6 Designing Robust Multi-Layer Networks

The SWIM product suite includes all the features and operations available in SP Guru Network Planner and SP Guru Transport Planner for designing, analyzing and troubleshooting networks. In addition, SWIM includes features that enable you to

- Shared Risk Groups—Predict how failures in the Transport network will affect performance in the Layer-2/3 network

- SWIM Failure Analysis—Design IP/MPLS networks to be robust against failures in the transport network

Shared Risk Groups

In SP Guru Network Planner, a *shared risk group* (SRG) defines a failure relationship between two sets of network objects, where failures in one set cause failures in the other set. Shared risk groups are useful for modeling dependency relationships such as the following:

- Several links that depend on a fiber: if the fiber fails, the links also fail

- A power source for a building: if the power source fails, all nodes in that building fail

Every shared risk group specifies two sets of network objects:

1) The *risk element set* contains one or more network objects that other objects (those in the impacted element set) depend on to function.

2) The *impacted element set* contains one or more network objects that depend on objects (those in the risk element set) to function. If a risk element fails, the impacted elements also fail.

With SWIM, you can create SRGs that model the dependency relationship between Transport resources (the risk elements) and Layer-2/3 links (the impacted elements). For example, suppose you have a set of links that depend on connections that are routed over the same optical fiber. Because these connections (and, by extension, the links) depend on the same fiber, you could create an SRG in which the fiber is the risk element and the links are the impacted elements.

Use Cases for SRGs

SRGs are especially useful for two use cases, which are described in the following sections:

- Failure Impact Analysis in SP Guru Network Planner on page TC-6-2

- SRGs and MPLS Traffic Engineering on page TC-6-2

Failure Impact Analysis in SP Guru Network Planner

In SP Guru Network Planner, you can run survivability analysis studies for SRGs defined in the transport layer. The workflow is as follows:

1) Define SRGs in the transport layer, as described in Creating Transport-Layer SRGs on page TC-6-3.

2) In SP Guru Network Planner, choose Flow Analysis > Configure/Run Failure Impact Analysis.

3) In the Configure/Run Survivability Analysis dialog box, select the SRGs from the object types tree.

4) Run the survivability analysis.

The Failure Analysis reports show the effects of Transport element failures on the Layer-2/3 network. For more information about Failure Analysis, see SWIM Failure Analysis on page TC-6-5.

SRGs and MPLS Traffic Engineering

MPLS uses label switched paths (LSPs) to route IP traffic.
SP Guru Network Planner includes a design action (mpls_te) that you can use to networks that support MPLS TE. This design action computes primary and secondary explicit routes (ERs) for LSPs. One LSP can have a primary and secondary ER; the secondary route is used if the primary is unavailable due to a network failure.

You can use mpls_te to design your IP/MPLS network to be robust against failures in the transport network. The mpls_te design action has an attribute called "SRG Disjoint". This attribute is useful for computing primary and secondary ERs when SRGs have been created for failures in the transport network. mpls_te tries to find SRG-disjoint routes to ensure that at least one route (primary or secondary) will be available, even if a transport-network failure (for which an SRG is defined) occurs.

For general information about MPLS TE, perform the tutorial Defining a Multi-Layer IP-Over-WDM Network on page SWIMT-2-1, or see the following sections of the SP Guru Network Planner documentation:

- "MPLS User Guide" chapter (Specialized Models *User Guides*)

- "MPLS Traffic Engineering" chapter (Design Module *User Guide*)

Creating Transport-Layer SRGs

To create transport-layer SRGs, open the SWIM project in SP Guru Network Planner and choose SWIM > Create Shared Risk Groups From Transport Network. When the dialog box appears, you can specify the types of SRGs to create (see Figure 6-1 and Table 6-1 on page TC-6-4). SWIM uses the current node and link mapping information to specify the Impacted Elements (Layer-2/3 links) for each specific risk group.

Figure 6-1   Create Shared Risk Groups From Transport Network Dialog Box
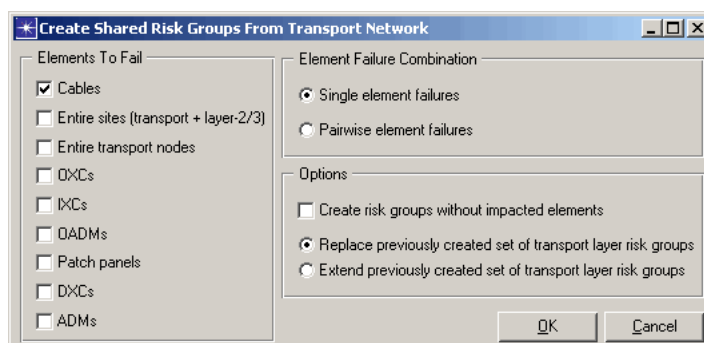
Table 6-1   Created Shared Risk Groups from Transport Network Dialog Box

Option/Field	Description
Elements to Fail	The types of Transport network elements to fail. For every instance of a network object selected in this table, SWIM creates an SRG. You can select the following types of objects: • Cables—Failure of an optical cable (in OTS layer) • Entire sites (transport + layer-2/3)—Failure of an entire Transport node (including all OXCs, DXCs, OADMs, and other equipment present at the site) as well as the Layer-2/3 node(s) that have been mapped onto it • Entire transport nodes—Failure of an entire transport node (including all OXCs, DXCs, OADMs and other equipment present at that site) • OXCs—Failure of individual optical cross-connect (OXC). This does not include optical cross-connect parts of IXCs. • IXCs—Failure of individual integrated electrical/optical cross-connect (IXC) • OADMs—Failure of individual optical add/drop multiplexer (OADM) • Patch Panels—Failure of patch panel • DXCs—Failure of individual digital cross connect (DXC). This does not include digital cross connect parts of IXCs. • ADMs—Failure of individual digital add/drop multiplexer (ADM)
Element Failure Combination	The following options are available: • Single—For each instance of the specified type, create one SRG. Thus if you selected "Cables" under "Elements to Fail", SWIM will create one SRG for every cable in the Transport network. • Pairwise—Generate a pairwise-failure case for every two-object combination of network objects whose type is selected. Thus if you selected "Cables" and "OXCs" under "Elements to Fail", the report will generate one SRG for every possible pairwise failure of the specified element types.
Create risk groups without impacted elements	If this option is selected, an SRG will be created for every failure case, even if the failure case has no effect on the Layer-2/3 network (specifically, even if an SRG has no Impacted Elements). If this option is not selected, the only SRGs created are those that have impacted elements in the Layer-2/3 network.
Replace previously created set of transport layer risk groups	If this option is selected, the new SRGs replace all existing SRGs that were created using this dialog box. This option has no effect on manually created SRGs.
Extend previously created set of transport layer risk groups	If this option is selected, the new SRGs are added to SRGs already in the scenario.
End of Table 6-1	

SWIM Failure Analysis

Using SWIM, you can generate a web report that shows the effects of failures in the transport layer on links in the Layer-2/3 network. Each Failure Analysis report iterates through a set of failure cases; for each failure case, the report shows all failed links, unaffected links, and affected links (an "affected link" is a link whose delay is affected by the specified failure).

SP Guru Network Planner and SP Guru Transport Planner each have their own Failure Analysis operations. These operations differ in the following ways:

- SP Guru Transport Planner failure analysis (Info > Failure Analysis) analyzes the effects of transport-layer failures on the transport network only, and does not consider the effects of these failures on the Layer-2/3 network.

- SP Guru Network Planner survivability analysis (Flow Analysis > Configure/Run Survivability Analysis) studies the effects of failures in the transport network—fibers, cables, OXCs, DXCs—on link performance in the layer-2/3 network. For each failure scenario in the transport layer, survivability analysis analyzes the effects on Layer-2/3 links. Information on the effects of transport layer failures are included in the following reports:

  — Analyses > Failure Impact-Demands: This report includes columns that show delay-impacted demands.

  — Analyses > Delay Impacted Demands: This report summarizes the set of demands that were delayed by the transport-layer failure.

  — Analyses > Failed Demands: This report includes columns that show the end-to-end delay for failure and baseline scenarios.

  — Analyses > Rerouted Demands: This report includes columns that show the end-to-end delay for failure and baseline scenarios.

Figure 6-2 Failure Impact-Demands Report with Failed Transport Nodes

	Failed Object	Failed Object	BW Failed (%)	BW Failed (Mbps)	Demands Failed (#)	Demands Failed (%)	BW Rerouted (%)	BW Rerouted (Mbps)	Demands Rerouted (#)	Demands Rerouted (%)	BW Delay Impacted (%)	
1	Node Barcelona (OTS)		43.94	0.058	58	43.94	0.0	0.0	0	0.0	0.0	C
2	Node Rome (OTS)		43.94	0.058	58	43.94	4.55	0.006	6	4.55	4.55	C
3	Node London (OTS)		43.94	0.058	58	43.94	9.09	0.012	12	9.09	9.09	C
4	Node Belgium (OTS)		40.91	0.054	54	40.91	4.55	0.006	6	4.55	4.55	C
5	Node Paris (OTS)		0.0	0.0	0	0.0	0.0	0.0	0	0.0	37.88	C
6	Node Munchen (OTS)		0.0	0.0	0	0.0	0.0	0.0	0	0.0	16.67	C
7	Node Madrid (OTS)		0.0	0.0	0	0.0	0.0	0.0	0	0.0	30.3	C
8	Node Porto (OTS)		30.3	0.04	40	30.3	0.0	0.0	0	0.0	0.0	C
9	Node Glasgow (OTS)		30.3	0.04	40	30.3	0.0	0.0	0	0.0	0.0	C
10	Node Bordeaux (OTS)		0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	C
11	Node Padova (OTS)		30.3	0.04	40	30.3	0.0	0.0	0	0.0	0.0	C
12	Baseline		0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	C

For more information about the other types of Failure Analysis, see the following sections:

- "Using Failure Impact Analysis" chapter (Flow Analysis *User Guide* in SP Guru Network Planner documentation)

• Failure Evaluation on page TrP-14-1

Table 6-2   Generate Failure Analysis Report for Transport Layer Failures Dialog Box

Option/Field	Description
Elements to Fail	The types of Transport network elements to fail. For every instance of a network object selected in this table, SWIM creates an SRG. You can select the following types of objects: • Cables—Failure of an optical cable (in OTS layer) • Entire transport nodes—Failure of an entire Transport node (including all OXCs, DXCs, OADMs, and other equipment present at the site) as well as the Layer-2/3 node(s) that have been mapped onto it • OXCs—Failure of individual optical cross-connect (OXC). This does not include optical cross-connect parts of IXCs • IXCs—Failure of individual integrated electrical/optical cross-connect (IXC) • OADMs—Failure of individual optical add/drop multiplexer (OADM) • Patch Panels—Failure of patch panel • DXCs—Failure of individual digital cross-connect (DXC). This does not include digital-cross connect parts of IXCs • ADMs—Failure of individual digital add/drop multiplexer (ADM)
Element Failure Combination	The following options are available: • Single—General a single-failure case for every network object of a selected type. Thus if you selected "Cables" under "Elements to Fail", the report will show the effect of every individual cable failure in the network. • Pairwise—General a pairwise-failure case for every two-object combination of network objects whose type is selected. Thus if you selected "Cables" and "OXCs" under "Elements to Fail", the report will show the results of every pairwise-failure case (two cable failures, two OXC failures, or one cable/one OXC failure).
End of Table 6-2	

Viewing the Effects of a Custom Failure Scenario

You can study the effect of specific failure scenarios using the Failure Analysis mode in SWIM, as described in Procedure 6-1.

For more information, see the tutorial Protection in an MPLS-Enabled IP-Over-WDM Network on page SWIMT-3-1.

Procedure 6-1   Analyzing a Custom Failure Scenario Using SWIM

1 Open the SWIM project in SP Guru Network Planner, then choose SWIM > Switch to Corresponding Transport Network.

2 Choose Info > Failure Analysis.

➥ The Failure Analysis dialog box opens.

3 Fail the desired objects in the transport network. To fail an object, right-click on it and choose Fail. (Keep the Failure Analysis dialog box open as you do this step.)

4 After you define the failed objects, click Evaluate in the Failure Analysis dialog box.

5 Leaving the Failure Analysis dialog box open, choose SWIM > Switch to Corresponding Layer-2/3 Network.

6 If the "SWIM > Automatically Update Operational Status Visualization" menu item is unchecked, select this menu item to turn on visualization.

7 To view delay characteristics, transport-layer routing, and other information about mapped links, open the Mapped Connections Browser (for more information, see Mapped Connections Browser on page TC-5-11).

End of Procedure 6-1