

**RESTRUCTURING AND EXPANSION: NEW
DIMENSIONS FOR CHINA TELECOM SECTOR**
GRADUATE PROJECT

5/7/2009



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INTRODUCTION

As the wave of Restructuring hits China Telecom industry, the leading telecom companies have started to expand and revamp their networks. “As part of the move, China Telecom has acquired the CDMA line of China Unicom, and China Unicom has been merged with China Netcom. Another incumbent operator, China Mobile, has acquired China Railcom”.[1] China telecom, the largest mobile operator in the world and also one of the biggest telecom players in Chinese Telecom business industry has decided to expand the networks in the country. As a Network Designer Representative for China Mobile, this project is one of the designs proposed for the network. Further, this basic network will have growth aspect and more money and designing investment shall be done in near future.

As we go through this journey of the network design, we will have two basic type of network considerations:

1. Opaque
2. Transparent

In the transparent mode, the transponders are present at the tributary ports of the OXC/OADM. In opaque mode, the transponders are present in WDM line system. The transparent systems can transmit through thousands of kilometers. And as we are also looking forward for a cost effective solution, this comparison would provide us option to choose.

As mentioned in the proposal/milestone, emphasize would be on:

- Failure analysis
- Wavelength utilizations
- Utilization of the fiber pairs deployed



- Cost parameter
- Overall performance of the network
- Optimal solution for the network design proposed

[1] Reference: <http://www.cn-c114.net/576/a403467.html>

THE SCENARIO

As already mentioned above, this would be my proposed solution. So, for this purpose I have selected twelve nodes across the China country. The network is shown as below:

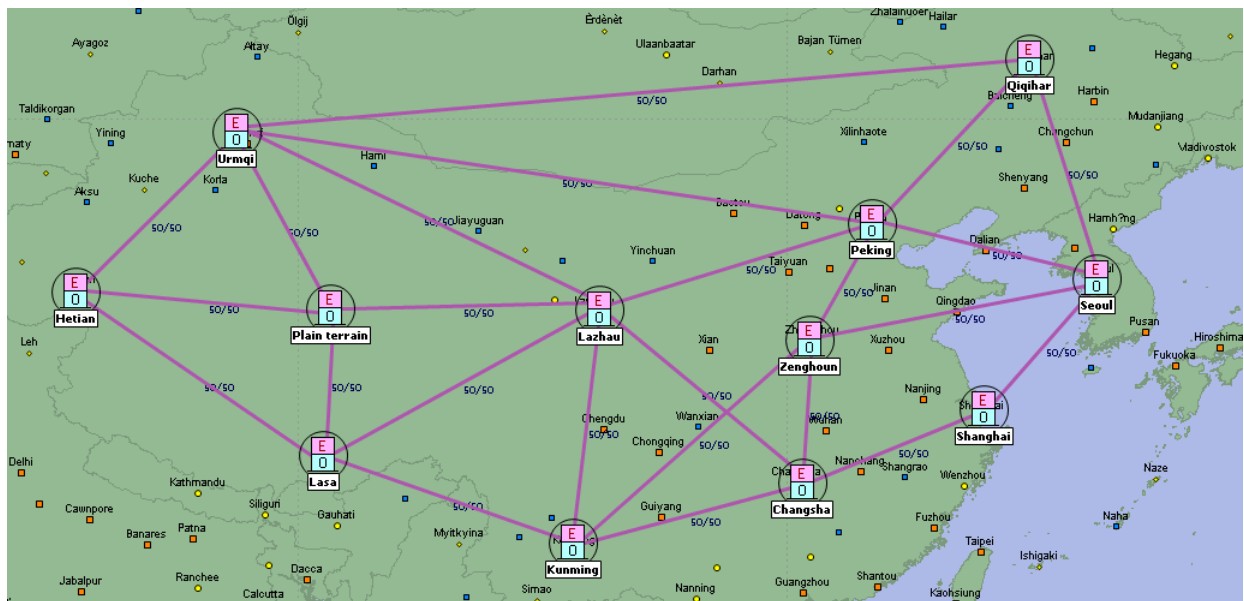


Figure 1: The network topology

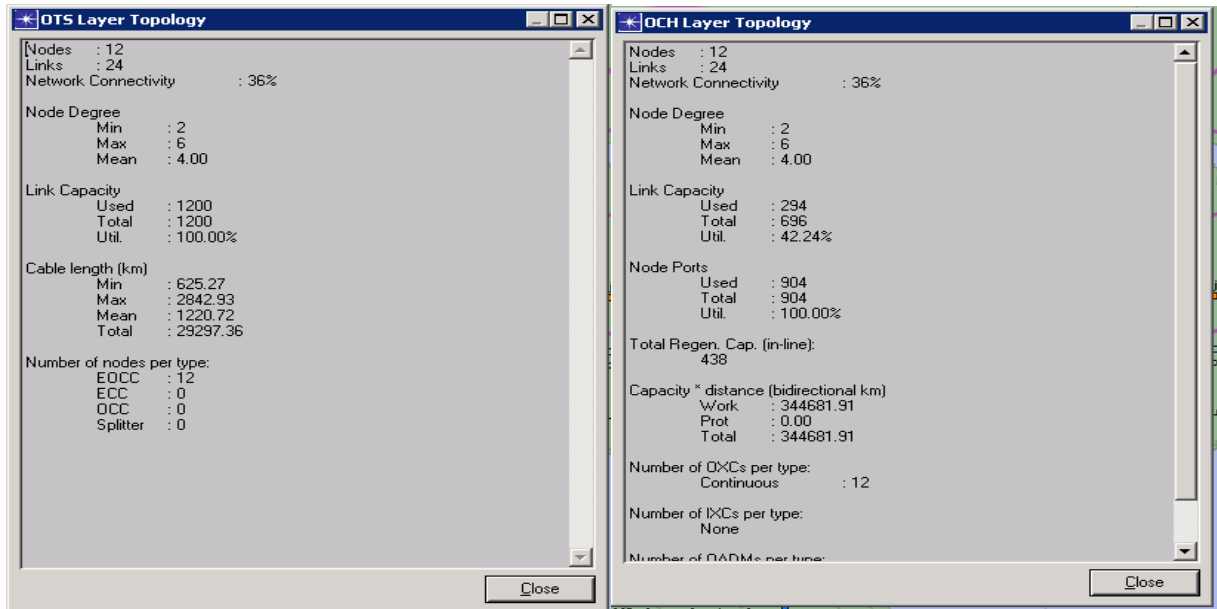


Figure 2: Network Topologies details

As seen the topology is partial mesh topology. Also there exists a ring topology also. There are total twenty four nodes in the network.

THE ANALYSIS PROCESS

The analysis would be followed as:

OPAQUE SCENARIO		TRANSPARENT SCENARIO	
NETWORK PROPERTIES		NETWORK PROPERTIES	
TRAFFIC IN THE NETWORK		TRAFFIC IN THE NETWORK	
WDM PROPERTIES		WDM PROPERTIES	
LINK DESIGN		LINK DESIGN	
FIBERS LIT/USED		FIBERS LIT/USED	
NORMAL SCENARIO	20%GROWTH	NORMAL SCENARIO	20%GROWTH
ROUTING	ROUTING	ROUTING	ROUTING
INFORMATION	INFORMATION	INFORMATION	INFORMATION
NETWORK COST	NETWORK COST	NETWORK COST	NETWORK COST
UTILIZATION	UTILIZATION	UTILIZATION	UTILIZATION
FAILURE ANALYSIS	FAILURE ANALYSIS	FAILURE ANALYSIS	FAILURE ANALYSIS
AVAILABILITY REPORT OF THE BEST SOLUTION(ATTACHED AS APPENDIX)			
FAILURE ANALYSIS REPORTS OF ALL SCENARIOS(ATTACHED AS APPENDIX)			

OPAQUE SCENARIO

NETWORK PROPERTIES

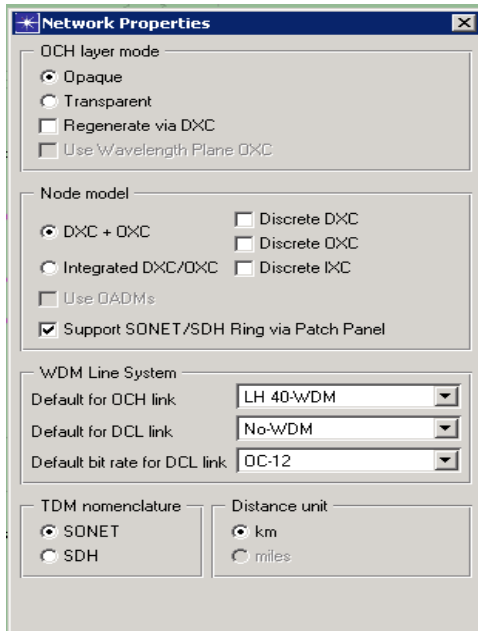
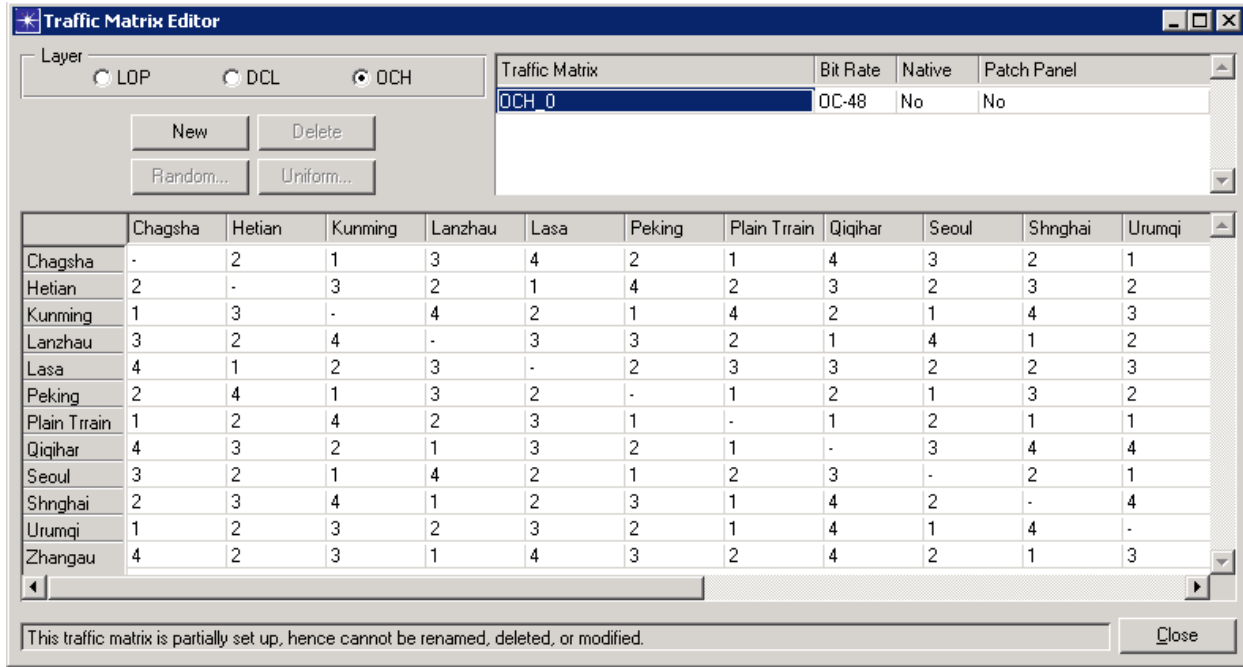


Figure 3: the network properties

The network property shows that it's an opaque model and DXC and OXC are used for nodes. Also SONET is used as TDM nomenclatures and the distances are in kilometers.

TRAFFIC IN THE NETWORK

The traffic matrix editor feature in OPNET provides user to enter the traffic on random or uniform basis. The units that are followed are in terms of wavelengths. The specialty about the traffic matrix is, once is set up it user is unable to modify, delete or reset it.



WDM PROPERTIES

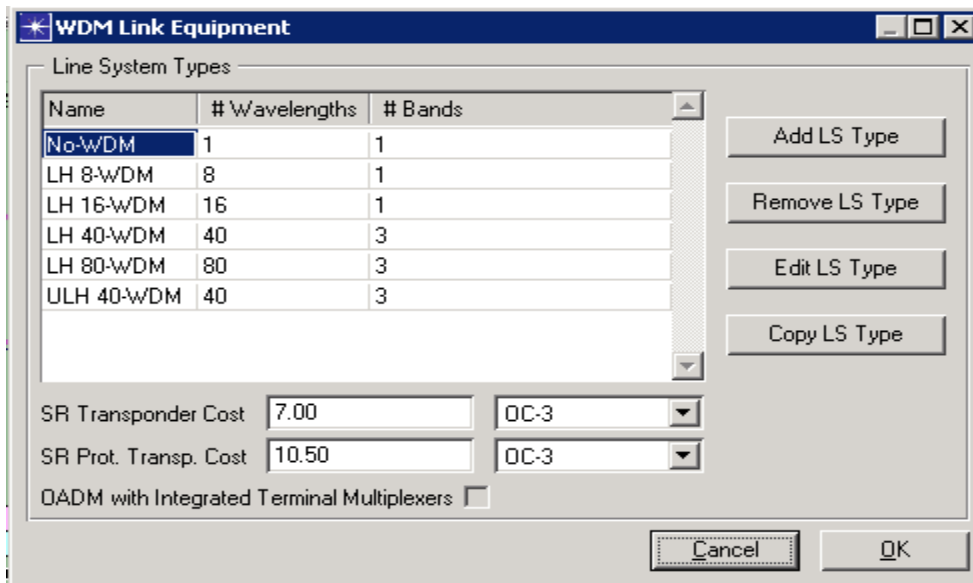


Figure 4: WDM link properties

LINK DESIGN

Links designs are based upon transmission characteristics of WDM line system types. This facilitates dimensioning and other functions in the simulation to take into account the cost of regenerators and amplifiers.



The utilization is also set to a limit of 50%. OPNET provides the facility to threshold this limit. After setting up the parameters, the link design process is as follows:

The screenshot displays the OPNET software interface. On the left, a map of China shows a network design with purple links connecting various cities. Two dialog boxes are overlaid on the map:

- Link Design Dialog:** This dialog is used to configure the link design parameters. It includes:
 - Radio buttons for "OTS links" (selected) and "Fiber routes".
 - A dropdown menu set to "ALL LINKS".
 - Fields for "Designed", "Length", "# Sites", "# Regen", and "# OA", all showing "N/A".
 - Fields for "LS type" (set to "LH 40-wDM"), "Span length" (set to "100.0"), and "Max. OA spans" (set to "6").
 - Dropdown menus for "Site locations" (set to "Asymmetrical, Maximum Span Lengths") and "Regeneration locations" (set to "Mid Span").
 - "Design" and "Close" buttons.
- Link Design Results Dialog:** This dialog displays the results of the link design process. It lists several link designs with their lengths and the number of regeneration and OA sites added. For example:
 - Performed link design on all links
 - Performed link design on Urmqi <-> Hetian (1) (length = 991.803); 1 Regeneration sites added at 500 km; 8 OA sites added at 100, 200, 300, 400, 600, 700, 800, and 900 km;
 - Performed link design on Hetian <-> Lasa (1) (length = 1275.75); 2 Regeneration sites added at 500, and 1000 km; 10 OA sites added at 100, 200, 300, 400, 600, 700, 800, 900, 1100, and 1200 km;
 - Performed link design on Lasa <-> Kunming (1) (length = 1270.83); 2 Regeneration sites added at 500, and 1000 km; 10 OA sites added at 100, 200, 300, 400, 600, 700, 800, 900, 1100, and 1200 km;
 - Performed link design on Urmqi <-> Plain terrain (1) (length = 948.916); 1 Regeneration sites added at 500 km; 8 OA sites added at 100, 200, 300, 400, 600, 700, 800, and 900 km;
 - Performed link design on Plain terrain <-> Lasa (1) (length = 679.623); 1 Regeneration sites added at 400 km; 5 OA sites added at 100, 200, 300, 500, and 600 km;
 - Performed link design on Urmqi <-> Lashau (1) (length = 1651.96); 2 Regeneration sites added at 600, and 1200 km; 14 OA sites added at 100, 200, 300, 400, 500, 700, 800, 900, 1000, 1100, 1300, 1400, 1500, and 1600 km;
 - Performed link design on Urmqi <-> Peking (1) (length = 2423.62); 4 Regeneration sites added at 500, 1000, 1500, and 2000 km; 20 OA sites added at 100, 200, 300, 400, 600, 700, 800, 900, 1100, 1200, 1300, 1400, 1600, 1700, 1800, 1900, 2100, 2200, 2300, and 2400 km;
 - Performed link design on Urmqi <-> Qiqihar (1) (length = 2842.93); 4 Regeneration sites added at 600, 1200, 1800, and 2400 km; 24 OA sites added at 100, 200, 300, 400, 500, 700, 800, 900, 1000, 1100, 1300, 1400, 1500, 1600, 1700, 1900, 2000, 2100, 2200, 2300, 2500, 2600, 2700, and 2800 km.

FIBERS LIT/USED

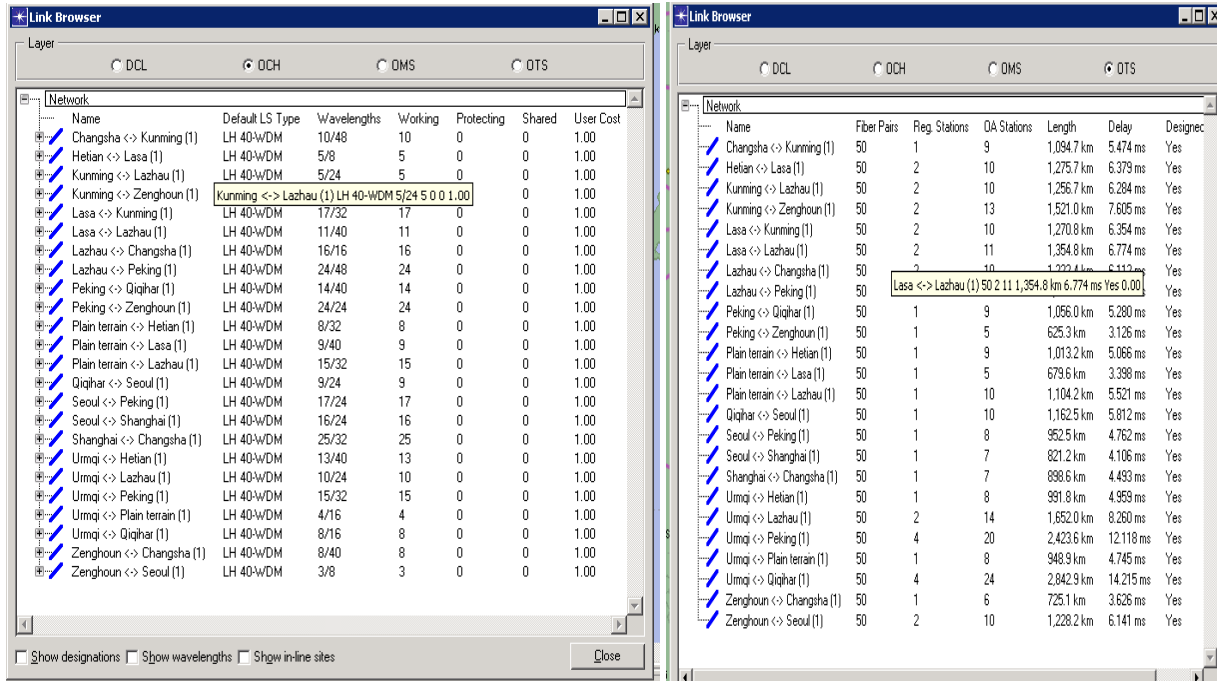


Figure 5: the fiber pair details in OCH and OTS layers

THE GROOMING AND DIMENSIONING

As we move ahead, you will notice that the routed traffic value in opaque layer is 100% hence, dimensioning and grooming is not required. However in the transparent layer, it is required and hence performed.

INITIAL SCENARIO



AFTER ROUTING

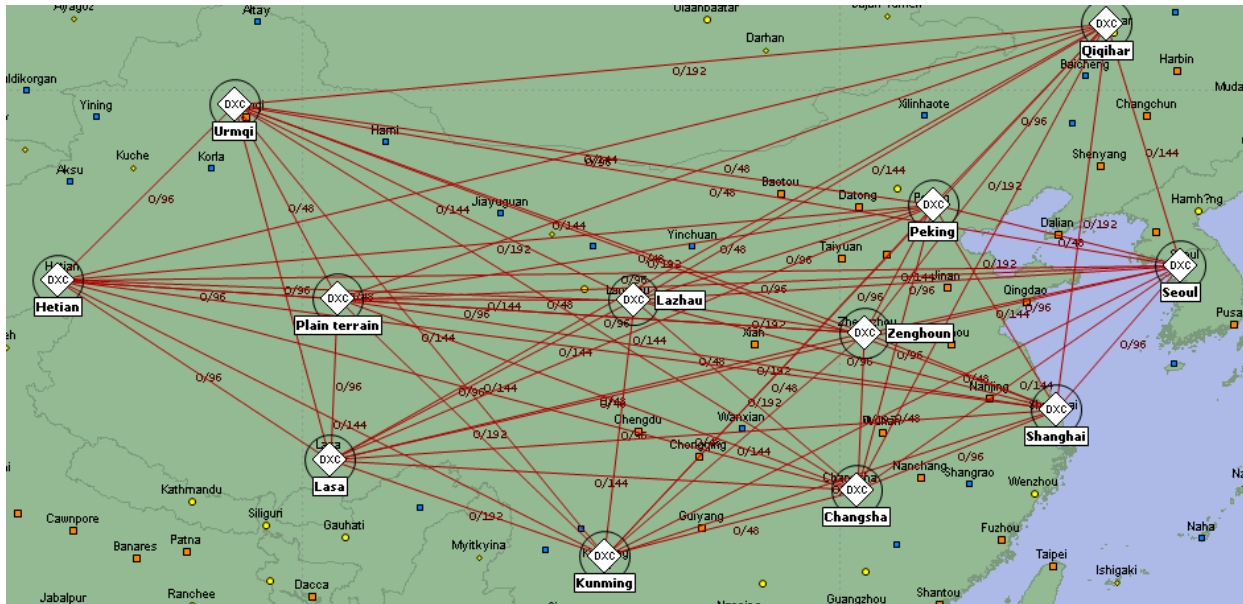


Figure 6: The topology view after routing

ROUTING INFORMATION AND LINK UTILIZATION

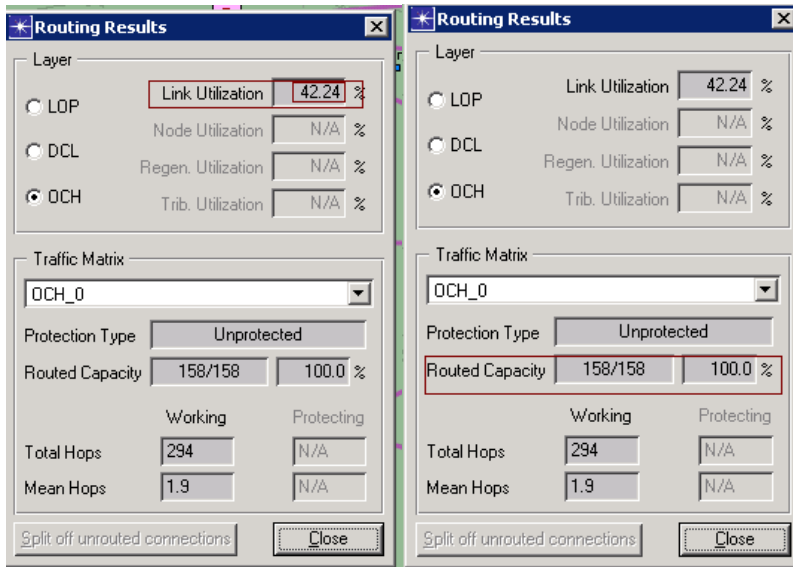


Figure 7: The routing and link utilization

NETWORK COST



Overview Total Cost

Category		Cost	Total
Link Cost	Cable	0.00	87,295.00
	Fiber	43,375.00	
	Channel	43,920.00	
	SDH Equipment	0.00	
Node Cost	Electrical	121,580.00	255,360.00
	Optical	133,780.00	
Total Network Cost			342,655.00

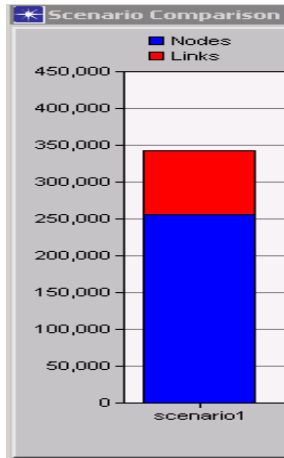


Figure 8: Total cost of the network

FAILURE ANALYSIS

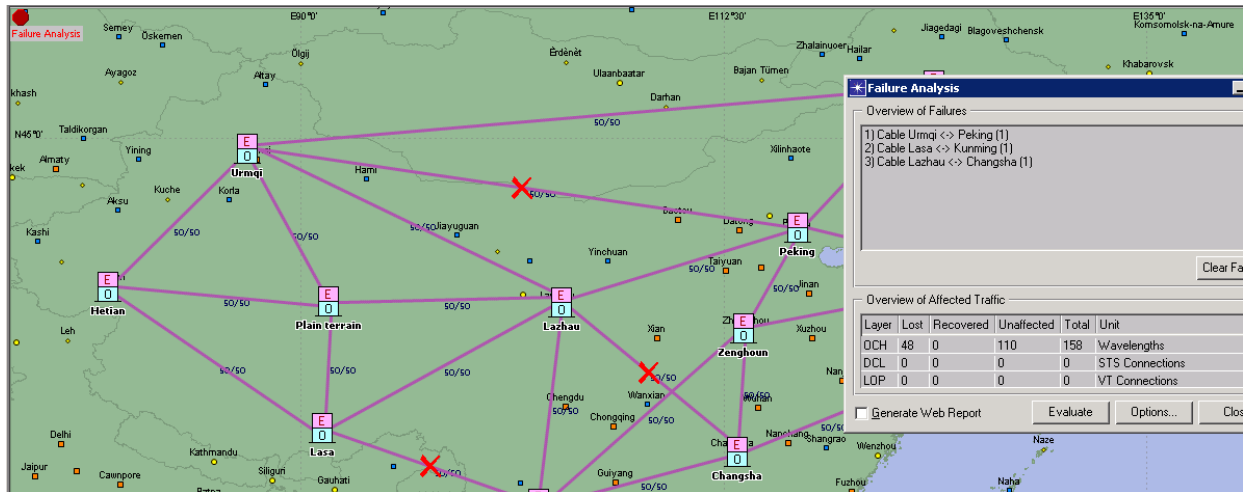


Figure 9: The failure analysis scenario

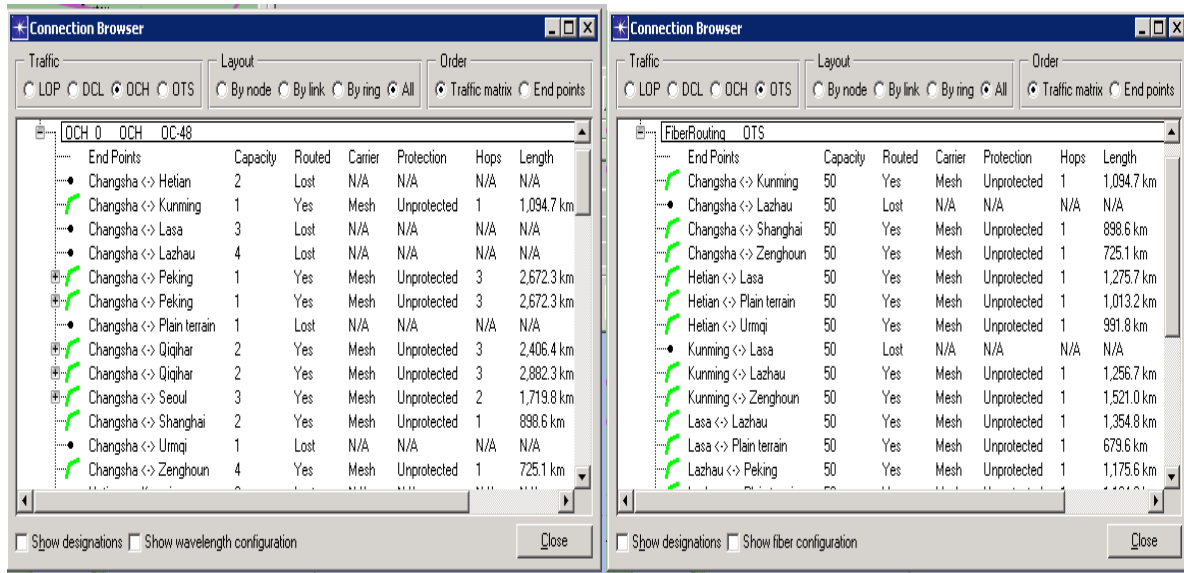


Figure 10: The failure analysis details in different layers

The failure analysis enables user to check the performance of the network under link failure conditions. In the above scenario, I have failed three fiber links in order to check the performance. The small box in the figure 9 shows the overview of affected traffic. And the connection browser windows below show the details.

The report is attached at the end as Appendix -1.



SAME SCENARIO WITH 20% TRAFFIC GROWTH

ROUTING INFORMATION AND LINK UTILIZATION

The image shows two identical screenshots of the 'Routing Results' dialog box. The left screenshot has a red box around the 'Routed Capacity' field (224/224, 100.0%). The right screenshot has a red box around the 'Link Utilization' field (65.4%).

Overview utilization links per layer

Layer	Number of Links	Link Utilization			Used Capacity	Total Capacity	Utilization (%)	Unit
		Between 100.0 and 90.0 %	Between 90.0 and 75.0 %	Between 75.0 and 0.0 %				
OTS	24	24	0	0	1,200	1,200	100.00	Fiber Pairs
OMS	24	0	0	24	37	1,200	3.08	Fiber Pairs
OCH	24	5	6	13	429	656	65.40	Wavelengths
DCL	66	0	0	66	0	10,752	0.00	STS-1 Units

Figure 11: the utilization and routing details



NETWORK COST

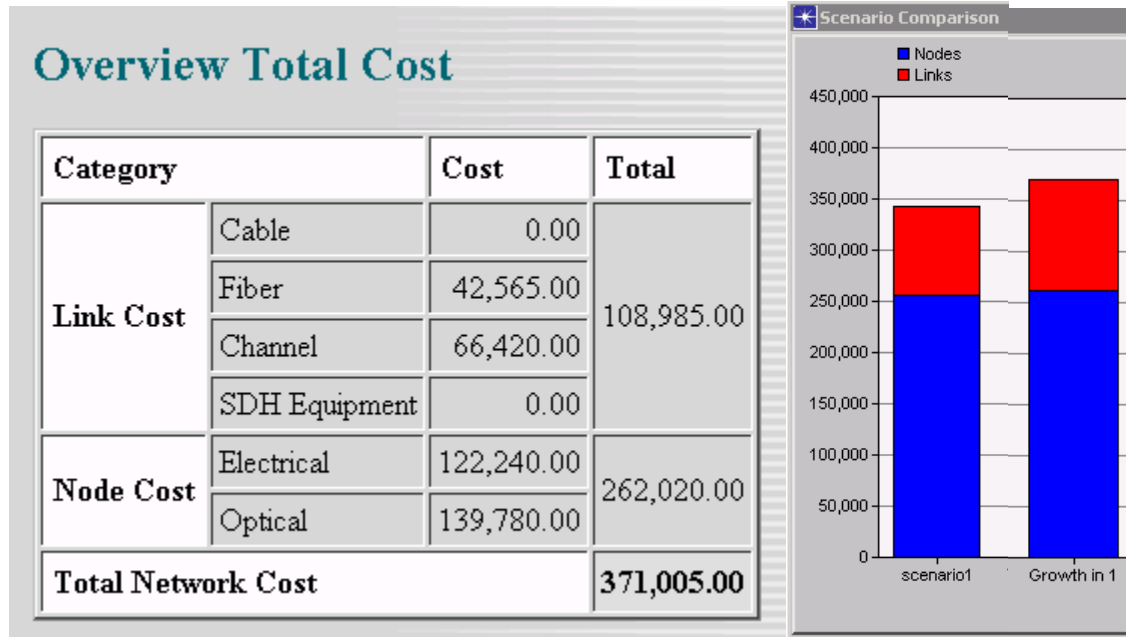
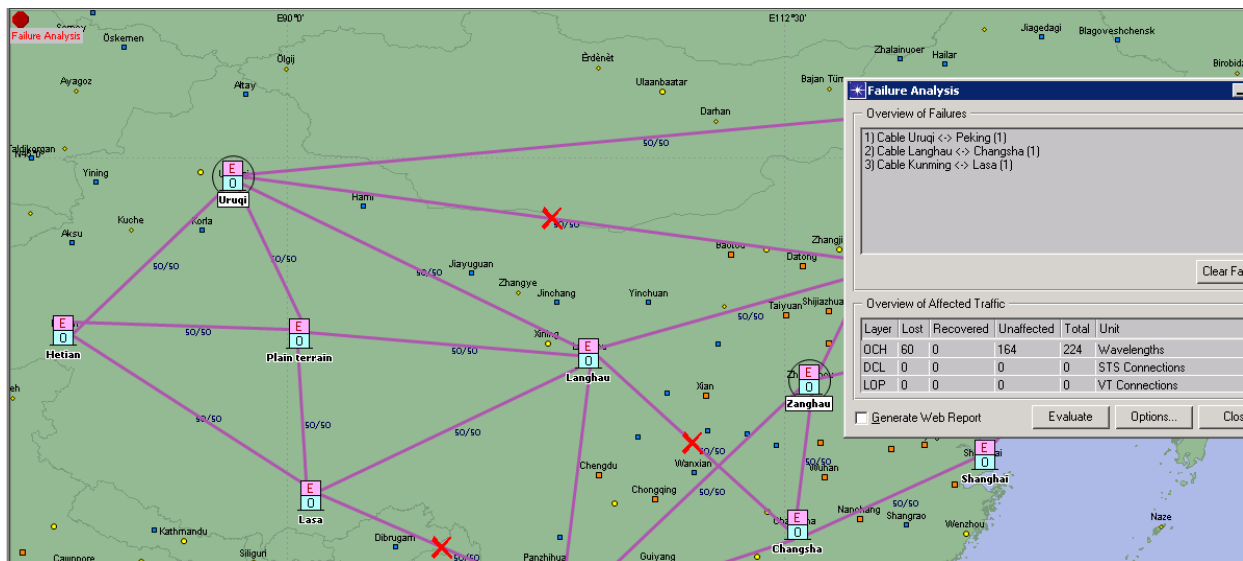


Figure 12: Total cost of the network

FAILURE ANALYSIS



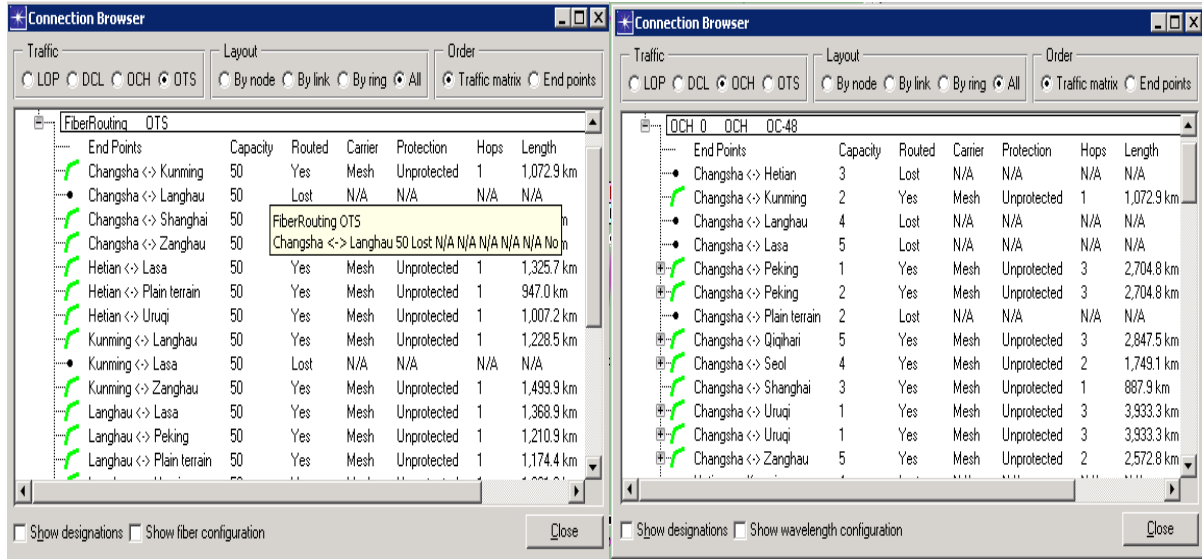
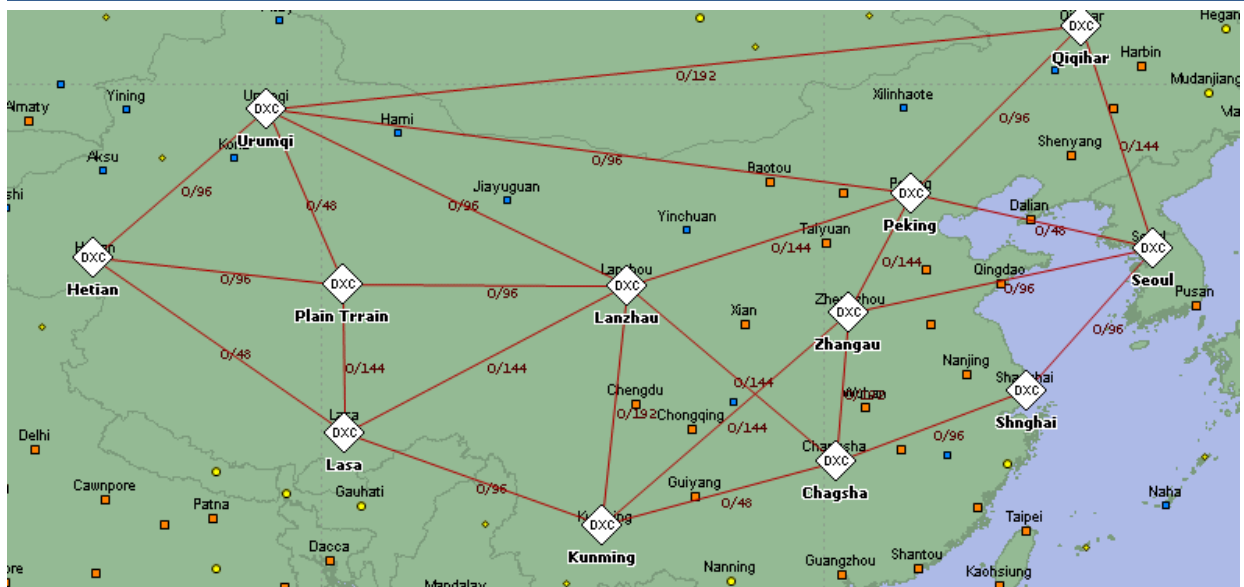


Figure 13: The failure analysis scenario

The report is attached at the end as Appendix -2.



TRANSPARENT SCENARIO



NETWORK PROPERTIES

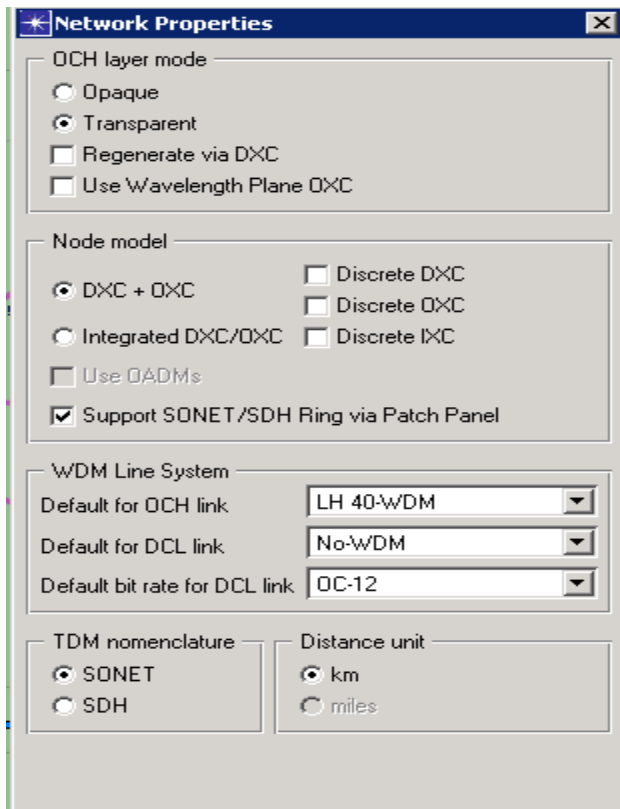


Figure 14: Network properties



WDM PROPERTIES

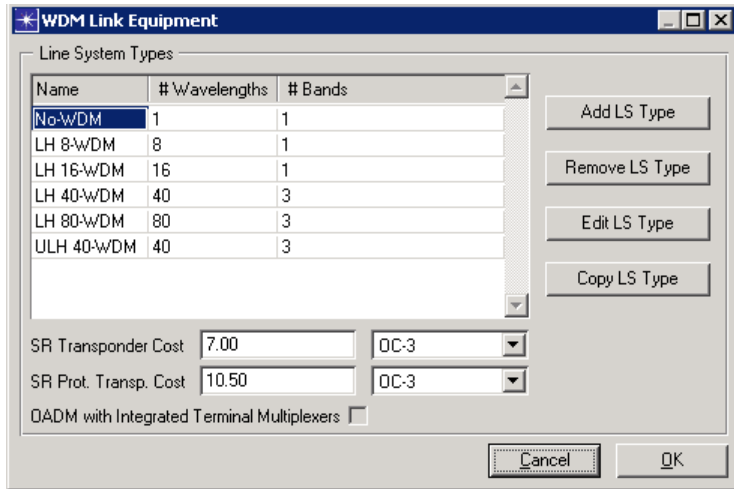


Figure 15: the link equipment details

FIBERS DETAILS

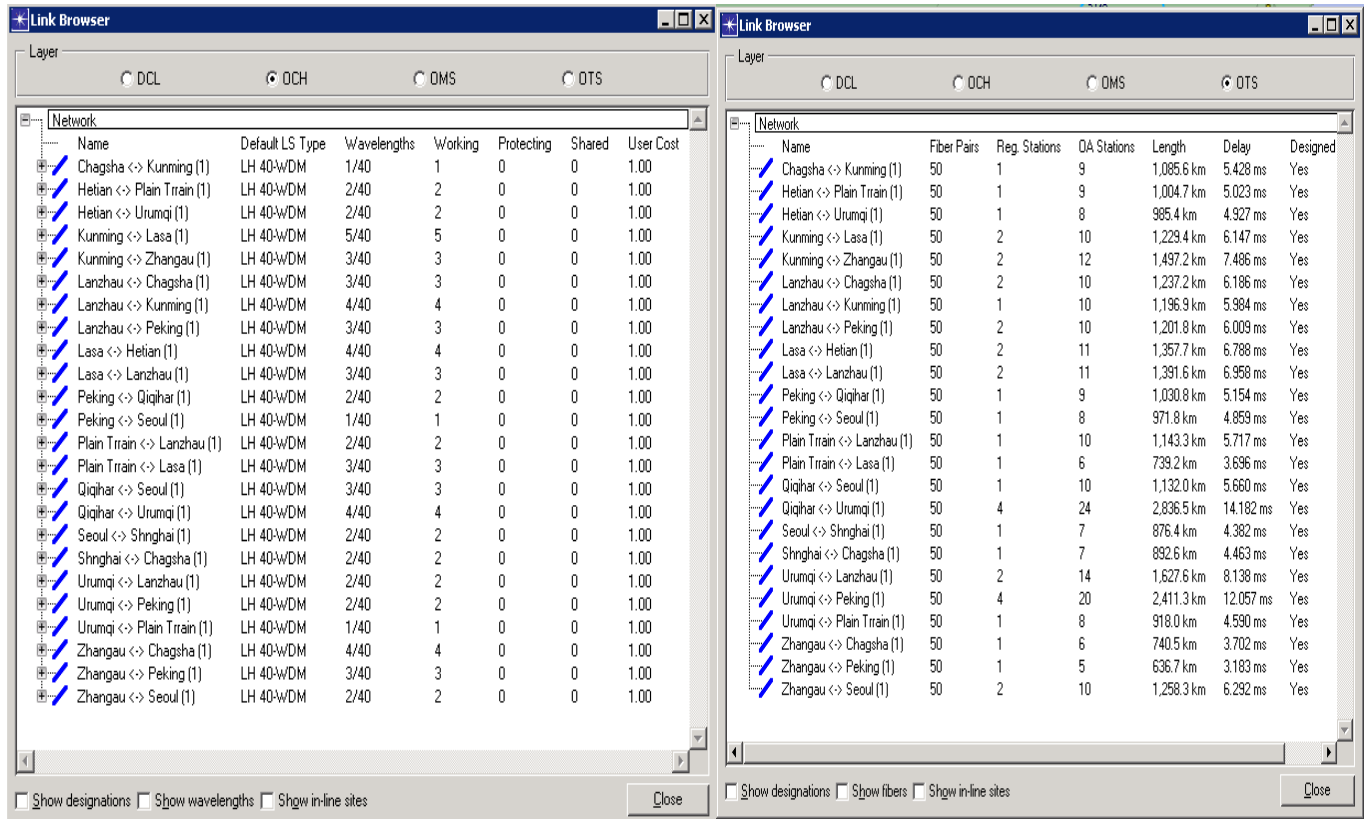


Figure 16: Fibers details



INITIAL SCENARIO

ROUTING INFORMATION AND LINK UTILIZATION

Overview utilization links per layer

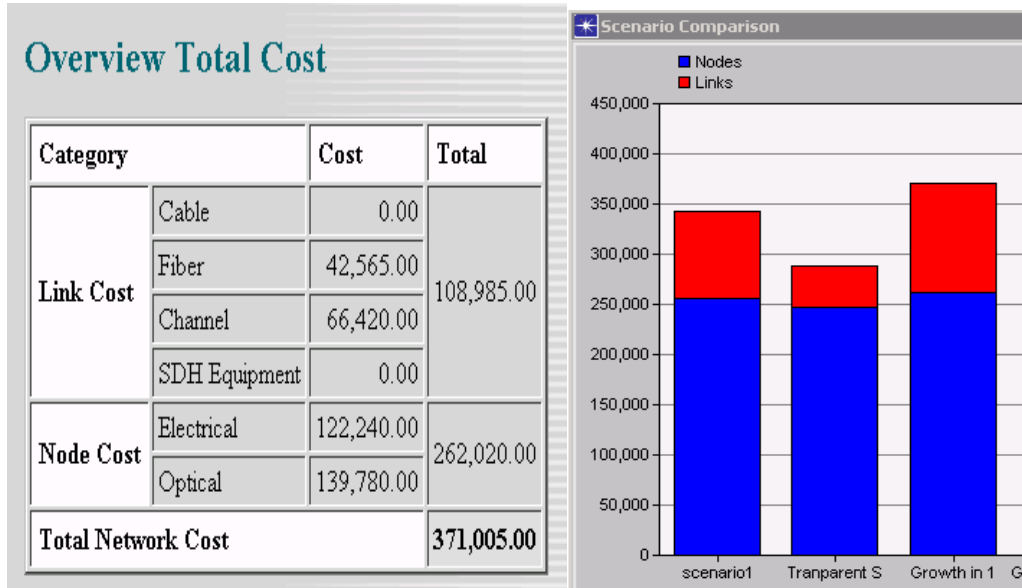
Layer	Number of Links	Link Utilization			Used Capacity	Total Capacity	Utilization (%)	Unit
		Between 100.0 and 90.0 %	Between 90.0 and 75.0 %	Between 75.0 and 0.0 %				
OTS	24	24	0	0	1,200	1,200	100.00	Fiber Pairs
OMS	24	0	0	24	38	1,200	3.17	Fiber Pairs
OCH	24	0	0	24	57	672	8.48	Wavelengths
DCL	24	0	0	24	0	2,736	0.00	STS-1 Units

Figure 17: the routing and link utilization details



NETWORK COST

The noticeable cost factor in transparent layer is the transponder cost. This cost is specially added for reference.



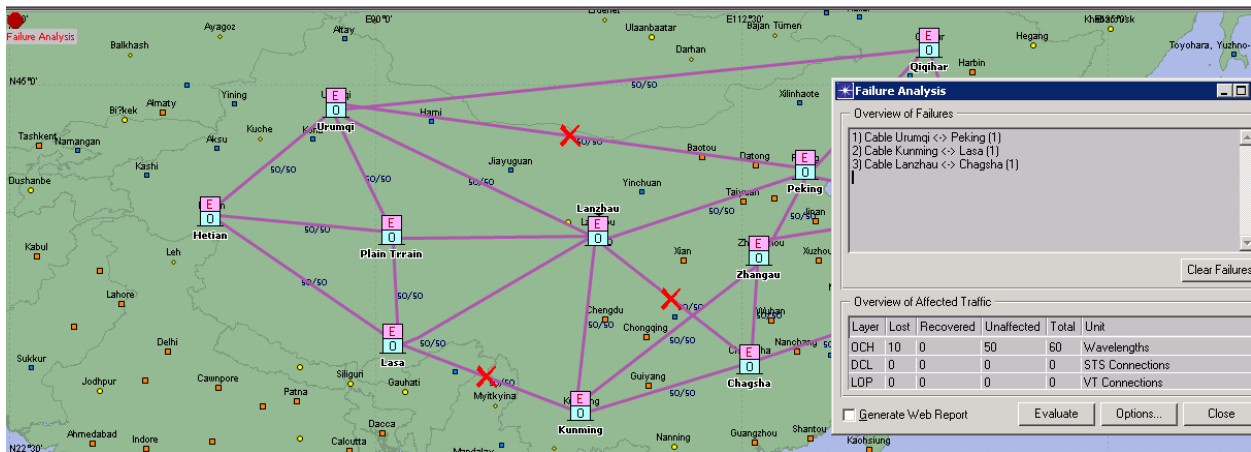
Transponder

	OC-48	Total	Cost
SR Transponder - Trib Opaque Nodes	0	0	0.00
SR Protection Transponder - Trib Opaque OXC/OADM/PP	0	0	0.00
LR Transponder - Trib Transparent + Trunk Opaque	120	120	3,600.00
LR Protection Transponder - Trib OXC/OADM/PP	0	0	0.00
Total	120	120	3,600.00

Figure 18: Cost information and simultaneous comparison with previous scenarios



FAILURE ANALYSIS



Connection Browser

Traffic: LDP DCL OCH OTS | Layout: By node By link By ring All | Order: Traffic matrix End points

End Points	Capacity	Routed	Carrier	Protection	Hops	Length
Chagsha <-> Kunming	50	Yes	Mesh	Unprotected	1	1,085.6 km
Chagsha <-> Lanzhou	50	Lost	N/A	N/A	N/A	N/A
Chagsha <-> Shinghai	50	Yes	Mesh	Unprotected	1	832.6 km
Chagsha <-> Zhangou	50	Yes	Mesh	Unprotected	1	740.5 km
Hefan <-> Lasa	50	Yes	Mesh	Unprotected	1	1,357.7 km
Hefan <-> Plain Train	50	Yes	Mesh	Unprotected	1	1,004.7 km
Hefan <-> Urumiqi	50	Yes	Mesh	Unprotected	1	985.4 km
Kunming <-> Lanzhou	50	Yes	Mesh	Unprotected	1	1,196.9 km
Kunming <-> Lasa	50	Lost	N/A	N/A	N/A	N/A
Kunming <-> Zhangou	50	Yes	Mesh	Unprotected	1	1,487.2 km
Lanzhou <-> Lasa	50	Yes	Mesh	Unprotected	1	1,391.6 km
Lanzhou <-> Peking	50	Yes	Mesh	Unprotected	1	1,201.8 km
Lanzhou <-> Plain Train	50	Yes	Mesh	Unprotected	1	1,143.3 km

Connection Browser

Traffic: LDP DCL OCH OTS | Layout: By node By link By ring All | Order: Traffic matrix End points

End Points	Capacity	Routed	Carrier	Protection	Hops	Length
Chagsha <-> Hefan	2	No	N/A	N/A	N/A	N/A
Chagsha <-> Kunming	1	Yes	Mesh	Unprotected	1	1,085.6 km
OCH_0 OCH_OC-48						
Chagsha <-> Hefan	2	No	N/A	N/A	N/A	N/A
Chagsha <-> Peking	2	No	N/A	N/A	N/A	N/A
Chagsha <-> Plain Train	1	No	N/A	N/A	N/A	N/A
Chagsha <-> Qiqihar	4	No	N/A	N/A	N/A	N/A
Chagsha <-> Seoul	3	No	N/A	N/A	N/A	N/A
Chagsha <-> Shinghai	2	Yes	Mesh	Unprotected	1	832.6 km
Chagsha <-> Urumiqi	1	No	N/A	N/A	N/A	N/A
Chagsha <-> Zhangou	4	Yes	Mesh	Unprotected	1	740.5 km
Hefan <-> Kunming	3	Lost	N/A	N/A	N/A	N/A
Hefan <-> Lanzhou	2	No	N/A	N/A	N/A	N/A

Figure 19: The failure analysis details

The report is attached at the end as Appendix -3.



SAME SCENARIO WITH 20% TRAFFIC GROWTH

ROUTING INFORMATION AND LINK UTILIZATION

The image shows two identical 'Routing Results' dialog boxes. Each dialog has a 'Layer' section with radio buttons for LOP, DCL, and OCH (selected). Below this are fields for Link Utilization (65.4%), Node Utilization (N/A), Regen. Utilization (N/A), and Trib. Utilization (N/A). The 'Traffic Matrix' section shows 'OCH_0' selected in a dropdown. Below that is 'Protection Type' set to 'Unprotected' and 'Routed Capacity' set to '224/224' (100.0%). A table shows 'Total Hops' (429 Working, N/A Protecting) and 'Mean Hops' (1.9 Working, N/A Protecting). At the bottom are buttons for 'Split off unrouted connections' and 'Close'.

Overview utilization links per layer

Layer	Number of Links	Link Utilization			Used Capacity	Total Capacity	Utilization (%)	Unit
		Between 100.0 and 90.0 %	Between 90.0 and 75.0 %	Between 75.0 and 0.0 %				
OTS	24	24	0	0	1,200	1,200	100.00	Fiber Pairs
OMS	24	0	0	24	37	1,200	3.08	Fiber Pairs
OCH	24	5	6	13	429	656	65.40	Wavelengths
DCL	66	0	0	66	0	10,752	0.00	STS-1 Units

Figure 20: The routing and utilization details



NETWORK COST

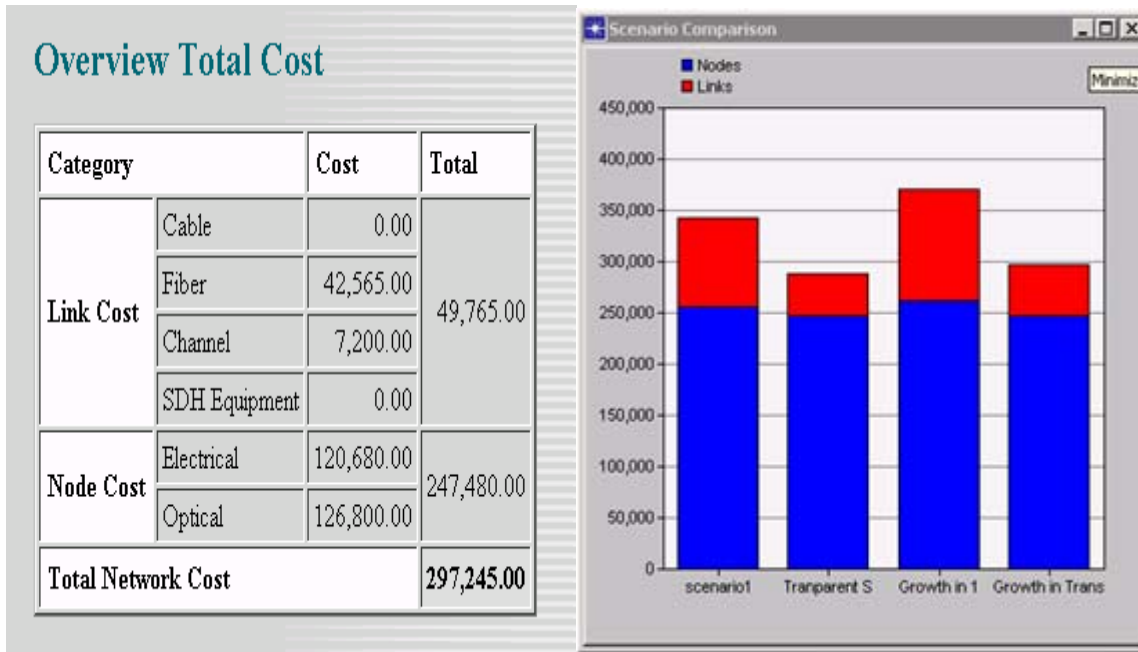
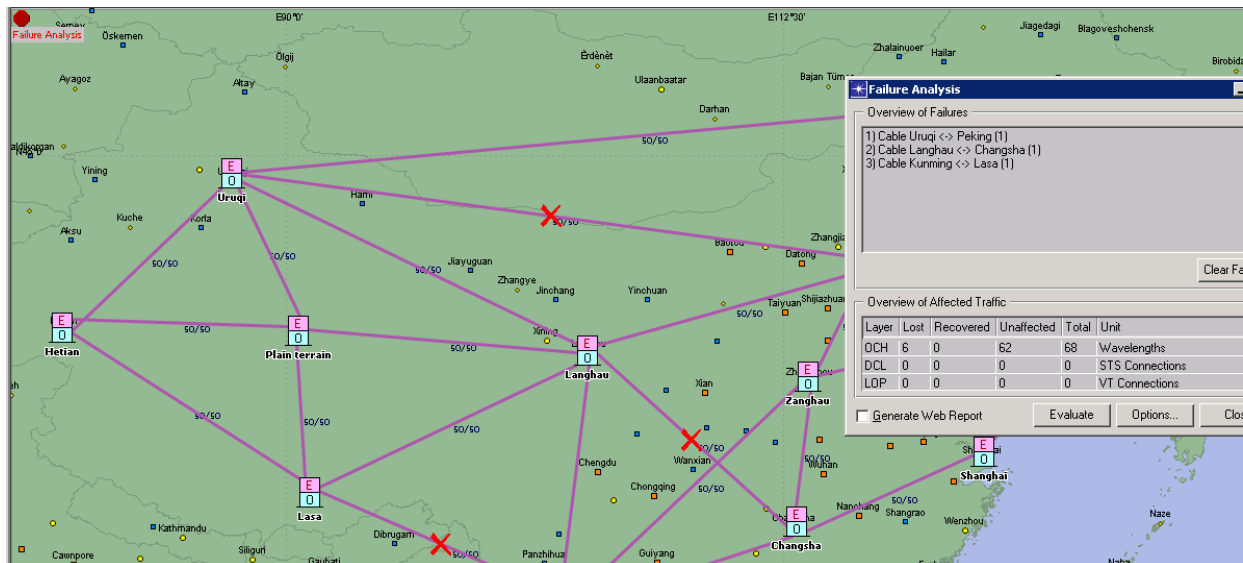


Figure 21: Total cost information and simultaneous cost comparison with all scenarios

FAILURE ANALYSIS



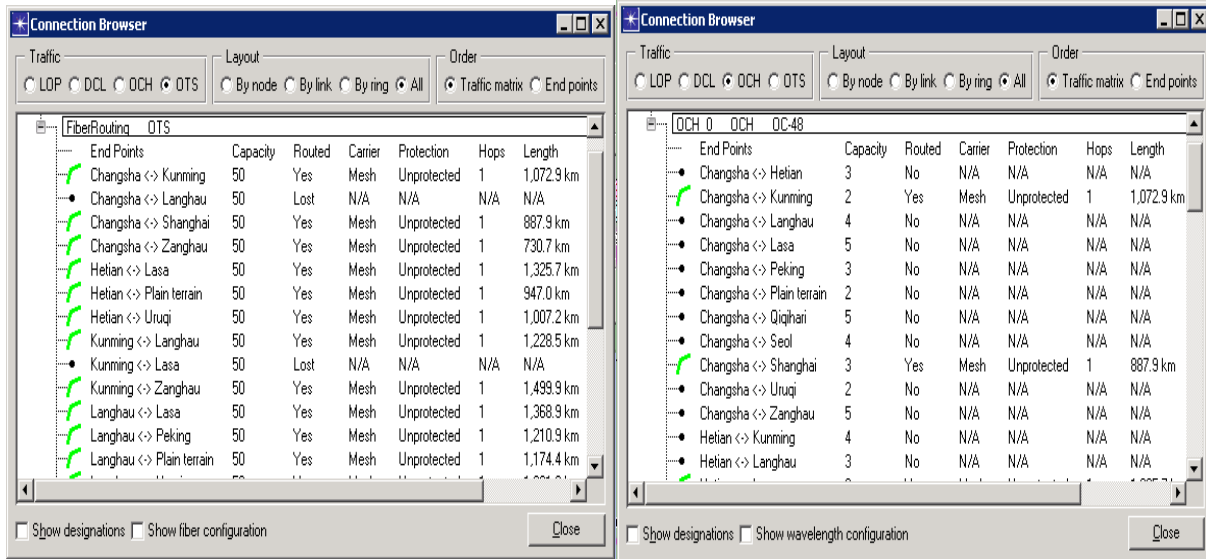


Figure 22: The failure analysis details

The report is attached at the end as Appendix -4.



COMPARISON BETWEEN ALL SENARIOS

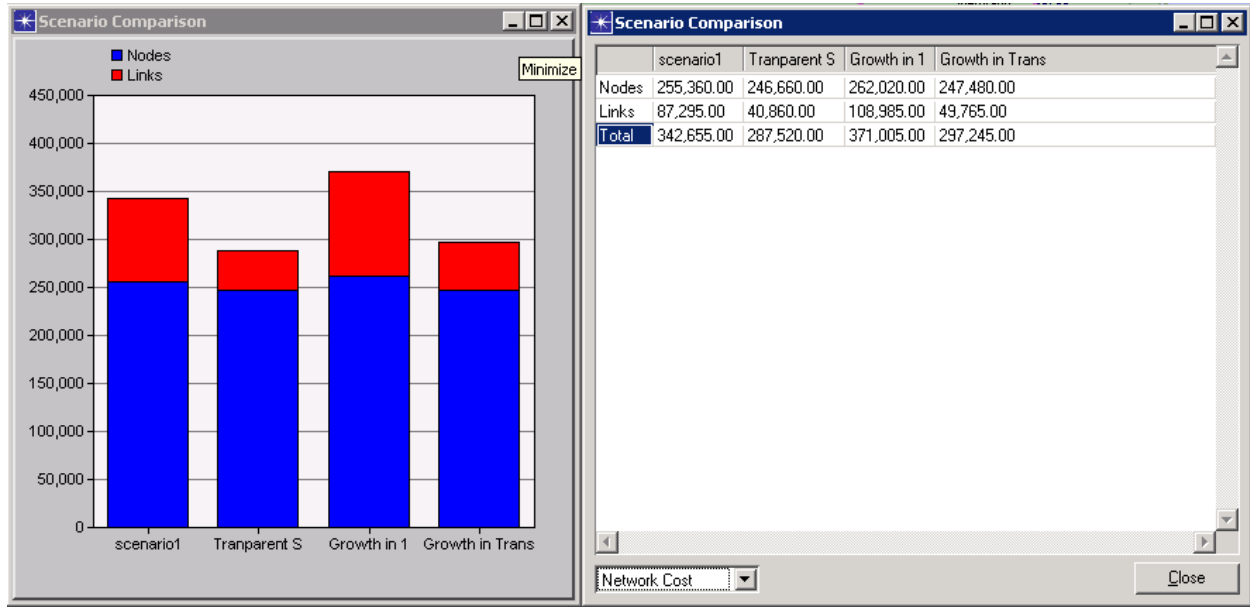


Figure 23: Comparison of all scenarios

The cost varies from scenario to scenario. As we increase the traffic, the cost changes. The reasons for specific growth in specific scenario in explained in the conclusion part which follows the next.

AVAILABILTY REPORT

The availability reports are long. So, for the demonstration purpose, only the availability of the best solution scenario that is the transparent scenario is attached as Appendix. The availability settings allow us to set the Mean Time between Failures and MTBF to be set which is highly important in a real time scenario.

These reports are in a web format and are very simple to understand. Only one example of availability report is given as it would occupy more space in the report. The report consists of overall availability of links, nodes and also details for the same.

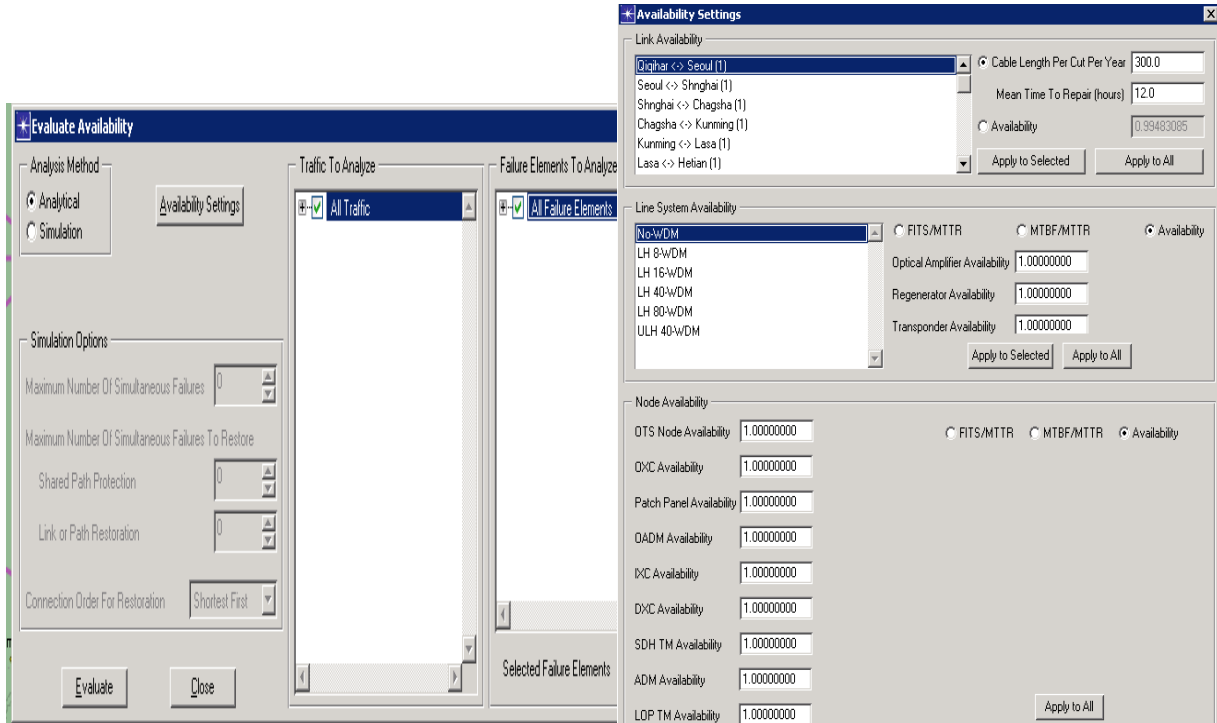


Figure 24: the availability settings for the detailed availability report

EXTRA MILE

Some information about the China Mobile restructuring in China:

Being the monopolist in telecom industry in China, it has the largest coverage area. In this restructuring mainly they are planning to cover the rural part of the country. “As part of its industry restructuring, China Mobile was asked to take over minor fixed line operator China Tietong including its US\$5.8 billion dollar debt, US\$1.5 billion of which is due this year. Meanwhile, China Mobile is essentially forced to adopt the country’s homegrown 3G technology, TD-SCDMA, which lags WCDMA and EV-DO in terms of technology maturity and handset development.”[2]

By this expansion, their revenue will increase up to \$20.1 billion this year.

[2] Reference: <http://www.commsday.com/node/259>



CONCLUSION

After performing all the above operations I could draw following conclusions:

- ✚ Undoubtedly, OPNET is a wonderful tool for a network designer and it truly accomplishes the analyzing of **holistic nature of the network**.
- ✚ Also, the utilization depends on how effectively the fiber pairs are equipped.
- ✚ The performance of the network definitely depends on
 - The topology of the network
 - The link design
 - The amount of traffic in the network
 - The failure protection it can provide
- ✚ The dimensioning and grooming are certainly one of the best features by OPNET. They facilitate 100 % routed traffic with our specified type of network by increasing the node capacity and still keeping the link utilization factor stable.
- ✚ Specific to the above project, we see that as the traffic was increased by 20 % the cost also increased which was obvious. **But the highlighting point is that when traffic was grown by 20 % in opaque layer, the growth in cost is more than the cost of 20% growth in transparent layer. The reason for this is in opaque layer the link cost is high due to the fact that the transponders are present in WDM terminals. Also, due to this, when traffic is increased, the regeneration occurs and the cost increases.**

However in case of transparent layer, the transponders are at the tributary end hence they result in low link cost but comparative high node cost. Also, due to this the cost in the 20 % growth scenario doesn't increase much.

So, for China mobile network which would definitely have a strong growth factor, the transparent layer design solution is definitely effective for now and also for the long run in terms of cost and future growth of network.

