**SEMINAR ON NETWORK PLANNING
STRATEGY FOR EVOLVING NETWORK
ARCHITECTURES
FOR ASIA PACIFIC REGION**

Session 5.6

**VPI: Core Network Planning with
VPIserviceMaker™ / VPItransportMaker™:
Traditional TDM and IP Networks**

Live demo:

Voice over IP over WDM

ITU, Bangkok, Thailand, 11-15 November 2002

Interworking VPIserviceMaker[TM] and VPItransportMaker[TM]

Demo: Voice over IP over WDM

Introduction

This example is meant to demonstrate how one can conduct an integrated network planning across multiple layers and technologies. The example is selected with the consideration that it should represent a typical network planning problem from a nationwide network provider's perspective as realistically as possible.

IP Network Planning

Since our aim is to plan an multi-layer carrier scale national backbone network, the IP layer network should represent a typical nationwide internet service provider's (ISP) network. Typical ISPs (such as AOL and AtHome) not only provide Internet connectivity services, but also content services. The Internet connectivity services can create both intra-network and inter-network traffic, while content services only create intra-network traffic between users and content servers. Estimating traffic is the first step and a key to network planning. To model the traffic characteristics of such ISPs, we need to consider the following elements:

1. Subscriber population by city.
2. Subscriber usage profile
3. Content servers
4. Intra and inter network traffic percentages.

In terms of types of traffic, we will consider the native IP services such as HTTP, EMAIL, FTP etc., as well as VoIP.

We choose a typical US ISP backbone network as show in figure 1 with reference to the physical fiber topology. The nodes of the backbone network are points of presence (POP) at all major cities. In this example there are 13 POPs, representing 13 major metropolitan areas. Each POP may be composed of a number of routers of different types. Here we use only one router icon to represent each POP because what we want to model is the backbone network, not the intra POP structure.

To model subscriber population by city, a computer group icon for each city is created representing all the users served by the ISP in the city. Also a few cities are locations of content server centers of the ISP and represented by the server icon.

It is assumed that the network has only one gateway to the global internet and therefore the network has no transit traffic.

In each city, the computer group, the server (if exits) and the global gateway (if exits) are directly connected to the POP of the city.
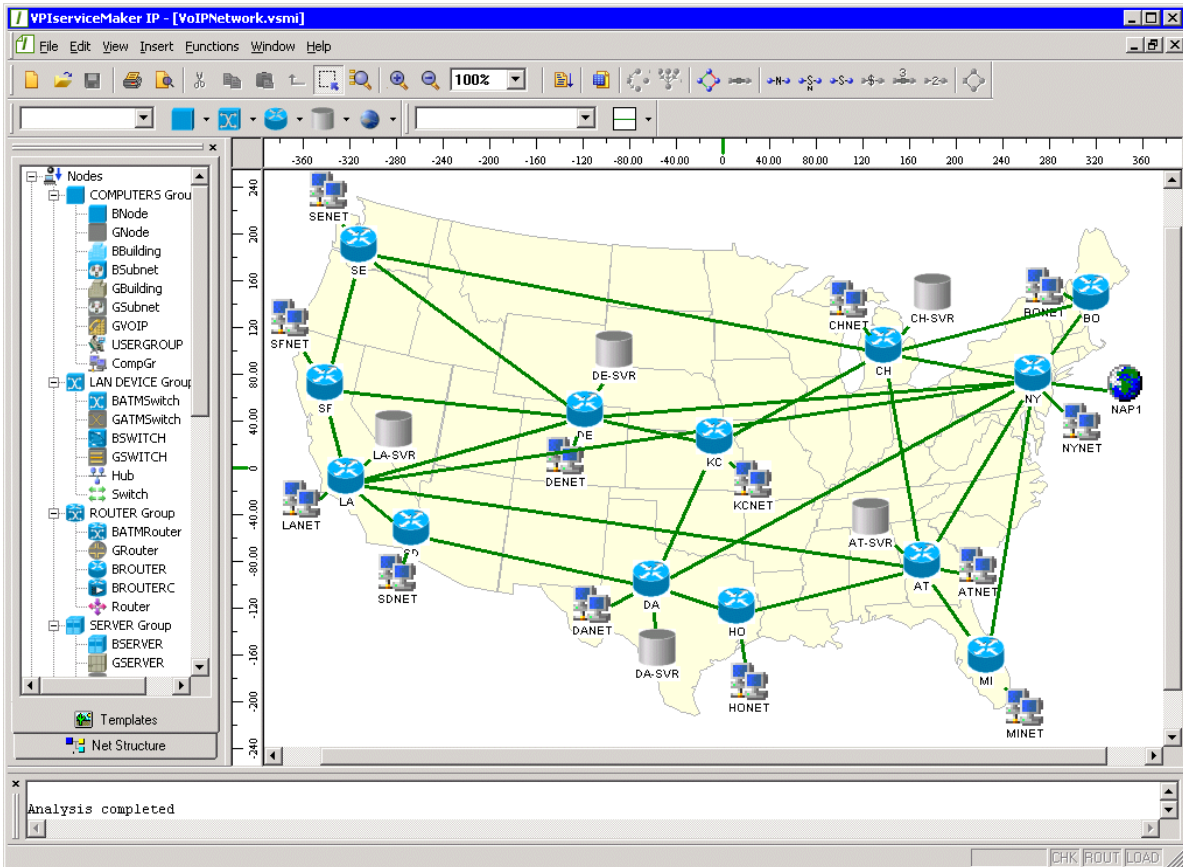
Figure 1. A Sample US Nationwide ISP Backbone Network

As an example, figure 2 shows the parameter settings of computer group NY-NET.

As an example, figure 3 shows the parameter settings of NY POP. The maximal switching capacity is set to 500 Gbit/s.
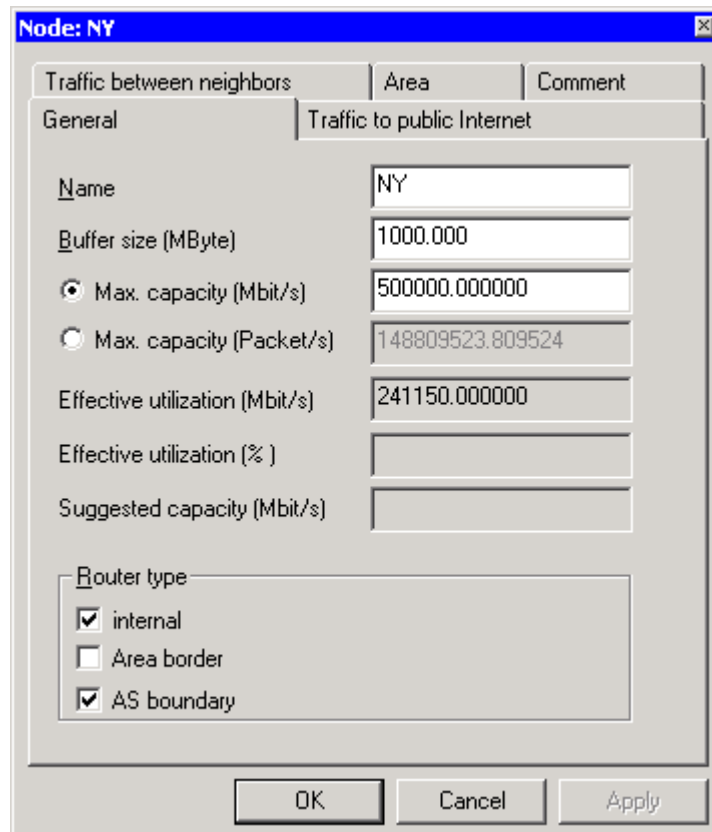

Figure 3. Sample POP Setting

We assume there already exists a voice matrix, with values as shown in figure 4.

from/to	ATNET	BONET	CHNET	DANET	DENET	HONET	KCNET	LANET	MINET	NAP1	NYNET	SDNET	SENET
ATNET		1250.00	2500.00	2500.00	1250.00	2500.00	1250.00	2500.00	1250.00	0.00	2500.00	1250.00	1250.00
BONET	1250.00		1250.00	1250.00	625.00	1250.00	625.00	1250.00	625.00	0.00	1250.00	625.00	625.00
CHNET	2500.00	1250.00		2500.00	1250.00	2500.00	1250.00	2500.00	1250.00	0.00	2500.00	1250.00	1250.00
DANET	2500.00	1250.00	2500.00		1250.00	2500.00	1250.00	2500.00	1250.00	0.00	2500.00	1250.00	1250.00
DENET	1250.00	625.00	1250.00	1250.00		1250.00	625.00	1250.00	625.00	0.00	1250.00	625.00	625.00
HONET	2500.00	1250.00	2500.00	2500.00	1250.00		1250.00	2500.00	1250.00	0.00	2500.00	1250.00	1250.00
KCNET	1250.00	625.00	1250.00	1250.00	625.00	1250.00		1250.00	625.00	0.00	1250.00	625.00	625.00
LANET	2500.00	1250.00	2500.00	2500.00	1250.00	2500.00	1250.00		1250.00	0.00	2500.00	1250.00	1250.00
MINET	1250.00	625.00	1250.00	1250.00	625.00	1250.00	625.00	1250.00		0.00	1250.00	625.00	625.00
NAP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
NYNET	2500.00	1250.00	2500.00	2500.00	1250.00	2500.00	1250.00	2500.00	1250.00	0.00		1250.00	1250.00
SDNET	1250.00	625.00	1250.00	1250.00	625.00	1250.00	625.00	1250.00	625.00	0.00	1250.00		625.00
SENET	1250.00	625.00	1250.00	1250.00	625.00	1250.00	625.00	1250.00	625.00	0.00	1250.00	625.00	
SFNET	2500.00	1250.00	2500.00	2500.00	1250.00	2500.00	1250.00	2500.00	1250.00	0.00	2500.00	1250.00	1250.00

Figure 4. Imported VoIP matrix

In order to perform the dimensioning for all defined services a selection of services is performed as indicated in figure 5.
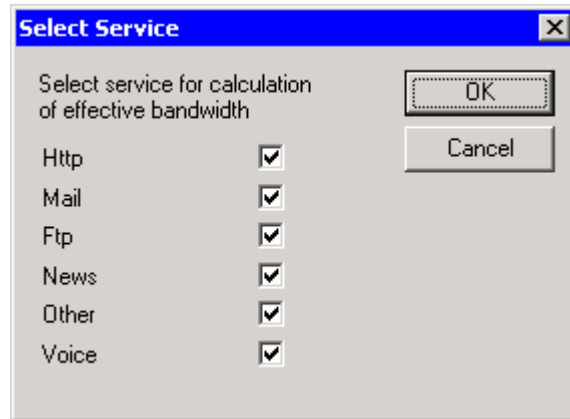

Figure 5. Select Service Dialog

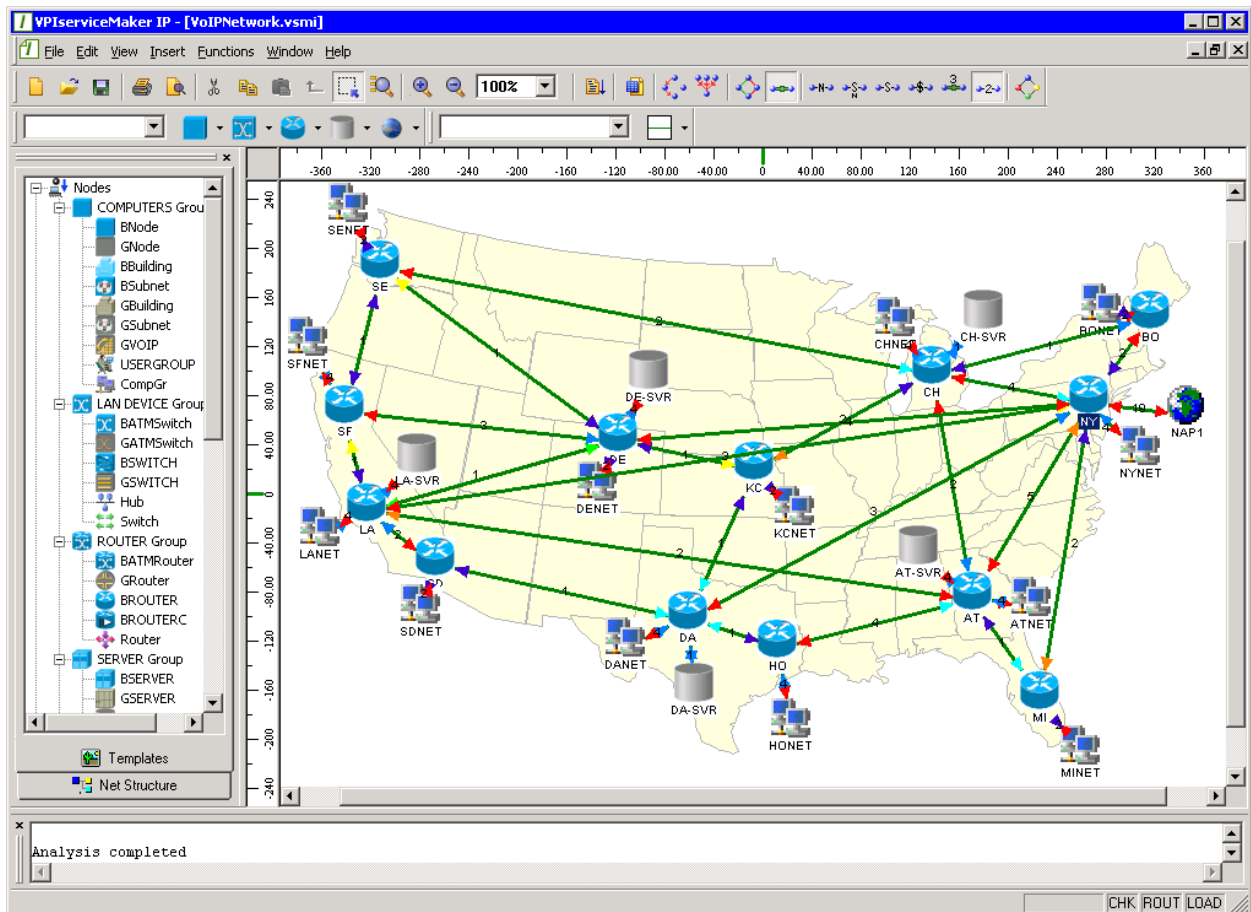The design results are compiled into a set of detailed reports.

Figure 6. IP Network Dimensioning

After the design, network bottlenecks and under-utilized resources can be identified. Topology improvement can be made by simply looking at link load.

Finally once the IP network design is satisfactory, we would like to design an underlying transport network to provide the required bandwidth for IP links.
IP network links will be treated as a traffic matrix of point to point bandwidth demands for the transport network design.

VoIP Matrix Generation

Task is to generate a matrix of point to point voice traffic as VoIP traffic for the IP network design.
Normally the units of traffic quantities are Erlangs but for VoIP we interpret them as simultaneous voice channels between a pair of nodes.

Since VoIP traffic is only between computer (subscriber) groups, we do not need to consider the other nodes. The corresponding network with all VoIP relevant nodes are shown in figure 7.
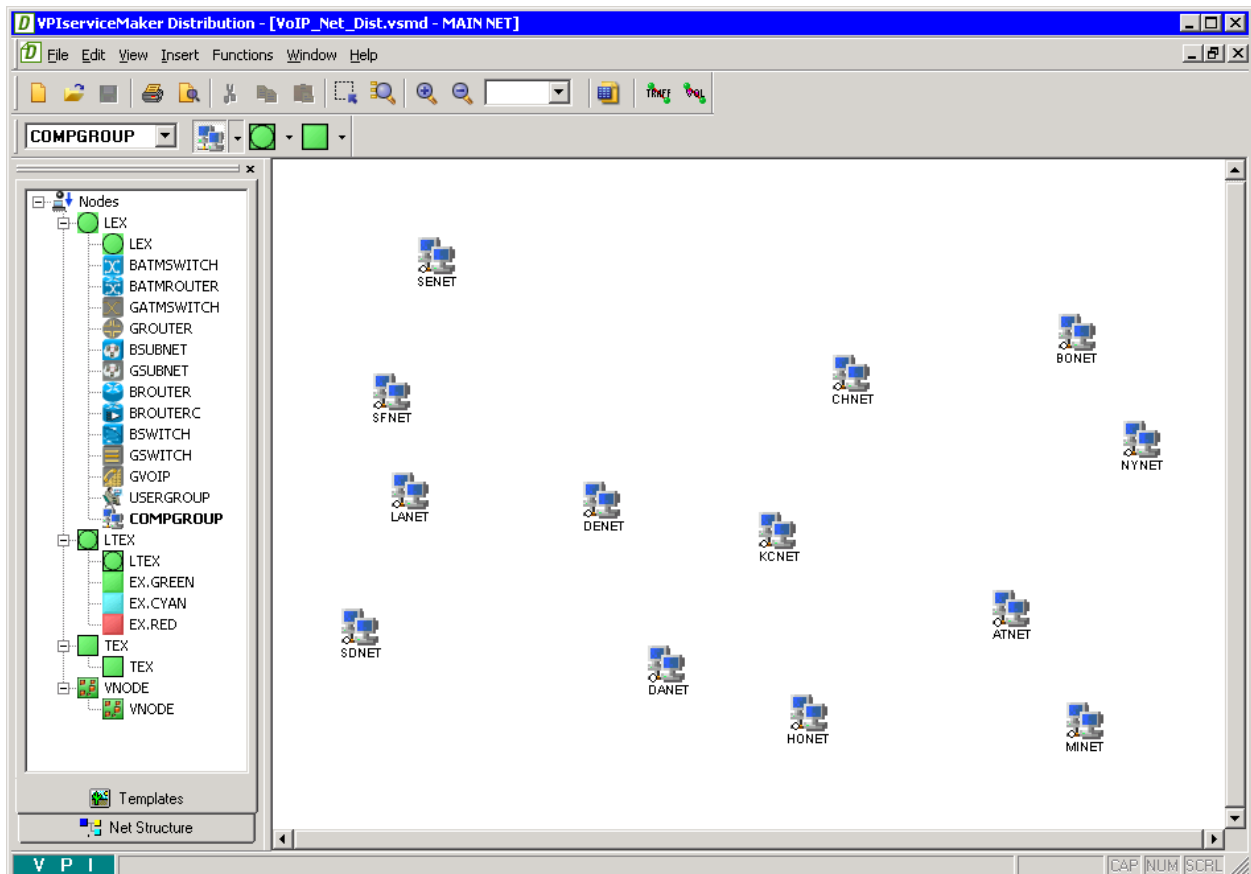

Figure 7. The set of VoIP nodes

It is assumed that the amount of voice traffic between two cities is proportional to the populations of the two cities.

We also need to specify other parameters such as average traffic per subscriber and call originating/termination percentages which are all shown in figure 8.

No.	node name	no. of traffic entities	average traffic per entity	percentage of originating traffic	percentage of terminating traffic	Area	weighting factor	AI o
1	ATNET	500000	0.10	50.00	50.00	NONE	1.00	
2	BONET	250000	0.10	50.00	50.00	NONE	1.00	
3	CHNET	500000	0.10	50.00	50.00	NONE	1.00	
4	DANET	500000	0.10	50.00	50.00	NONE	1.00	
5	DENET	250000	0.10	50.00	50.00	NONE	1.00	
6	HONET	500000	0.10	50.00	50.00	NONE	1.00	
7	KCNET	250000	0.10	50.00	50.00	NONE	1.00	
8	LANET	500000	0.10	50.00	50.00	NONE	1.00	
9	MINET	250000	0.10	50.00	50.00	NONE	1.00	
10	NYNET	500000	0.10	50.00	50.00	NONE	1.00	
11	SDNET	250000	0.10	50.00	50.00	NONE	1.00	
12	SENET	250000	0.10	50.00	50.00	NONE	1.00	
13	SFNET	500000	0.10	50.00	50.00	NONE	1.00	

Figure 8. Input Data

The tool will create a matrix of point to point voice traffic.
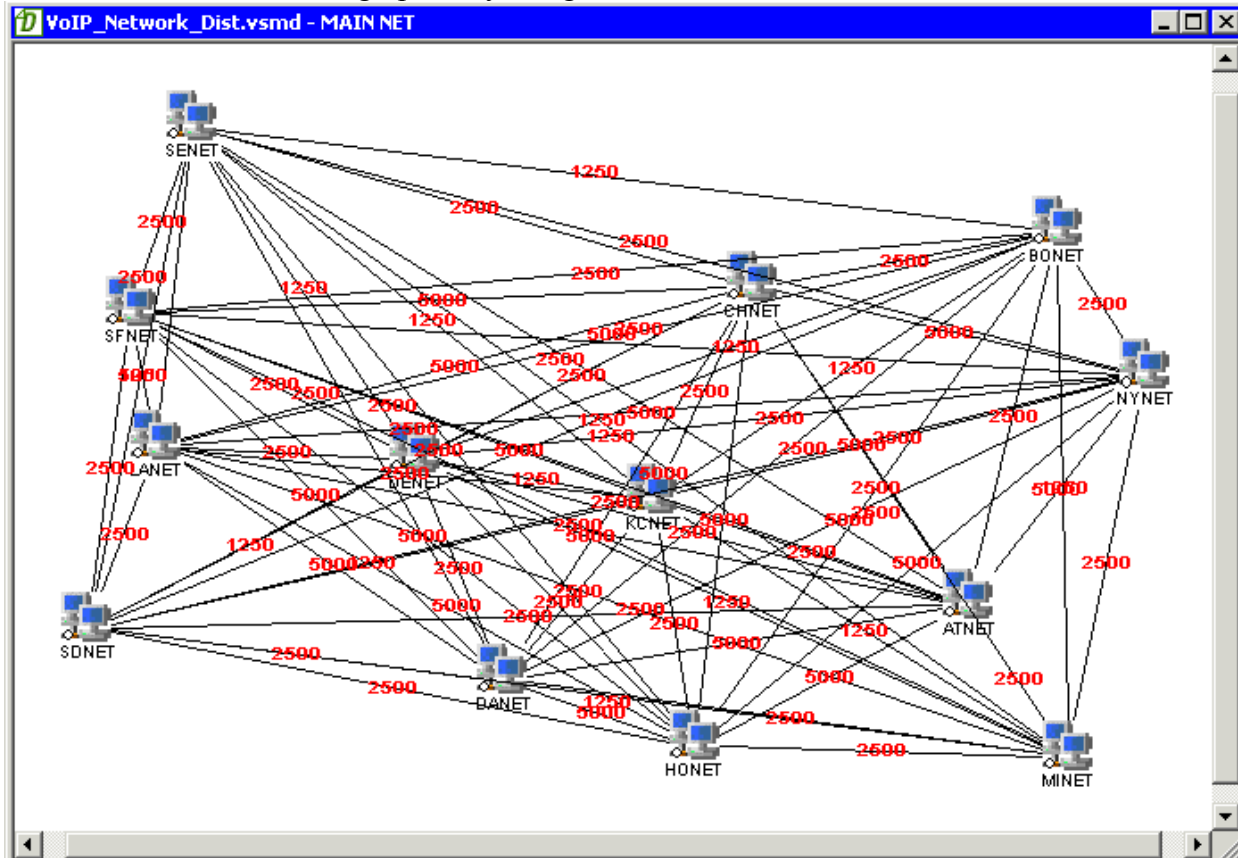The traffic matrix is shown graphically in figure 11.

Figure 9. Voice traffic matrix

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Transport Network Planning

Figure 10 shows the IP links, grouped into a traffic matrix called STM64 (to indicate their signal rate of OC192). The server window (right) initially contains only nodes, without OMS links. The OMS links can be either manually created or imported from a topology file. The client window (left) represents graphically the traffic matrix, where each link represents a demand and the number by the link represents quantity in OC192 (STM64) units.
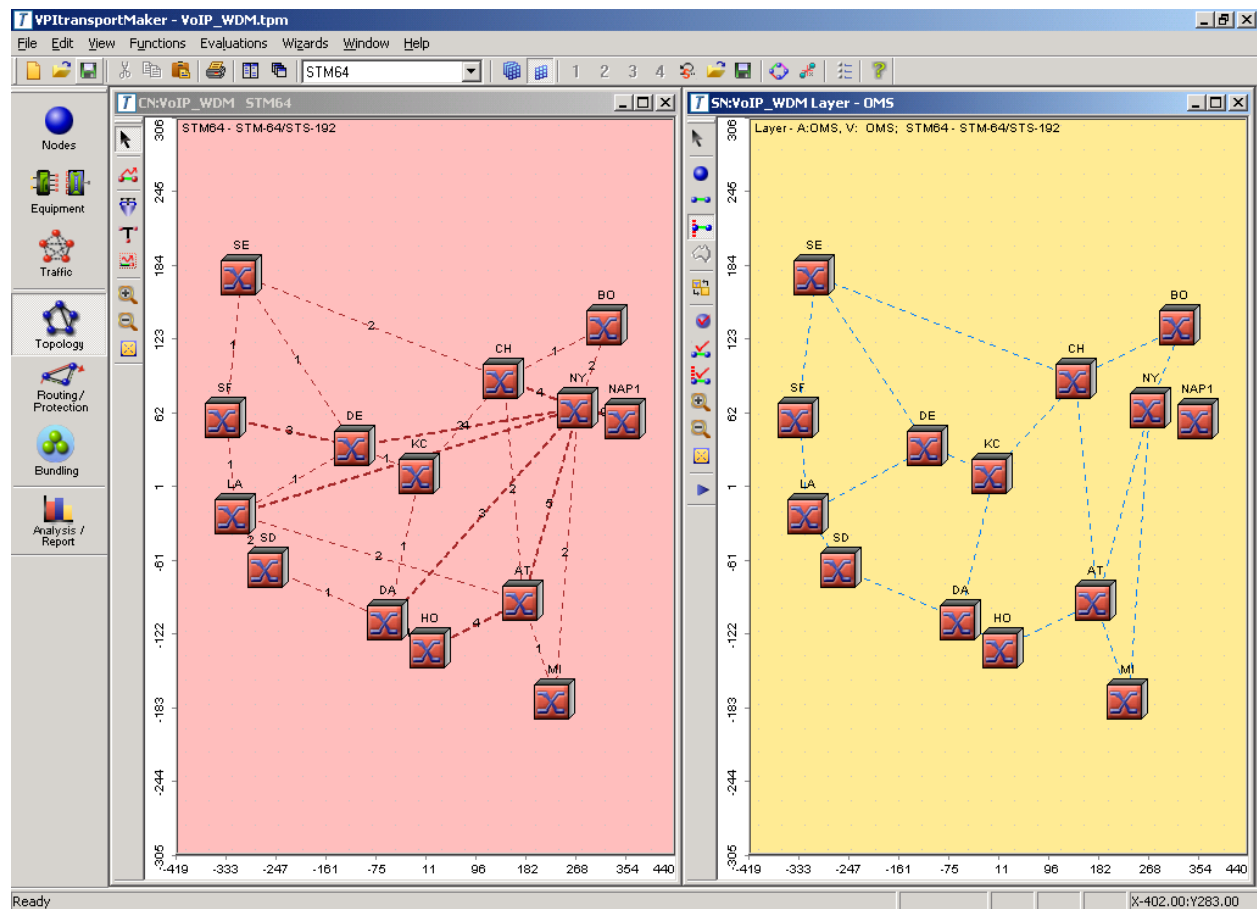

Figure 10. Transport project exported from IP

We want to plan a two layer IP over optical network. For the optical layer, we want to design a mesh network with wavelength routing and protection capabilities. Further down, DWDM systems provide point to point optical multiplexing section links. For this purpose, when we create the server layer topology (the right window), we need to specify that all links are multiplexing links at the OMS layer.

Before create the OMS links, we want to set the number of channels available to each DWDM system.
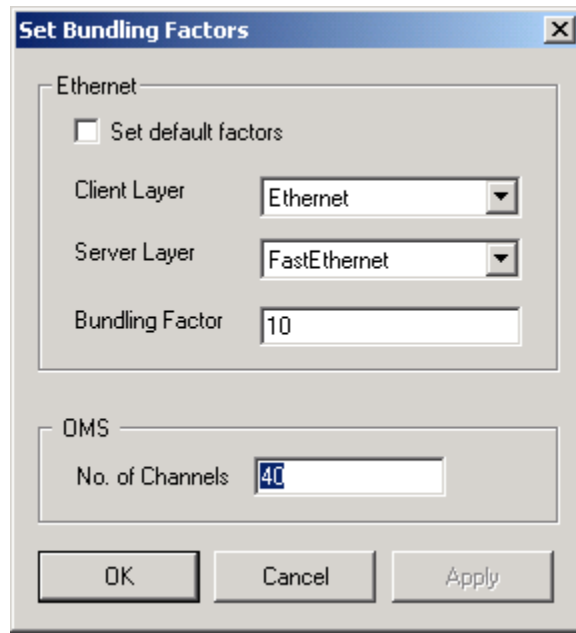
Figure 11. Set Bundling Factors

To design a wavelength routed optical network, we choose Planning for better optimization (at the price of more computation). We select no wavelength conversion because we assume that optical cross connects are not capable of converting wavelengths based on the reality of today's technology. We also select the 1+1 path protection option because no protection is considered when we design the IP network. After the run, the design result is compiled into a report.
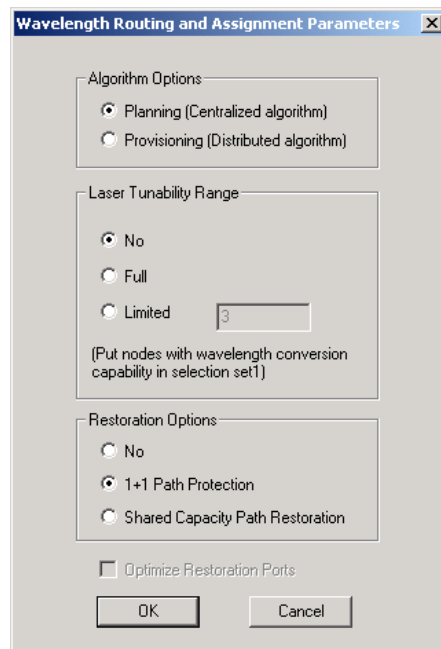

Figure 12. Wavelength routing parameters

The design can also be visually displayed on the GUI. Figure 13 shows the network of DWDM facilities where each dashed line represents one DWDM system and the number by the line indicate the number of wavelengths carried by the system. It can be seen that there is only one line over each fiber link, which means there is only one DWDM system deployed over each fiber route. This is because each DWDM system offers a capacity of 40 wavelengths (OC192s) which is more than sufficient for our traffic.
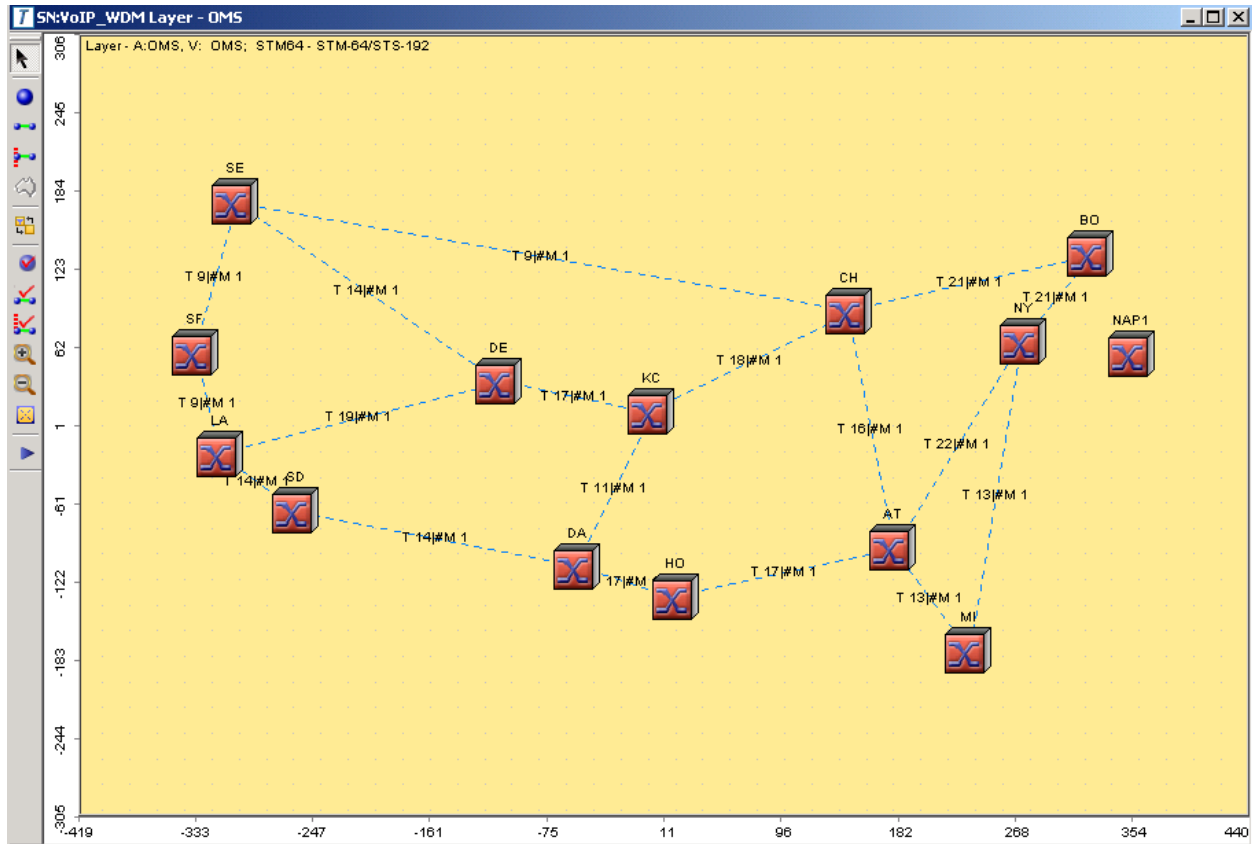

Figure 13. Wavelength load on each link

Summary

In this design exercise is shown how to leverage the VPI software and the complete suite of design tools it provides to do an integrated network planning across multiple layers.

So far in this design exercise the data flows are one way: from traffic distribution to service layer design to transport layer design. It is also possible to have a feedback process from transport layer to the service layers. For example, by looking at the spare capacity of the transport layer, one can estimate how to expand a service network, or to adjust transport bandwidths allocated to different service layer networks. Another way is to conduct what-if scenario analysis on potential impact of any service layer changes over the transport layer.

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