Network Planning and Optimization Tools

Getting the Most out of IP-Centric Networks

New services and IP-centric networking

Network evolution to new services and the widespread adoption of IP pose new challenges for network operations such as network dimensioning, planning, and engineering.

On the one hand, operators have to rapidly deploy new services on a converged network, making sure that the Quality of Services (QoS) and Service Level Agreement (SLA) are fulfilled. These data-oriented new services generate a wide variety of traffic profiles, characterized by dynamics on a broad time-scale.

To answer the above constraints, carriers have to take advantage of new networking technologies. And these have to be able to provide their infrastructure with a high level of flexibility: a combination of packet-and-circuit switching, distributed control plane, multilayer networks, carrier-grade packet transport, supporting multiple services such as IP/MPLS, Ethernet, and legacy.

Carriers need to effectively address the above concern to optimize their CAPEX (through proper equipment dimensioning) and OPEX (through streamlined deployment of services, pro-active maintenance operations, etc.). In this context, network simulations and optimization tools adapted to the new challenges could provide valuable support, allowing:

- accurate modeling of network behavior;
- effective planning of network extensions: evaluate/compare new technologies; accurately identify the portions of the network to extend or upgrade; validate proposed network evolution before implementation;
- support of Quality of Service, fault and Service Level Agreement management: predict feasibility/impact of new services or SLAs, validate QOS and restoration policies;
- support of network, traffic and policies engineering: optimization and validation of traffic engineering strategies to optimize resource and fulfil SLAs.

As a result of several years of experience in network design, Alcatel's research has developed a tool chain for network dimensioning, real-time simulation and traffic and network engineering optimization. In addition to being valuable for analyzing and benchmarking forward-looking proposals, these tools can also be used to support the tendering process as well as allow Alcatel to provide its customers with more complete support in engineering and optimizing their networks.

Ethernet traffic and network engineering: COMET

As Ethernet becomes widely deployed in carrier networks, there is a need for network and traffic engineering tools specifically tailored to Ethernet networks. COMET is a flexible and easy-to-use traffic engineering tool for Metro Ethernet networks. It enables network operators to achieve proper network configuration and efficient resource utilization. COMET implements a complete set of optimization algorithms to assist operators in managing bridged Ethernet networks. It can be used to optimally configure STP parameters, form the actual tree instances, and map VLANs intelligently into the different spanning tree instances for load balancing.

The COMET tool also helps optimizing MPLS/GMPLS networks and consequently facilitates the transition from connectionless to connection-oriented networks. It provides computation of primary and protection path and optimal load balancing.

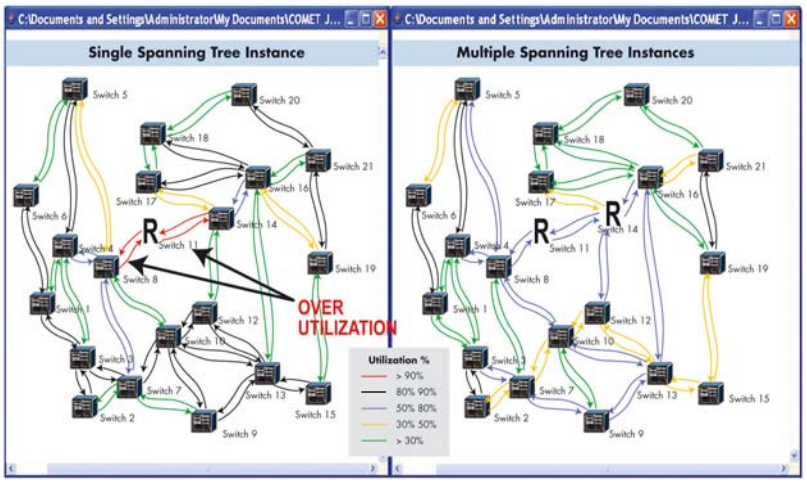

Figure 1: Alcatel COMET VLAN mapping optimization results. Multiple spanning trees help mitigate link over-utilization

Furthermore, COMET provides the ability to perform "what-if" analysis, where the network operator can study different network configurations, analyze the impact of network failures, or examine network growth.

Multilayer network dimensioning & optimization

Two complementary dimensioning and optimization tools are used for the design of multilayer networks consisting of IP/MPLS routers and transport equipments. The Forwarding Adjacency Builder (FAB) focuses on optimizing topologies, while networks IP enables the configuration of network elements and performs detailed cost analysis.

Forwarding Adjacency Builder (FAB)

The main purpose of the Forwarding Adjacency Builder (FAB) is to design virtual topologies and dimension multilayer resilient networks. From IP/MPLS over SDH overlay networks to Multi Service Transport Platform-based networks, the FAB supports a variety of packet/frame and transport technology integration models. The FAB can both realistically and accurately estimate bandwidth needs between router pairs. Faced with the ever increasing traffic volume, network operators need to either upgrade their IP/MPLS infrastructure or introduce a flexible transport network to offload transit traffic from routers where it is unnecessarily routed at such fine granularity. For the latter option, the FAB helps finding an optimized virtual topology, i.e. the set of connections provided by the transport network and needed between router pairs. In this way, it achieves a resilient and globally optimized multilayer network. It addresses the trade-off between direct switching of bigger granularities (to save costly ports in the upper layers), and multi-hopping (to increase efficiency of resource filling). Significant gains in network equipment cost by such optimization have been demonstrated on typical real-use cases of customer networks.

Networks IP

Networks IP is a multi-layer planning and dimensioning tool intended for IP/MPLS and subjacent SDH/WDM/OTH transport layers. The original version is available from Detecon and is being extended by Alcatel's research to include support for statistical multiplexing through new algorithms, algorithms for wavelength assignment, as well as models of Alcatel's products. It supports all planning steps, from analysis of the current network status, capacity planning and cost analysis to detailed network device configurations. The required capacities in each network layer can be determined by 'what-if' analysis of link or device failures. Its output consists of detailed technical system and device configurations (e.g. IP routing tables, but also the number of frames, boards, ports, etc.). With these extensions, the Networks IP tool has been used for dimensioning studies to optimize overall network costs of a real customer IP core network, in terms of different Class of Service (CoS), IP overlay topologies, and aspects of load sharing and protection.

Figure 2 shows the network layout and the resulting wavelength assignment by networks IP tool of a study on the influence of lambda conversion in optical transport networks.

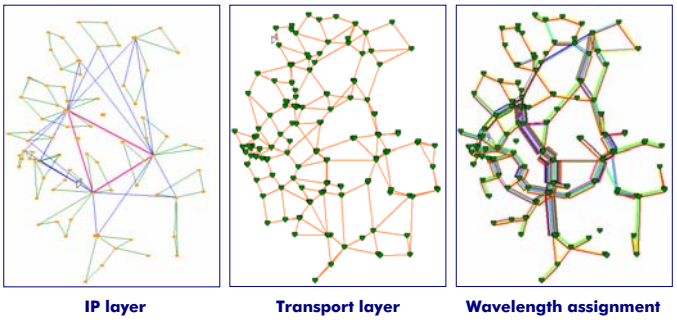

Figure 2: Wavelength assignment (path coloring) on fibers of the transport layer for an overlaying IP topology

Network modeling under realistic traffic conditions: Dynamic Flow Simulator

The Dynamic Flow Simulator (DFS) is a simulation tool intended for in-depth simulation of packet networks under realistic traffic conditions, allowing both bandwidth and queue dimensioning. It takes into account the dynamics of the network by simulating the continuous variations of the traffic at different time-scales on each link. Owing to a versatile flow-based model, it copes with a huge scale of dynamics, taking into account the different time-profiles of all the traffic sources, resulting in traffic very close to measured traces. In addition, the DFS simulates provisioning and restoration of connections via a distributed control plane, by implementing the semantics of GMPLS protocols. The DFS tool can be used for network performance evaluation or for network dimensioning, including bandwidth and queue dimensioning. For performance evaluation, the DFS evaluates parameters such as the load distribution inside the network, the connection blocking probability and the recovery speed. For network dimensioning and planning, the DFS gives the required resources inside each network element according to the simulated traffic variations. It provides the possibility to use some traffic engineering rules and to take into account any planning constraints due to the node architectures.

Alcatel's cutting-edge innovation

Evolution of networks, with their mix of heterogeneous technologies (packet, circuit) and multiple layers (IP, SDH, Ethernet, WDM, etc.) requires a new generation of dimensioning, simulation, and optimization tools. Using the latest networking technologies, Alcatel's research, with its substantial expertise in network architecture and engineering, has designed a tool chain that brings valuable support to network planning and optimization.

This project is partially funded by the European IST and the EUREKA ITEA programs. It represents one of the research initiatives underway in Alcatel's Research & Innovation labs.

Contact: alcatel.publications@alcatel.com