3 Network Design Operations

SP Guru Transport Planner supports network design operations based on meshed or ring network architectures. This section gives an overview of the different network design operations. Later sections step through these design operations.

- Link Design

  Before performing mesh- or ring-based network design, it is important to do OTS link design. This calculates the number of amplifiers and regenerators required on each link. Subsequent design actions take these costs into account when deciding whether to make use of particular links.

- Mesh Design

  SP Guru Transport Planner supports both SONET and optical mesh network architectures. It makes a clear distinction between mesh routing and dimensioning functions. **Routing** (both in DCL and OCH layers) tries to accommodate in the network as much traffic as possible using only the existing infrastructure. In this case, link capacities are fixed and, if there is insufficient capacity, part of the traffic remains unrouted. **Dimensioning** adds additional resources (if needed) to accommodate all traffic in the OCH layer. Resources are added while respecting a specified objective (minimum cost, shortest path, etc.). Dimensioning of the DCL layer is called **grooming** and results in a (non-native) OCH traffic demand. Analogously, grooming at the LOP layer results in a non-native DCL traffic matrix. Routing, dimensioning, and grooming algorithms are performed per traffic matrix. Successive routing, dimensioning, and grooming actions can be performed exploiting different protection strategies per traffic matrix.

- Ring Design

  SP Guru Transport Planner also supports the design of interconnected SONET/ SDH rings at the DCL layer. You can define SONET/ SDH rings (directly supported by fiber or supported by optical channels of a WDM system) and route within the capacity of these legacy rings. If all traffic cannot be routed, the rings can be upgraded to route all traffic of a SONET/ SDH demand matrix by adding stacked rings. Instead of upgrading the rings, you can choose to route the unrouted traffic on the meshed network. Also, if the rings do not cover the entire network, the mesh network can support part of the traffic matrix to create a hybrid ring-mesh network.

Link Design

To overcome signal degradation on long fiber links, the signal must be amplified and regenerated at regular intervals. Amplifier and regenerator locations are calculated according to the transmission characteristics of the line system. This is accomplished through the Link Browser dialog box at the OTS layer or the **Design > OTS Link Design** dialog box. However, in a production network the locations are already known. You can import this information from a data file, as explained in the Importing and Exporting Data chapter of the SP Guru Transport Planner *User Guide*.

Example import files are located in the following directory:

`<install_dir>\<release>\models\std\wdmguru\examples`

Procedure 3-1   Calculating Amplifier and Regenerator Locations

1 Open the WDMGuru_Examples project.

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

1.2 Select the **WDMGuru_Examples** project, then click **Open**.

➥ The example project, which contains multiple scenarios, is loaded. The Australia scenario appears in the workspace.

2 Select **Scenarios > Switch To Scenario > USA** to load the USA scenario in the workspace.

3 Do OTS link design to calculate the amplifier and regenerator locations.

3.1 Select **Design > Link Design...**.

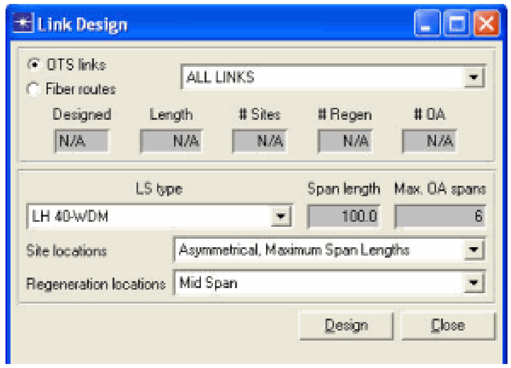
➥ The **Link Design** dialog box appears.

You can select one link or design all the links simultaneously.

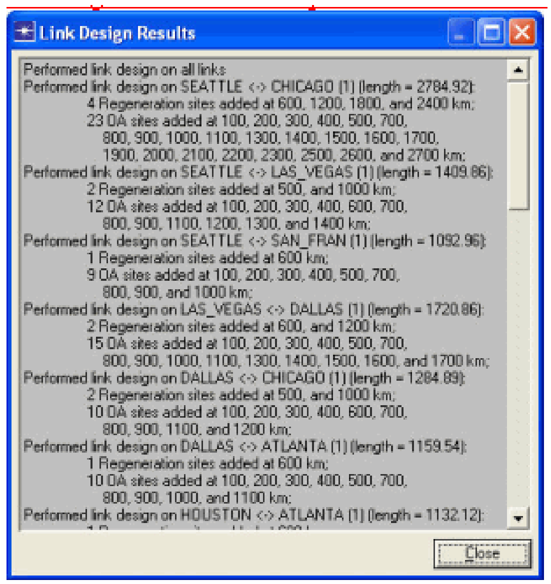
3.2 Choose **ALL LINKS** to design all links.

3.3 You can design a link for a specific WDM line system type or for ALL LSTYPES (a worst-case link design). For this example, select **LH 40-WDM** to design for the default line system type (LH 40-WDM). The other options refer to the actual placement of the sites on the link (refer to the SP Guru Transport Planner *User Guide*).

3.4 Select **Asymmetrical, Maximum Span Lengths** and **Mid Span**, then press the **Design** button.



➥ The **Link Design Results** window appears with a list of sites added on the links.



3.5 Close the **Link Design Results** and the **Link Design** dialog box.

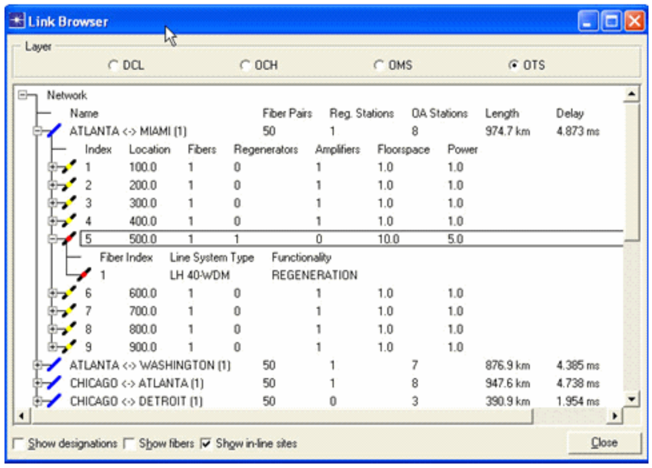
4 Inspect the OTS links.

4.1 Select **Network > Link Browser** (or double click on a link) to open the link browser.

4.2 Select **OTS** to inspect the links in the OTS layer. Mark the **Show in-line sites** option.

4.3 Click on the **+** icon (next to the links) to display the details of the amplifier and regeneration site locations. A yellow icon indicates an amplifier site, while a red icon indicates a regenerator site.

4.4 Click on the **+** icon (next to the sites) to see the functionality performed on the specific fibers in that site.



4.5 Close the link browser.

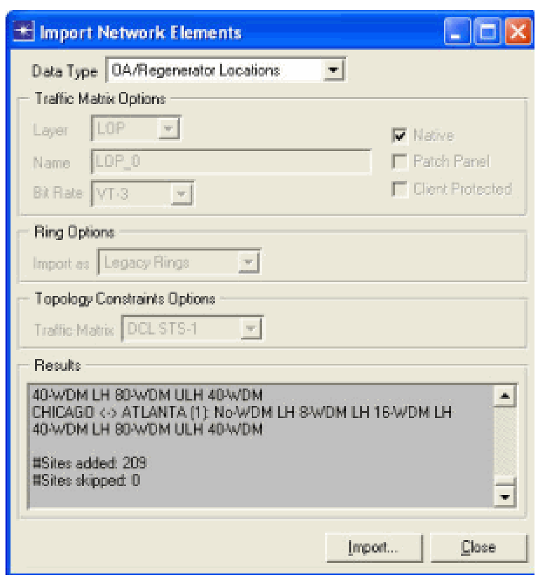
5 Import the amplifier and regenerator locations.

5.1 Select **File > Import > Network Elements...**.

5.2 Select **OA/Regenerator Locations** as the **Data Type** to import.

5.3 Click **Import** and select the file **WDMGuru_import_USA_OA_regen_locations.csv** in the directory `<install_dir>\<release>\models\std\wdmguru\examples`.

5.4 After you select the data file, 209 in-line amplifier or regenerator sites are imported. Note that the site locations calculated in the previous paragraph have been overwritten by the imported site locations.



5.5 Close the **Import Network Elements** dialog box.

6 Inspect the OTS links.

6.1 Select **Network > Link Browser** (or double click on a link) to open the link browser.

6.2 Select **OTS** to inspect the links in the OTS layer. Mark the **Show in-line sites** option.

6.3 Click on the **+** icon (next to the links) to display the details of the amplifier and regeneration site locations.

6.4 Click on the **+** icon (next to the sites) to see the functionality performed on the specific fibers in that site.

6.5 Close the link browser.

7 Close the project.

7.1 Select **File > Close**. Select **Don't Save** in the Close Confirm dialog box.

End of Procedure 3-1

Note—To export the OTS in-line sites, use the **File > Export > Network Elements...** dialog box. Exporting information from a simple network into a file is a good way to discover the required file format in case you want to generate a file by hand, or by some other means.

Routing Automatically

The examples in this section show routing actions at the OCH and DCL layer. The aim of routing is to establish as much traffic as possible within the given capacity of a network layer. These examples describe the impact of the main routing options. For more information on routing options, see the SP Guru Transport Planner User Guide.

Procedure 3-2 Routing Traffic in the Optical Layer (OCH Layer)

1 Open the WDMGuru_Examples project.

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

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

➥ The example project, which contains multiple scenarios, is loaded. The Australia scenario appears in the workspace.

2 Switch to the USA scenario.

2.1 Select **Scenarios > Switch To Scenario > USA**.

➥ The USA scenario appears in the workspace.

2.2 Use the **OMS** button on the toolbar to inspect the OMS layer. Note that initially one fiber pair is lit on each link.

2.3 Use the **OCH** button on the toolbar to inspect the OCH layer. Note that no wavelengths are in use on the links.

3 Route an OCH traffic matrix (with node limitations).

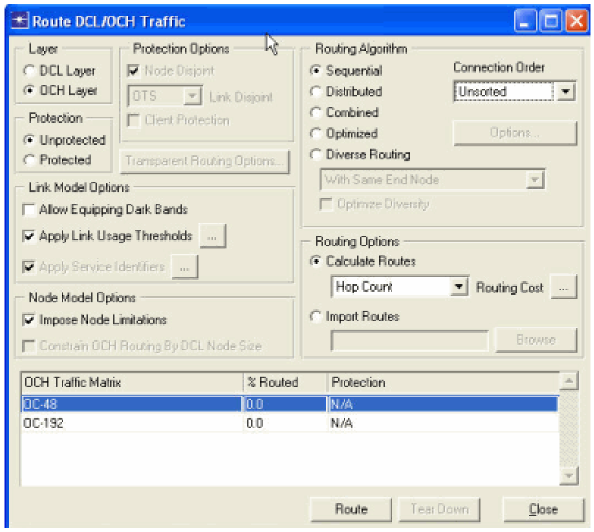
3.1 Click the  button on the toolbar or select the **Design > Route DCL/OCH Traffic** dialog box.

3.2 Select **OCH Layer** as the **Layer** and **OC-48** as the **Traffic Matrix**.

3.3 Choose the following options:

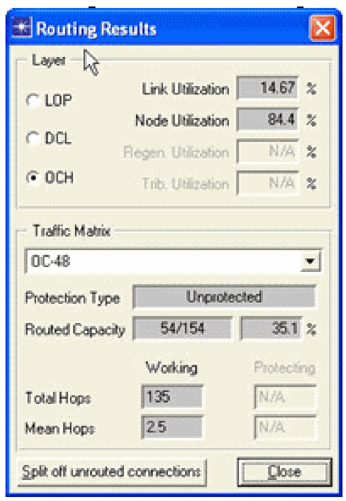
- **Unprotected** (Protection)
- **Sequential** (Routing Algorithm)
- **Unsorted** (Connection Order)
- **Hop Count** (Routing Cost)
- **Impose Node Limitations** (Node Model Options)

3.4 Uncheck **Allow Equipping Dark Bands** in the Link Model Options panel. For more information on these options, see the SP Guru Transport Planner *User Guide*.



3.5 Press **Route**.

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



Only 35 percent of the traffic could be accommodated in the network. Fourteen percent of the link capacity in the OCH layer is in use and 84 percent of the OXC capacity. Notice that the node utilization is much higher than the link utilization, and therefore the capacity shortage must be in the nodes. Also, some other statistics are reported, such as the average hop length of the connections. Access the **Routing Results** dialog box at any time using **Design > Routing Results**.

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

4 Inspect the routes of the connections.

4.1 Select **Network > Connection Browser**.

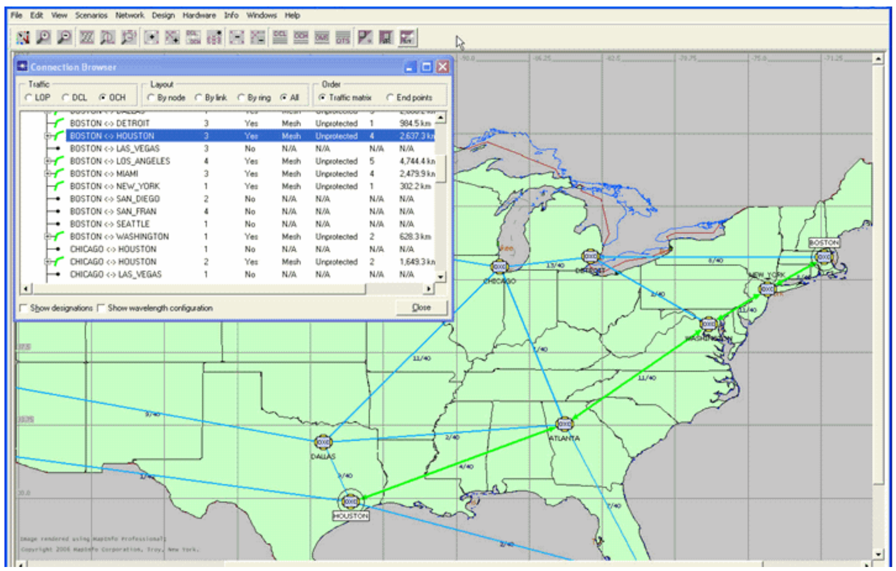
4.2 Select **OCH** for **Traffic**, **All** for **Layout**, and **Traffic Matrix** for **Order**.

4.3 Click on the **+** icon (next to OC-48) to inspect the connection details of traffic matrix OC-48.

For each connection, the following information is shown:

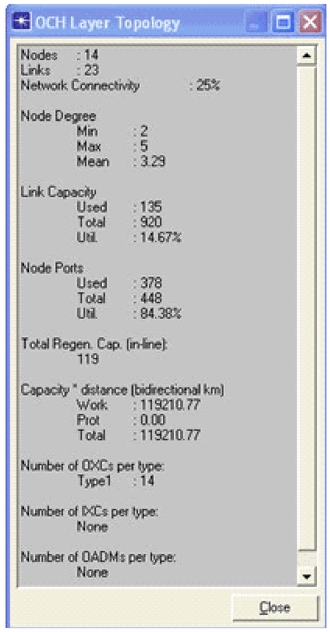
- its capacity (**Capacity**)
- whether it is routed (**Routed**)
- whether it is carried on mesh or on rings (**Carrier**)
- its protection type (**Protection**)
- its number of hops (**Hops**), length (**Length**), delay (**Delay**), etc.

When you select a connection in the browser, its route is visualized in the workspace. Click on the + icon (next to a connection), to see the route of the connection in the connection browser. To inspect the wavelengths used on the links by the selected connection, mark **Show Wavelength Configurations** in the lower-left corner of the connection browser.



4.4 Close the connection browser.

4.5 Select **Info** > **Topology** > **OCH Layer**. This dialog box provides additional network-wide statistics for the OCH layer, such as the node degree and the node and link utilization. Similar reports can be generated for each of the other layers.



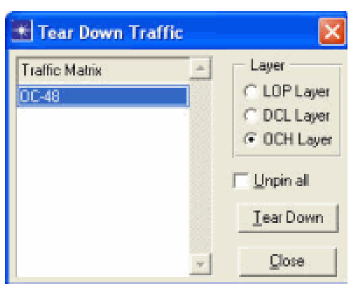
4.6 Close the **OCH Layer Topology** dialog box.

5 Tear down the OCH traffic matrix.

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

5.2 Select the **OCH Layer** and the (partly accommodated) traffic matrix **OC-48**, then press **Tear Down**.

➥ The OC-48 traffic matrix is released from the network and all capacity in the OCH layer becomes available again.



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

6 Route an OCH traffic matrix (without node limitations).

6.1 Select the **Design > Route DCL/OCH Traffic...** dialog box, choose **OCH Layer** as the **Layer**, and **OC-48** as the **Traffic Matrix**.

6.2 Choose the following options:

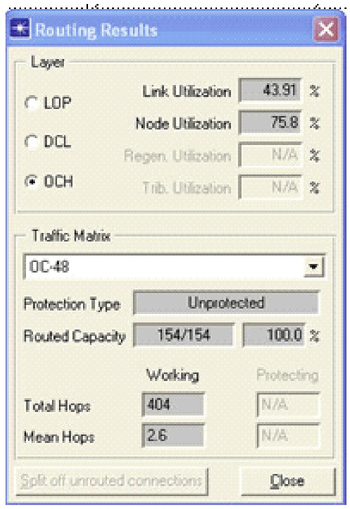
- **Unprotected** (Protection)

- **Sequential** (Routing Algorithm)
- **Unsorted** (Connection Order)
- **Hop Count** (under Routing Options, next to Routing Cost)
- Uncheck **Allow Equipping Dark Bands** in the Link Model Options panel, and also the **Impose Node Limitations** option.

6.3 Press **Route**.

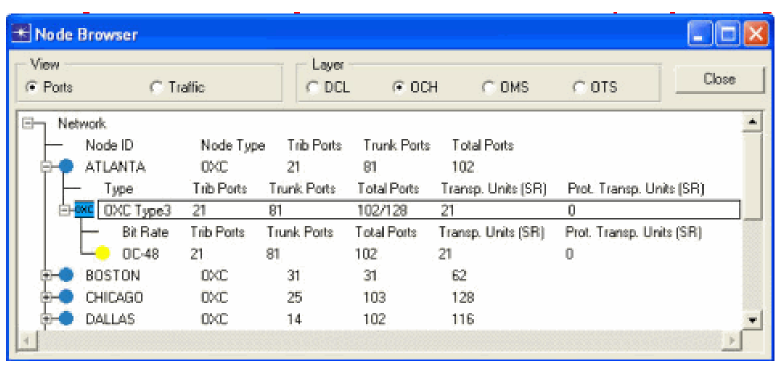
➥ The **Routing Results** dialog box appears.

Observe that 100 percent of the traffic is routed. Because the node limitations were not imposed, the discrete nodes have been upgraded to the correct size to allow them to route the entire traffic matrix.



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

8 To inspect the nodes in the OCH layer more in depth, open the **Network > Node Browser**, and then select **Ports** as the **View** and **OCH** as the **Layer**.



9 Close the node browser.

10 Tear down the OCH traffic matrix.

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

10.2 Select the **OCH Layer** and the (entirely accommodated) traffic matrix **OC-48**, then press **Tear Down**.

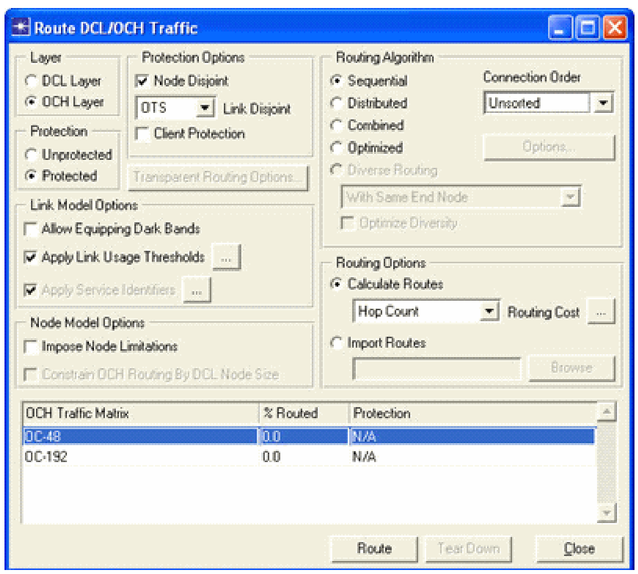
10.3 Close the dialog box.

11 Route an OCH traffic matrix (with protection).

11.1 Select **Design > Route DCL/OCH Traffic...**. In the dialog box, select **OCH Layer** and the traffic matrix **OC-48**.

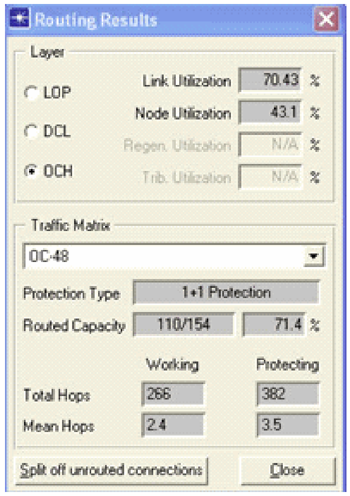
11.2 Choose the following options:

- **Protected** (Protection)
- **Node Disjoint**
- **OTS Link Disjoint**
- **Sequential** (Routing Algorithm)
- **Unsorted** (Connection Order)
- **Hop Count** (Routing Cost)
- Uncheck **Client Protection**
- Uncheck **Allow Equipping Dark Bands** (Link Model Options)
- Uncheck **Impose Node Limitations** (Node Model Options)



11.3 Press **Route**.

➥ The **Routing Results** dialog box indicates that the traffic matrix OC-48 could not be entirely accommodated in the network. Therefore, there must be a capacity shortage on the links (as indicated by the high link utilization), because not all traffic can be assigned a working path and a diverse protection path.



11.4 Close the **Routing Results** dialog box.

Note that the traffic matrix OC-48 remains part of the list of traffic matrices in the **Routing** dialog box, because it is not entirely routed. This gives the opportunity to try to route the unrouted part of the traffic matrix, for example, after adding link or node capacity.

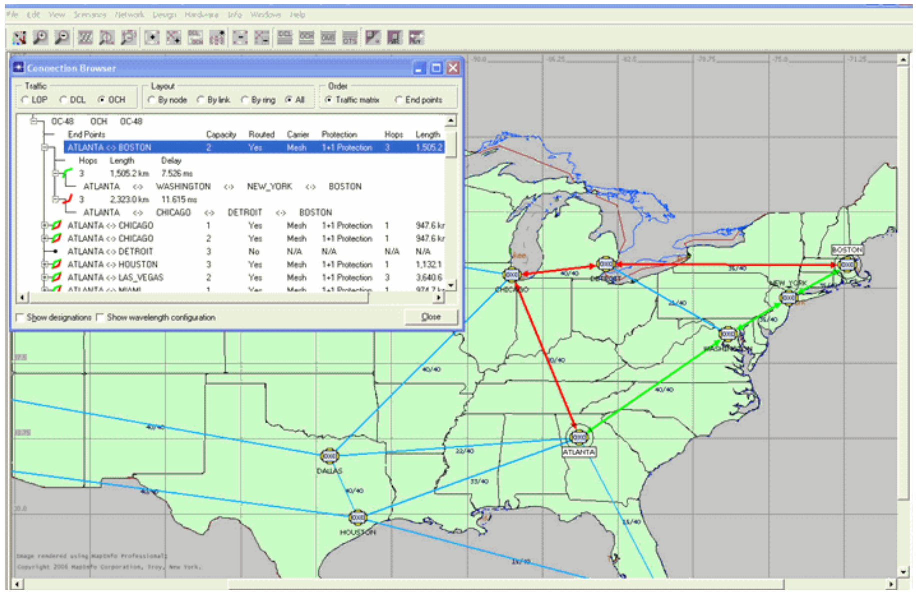
11.5 Close the **Route DCL/OCH Traffic** dialog box.

12 Inspect the routes of the connections.

12.1 Select **Network > Connection Browser**.

12.2 Select **OCH** for the **Traffic**, **All** for the **Layout**, and **Traffic Matrix** for the **Order**.

12.3 Click on the **+** icon (next to OC-48) to inspect the connection details of traffic matrix OC-48. Select a connection: the working path (in green) and back-up path (in red) are shown on the workspace.



12.4 Close the connection browser.

13 Close the project

13.1 Select **File** > **Close**.

13.2 Select **Don’t Save** in the **Close Confirm** dialog box.

End of Procedure 3-2

Procedure 3-3 Routing Traffic in the SONET/ SDH Layer (DCL Layer)

1 Open the WDMGuru_Examples project.

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

1.2 Select the **WDMGuru_Examples** project an press **Open**.

➥ The example project, which contains multiple scenarios, is loaded. The Australia scenario appears in the workspace.

2 Select **Scenarios > Switch To Scenario > USA** to view the USA scenario in the workspace.

3 Route an OCH traffic matrix (without node limitations).

3.1 Select **Design > Route DCL/OCH Traffic...** dialog box.

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

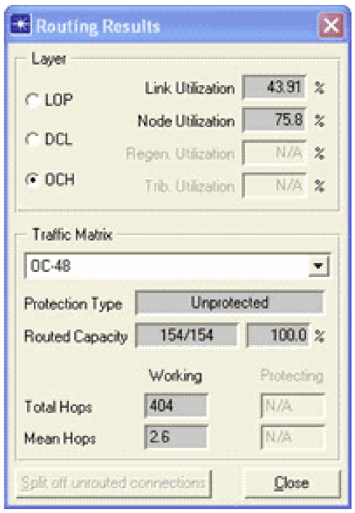
3.3 Choose the following options:

- **Unprotected** (Protection)
- **Sequential** (Routing Algorithm)
- **Unsorted** (Connection Order)
- **Hop Count** (Routing Cost)
- Uncheck **Allow Equipping Dark Bands** (Link Model Options)
- Uncheck **Impose Node Limitations** (Node Model Options)

3.4 Press **Route**.

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

The traffic matrix OC-48 is entirely accommodated in the network.



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

3.6 Switch to the DCL layer view using the **DCL** button in the toolbar.

Note that the traffic routed in the OCH layer results in a logical (or virtual) topology in the DCL layer. This is because each non-native connection that is routed in the OCH layer results in a logical DCL link with capacity corresponding to the bit rate of the OCH connection. DCL traffic can be routed on these logical DCL links (see the next step).

4 Route a SONET/SDH traffic matrix.

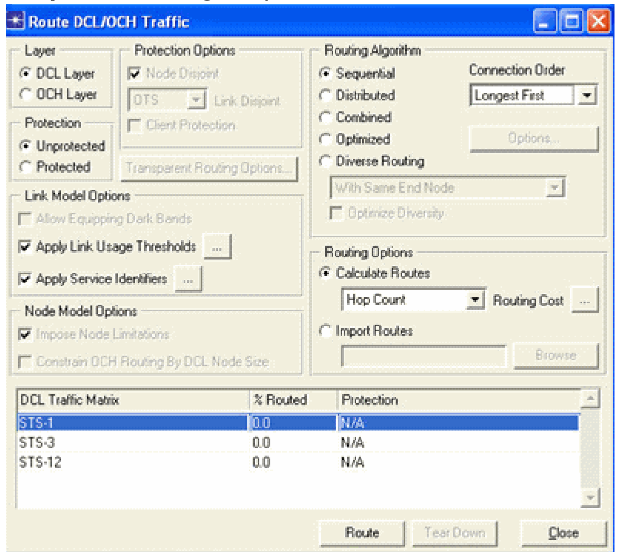
4.1 Select the **Design > Route DCL/OCH Traffic...** dialog box.

4.2 Select **DCL Layer**, and the traffic matrix **STS-1**.

4.3 Choose the following options:

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

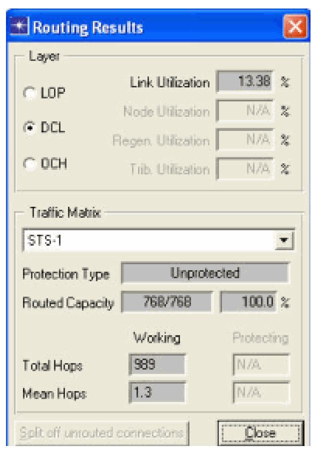
Note that the option **Impose Node Limitations** is always checked and cannot be unchecked for DCL traffic, because continuous node models are being used in the DCL layer (this can be verified in the **Network > Network Properties** dialog box).



4.4 Press **Route**.

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

The traffic matrix STS-1 is entirely accommodated in the network.



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

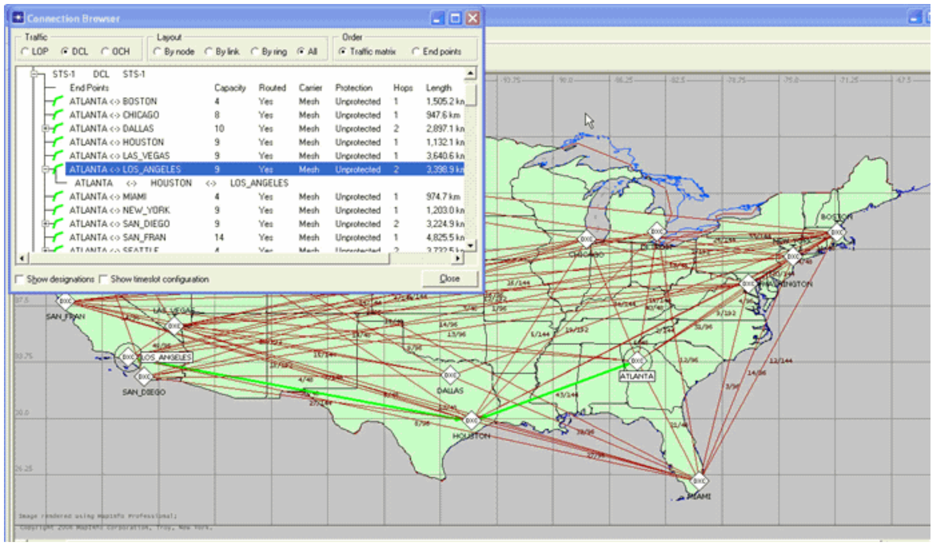
4.6 Switch to the DCL layer using the **DCL** button in the toolbar. Note that some link capacity at the DCL layer is in use now.

5 Inspect the routes of the SONET/SDH connections.

5.1 Select **Network > Connection Browser**.

5.2 Select **DCL** for the **Traffic**, **All** for the **Layout**, and **Traffic Matrix** for the **Order**.

5.3 Click on the **+** icon (next to STS-1) to inspect the connection details of traffic matrix STS-1.



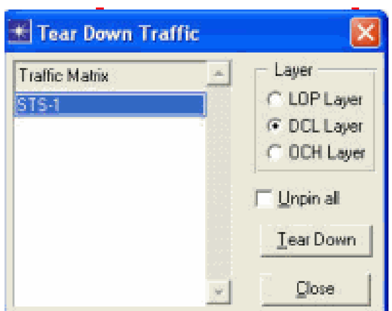
5.4 Close the connection browser.

6 Tear down the traffic matrices.

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

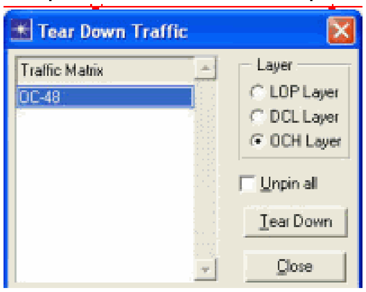
6.2 Select the **DCL Layer** and the traffic matrix **STS-1**, and press **Tear Down**.

➥ The DCL traffic matrix is released from the network, and all capacity in the DCL layer becomes available. The OCH traffic matrix OC-48 is still accommodated in the network.



6.3 Select the **OCH Layer**; select **OC-48** and press **Tear Down**.

➥ The OCH traffic matrix is released from the network. Note that the order in which traffic matrices are torn down is important. Before tearing down an OCH traffic matrix, any dependent DCL traffic matrix must be torn down first. If you do try to tear down an OCH traffic matrix that is still supporting routed DCL layer traffic, you will receive an error message directing you to first perform a tear down operation for DCL traffic matrices.



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

7 Close the project

7.1 Select **File** > **Close**.

7.2 Select **Don’t Save** in the **Close Confirm** dialog box.

End of Procedure 3-3

Routing Manually

The previous routing actions attempt to route all connections that are part of a selected traffic matrix. An algorithm automatically calculates routes, driven by the chosen routing criteria. Automated routing of an entire traffic matrix does not allow you to specify how individual connections are to be routed. To address this need, the **Routing Wizard** allows you to select individual connections and route them manually.

Procedure 3-4 Routing OCH and DCL Connections Manually

1 Open the WDMGuru_Examples project.

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

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

➥ The example project, which contains multiple scenarios, is loaded. The Australia scenario appears in the workspace.

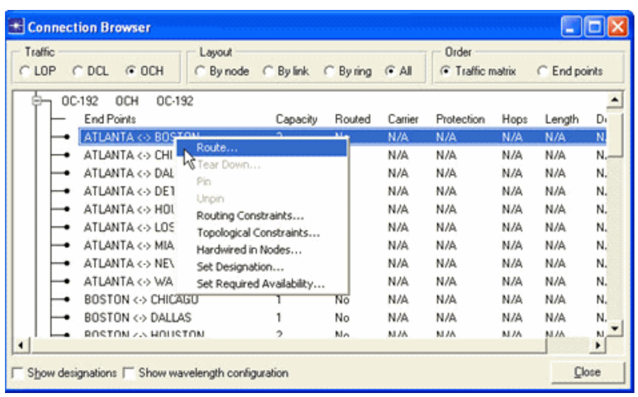
2 Select **Scenarios > Switch To Scenario > USA** to view the USA scenario in the workspace.

3 Routing manually in the OCH layer.

3.1 Select **Network > Connection Browser**.

3.2 Select the **OCH** layer and expand the **OC-192** traffic matrix (using the **+** icon).

3.3 Right click on the **ATLANTA <-> BOSTON** connection and select **Route**.



➥ The **Routing Wizard ATLANTA = BOSTON** dialog box appears.

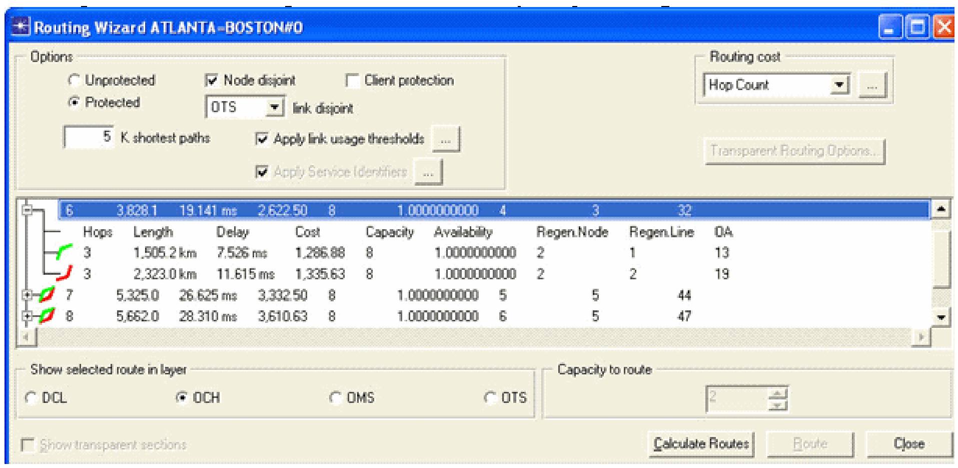
3.4 Select **Protected** to route the connection using the 1+1 protection scheme. Put a checkmark next to **Node Disjoint** (do not put a checkmark next to **Client Protection**) and select **OTS Link Disjoint**.

3.5 Click **Calculate Routes**.

➥ This dialog box now shows a list of possible routes with the main characteristics of each route (length, cost, capacity, availability, etc.). You can sort the connections according to these criteria by setting the appropriate criterion in the **Routing Cost** field. By clicking on a proposed route in the list, the path that would be assigned is displayed in the workspace.

3.6 Use the **+** icon to inspect the characteristics of the working and protection paths. Select the first route. In the **Capacity to Route** field you can select the capacity to route along this path. Select **2** (Capacity to Route), then click **Route**.

➥ The connection is now accommodated in the network. The connection browser shows that the connection ATLANTA <-> BOSTON is now routed in the network.



3.7 Right-click on the connection **ATLANTA <-> CHICAGO** in the connection browser and select **Route…** to route this connection manually.

➥ The **Routing Wizard** dialog box for this connection appears.

Note that it is no longer possible to route this connection unprotected, because all connections of a given traffic matrix must use the same protection scheme.

3.8 Accept the default settings and click **Calculate Routes**.

➥ A list of candidate routes appears in the treeview.

3.9 Select the route with the shortest fiber length and click **Route**.

➥ The connection **ATLANTA <-> CHICAGO** is now also accommodated in the network.

3.10 Close the **Routing Wizard** dialog box and the connection browser.

3.11 Select the DCL layer view by clicking on the **DCL** button in the toolbar.

➥ As a result of routing two connections in the OCH layer, two logical links are created in the DCL layer.

4 Now you will perform manual routing in the DCL layer.

4.1 Select **Network > Connection Browser**.

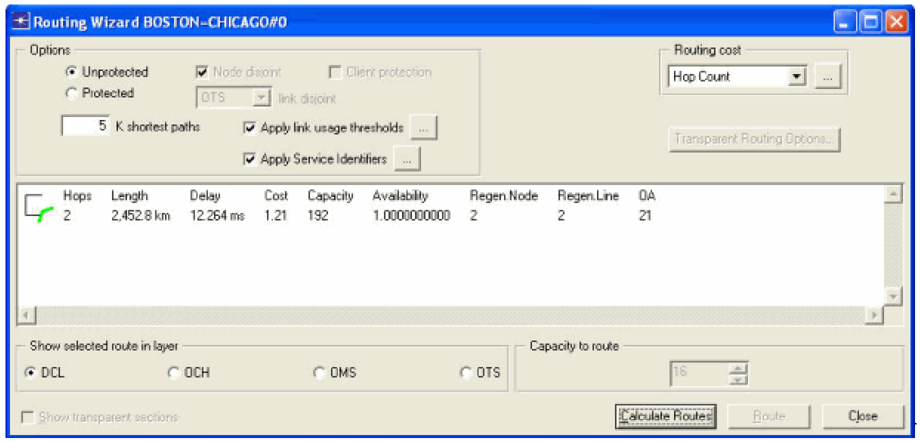
4.2 Select the **DCL** layer and expand the **STS-1** traffic matrix (using the **+** icon).

4.3 Right-click on the **BOSTON <-> CHICAGO** connection and select **Route.**

➥ The **Routing Wizard** dialog box for this connection appears.

4.4 Accept the default settings and click **Calculate Routes**.

➥ A list of potential routes appears, but now it shows routes through the DCL-layer infrastructure. There is only one possible route, because there are only two links in the DCL layer.



4.5 Select the only available route, choose **16** for the **Capacity to Route**, and then press **Route** to accommodate the connection in the network.

➥ The connection appears routed in the connection browser.

You can also visualize the route of the DCL connection in the OCH layer by clicking on the **OCH** button in the toolbar. Both the working and protection parts are shown. Even though there was no path diversity available at the DCL layer, there is underlying diversity in the OCH layer, as a result of routing the OCH connections with protection.

5 Close the project

5.1 Select **File** > **Close**.

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

End of Procedure 3-4

Dimensioning

The following procedure shows how to dimension the OCH layer to accommodate all traffic of a specified OCH traffic matrix in the network. Two routing strategies are described: a shortest-path algorithm and an optimized algorithm. For more information about other dimensioning options, see the SP Guru Transport Planner User Guide.

Procedure 3-5 Dimensioning the OCH Layer

1 Open the **WDMGuru_Examples** project.

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

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

➥ The example project which contains various scenarios loads. The Australia scenario appears in the workspace.

2 Select **Scenarios > Switch To Scenario > USA** to view the USA scenario in the workspace.

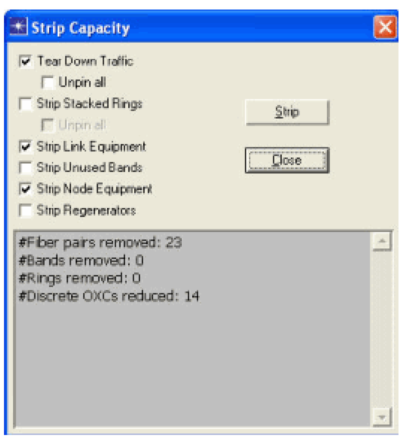
3 Strip capacity.

3.1 Select **Design > Strip Capacity...**.

3.2 Select **Tear Down Traffic** to release all OCH and DCL traffic in the network.

3.3 Select **Strip Node Equipment** to downgrade all discrete nodes to their smallest possible size.

3.4 Select **Strip Link Equipment** to remove all fiber pairs that carry no traffic. then press **Strip**.



3.5 Close the **Strip Capacity** dialog box.

4 Dimension the OCH layer (shortest path algorithm).

4.1 Select **Design** > **Dimension DCL/OCH Layer...**, and choose traffic matrix **OC-48.**

➥ This dialog box is used to fully route and accommodate wavelength demands in the network. If needed, extra equipment is installed in the network to make sure all traffic demands can be accommodated.

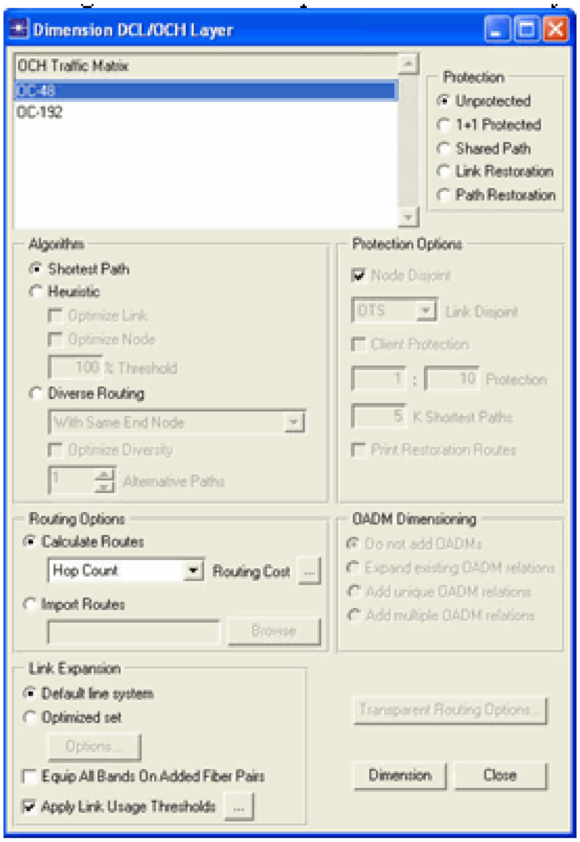
4.2 Choose **Shortest Path** (Algorithm).This implies that each connection is routed along the shortest path—that is, the path with the lowest cost—between its two endnodes.

4.3 Choose **Unprotected** (Protection). This implies that no back-up path is created for the routed connections.

4.4 Choose **Hop Count** (Routing Cost). The algorithm searches the path with the fewest hops.

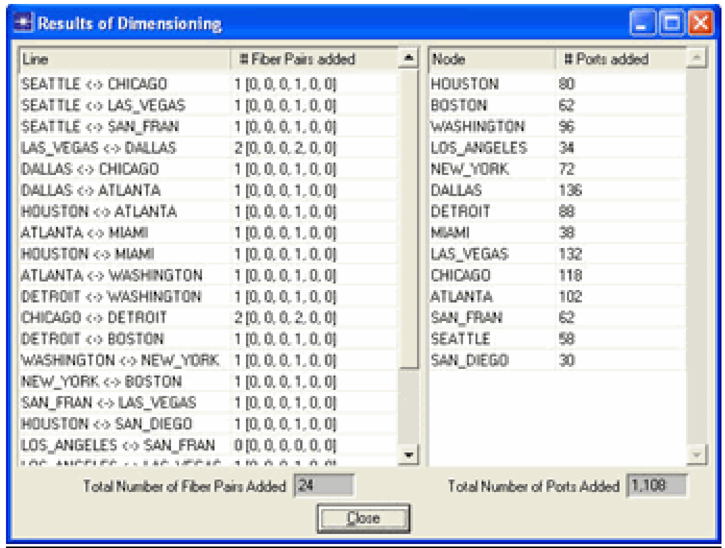
4.5 Choose **Default line system** (Link Expansion). This ensures that all added line systems are of the default type (LH 40-WDM).

4.6 Uncheck **Equip All Bands On Added Fiber Pairs** (Link Expansion). This means that only the necessary bands are equipped on the added fiber pairs.



4.7 Click **Dimension**.

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



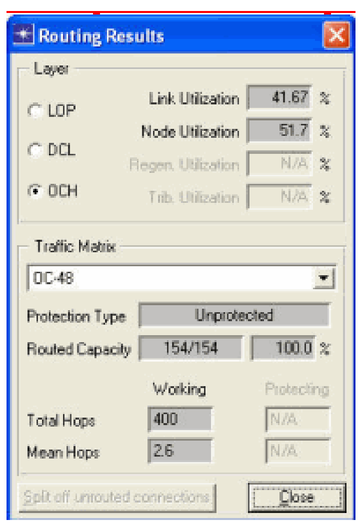
This dialog box gives an overview of the equipment added in the network to accommodate the traffic matrix OC-48. Pay attention to the total number of fiber pairs and OXC ports to compare these with the results of step 9.5, below.

4.8 Close the dialog boxes.

5 Inspect the results.

5.1 Select **Design > Routing Results**.

5.2 Select the **OCH** layer and the traffic matrix **OC-48**. As expected, the traffic matrix OC-48 is entirely accommodated in the network. Additional statistics regarding the capacity and hop length are provided.

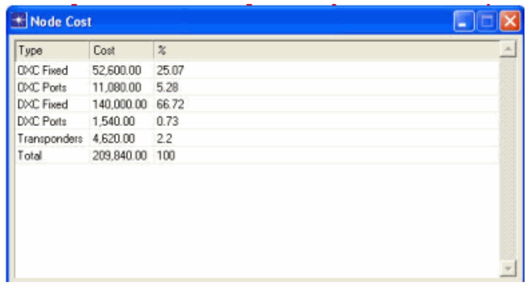


5.3 Close the dialog box.

6 Inspect the required equipment.

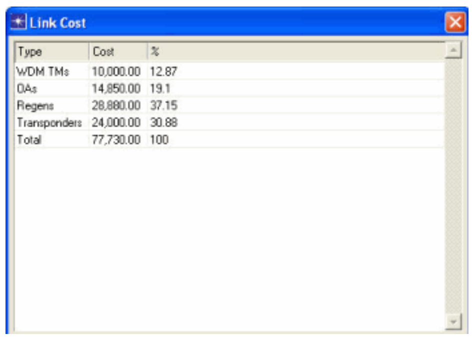
6.1 Select **Info > Network Cost > Node Cost**.

➥ The **Node Cost** dialog box appears with an overview of the required node components and their cost.



6.2 Select **Info > Network Cost > Link Cost**.

➥ The Link Cost dialog box appears with an overview of the required link components and their cost.

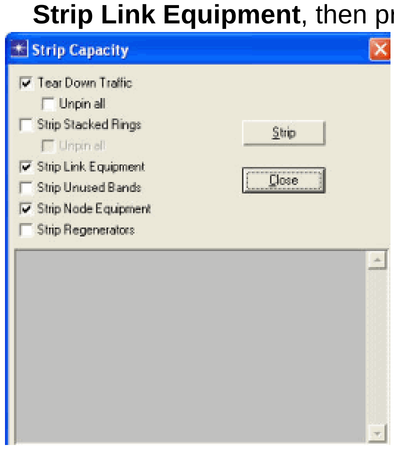


7 Close the **Node Cost** and **Link Cost** windows.

8 Strip capacity.

8.1 Select **Design > Strip Capacity...**.

8.2 Put a checkmark next to **Tear Down Traffic**, **Strip Node Equipment,** and **Strip Link Equipment**, then press **Strip**.



➥ This removes all traffic and equipment from the network.

8.3 Close the dialog box.

9 Dimension the OCH layer (heuristic algorithm).

9.1 Select **Design > Dimension DCL/OCH layer...**.

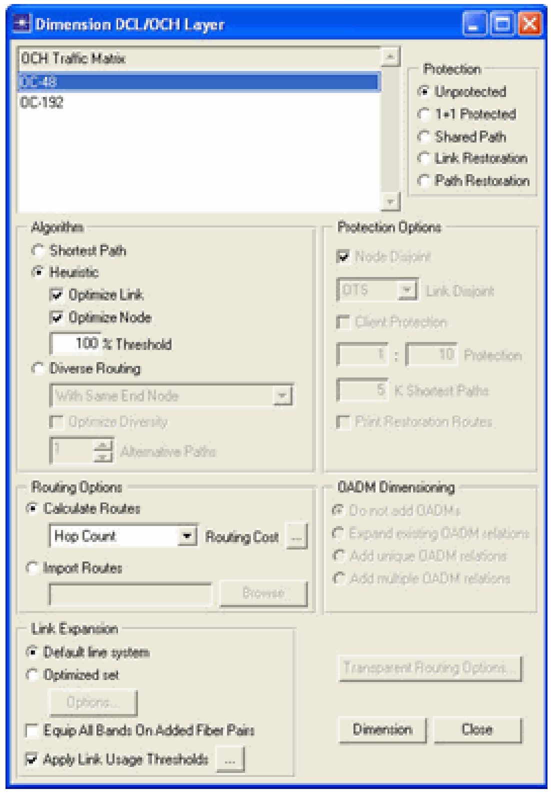
9.2 Select **OC-48**, **Unprotected**, **Hop Count,** and **Default line system**.

9.3 Select **Heuristic** (Algorithm) and put a checkmark next to **Optimize Link**. With this option selected, the heuristic tries to remove poorly utilized line systems, by rerouting traffic along other (longer) routes.

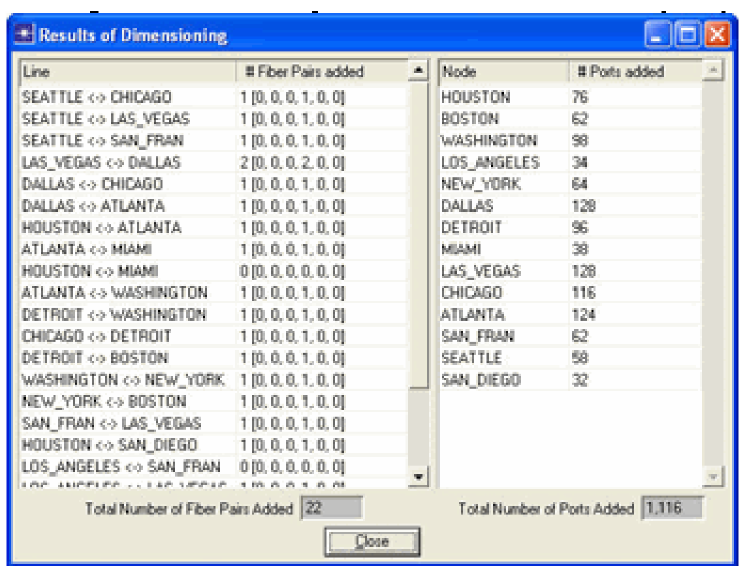
9.4 Put a checkmark next to **Optimize Node**. With this option selected, the heuristic tries to reroute some of the traffic to downgrade poorly-utilized node facilities and reduce costs.

Note that the latter option is valid only for discrete OCH nodes. You can also specify a threshold: if the threshold indicates 50 percent, the heuristic only attempts to remove fiber pairs (or node types) for which the utilization is lower than 50 percent.

9.5 Enter **100** percent for the **Threshold**, then click **Dimension**.



➥ The **Results of Dimensioning** dialog box indicates that the heuristic results in fewer fiber pairs (on the link between HOUSTON and MIAMI, for example) and smaller OXCs (in node NEW_YORK, for example) than the shortest path algorithm. The number of used OXC ports is higher, however, due to the longer routes taken by some of the connections.



9.6 Close the dialog boxes.

10 Close the project.

10.1 Select **File** > **Close**.

10.2 Select **Don’t Save** in the **Close Confirm** dialog box.

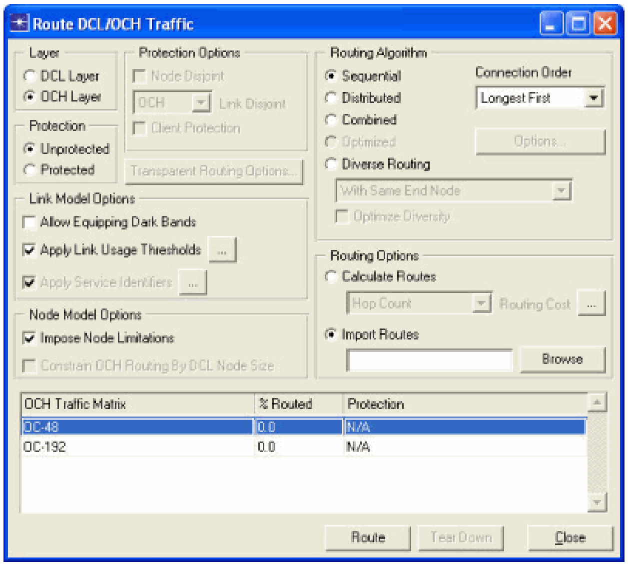
End of Procedure 3-5

Additional Exercises

- After dimensioning the OCH layer for a specific traffic matrix, you can upgrade the design for another traffic matrix. This traffic matrix could represent traffic later in time, or additional traffic that needs to be established using a different protection mechanism. For each traffic matrix, a separate dimensioning action can be applied using the most appropriate protection mechanism for that traffic matrix. This allows you to accommodate traffic with different service levels within the same network.

- In the examples considered in this tutorial, the OTS, OMS, and OCH topologies are identical. This means that protected routing on the OCH layer results in working and protecting paths that are disjoint from the OCH layer down to the OTS layer. With the introduction of cable splitters (**Edit > Open Object Palette**) and fiber routes (**Design > Fiber Routing...**), you can create a network with different topologies at each network layer. In such a network, the **Link Disjoint** option becomes important. The routing and dimensioning algorithm take the shared risk link group concept into account down to the layer selected. For example, selecting **OCH Link Disjoint** results in a working and protecting path that are disjoint at the OCH layer, but these paths are not necessarily disjoint down to the OMS or OTS layer. To make sure that the working and protecting paths are disjoint to the physical layer in such a network, choose **OTS Link Disjoint** in the routing or dimensioning dialog box.

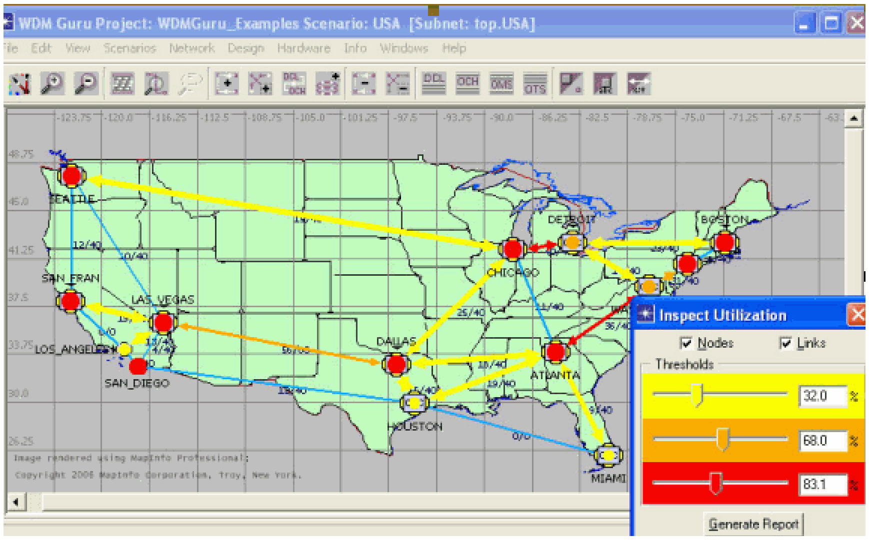
- In the examples in this tutorial, the routing or dimensioning algorithm always determines the routes. However, SP Guru Transport Planner lets you define routes. Therefore, select **Import OTS Routes** in the routing or dimensioning dialog box and specify the .csv file containing the routes. The routing or dimensioning algorithm then takes these routes into account. For a description of the file format, see the SP Guru Transport Planner User Guide.



- Even when the routing or dimensioning algorithm determines the routes, SP Guru Transport Planner still allows you to control the route. This is done by defining routing constraints. Select **Network > Connection Browser**, right-click on a connection and select **Routing Constraints**. In this dialog you can specify constraints that apply only to the selected connection. Repeat this step for each connection that you want to have constraints, and confirm each constraint by clicking **OK** in the **Routing Constraints** dialog box. When you're done, close the Connection Browser and select a design action (routing, dimensioning, and so on). The routing and dimensioning algorithm then searches the optimal route that satisfies the routing constraints of the connection. If the algorithm cannot find a route that meets the routing constraints, it does not set up a connection. See the figure below. The routing or dimensioning algorithm will search a working path shorter than 200 km and a protecting path shorter than 500 km for the given connection. Also, the number of hops of the working path has to be smaller than or equal to three. If SP Guru Transport Planner does not find a working path shorter than 200 km and shorter than 3 hops, the given connection is not set up and left unrouted.

- The Utilization Viewer allows visualizing the utilization of the nodes and the links in a layer of the network. Select **Info > Inspect Utilization**. In the **Inspect Utilization** dialog box, three levels of utilization can be defined. The links and nodes are colored according to the specified levels. The links and nodes reaching utilization level 1, 2, or 3 are colored in yellow, orange, or red, respectively. By using the toolbar buttons (**DCL**, **OCH**, **OMS** or **OTS**), the utilization can be visualized in the different layers. See the following figure. The link between Chicago and Detroit is red, which means that the utilization on this link is higher than 83.1percent. The link between San Francisco and

Los Angeles is not colored, implying that the utilization on this link is lower than 32 percent. The utilization in node Houston lies between 32 and 68 percent. To generate a report containing link utilization information, click **Generate Report** in the **Inspect Utilization** dialog box.



Grooming DCL to OCH Traffic

Routing non-native OCH traffic creates a logical DCL topology. This topology can be used for routing DCL traffic in a bottom-up approach: first traffic in the lower (OCH) layer is routed and the resulting logical topology in the upper (DCL) layer is used for routing DCL traffic. Another approach is referred to as top-down. In this approach, dimensioning of the DCL layer drives the demand for the OCH layer, which can subsequently be dimensioned. The top-down approach is called grooming in SP Guru Transport Planner. Grooming determines a logical DCL topology and maps this logical topology on the wavelengths of the OCH layer. SP Guru Transport Planner supports four grooming strategies:

- Basic end-to-end grooming
- Optimized end-to-end grooming
- Basic link-by-link grooming
- Optimized link-by-link grooming

Each of these grooming strategies results in a different logical DCL topology. Basic end-to-end grooming results in a fully meshed DCL topology, in which no electrical switching at the DCL layer occurs. Basic link-by-link grooming results in a logical DCL topology that mirrors the fiber topology, and in which electrical switching occurs in every intermediate node. Both optimized end-to-end grooming and optimized link-by-link grooming start from the corresponding basic strategies and evolve to a solution in which the logical DCL topology is a cost-optimized result which balances the cost of electrical and optical switching.

Procedure 3-6 Grooming DCL to OCH Traffic

1 Open the WDMGuru_Examples project.

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

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

➥ The example project, which contains multiple scenarios, is loaded. The Australia scenario appears in the workspace.

2 Select **Scenarios > Switch To Scenario > USA** to view the USA scenario in the workspace.

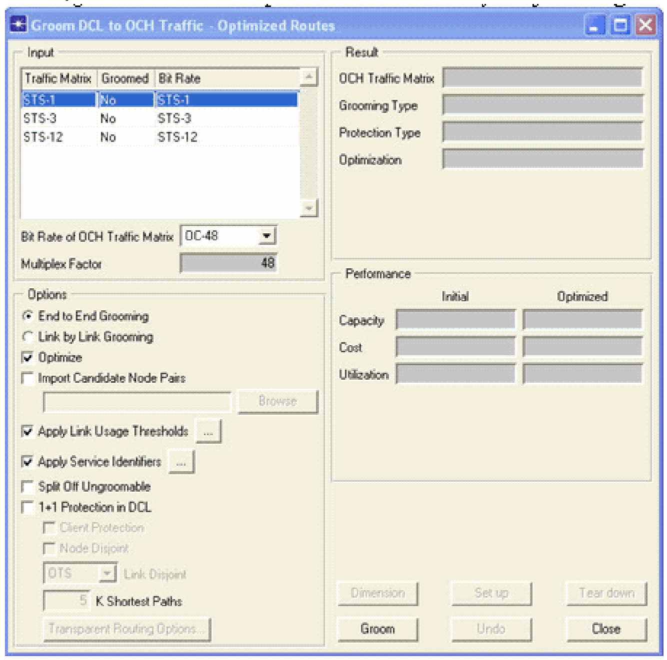
3 Groom the SONET/SDH traffic matrix.

3.1 Select the **Design > Groom DCL to OCH Traffic > Optimized Routes...** dialog box.

3.2 Select the **STS-1** DCL traffic matrix in the traffic matrix table. Select **OC-48** as target bit rate for the OCH traffic matrix in which you want to carry the DCL traffic.

This results in a multiplex factor of 48, indicating the granularity of the OCH signal versus one unit of the DCL signal.

3.3 Select **End to End Grooming** and select **Optimize** to perform optimized end-to-end grooming (do not put a checkmark next to **1+1 Protection in DCL**).

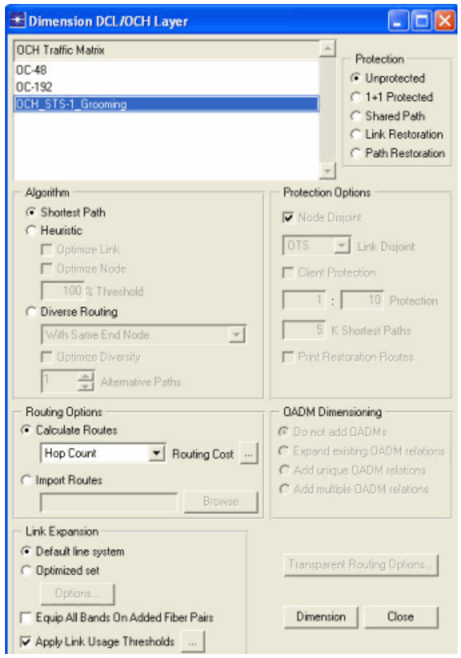


3.4 Press **Groom**.

➥ The **Grooming Optimization Progress** dialog box appears.

3.5 When the status is **Finished**, close the dialog box.

The results of the grooming action are shown on the right side of the **Grooming DCL to OCH Traffic – Optimized Routes** dialog box. The OCH_STS-1_Grooming traffic matrix contains the optical channels that are used to create the logical DCL links. The **Capacity** field indicates the number of needed optical channels, while the **Utilization** field indicates how well the capacity is used by the DCL traffic that is groomed in these optical channels.

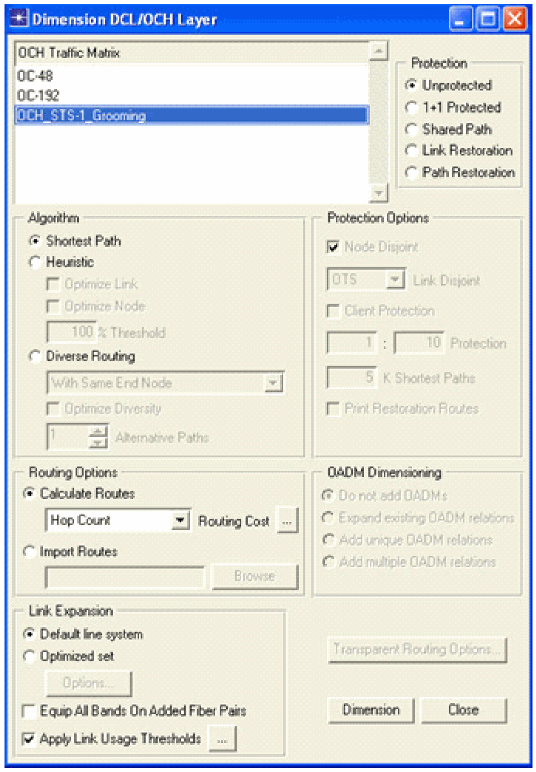


4 Dimension the OCH layer for the traffic matrix resulting from the grooming action:

4.1 Click the **Dimension** button in the **Groom DCL to OCH Traffic – Optimized Routes** dialog box.

➥ The **Dimension DCL/OCH Layer** dialog box appears.

4.2 Select the traffic matrix **OCH_STS-1_Grooming** and choose **Unprotected** (Protection Type), **Shortest Path** (Algorithm), as routing cost **Hop Count** (Routing Cost), and **Default line system** (Link Expansion).



4.3 Click **Dimension**.

➥ The OCH traffic resulting from the grooming action (OCH_STS-1_Grooming) and the groomed DCL traffic matrix STS-1 are now accommodated in the network.

4.4 Close all windows.

4.5 Click the **DCL** button on the toolbar to inspect the DCL layer view.

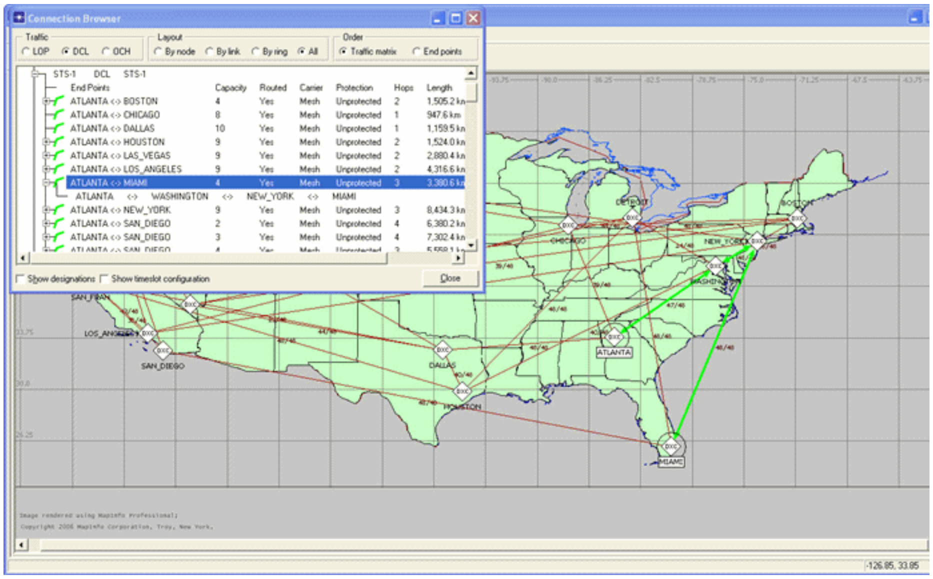
5 Inspect the routed connections.

5.1 Select **Network > Connection Browser**.

5.2 Select the **DCL** for **Traffic**, **All** for the **Layout**, and **Traffic Matrix** for the **Order**.

5.3 Expand the **STS-1** traffic matrix (using the **+** icon) and inspect the routes of this traffic matrix.

By using the tool bar button to switch the view between the OCH and DCL layer, you can inspect the routes in both layers. Inspecting a DCL route in the OCH layer reveals the path taken in the OCH layer.



6 Close the project.

6.1 Select **File** > **Close**.

6.2 Select **Don’t Save** in the **Close Confirm** dialog box.

End of Procedure 3-6

Additional Exercises

- Redo the example with different grooming strategies (basic end-to-end grooming, basic link-by-link grooming, and optimized link-by-link grooming) and compare the difference in terms of DCL topology and DCL capacity requirements. Use the **Info > Topology > DCL Layer** and **Info > Topology > OCH Layer** dialog boxes to see the link and node capacity in both layers.

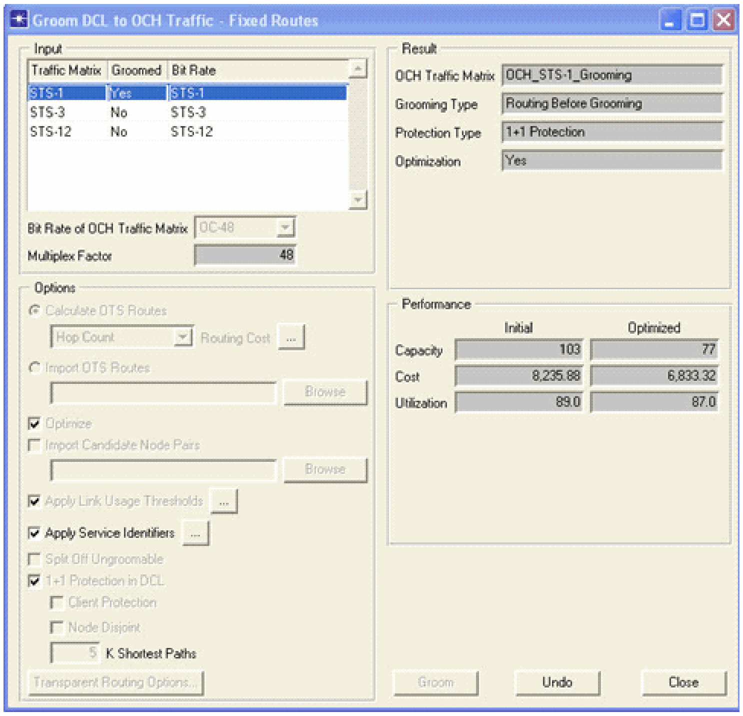
- Redo the example with 1+1 protection in the DCL layer. Using the **Link Disjoint** setting, you can force disjointness of working and protection path only at the DCL layer or down to the OCH, OMS, or OTS layer. For OTS, it is guaranteed that working and protection path will not use the same physical infrastructure—both the grooming of the DCL traffic matrix and OCH dimensioning occur in one step.

- You can disable the grooming function in specific nodes. To do so, select **Network > Node Browser** (or double click on a node). Select **Ports** for the **View** and **DCL** as the **Layer**. Right-click on a node and select **Change to TM**. A terminal multiplexer (TM) replaces the DXC. With the TM in place, the node cannot switch traffic at the DCL level, but can only aggregate or segregate DCL traffic terminated in that node. The node type cannot be changed if traffic has already been routed or groomed.

- You can groom multiple traffic matrices with or without reusing unused DCL capacity. Grooming with reuse of unused DCL capacity is achieved by grooming, dimensioning, and establishing the DCL traffic of the first traffic matrix before performing the same process for the second traffic matrix. This allows you to reuse the unused part of the DCL capacity created during the first grooming action, to host the traffic of the second traffic matrix. Grooming without reuse of unused DCL capacity is achieved by first grooming all DCL traffic matrices and then accommodating the OCH matrices (resulting from the grooming actions) and the groomed DCL matrices in the network.

- The **Design > Groom DCL to OCH Traffic > Optimized Routes...** feature optimizes routes in the DCL layer to get the lowest-cost design. This might result in some unnatural routes (e.g., with backhauling) in the OCH layer. To prevent this, the **Design > Groom DCL to OCH Traffic > Fixed Routes...**

feature is used. In this case, the (physical) routes of the DCL connections are fixed (calculated on the OTS topology or imported from a file) and the grooming optimization algorithm does not alter these physical routes; it only optimizes whether traffic is best switched optically or electrically in the nodes.



Grooming LOP to DCL Traffic

An analogous relationship as between DCL and OCH traffic (see paragraph 3.5) exists between LOP (Lower Order Path layer) and DCL traffic. Also in this case we can distinguish two approaches. The first approach is the “bottom-up” approach. Firstly, a logical LOP topology is created by accommodating non-native DCL traffic in the network. Secondly, LOP traffic is routed in this logical topology. The other approach is referred to as “top-down” or the “grooming” approach. Here, dimensioning of the LOP layer drives the demand for the DCL layer, which can subsequently be dimensioned.

SP Guru Transport Planner supports only one approach to groom LOP to DCL traffic, namely the basic end-to-end grooming approach. This implies that all LOP connections have one-hop routes (only working path) and that no switching is performed in the nodes at the LOP layer.

Procedure 3-7 Grooming LOP to DCL traffic

1 Open the **WDMGuru_Examples** project.

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

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

➥ The example project which contains various scenarios loads. The Australia scenario appears in the workspace.

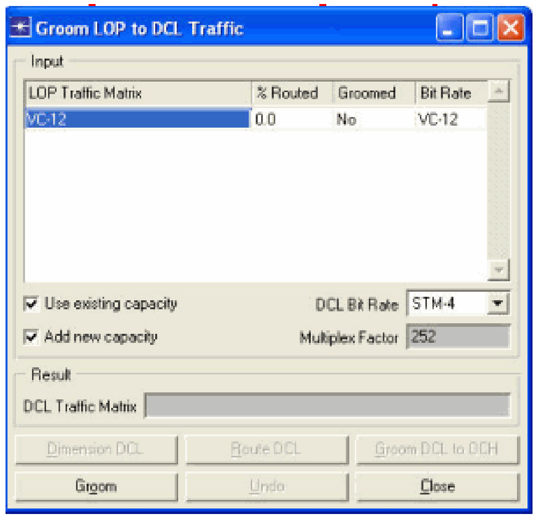
2 Groom the LOP traffic matrix.

2.1 Go to the **Design > Groom LOP to DCL Traffic** dialog box.

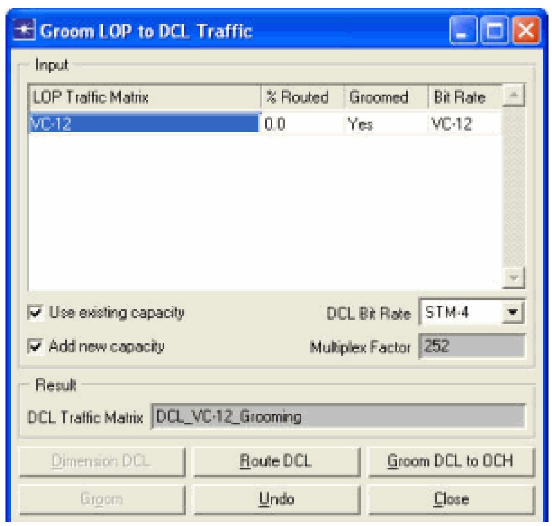
2.2 Select the **VC-12** LOP traffic matrix in the traffic matrix table. Select **STM-4** as target bit rate in which the DCL traffic matrix will carry the LOP traffic. This results in a multiplex factor of 252 between the LOP signal and the DCL signal.

2.3 Select **Use existing capacity**, implying the grooming algorithm to use the spare capacity present in the LOP layer to accommodate the LOP traffic. Note that in this example there is no spare capacity in the LOP layer, because no DCL traffic has yet been accommodated in the network. Use the **DCL** toolbar button to verify this in the DCL layer view before opening the LOP grooming dialog box.

2.4 Select **Add new capacity**. This implies that the grooming algorithm creates (if needed) a new DCL traffic matrix to host the LOP traffic.

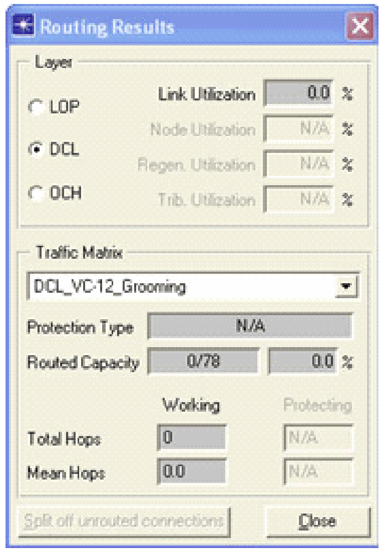


2.5 Press **Groom**. Close the results dialog box. Note that a new DCL traffic matrix (i.e. DCL_VC-12_Grooming) has been created to host the LOP traffic.



2.6 Close the **Grooming LOP to DCL Traffic** dialog box.

2.7 Go to **Design > Routing Results.** Select **DCL** (Layer) and **DCL_VC-12_Grooming** (Traffic Matrix). Note that this traffic matrix has 78 connection units, but none of them are yet accommodated in the network (0% routed).



2.8 Close the Routing Results dialog box.

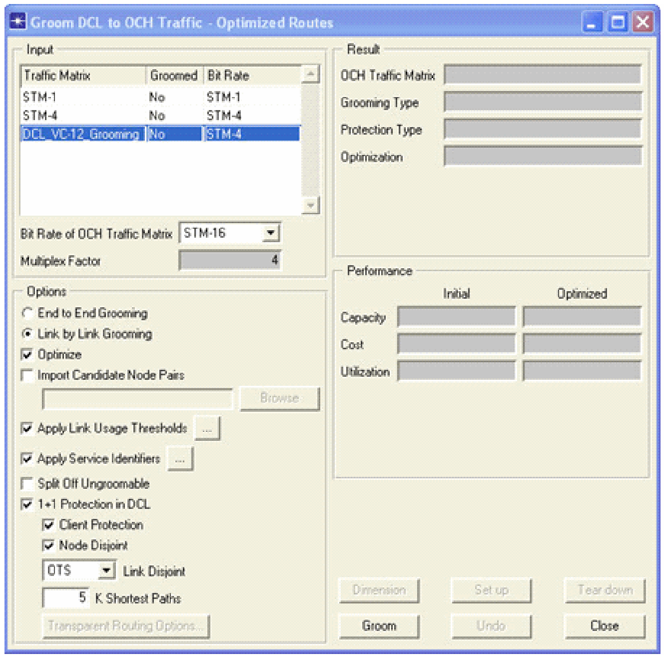
3 Groom the DCL traffic matrix (resulting from the LOP grooming action).

3.1 Return to the **Design > Groom LOP to DCL Traffic** dialog box.

3.2 Press the **Groom DCL to OCH** button.**The Groom DCL to OCH Traffic** dialog box appears.

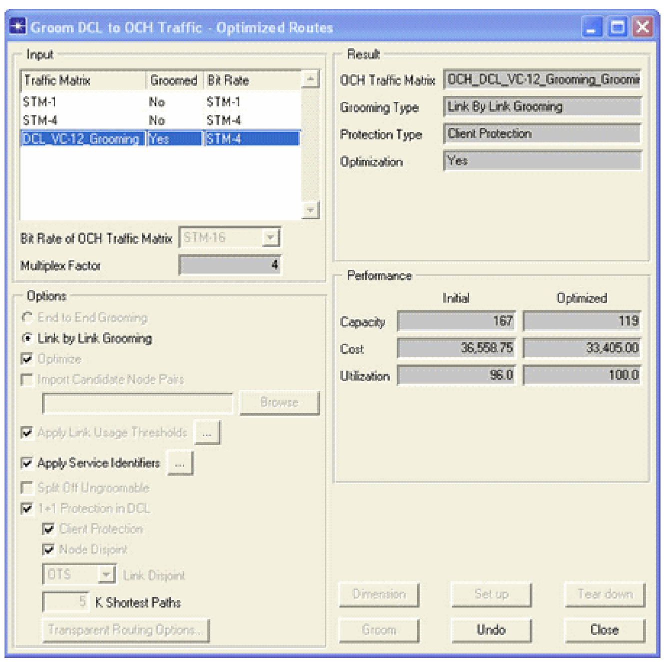
3.3 Select the traffic matrix **DCL_VC-12_Grooming** and **STM-16** as target bit rate (resulting in multiplex factor 4 between the DCL and the OCH traffic)

3.4 Select the following options: **Link by Link Grooming**, **Optimize**, **1+1 Protection in DCL**, **Client Protection**, **Node Disjoint**, and **OTS Link Disjoint**.



3.5 Press **Groom**. The **Grooming Optimization Progress** dialog appears. Once the status is Finished, close this dialog box.

3.6 The grooming algorithm has created a new OCH traffic matrix, **OCH_DCL_VC-12_Grooming_Grooming**, to host the DCL traffic.



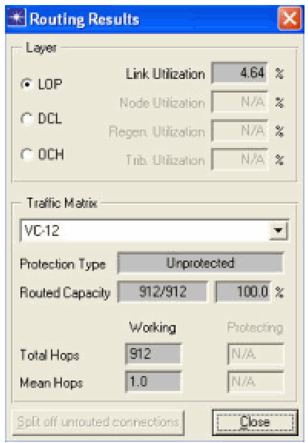
3.7 Close the **Grooming Optimization Progress**, **Groom DCL to OCH Traffic**, and **Groom LOP to DCL Traffic** dialog boxes.

3.8 Go to the **Design > Routing Results** dialog box.

3.9 Select **OCH** (Layer) and **OCH_DCL_VC-12_Grooming_Grooming** (Traffic Matrix). All connection units of this traffic matrix are accommodated in the network (without protection).

3.10 Select **DCL** as layer and **DCL_VC-12_Grooming** as traffic matrix. Note that this traffic matrix is entirely accommodated in the network exploiting the 1+1 protection scheme.

3.11 Select the **LOP** layer and the traffic matrix **VC-12**. This traffic matrix is entirely accommodated in the network without protection. The link utilization in the LOP layer amounts to 4.64%. Note that the total number of hops amounts to 912 units, which is the same as the number of connection units of the traffic matrix. This could be expected, because each connection is routed along a one-hop path (basic end-to-end grooming approach).



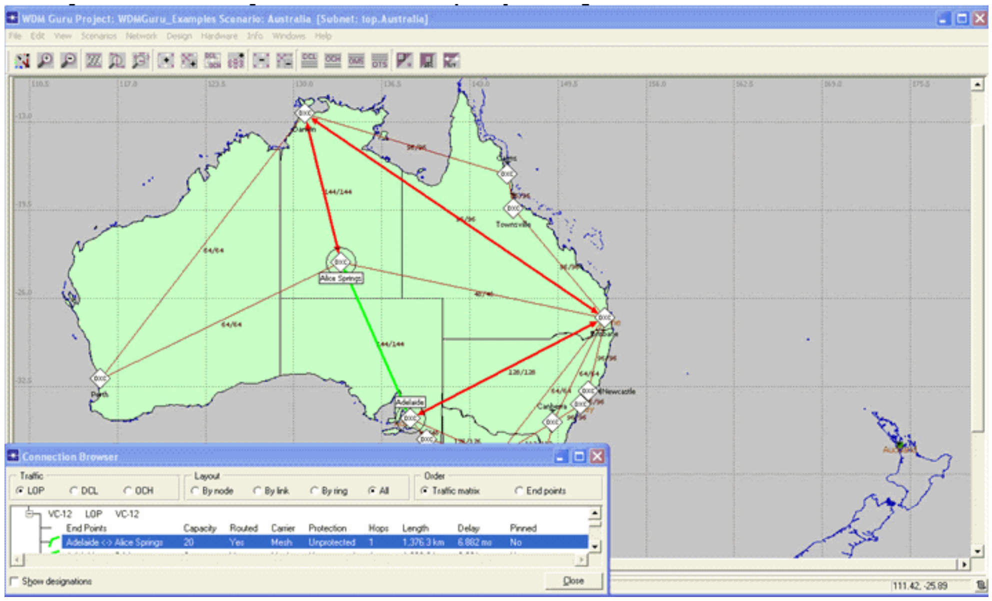
3.12 Close the **Routing Results** dialog box.

4 Inspect the routed connections:

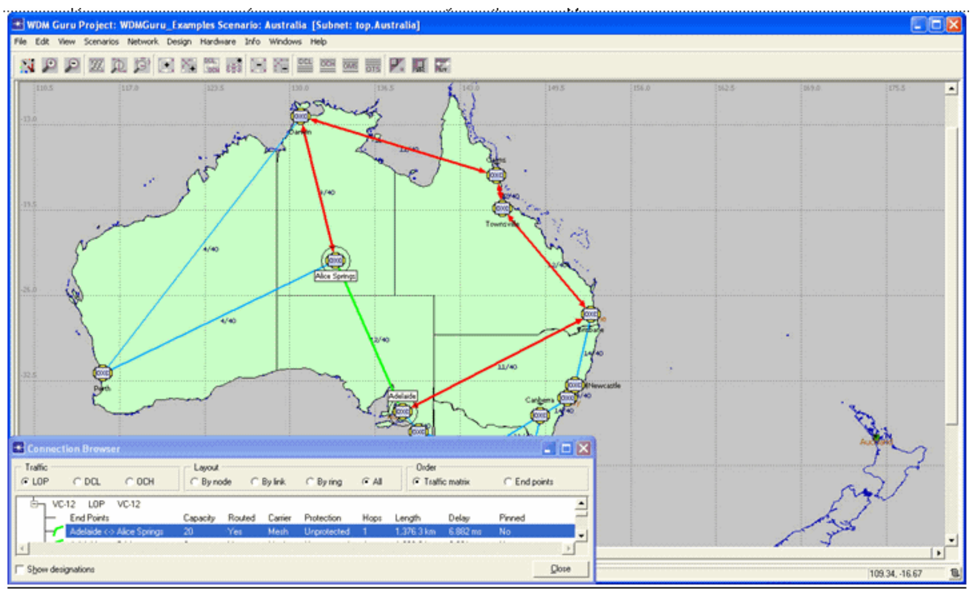
4.1 Go to **Network > Connection Browser**.

4.2 Select **LOP** (Traffic), **All** (Layout) and **Traffic Matrix** (Order). Expand the **VC-12** traffic matrix (using the **+** icon) and select the connection **Adelaide <-> Alice Springs.**

4.3 Use the **DCL** button on the toolbar to view the route of the selected connection in the DCL layer. Note that the connection is protected at the DCL layer level (however, it is not protected at the LOP layer level). The protection path of the connection is switched at the electrical level in the nodes **Darwin** and **Brisbane**.



4.4 Click on the **OCH** toolbar button. The route of the selected connection is now displayed in the OCH layer. Note that the protection path of the connection is switched at the optical level in the nodes **Cairns** and **Townsville**.



5 Close the project.

5.1 Select **File > Close**.

5.2 Click **Don't Save** in the **Close Confirm** dialog.

End of Procedure 3-7

Ring Design

This section shows how to design a network based on interconnected rings. You can manually define or import SONET rings and then route traffic on these rings. You can also expand these legacy rings by adding stacked rings on top of them. The first example shows how to create rings. The second example shows how to size the rings. You can start from the second example by opening the appropriate file.

Procedure 3-8 Creating a Ring

1 Open the WDMGuru_Tutorial_Ring_topology project.

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

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

➥ The example project is loaded.

2 Save the file under a new name.

2.1 Select **File** > **Save As...**.

➥ The **Save As** dialog box appears.

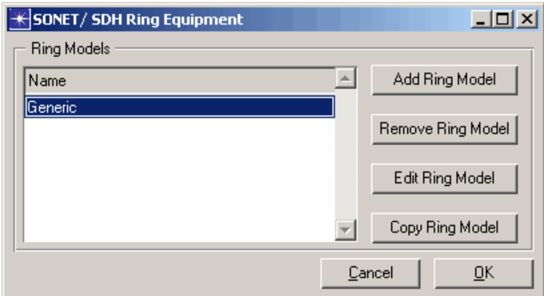
2.2 In the treeview (left) pane, select your default models directory; the folder icon has a small green mark to indicate that it is the default directory.

2.3 Specify **Example14** as file name, and click **Save**.

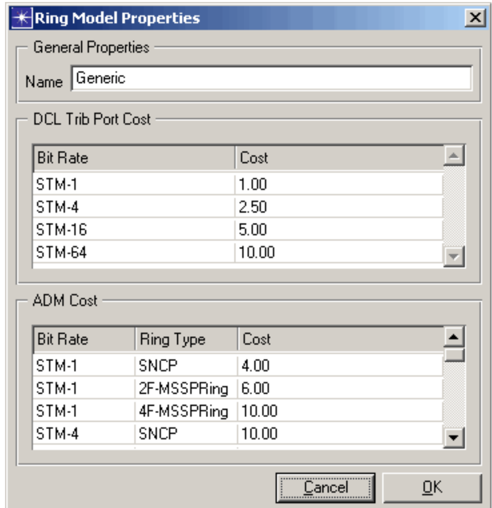
3 Inspect the SONET/SDH Ring Equipment dialog box.

3.1 Select **Network > Equipment Properties > SONET/SDH Ring Equipment…**

➥ This dialog box gives an overview of the different ring models supported in this project file. Note that there is only one ring model in this example. This is the default ring model, called “Generic”. You can add, remove, edit, and copy ring models from this dialog box.



3.2 Select **Generic** and click on **Edit Ring Model** to inspect the **Generic** ring equipment model.



➥ Use the Ring Model Properties dialog box to manage the costs for the selected ring model. You can specify costs for the SONET/SDH ADM equipment and the SONET/SDH tributary cards for each distinct bit rate. Select any field under Cost to edit and enter new values.

3.3 Click **Cancel** to close both dialog boxes.

4 Create SONET rings.

4.1 Select **Network > Ring Browser** (or press the  icon on the toolbar) In this dialog box you can view, add, and edit rings. At this point, no rings are present in the network.

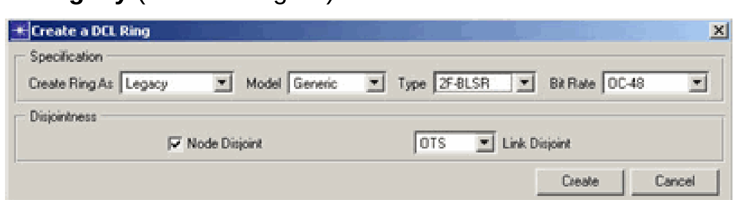
4.2 Press **Create** to define rings.

➥ The **Create a DCL Ring** dialog box appears.

4.3 Define the path of the ring by left-clicking on the nodes. Select **node_01**, **node_00**, **node_06,** and **node_02**.

4.4 Set the properties of the ring you want to create in the **Create a DCL Ring** dialog box:

- **OC-48** (Bit Rate)
- **2F-BLSR** (Type)
- **Generic** (Model)
- **Legacy** (Create Ring As)

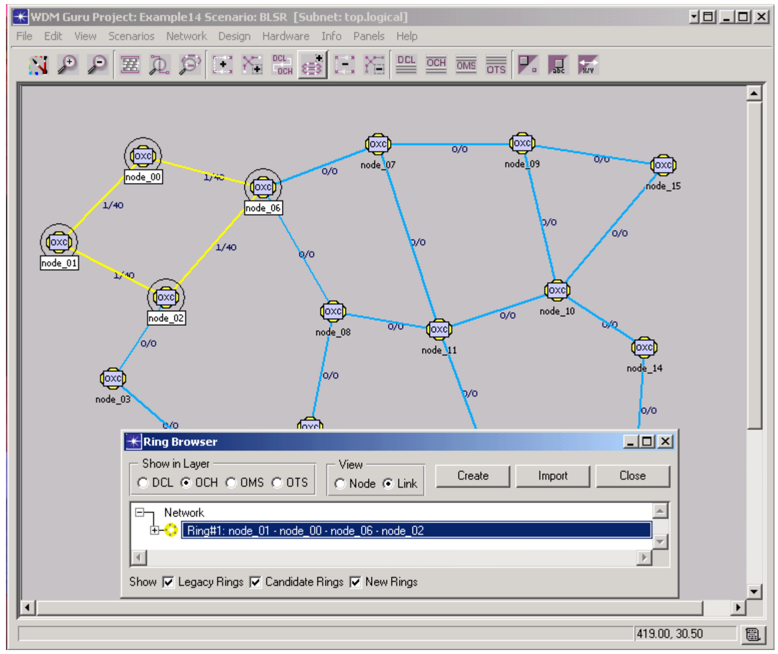


The following parameters are important only if you create a DCL ring supported by the OCH layer, such as a DCL ring that contains EOCC nodes:

- **OTS Link Disjoint**
- **Node Disjoint**

4.5 Click **Create**.

➥ The ring is added to the ring browser.



4.6 Define five more OC-48 2F-BLSR rings, as follows:

- A first ring between **node_02**, **node_06**, **node_08**, **node_05**, **node_04,** and **node_03**
- A second ring between **node_06**, **node_07**, **node_11,** and **node_08**
- A third ring between **node_05**, **node_08**, **node_11,** and **node_12**
- A fourth ring between **node_07**, **node_09**, **node_15**, **node_10,** and **node_11**
- A fifth ring between **node_11**, **node_10**, **node_14**, **node_13,** and **node_12**

4.7 Close the ring browser.

5 Inspect the DCL nodes.

5.1 Select **Network** > **Node Browser**.

5.2 Select **Ports** (View) and **DCL** (Layer).

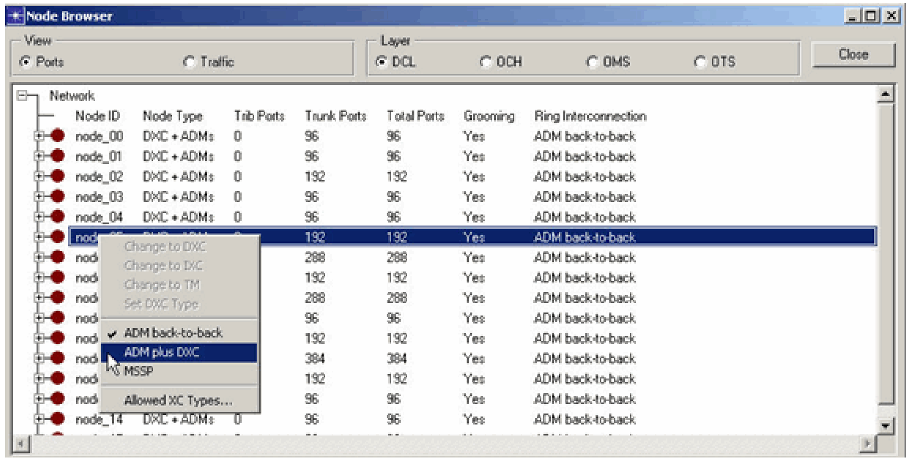
➥ The browser lists the number of ADMs used per node.

5.3 Right-click on a node in the node browser to change the ring interconnection type. Three types of ring interconnection are supported:

- ADM back-to-back

- ADM plus DXC
- MSSP

5.4 Set the interconnection type of **node_05**, **node_06,** and **node_12** to **ADM plus DXC**.



5.5 Set the interconnection type of **node_08** and **node_11** to **MSSP**.

5.6 Leave the interconnection type of all other nodes as **ADM back-to-back**.

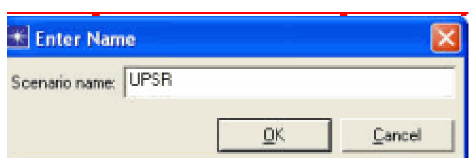
➥ For more information on the different ring interconnection types supported in SP Guru Transport Planner, refer to the SP Guru Transport Planner *User Manual*.

5.7 Close the node browser.

6 Create the UPSR scenario.

6.1 Select **Scenarios > Duplicate Scenario...**.

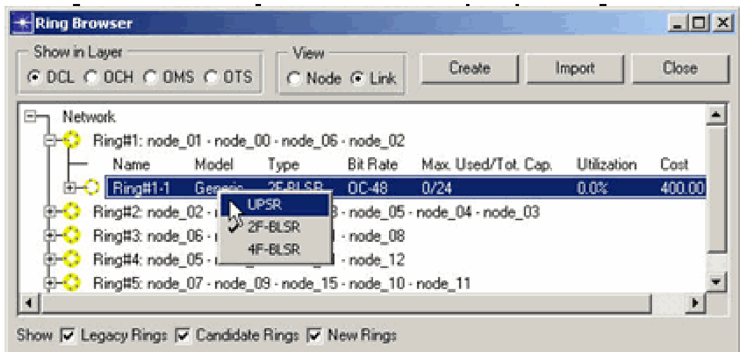
6.2 Enter **UPSR** as **Scenario Name** in the **Enter Name** dialog box.



7 Change the type of the rings (UPSR scenario).

7.1 Select **Network > Ring Browser** to visualize the rings. Expand the ring information by clicking on the **+** icon. Right-click on each stacked ring (for example, **Ring#1-1**), choose **Set Type,** and choose **UPSR**.

➥ Each ring changes to an UPSR ring.



7.2 Close the ring browser.

8 Save and close the project

8.1 Select **File** > **Save**.

8.2 Select **File** > **Close**.

End of Procedure 3-8

Procedure 3-9 Sizing a Ring

1 Open the project.

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

1.2 Select the project **Example14**.

Note—The project file **Example14** was created in Procedure 3-8 Creating a Ring on page TrPT-3-44. If you did not do this procedure, select the **WDMGuru_Tutorial_Rings** project, then press **Open**.

The project contains two scenarios. Both scenarios contain a network of six rings. The **UPSR** scenario uses Unidirectional Path Switched Rings and the **BLSR** scenario uses Bidirectional Line Switched Rings. Start with the **BLSR** scenario.

2 Choose **Scenarios > Switch to Scenario > BLSR**.

3 Inspect the SONET rings.

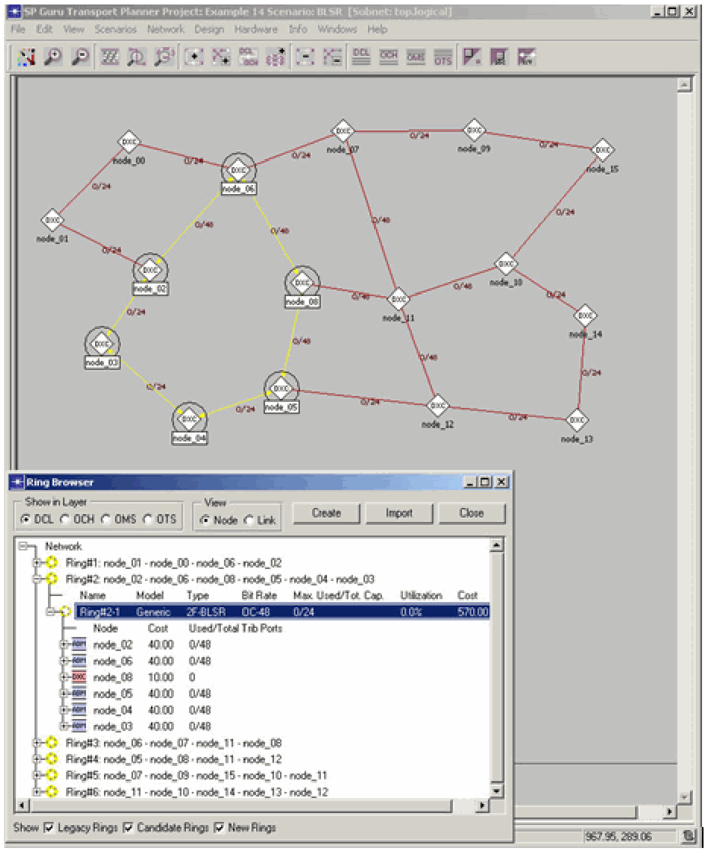
3.1 Select **Network > Ring Browser** or press the  icon to visualize the rings.

On the first level of the ring browser, the so-called ring footprint is shown (i.e. the topological location of the ring).

3.2 Click on the **+** icon to expand the footprint ring and on the second level of the ring browser all rings deployed in this location are shown (i.e. the stacked rings).

3.3 Click on a ring to highlight the ring location on the screen.

3.4 Click again on the **+** icon next to a ring to highlight all the nodes or links (depending on the **View** setting) in the third level of the ring browser.



By switching between layers, you can also see how the ring is accommodated in the lower layers.

3.5 Close the ring browser.

4 Inspect the DCL nodes.

4.1 Select **Network** > **Node Browser**.

4.2 Select **Ports** (View) and **DCL** (Layer).

➥ The number of ADMs used per node is shown. You can also change the ring interconnection type in the node browser by right-clicking on a node.

4.3 Close the node browser.

5 Route SONET traffic on the ring (without adding SONET rings).

5.1 Select **Design** > **Dimension DCL Rings...**.

This dialog box allows you to route traffic on the rings in the network.

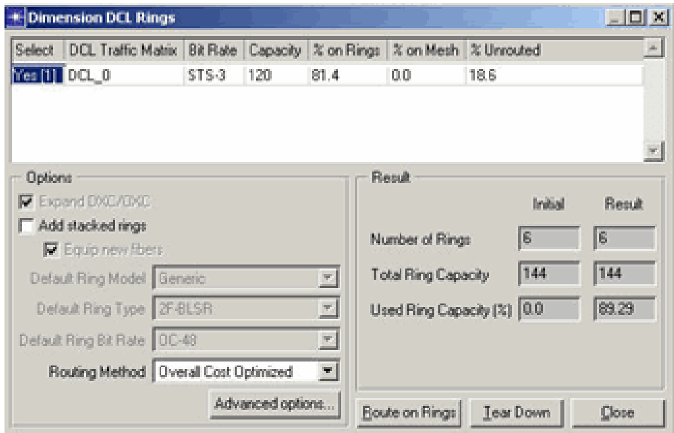
5.2 Select the traffic matrix **DCL_0**.

5.3 Uncheck the option **Add stacked rings**. With this option selected, the algorithm tries to route the traffic in the existing set of rings without adding new rings.

5.4 Select the routing method **Overall Cost Optimized**, then click **Route on Rings** to route the traffic matrix DCL_0 on the rings.

➥ The results show that the ring capacity is used at about 89 percent.

The traffic matrix table shows that about 81 percent of the traffic has been routed on the rings. The rest of the traffic could not be routed on rings due to a capacity shortage and has been off-loaded to a mesh traffic matrix. This traffic can be accommodated in the network using the mesh routing or grooming functions.



6 Route SONET traffic on the ring (adding 2F-BLSR rings).

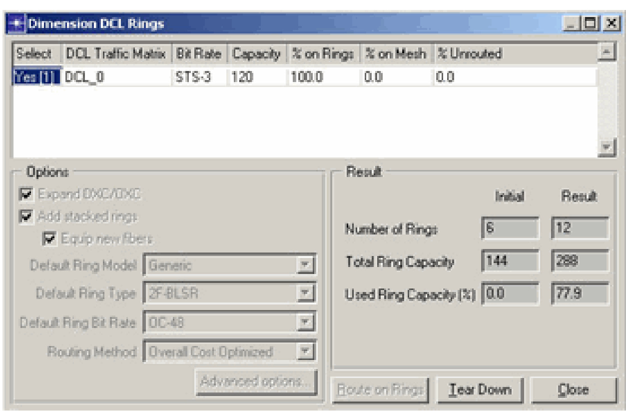
6.1 Click **Tear Down** in the **Dimension DCL Rings** dialog box to remove the traffic from the rings again.

6.2 Put checkmarks next to the options **Add stacked rings** and **Equip new fibers**. This allows new rings to be added on top of existing rings.

6.3 Select **2F-BLSR** rings of the **Generic** ring model at **OC-48** rate as the rings to add.

6.4 Choose the routing method **Overall Cost Optimized**, then press **Route on Rings**.

➥ The results show that six new rings were added to route all traffic. The ring capacity has been used at about 78 percent. The traffic matrix table indicates that the rings accommodate 100 percent of the traffic.



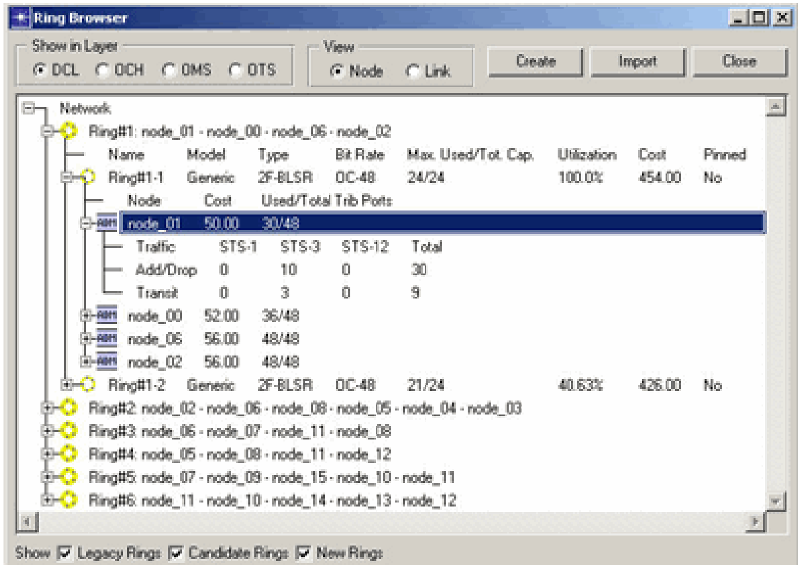
6.5 Close the **Dimension DCL Rings** dialog box.

7 Inspect the SONET rings.

7.1 Select **Network > Ring Browser**.

7.2 Expand the ring information using the **+** icon and inspect the stacked rings added to each ring footprint.

Also inspect the detailed link and node usage of each individual ring, by using the **View** per **Node** or **Link** radio buttons.



7.3 Close the ring browser.

8 Inspect the routed connections.

8.1 Select **Network > Connection Browser**.

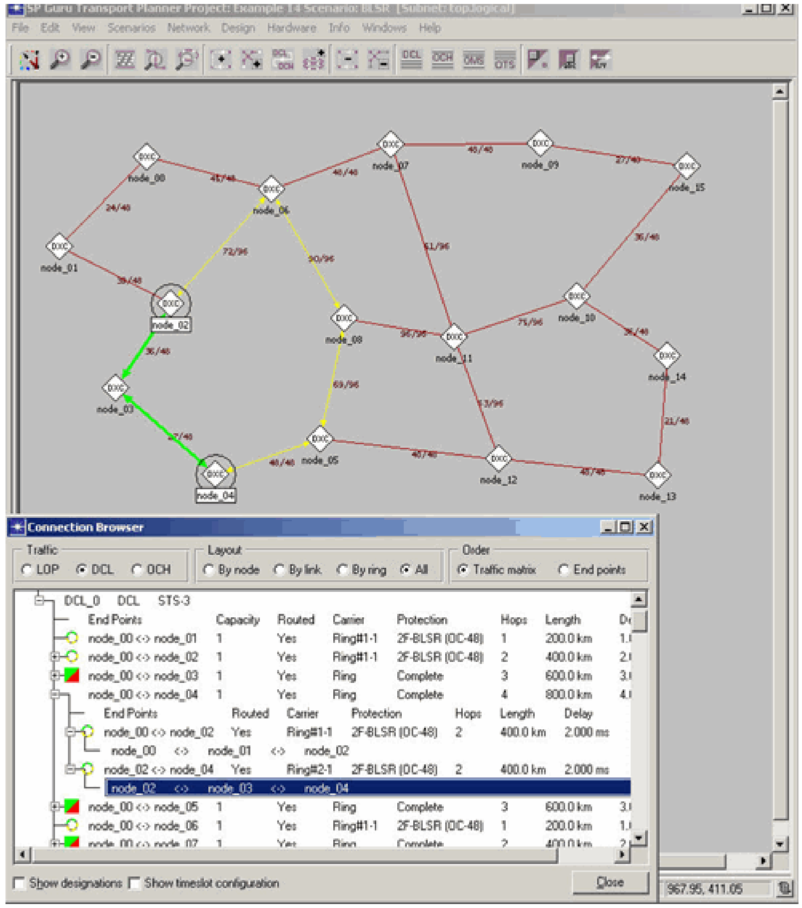
8.2 Select the **DCL** layer.

8.3 Expand the **DCL_0** traffic matrix (using the **+** icon) and inspect the routes of this traffic matrix.

➥ Some connections are routed over one ring and others are routed over multiple rings.

Connections routed over more than one ring can be expanded and the individual paths on the rings can be inspected in more detail. Note that on BLSR rings, no protection path is shown since the protection path is intrinsic to the ring and is failure-dependent.

8.4 Close the connection browser.



9 Select **Scenarios** > **Switch to Scenario > UPSR** to view the **UPSR** scenario.

10 Route SONET traffic on the ring (adding UPSR rings).

10.1 Select **Design > Dimension DCL Rings...**.

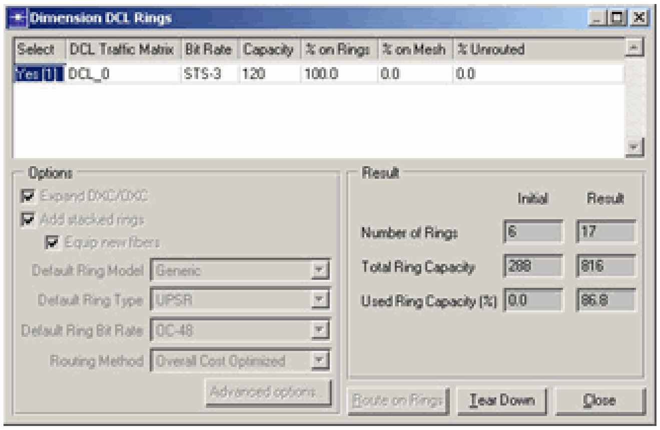
10.2 Select the traffic matrix **DCL_0**.

10.3 Select the options **Add stacked rings** and **Equip new fibers**. This allows new rings to be added on top of the existing rings.

10.4 Select **UPSR** rings of the **Generic** ring model at **OC-48** rate as the rings to add.

10.5 Choose the routing method **Overall Cost Optimized**, then click **Route on Rings**.

➥ The results show that now 11 new rings are added in the BLSR case. This is because BLSR rings are more capacity-efficient than USPR rings.



11 Close the **Dimension DCL Rings** dialog box.

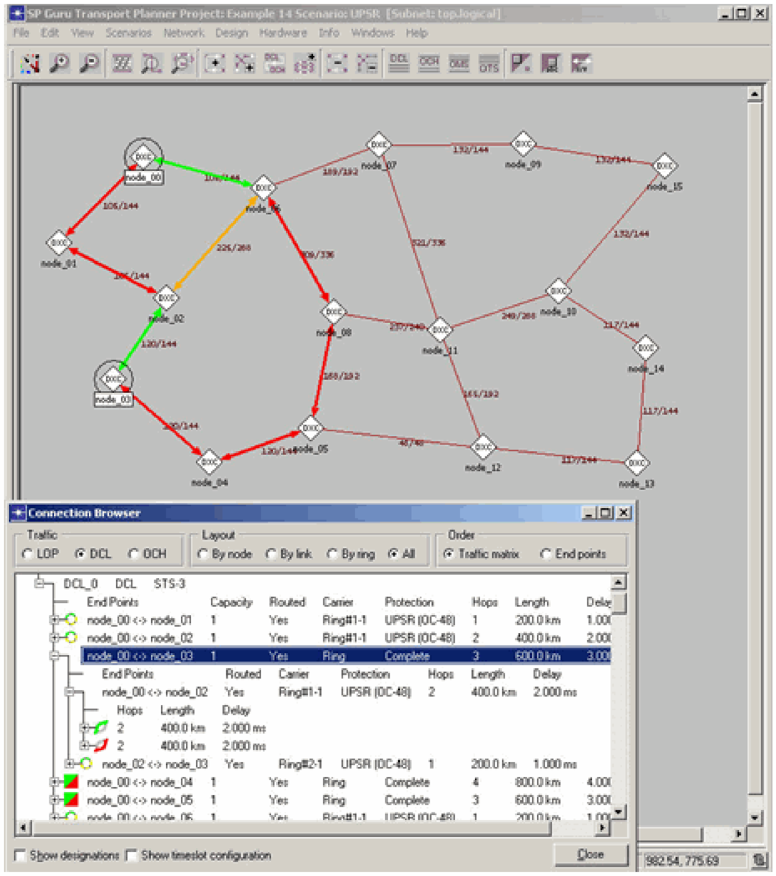
12 Inspect the routed connections.

12.1 Select **Network > Connection Browser**.

12.2 Select the **DCL** layer.

12.3 Expand the **DCL_0** traffic matrix (using the **+** icon) and inspect the routes of this traffic matrix.

➥ Connections on a UPSR ring have an explicit protection path (in red), because the protection path is not failure-dependent. The overlap of working and protection paths is indicated in orange.

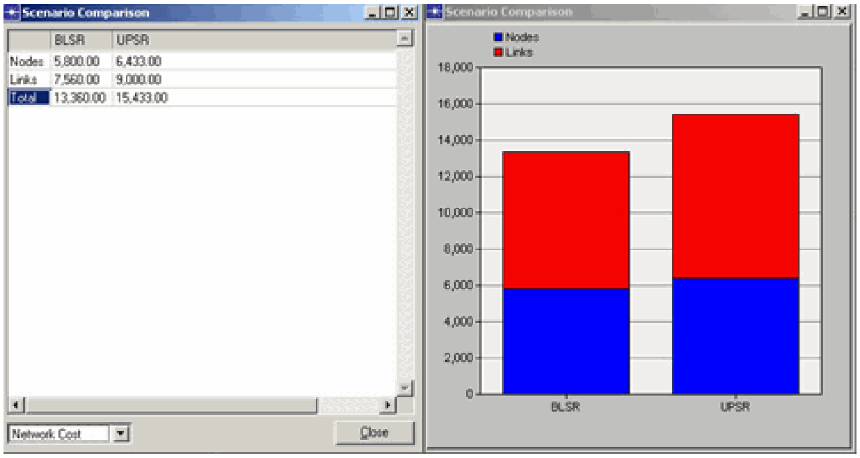


12.4 Close the connection browser.

13 Compare scenarios.

13.1 Select **Scenarios > Compare Scenarios**.

➥ This shows the differences between the UPSR and BLSR design in terms of cost and capacity. The BLSR design is the cheapest solution, although the ADMs for BLSR are more expensive than for UPSR rings.



13.2 Close the dialog boxes.

14 Close the project

14.1 Select **File** > **Close**.

14.2 Select **Don’t Save** in the Close Confirm dialog box.

End of Procedure 3-9

Express Layer Design

The goal of an optical express layer is to reduce the amount of switching equipment in the OCH nodes by providing express links between nodes that exchange a lot of traffic. To create an express layer, you use the Express Layer Design Wizard (**Design > Express Layer Design**).

The wizard guides you through the three main steps to construct an express layer:

- Selecting the gateway nodes
- Selecting the express links between the gateway nodes
- Selecting the fiber routes that implement the express links

Procedure 3-10 Using Express Layer Design

1 Open the project.

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

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

➥ The example project loads with the scenario **scenario1** in the workspace.

2 Define an express layer.

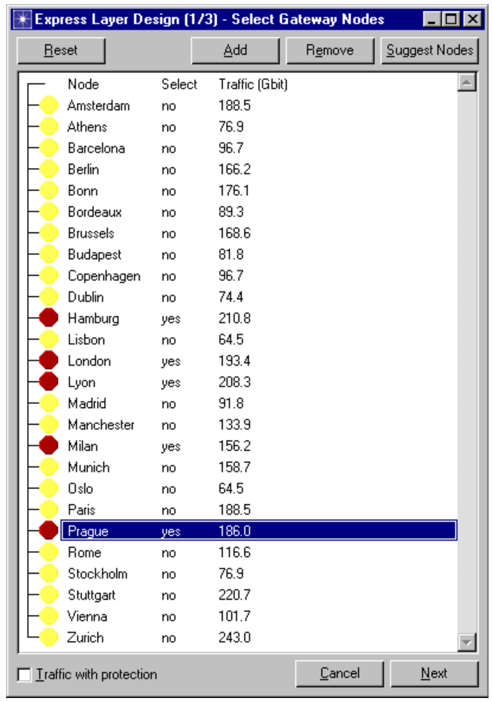
2.1 Select **Design > Express Layer Design**.

➥ The Express Layer Design wizard appears. The wizard will guide you through the creation of an optical express layer.

2.2 Create gateway nodes (that is, nodes that are part of the optical express layer). Double-click on the node **Hamburg** in the **Express Layer Design (1/3) – Select Gateway Nodes** dialog box.

➥ This makes Hamburg a gateway node, marked by a red icon (in the dialog box and in the workspace).

2.3 Repeat the previous step for the nodes **London**, **Lyon**, **Milan,** and **Prague**.



2.4 Press **Next** in the **Express Layer Design (1/3) – Select Gateway Nodes** dialog box.

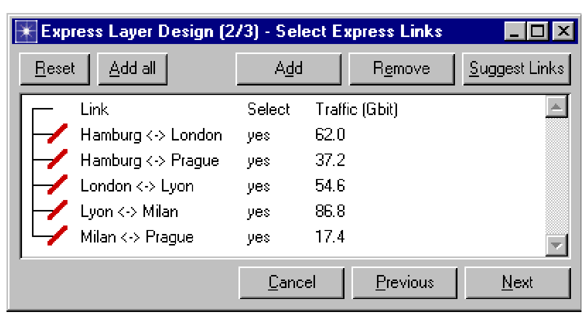
2.5 Create express links between the gateway nodes. In the workspace, select node **Hamburg**, press the Shift key and select node **London**.

2.6 Press **Add** in the **Express Layer Design (2/3) – Select Express Links** dialog box.

➥ An express link is created between Hamburg and London. This link now appears in the dialog box.

2.7 Create the following additional express links:

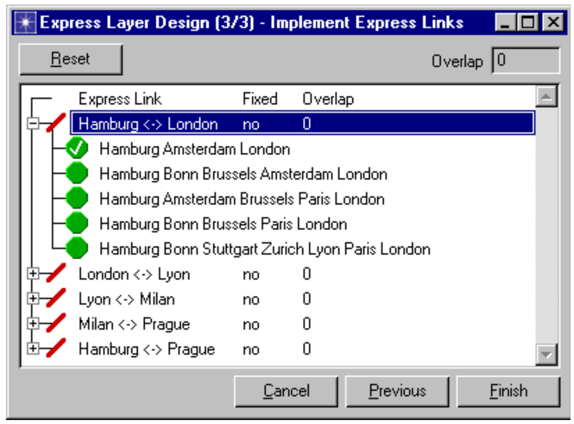
- London<->Lyon
- **Lyon<->Milan**
- **Milan<->Prague**
- **Prague<->Hamburg**



2.8 Press **Next** in the **Express Layer Design (2/3) – Select Express Links** dialog box.

In the last step of the express layer design, the fiber routes for the express links are selected.

2.9 Click on the **+** icon to see the candidate fiber routes for an express link. A fiber route can be selected by double-clicking on the route. By default, SP Guru Transport Planner chooses the routes so that the amount of overlap between the different fiber routes is minimal. In this example, there is no overlap between the selected routes.

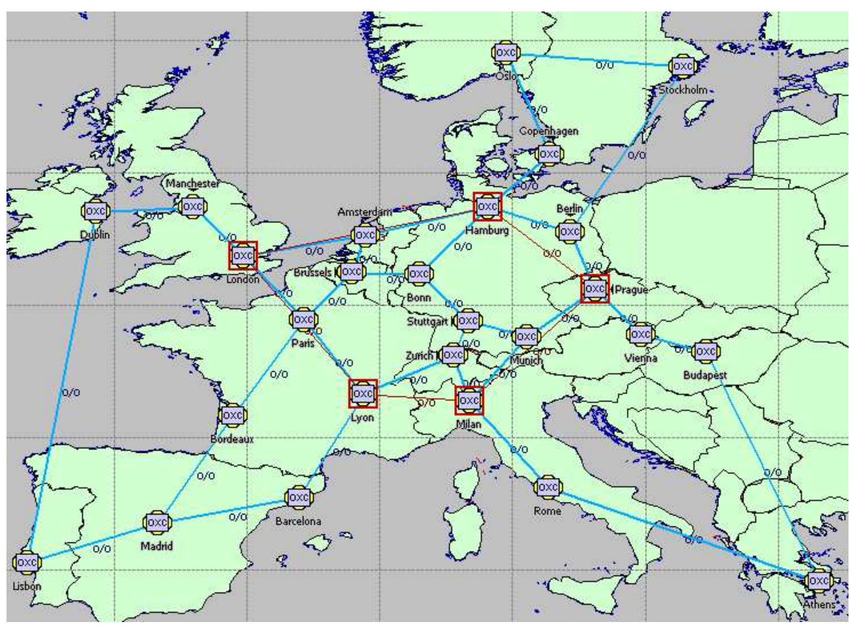


2.10 Press **Finish** to close the **Express Layer Design (3/3) – Implement Express Links** dialog box.

➥ The optical express layer has now been defined.

2.11 Right-click in the workspace, then select **OCH Express Layer**.

➥ The gateway nodes and the express links are marked in red.



In this example, the gateway nodes and the express links were selected manually. However, you can let SP Guru Transport Planner suggest the gateway nodes (based on traffic or cost measures) by selecting **Suggest Nodes** in the **Express Layer Design (1/3) – Select Gateway Nodes** dialog box. You can also let SP Guru Transport Planner suggest the express links by selecting **Suggest Links** in the **Express Layer Design (2/3) – Select Express Links** dialog box.

3 Dimension the OCH layer.

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

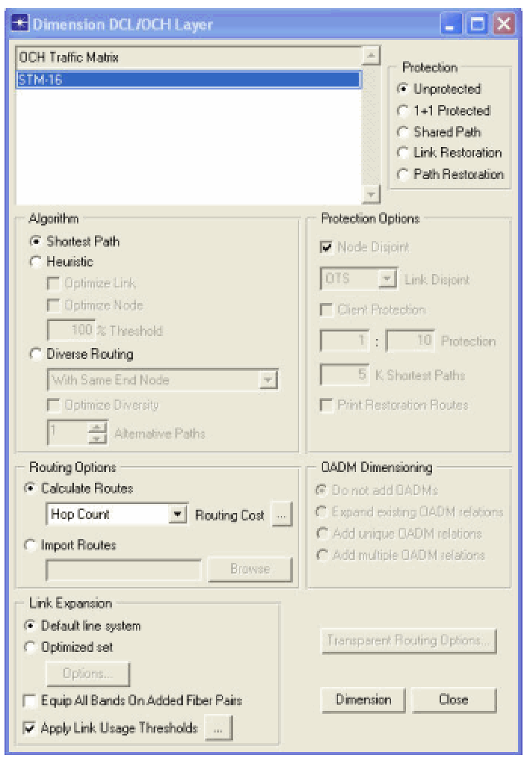
3.2 Select the traffic matrix **STM-16**.

3.3 Select the default setting for all options:

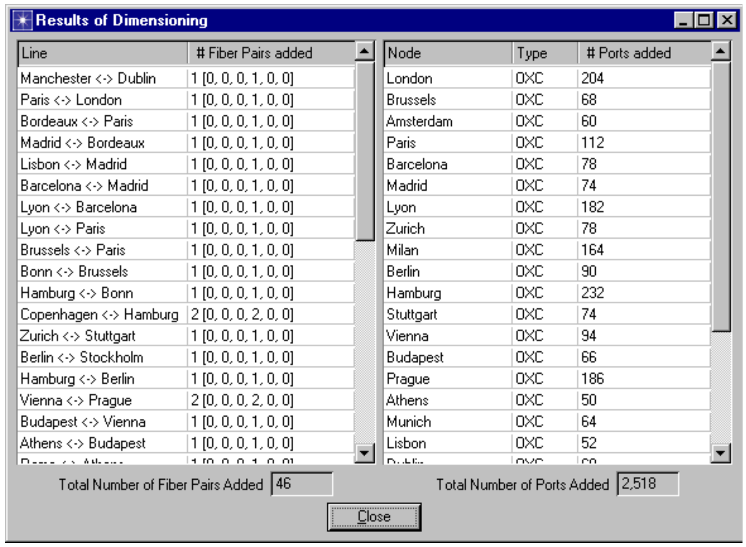
- **Unprotected** as protection type
- **Shortest Path** as algorithm
- **Hop Count** as routing cost
- **Default line system** as link expansion

3.4 Unmark **Equip All Bands On Added Fiber Pairs**.

3.5 Press **Dimension**.



➥ The **Results of Dimensioning** dialog box shows that 46 fiber pairs have been added to the network.



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

4 Inspect the links.

4.1 Select **Network > Link Browser**.

4.2 Select **OCH** as Layer and mark the **Show in-line sites** option.

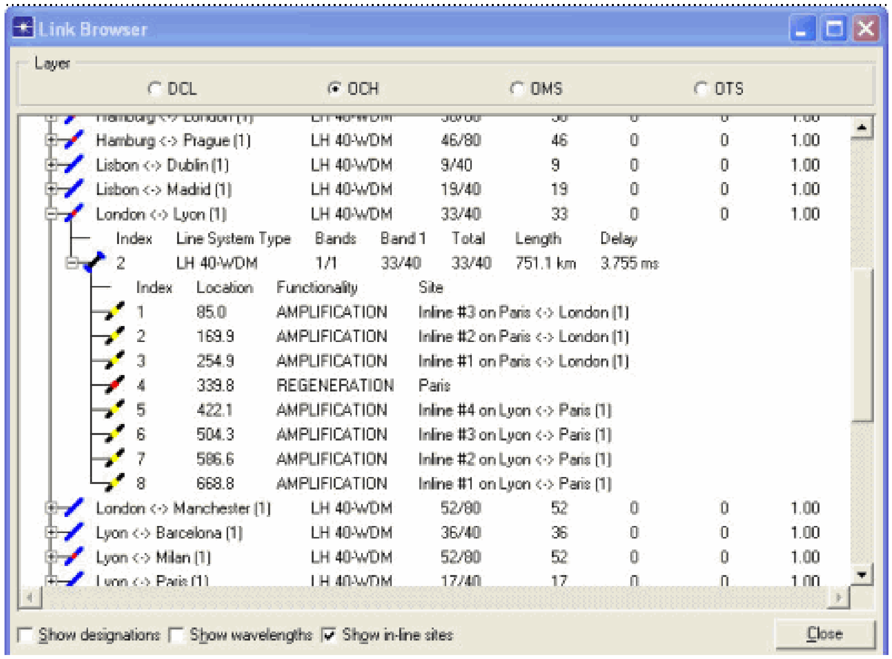
➥ A blue and red icon indicates the express links.

The express links are responsible for carrying a large amount of traffic, because a lot of transit traffic is off-loaded toward the express links.

4.3 Select the express link **Lyon<->London**. (This link might appear as **London<->Lyon** in the treeview.)

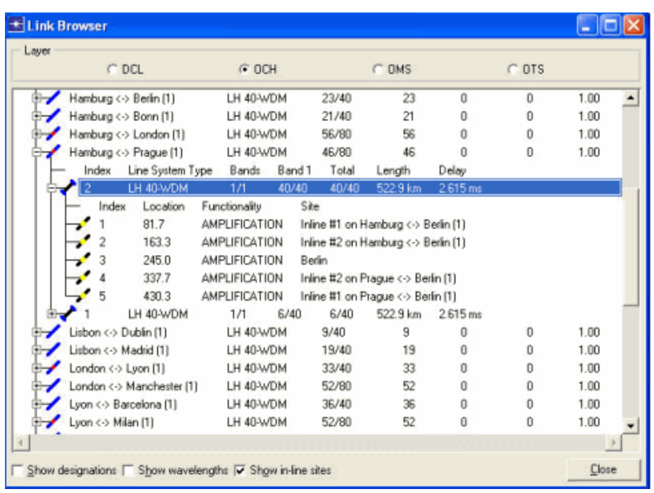
➥ Thirty-three of the 40 available wavelengths are in use.

4.4 Use the **+** icon to view the line system installed on the link and its amplification and regeneration locations. The line-system type is LH 40-WDM. This express link has a total length of 751 km. This is longer than the maximum unregenerated distance (600 km), while its constituting links London<->Paris and Paris<->Lyon are shorter than 600 km. Therefore, there is no in-line regeneration needed on these constituting links, but the express link needs to be regenerated at the intermediate node Paris.



4.5 Select the express link **Prague<->Hamburg** (or **Hamburg<->Prague**) on which 46 of the 80 wavelengths are in use. Two line systems of type LH 40-WDM have been installed on it.

4.6 Click on the **+** icon. The total length of this express link is 523 km, implying no regeneration is needed on this link. The amplification span (the maximum distance without amplification) is 100 km. The distance between the last amplifier on the constituting link Hamburg<->Berlin and the next amplifier (first amplifier on the constituting link Prague<->Berlin) amounts to 175 km. Therefore, an amplifier is needed in the intermediate node Berlin.



4.7 Close the link browser.

5 Inspect the routed connections.

5.1 Select **Network > Connection Browser**.

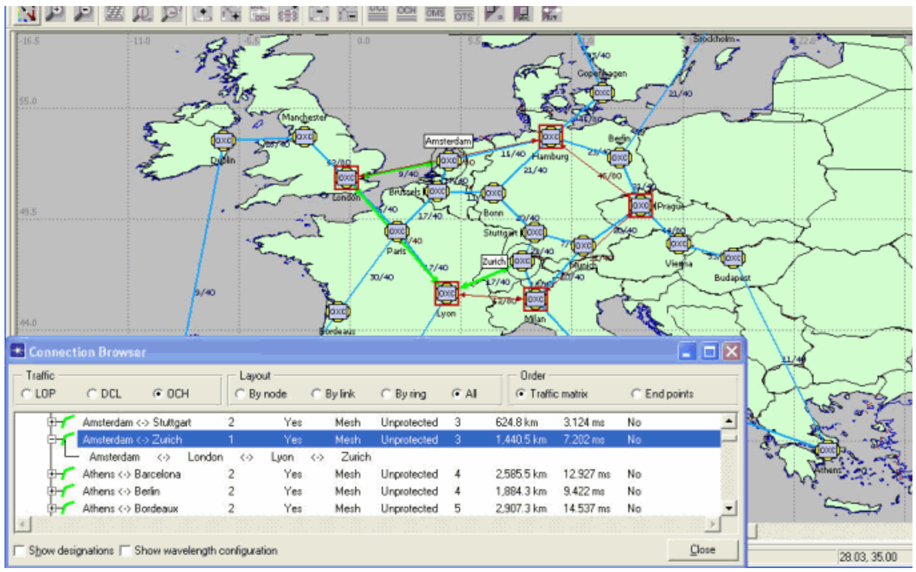
5.2 Select **OCH** (Traffic), **All** (Layout), and **Traffic Matrix** (Order).

5.3 Select the traffic matrix STM-16 and click on the **+** icon to view its connections.

5.4 Select the connection **Amsterdam<->Zurich**.

➥ The path is highlighted on the workspace (in the OCH layer).

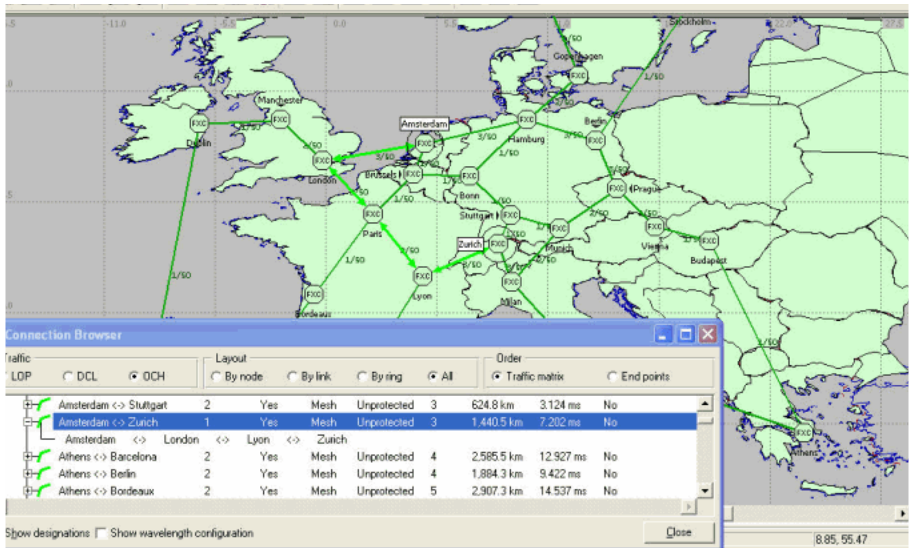
This connection is routed through the nodes Amsterdam, London, Lyon, and Zurich. It contributes to the OXC in these nodes. Note that it is routed along the express link between London and Lyon.



5.5 Use the **OMS** button on the toolbar to see the path of the connection in the OMS layer.

➥ The connection is routed through the nodes Amsterdam, London, Paris, Lyon, and Zurich.

It is switched at the OMS layer in node Paris (part of the express link between London and Lyon), and at the OCH layer in the other nodes. Therefore, the connection does not contribute to the OXC in Paris. So, because of the express link between London and Lyon, traffic is bypassed at the fiber level in Paris, resulting in a smaller OXC in this node.



5.6 Close the connection browser.

6 Close the project

6.1 Select **File** > **Close**.

6.2 Select **Don’t Save** in the **Close Confirm** dialog box.

End of Procedure 3-10

Additional Exercise

Perform the same design for the Europe network without an express layer and compare the results using the **Compare Scenarios** feature.