1 SWIM Overview

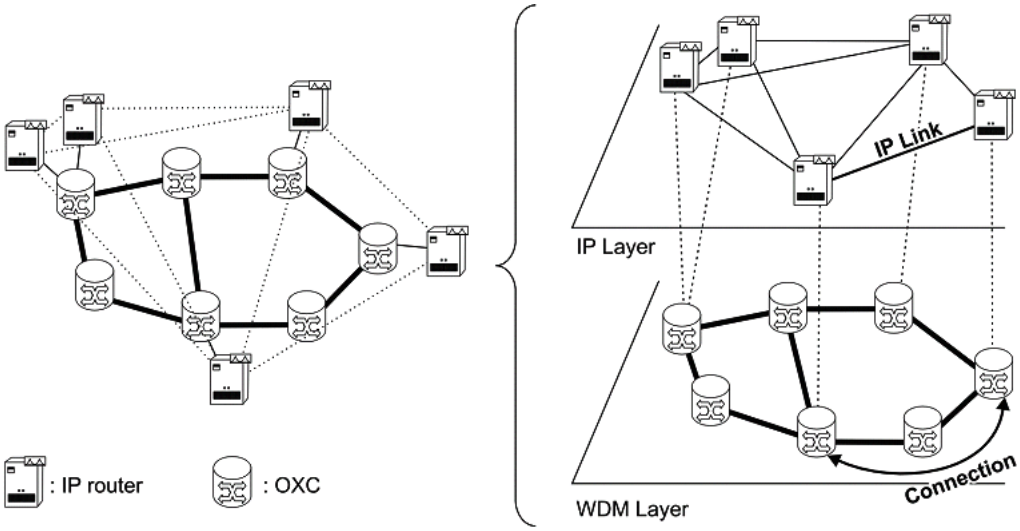
The SWIM (SP Guru with Interlayer Modeling) product suite enables you to create and analyze network designs that integrate a layer-2/3 network (one that uses IP, ATM, or other Layer-2/3 technologies) with an underlying transport network. This chapter provides an overview of IP-over-transport networks and a description of the workflow for designing these networks using SWIM.

IP-over-WDM Networks

In recent years, telecommunications networks have faced an explosive growth in traffic, fueled largely by the popularity of the Internet, and the demand for ever-more bandwidth is likely to continue. TCP/IP is functioning as the convergence layer for nearly all end-user communication in today's communication networks. As a result, networks are increasingly optimized to support IP traffic. This trend is also likely to continue.

Many enterprises and service providers have adopted wavelength-division multiplexing (WDM) technology to support the high bandwidth requirements on multi-service networks. Due to the growing importance of IP traffic and the opportunities offered by WDM technology, current transport networks are evolving into "IP-over-WDM" networks, in which the IP network relies on an underlying WDM network for the required connectivity and capacity. This type of network is based on a set of IP routers combined with a transport network infrastructure. Typically, the transport network consists of SONET/SDH equipment that provides the necessary interconnections between the routers, as illustrated in Figure 1-1.

Figure 1-1 IP-over-WDM Networks: Multi-Layer Network View



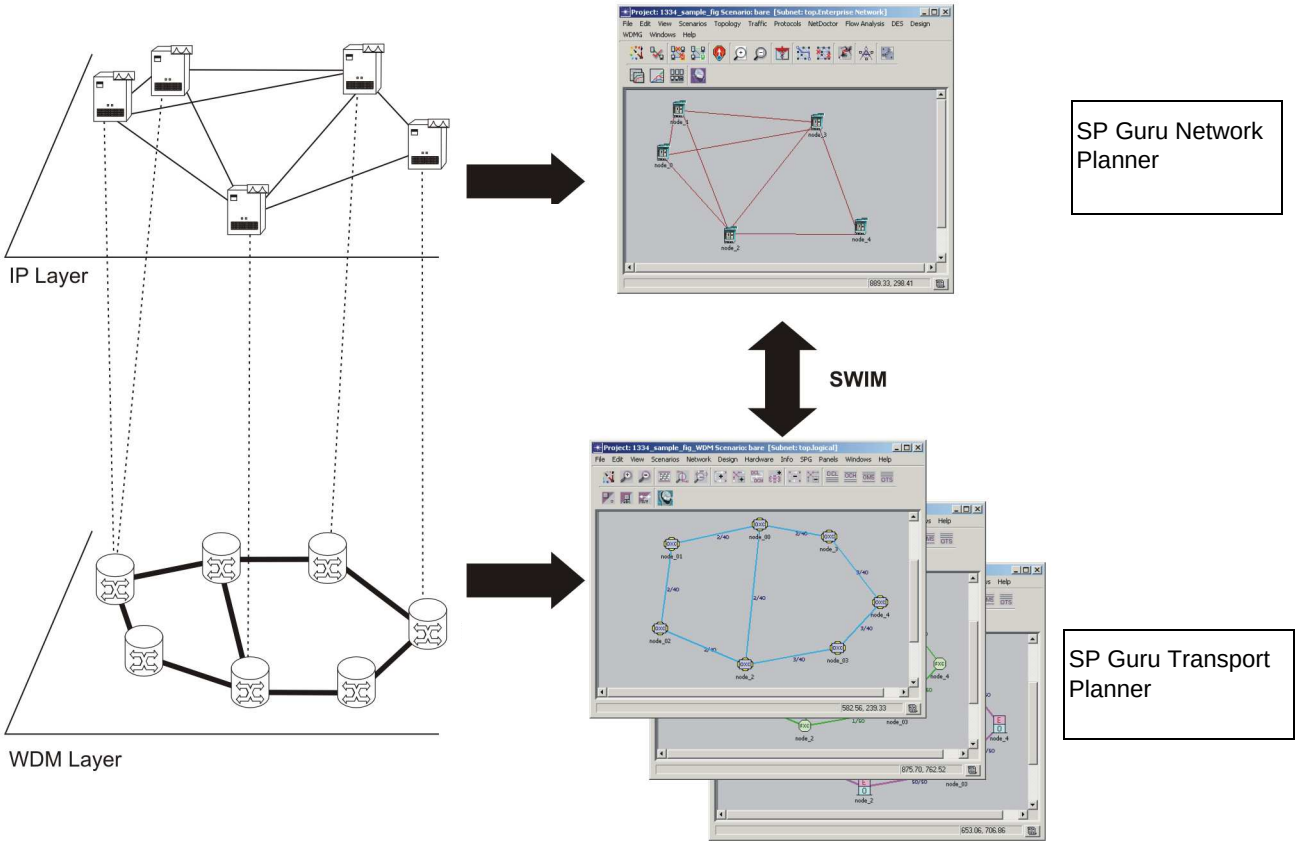
You can think of this network as consisting of two conceptual layers–the IP layer and the transport layer—in which each layer relies on its own functionality and protocols. These layers have a client/server relationship: the IP layer relies on the transport layer to provide connectivity between IP routers. IP links rely on transport-layer connections between transport-layer nodes (such as DXCs or OXCs). These nodes are collocated with, and connected to, the IP routers.

Advantages of Multi-Layer Network Design

To implement a truly multi-layer design and analysis of such a multi-layered network, you must model the relationship between the IP and transport layers accurately. It is not enough to model each layer independently. In a SWIM network scenario, Layer-2/3 links are supported by transport connections; this means that link attributes depend on the status of the underlying connections. If a transport connection fails (for any reason), any dependent Layer-2/3 link also fails. If a transport connection is running, the routing of that connection affects the IP link delay. A multi-layered design offers the following advantages:

- Realistic Service Level Agreement (SLA) modeling—Because Layer-2/3 link delays are calculated based on the underlying transport network, you can verify SLAs realistically and enforce SLAs using constraint-based routing.
- Multi-layered Failure Analysis studies—A multi-layered design enables you to study how failures in the transport layer affect performance in the Layer-2/3 network, which you cannot do with layer-specific Failure Analysis operations in SP Guru Network Planner or SP Guru Transport Planner alone.

Figure 1-2 SWIM Architecture for Modeling Multi-Layer Networks



SP Guru Network Planner/SP Guru Transport Planner Integration

SWIM integrates two OPNET analysis software products (SP Guru Network Planner and SP Guru Transport Planner) that include extensive features for studying IP and WDM networks. SWIM provides you with an integrated view for designing and analyzing multi-layer, IP-over-WDM networks.

One important step in the SWIM workflow is to map Layer-2/3 objects with their corresponding transport-layer objects. Specifically, you must specify two types of mapping:

- Node mapping—This step specifies the relationship between Layer-2/3 devices and the optical-transport equipment with which they are connected. For example, you might need to specify that a Layer-2/3 router or switch is connected to a DXC (digital cross-connect) and is collocated with an OXC (optical cross-connect) in the transport network.
- Connection mapping—You might also need to specify the relationship between Layer-2/3 links and transport connections that support those links—for example, that a 10G Ethernet link in the layer-2/3 network is supported by an OC-192 connection in the transport network.

After you specify the mapping of nodes, links, and connections in the two network layers, SWIM configures IP link attributes (such as operational status and delay) based on the status of underlying connections.

Keep in mind that SP Guru Transport Planner models a transport network at different layers: physical layers (cables/fibers), optical-channel layer (wavelength switching), and digital-client layer (SONET/SDH circuits). You can think of SWIM as adding another layer—the Layer-2/3 network, modeled in SP Guru Network Planner—to the SP Guru Transport Planner network. SWIM maintains the relationships between the Layer-2/3 and the transport-layer views, and provides the interface to switch between the two programs.

For a detailed description of the network layers modeled in SP Guru Transport Planner, see Layers in SP Guru Transport Planner on page TrP-2-8.

Common Use Cases

This section describes some common use cases for SWIM:

Multi-Layer Network Design: Transport Network Supporting a Layer-2/3 Network

Given an existing Layer-2/3 network modeled in SP Guru Network Planner, SWIM can generate a transport network to support the Layer-2/3 infrastructure and demands. This means that you can easily determine the transport-layer resources needed to support a Layer-2/3 network. The Node Mapping dialog box enables you to define the relationships between transport nodes (such as

OXCs or DXCs) and Layer-2/3 nodes (such as routers and switches) in one step. You can also define links (optical cables with fibers) in SP Guru Transport Planner. You can use SWIM to create traffic matrices based on IP traffic demands; then you can design the transport network using the traffic matrices and standard SP Guru Transport Planner design operations (such as routing or dimensioning).

This workflow is described in detail in the following procedures of the SWIM Tutorial:

- Procedure 2-1 Defining the Integrated SP Guru Network Planner / SP Guru Transport Planner Project on page SWIMT-2-1
- Procedure 2-2 Dimension the Transport Network to Accommodate the New Traffic on page SWIMT-2-6

Multi-Layer Failure Analysis for Specific Cases

SWIM enables you to perform multi-layered failure analysis studies. Transport-layer equipment failures (such as cable cuts or OXC failures) can affect the corresponding Layer-2/3 network. You can analyze these effects in SWIM: using the built-in failure analysis features in SP Guru Transport Planner, you can explicitly fail one or more elements and see how these failures affect connections in the transport layer. SWIM propagates the failure status of connections to Layer-2/3 links in SP Guru Network Planner: if a transport-layer connection fails, any Layer-2/3 link that depends on that connection also fails. Other links might have increased delay times due to longer protection routes in the underlying transport network.

This workflow is described in Procedure 2-4 Failure Analysis on page SWIMT-2-12 of the SWIM Tutorial.

Multi-Layer Failure Analysis Reports

SWIM can also generate Failure Analysis reports automatically. You can specify a set of failure scenarios (for example, all single and pairwise cable cuts) in SP Guru Transport Planner. For each failure scenario, SWIM shows the links that have gone down or suffered higher delays.

Constraint-Based Routing and SLAs

The constraint-based routing capabilities of SP Guru Network Planner enable you to design Layer-2/3 networks to meet specific SLA requirements. Because SWIM provides an integrated view of a multi-layered network, Layer-2/3 link delays are based on delays in the underlying transport connections.

Diverse Routing with MPLS

The growing importance of IP networks make it critical to ensure maximum availability of the network and the services its supports. You should design a network to be robust against failures. Most optical-transport networks have protection mechanisms to protect against failures such as cable cuts. Layer-2/3 networks can use Multi-Protocol Label Switching (MPLS) to specify protection paths in case working paths fail. MPLS supports primary and secondary path definitions, in which the secondary path is used whenever the primary path fails. With SWIM, you can use MPLS to find primary and secondary paths that do not share resources in the transport layer. Using MPLS-based protection, you can design a network that is robust against failures in both the Layer-2/3 network and the transport network.

A detailed use case is illustrated in Protection in an MPLS-Enabled IP-Over-WDM Network on page SWIMT-3-1 of the SWIM Tutorial.

Workflow Description

The SWIM workflow is divided into three main phases:

1) Define the multi-layer scenario, including the network topology and traffic (both the Layer-2/3 network in SP Guru Network Planner and the transport network in SP Guru Transport Planner).

2) Design the transport layer using the routing and dimensioning design operations in SP Guru Transport Planner. This sets up the connections needed to support the network traffic.

3) Analyze the network using features in SP Guru Network Planner, SP Guru Transport Planner, and SWIM.

Defining a Multi-Layer Network Scenario

A multi-layered network scenario consists of a network scenario in SP Guru Network Planner, a corresponding scenario in SP Guru Transport Planner, and a SWIM file that defines the correspondence between the two scenarios.

A network topology defines the nodes present in the network (IP routers, OXCs, and DXCs) and how they are connected using links and connections. To create the initial topologies, you can use any of the standard methods provided in SP Guru Network Planner and SP Guru Transport Planner, such as importing from device configurations or data files. SWIM also includes the following features to help you create multi-layered networks:

- A “Create corresponding Transport Planner Project” operation that creates a SP Guru Transport Planner project with a matching scenario for each SP Guru Network Planner scenario.

- A “Map Nodes” operation for mapping Layer-2/3 nodes to transport nodes—for example, to specify which IP routers are collocated with, or connected to, which OXCs and DXCs.
- A “Map Links” operation for mapping Layer-2/3 links to transport connections. This operation also creates traffic matrices in SP Guru Transport Planner that you can use to design the transport network.

Designing the Network

After you create the multi-layered scenario, you can design the network at Layer-2/3 and at the transport layer. Standard design operations available in SP Guru Transport Planner (such as routing, grooming, and dimensioning) set up the connections defined in the newly-created traffic matrices.

You can also design the Layer-2/3 network using design actions available in SP Guru Network Planner (such as link dimensioning and MPLS Traffic Engineering). These design actions consider information that is based on the transport layer, such as link delays and shared risk groups.

Analyzing the Network

You can analyze your network within one layer using any of the standard operations available in SP Guru Network Planner or SP Guru Transport Planner. SWIM also includes operations (such as multi-layered Failure Analysis) for analyzing a network at both levels.