Rethinking Homing Architectures

Eleni Palkopoulou[+θ], **Dominic A. Schupke**[+], **Thomas Bauschert**[θ]

[+] Nokia Siemens Networks, Research, Munich, Germany
[θ] Chemnitz University of Technology, Chemnitz, Germany

eleni.palkopoulou.ext@nsn.com

Motivation

Increasing pressure to drive down network costs

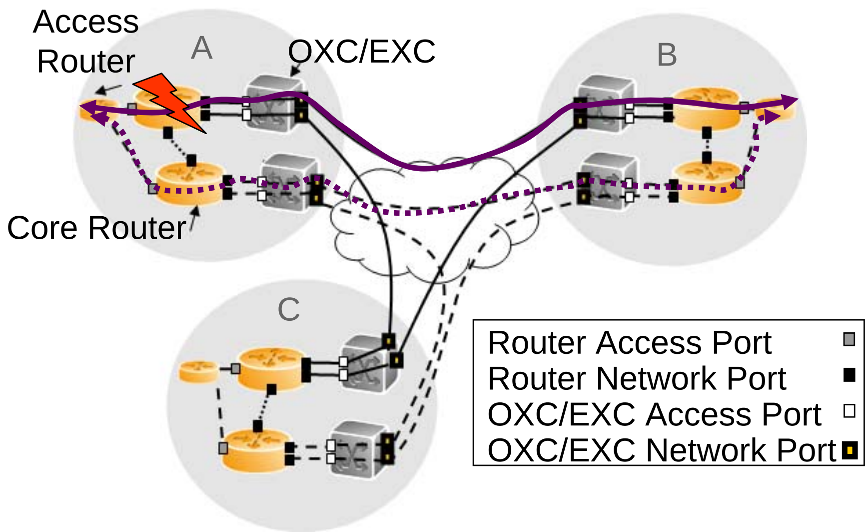
High availability requirements imposed by Service Level Agreements (SLAs)

→

Investigation of resource efficient homing architectures

Homing Architectures: Dual Homing (DH)

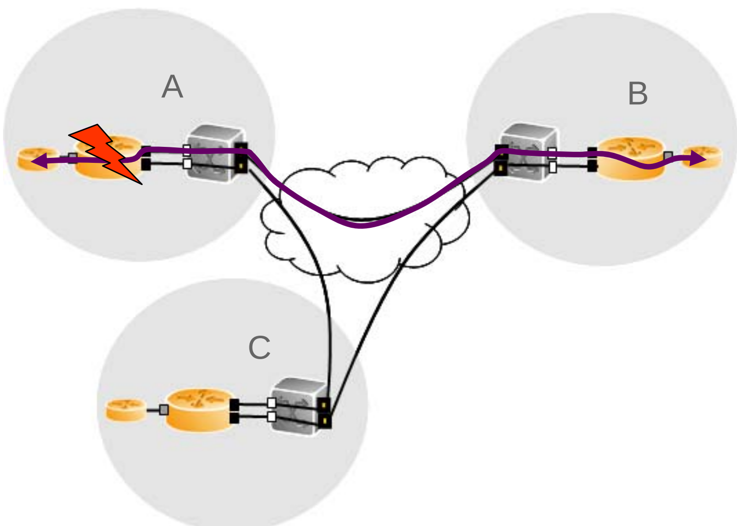
- ”1 : 1” router protection scheme
- Highly robust against core router failures
- Bypass techniques reduce the requirements on IP equipment



 © Nokia Siemens Networks

Homing Architectures: Single Homing (SH)

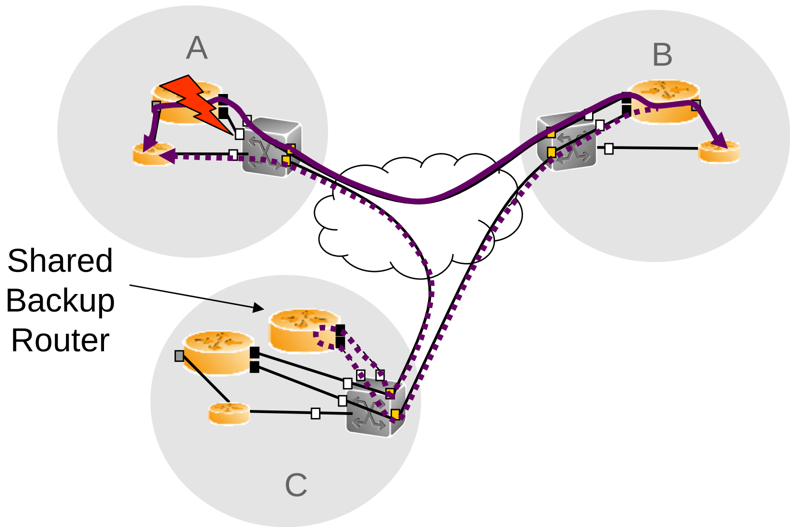
- No router protection scheme for the edge traffic
- For increased router reliability can this be tolerated?



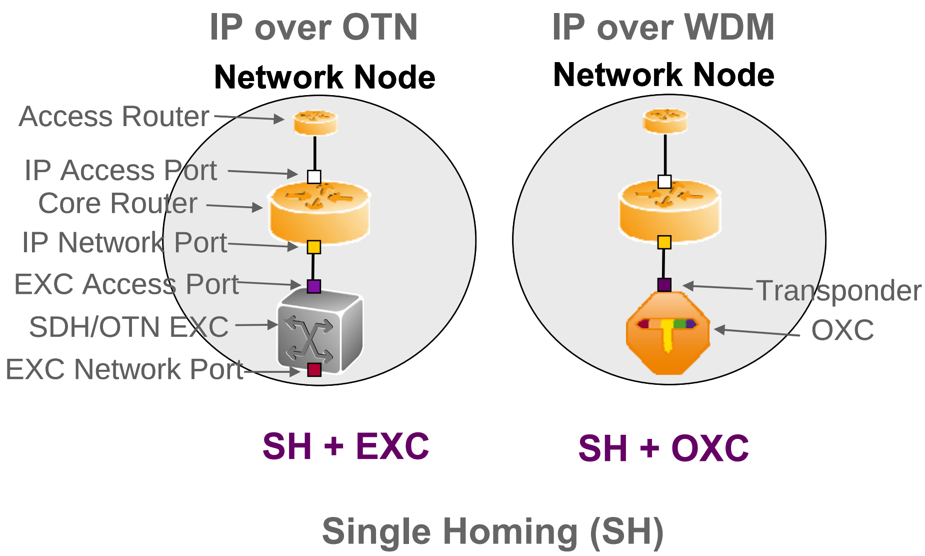
 © Nokia Siemens Networks

Homing Architectures:
Dual homing with shared backup router resources (SBRR)

- ”k : n” router protection scheme
  - k : number of shared router resources locations
  - n : number of network nodes
- Switches establish connectivity with the shared router resources



Network Architectures



Mathematical Model: Optimization Objective

- Generic multi-layer mathematical model offering extensions into multiple dimensions (E.Palkopoulou et al., DRCN 2009)
- Optimization objective: minimization of CAPEX for network equipment

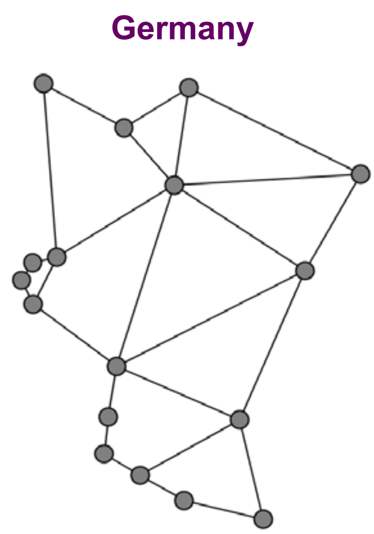
$$\min \sum_{l \in \mathcal{L}} \left(\sum_{k \in \mathcal{N}^l} \psi^l + y^l \right)$$

- $\mathcal{L}$: Set containing the network layers
- $\mathcal{N}^l$: Set containing all the nodes of layer l
- ψ^l : Basic cost of one node in layer l
- y^l : Total cost of the interfaces required in layer l
- $\mu^{s,d}$: The multiplexing factor from layer *s* to layer *d*
- $x^{s,d}_{t,p}$: The demand mapped from node pair *t* of layer *s* to path *p* of layer *d*

© Nokia Siemens Networks

Case Studies

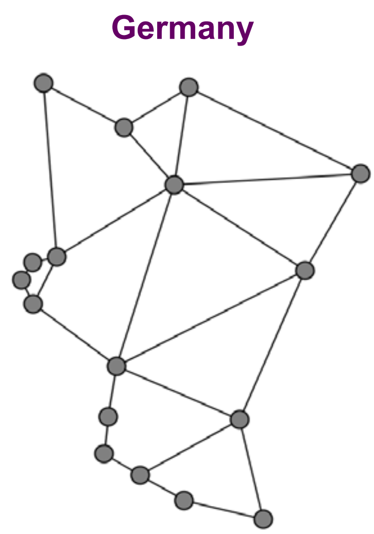
- Reference network topology:
  - Germany (17 nodes, 26 links)
- Inter-node traffic demand uniformly distributed between 0 and *x* Gbit/s
  - *x* is dependent on the required average value
- Cost model (Hülsermann et al., JoN 2008)



© Nokia Siemens Networks

Case Studies

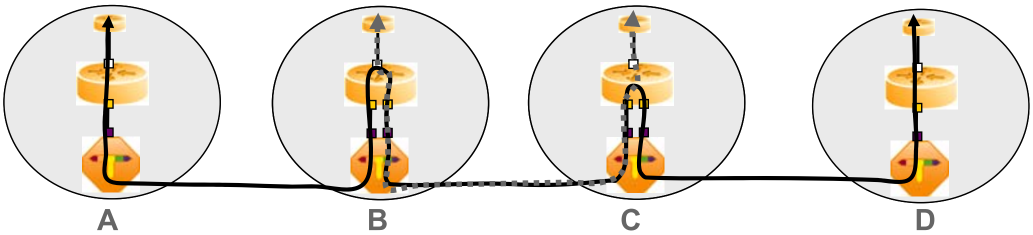
- Set of candidate paths limited to the ten shortest paths for every node-pair
- Wavelength assignment not considered
- Single failure scenarios considered
- One network-wide shared backup router deployed



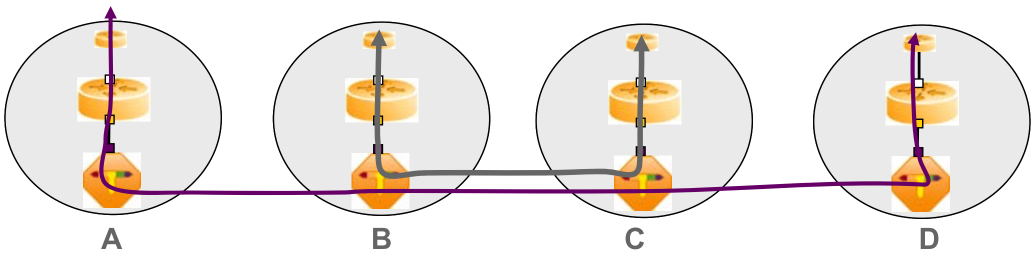
Case Studies: Router Bypassing Options

Example 1

(A) Intermediate grooming at all traversed nodes: 6 transponders



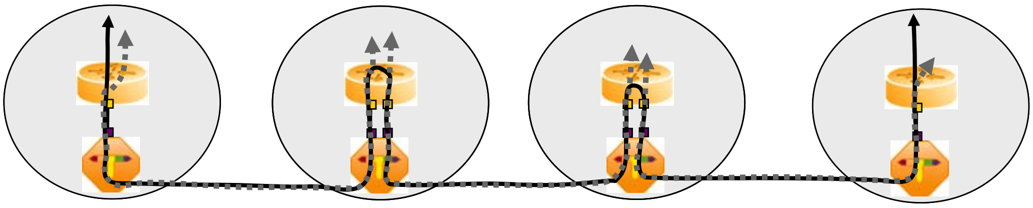
(B) Establishment of a transparent path: 4 transponders



Case Studies: Router Bypassing Options

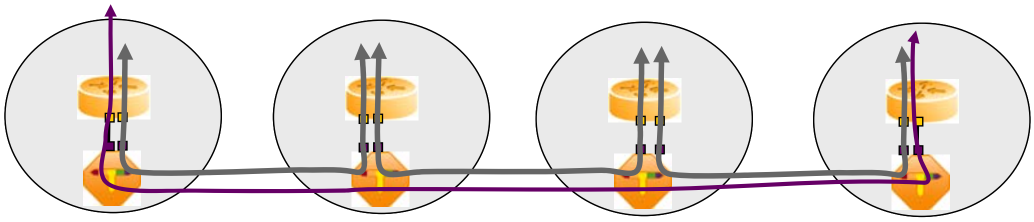
Example 2

(A) Intermediate grooming at all traversed nodes: 6 transponders



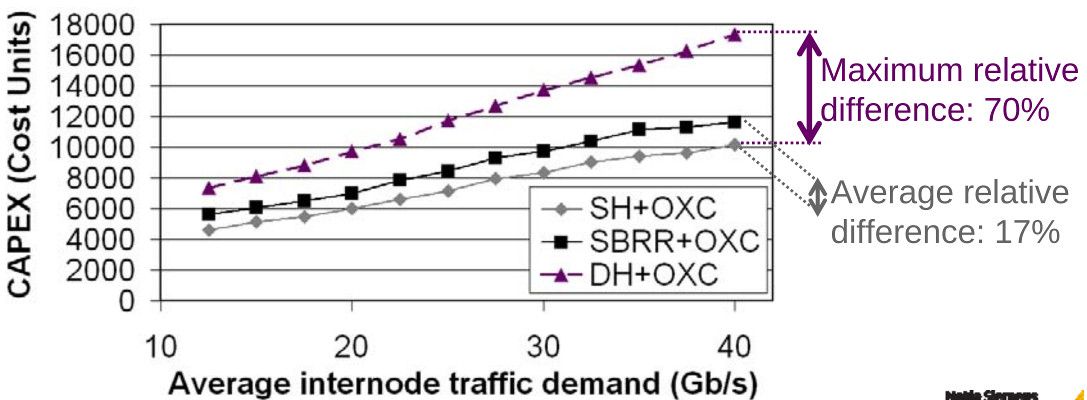
Optimal combination of options (A) and (B) is selected by the solver

(B) Establishment of a transparent path: 8 transponders



CAPEX over Traffic Demand: IP over WDM

- Costs are relative costs normalized to the cost value of a 10G LH transponder
- Approximately linear relationship with the traffic demand
- SBRR architecture would require marginal additional software costs



Availability Analysis

- Calculation of the lower bound of the end-to-end availability for all connections (worst case analysis)

  - Contribution of end-nodes:
    Availability block diagrams (Palkopoulou et al., ONDM 2009)

  - Contribution of network:

$$r_c \geq \prod_{i \in I} r_i + \sum_{j \in I} [(1 - r_j) \cdot \prod_{k \in I \setminus \{j\}} r_k]$$

r_c : network's contribution to the end-to-end availability

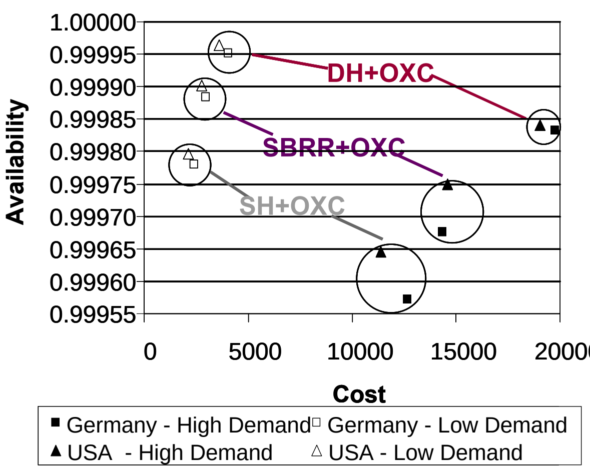
I : set containing all network elements under consideration

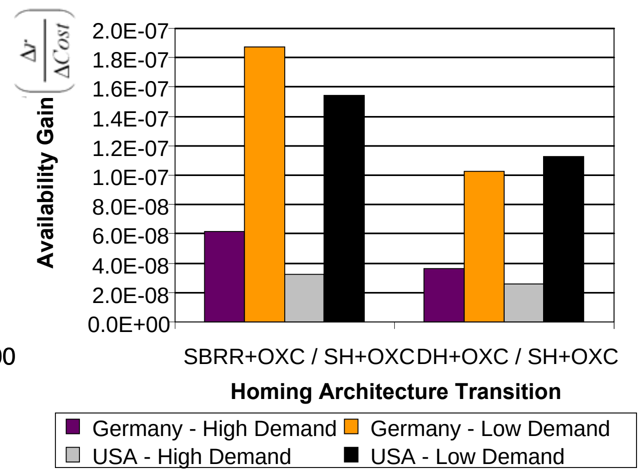
r_i : parameter representing the availability of element i

 © Nokia Siemens Networks

End-to-End Availability versus CAPEX

- Single transport link, router, OXC, router port, and transponder failures considered
- The approximation of the availability by its lower bound underestimates the actual value for the high demand case
- Higher availability gain for SBRR+OXC





 © Nokia Siemens Networks

Conclusions

- Alternative homing architectures studied in a multi-layer consideration
- Objective: minimization of network equipment CAPEX
- Two flavors of homing architectures examined
  - Deploying OXCs
  - Deploying EXCs
- On average 17% higher costs required for SBRR+OXC than single homing
- Availability tradeoffs quantified with higher availability gain observed for SBRR+OXC

Q&A

Thank you for your attention!

Contact: eleni.palkopoulou.ext@nsn.com