Exploiting Network Kriging for Fault Localization

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Introduction

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- Evolution toward high flexibility:
  - transmission parameters optimized for setup and changed in case of degradations/faults
  - reduction of worst-case margins to reduce costs (e.g., [a])
    - soft failures (e.g., implying Quality of Transmission – QoT – degradations) more frequent

    → need of monitoring to re-act to both soft- and hard-failures
- At the control plane, ABNO is emerging as an architecture for the control and management
  - ABNO OAM Handler responsible to receive alarms, to **correlate** the alarms, and to take actions to preserve services
- Network Kriging (NK) [b]: mathematical framework used for correlation

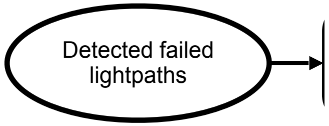
In this paper:

- a correlation framework based on NK for (soft or hard) fault localization
- if correlation does not solve localization (ambiguity): setup of new lightpaths with the scope of identifying unambiguously the failed elements
  - alternatively, pre-establishment of LPs for monitoring and failure localization
- We also propose a heuristic Failure Localization-Aware Routing and Spectrum Allocation (FLA-RSA) algorithm that provisions lightpaths with the objective of reducing the failure localization ambiguity

[a] Y. Pointurier, invited talk OFC 2016
[b] D.B. Chua et al., IEEE JSAAC 24(1)

Control&management workflow for failure localization

Assumption: lightpath monitors based on DSP employed at the receiver



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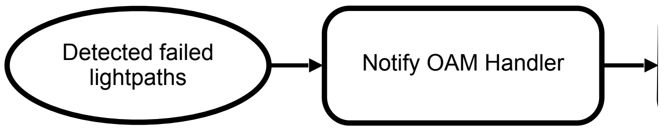

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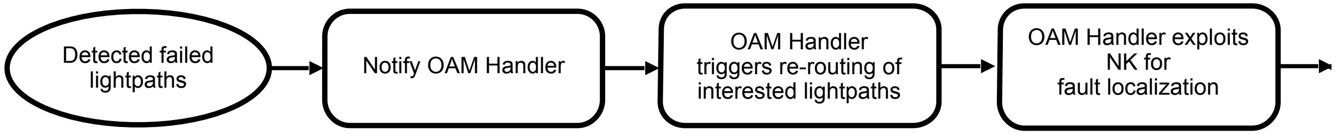

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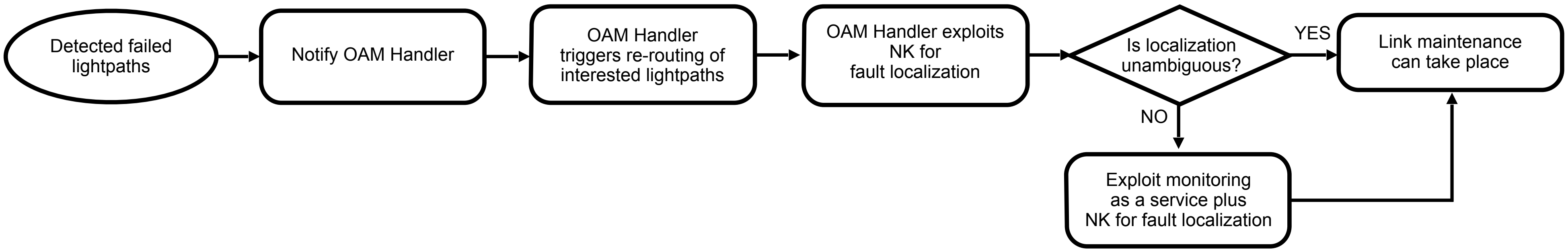
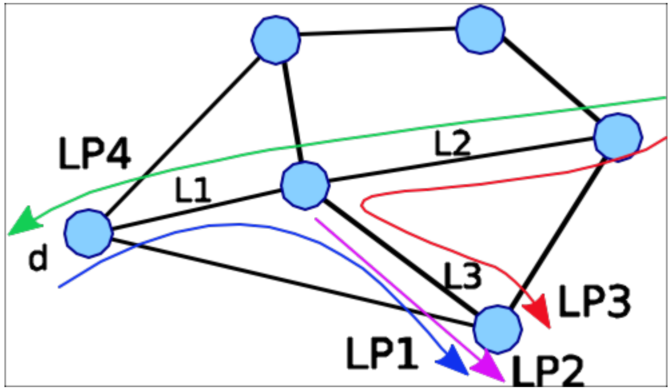


Network Kriging concept

- Suppose LP_1, LP_2, LP_3 established and monitored
- LP_4 to be estimated
- Given additive metric y s.t. y=Gx
  - y=e2e metric, G=routing matrix, x=link metric



- $[y'_m \; y'_n]=[G'_m \; G'_n]x$, where by m we represent the lightpaths for which monitoring data are available and by n those that it should be estimated
- Can estimate $\hat{y}_4$ given y_1, y_2, y_3
- Estimation technique = "network kriging"

$$y_n=G_nG_m(G_mG^T{}_m)^{+}y_m$$

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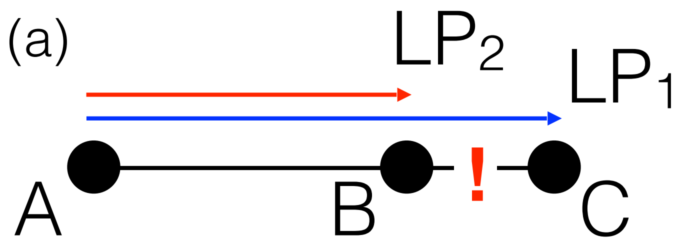

Unambiguous:

AP_{AB}=1; AP_{BC}=0

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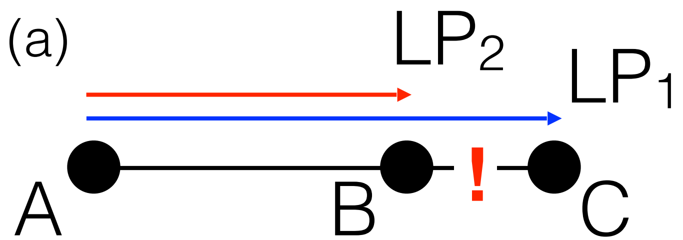

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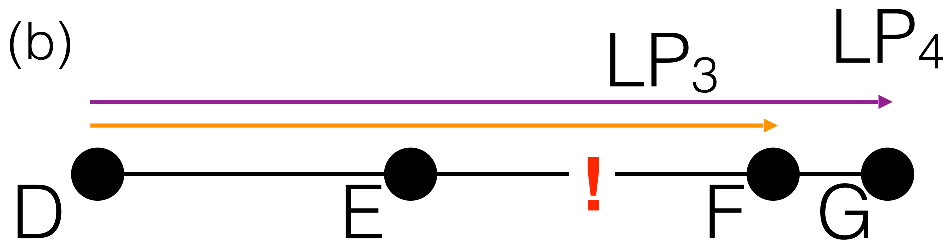

Ambiguous:

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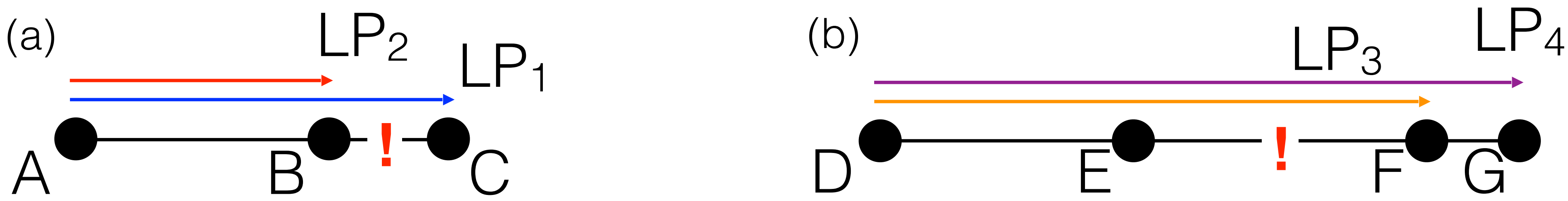

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If ambiguous → *monitor as a service*: set up of new lightpaths for failure localization

Failure Localization Aware RSA (FLA-RSA)

- **Objective:** increase the probability of unambiguous failure localization in case of failure
- It is an extension of [c]

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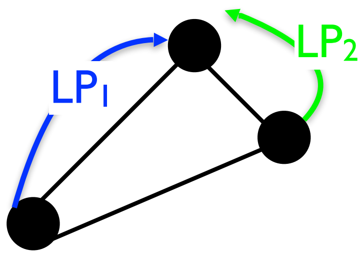

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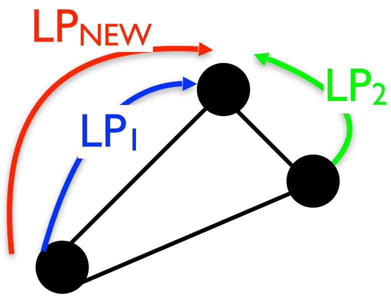

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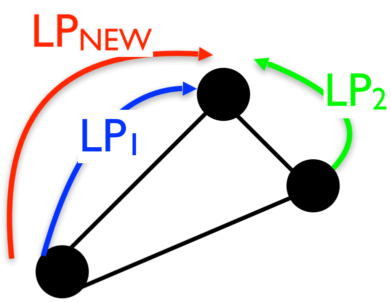

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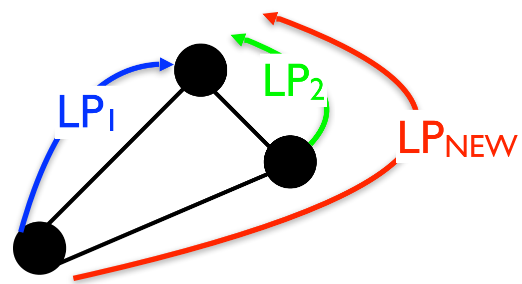

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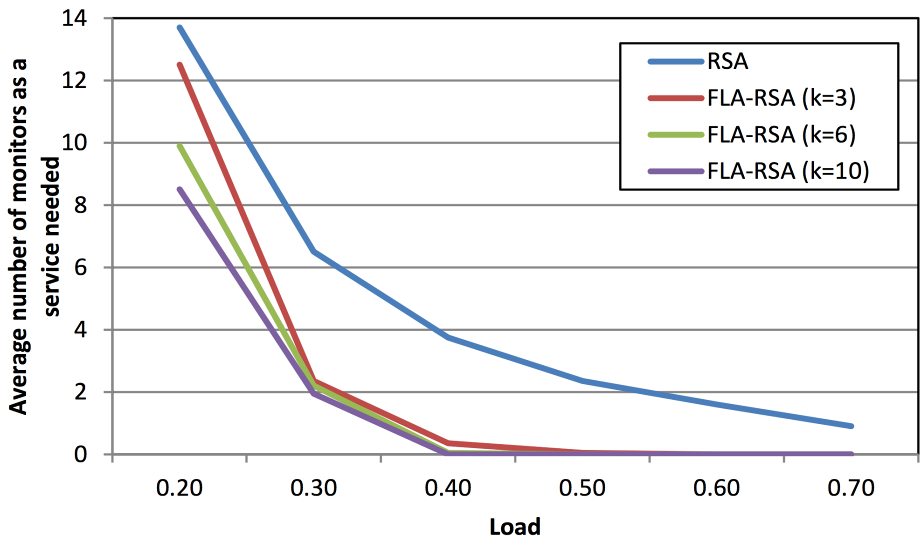
Simulation scenario

- Compare Failure localization aware (FLA)-RSA with simple RSA
  - DT network topology
  - load is expressed as a percentage, with load=1 denoting the all-to-all communication (note that for load=1 we have unambiguous localization)
  - 100 Gbps PM-QPSK lightpaths, 37.5 GHz and 1500 km reach
- (FLA)-RSA using k=3,6,10 paths
- Metrics:
  - number of monitors as a service required for achieving unambiguous failure localization
  - number of slots required for serving traffic

Results

- Plenty extra monitors are required at low load (up to 40%) to resolve ambiguity
- FLA-RSA reduces substantially the extra monitors required
  - k=3 is enough for loads higher than 0.5



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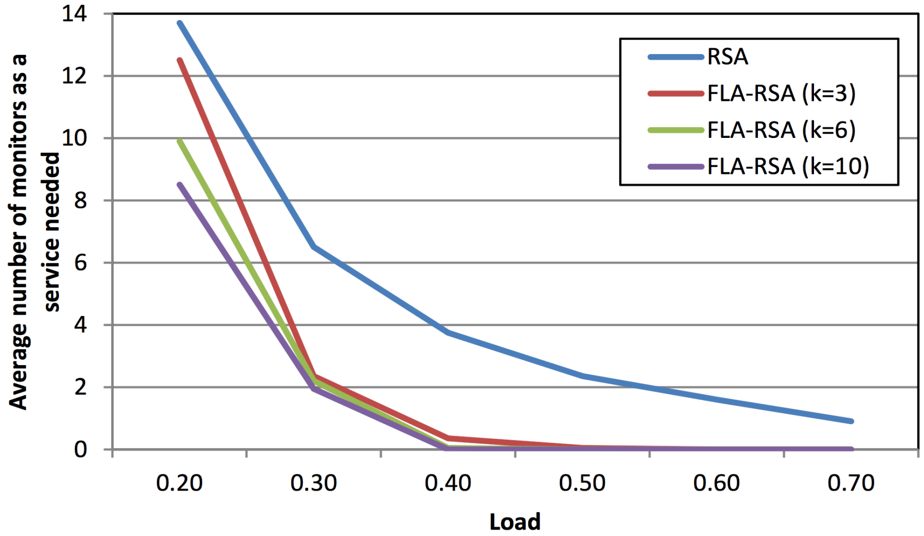

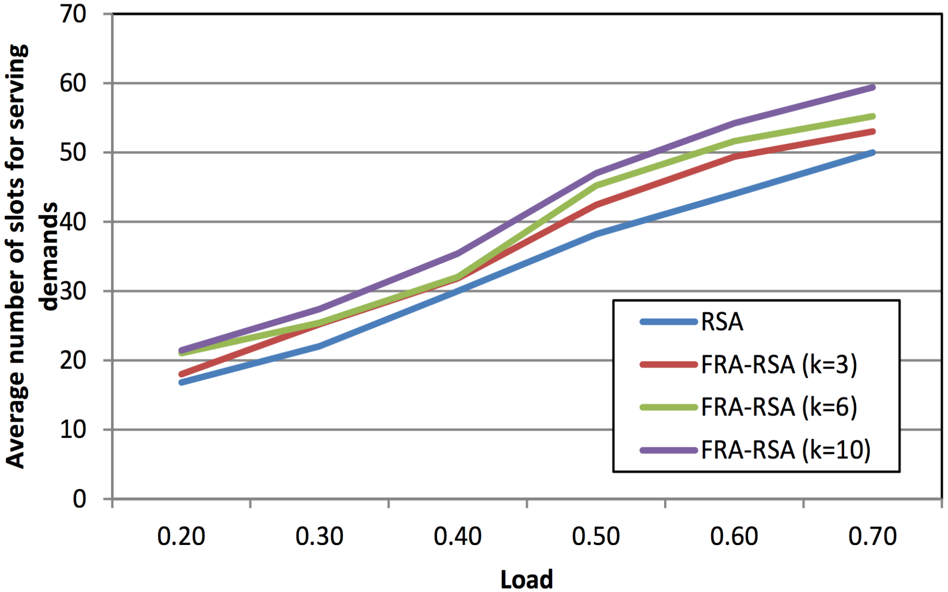

- The price paid to improve failure localization is that of longer paths → a higher spectrum utilization
- The increase in spectrum is small, which is less than 5 slots for k=3

Conclusions

- We proposed a correlation framework for (soft- or hard) fault localization, leveraging information from established lightpaths
- Since a fault can be localized with ambiguity, the control plane triggers the setup of new lightpaths (monitors as a service) with the scope of identifying the failed element
- The ambiguity can be reduced using the proposed Failure Localization-Aware Routing and Spectrum Allocation (FLA-RSA) algorithm.

→ lower monitors as a service → more fast and responsive reaction to failures

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