# 5 Optical Network Architectures

The default OCH layer mode of SP Guru Transport Planner is an opaque mode. This represents the optical network scenario in which the optical cross-connects have front-end transponders to allow regeneration at every intermediate node. Since a connection is converted to the electrical domain while being switched from one fiber to another, the wavelength is not required to be the same on both fibers. Therefore, the opaque mode implies intrinsic wavelength conversion.

In contrast, in transparent mode we distinguish between a fully transparent, a selective, and an opaque OXC. In a fully transparent node, no regeneration equipment is present implying regeneration or wavelength conversion is impossible in such a node. In a selective node, the OXC is transparent but connected to a regeneration bank. This regeneration bank can be accessed to perform selective regeneration for those connections that exceed the transparent reach or to perform wavelength conversion to solve the wavelength contention.

## Opaque Mode

**Procedure 5-1 Opaque Mode**

**1** Open the **WDMGuru_Tutorial_Transparent_Routing** project.

**1.1** Select **File > Open...**.

**1.2** Select the **WDMGuru_Tutorial_Transparent_Routing** project, then press **Open**.

➥ The opaque scenario appears in the workspace.

This project contains two scenarios. In this scenario, the OCH layer mode is opaque, which means that all nodes are opaque. This can be verified in the **Network > Network Properties...** dialog box.

**2** Route the traffic matrix **OC-48.**

**2.1** Select **Design > Route DCL/OCH Traffic...**

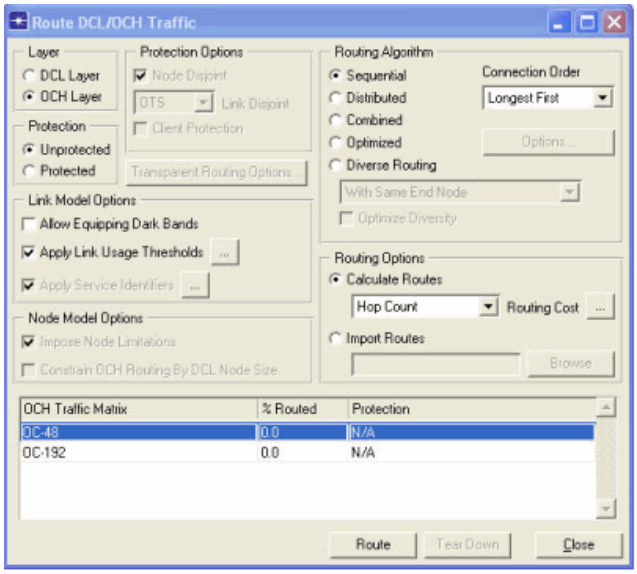
➥ The **Route DCL/OCH Traffic** dialog box appears.

**2.2** Select the **OCH Layer** and the traffic matrix **OC-48**.

**2.3** Choose the default settings for all options, as follows:

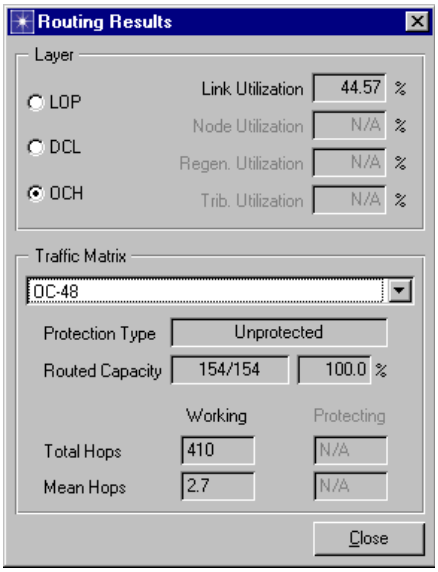
- **Unprotected** (Protection)
- **Sequential** (Routing Algorithm)
- **Longest First** (Connection Order)
- **Hop Count** (Routing Cost)

- Unmark **Allow Equipping Dark Bands**.




**2.4** Press **Route**.

➥ The **Routing Results** dialog indicates that the traffic matrix **OC-48** is entirely accommodated in the network.




**2.5** Close the **Routing Results** and the **Route DCL/OCH Traffic** dialog boxes.

**3** Check the installed transponders in the network.

**3.1** Select **Info > Export to Web Report > Bill of Materials**.

➥ The web browser is launched and the bill of materials report appears.

**3.2** Select **Transponder**.

➥ This table shows the number of short-reach transponders. These transponders are needed at the tributary side of the OXCs in the network (interfacing with client equipment). In this example, 308 short-reach transponders are installed in the network.

| | OC-48 | Total | Cost |
|---|---|---|---|
| SR Transponder - Trib Opaque Nodes | 308 | 308 | 4,620.00 |
| SR Protection Transponder - Trib Opaque OXC/OADM/PP | 0 | 0 | 0.00 |
| **Total** | **308** | **308** | **4,620.00** |

**3.3** Select **WDM Terminal Equipment**.

This section shows the number of long-reach transponders (per bit rate and per line system type) which terminate the line system channels. In this example, 820 long-reach transponders are installed in the network.

| Name | Fiber LH 40-WDM | #Fiber Pairs | #Regen Stations | WDM Term LH 40-WDM | #WDM Term | #Bidir Channels Available | #Bidir Channels Used | #Bidir Channel Cards | #LR Transp | Cards LH 40-WDM | LR Transp LH 40-WDM OC-48 | Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ATLANTA <-> MIAMI | 1 | 1 | 1 | 4 | 4 | 40 | 11 | 22 | 22 | 22 | 22 | 1,060.00 |
| ATLANTA <-> WASHINGTON | 1 | 1 | 1 | 4 | 4 | 40 | 36 | 72 | 72 | 72 | 72 | 2,560.00 |
| CHICAGO <-> ATLANTA | 1 | 1 | 1 | 4 | 4 | 40 | 8 | 16 | 16 | 16 | 16 | 880.00 |
| CHICAGO <-> DETROIT | 1 | 1 | 0 | 2 | 2 | 40 | 40 | 80 | 80 | 80 | 80 | 2,600.00 |
| DALLAS <-> ATLANTA | 1 | 1 | 1 | 4 | 4 | 40 | 15 | 30 | 30 | 30 | 30 | 1,300.00 |
| DALLAS <-> CHICAGO | 1 | 1 | 2 | 6 | 6 | 40 | 33 | 66 | 66 | 66 | 66 | 2,580.00 |
| DALLAS <-> HOUSTON | 1 | 1 | 0 | 2 | 2 | 40 | 18 | 36 | 36 | 36 | 36 | 1,280.00 |
| DETROIT <-> BOSTON | 1 | 1 | 1 | 4 | 4 | 40 | 19 | 38 | 38 | 38 | 38 | 1,540.00 |
| DETROIT <-> WASHINGTON | 1 | 1 | 1 | 4 | 4 | 40 | 10 | 20 | 20 | 20 | 20 | 1,000.00 |
| HOUSTON <-> ATLANTA | 1 | 1 | 1 | 4 | 4 | 40 | 11 | 22 | 22 | 22 | 22 | 1,060.00 |
| HOUSTON <-> MIAMI | 1 | 1 | 2 | 6 | 6 | 40 | 8 | 16 | 16 | 16 | 16 | 1,080.00 |
| HOUSTON <-> SAN_DIEGO | 1 | 1 | 3 | 8 | 8 | 40 | 21 | 42 | 42 | 42 | 42 | 2,060.00 |
| LAS_VEGAS <-> DALLAS | 1 | 1 | 2 | 6 | 6 | 40 | 40 | 80 | 80 | 80 | 80 | 3,000.00 |
| LOS_ANGELES <-> LAS_VEGAS | 1 | 1 | 0 | 2 | 2 | 40 | 14 | 28 | 28 | 28 | 28 | 1,040.00 |
| LOS_ANGELES <-> SAN_DIEGO | 1 | 1 | 0 | 2 | 2 | 40 | 7 | 14 | 14 | 14 | 14 | 620.00 |
| LOS_ANGELES <-> SAN_FRAN | 1 | 1 | 0 | 2 | 2 | 40 | 4 | 8 | 8 | 8 | 8 | 440.00 |
| NEW_YORK <-> BOSTON | 1 | 1 | 0 | 2 | 2 | 40 | 12 | 24 | 24 | 24 | 24 | 920.00 |
| SAN_DIEGO <-> LAS_VEGAS | 1 | 1 | 0 | 2 | 2 | 40 | 10 | 20 | 20 | 20 | 20 | 800.00 |
| SAN_FRAN <-> LAS_VEGAS | 1 | 1 | 1 | 4 | 4 | 40 | 11 | 22 | 22 | 22 | 22 | 1,060.00 |
| SEATTLE <-> CHICAGO | 1 | 1 | 4 | 10 | 10 | 40 | 22 | 44 | 44 | 44 | 44 | 2,320.00 |
| SEATTLE <-> LAS_VEGAS | 1 | 1 | 2 | 6 | 6 | 40 | 9 | 18 | 18 | 18 | 18 | 1,140.00 |
| SEATTLE <-> SAN_FRAN | 1 | 1 | 1 | 4 | 4 | 40 | 16 | 32 | 32 | 32 | 32 | 1,360.00 |
| WASHINGTON <-> NEW_YORK | 1 | 1 | 0 | 2 | 2 | 40 | 35 | 70 | 70 | 70 | 70 | 2,300.00 |
| Total | 23 | 23 | 24 | 94 | 94 | 920 | 410 | 820 | 820 | 820 | 820 | 34,000.00 |

**3.4** Close the Bill-Of-Materials file.

**End of Procedure 5-1**

# Transparent Mode

**Procedure 5-2 Transparent Mode**

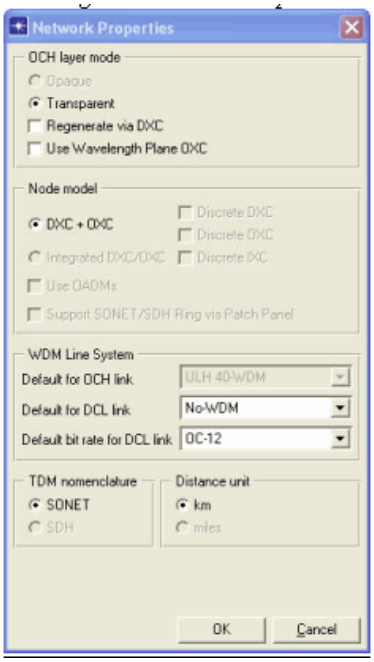
**1** Switch to the transparent scenario.

**1.1** Select **Scenarios > Switch To Scenario > transparent**.

**1.2** Select **Network > Network Properties...**.

The OCH layer mode is transparent in this scenario. The ULH-40 WDM system has been selected as the default WDM line system, which means all lit fibers pairs are equipped which such a line system.

**1.3** Press **Cancel** to close the **Network Properties** dialog box.




**2** Inspect the properties of the ULH 40-WDM line system type.

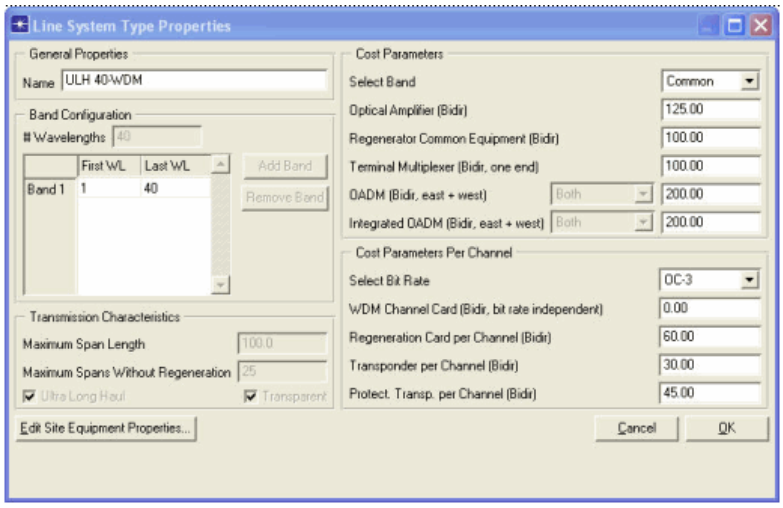
**2.1** Select **Network > Equipment Properties > WDM Link Equipment...**.

**2.2** Select the **ULH 40-WDM** line system type, then press **Edit LS Type**.

➥ The **Line System Type Properties** dialog box appears.

This dialog box displays the properties of the **ULH 40-WDM** line system type.

The Maximum Span Length is 100 kilometers and the Maximum Spans Without Regeneration is 25 span units. This implies that the maximum transparency length of this line system is 2500 kilometers.



**2.3** Close the **Line System Type Properties** and the **WDM Link Equipment** dialog boxes.

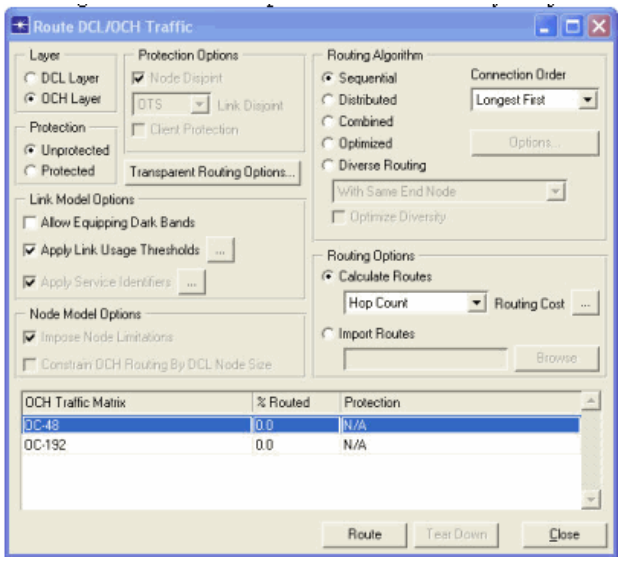
**3** Route the traffic matrix **OC-48**.

**3.1** Select **Design > Route DCL/OCH Traffic...**. In transparent mode, routing a traffic matrix implies that no link equipment is being added to the network (as in the opaque mode) and no regeneration capacity is being added to the nodes. So we try to establish as much traffic as possible within the existing link capacity and the existing in-node regeneration capacity. In this example, the node limitations do not come into play because we are using continuous node models.

**3.2** Select the **OCH Layer** and the traffic matrix **OC-48**.

**3.3** Choose the default settings for all options:

- **Unprotected** (Protection)
- **Sequential** (Routing Algorithm)
- **Longest First** (Connection Order)
- **Hop Count** (Routing Cost)
- Unmark **Allow Equipping Dark Bands**.

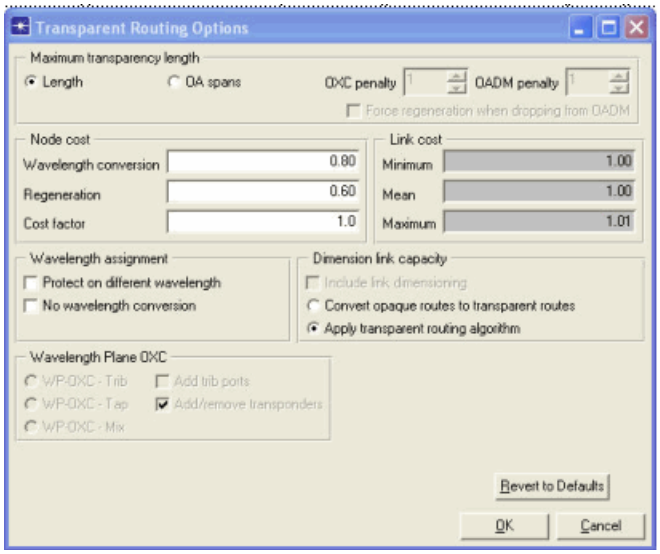



**3.4** Press the **Transparent Routing Options** button.

➥ The **Transparent Routing Options** dialog box appears.

This dialog box lets you specify some extra settings for the transparent mode. For example, the cost model for wavelength conversion and regeneration can be specified here. Refer to the SP Guru Transport Planner User Manual for more details on this cost model.

**3.5** Select **Apply Transparent Routing Algorithm** (under Dimension Link Capacity).

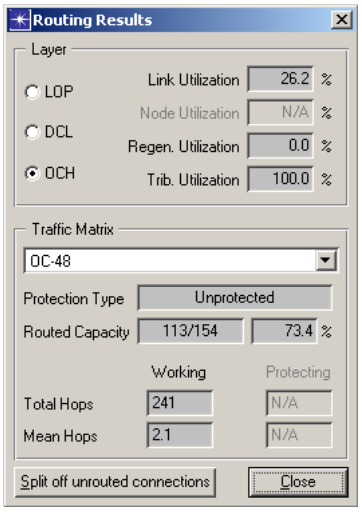



**3.6** Press **OK** to close the **Transparent Routing Options** dialog box.

**3.7** Press **Route** in the **Route DCL/OCH Traffic** dialog box.

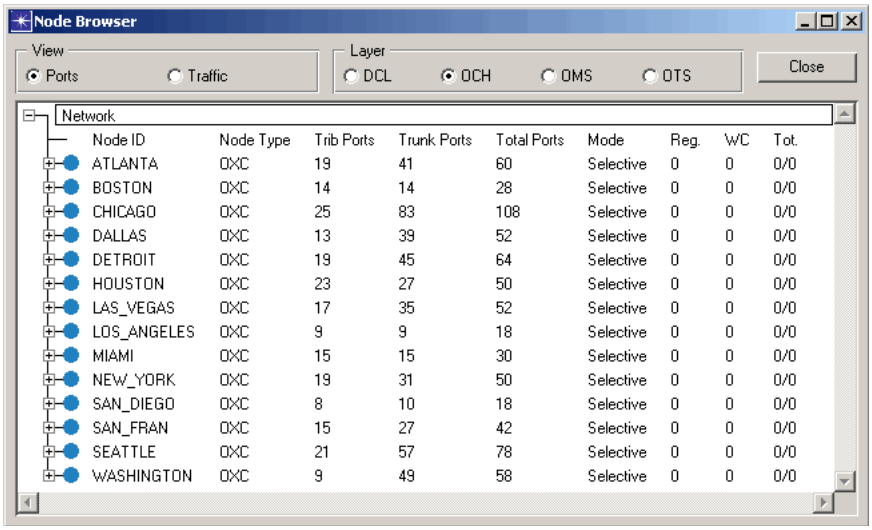
➥ The **Routing Results** dialog box appears.

**Routing Results** indicates that only 73.4% of the traffic matrix **OC-48** could be accommodated in the network. The unrouted traffic is caused by the fact that certain paths exceed the transparency reach (i.e. 2500 km) and no regeneration capacity is present in the network to solve this. Note that there is enough link capacity provided in the network: the link equipment utilization only amounts to 26%.




**3.8** Close the **Routing Results** and the **Route DCL/OCH Traffic** dialog boxes.

**3.9** Select the **Network > Node Browser** and expand the network node. All nodes are selective, but none of the nodes perform regeneration or wavelength conversion.




| Node ID | Node Type | Trib Ports | Trunk Ports | Total Ports | Mode | Reg. | WC | Tot. |
|---|---|---|---|---|---|---|---|---|
| ATLANTA | OXC | 19 | 41 | 60 | Selective | 0 | 0 | 0/0 |
| BOSTON | OXC | 14 | 14 | 28 | Selective | 0 | 0 | 0/0 |
| CHICAGO | OXC | 25 | 83 | 108 | Selective | 0 | 0 | 0/0 |
| DALLAS | OXC | 13 | 39 | 52 | Selective | 0 | 0 | 0/0 |
| DETROIT | OXC | 19 | 45 | 64 | Selective | 0 | 0 | 0/0 |
| HOUSTON | OXC | 23 | 27 | 50 | Selective | 0 | 0 | 0/0 |
| LAS_VEGAS | OXC | 17 | 35 | 52 | Selective | 0 | 0 | 0/0 |
| LOS_ANGELES | OXC | 9 | 9 | 18 | Selective | 0 | 0 | 0/0 |
| MIAMI | OXC | 15 | 15 | 30 | Selective | 0 | 0 | 0/0 |
| NEW_YORK | OXC | 19 | 31 | 50 | Selective | 0 | 0 | 0/0 |
| SAN_DIEGO | OXC | 8 | 10 | 18 | Selective | 0 | 0 | 0/0 |
| SAN_FRAN | OXC | 15 | 27 | 42 | Selective | 0 | 0 | 0/0 |
| SEATTLE | OXC | 21 | 57 | 78 | Selective | 0 | 0 | 0/0 |
| WASHINGTON | OXC | 9 | 49 | 58 | Selective | 0 | 0 | 0/0 |

**3.10** Close the node browser.

**4** Tear down the traffic matrix.

**4.1** Select **Design > Tear Down Traffic...**.

**4.2** Select the **OCH Layer** and the traffic matrix **OC-48**, then press **Tear Down**.

➥ The **OCH** traffic matrix is released from the network.

**4.3** Close the **Tear Down Traffic** dialog box.

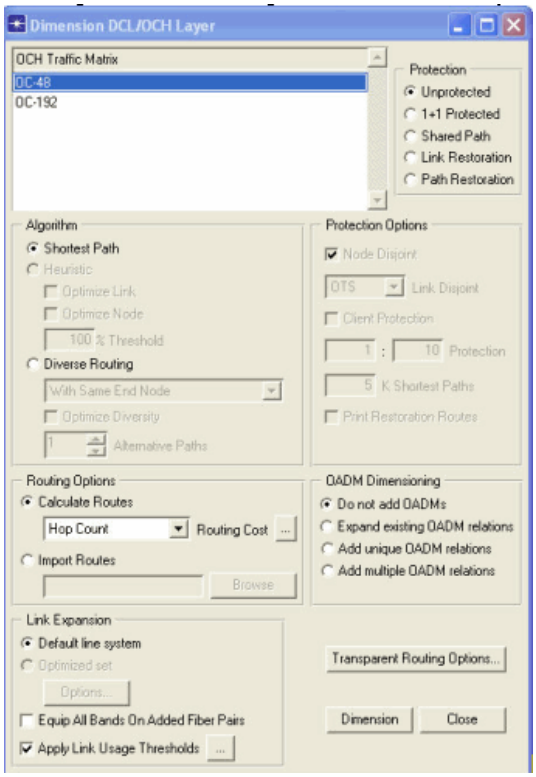
**5** Dimension the **OCH** layer.

**5.1** Select the **Design > Dimension DCL/OCH Layer...**. In transparent mode, dimensioning the OCH layer provides regeneration capacity in the selective nodes needed to try to accommodate the traffic matrix entirely in the network.

**5.2** Select the traffic matrix **OC-48** and choose the following:

- **Unprotected** as protection type
- **Shortest Path** as algorithm
- **Hop Count** as routing cost
- **Do not add OADMs** as OADM dimensioning

- Unmark **Equip All Bands On Added Fiber Pairs** (Link Expansion)




**5.3** Press **Transparent Routing Options**.

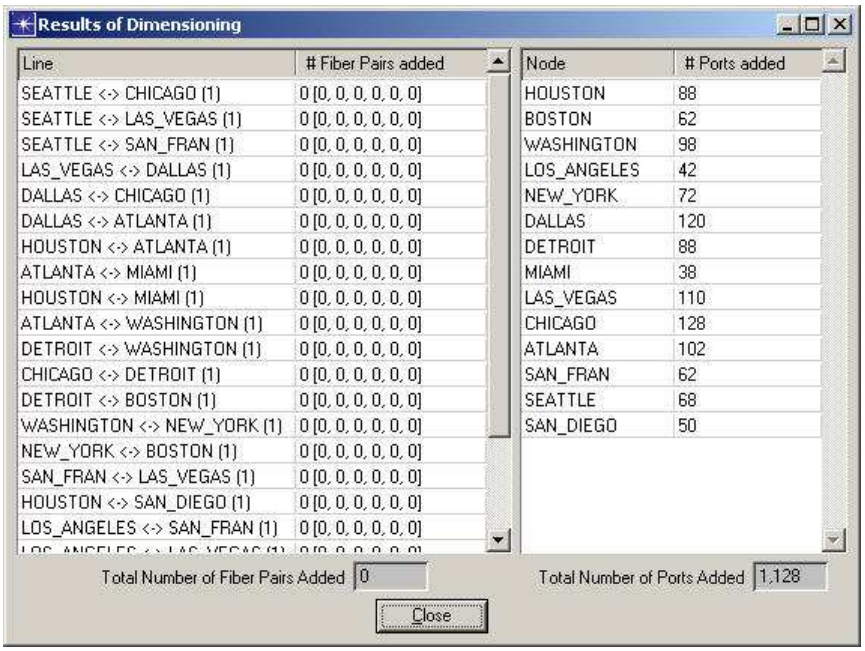
**5.4** Uncheck **Include Link Dimensioning** in the **Transparent Routing Options** dialog box. This implies that no extra link equipment will be added to the network.

**5.5** Press **OK**.

**5.6** Press **Dimension** in the **Dimension OCH/DCL Layer** dialog box.

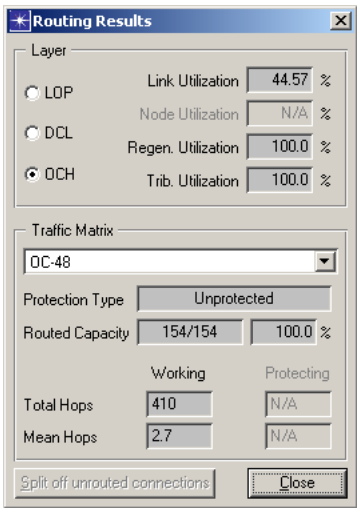
➥ The **Results of Dimensioning** dialog box appears.

No fiber pairs have been added to the network (as expected), but there has been capacity added to the nodes.



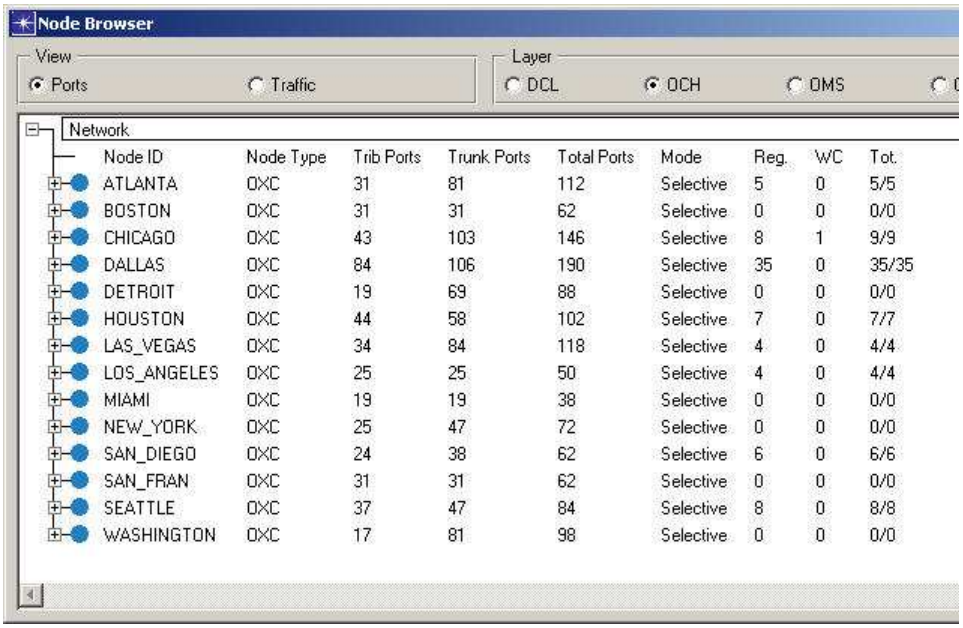

**5.7** Close the **Results of Dimensioning** and the **Dimension OCH/DCL Layer** dialog boxes.

**5.8** Open the **Design > Routing Results** dialog box. The traffic matrix **OC-48** is entirely accommodated in the network. The utilization of the in-node regeneration capacity amounts to 100 percent. This means that only the necessary regeneration capacity has been added to the selective nodes.




**5.9** Close the dialog box.

**5.10** Select the **Network > Node Browser**. Regeneration capacity has been added to some nodes. For example, in node **DALLAS** 35 regenerations are needed.




| Node ID | Node Type | Trib Ports | Trunk Ports | Total Ports | Mode | Reg. | WC | Tot. |
|---|---|---|---|---|---|---|---|---|
| ATLANTA | OXC | 31 | 81 | 112 | Selective | 5 | 0 | 5/5 |
| BOSTON | OXC | 31 | 31 | 62 | Selective | 0 | 0 | 0/0 |
| CHICAGO | OXC | 43 | 103 | 146 | Selective | 8 | 1 | 9/9 |
| DALLAS | OXC | 84 | 106 | 190 | Selective | 35 | 0 | 35/35 |
| DETROIT | OXC | 19 | 69 | 88 | Selective | 0 | 0 | 0/0 |
| HOUSTON | OXC | 44 | 58 | 102 | Selective | 7 | 0 | 7/7 |
| LAS_VEGAS | OXC | 34 | 84 | 118 | Selective | 4 | 0 | 4/4 |
| LOS_ANGELES | OXC | 25 | 25 | 50 | Selective | 4 | 0 | 4/4 |
| MIAMI | OXC | 19 | 19 | 38 | Selective | 0 | 0 | 0/0 |
| NEW_YORK | OXC | 25 | 47 | 72 | Selective | 0 | 0 | 0/0 |
| SAN_DIEGO | OXC | 24 | 38 | 62 | Selective | 6 | 0 | 6/6 |
| SAN_FRAN | OXC | 31 | 31 | 62 | Selective | 0 | 0 | 0/0 |
| SEATTLE | OXC | 37 | 47 | 84 | Selective | 8 | 0 | 8/8 |
| WASHINGTON | OXC | 17 | 81 | 98 | Selective | 0 | 0 | 0/0 |

**5.11** Close the node browser.

**6** Check the installed transponders in the network.

**6.1** Select **Info > Export to Web Report > Bill of Materials**.

➥ The web browser is launched and the bill of materials report appears.

**6.2** Select **Transponder**. In selective nodes, only long-reach transponders are installed. These are located at the tributary side of the OXC, to steer the channel into the network, and at the regeneration bank to regenerate pass-through traffic in the intermediate nodes. In this example, 464 long-reach transponders have been installed in the network compared to 820 long-reach transponders in opaque mode.

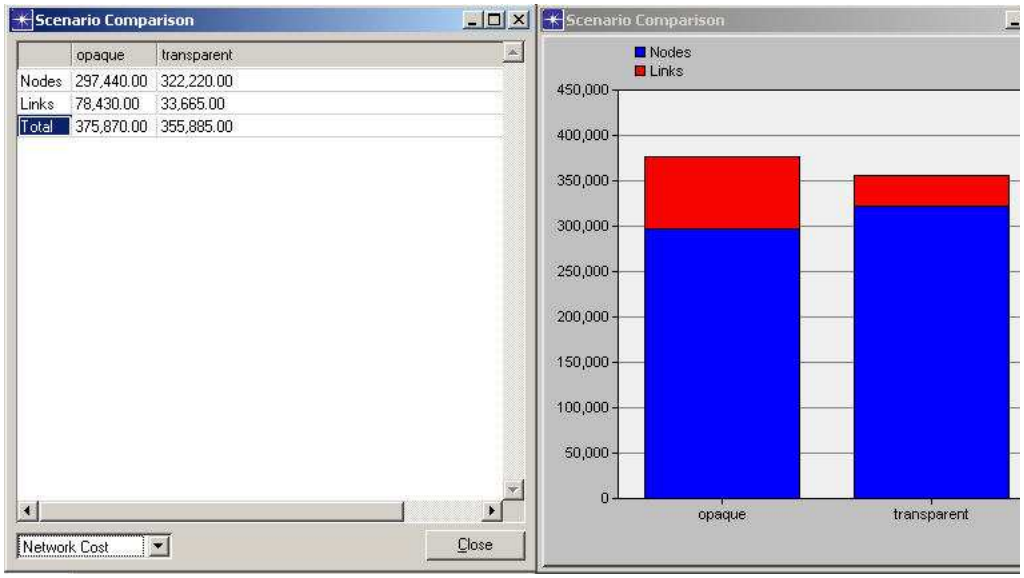
| | OC-48 | Total | Cost |
|---|---|---|---|
| SR Transponder - Trib Opaque Nodes | 0 | 0 | 0.00 |
| SR Protection Transponder - Trib Opaque OXC/OADM/PP | 0 | 0 | 0.00 |
| LR Transponder - Trib Transparent + Trunk Opaque | 464 | 464 | 27,840.00 |
| LR Protection Transponder - Trib OXC/OADM/PP | 0 | 0 | 0.00 |
| **Total** | **464** | **464** | **27,840.00** |

**6.3** Close the **Bill of Materials** file.

**7** Compare the opaque and the transparent network design scenarios.

**7.1** Select **Scenarios > Compare Scenarios**. These dialog boxes allow you to compare the two different network design scenarios.

**7.2** Select **Network Cost** in the lower left corner of the tabular dialog box. Note the large difference in node and link cost for both designs. The link cost in the opaque scenario is high due to the long-reach transponders present in the DWDM terminals. In the transparent scenario, the long-reach transponders are installed at the tributary site of the OXCs, which results in a higher node cost and in a much lower link cost. In this example with these cost settings, the transparent scenario has a lower overall network cost.




**8** Close the dialog boxes.

**9** Close the project.

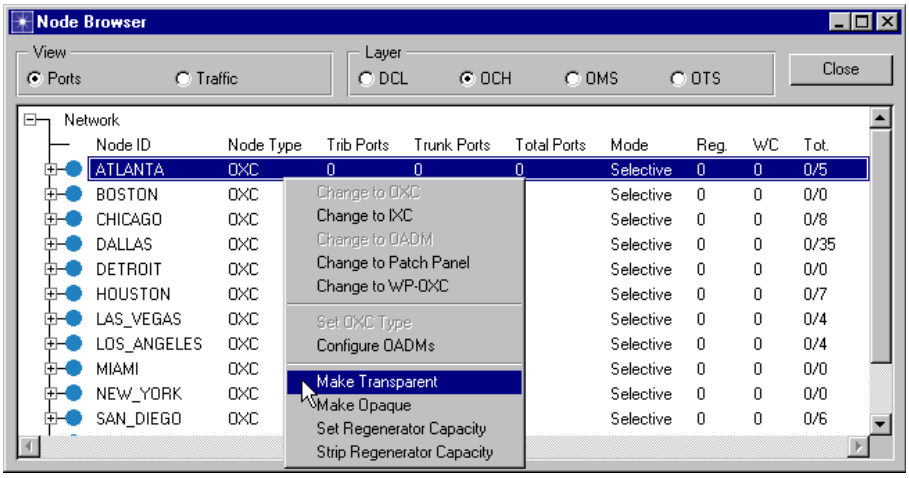
**9.1** Select **File > Close**.

**9.2** Select **Don't Save** in the **Close Confirm** dialog box.

**End of Procedure 5-2**

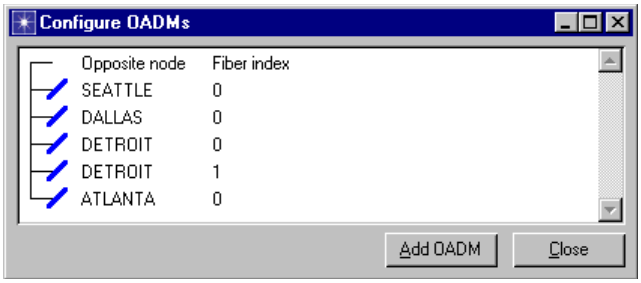
## Additional Exercises

- In the previous example, only selective nodes were considered. SP Guru Transport Planner also supports fully transparent and opaque nodes in transparent OCH layer mode. The transparency of a node can be set in the node browser.




- The example only considered OXCs in the nodes. However, SP Guru Transport Planner also supports OADM nodes in transparent mode. These nodes contain, next to an OXC, OADMs between selected fiber pairs. There are two ways to add OADMs to a node: manually or automatically.

  To create an OADM manually, select **Network > Node Browser** and choose **OCH** as layer. Right-click on a node and select **Configure OADMs**. This dialog box displays a list of all unused fiber pairs incident to the selected node. Select two fibers while holding down the Control key and press **Add OADM** to create an OADM in the node between the selected fiber pairs.




  SP Guru Transport Planner can also install the OADMs automatically while dimensioning the OCH layer. This is supported by the **OADM Dimensioning** option in the **Design > Dimension DCL/OCH Layer** dialog box.

  Redo step 5 of the previous exercise, but this time add OADMs to the nodes.

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**Procedure 5-3 Installing OADMs**

1 Open the **WDMGuru_Tutorial_Transparent_Routing** project.

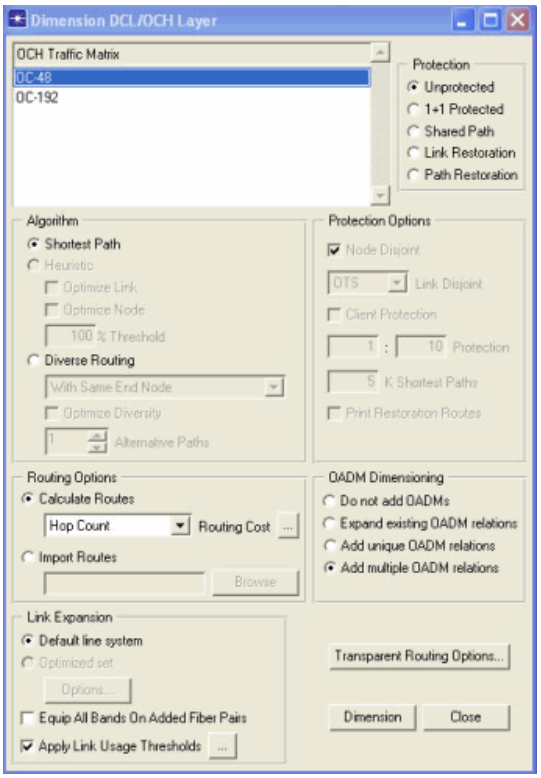
2 Switch to the **transparent** scenario (choose **Scenarios > Switch to Scenario > transparent**).

3 Strip all fibers in the network (using the **Design > Strip Capacity...** dialog box).

4 Select **Design > Dimension DCL/OCH Layer...**.

5 Select **OC-48** (OCH Traffic Matrix) and **Add multiple OADM relations** (OADM Dimensioning). Use the default settings for the other options.

6 Press **Dimension**.

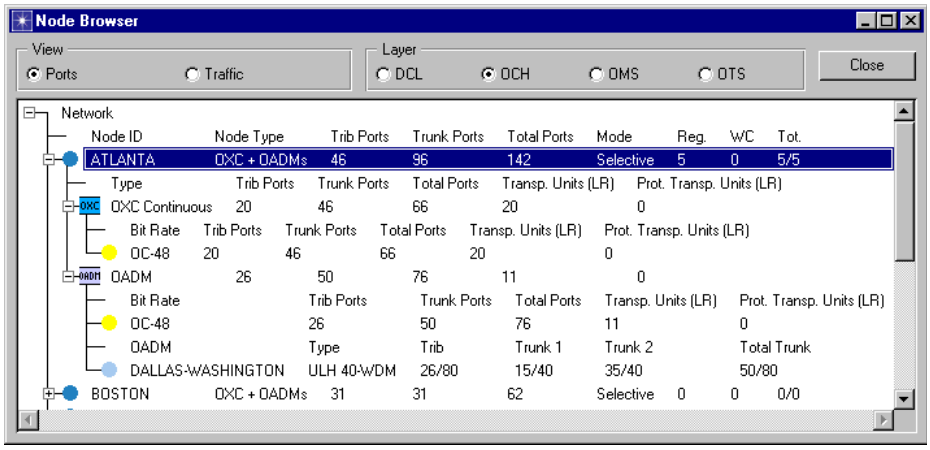



7 Close the **Dimensioning Results** and the **Dimension DCL/OCH Layer** dialog boxes.

8 Select the **Network > Node Browser**.

**9** Select node **ATLANTA**.

➥ Note that one OADM has been added to the node. The OADM is oriented between “Dallas” and “Washington”.




For more information on the OADM node models and the OADM dimensioning options, see the SP Guru Transport Planner User Guide.

**End of Procedure 5-3**