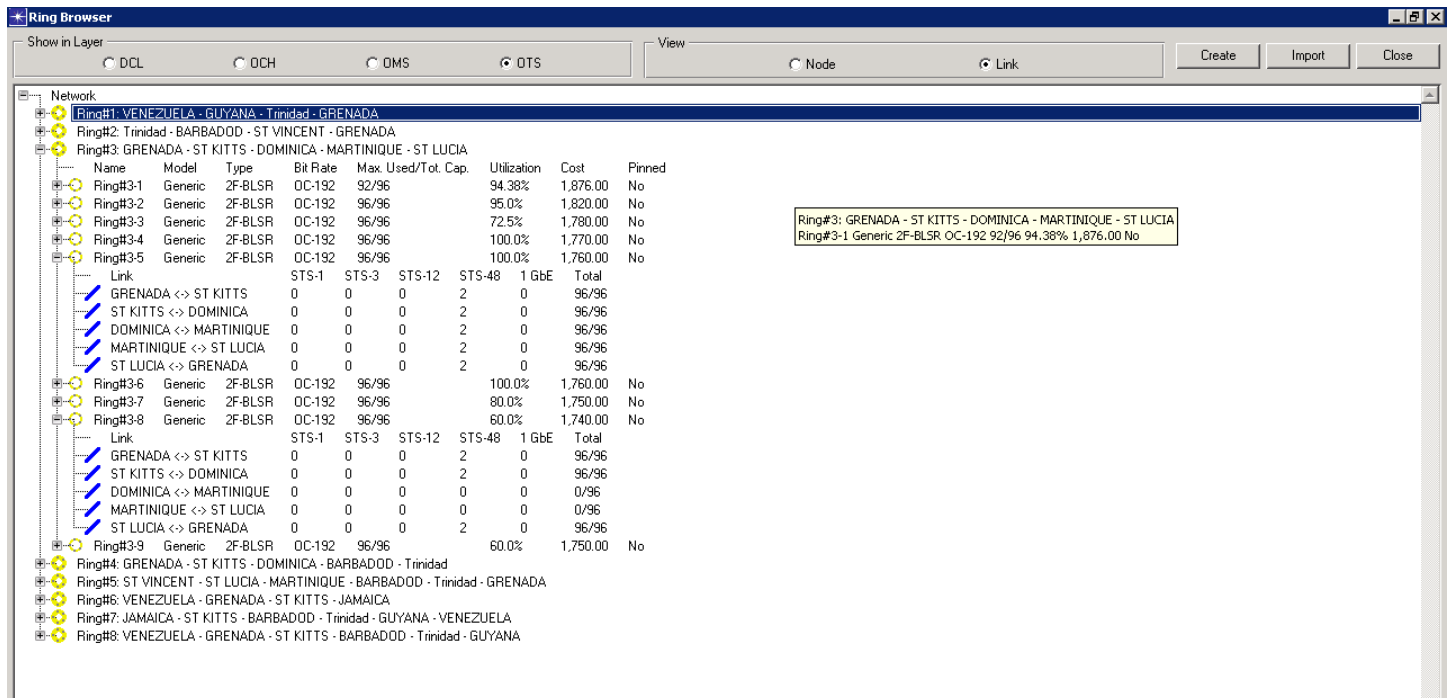


Figure 5

Figure 5 shows that there are 8 rings on the network that links the Islands. The rings are created on the optical transport layer (OTS).

Cost comparison between 2F BLSR and UPSR

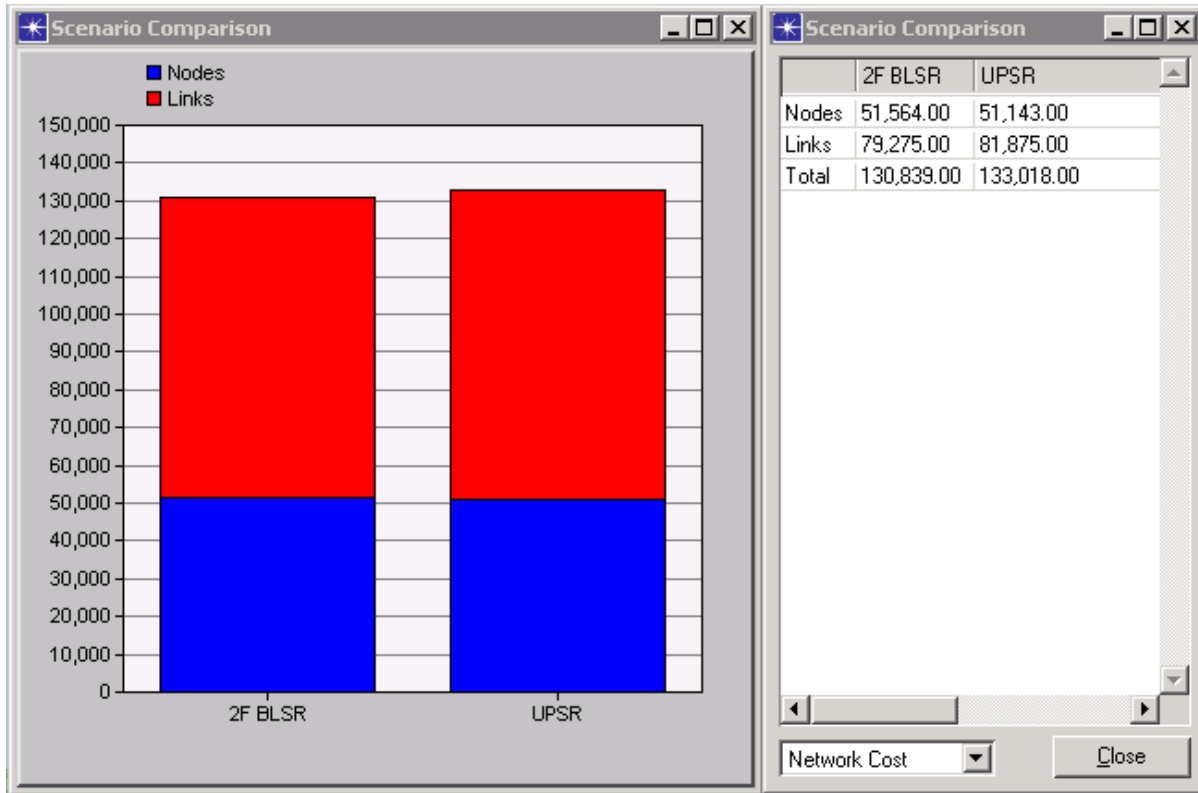


Figure 6

Figure 6 shows a comparison was done between SONET ring topology to used (2F-BLSR or UPSR) base on cost. From the scenario comparison 2F BLSR is cheaper by \$3000.00 therefore 2F BLSR will be used.

Traffic matrix for DCL and OCH layer

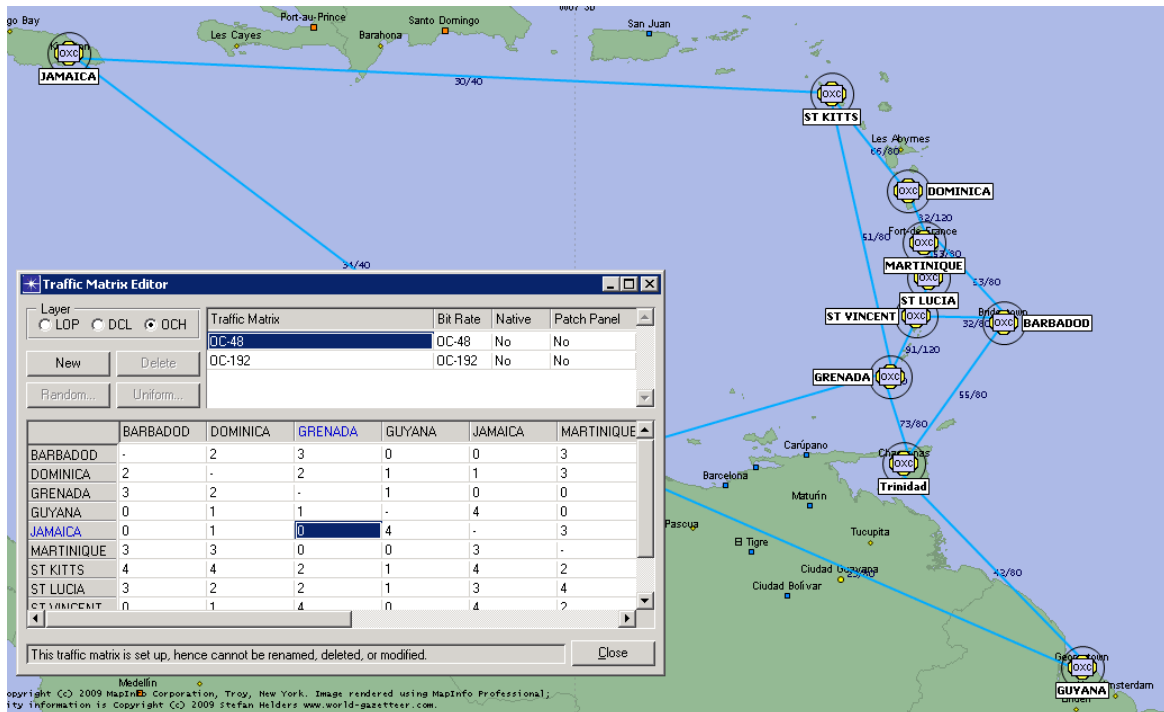


Figure 7

Figure 7 shows the OCH layer in the back ground of OCH traffic matrix.

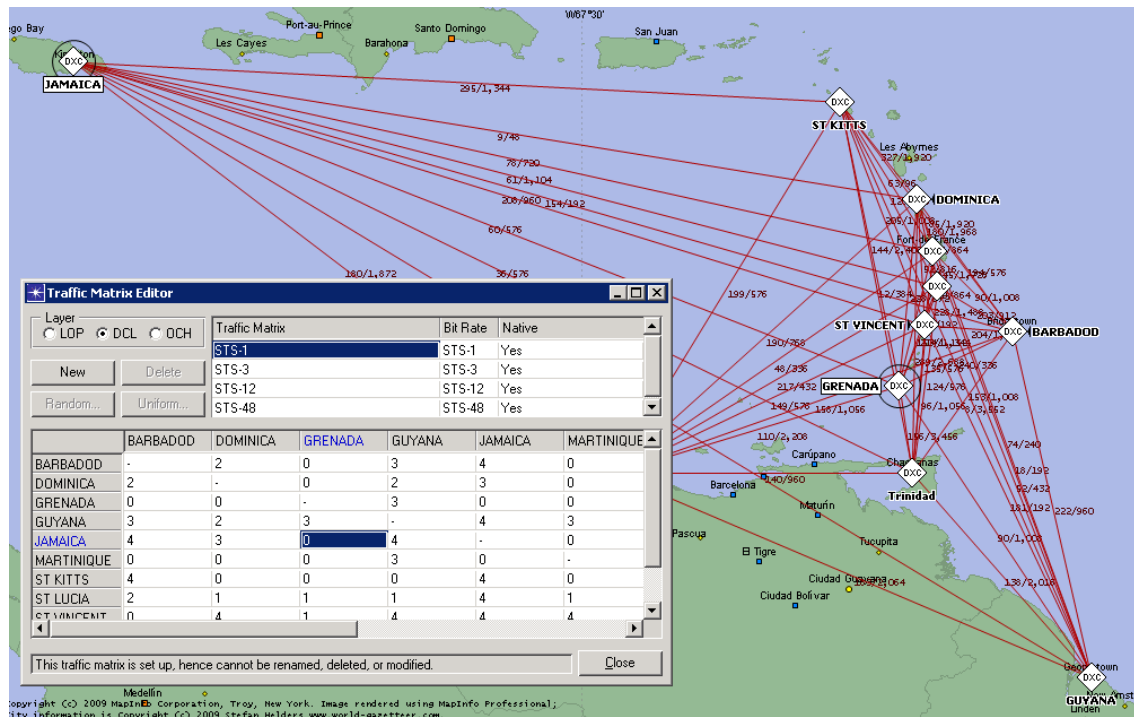


Figure 8

Figure 8 shows the DCL layer in the back ground of DCL traffic matrix. The traffic is random from 1 to 4 for both OCH and DCL layers, and will be used all Scenarios.

1.0 Scenario 1: Unprotected

Routing result on the DCL layer

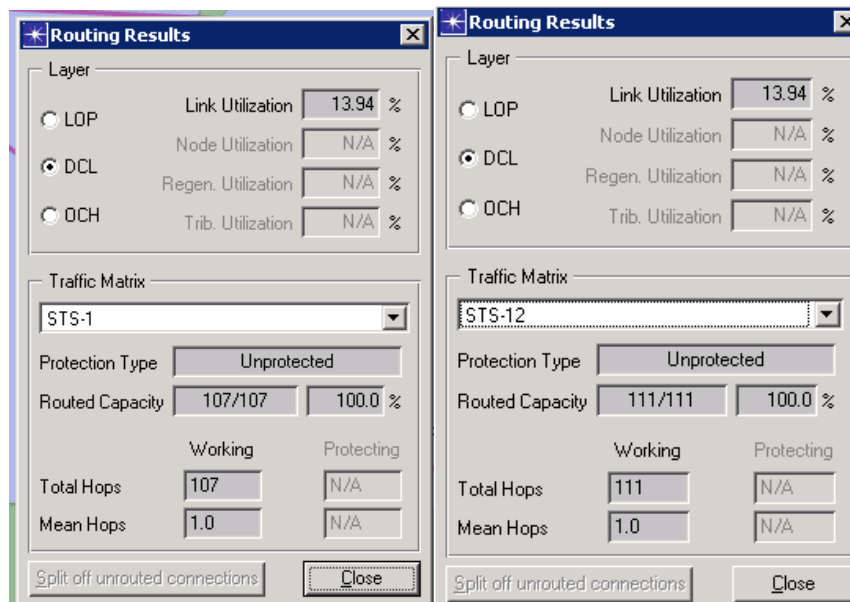


Figure 9

Figure 9 above shows 100% routed traffic on the DCL layer.

1.1 Routing result on the OCH layer

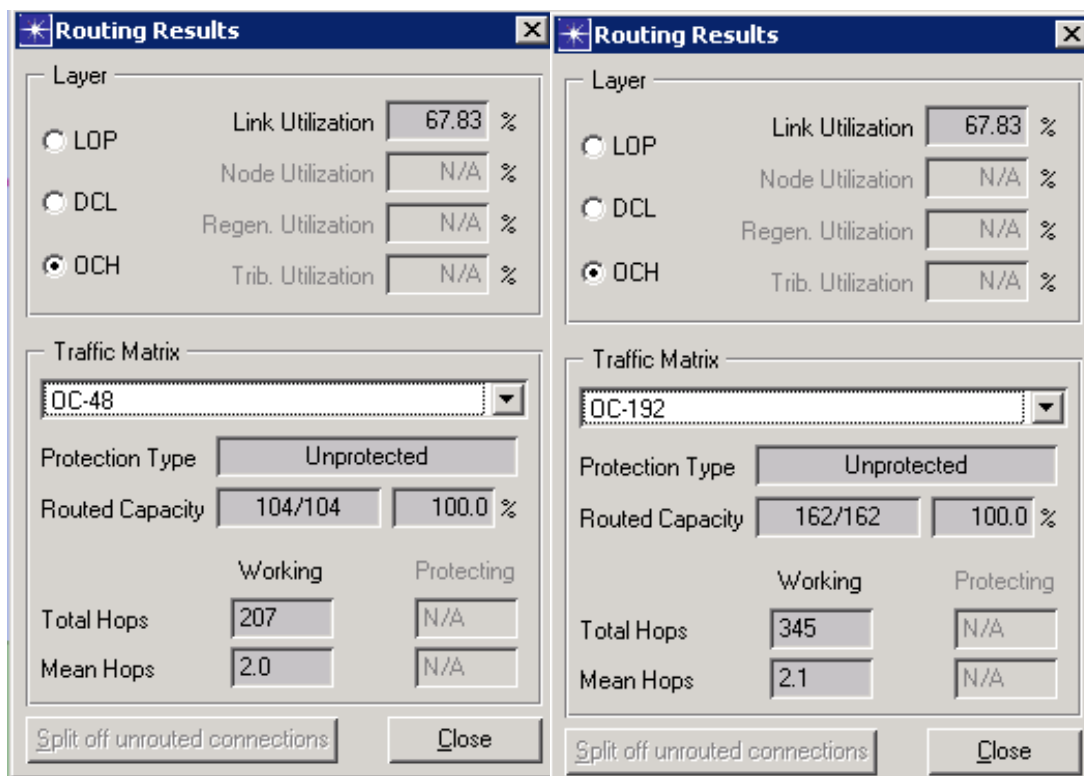


Figure 10

Figure 10 above shows 100% routed traffic on the OCH layer.

1.2 Link connection on the OMS layer

Name	Fiber Pairs	Length	Delay	User Cost
BARBADOD <-> MARTINIQUE (1)	2/50	236.8 km	1.184 ms	1.00
DOMINICA <-> ST KITTS (1)	2/50	248.9 km	1.244 ms	1.00
GRENADA <-> ST KITTS (1)	2/50	590.4 km	2.952 ms	1.00
GRENADA <-> ST VINCENT (1)	3/50	134.1 km	0.671 ms	1.00
GUYANA <-> Trinidad (1)	2/50	552.3 km	2.762 ms	1.00
JAMAICA <-> VENEZUELA (1)	1/50	1,358.3 km	6.792 ms	1.00
MARTINIQUE <-> DOMINICA (1)	3/50	107.5 km	0.538 ms	1.00
ST KITTS <-> JAMAICA (1)	1/50	1,494.4 km	7.472 ms	1.00
ST LUCIA <-> MARTINIQUE (1)	2/50	75.4 km	0.377 ms	1.00
ST VINCENT <-> BARBADOD (1)	2/50	175.0 km	0.875 ms	1.00
ST VINCENT <-> ST LUCIA (1)	2/50	82.5 km	0.413 ms	1.00
Trinidad <-> BARBADOD (1)	2/50	351.2 km	1.756 ms	1.00
Trinidad <-> GRENADA (1)	2/50	180.2 km	0.901 ms	1.00
VENEZUELA <-> GRENADA (1)	2/50	600.1 km	3.001 ms	1.00
VENEZUELA <-> GUYANA (1)	2/50	1,053.4 km	5.267 ms	1.00

Figures 11

Figures 12

Nodes	: 11
Links	: 15
Network Connectivity	: 27%
Node Degree	
Min	: 2
Max	: 4
Mean	: 2.73
Link Capacity	
Used	: 30
Total	: 750
Util.	: 4.00%
Number of fibers per LS type:	
LH 40-WDM	: 30
Total fiber length (bidirectional km)	
Min	: 150.72
Max	: 2106.71
Mean	: 791.34
Total	: 11870.05

Figure 11 show the amount of fiber in use on a link; the length and the delay. Figure 12 show that the network has 11 Nodes, 15 links, 27% connectivity among other information.

Figure 13 illustrate the OTS layer in the link browser which shows many regeneration station and optical amplifier station in a link.

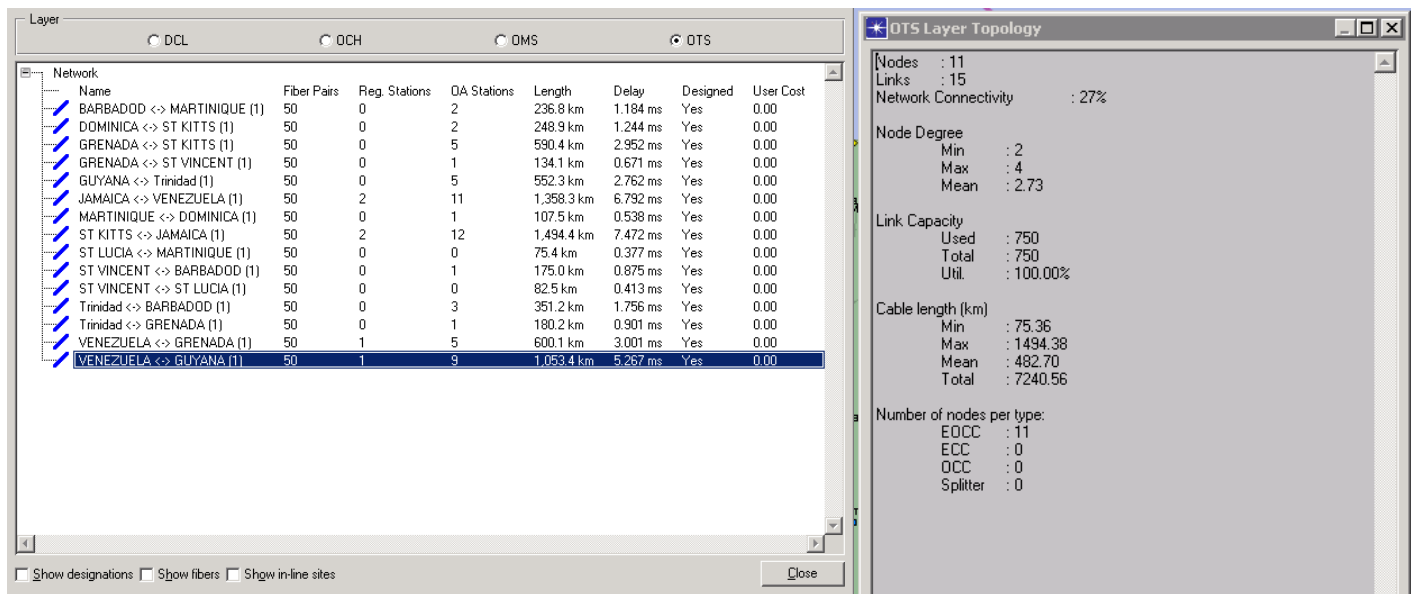
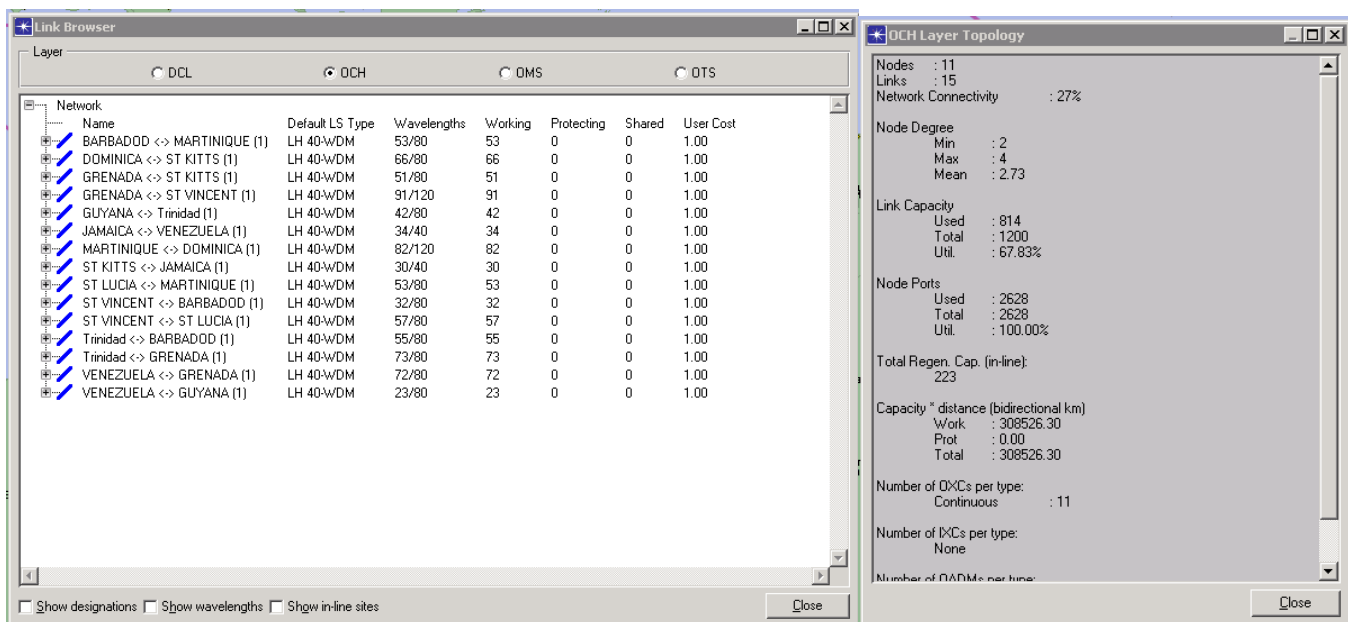


Figure 13

Figures 14 show the OCH layer which indicate how many wavelengths in use on the different links, and also if there are protected and shared.



Figures 14

Figure 15 show the DCL layer which indicates how many timeslots are in use on the different links, and also if there are protected and shared.

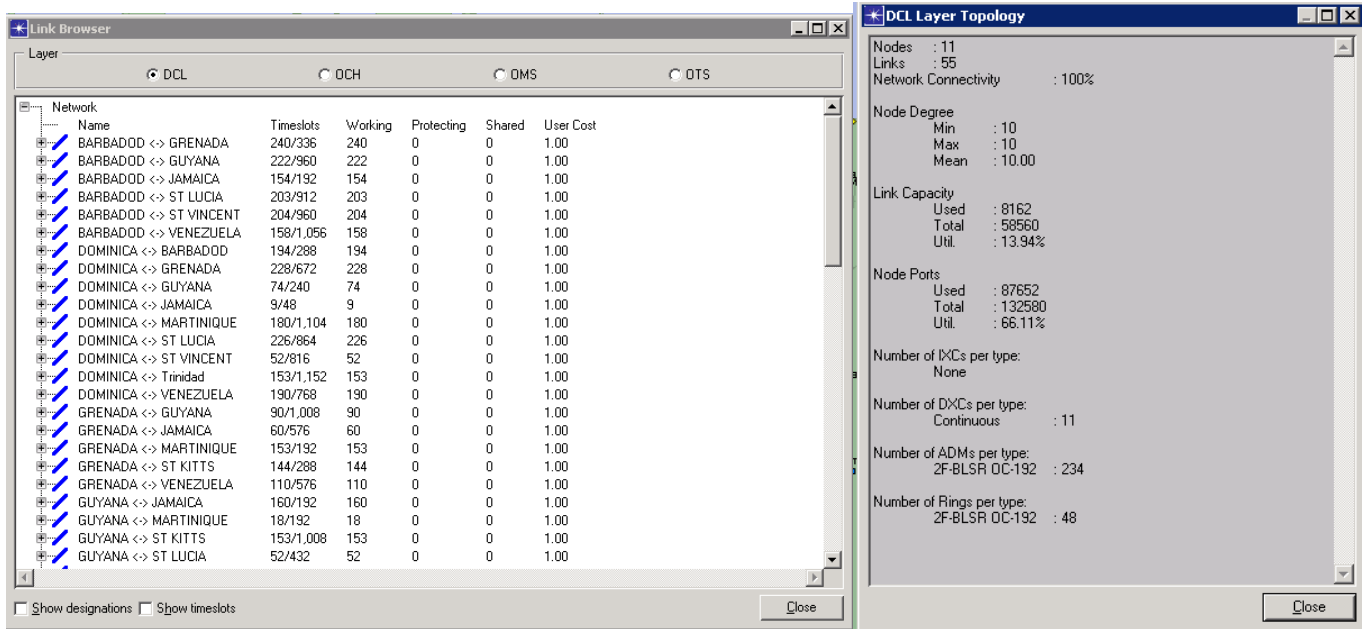
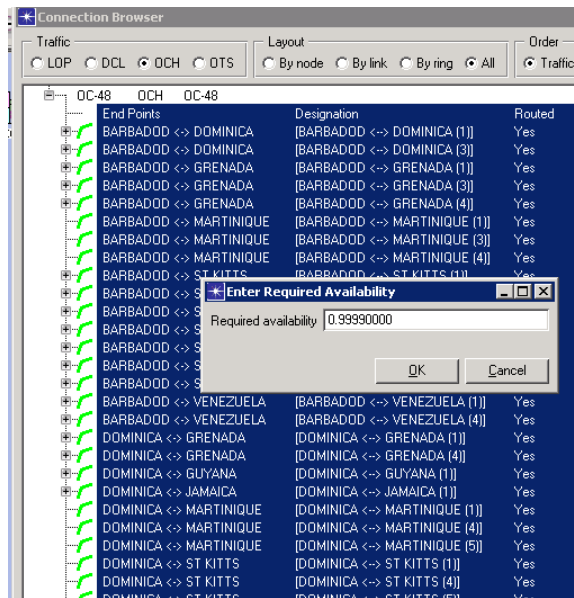


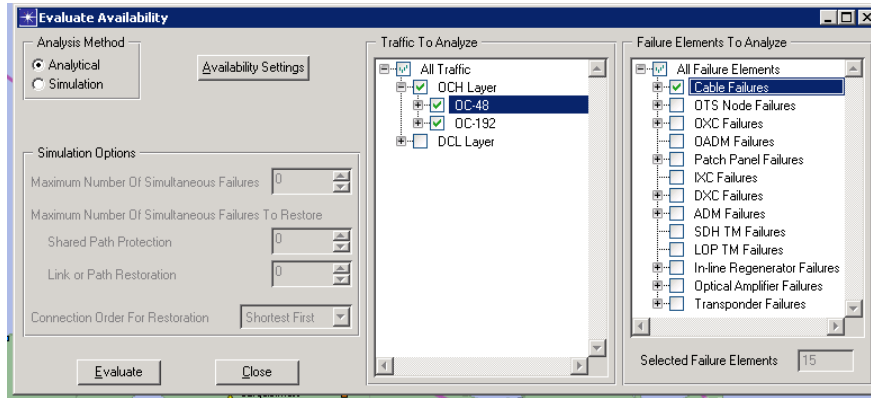
Figure 15

1.3 Availability Analysis:

For the availability analysis, 40 kilometers of cable is considered to cut every year, which occurs on the ocean bed. “The Mean Time to Repair,” is considered to be 20 hours since it is offshore and under water. Also the availability of the OCH layer (OC-48 & OC-192) is 0.9999. The equipments are considered to be 1.0. These values are used for all scenarios.



Figures 16 show the setting of the availability of OC-48 circuit.



Figures 17; Show evaluation setting of the OCH layer

OC-48

Summary

Average Availability	0.9566565168	
Expected Loss of Traffic	353,682,955.98	Gb/year
	39,487.65	OC-48 hours/year
Average Expected Loss of Traffic	3,400,797.65	Gb/year
	379.69	OC-48 hours/year

Connections failing to meet availability requirements

Connection	From	To	Protection Type	Minimal Availability	Estimated Availability	Maximal Availability	Required Availability
[BARBADOD <--> DOMINICA (1)]	BARBADOD	DOMINICA	Unprotected	0.9804283742	-	0.9804283742	0.9999000000
[BARBADOD <--> DOMINICA (3)]	BARBADOD	DOMINICA	Unprotected	0.9804283742	-	0.9804283742	0.9999000000
[BARBADOD <--> GRENADA (1)]	BARBADOD	GRENADA	Unprotected	0.9824306215	-	0.9824306215	0.9999000000

Figure 18; Show the average availability of the OC-48

OC-192

Summary

Average Availability	0.9564696921	
Expected Loss of Traffic	2,213,438,016.45	Gb/year
	61,774.73	OC-192 hours/year
Average Expected Loss of Traffic	13,663,197.63	Gb/year
	381.33	OC-192 hours/year

Connections failing to meet availability requirements

Connection	From	To	Protection Type	Minimal Availability	Estimated Availability	Maximal Availability	Required Availability
[BARBADOD <--> DOMINICA (2)]	BARBADOD	DOMINICA	Unprotected	0.9804283742	-	0.9804283742	0.9999000000
[BARBADOD <--> GRENADA (2)]	BARBADOD	GRENADA	Unprotected	0.9824306215	-	0.9824306215	0.9999000000
[BARBADOD <--> GUYANA (1)]	BARBADOD	GUYANA	Unprotected	0.9490626892	-	0.9490626892	0.9999000000

Figure 19; Show the average availability of the OC-192

1.4 Failure Analysis:

The failure analysis is carried with the cable failures between Grenada-St Kitts, Trinidad-Barbados and Jamaica-St Kitts. These cables will be the same for the other scenarios.

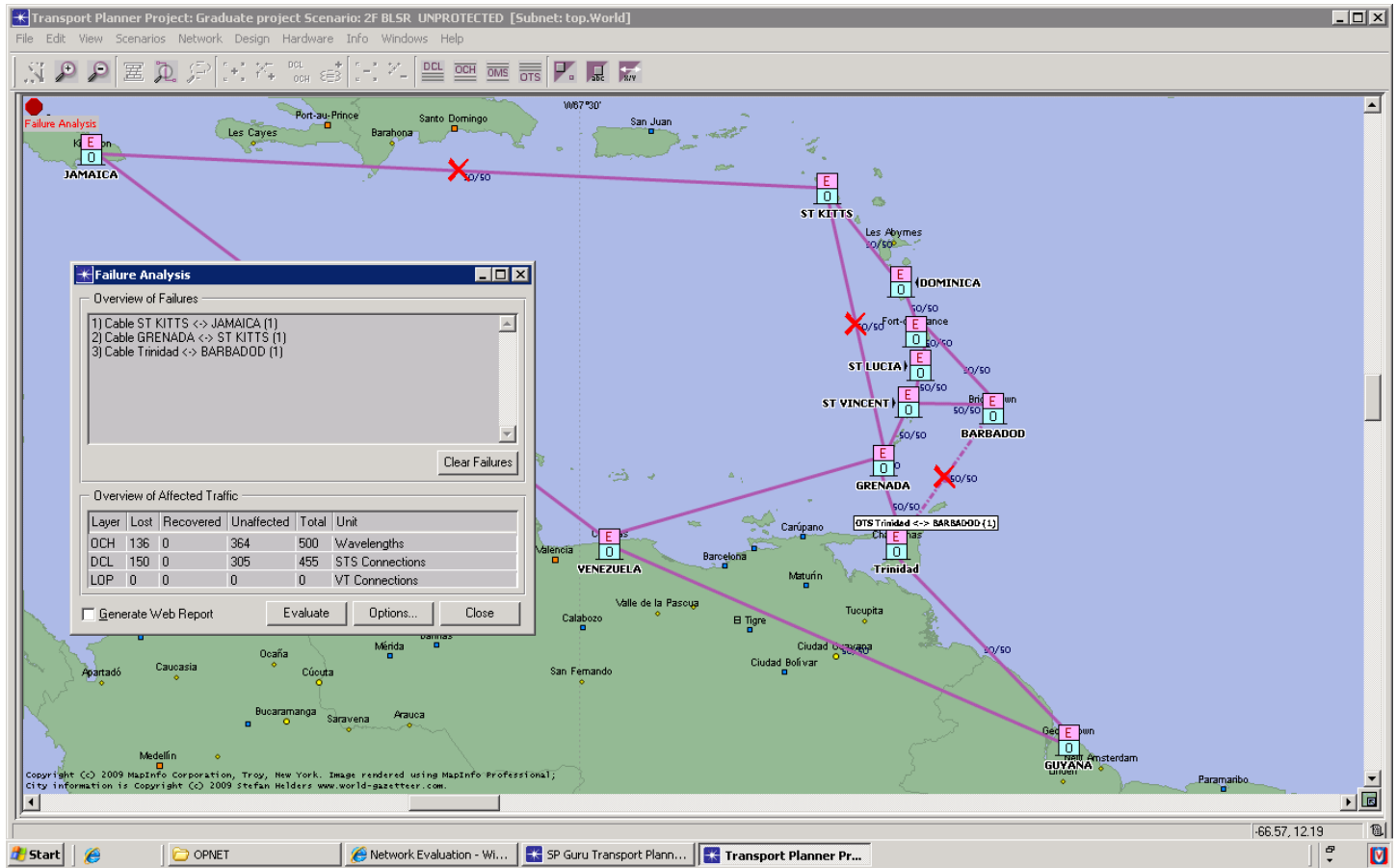


Figure 20; Failure Analysis

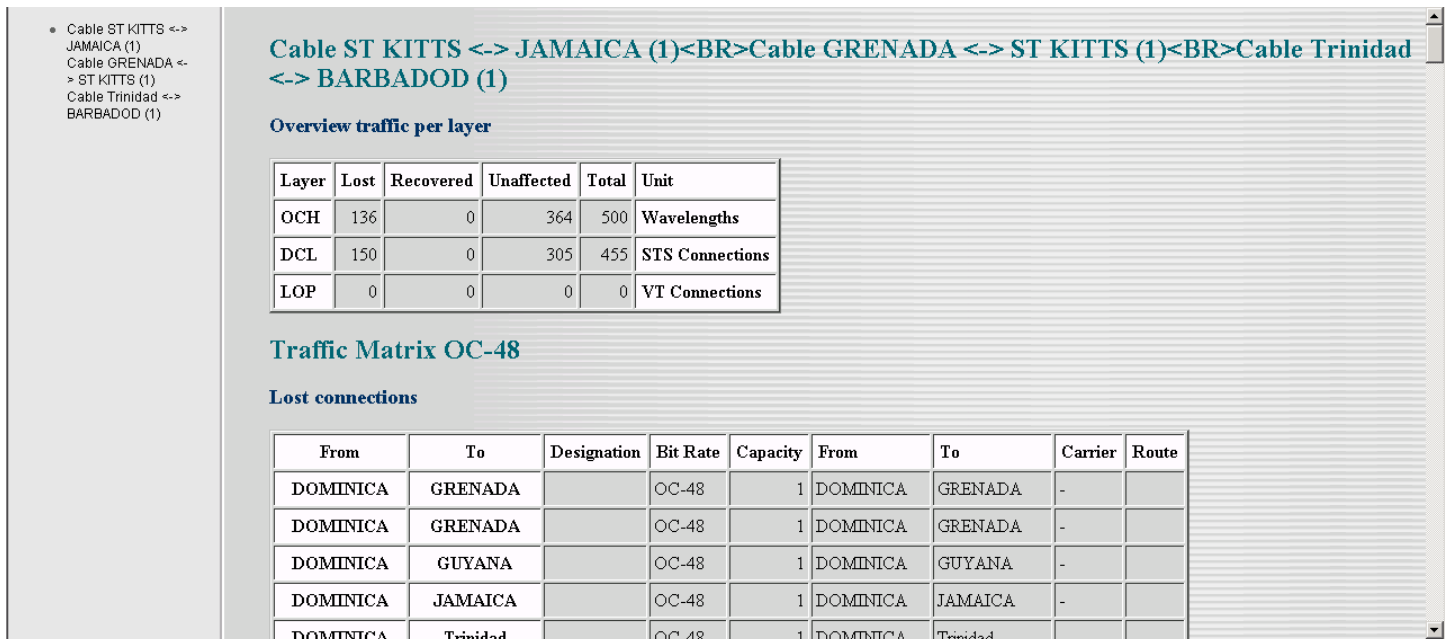
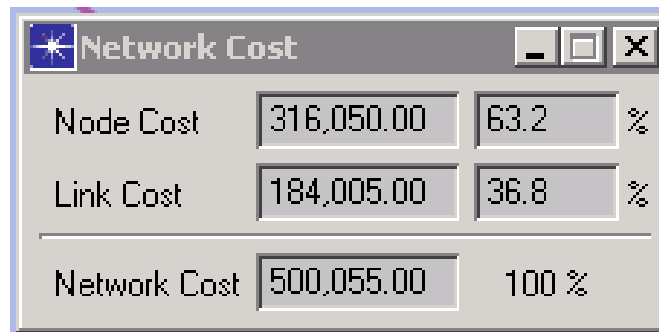


Figure 21; Failure Analysis of the three same links

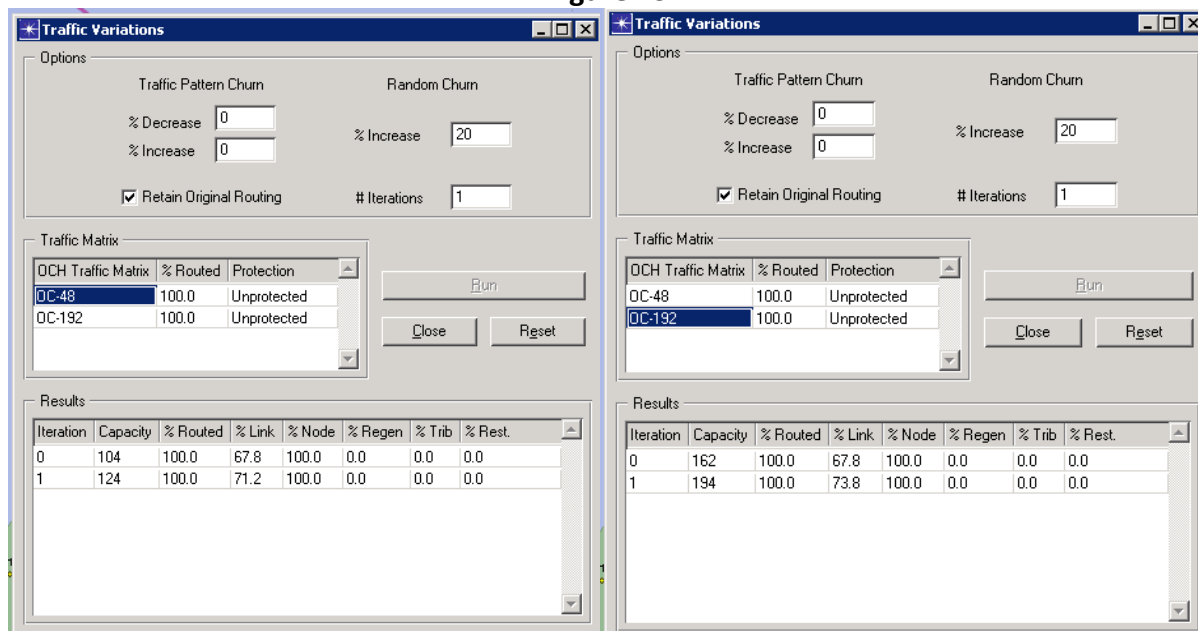
1.5 Network cost



Figures 22; Total Network Cost

1.6 Traffic growth of 20%:

Figure 23



Figures 23 show a 20% increase in traffic on the network. There is 100% routed traffic which means that the network is able to handle a traffic growth.

2.0 Scenario 2: 1+1 protection

Figure 24 show the connection browser in which you can see that on the OTS layer the links are unprotected.

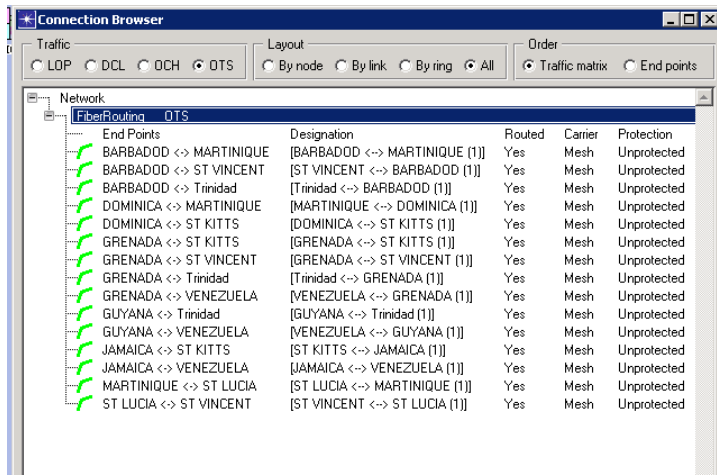


Figure 24

Figure 25 show the connection browser in which you can see that on the OCH layer the links have 1+1 protection. The green represent the working path and the red the protected path.

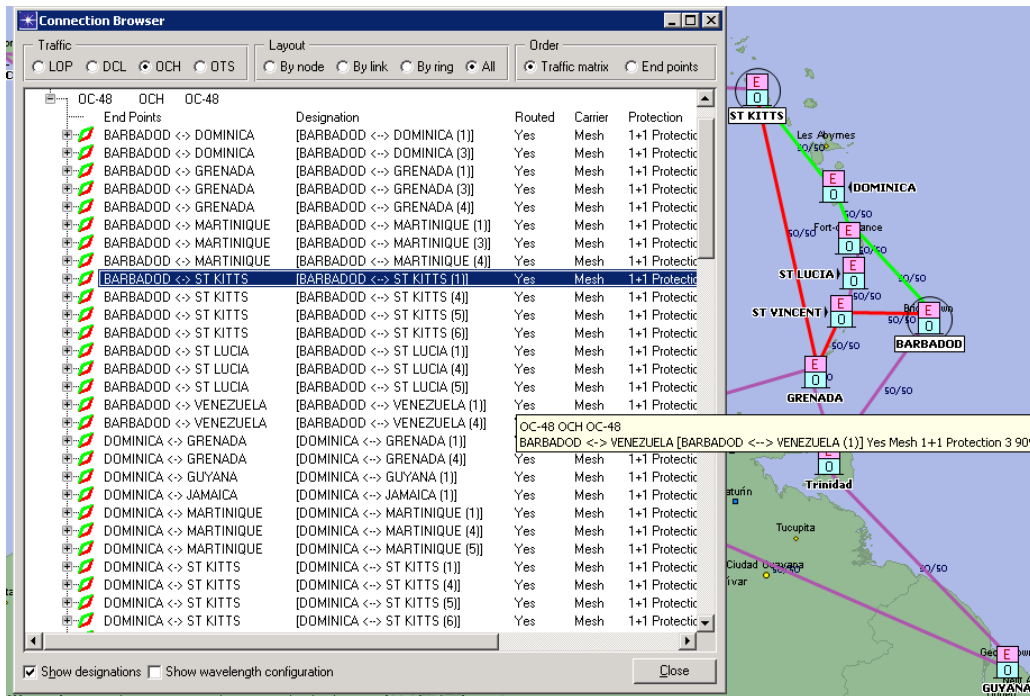


Figure 25

2.1 Availability Analysis

OC-48

Summary

Average Availability	0.9953482514	
Expected Loss of Traffic	37,958,283.25	Gb/year
	4,237.93	OC-48 hours/year
Average Expected Loss of Traffic	364,983.49	Gb/year
	40.75	OC-48 hours/year

Connections failing to meet availability requirements

Connection	From	To	Protection Type	Minimal Availability	Estimated Availability	Maximal Availability	Required Availability
[BARBADOD <--> DOMINICA (1)]	BARBADOD	DOMINICA	1+1 Protection	0.9987442516	-	0.9987442516	0.9999000000
[BARBADOD <--> DOMINICA (3)]	BARBADOD	DOMINICA	1+1 Protection	0.9987442516	-	0.9987442516	0.9999000000
[BARBADOD <--> GRENADA (1)]	BARBADOD	GRENADA	1+1 Protection	0.9994707602	-	0.9994707602	0.9999000000

Figure 26 Show the average availability of the OC-48

OC-192

Summary

Average Availability	0.9953510459	
Expected Loss of Traffic	236,390,969.21	Gb/year
	6,597.42	OC-192 hours/year
Average Expected Loss of Traffic	1,459,203.51	Gb/year
	40.72	OC-192 hours/year

Connections failing to meet availability requirements

Connection	From	To	Protection Type	Minimal Availability	Estimated Availability	Maximal Availability	Required Availability
[BARBADOD <--> DOMINICA (2)]	BARBADOD	DOMINICA	1+1 Protection	0.9987442516	-	0.9987442516	0.9999000000
[BARBADOD <--> GRENADA (2)]	BARBADOD	GRENADA	1+1 Protection	0.9994707602	-	0.9994707602	0.9999000000

Figure 27 Show the average availability of the OC-192

2.2 Failure Analysis:

Cable ST KITTS <-> JAMAICA (1)
Cable GRENADA <-> ST KITTS (1)
Cable Trinidad <-> BARBADOD (1)

Overview traffic per layer

Layer	Lost	Recovered	Unaffected	Total	Unit
OCH	92	51	357	500	Wavelengths
DCL	69	0	386	455	STS Connections
LOP	0	0	0	0	VT Connections

Figure 28 Failure Analysis of the three same links

2.3 Network cost

Overview Total Cost

Category		Cost	Total
Link Cost	Cable	0.00	364,445.00
	Fiber	27,225.00	
	Channel	337,220.00	
	SDH Equipment	0.00	
Node Cost	Electrical	139,808.00	355,980.00
	Optical	216,172.00	
Total Network Cost			720,425.00

Figure 29 Total Network Cost

2.4 Traffic growth of 20%

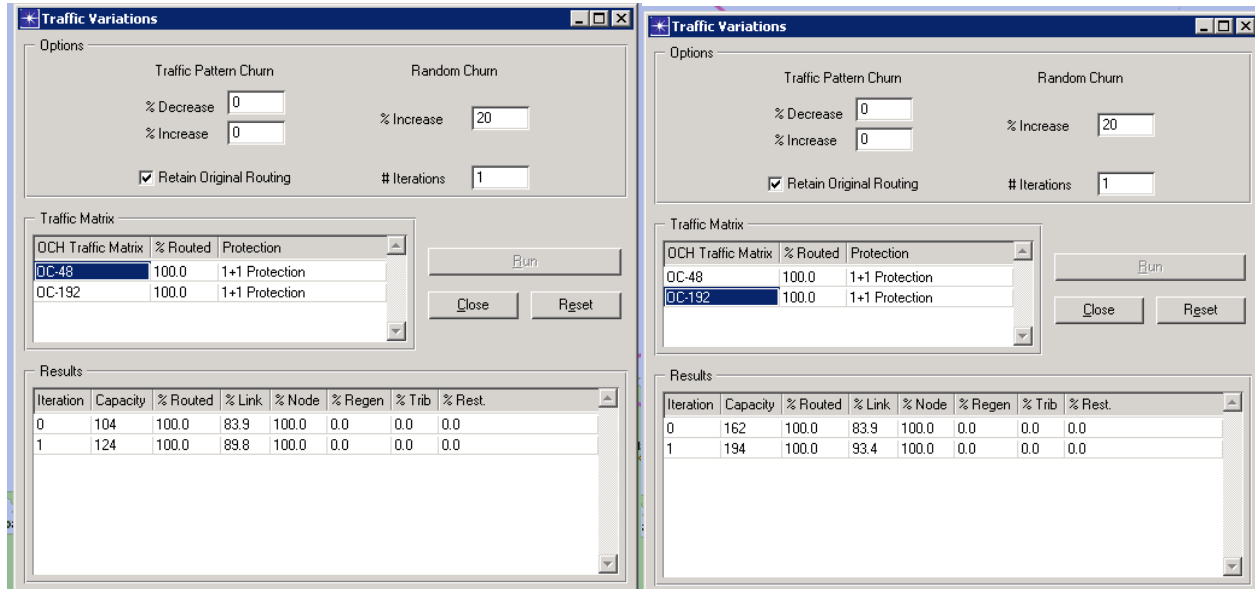


Figure 30

Figure 30 the figures above, there is 100% routed traffic which means that the network is able to handle a traffic growth of 20%.

3.0 Scenario 3: Shared Path protection

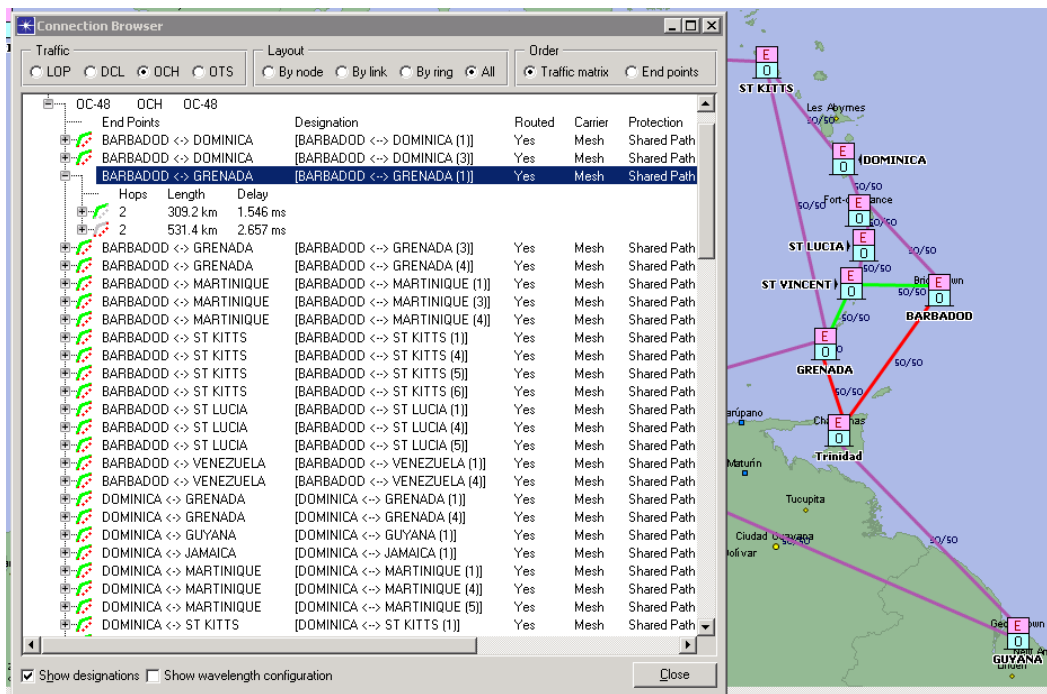


Figure 31

Figure 31 the connection browser in which you can see that on the OCH layer, the links have shared protection. The green represent the working path and the dotted red the shared protected path.

3.1 Availability Analysis:

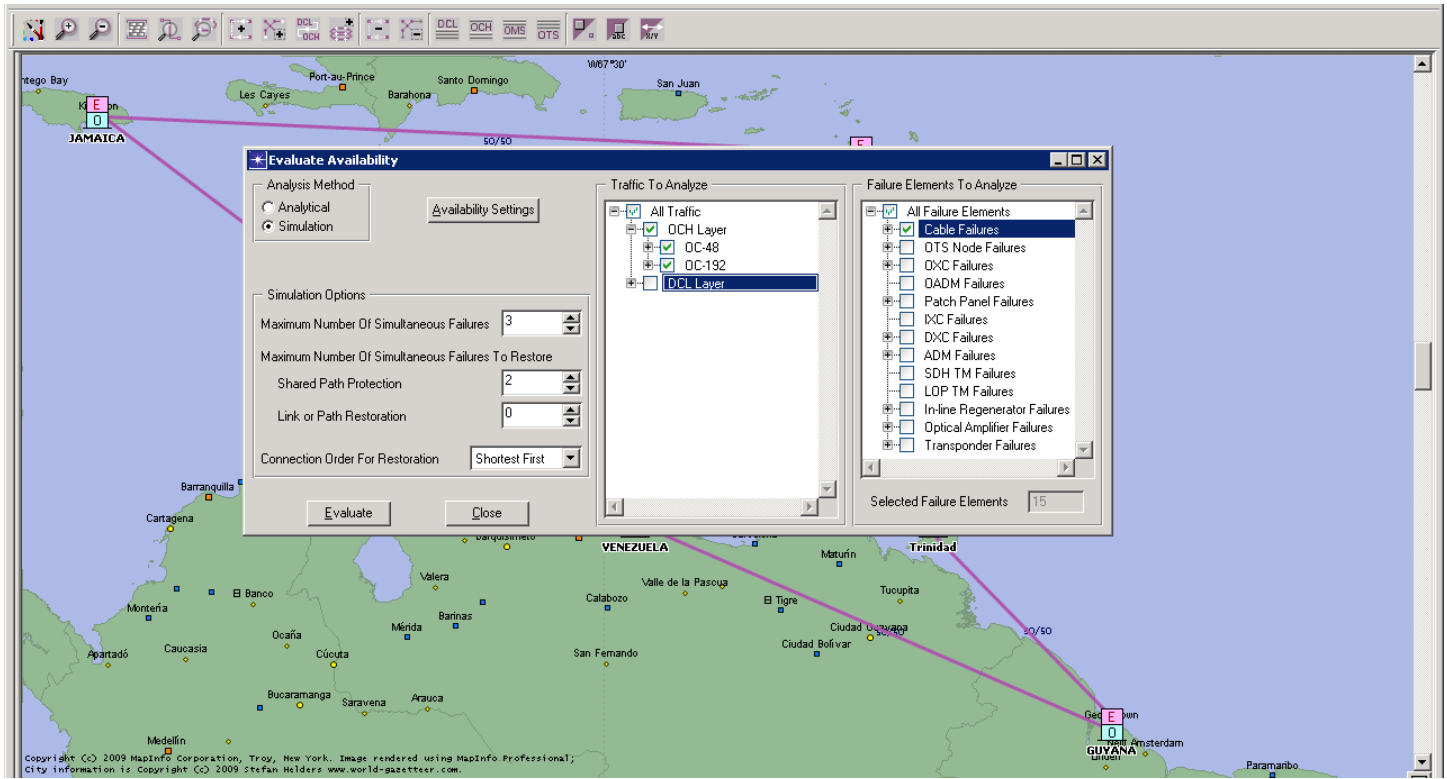


Figure 32 Show evaluations setting of the OCH layer

OC-48

Summary

Average Availability	0.9939572052	
Expected Loss of Traffic	49,309,224.21	Gb/year
	5,505.23	OC-48 hours/year
Average Expected Loss of Traffic	474,127.16	Gb/year
	52.93	OC-48 hours/year

Connections failing to meet availability requirements

Connection	From	To	Protection Type	Minimal Availability	Estimated Availability	Maximal Availability	Required Availability
[BARBADOD <--> DOMINICA (1)]	BARBADOD	DOMINICA	Shared Path Protection	0.9976024464	0.9979403993	0.9979410967	0.9999000000
[BARBADOD <--> DOMINICA (3)]	BARBADOD	DOMINICA	Shared Path Protection	0.9976955922	0.9980335766	0.9980342426	0.9999000000

Figure 33 Show the average availability of the OC-48

OC-192

Summary

Average Availability	0.9938664454	
Expected Loss of Traffic	311,880,242.61	Gb/year
	8,704.25	OC-192 hours/year
Average Expected Loss of Traffic	1,925,186.68	Gb/year
	53.73	OC-192 hours/year

Connections failing to meet availability requirements

Connection	From	To	Protection Type	Minimal Availability	Estimated Availability	Maximal Availability	Required Availability
[BARBADOD <--> DOMINICA (2)]	BARBADOD	DOMINICA	Shared Path Protection	0.9976955922	0.9980335766	0.9980342426	0.9999000000
[BARBADOD <--> GRENADA (2)]	BARBADOD	GRENADA	Shared Path Protection	0.9983016574	0.9986762133	0.9986767098	0.9999000000

Figure 34 Show the average availability of the OC-192

3.2 Failure Analysis:

Cable ST KITTS <=> JAMAICA (1)
Cable GRENADA <=> ST KITTS (1)
Cable Trinidad <=> BARBADOD (1)

Overview traffic per layer

Layer	Lost	Recovered	Unaffected	Total	Unit
OCH	93	50	357	500	Wavelengths
DCL	69	0	386	455	STS Connections
LOP	0	0	0	0	VT Connections

Figure 35 Failure Analysis of the three same links

3.3 Network cost

Category	Cost	Total
Link Cost	Cable	0.00
	Fiber	27,225.00
	Channel	260,880.00
	SDH Equipment	0.00
Node Cost	Electrical	139,808.00
	Optical	189,022.00
Total Network Cost		616,935.00

Figure 36 Total Network Cost

4.0 Scenario 4: Link Restoration

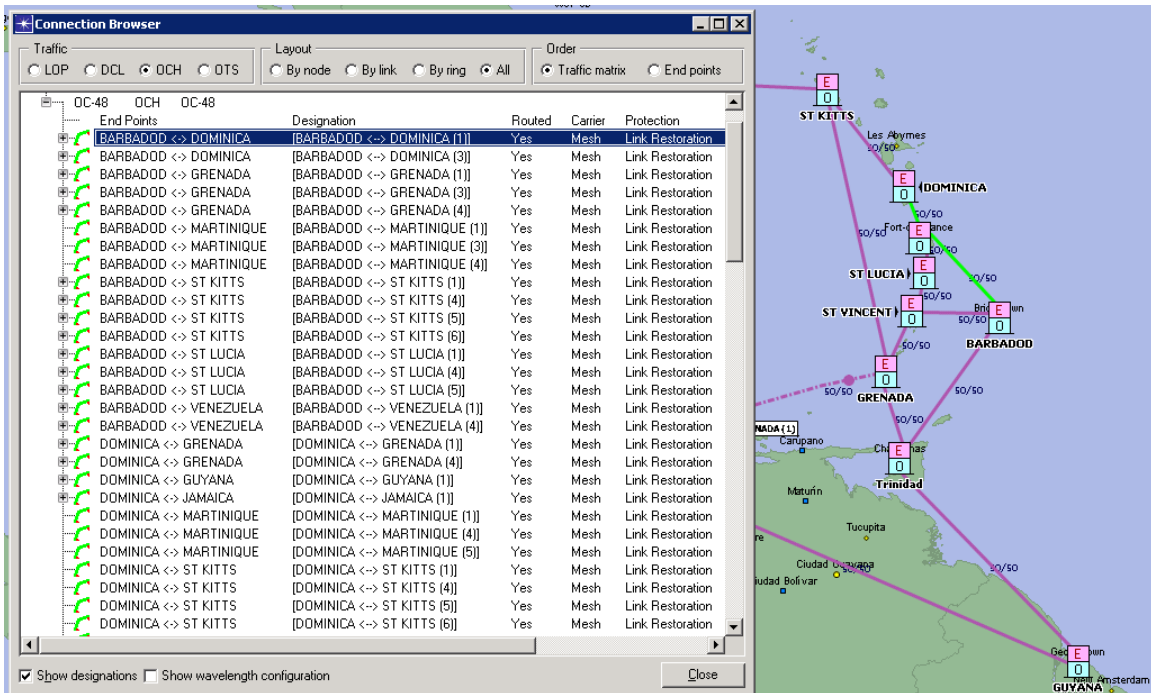


Figure 37

Figure 37 show the connection browser in which you can see that on the OCH layer the links have Link Restoration protection. The green represent the working path. Like shared and 1+1 protection, link restoration does have a pre-established path. The restoration of paths and reroutes of affected traffic will only occur if there is a failure. Restoration capacity will be shared on network links.

4.1 Availability Analysis

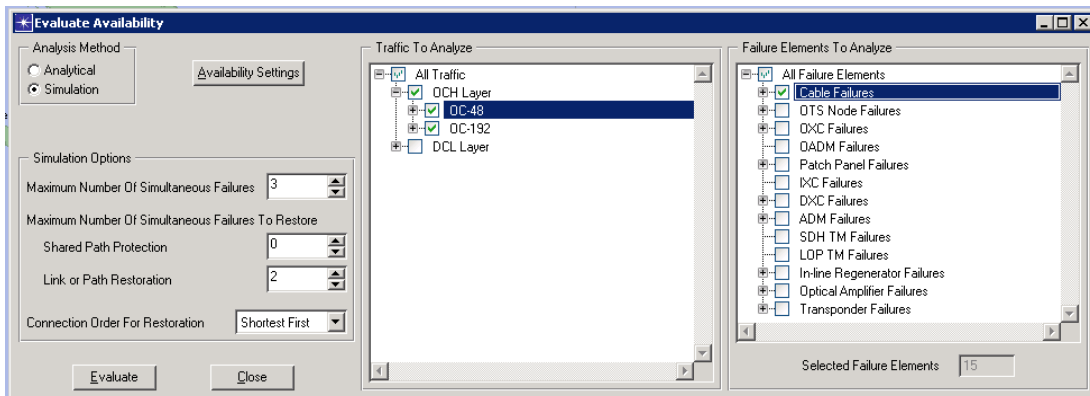


Figure 38 Show evaluations setting of the OCH layer

OC-48			OC-192		
Summary			Summary		
Average Availability	0.9942033085		Average Availability	0.9942560504	
Expected Loss of Traffic	47,301,020.65	Gb/year	Expected Loss of Traffic	292,069,527.24	Gb/year
	5,281.02	OC-48 hours/year		8,151.35	OC-192 hours/year
Average Expected Loss of Traffic	454,817.51	Gb/year	Average Expected Loss of Traffic	1,802,898.32	Gb/year
	50.78	OC-48 hours/year		50.32	OC-192 hours/year

Figures 39 Show the availability of OC-48 & 192 circuits

4.2 Failure Analysis:

Cable ST KITTS <-> JAMAICA (1)
Cable GRENADA <-> ST KITTS (1)
Cable Trinidad <-> BARBADOD (1)

Overview traffic per layer

Layer	Lost	Recovered	Unaffected	Total	Unit
OCH	108	28	364	500	Wavelengths
DCL	103	0	352	455	STS Connections
LOP	0	0	0	0	VT Connections

Traffic Matrix OC-48

Recovered connections

From	To	Length (km)	Delay (ms)	Designation	Bit Rate	Capacity	From	To	Carrier	Route
DOMINICA	GRENADA	897.3	4.486		OC-48	1	DOMINICA	GRENADA	Mesh	DOMINICA ST KITTS DOMINICA MARTINIQUE ST LUCIA ST VINCENT GRENADA

Figure 40 Failure Analysis of the three same links

4.3 Network cost:

Overview Total Cost

Category		Cost	Total
Link Cost	Cable	0.00	313,630.00
	Fiber	27,850.00	
	Channel	285,780.00	
	SDH Equipment	0.00	
Node Cost	Electrical	139,808.00	332,850.00
	Optical	193,042.00	
Total Network Cost			646,480.00

Figure 41 Network Cost

4.4 Traffic growth of 20%

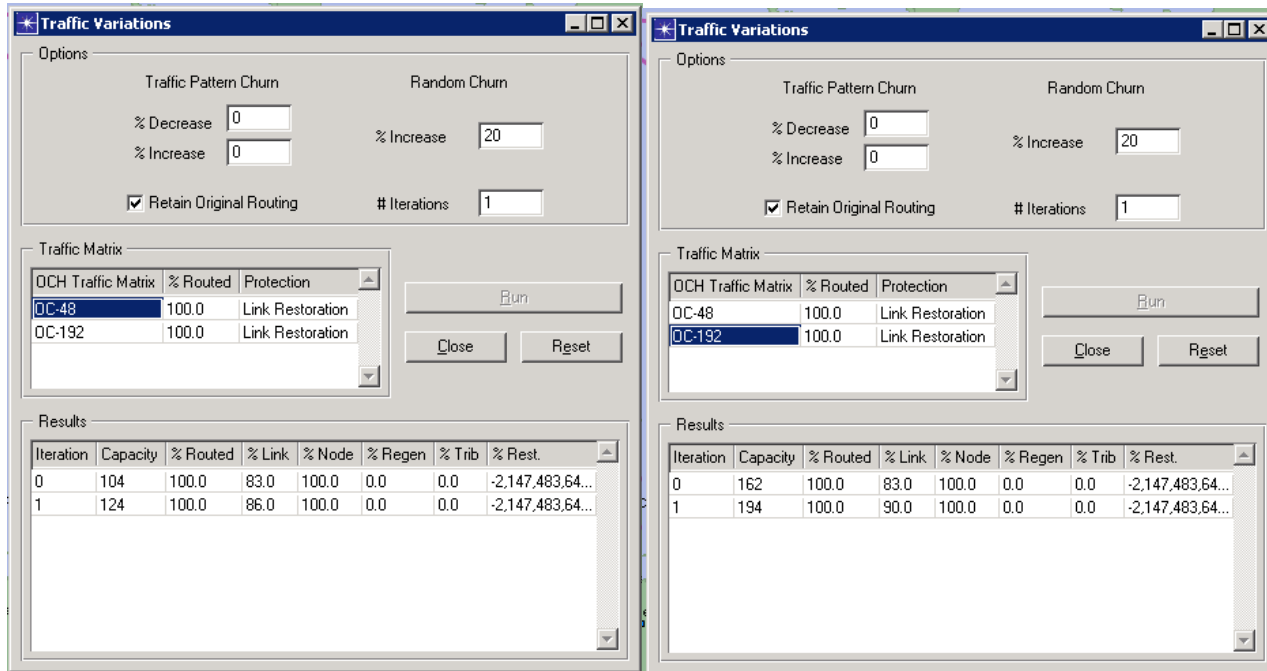


Figure 42 Traffic variations (20% growth)

5.0 Scenario 5: Path Restoration

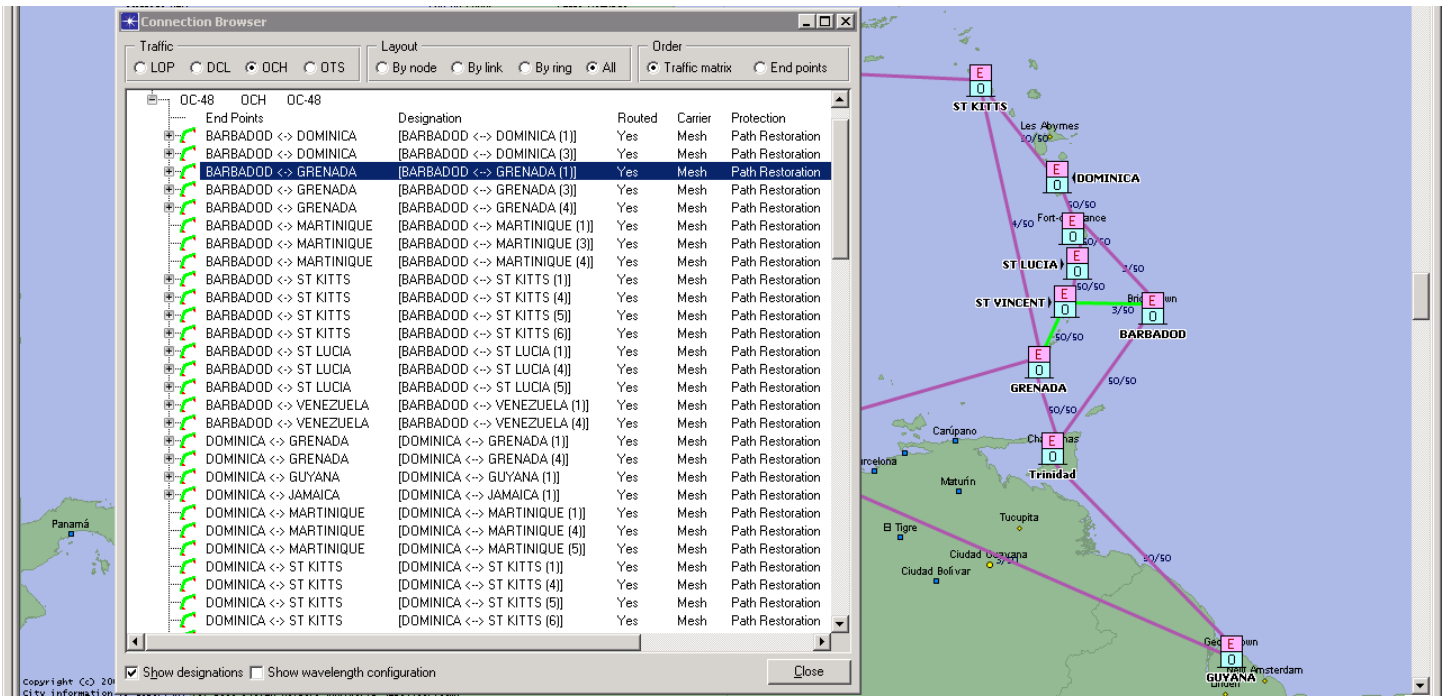


Figure 43

Figure 43 show the connection browser in which you can see that on the OCH layer, the links have Path Restoration protection. The green represent the working path. Like shared and 1+1 protection, path restoration does have a pre-established path. The restoration of paths and reroutes of affected traffic will only occur if there is a failure. Path restoration is more flexible in surviving from multiple failures since the network reroutes each connection individually around the failing entity between the end-points of the connection; and not, as in link restoration, between the endpoints of the failed link.

5.1 Availability Analysis

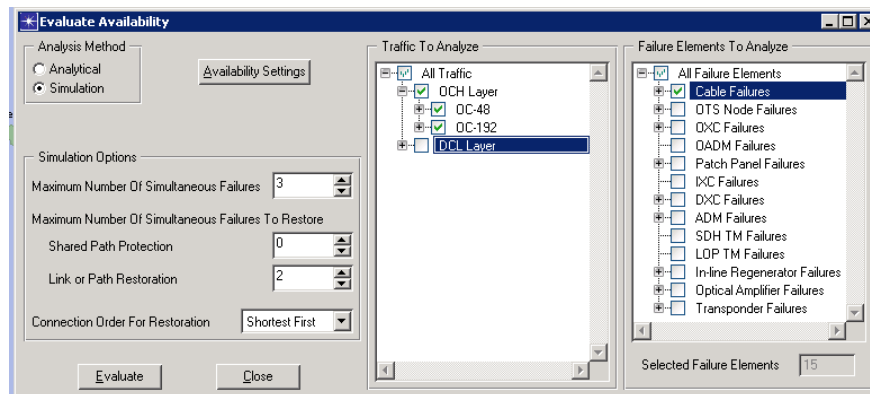


Figure 44 Show the evaluations setting of the OCH layer

OC-48		OC-192	
Summary		Summary	
Average Availability	0.9937133556	Average Availability	0.9943449257
Expected Loss of Traffic	51,299,037.95 Gb/year	Expected Loss of Traffic	287,550,376.19 Gb/year
	5,727.38 OC-48 hours/year		8,025.23 OC-192 hours/year
Average Expected Loss of Traffic	493,259.98 Gb/year	Average Expected Loss of Traffic	1,775,002.32 Gb/year
	55.07 OC-48 hours/year		49.54 OC-192 hours/year

Figure 45 Show the availability of OC-48 & 192 circuits

5.2 Failure Analysis:

Cable ST KITTS <-> JAMAICA (1)
Cable GRENADA <-> ST KITTS (1)
Cable Trinidad <-> BARBADOD (1)

Overview traffic per layer

Layer	Lost	Recovered	Unaffected	Total	Unit
OCH	111	25	364	500	Wavelengths
DCL	103	0	352	455	STS Connections
LOP	0	0	0	0	VT Connections

Figure 46 Failure Analysis of the three same links

5.3 Network cost:

Overview Total Cost			
Overview Node Cost			
<ul style="list-style-type: none"> • LOP TM • DXC • ADM • OXC • OADM • IXC • Patch Panel • Transponder 			
Overview Link Cost			
<ul style="list-style-type: none"> • WDM Terminal Equipment • In-line Regeneration/Amplification 			
Category		Cost	Total
Link Cost	Cable	0.00	292,550.00
	Fiber	27,850.00	
	Channel	264,700.00	
	SDH Equipment	0.00	
Node Cost	Electrical	139,808.00	328,380.00
	Optical	188,572.00	
Total Network Cost			620,930.00

Figure 47 Total Network Cost

5.4 Traffic growth of 20%:

Traffic Variations (Left: 0% Increase)							
Options		Traffic Pattern Churn		Random Churn			
% Decrease	0	% Increase	0	% Increase	20		
<input checked="" type="checkbox"/> Retain Original Routing				# Iterations	1		
Traffic Matrix			Run		Close Reset		
DCH Traffic Matrix	% Routed	Protection					
OC-48	100.0	Path Restoration					
OC-192	100.0	Path Restoration					
Results							
Iteration	Capacity	% Routed	% Link	% Node	% Regen	% Trib	% Rest.
0	104	100.0	60.0	100.0	0.0	0.0	-2,147,483,64...
1	124	100.0	62.0	100.0	0.0	0.0	-2,147,483,64...

Traffic Variations (Right: 20% Increase)							
Options		Traffic Pattern Churn		Random Churn			
% Decrease	0	% Increase	0	% Increase	20		
<input checked="" type="checkbox"/> Retain Original Routing				# Iterations	1		
Traffic Matrix			Run		Close Reset		
DCH Traffic Matrix	% Routed	Protection					
OC-48	100.0	Path Restoration					
OC-192	100.0	Path Restoration					
Results							
Iteration	Capacity	% Routed	% Link	% Node	% Regen	% Trib	% Rest.
0	162	100.0	60.0	100.0	0.0	0.0	-2,147,483,64...
1	194	100.0	63.0	100.0	0.0	0.0	-2,147,483,64...

Figure 48 Traffic variations (20% growth)

6.0 Conclusion

Scenario Comparison					
	2F BLSR UNPROTECTED	2F BLSR 1 PLUS 1 PROTECTION	2F BLSR SHARED PATH	2F BLSR LINK R...	2F BLSR PATH RESTORATION
# Nodes	11	11	11	11	11
Min. Degree	2	2	2	2	2
Max. Degree	4	4	4	4	4
Mean Degree	2.7	2.7	2.7	2.7	2.7
Connectivity %	27.27	27.27	27.27	27.27	27.27
# Links	15	15	15	15	15
Used Capacity	814	1,712	1,309	1,458	1,284
Total Capacity	1,200	2,040	2,040	2,120	2,120
Utilization %	67.83	83.92	64.17	68.77	60.57
Capacity * Distance - Working	308,526.3	309,916.8	309,916.8	308,526.3	308,526.3
Capacity * Distance - Protecting	0.0	377,166.2	232,273.8	263,352.3	239,080.0
Capacity * Distance - Total	308,526.3	687,083.1	542,190.6	571,878.6	547,606.3
# Patch Panel Nodes	0	0	0	0	0
# OADM Nodes	0	0	0	0	0

Figure 49 Scenario comparison of the OCH topology

6.1 Network cost

Scenario Comparison					
	2F BLSR UNPROTECTED	2F BLSR 1 PLUS 1 PROTECTION	2F BLSR SHARED PATH	2F BLSR LINK RESTORATION	2F BLSR PATH RESTORATION
Nodes	316,050.00	355,980.00	328,830.00	332,850.00	328,380.00
Links	184,005.00	364,445.00	288,105.00	313,630.00	292,550.00
Total	500,055.00	720,425.00	616,935.00	646,480.00	620,930.00

Figure 50 Scenario comparison of the network cost for the different schemes

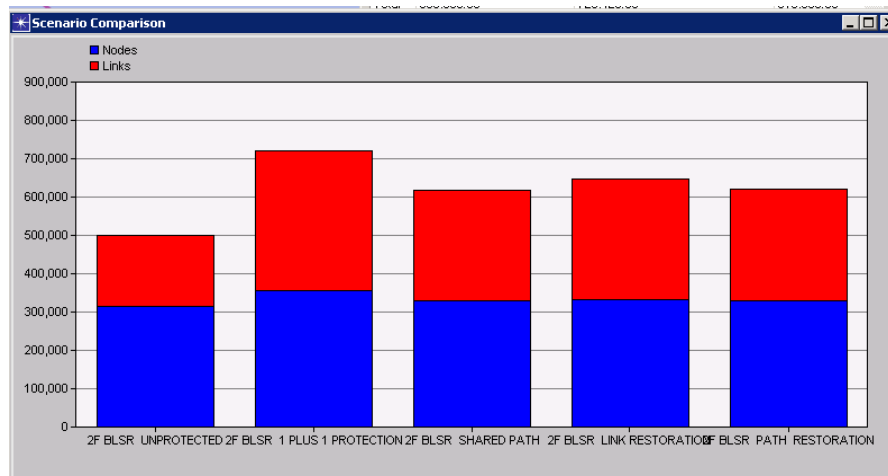


Figure 51 Scenario comparison of the network cost

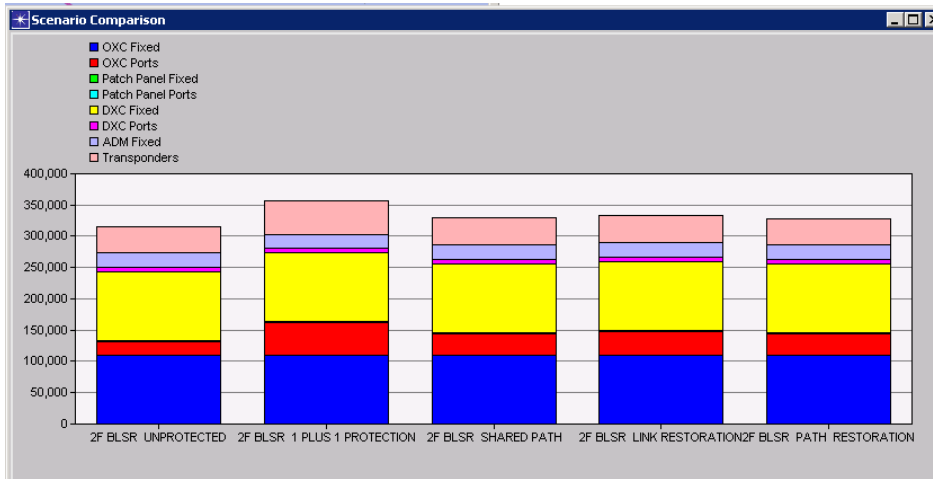


Figure 52 Shows Node cost break down

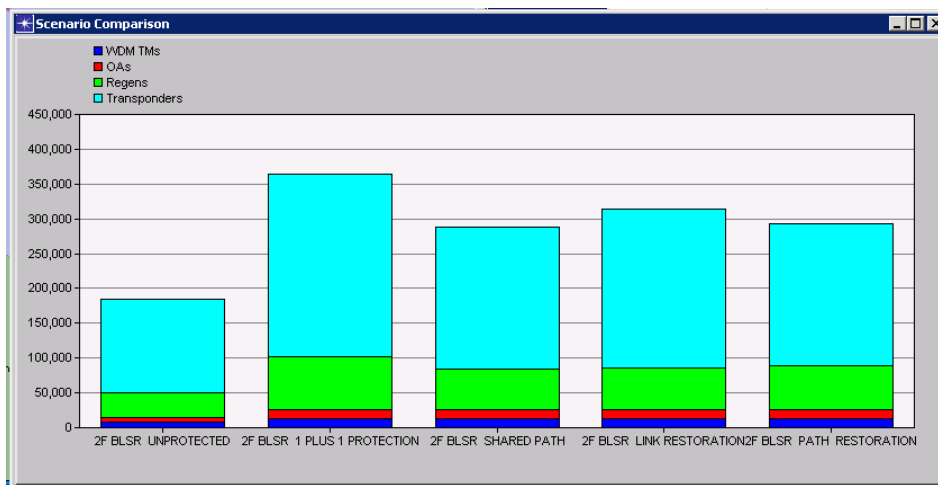


Figure 53 Shows Link cost break down

Rank (1-5; high, 1; low, 5)	Availability	Network survival ability	Cost
1	1+1 protection	1+1 protection	1+1 protection
2	Link Restoration	Shared Path	Link Restoration
3	Shared Path	Link Restoration	Path Restoration
4	Path Restoration	Path Restoration	Shared Path
5	Unprotected	Unprotected	Unprotected

Table 1

Tables 1 summarize the network availability, network survival ability and cost of the different protection that can be deployed on the network. 1+1 protection is proving to be the best scheme among the others although it is the most of all. Looking at the failure analysis in the different scenarios; routing the traffic on the DCL layer with 1+1 protection will increase the survival ability of each of the schemes. In the analysis carried out no protection was on the DCL layer, hence the reason there was no recovery on the DCL layer.

With 20% growth in traffic there was no structure adjustment to the network, therefore no cost increase. This is because of the large capacity circuit (OC-48 & OC-192) that were used to build the network. If there is an increase of 150% growth in traffic, the infrastructure will be modified to accommodate the new traffic. Hence there will be an increase in cost.

The simulation of the network went well using OpNet, but in reality there are many more factors that must be considered when building and running a network of that size.