

Benefits from 2-Layer Traffic Engineering for IP/MPLS Networks

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Content

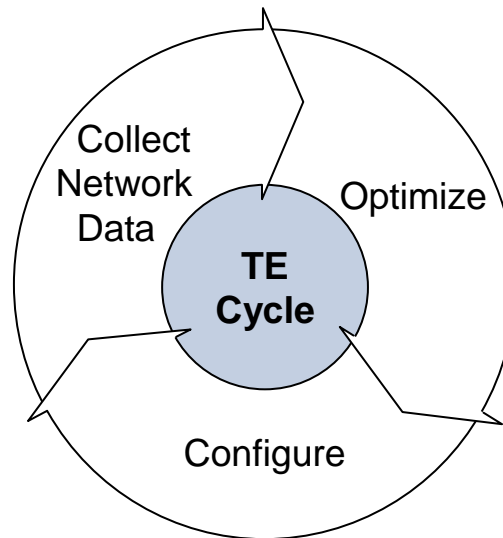
- 1. Traffic Engineering for Network Operators today**
- 2. Model for 2-Layer Traffic Engineering: SRLG Optimization**
- 3. Practical Implementation**
- 4. Results and Conclusions**

IP/MPLS Traffic Engineering Today

Single Layer Traffic Engineering Cycle

Traffic Engineering Objectives

- Performance evaluation and performance optimization of operational IP/ MPLS networks
- Optimize network resource utilization
- Reduce CAPEX
- Enforce SLA restriction for QoS classes (e.g. delay)
- Verify network state in defined failure situations

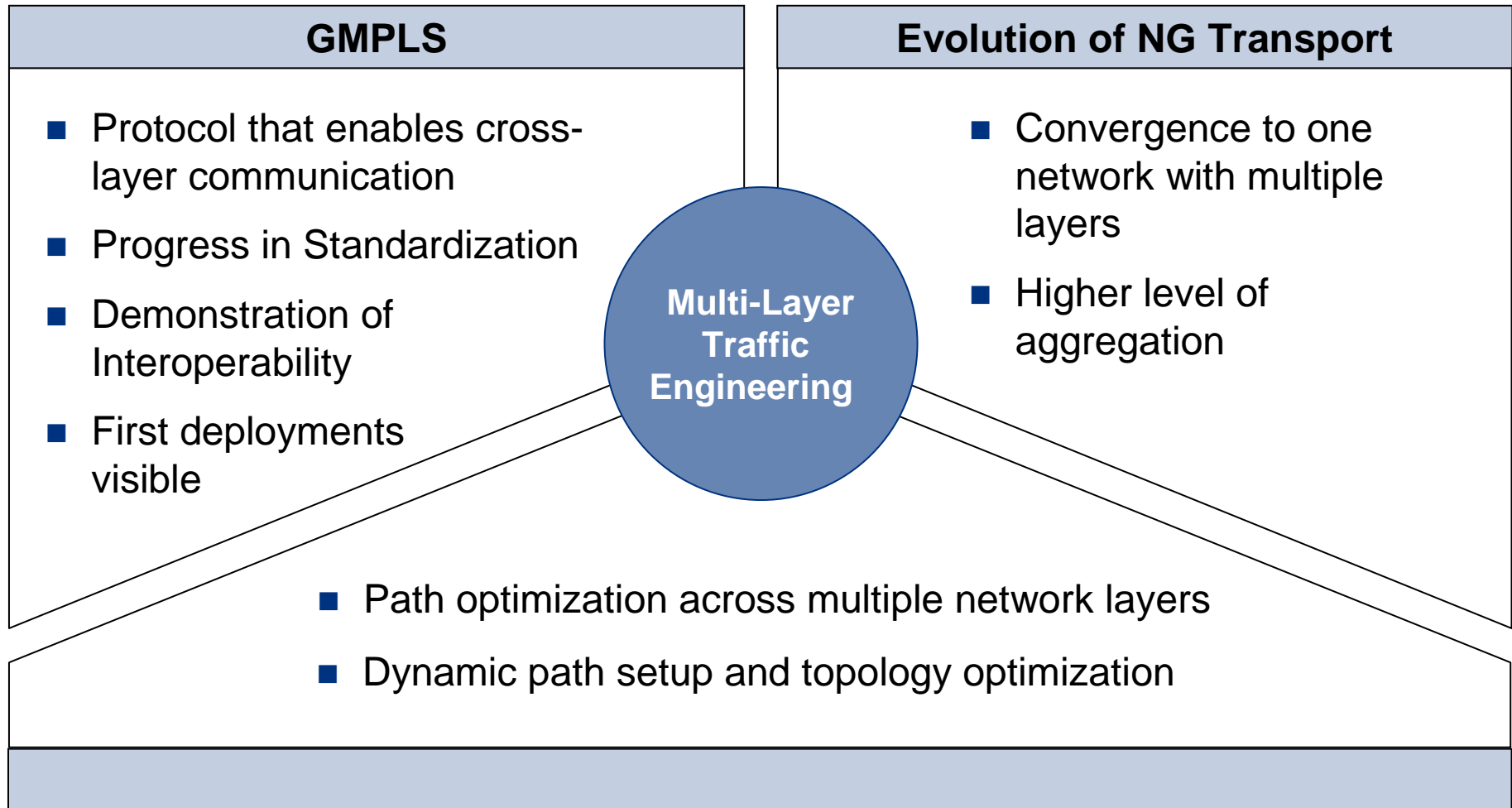


Traffic Engineering Methods

- Weight optimization for networks with SPF routing (IS-IS, OSPF)
- Path (LSP) optimization for MPLS networks
- BGP policy optimization
- Monitor delay restrictions for individual demands
- Failure simulations

Evolution towards Multi-Layer Traffic Engineering

Drivers, Enablers and Benefits



2-Layer Traffic Engineering and SRLG Optimization

Task Description and general Idea

- We focus only on routing optimization of existing IP-Links in lower layers (no IP topology optimization)
- By means of GMPLS the routing of IP links can be changed dynamically in the lower layer
- The routing of IP links defines **shared risk links groups (SRLG)** for the IP network
- Number and size of SRLGs affect the dimensioning of the IP network (CAPEX):
- The network planning process has to dimension the network such that an “acceptable” state of the network is maintained for any given failure scenario (including SRLG failures)
- Typically SRLG failures belong to the most severe failures
- If we can “reduce” SRLGs we might be able to transport the same traffic demand with less IP capacity

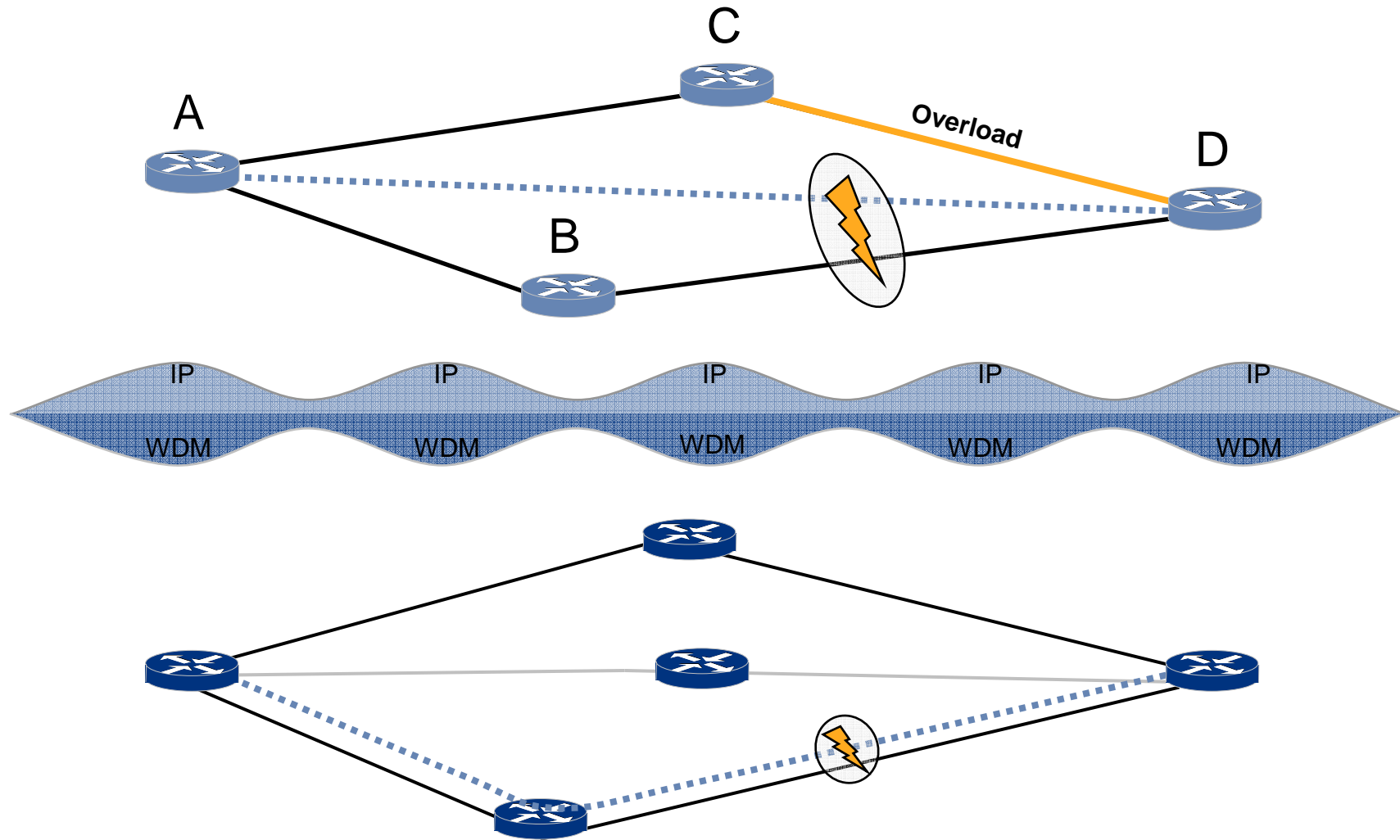
2-Layer Traffic Engineering and SRLG Optimization

Scenario Description

- We consider a two layer network: IP + WDM/OTN
- Use realistic IP/WDM topology from DT's global backbone network for the case study
- Assume that the static WDM network would be replaced by a GMPLS-enabled OTN network

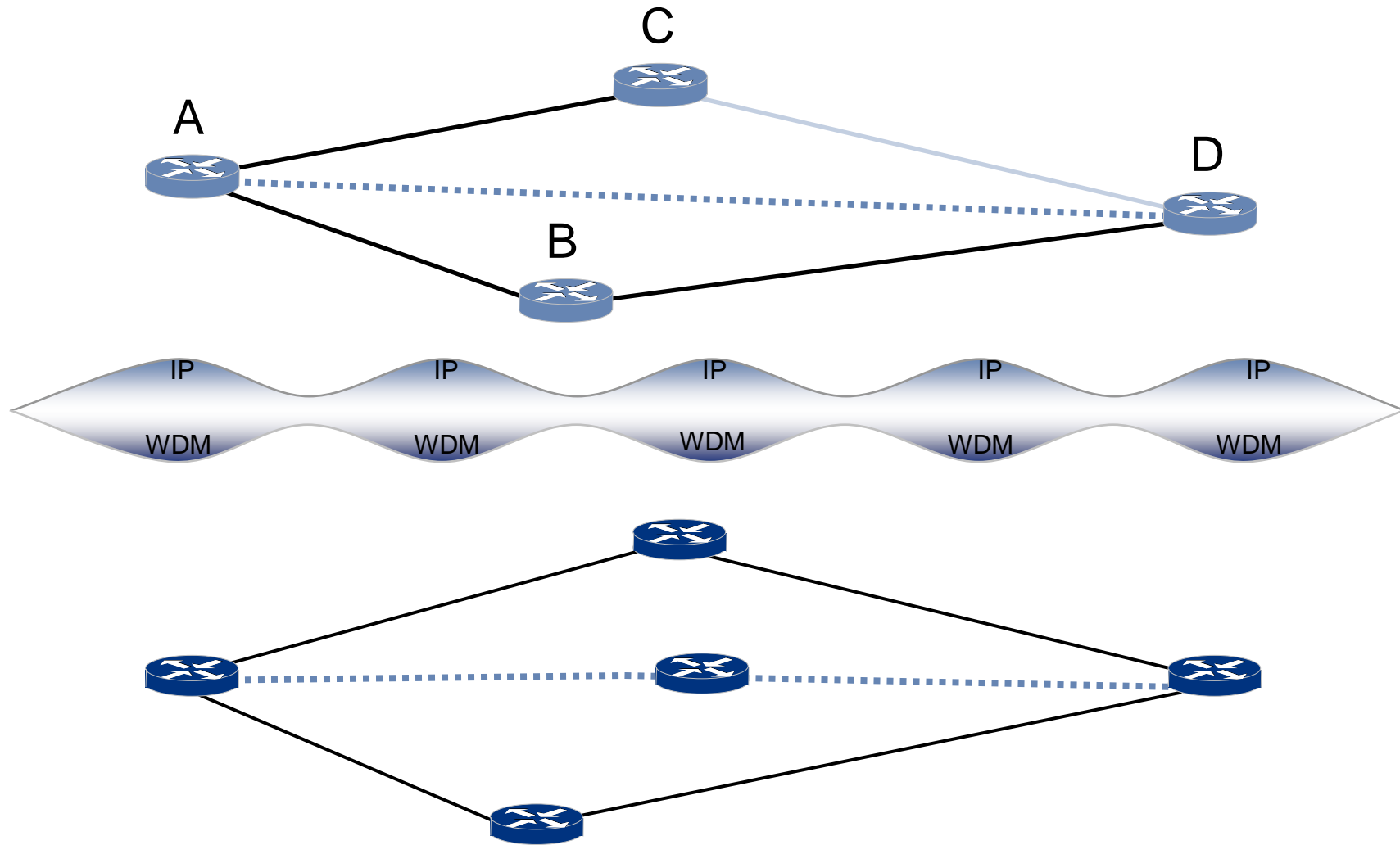
Simple Example for Multi-Layer Failures

No multi-layer Awareness



Simple Example for Multi-Layer Failures

Improve IP SRLGs



Undersea Cable Cuts in Q1/2008

Major Effect on Global Internet Traffic by 5 cable cuts within two weeks at the Beginning of 2008



Model for 2-Layer Traffic Engineering

SRLG Optimization == WDM/OTN Traffic Engineering

- Optimization Problem

Find a routing of IP links in WDM network such that the maximum SRLG size (with respect to the contained bandwidth) is minimized

- IP links are demands (clients layer) for WDM network (server layer)
- Routing of IP links introduces a utilization of WDM links
- For to the WDM network we have the equivalent problem:

Find a routing of IP links (demands) such that the maximum utilization of the WDM network is minimized

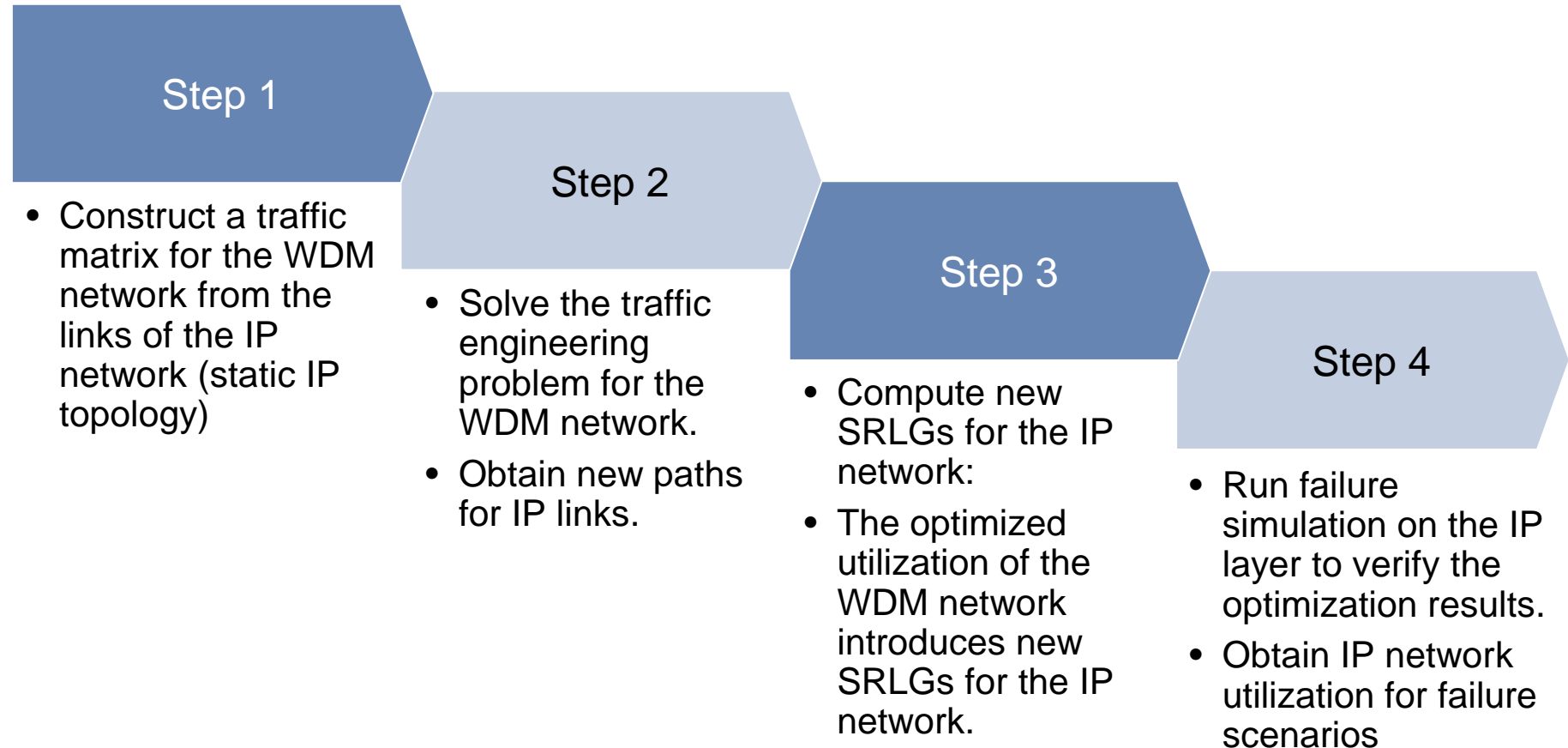
- This is a “classical” single layer TE problem for the WDM network

Restrictions and Approximations

- We use the size of SRLGs as an objective function
- This enables us to separate the problem:
 - Solve a traffic engineering problem for the lower layer
 - Use the optimized SRLGs for simulation on the IP layer
- The separation allows us to solve large/realistic network scenarios
- Our objective function is only an approximation for the actual goal:
Minimize the maximum link utilization for any failure scenario
- Theoretically (and practically) a failure of a smaller amount of (IP-) capacity can result in higher network utilizations
- A case study has to show if the approximate objective function improves the original goal in a realistic scenario, too.

Algorithmic Implementation

Summary

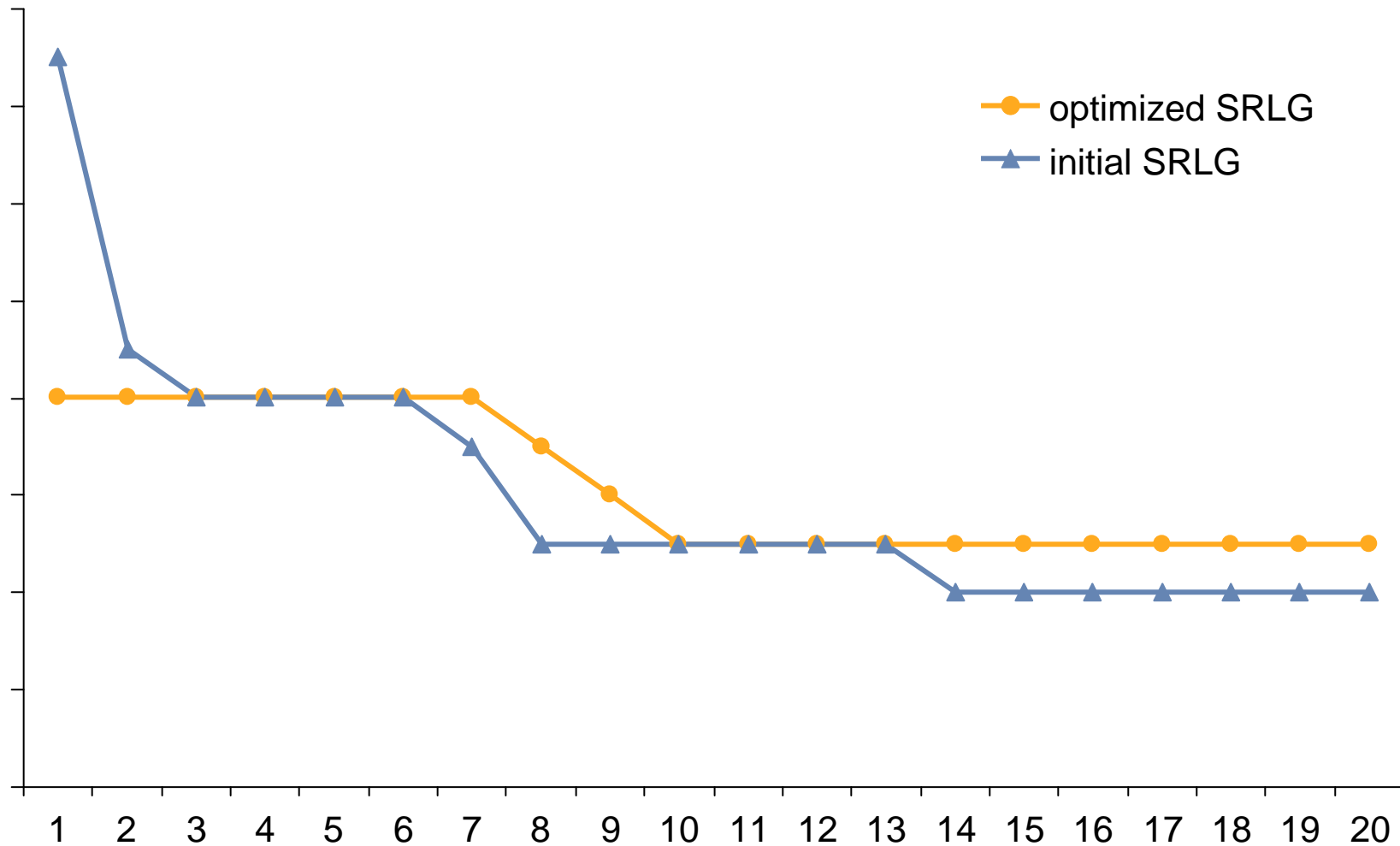


Some first practical Results

Scenario	Evaluation Metrics
<ul style="list-style-type: none">■ Measured IP traffic matrix;■ Operational IP/MPLS and WDM (backbone) network topologies;■ Around 200 nodes (router) in the IP layer.	<ul style="list-style-type: none">■ SRLG size distribution before/after the optimization <p><i>Evaluation of approximate objective function</i></p> <ul style="list-style-type: none">■ Maximum (IP-) link utilization in failure scenarios with original / optimized SRLGs (we consider SRLG failures only – others cannot be optimized here) <p><i>Evaluation of original objective function</i></p>

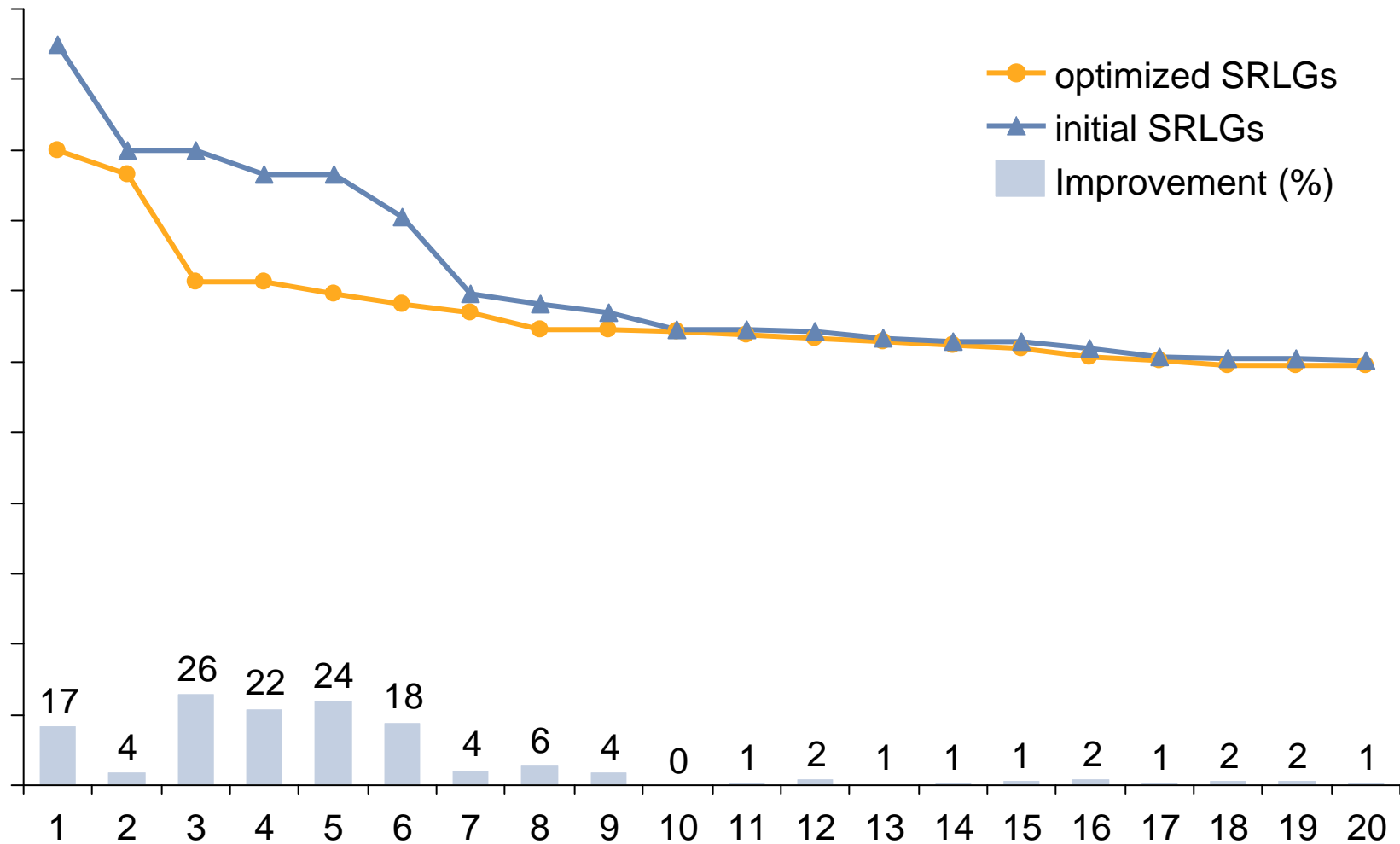
Distribution of SRLG size (Gbit/s)

TOP 20 SRLGs (ordered)



Maximum Utilization from any SRLG Failure

TOP 20 Links (ordered)



Conclusions and Future Research

- A smoothing of the SRLG size distribution can be observed
- Less SRLGs that contain a very large bandwidth

Successful traffic engineering for the lower/WDM layer

- Maximum link utilization in IP layer can be reduced

The chosen approximation does improve the original objective

- We presented a practical approach to leverage first benefits from multi-layer traffic engineering
- GMPLS would enable an automatic provisioning of the results but there is also immediate benefit for static IP+WDM networks: Let's talk across layers...

Detecon's Analysis, Planning and Optimization Software

The Subjects – Resources / Processes / Services

Detecon provides comprehensive multi-layer software solutions for analyzing, planning and optimizing resources and services in telecommunications networks.



Thank you for your attention!



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