Multilayer Optimization with Cisco WAN Automation Software Portfolio: Reduce Costs and Improve Resiliency

White Paper

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Contents

What You Will Learn

For the foreseeable future, network operators will combat unprecedented levels of traffic growth, constantly challenging the capacity and resiliency of their networks. Cisco has developed a new approach for tuning the capacity and resiliency of a network to greater levels of performance. It entails optimization of circuit and service provisioning based on up-to-date awareness of the IP and optical layers, including the interrelationships between those layers.

To be highly effective, multilayer optimization in IP-optical networking must account for traffic, topology, and current equipment state at both the IP and optical layers. To plan more resilient, cost-effective networks, the process must consider all the topological linkages between Layer 3 and Layer 1.

For example, Layer 1 failures such as fiber cuts can cause serious, unexpected Layer 3 traffic congestion. Knowing the fiber plan while designing alternate routes can substantially ease the task of planning for (and preventing) such congestion. In nearly all service provider operations today, the Layer 1 transport planners and Layer 3 IP and Multiprotocol Label Switching (MPLS) planners have little to no effective means of sharing and evaluating a combined network plan.

At the infrastructure level, Cisco addresses these needs through the Cisco® Evolved Programmable Network (EPN). The EPN readies the physical and virtual infrastructure for programmable networking, resulting in accelerated innovation and optimal resource use. Leading the EPN is the Evolved Services Platform (ESP), an orchestration and virtualization solution that reduces total cost of ownership (TCO) and spurs revenue growth.

The ESP includes the Cisco WAN Automation software portfolio of products. These products address multilayer optimization by allowing providers to optimize multilayer networks with Cisco WAN Automation Design, which provides a single model of multivendor, multilayer networks all the way from fiber ducts to IP routing, MPLS tunnels, and individual service classes.

As a result, designers can lower total costs by using the Layer 1 topology as the basis for designing Layer 3 networks. They can also evaluate resiliency of existing networks by using Cisco WAN Automation Design Layer 3 discovery tools and then mapping the current Layer 3 network state onto an existing Layer 1 topology.

This white paper illustrates Cisco WAN Automation Design multilayer planning capabilities and discusses how tier 1 service providers are now using these tools in conjunction with a Cisco nLight™ multilayer control-plane architecture for IP and optical convergence to improve cost savings with advanced multilayer resiliency schemes. The resultant multilayer restoration models take advantage of all the resources at Layer 3 and Layer 1 to avoid overprovisioning at Layer 3.

Introducing the Cisco WAN Automation Design Approach to EPN Modeling at Layer 1 and Layer 3

Cisco WAN Automation Design can be run in an online system, with collected information from Layer 1 and Layer 3. Fully heterogeneous networks from multiple vendors are supported at both layers, allowing network operators to model Layer 3 and Layer 1 topologies together to specify how Layer 3 circuits route over Layer 1 (fiber) links. Operators can simulate unlimited performance or failure conditions to reveal weak or vulnerable segments of the network and proactively mitigate their effects before a failure occurs.

For example, an express route might map a single Layer 3 circuit over a series of Layer 1 links. This association allows you to simulate failures of Layer 1 links individually or across all Layer 1 links to determine the effects on the Layer 3 topology and traffic. For instance, you can determine which circuits would fail, where IP and MPLS rerouting occurs, and the resultant traffic congestion.

Cisco WAN Automation Design also supports the analysis of link aggregation groups (LAGs) and shared-risk link groups (SRLGs):

- Routing the individual interfaces within a LAG bundle over different physical routes can substantially improve network resiliency. However, this configuration is typically not implemented because of the complexity of evaluating failure scenarios across network layers. Cisco MATE Design simplifies this evaluation process, helping you take full advantage of this LAG resiliency option.
- SRLGs are often used in the design of MPLS tunnels to increase network availability when multiple circuit failures occur as a result of Layer 1 link failures. These configurations are challenging to maintain with changing fiber maps, adding risk to the routing design. Cisco MATE Design helps eliminate this risk by allowing you to generate these SRLGs directly from the Layer 1 map. You can also take SRLGs a step further by evaluating risks due to multiple fiber failures, for instance, in a shared duct.

Framework for Importing Layer 1 Information to Cisco WAN Automation Engine

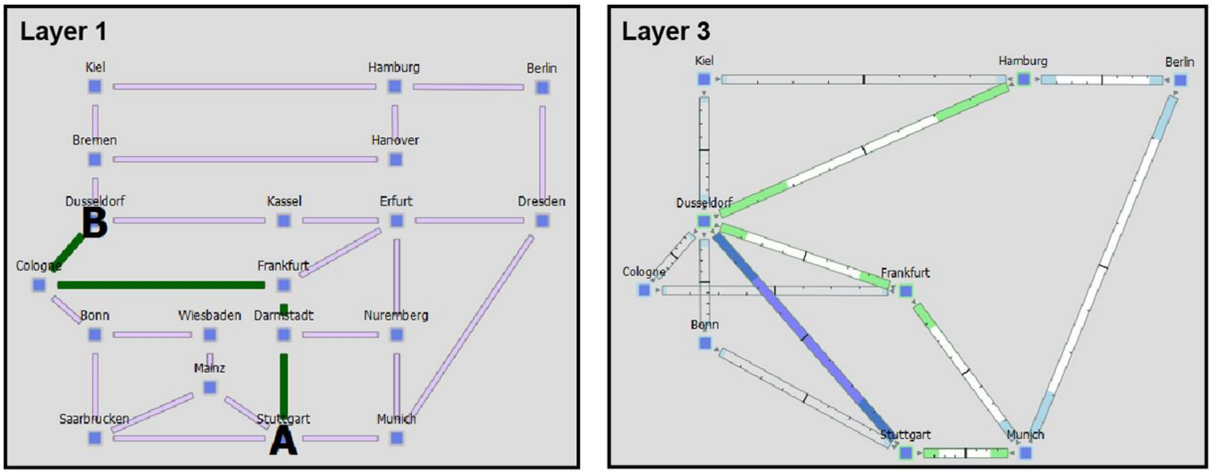
The WAN Automation Engine contains a vendor-independent model of the optical network. The fundamental visualization, simulation, and design features are common across networks built with different single- or multi-vendor equipment. Similar to the WAE Layer 3 collection system, vendor-specific WAE collector plugins populate this model for different vendors and different sources of data. These may be Element Management Systems (EMS), optical controllers, or operator-specific databases of optical topology and routing data.

Plugins that have been developed and deployed by Cisco include support for Cisco, Ciena, and Infinera equipment, and development of further plugins is active. The interface of the plugins into WAE is a common YANG module. This open specification allows 3rd parties to contribute to the optical plugin development.

Example: Evaluating and Redesigning Layer 3 Connectivity over a Layer 1 Topology

Figure 1 shows a Cisco WAN Automation Design model of a Layer 1 topology on the left, and an overlaid Layer 3 topology on the right, covering the major cities of Germany. With the Cisco WAN Automation Design GUI, you can model the routing of the Layer 3 circuits over the Layer 1 topology. For example, by selecting the Layer 3 circuit connecting Stuttgart to Dusseldorf, Cisco WAN Automation Design plots its Layer 1 fiber path through Darmstadt, Frankfurt, and Cologne. In this initial stage of the planning process, Cisco WAN Automation Design routes all circuits across their shortest Layer 1 paths.

Figure 1. Proposed Layer 3 Network Mapped on a Layer 1 Network



Using Simulation Analysis to Determine Effects of Layer 1 Link Failures

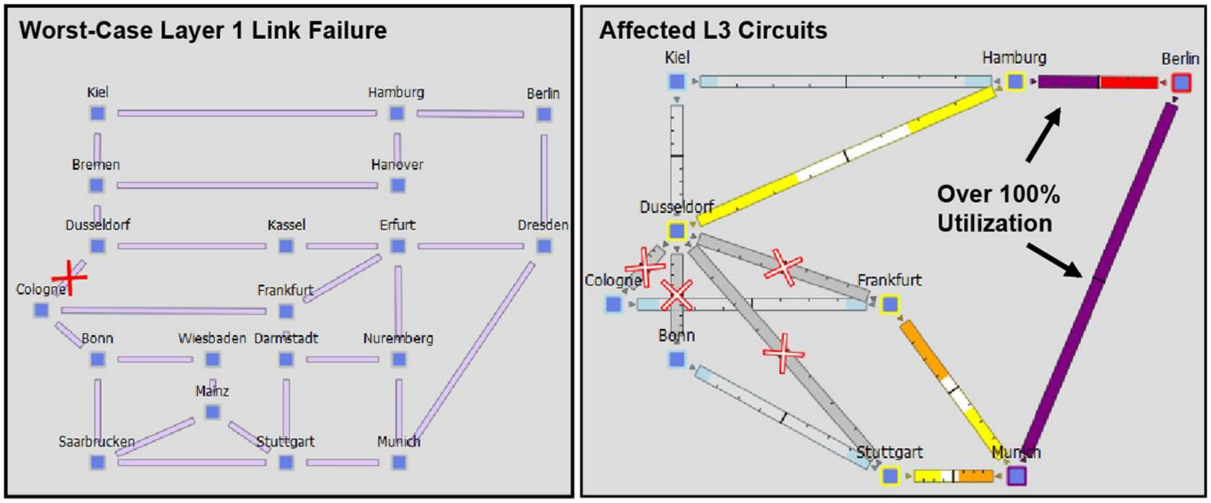
Using Cisco WAN Automation Design simulation analysis capability, you can quickly determine the resilience of the network with the initial circuit routing. In this example, you can simulate (one by one) the failure of each Layer 1 link in the network, and for each Layer 1 link failure, you can then calculate the following:

- Which Layer 3 circuits are affected
- The IP and MPLS rerouting triggered as a result of the failure
- The resulting traffic usage for each interface
- The highest usage each interface experiences over all these failures
- The effect on each traffic class of service (CoS) and which quality-of-service (QoS) violations occur

Figure 2 shows sample results. The analysis identified the failure of the Layer 1 link between Cologne and Dusseldorf (left side) as causing the worst-case usage in the network (right side). Under this failure, three Layer 3 interfaces reach a usage level of more than 100 percent (purple links at right), meaning that they would drop traffic under this scenario.

The analysis also demonstrates that, when the Cologne-Dusseldorf Layer 1 link fails (left side), four Layer 3 circuits are brought down (right side), as denoted by the red and white crosses. With this analysis, you can determine the potential for a large outage and create a prediction of the disruption it would cause in the network.

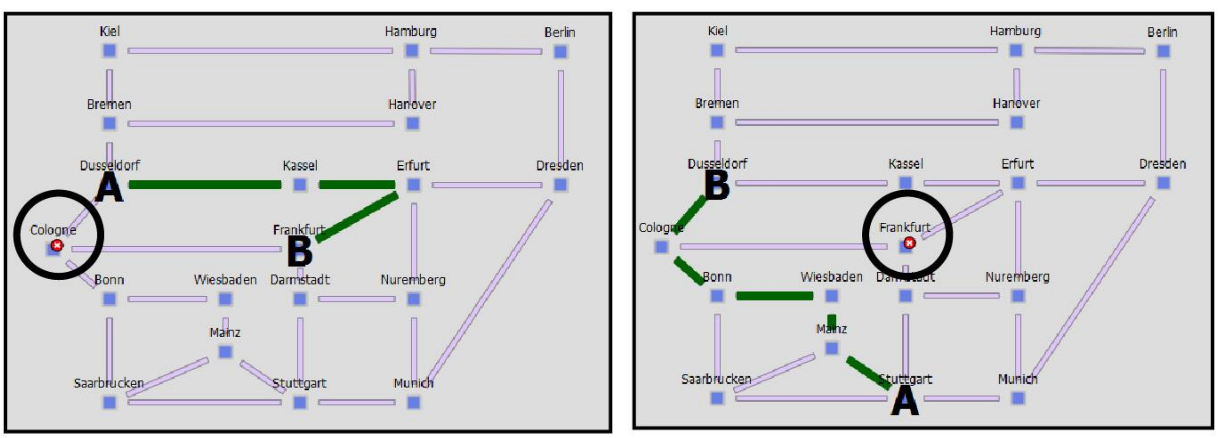
Figure 2. Effects of Worst-Case Layer 1 Link Failure on Layer 3 Network



Improving Layer 3 Network Design

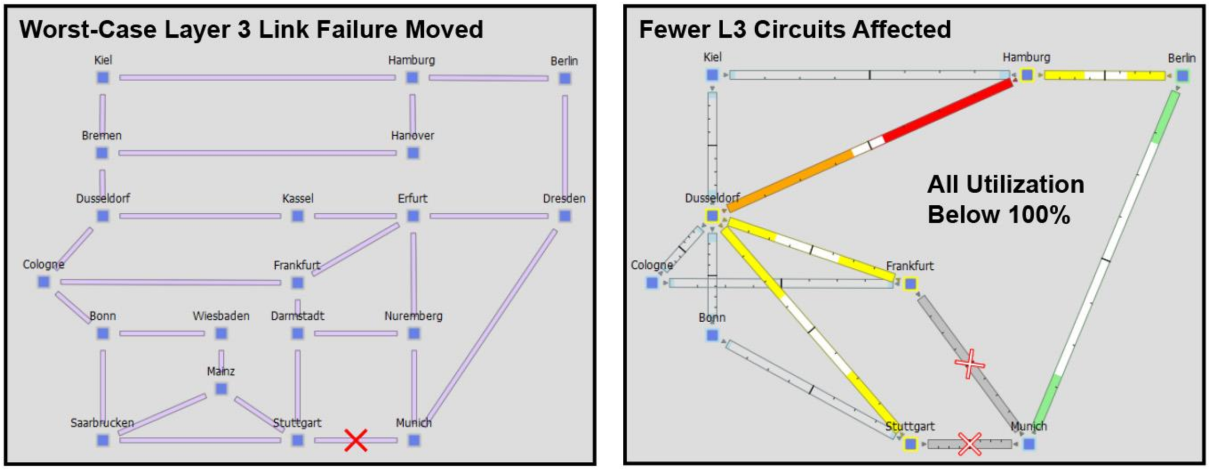
Identifying the failure that causes these worst-case usages helps guide a redesign of the circuit routing. An obvious first step is to reroute circuits off the Cologne-Dusseldorf Layer 1 link to reduce the effect of this failure. Cisco WAN Automation Design provides a quick, interactive way of experimenting with this rerouting. Figure 3 (left side) shows how you can set a Layer 1 "exclude hop" at Cologne to reroute the Dusseldorf-Frankfurt circuit away from Cologne and off of this Layer 1 link. Similarly (right side), using the exclude-hop feature to reroute the Stuttgart-Dusseldorf circuit away from Frankfurt would also reduce congestion.

Figure 3. Using Exclude Hops to Reroute Layer 1 Circuits



Running a simulation analysis on the redesigned network shows that worst-case usage has been improved and is below 100 percent everywhere (Figure 4). There is now a different failure causing the worst-case usage in the network, and it is far less disruptive. Figure 4 shows this failure scenario (on the left), the Layer 3 circuits affected (on the right), and the resultant traffic usage.

Figure 4. Improved Worst-Case Utilization



This example illustrates a successful step in a design process in which the Cisco WAN Automation Design GUI interactively evaluates alternative circuit routings. Other steps in a combined Layer 1 and Layer 3 design process that can be accomplished include:

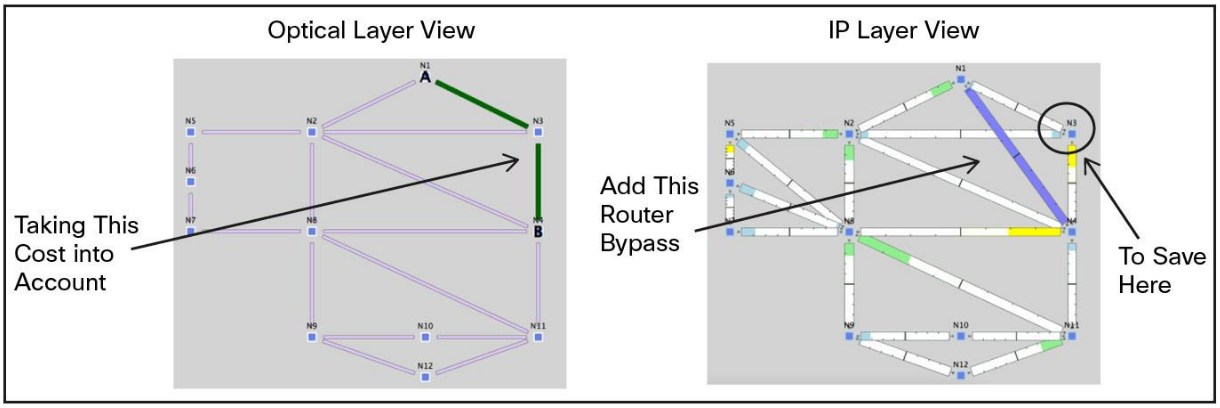
- Express route placement
- Diverse routing of LAG components for resilience
- Evaluation of latency changes in end-to-end Layer 3 routes under Layer 1 circuit routing scenarios
- Placement of diverse Layer 1 backup paths

Multilayer Planning for Cisco nLight Technology

Cisco WAN Automation Design offers a wide range of capabilities that are open and flexible, and they support add-on techniques for multilayer optimization scenarios, such as router-bypass optimization. These techniques are especially effective with a multilayer control-plane architecture such as Cisco nLight technology, which helps deliver significant capital and operating cost savings that are quantified most easily when viewed in conjunction with multilayer restoration.

Bypass optimization, for instance, optimizes Layer 3 by accounting for link costs at Layer 1. The goal is to find all opportunities to save Layer 3 transit costs. This goal is achieved by considering the traffic demands at Layer 3 and identifying intermediate routers in a path that should be bypassed to promote the lowest cost at Layer 1. This concept is illustrated in Figure 5, where the Layer 1 costs (left) to select the best Layer 3 route (right) are accounted for.

Figure 5. Multilayer Bypass Optimization



A more complete optimization then accounts for multilayer restoration schemes that deal selectively with Layer 1 and Layer 3 failures. Multilayer restoration efficiently deals with failed traffic by taking advantage of all available resources at both Layer 1 and Layer 3 after failures, and by helping to ensure that there's no overprovisioning at Layer 3.

Results on actual service provider networks have been modeled for these techniques in an IEEE Communications publication, which is listed in the "For More Information" section that follows. They demonstrate significant capital savings for Layer 3 ports and for transponders and wavelengths, with total projected savings on the order of 40 to 60 percent in large-core networks.

Conclusion

The Cisco Evolved Services Platform (ESP) with Cisco WAN Automation Software focuses on simple access to, and correlation of, intelligence from various points of the network. These capabilities help monetize and optimize the network and promote an enhanced subscriber experience. Cisco WAN Automation Design, in particular, provides capacity and traffic management to deliver improved network economics.

Layer 3 IP MPLS planning and design is greatly enhanced by incorporating details of circuit routing over Layer 1 topology. Using Cisco WAN Automation Software and Design, cross-functional groups can readily share multilayer plan files for improved efficiency in the Layer 3 planning process. The Cisco WAN Automation Design GUI provides a fast, convenient means of developing highly optimized and resilient multilayer networks plans.

This capability has been used by Tier 1 service providers with heterogeneous, multivendor networks that have accounted for resiliency requirements at all layers to improve cost savings in capacity planning over time.

For More Information

The following links provide additional information about multilayer optimization using Cisco WAN Automation and Cisco nLight technology, as well as the recent studies performed by Cisco in conjunction with global tier 1 service providers.

- ACG Business Case for Cisco Evolved Services and NFV: http://www.cisco.com/c/dam/en/us/solutions/collateral/service-provider/service-provider-strategy/case-study-acg.pdf
- Cisco Evolved Programmable Network: http://www.cisco.com/go/epn
- Cisco WAN Automation Engine: http://www.cisco.com/go/wae
- Cisco nLight Multilayer Control-Plane Architecture for IP and Optical Convergence: http://www.cisco.com/en/US/prod/collateral/routers/ps5763/whitepaper_c11-718852.html
- Multi-Layer Capacity Planning for IP-Optical Networks (IEEE Communications, January 2014): http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6710063

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