Deutsche Telekom
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# Transport-Layer Aware Engineering of an IP Backbone

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# Transport-Layer Aware Engineering of an IP Backbone.

## Outline.

- Initial Situation
- Current Status of Traffic-Engineering on the IP/MPLS-Backbone of Deutsche Telekom
- Requirements of the IP/MPLS Layer to the Transport Layer
- Considerations about Multi- Layer TE
- Outlook
- Backup

# Transport-Layer Aware Engineering of an IP Backbone.

## Initial Situation.

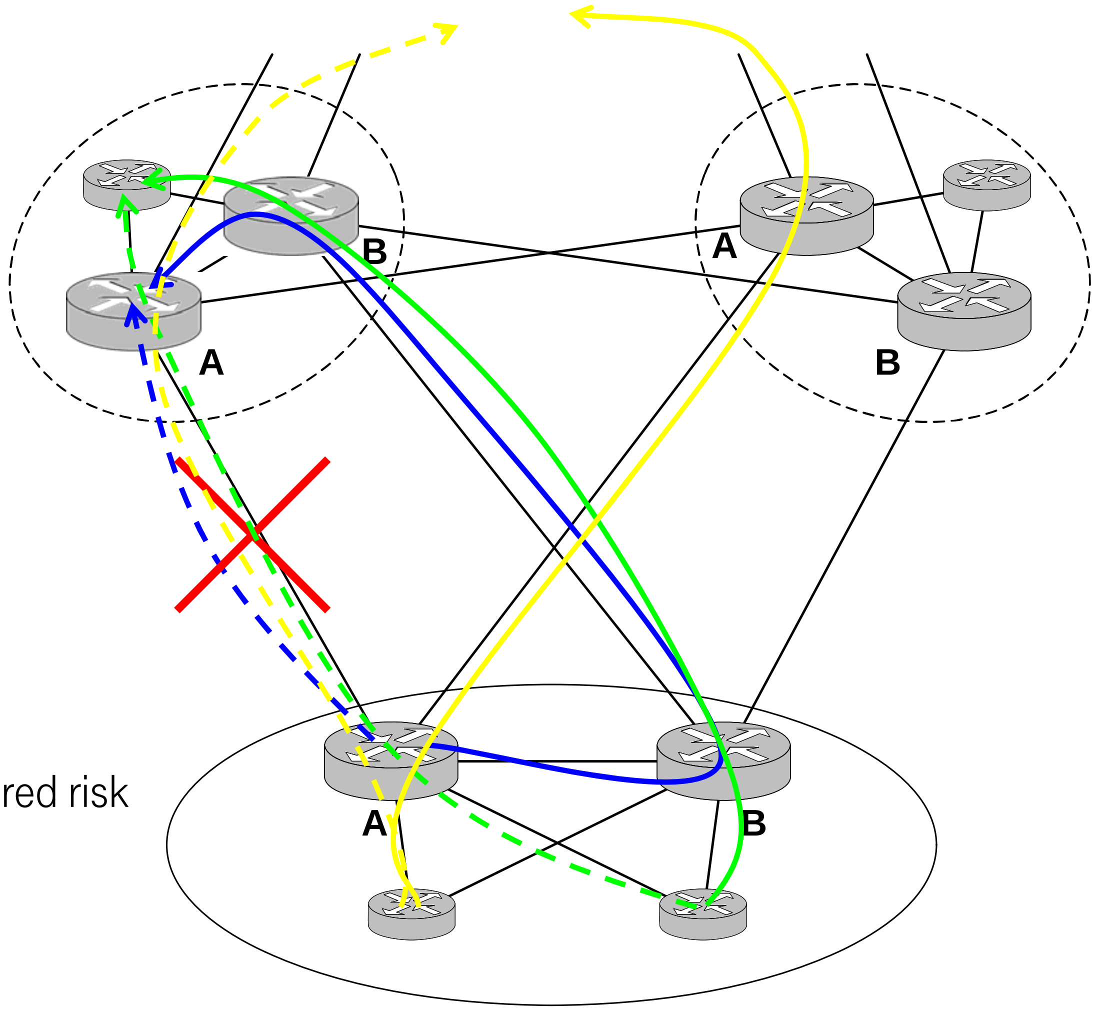
- New IP/MPLS backbone implemented in 2000 to cover exponentially growing IP traffic

- IP/MPLS technology to support multiple services (public IPv4, IPv6, VPN, PW, ...)
- Design with fixed topology, redundant fire sections (A/B network)
  - Conventional requirements to transport layer, e.g. disjoint paths for fire sections
- Planning based on link utilization:
  - Link upgrade before link utilization reaches 50 %
- Assumed to provide ≈ 1:1 protection
  - Wastes bandwidth in many cases due to multiple choices of backup paths
  - Proved not to be sufficient in all cases
- No verification of SLA possible, e.g. latency

# Transport-Layer Aware Engineering of an IP Backbone.

## Re-Routing.

- IP routing is based on local decisions considering the complete global network topology.
- Different demands take different paths in failure cases.




Failures can be:

- link failure
- node failure
- failure of a group of links with a shared risk (Shared Risk Link Groups, SRLG), e.g. WDM system, fiber bundle, fire section, building, ...

# Transport-Layer Aware Engineering of an IP Backbone.
## Current Satus.

- New system for traffic engineering developed and introduced in 2004
  - Infer traffic matrix from LDP based per-FEC counters
  - Correlate with IP topology
  - Simulate routing for normal case, failure cases and planning scenarios
- Optimization by tuning IGP link metrics
  - Improve network utilization, push more traffic through the same network
- Planning based on network simulation:
  - Network upgrade before any link utilization reaches 80 % in normal or 100 % in failure case
  - Planning decisions based on bottleneck analysis and comparison of simulated scenarios
  - Topology extension possible, e.g. increased meshing degree
- Verification of SLA (bandwidth/utilization, latency) by simulation
  - for normal case as well as for failure case

# Transport-Layer Aware Engineering of an IP Backbone.

## Requirements to the Transport Layer.

- Transport layer topology information must be available to the IP layer in order to allow failure case simulation and SLA verification. This includes:
  - link latency
  - SRLG
- Transport layer topology information must be up to date, i.e.
  - either static routing on transport layer and occasional updates, e.g. DB based,
  - or dynamic routing which is integrated with IP layer routing.

- Optimization of SRLG vs. latency (and cost) tradeoff is non-trivial and requires mutual influence and discussion.

- Signalling of advanced L1 link statistics (e.g. pre-FEC BER, receive level) to L3 allows proactive switchover in many failure cases.

# Multilayer Traffic Engineering and SRLG Optimization
## Possible Goals and Methods

- With GMPLS the routing of IP links in the transport layer (now WDM, possibly OTN in the future) can be changed dynamically.
- The routing of IP links determines parameters like latency and shared risk link groups (SRLG) for the IP network.
- If SRLGs can be „reduced" there is a potential for CAPEX savings since network dimensioning has to consider failure scenarios.
- **Is SRLG optimization a use or business case for GMPLS deployment?**

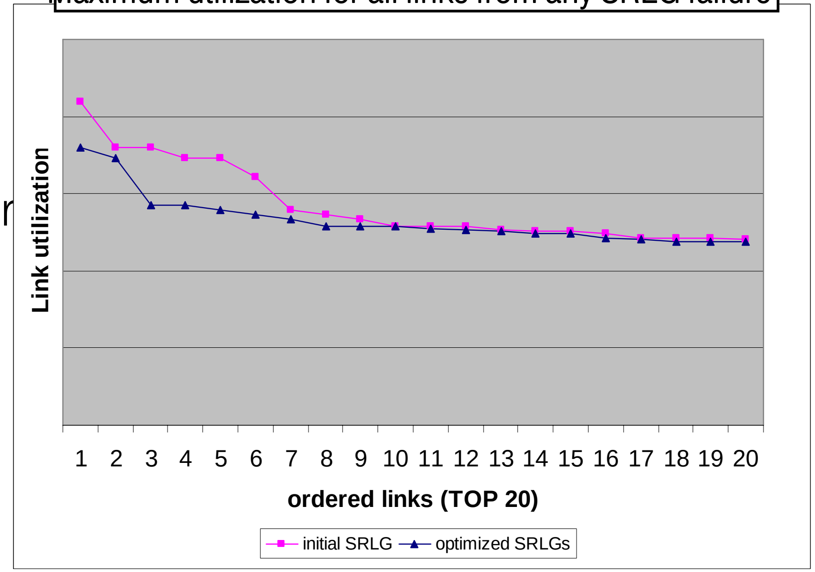
- An approximation for the SRLG optimization problem can be used:
  Find a routing of IP links that utilizes the transport network uniformly.
- Gives a „classical" traffic engineering problem for the transport layer.
- Tools and methods are well understood and available for large scale networks.

# Multilayer Traffic Engineering and SRLG Optimization.

## Some first practical results.

- **Scenario:**
  - measured IP traffic matrix, existing IP/MPLS and WDM (backbone) network topologies
- **Procedure:**
  - Build traffic matrix for WDM network (based on IP links)
  - Solve traffic engineering problem in WDM layer
  - Calculate new SRLGs for IP network
  - Simulate IP traffic with new failure scenarios

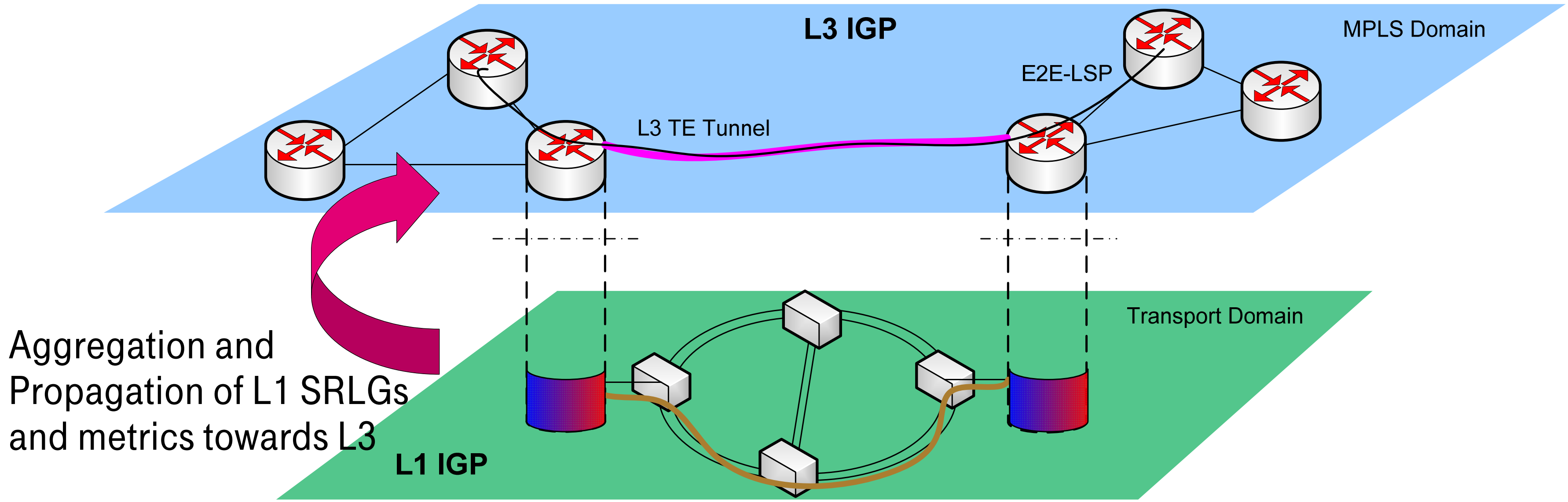
Maximum utilization for all links from any SRLG failure




- **Conclusions:**
  - First positive effects of SRLG optimization can be demonstrated.
    Example: Maximum link utilization in IP layer can be reduced
  - More research necessary - regarding optimality and feasibility

# Outlook.

## Automated Interworking between L1 and L3 using a GMPLS Control Plane.




- L1 IGP propagates topology information from the optical layer towards Layer 3.
- In case of FRR, e.g. information about SRLG is highly important to calculate an alternative disjoint path.
- GMPLS should be used to automate this process.

Thank you for your attention!

# Backup.
## How fast are fast re-route mechanisms?

| | |
|---|---|
| **Sub-second Requirement** | IGP convergence<br>■ Fast IGP: Conservative, available solution, deployed today |
| **Sub-200 ms Requirement** | IGP convergence<br>■ Fast IGP: More work for determinism and still milk a few 10's of milliseconds |
| **Sub-50ms Requirement** | Local Repair (aka Fast Re-Route, FRR)<br>■ MPLS FRR: mature technology, available, but limited scalability<br>■ IP FRR: new technology, low OPEX, high scalability; basic standard finished (IETF), implementation partly done. |