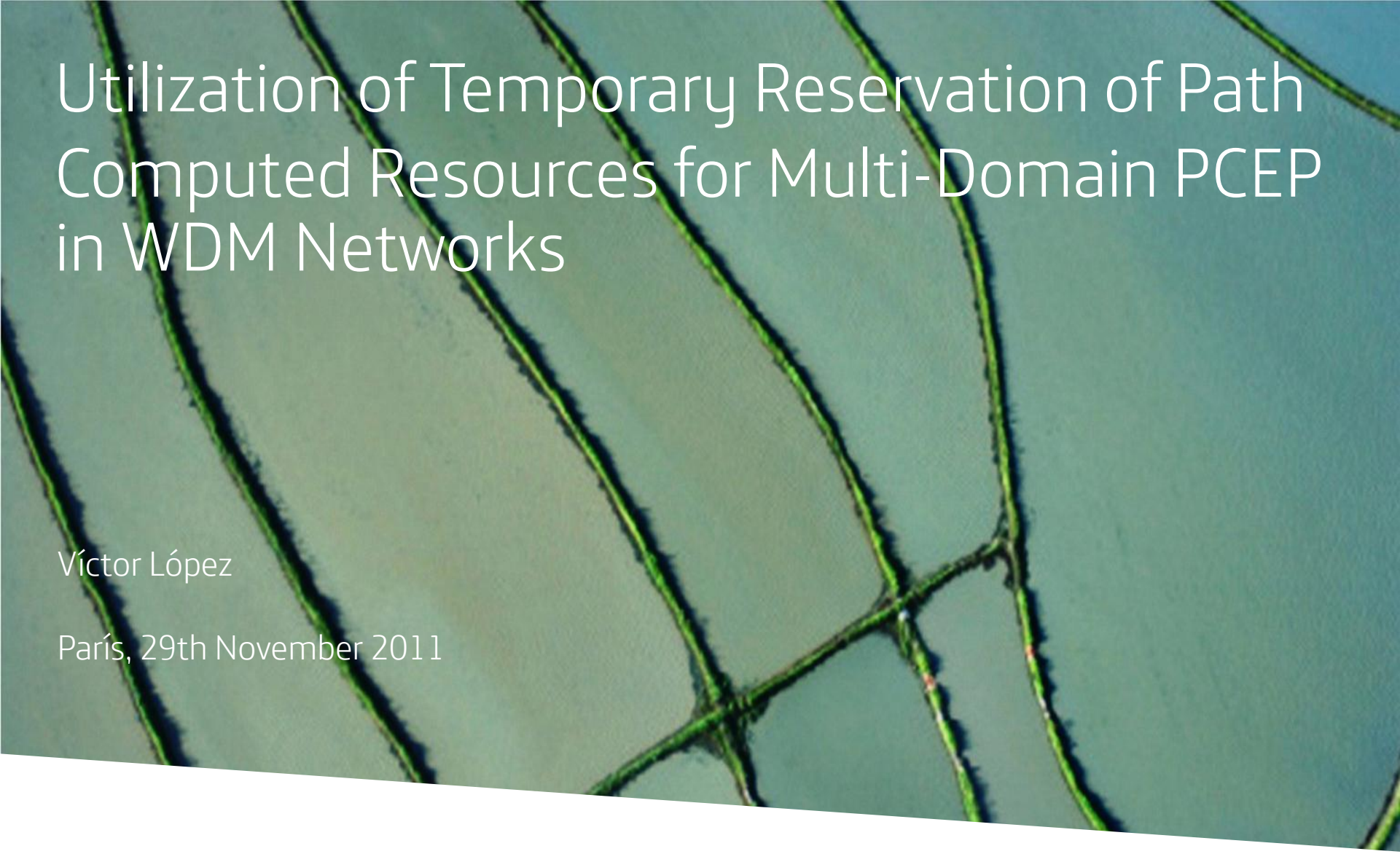

Utilization of Temporary Reservation of Path Computed Resources for Multi-Domain PCEP in WDM Networks

Víctor López

París, 29th November 2011

Telefónica

Outline

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01

Motivation

Motivation

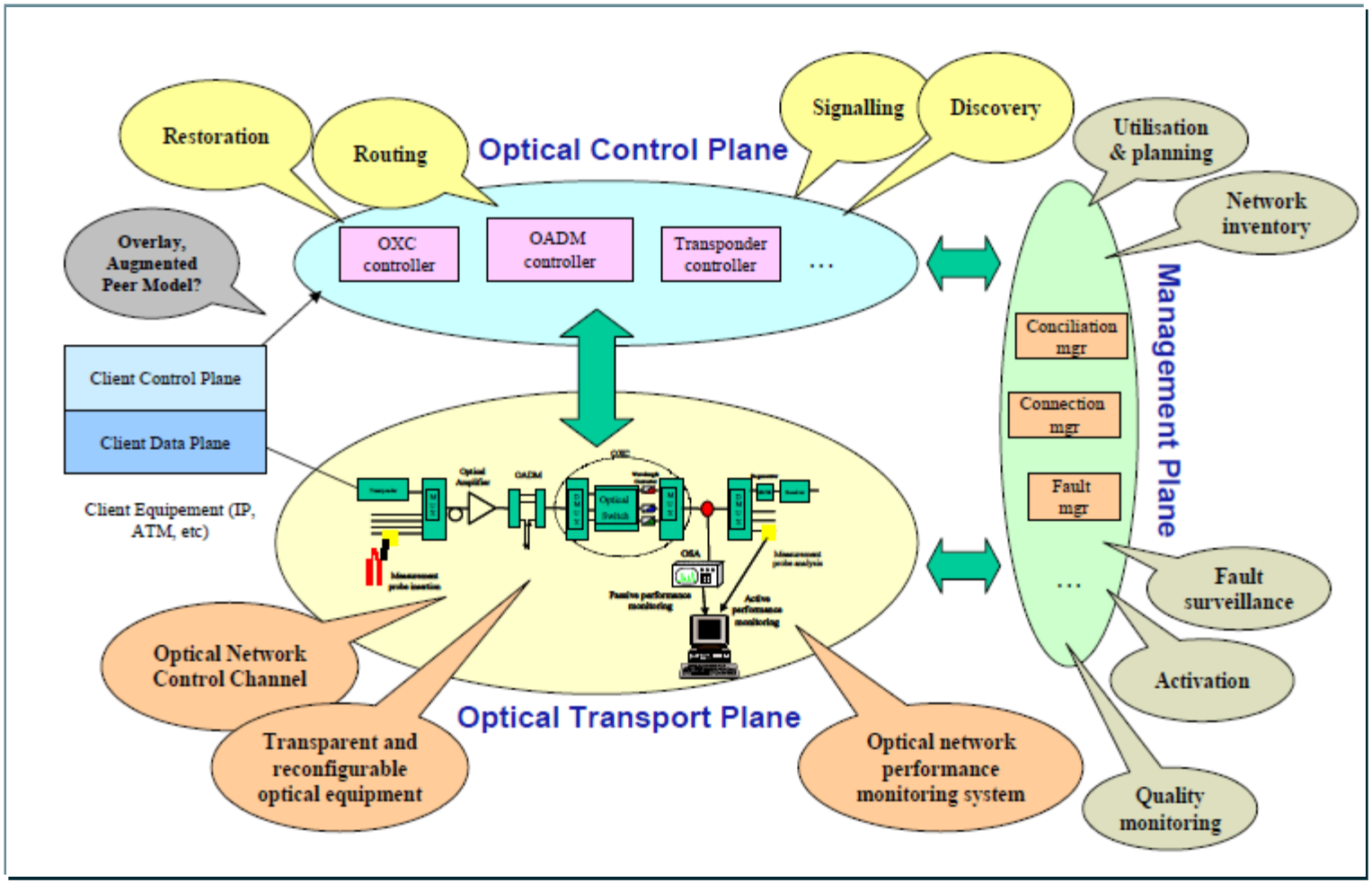
- Why is PCE architecture suitable for multi-domain wavelength switched optical networks (WSON) scenarios?
  - PCE allows computing complex algorithms for WSON → Physical impairments
  - In multi-vendor scenarios, the communication through the GMPLS control plane is not compatible → PCE enables this multi-vendor path computation

- Objectives:
  - Compare three multi-domain algorithms: Per-domain Path Computation, Backward-Recursive PCE-based Computation (BRPC) and Hierarchical Path Computation Element (H-PCE).
  - Assess a proposed solution to reduce the "stolen-lambda" blocking probability.

02

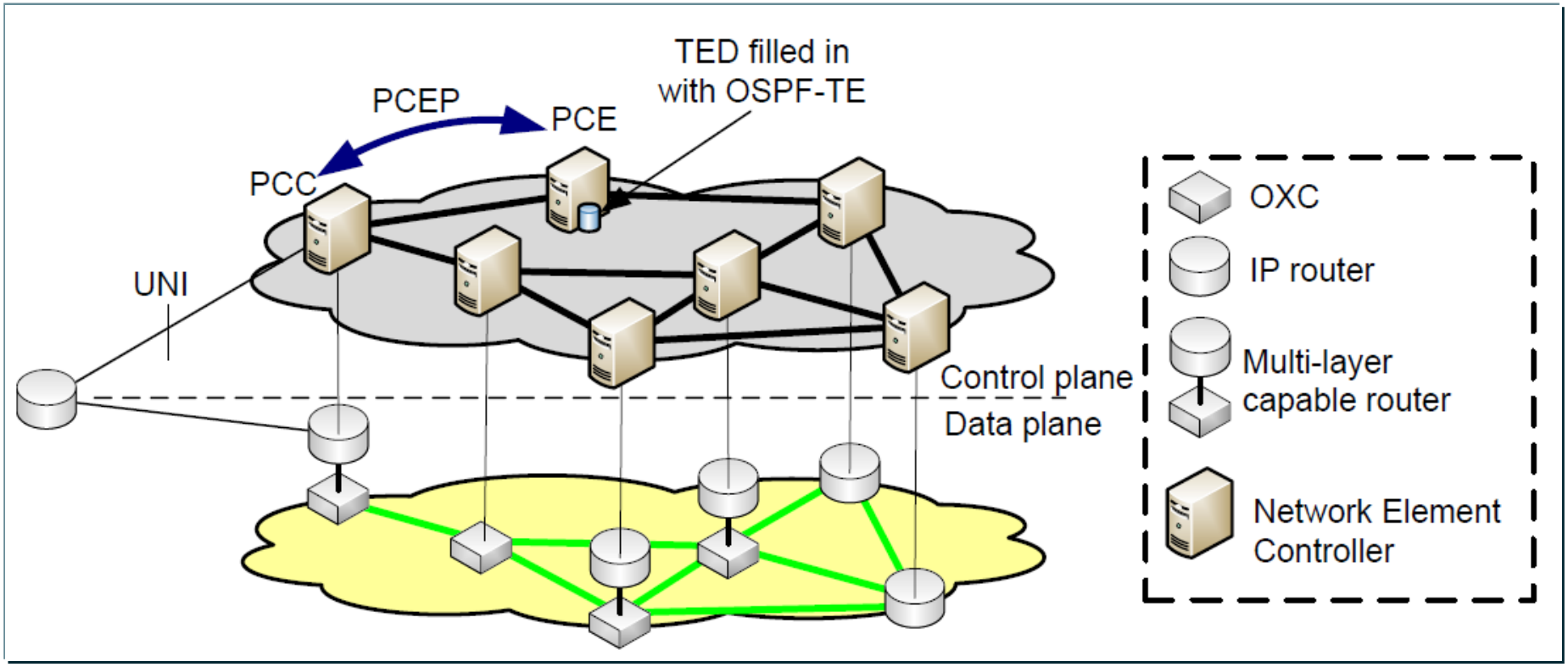
Multi-domain Path Computation Element Protocols

Next Generation Transport Networks



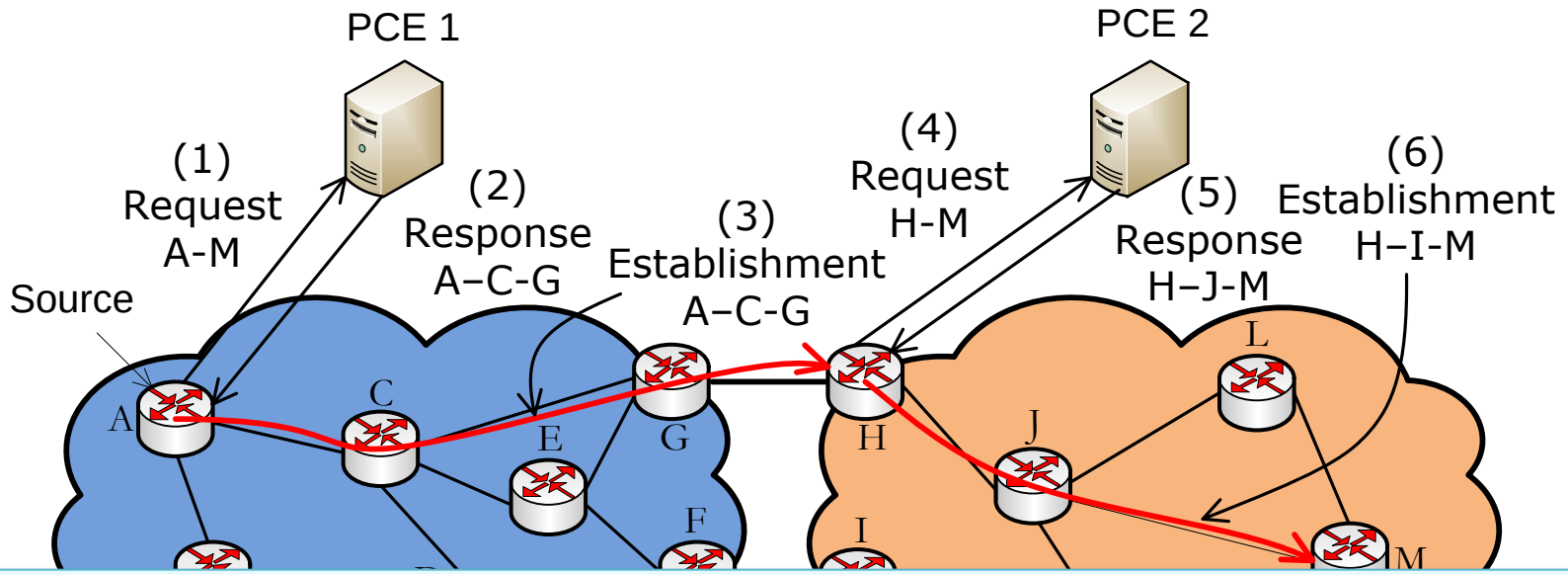
PCE architecture

- PCE offloads GMPLS controller to carry out the path computation process.



Per-domain Path Computation

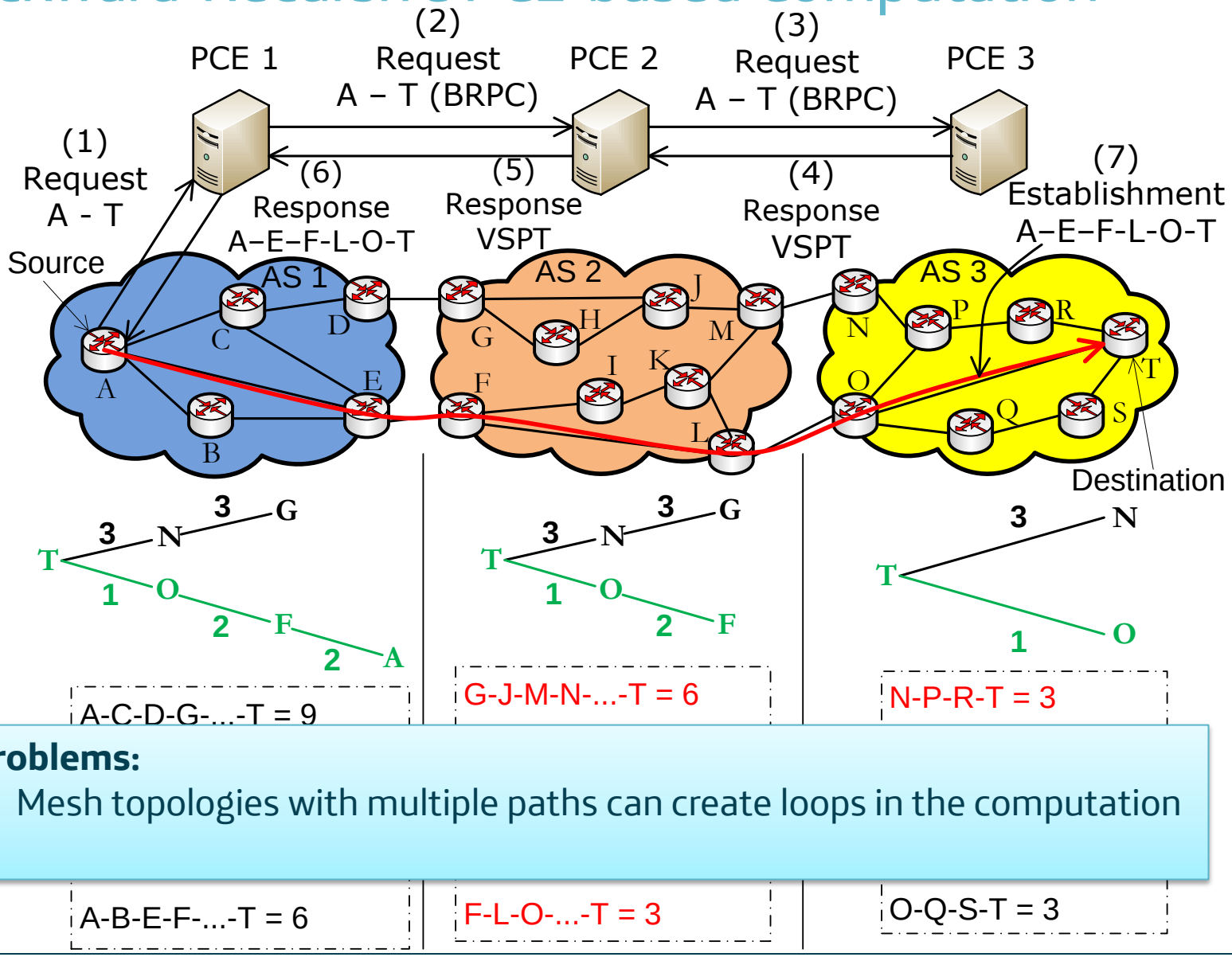
- Path computation during the signaling process per domain.
- There is no communication between the PCEs.
- Domain sequence is not beforehand.



Problems:

- Multidomain path is sub-optimal because there is no multi-domain information
- With complex multi-domain topologies its operation is more complex

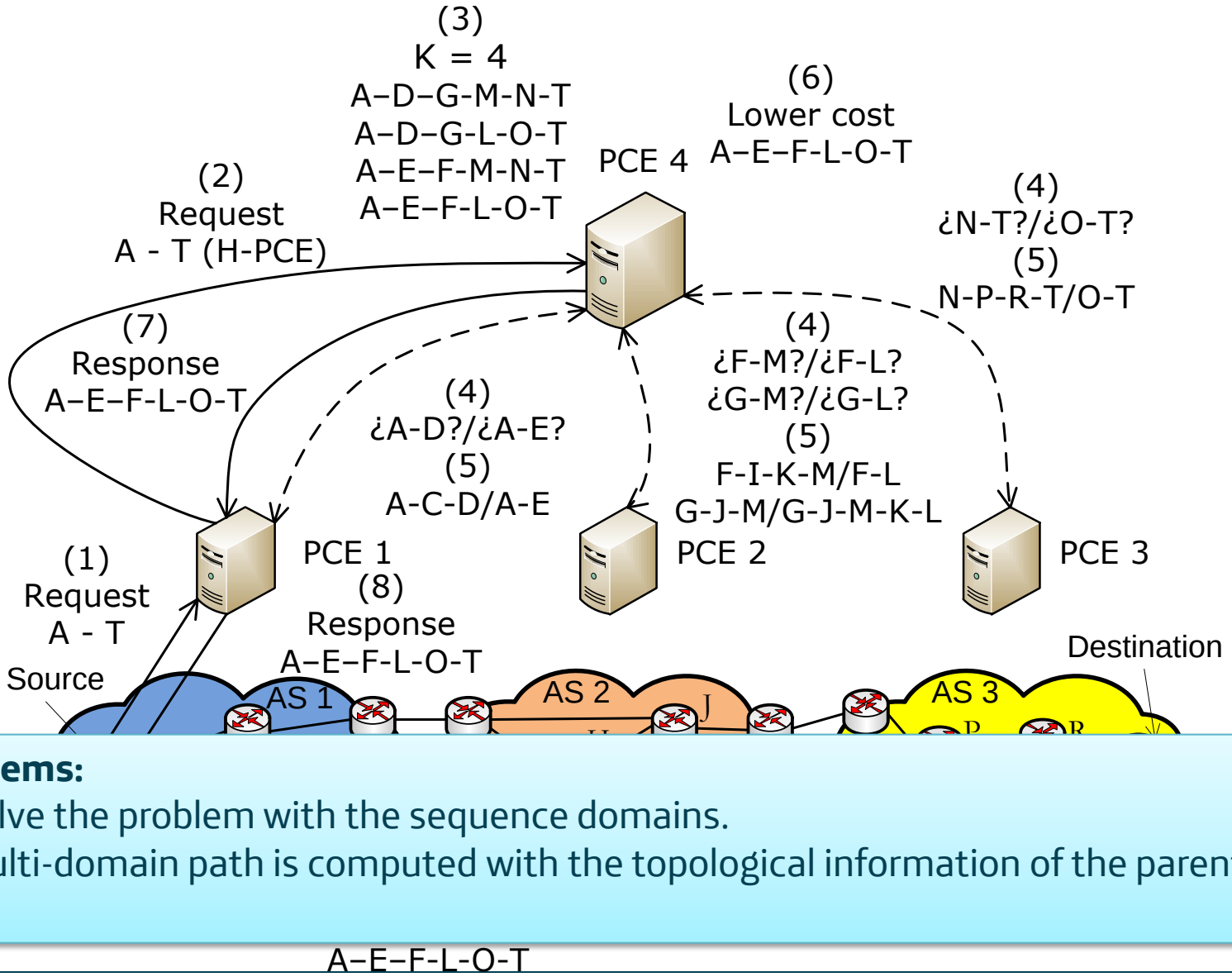
Backward-Recursive PCE-based Computation



Problems:

- Mesh topologies with multiple paths can create loops in the computation

Hierarchical PCE (H-PCE)



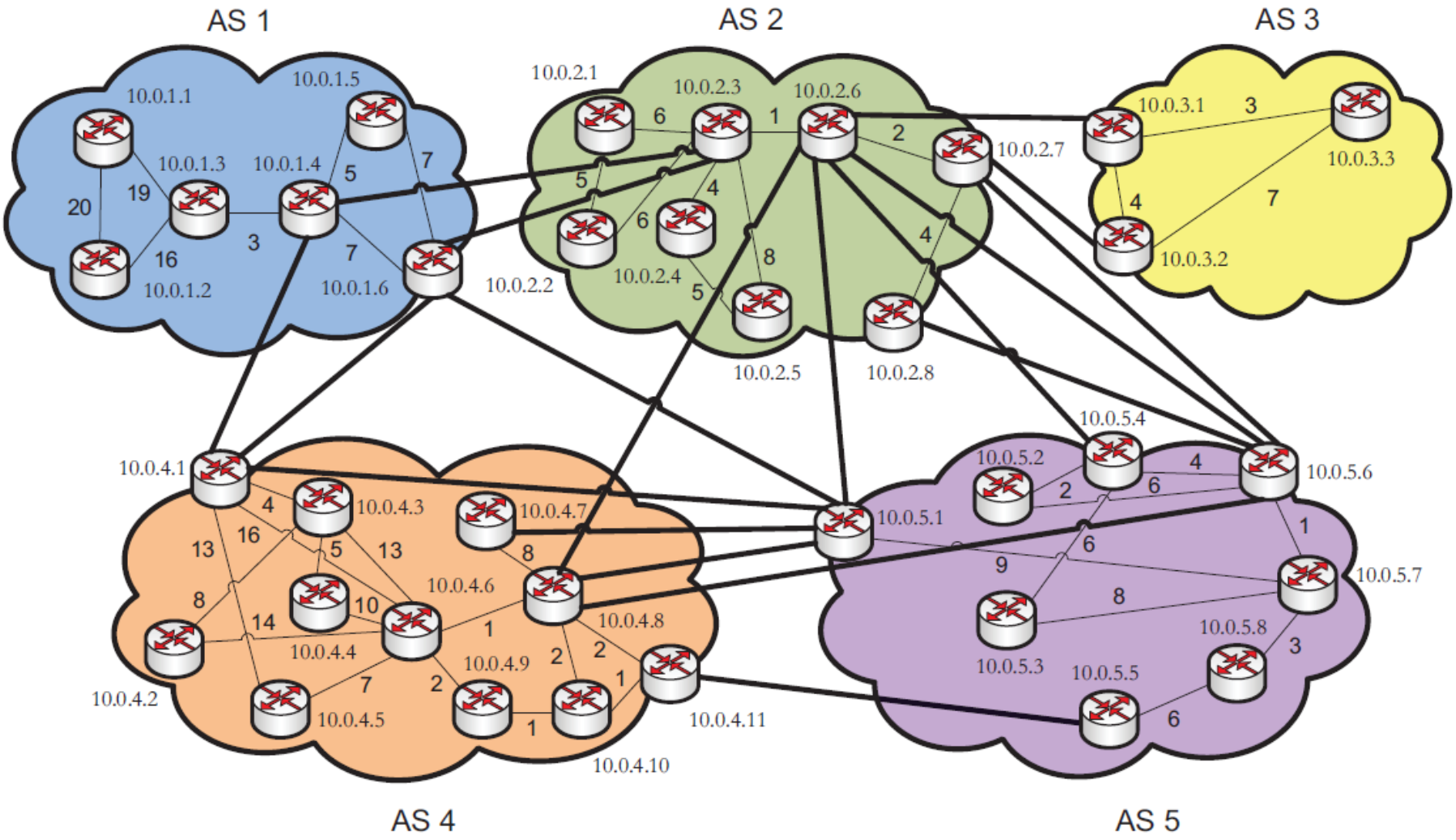
Problems:

- Solve the problem with the sequence domains.
- Multi-domain path is computed with the topological information of the parent PCE.

03

Experimental results

Scenario Definition



Y. Zhao, J. Zhang, Y. Ji, and W. Gu, "Routing and Wavelength Assignment Problem in PCE-Based Wavelength-Switched Optical Networks," *Optical Communications and Networking, IEEE/OSA Journal of*, vol. 2, no. 4, pp. 196–205, 2010.

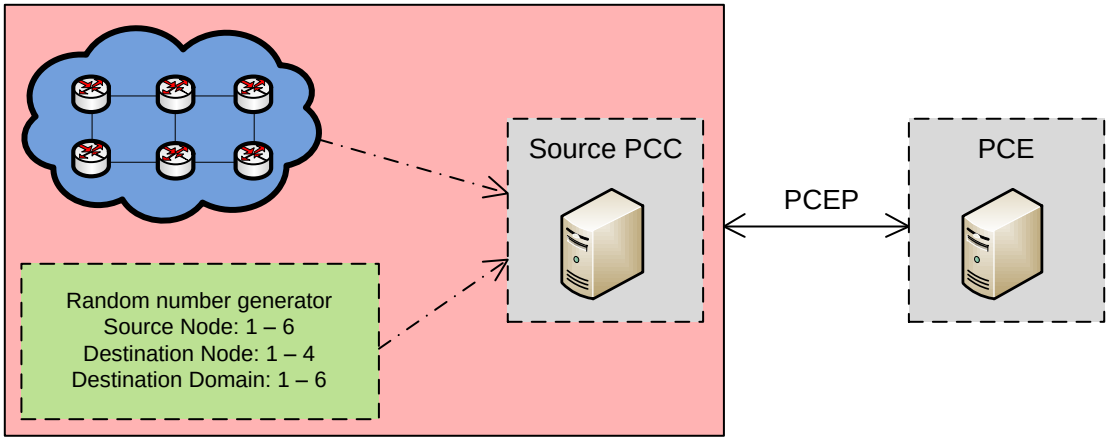
Scenario Definition

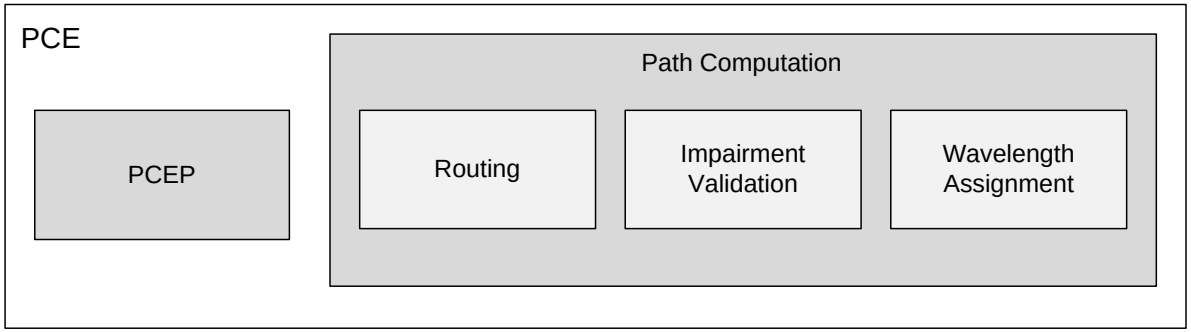
PCC and PCE are at the same server.

Traffic offered by a single domain:

$$A = aN = \frac{\lambda}{\mu} N$$

Arrival and holding time is exponentially distributed





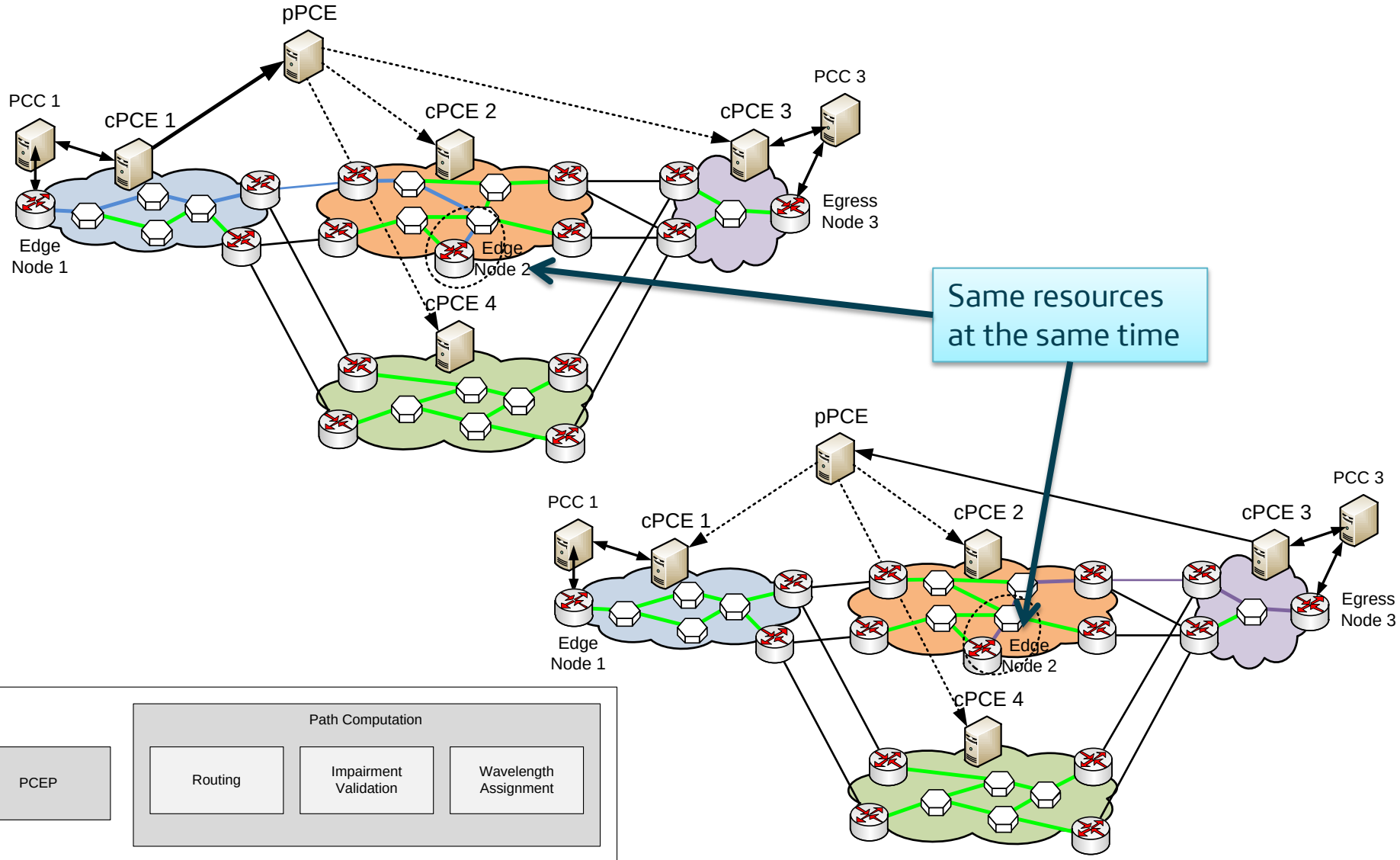
Routing
K-shortest Path (K=5)

Physical Impairments
OSNR, PMD

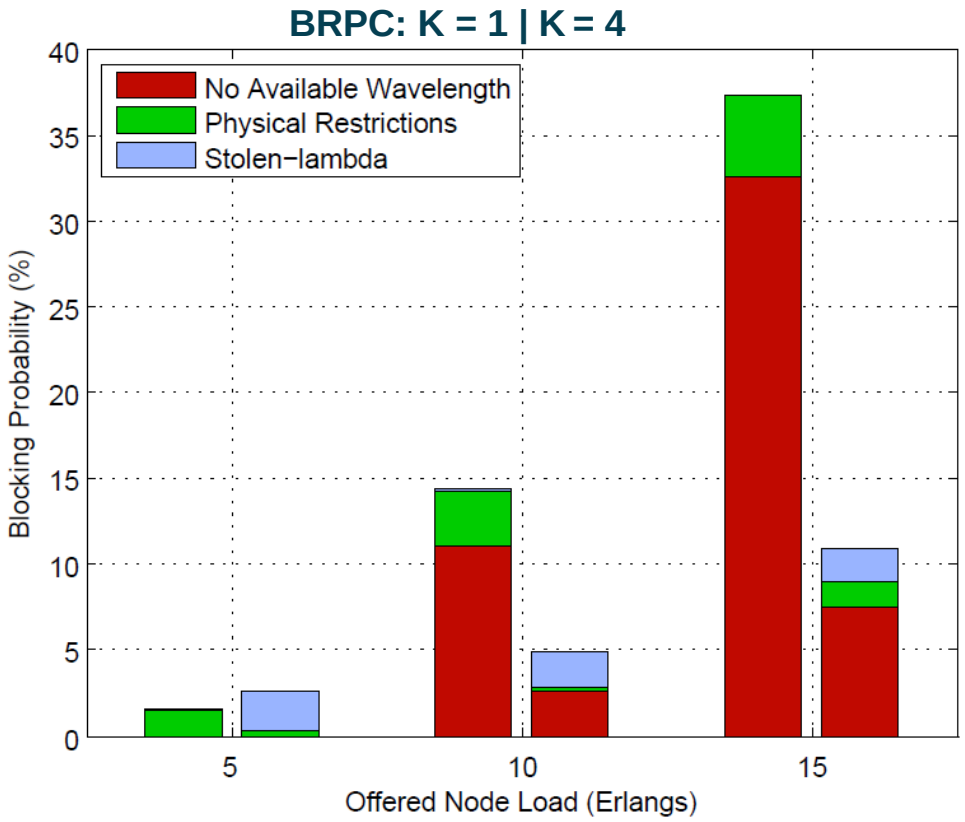
Wavelength Selection
First-Fit (M=80)

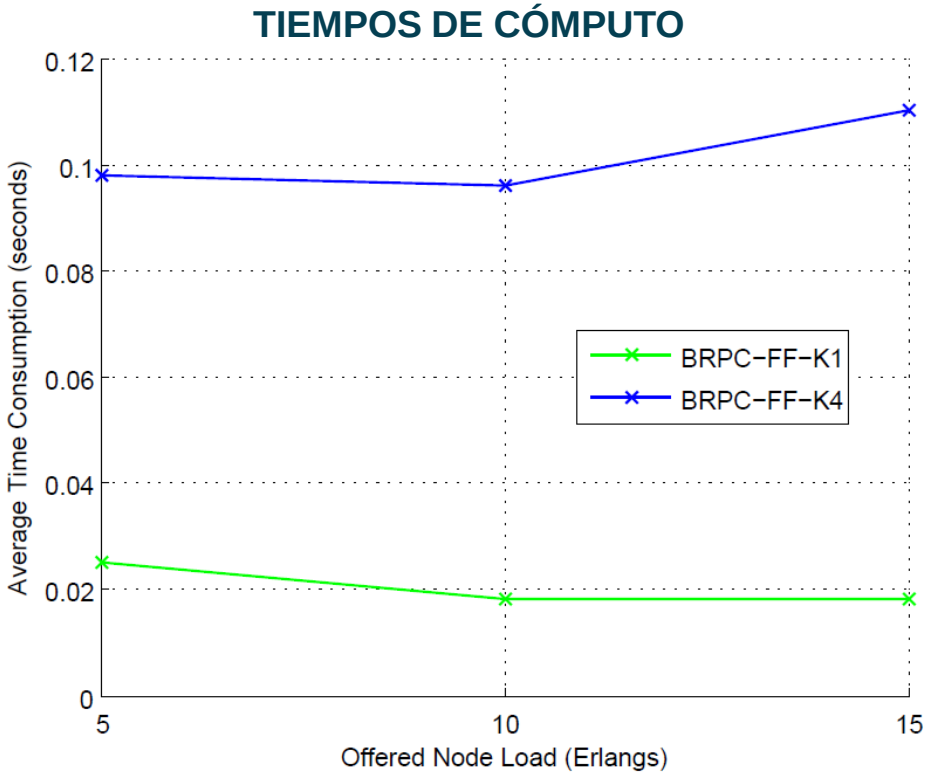
For multi-domain routing KSP is used too.

“Stolen-lambda” block



“Stolen-lambda” block





Higher K → **Lower blocking probability**

Higher K → **Higher time computation** → **“Stolen-lambda” block**

Solutions to reduce the "stolen-lambda" effect

- **Round-Robin First-Fit (RR-FF):**
  - This algorithm is like First-Fit (FF), but if the PCE responses with a lambda *n* to a given request, RR-FF begins the search from lambda *n+1* in the next request.
- **Pre-reservation:**
  - This mechanism pre-reserves the resources in the PCE TED when there is a path request for a given time (T_{res}).
  - Once the T_{res} timer expires, the PCE removes the reservation state of such resources.
  - Draft-RFC:
    - http://tools.ietf.org/html/draftgonzalezdedios-pce-reservation-state-00

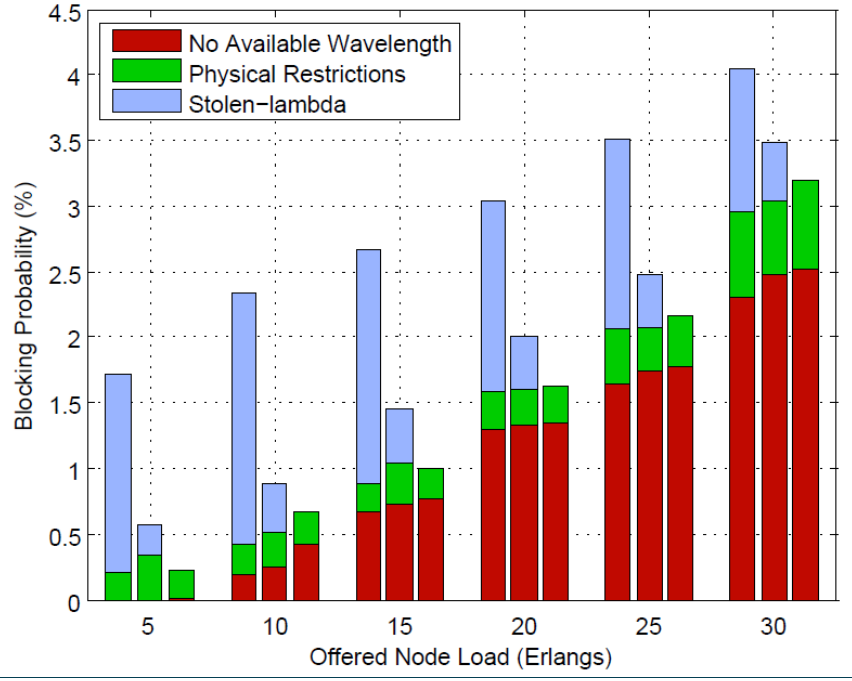
From the OSPF-LSA messages the topology is always updated.

Comparison of the solutions to reduce the "stolen-lambda" effect

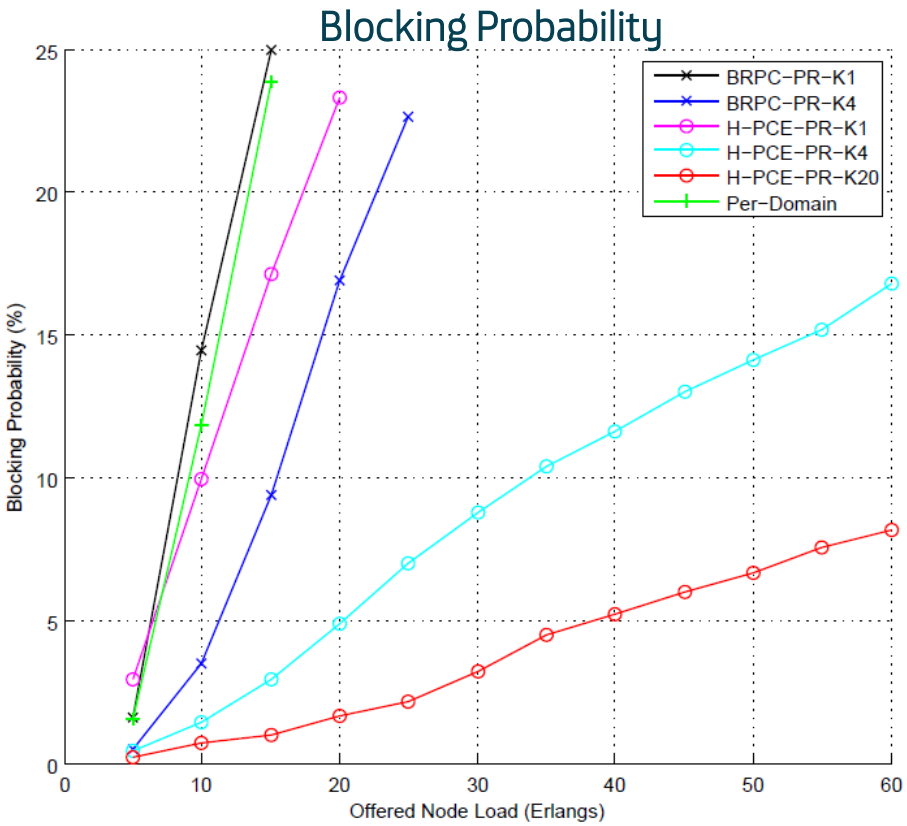
- Round-Robin First-Fit:
  - Important decrement of the "stolen-lambda" effect, but not complete. Pre-Reserva de recursos:
- Pre-Reservation:
  - There is no stolen-lambda effect with T_{res} = 3s.

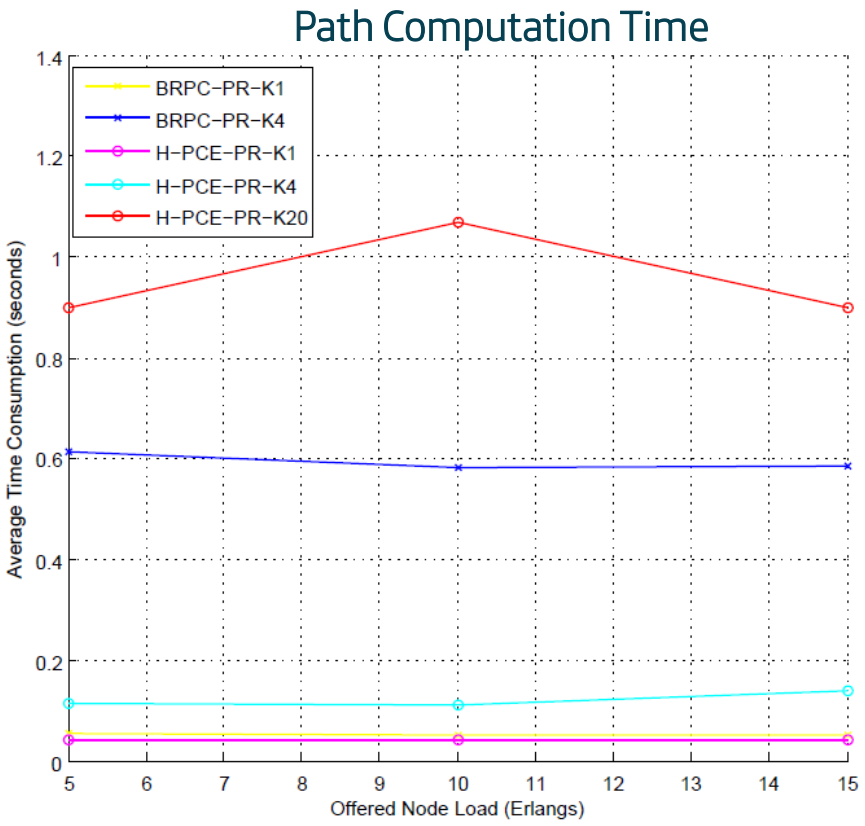
BRPC (K = 4): FF | RR-FF | PR

H-PCE (K = 20): FF | RR-FF | PR



Comparison all algorithms in terms of P_b





- H-PCE shows a lower blocking probability.
  - Path computation time increases with K.
- As with K = 1 BRPC and H-PCE only check a single path the performance is similar to per-domain path computation.

04

Summary and conclusions

Summary and conclusions

- The contribution of this work is two-fold:
  - Comparison of per-domain, BRCP and H-PCE in terms of blocking probability
    - HPCE has a better performance in terms of blocking probability.
  - Validation of temporary reservation mechanism as a solution to avoid "stolen-lambda" block.
- This work has implemented this RFCs and drafts:
  - IETF RFC 5152 "A Per-Domain Path Computation Method for Establishing Inter-Domain Traffic Engineering (TE) Label Switched Paths (LSPs)".
  - IETF RFC 5441 "A Backward-Recursive PCE-Based Computation (BRPC) Procedure to Compute Shortest Constrained Inter-Domain Traffic Engineering Label Switched Paths".
  - IETF Draft "Extensions to Path Computation Element Communication Protocol (PCEP) for Hierarchical Path Computation Elements (PCE)".
  - IETF Draft "The Application of the Path Computation Element Architecture to the Determination of a Sequence of Domains in MPLS and GMPLS".
  - IETF Draft "PCEP Extensions for Temporary Reservation of Computed Path Resources and Support for Limited Context State in PCE".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