Multi-layer Protection in IP over WDM Networks With and With No Backup Lightpath Sharing

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Outline

- Motivation
- Multi-layer protection and inter-level sharing
- Routing algorithms and sharing conditions
- Performance study
- Conclusions

1. Motivation

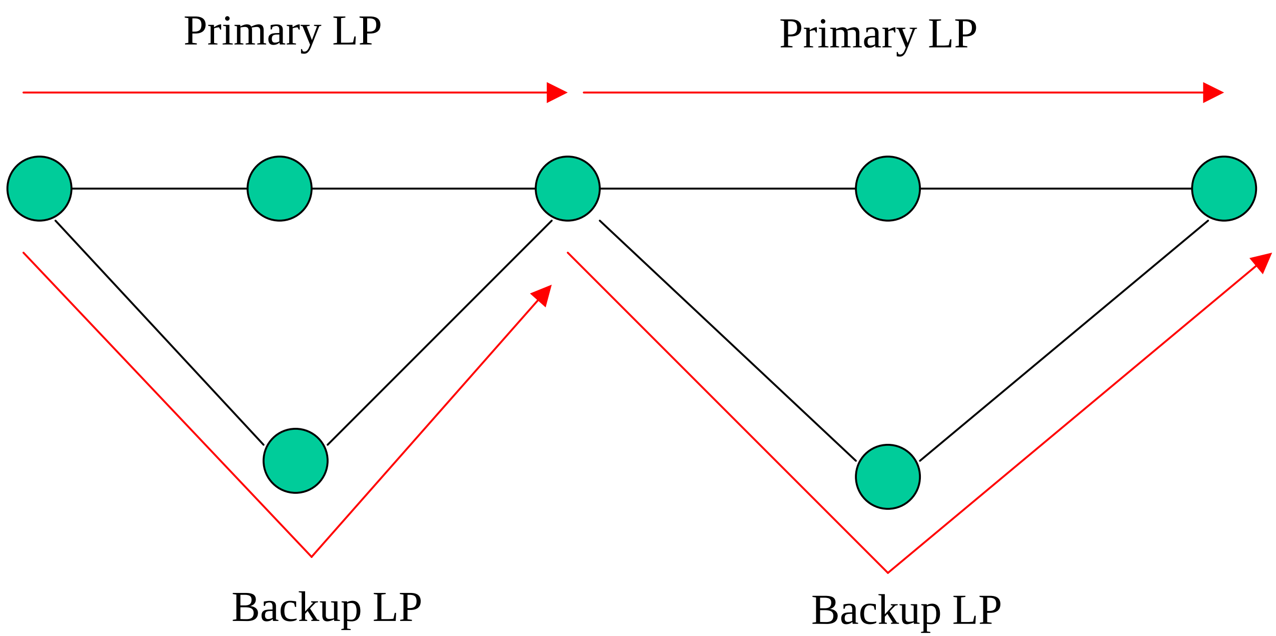
- Lightpath-level protection is coarse-grained (full wavelength).
  + recovery time on the order of tens of millisecond.
  - Resource efficiency is poor.

- LSP-level protection is fine-grained.
  + Better resource efficiency.
  - recovery time is long.

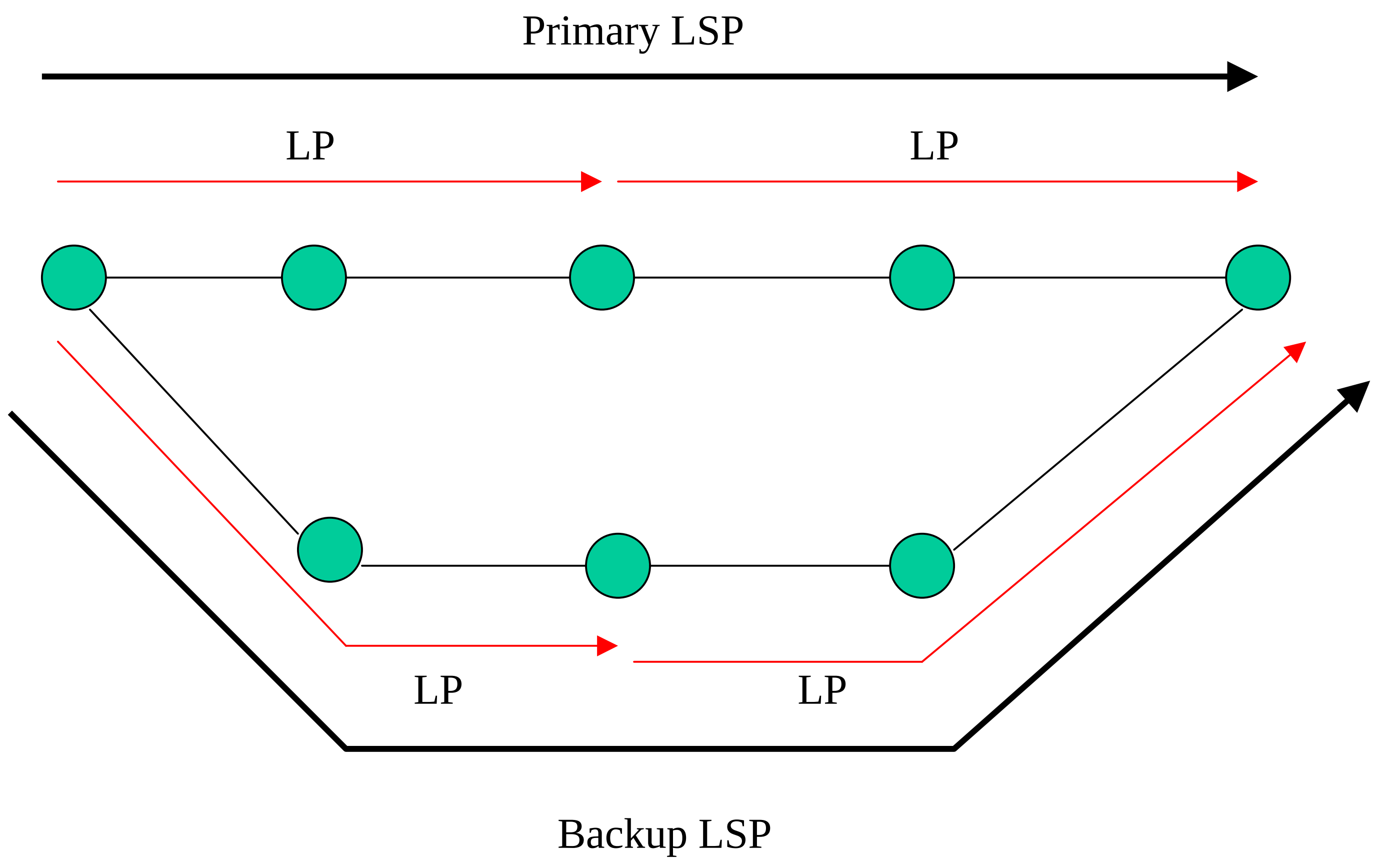
- Multi-layer protection where time-critical applications are protected at the lightpath level and other traffic are protected at the LSP level.

- Objective: optimize network resource while satisfy the SLAs

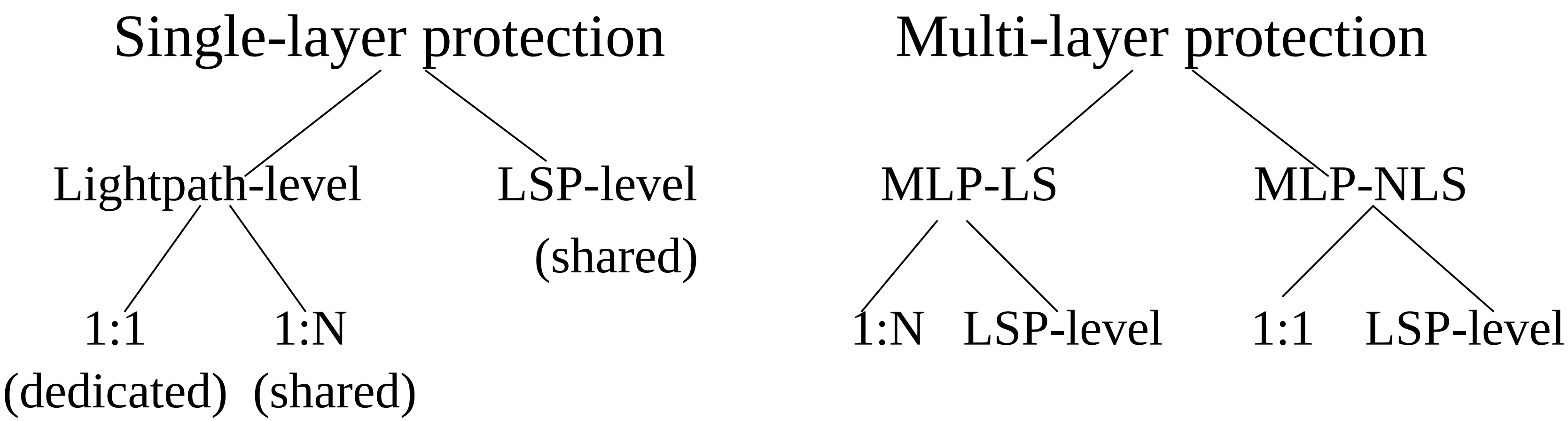
Lightpath-level Protection



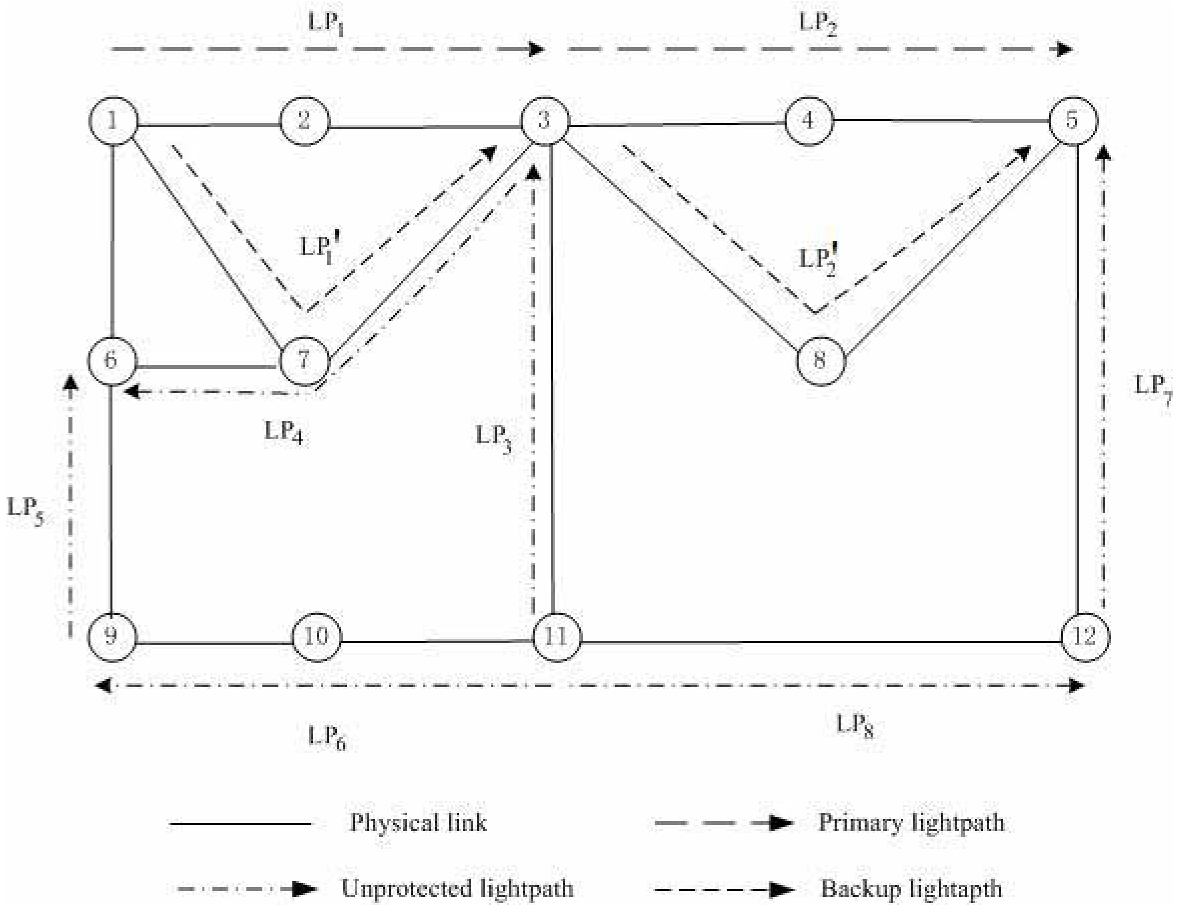
LSP-level Protection



Protection in IP over WDM networks



2. Multi-layer protection and inter-level sharing



Recovery operations after failure

- Failure detection

LSP-level protection can use its own detection mechanism such as exchange of `Hello' messages.
Optical layer can detect the failure and propagate it to the MPLS layer through signaling messages.

- Failure notification

- Recovery time

A fiber link is normally used by several lightpaths which in turn traversed by a number of LSPs
LSP-level protection needs more restoration actions
longer fault notification time and larger signaling message overhead

- Failure recovery operation coordination (holdoff timer)

The optical layer and MPLS layer need to be coordinated when failure occurs
The optical layer starts recovery immediately for the failed primary lightpaths
The MPLS layer will restore the failed primary LSP after the holdoff timer goes off.

3. Routing algorithms

- Assumptions:

  Dynamic traffic arrive one at a time with no prior-knowledge

  Single-link failure model

  WXCs have no wavelength conversion capabilities

- Problem definition

  Given an LSP-request <s, d, b, pl>

  s: source, d: destination, b: bandwidth, pl: specified protection level

  pl=0, find a path on primary lps each with a link-disjoint backup lp

  pl=1, find a primary LSP and a link-disjoint backup LSP on ordinary lps

OEO-routing and hop-routing

- The problem of finding two link-disjoint paths is NP-complete
- OEO-based integrated routing algorithm

  Objective: minimize the total number of OEO conversions
- Hop-based integrated routing algorithm

  Objective: minimize the total number of hops

Sharing conditions

- Lightpath sharing

- LSP sharing

- Inter-level sharing

  backup LSPs to utilize the bandwidth resources on the pre-configured backup lightpaths

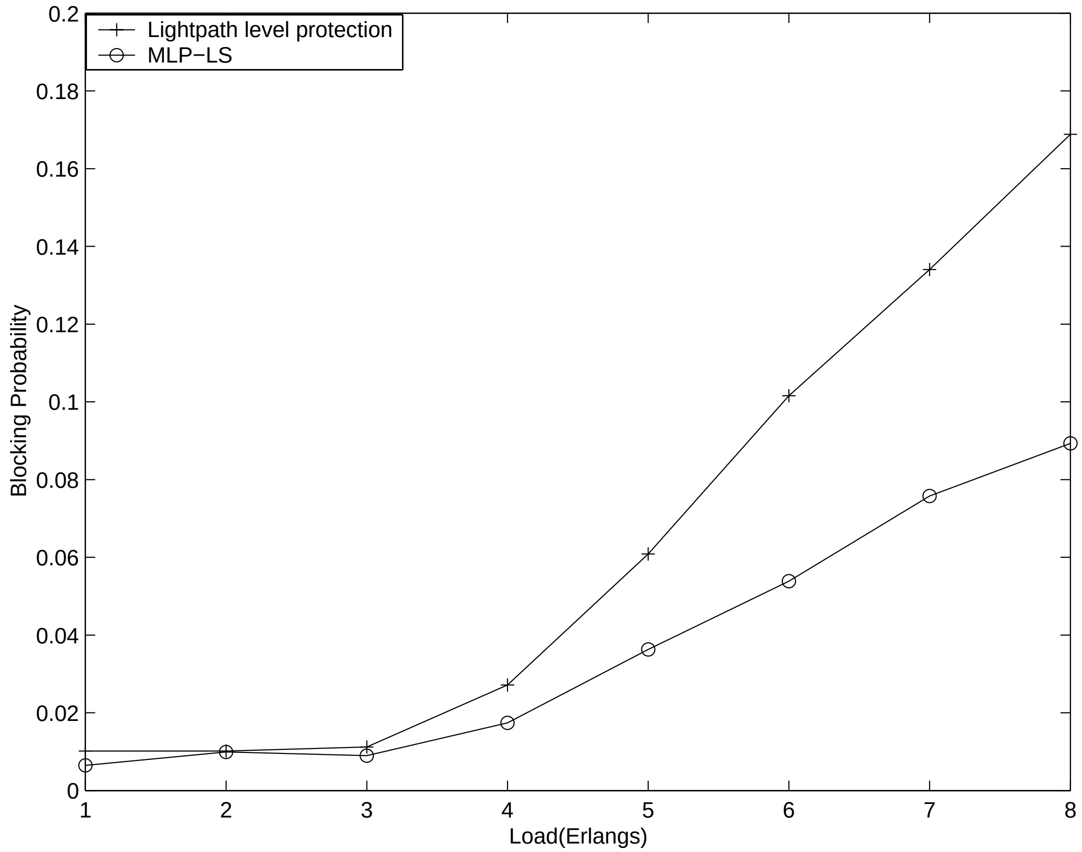
  Condition 1: the backup lightpath must be link-disjoint with the primary LSP

  Condition 2: the corresponding primary lightpath must be link-disjoint with the primary LSP

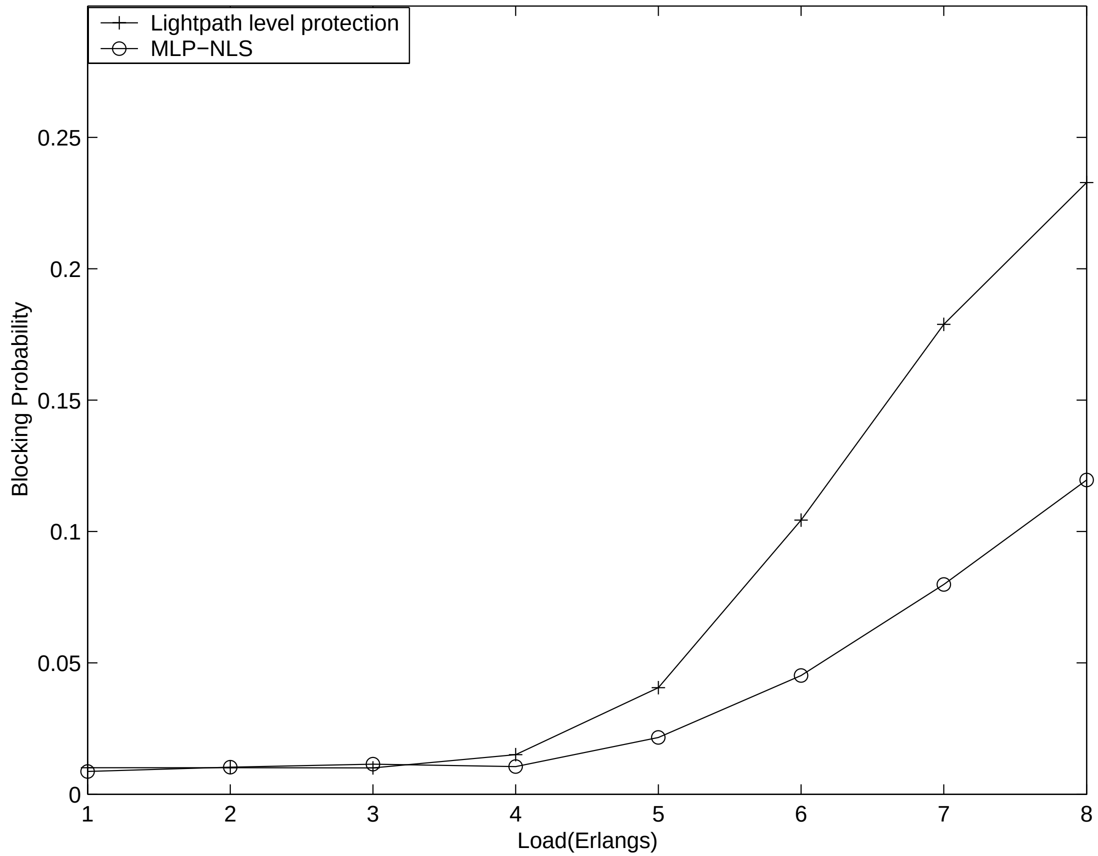
4. Performance study

- NSFNET with 14 nodes, 21 bi-directional links.
- Poisson arrival and exponentially distributed holding time.
- MLP-LS: 10 wavelengths per fiber; MLP-NLS: 16 wavelengths per fiber.
- The requests are generated with high- and low-priority randomly.
- We compare MLP-LS and MLP_NLS to lightpath-level protection.

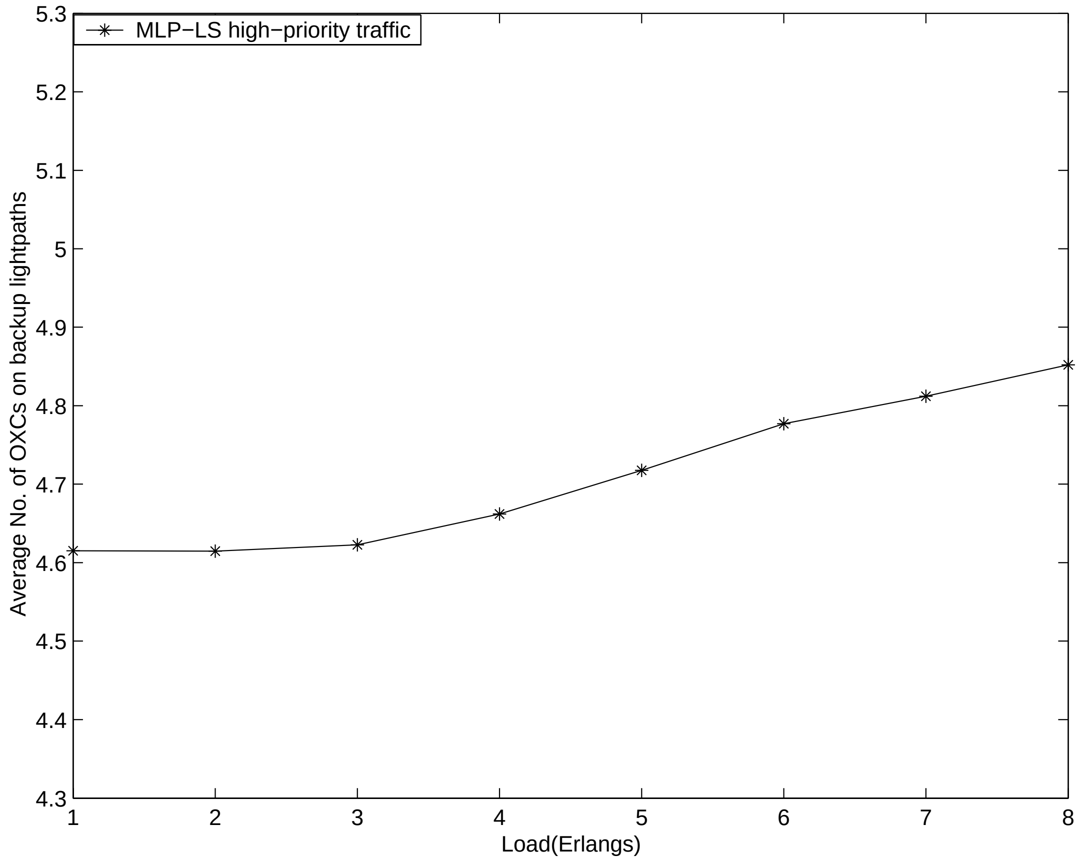
Blocking probability for MLP-LS and lightpath-level protection



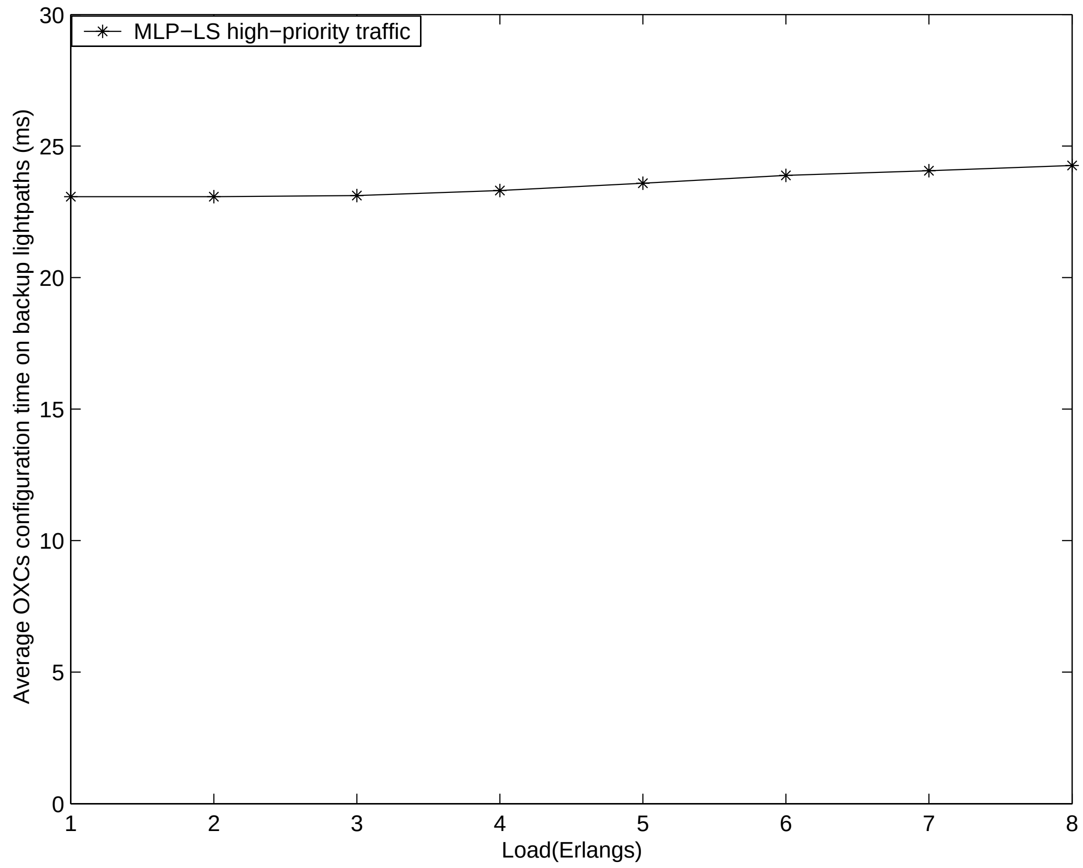
Blocking probability for MLP-NLS and lightpath-level protection



Average number of OXCs on backup lightpaths in MLP-LS



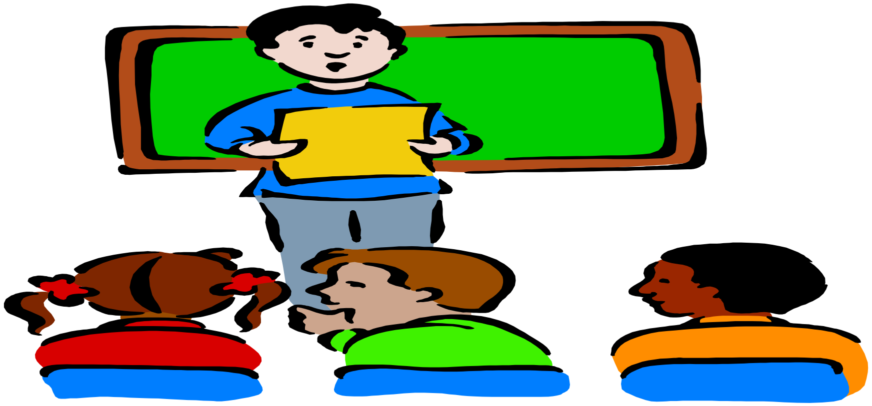
Average OXC configuration time on backup lightpaths in MLP-LS



5. Conclusions

- We developed two multi-layer protection schemes: MLP-LS and MLP-NLS.
- We proposed a new sharing method called inter-level sharing to be used in MLP-NLS.
- We developed two integrated-routing algorithms to select paths for lightpath-level protection and LSP-level protection.
- We demonstrated that MLP-LS and MLP-NLS perform better than lightpath -level protection in terms of blocking probability. Time-critical traffic can be recovered faster in MLP-NLS than in MLP-LS.

Any questions?



The slides can be found at my homepage
http://ccn.ece.nus.edu.sg/Qin Zheng/homepage.htm