



**Nokia Siemens
Networks**



Constraints in multi-layer optimization for
IP traffic over optical WDM networks

Detlef Stoll

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Workshop topics

- Goals and guidelines for **cost** optimization in multi-layer optical networks
- Network example: Discussion of three realization options
- Integration of multi-layer cost optimizing algorithms into optical network planning tools

Cost drivers

IP Routers



**CAPEX relation
per Gbps**

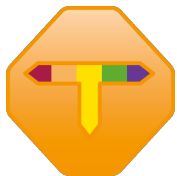
100%

Layer 2 switches



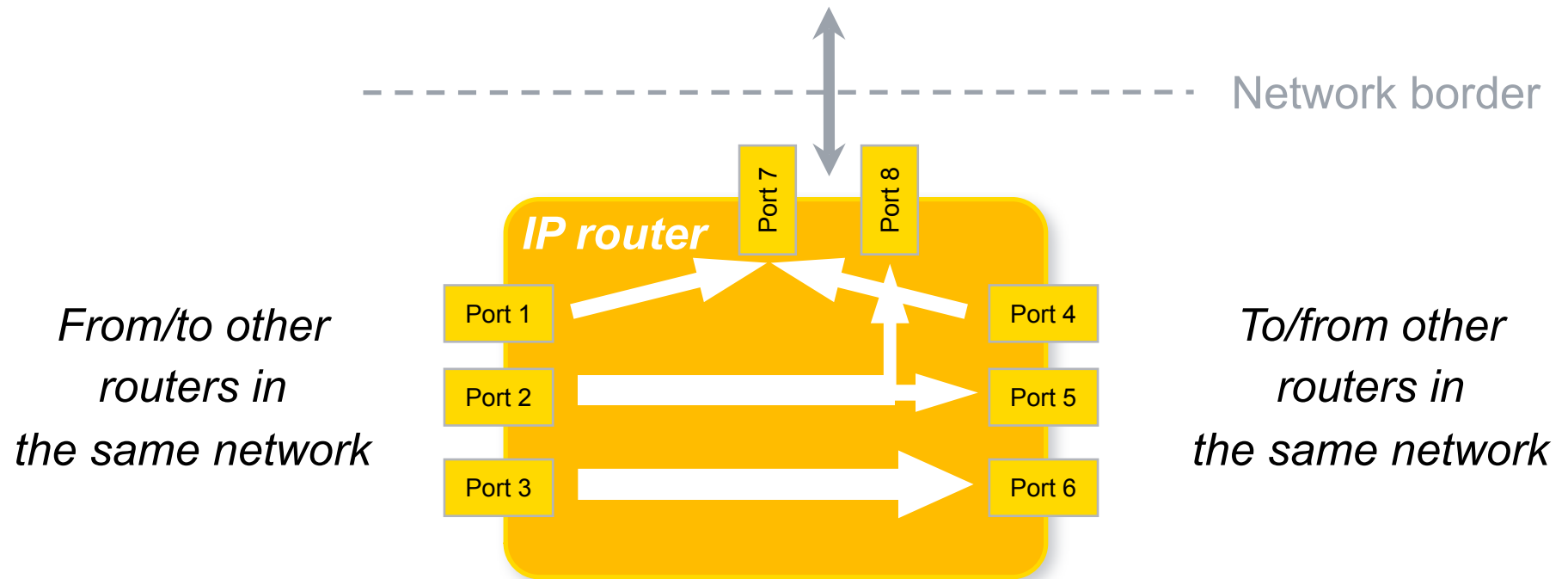
**5...50%
average: 20%**

Optical network elements



around 5%

Traffic through IP routers



- Extracted traffic **ok, this traffic really needs IP routing**
- Forwarded traffic (*in the same network*) **off-load this traffic !**
- Partly forwarded, partly extracted **try to keep both separated !**

Optimization guidelines in multi-layer networks

Simple cost optimization strategy:

Make all IP routers fully meshed !

Soft rules:

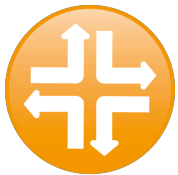
- ➔ Avoid IP router hopping !
- ➔ Off-load IP routers from traffic aggregation !
- ➔ Fill up optical channels as good as possible !

Network elements and their “added value”

**CAPEX relation
per Gbps**

IP Routers

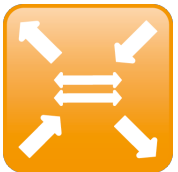
100%



- Traffic processing on a detailed level

Layer 2 switches

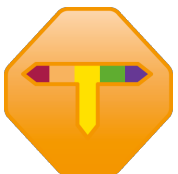
20%



- Traffic grooming for bypassing IP routers
- Combining data streams for filling optical channels

Optical network elements

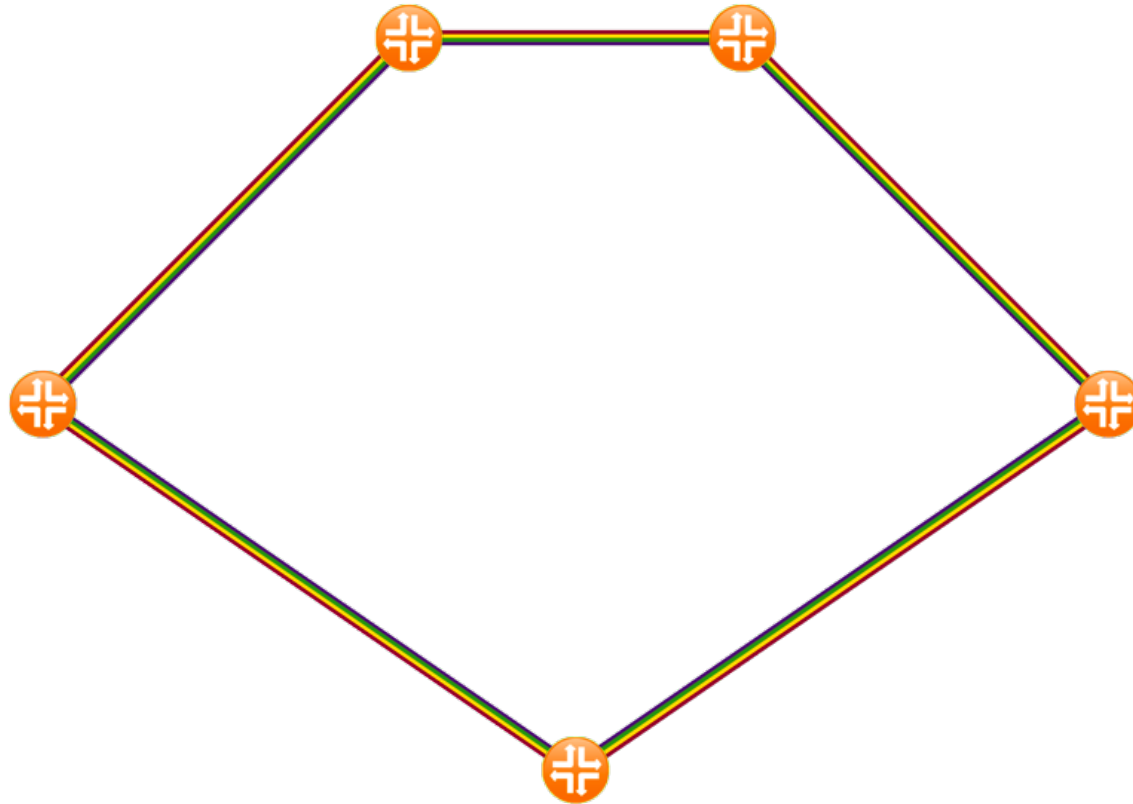
5%



- High capacity transmission pipes
- Full mesh connectivity even in non-mesh networks

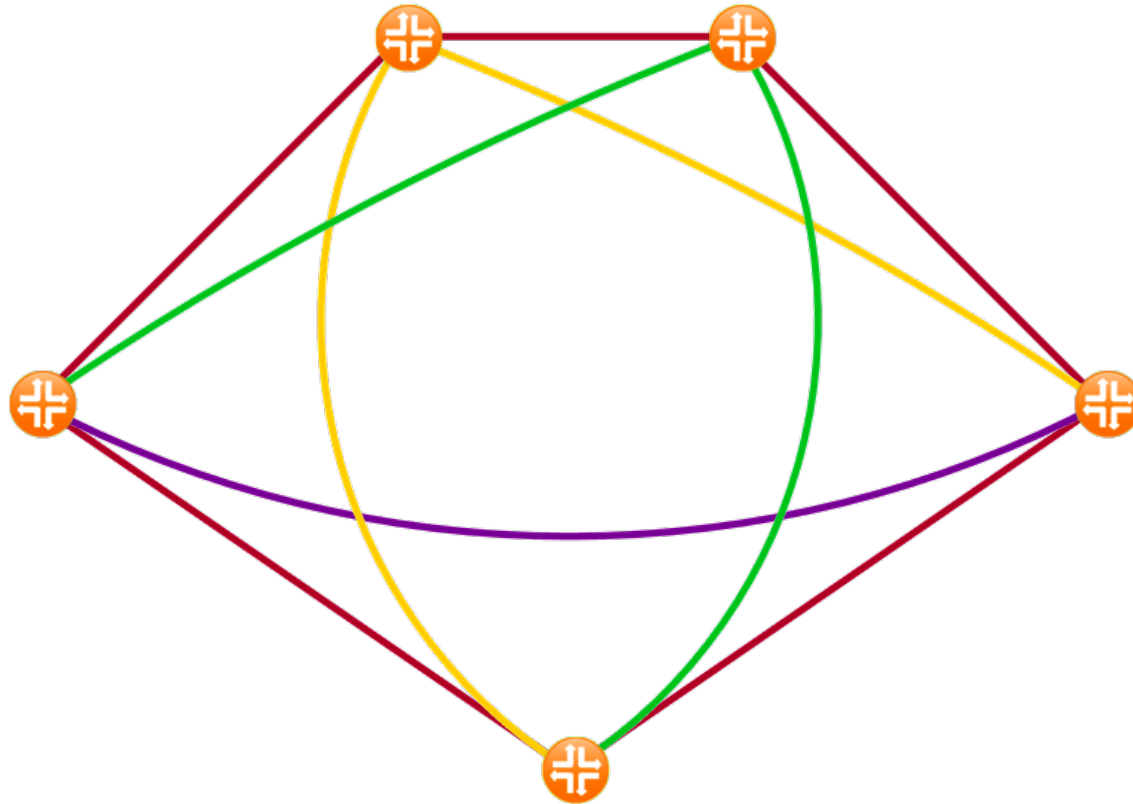
Realization Examples

Situation: Five IP routers in a WDM ring



Topology: Ring

Situation: Five IP routers in a WDM ring

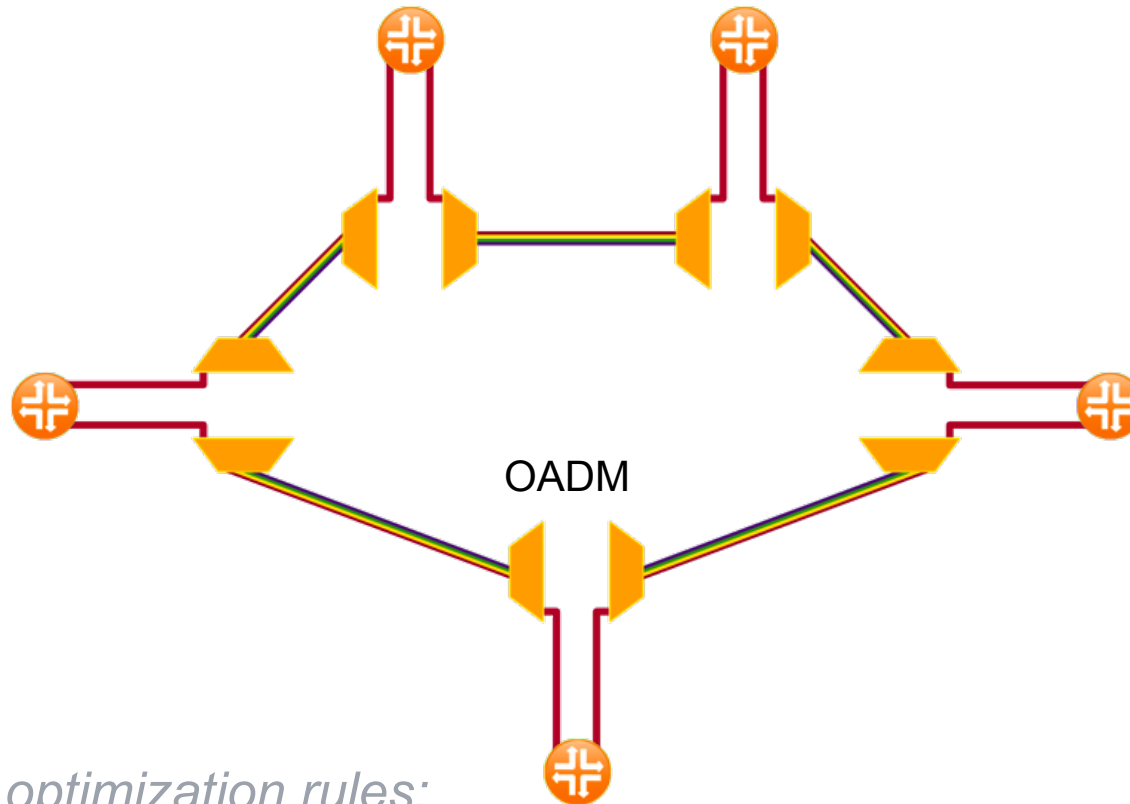


Topology: Ring

Traffic pattern: Full mesh

Each router sends the same traffic volume to each other router.

Option 1: Forwarding IP traffic over large pipes



Checking the optimization rules:

Avoid router hopping



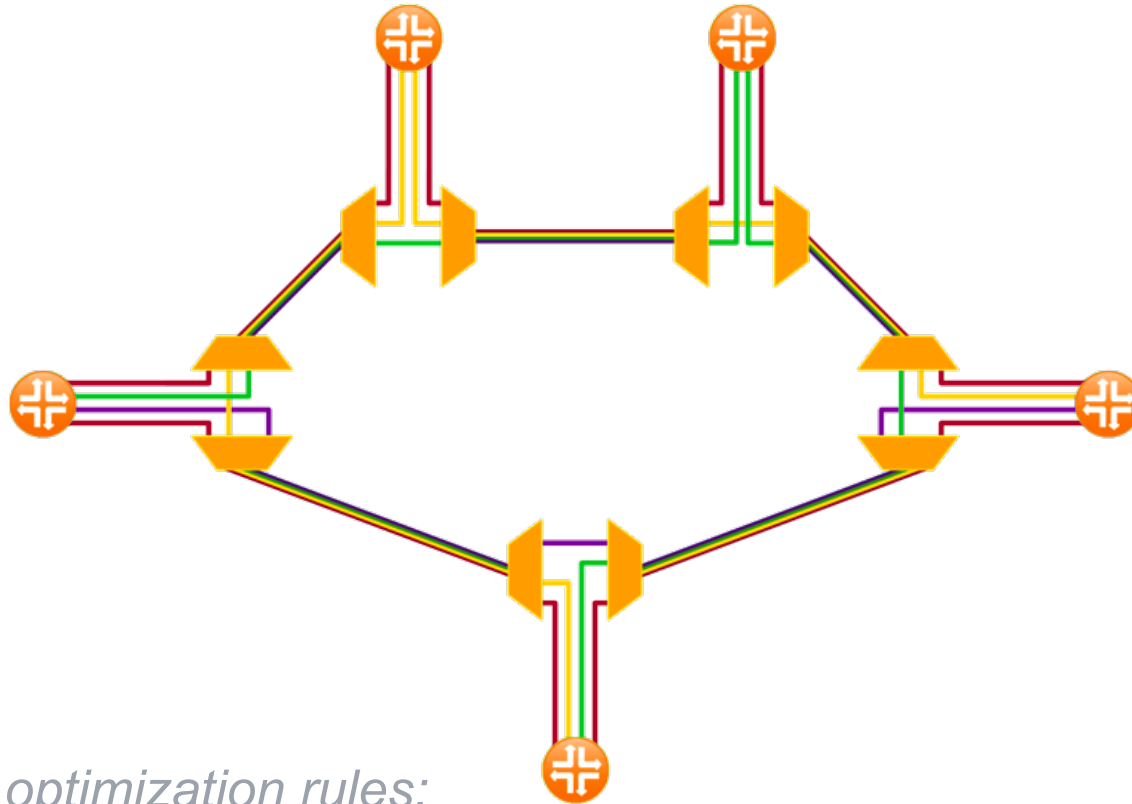
Off-load IP routers from traffic grooming



Fill up optical channels as good as possible



Option 2: Direct interconnection via WDM channels



Checking the optimization rules:

Avoid router hopping



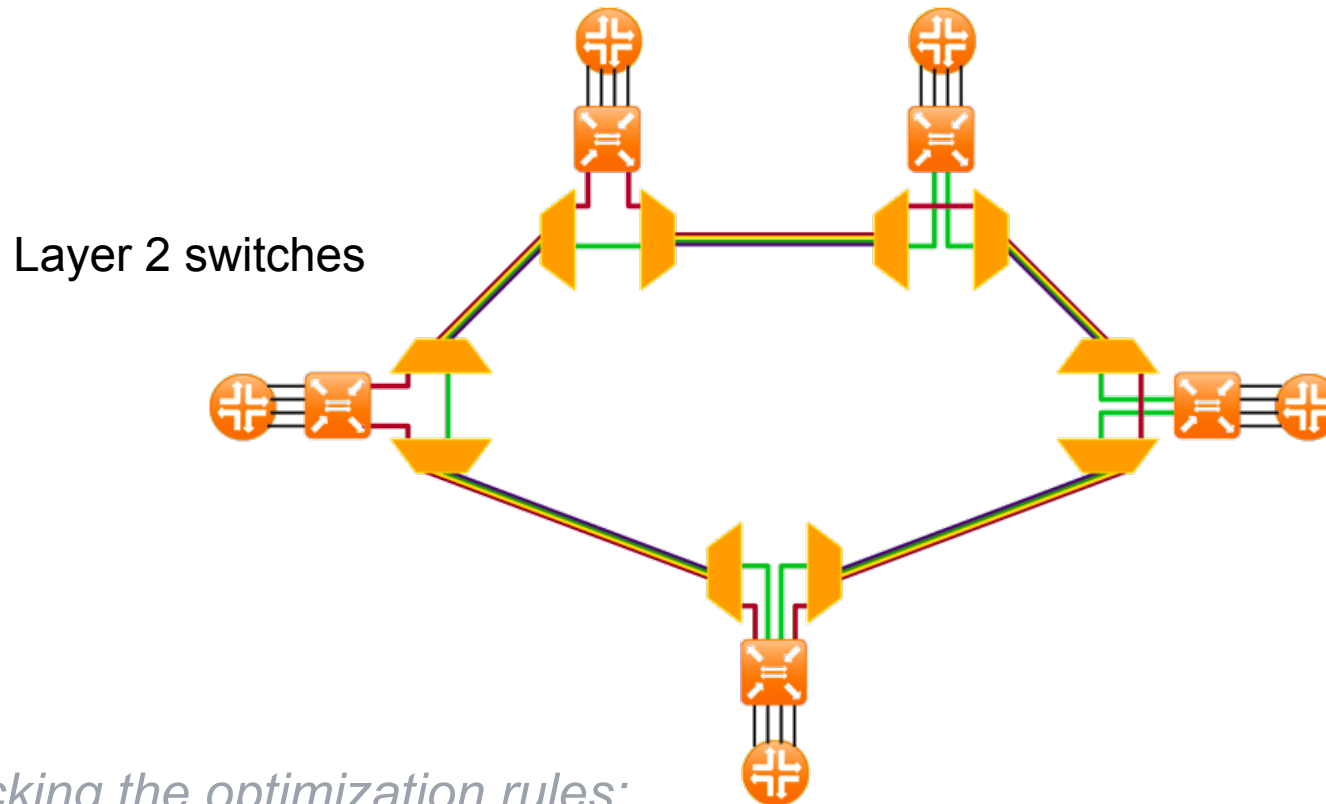
Off-load IP routers from traffic grooming



Fill up optical channels as good as possible



Option 3: Layer 2 switching



Checking the optimization rules:

Avoid router hopping



Off-load IP routers from traffic grooming



Fill up optical channels as good as possible



Conclusions

- Connecting all IP routers fully meshed yields significant CAPEX reduction potential. (*Simulation results have shown reductions of about 20% typically.*)
- WDM allows for fully meshed traffic in physical non-mesh topologies.
- The minimum cost solution varies for different network scenarios (Metro, Regio, backbone ...).

(cost relation: IP routing — L2 switching — WDM technology)

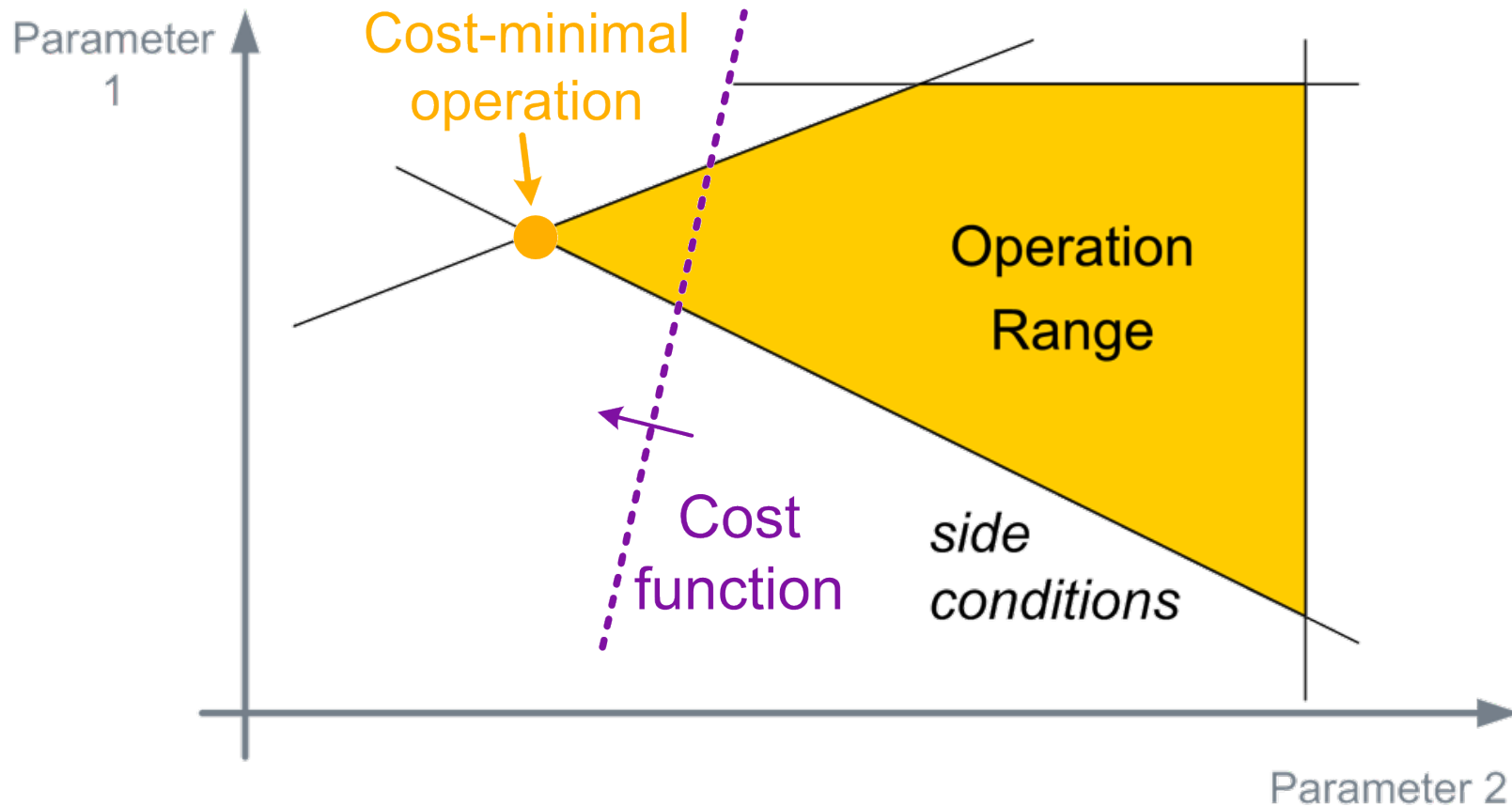


Integrated planning of IP and optical networks

Tool based multi-layer optimization

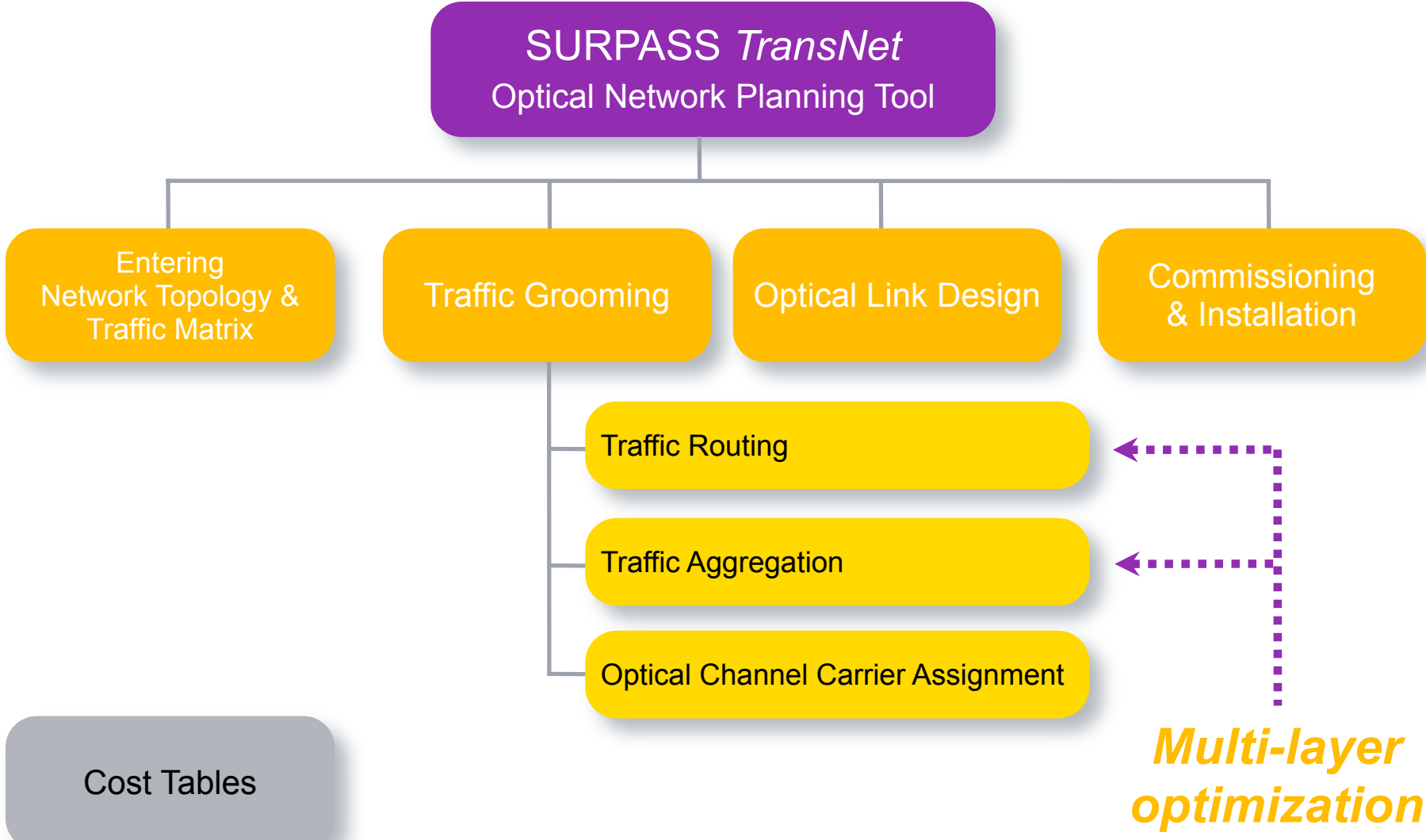
Multi-layer optimization tools

Classical optimization problem



Multi-layer optimization is a multi-dimensional optimization problem, defining a multi-dimensional operation range, identifying a cost-minimal operation point described by many parameters.

Integration into optical network planning tools



Thank you for your participation !