Experimental Demonstration of Centralized and Distributed Impairment-Aware Control Plane Schemes for Dynamic Transparent Optical Networks

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Overview

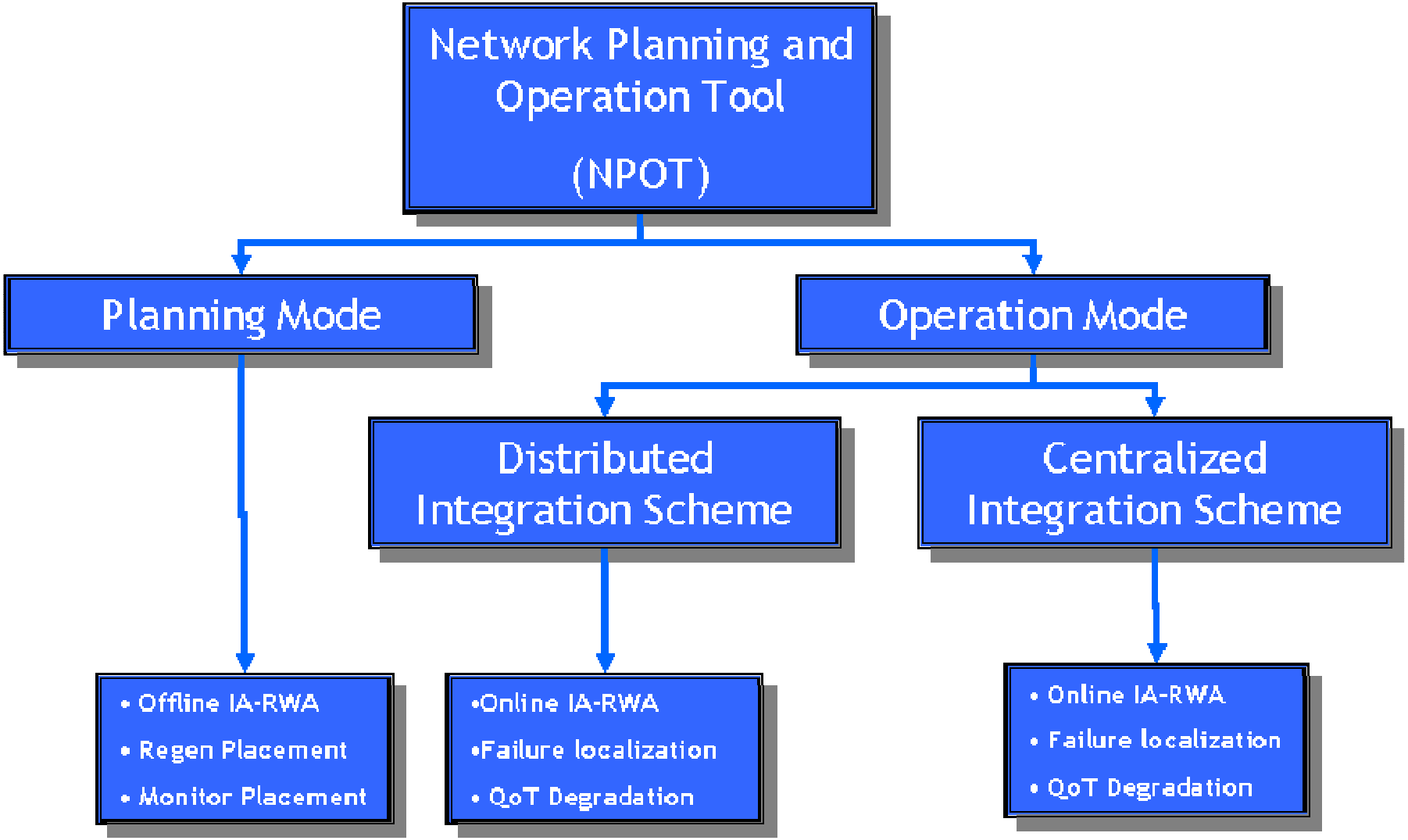
- Motivation
- “Network Planning and Operation” Tool (NPOT)
- Impairment-aware control plane architectures considered
- Impairment-aware control plane architectures implemented
- Experimental evaluation parameters
- Experimental results
- Summary and conclusions

DICONET EU project vision

- Limitations of all-optical networks:
  - Physical Impairments accumulation
  - Failure localization

- The vision of DICONET (Dynamic Impairment Constraint Optical Networking) EU project
  - Develop tools (integrated in a **Network Planning and Operation Tool – NPOT** and an **IA-control plane**) to overcome the limitations of transparent and translucent optical networks considering cross-layer optimization
    - Impairment Aware Routing and Wavelength Assignment algorithms
    - Algorithms for failure localization
    - Algorithms for optimized monitoring equipment and regenerators placement
      - All algorithms consider the quality of transmission (QoT) (either through estimations or/and measurements)

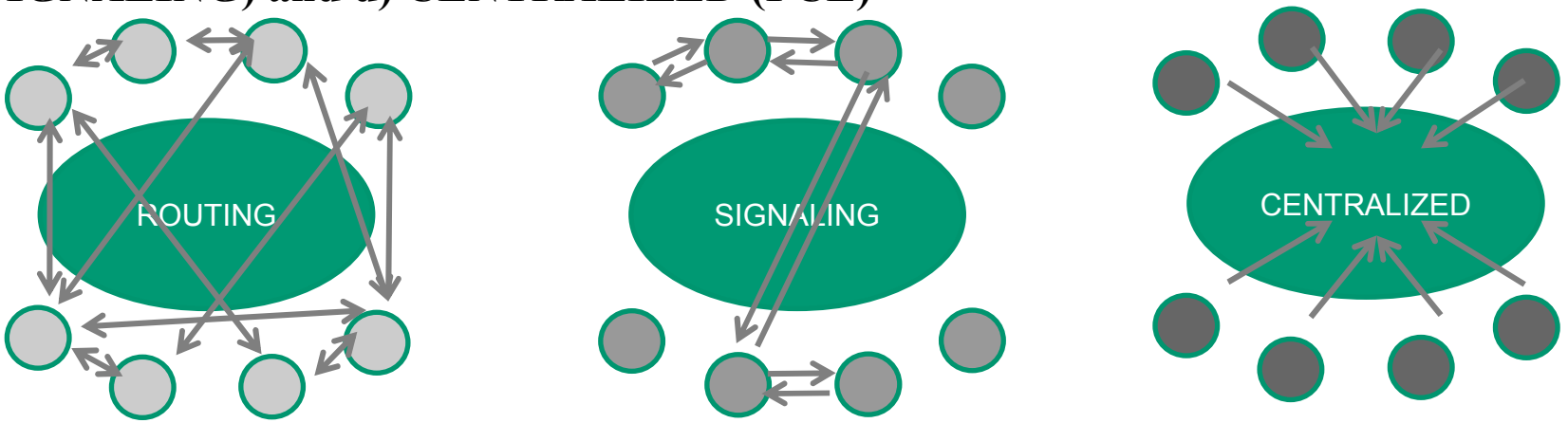
Network Planning and Operation Tool (NPOT)



Control plane approaches

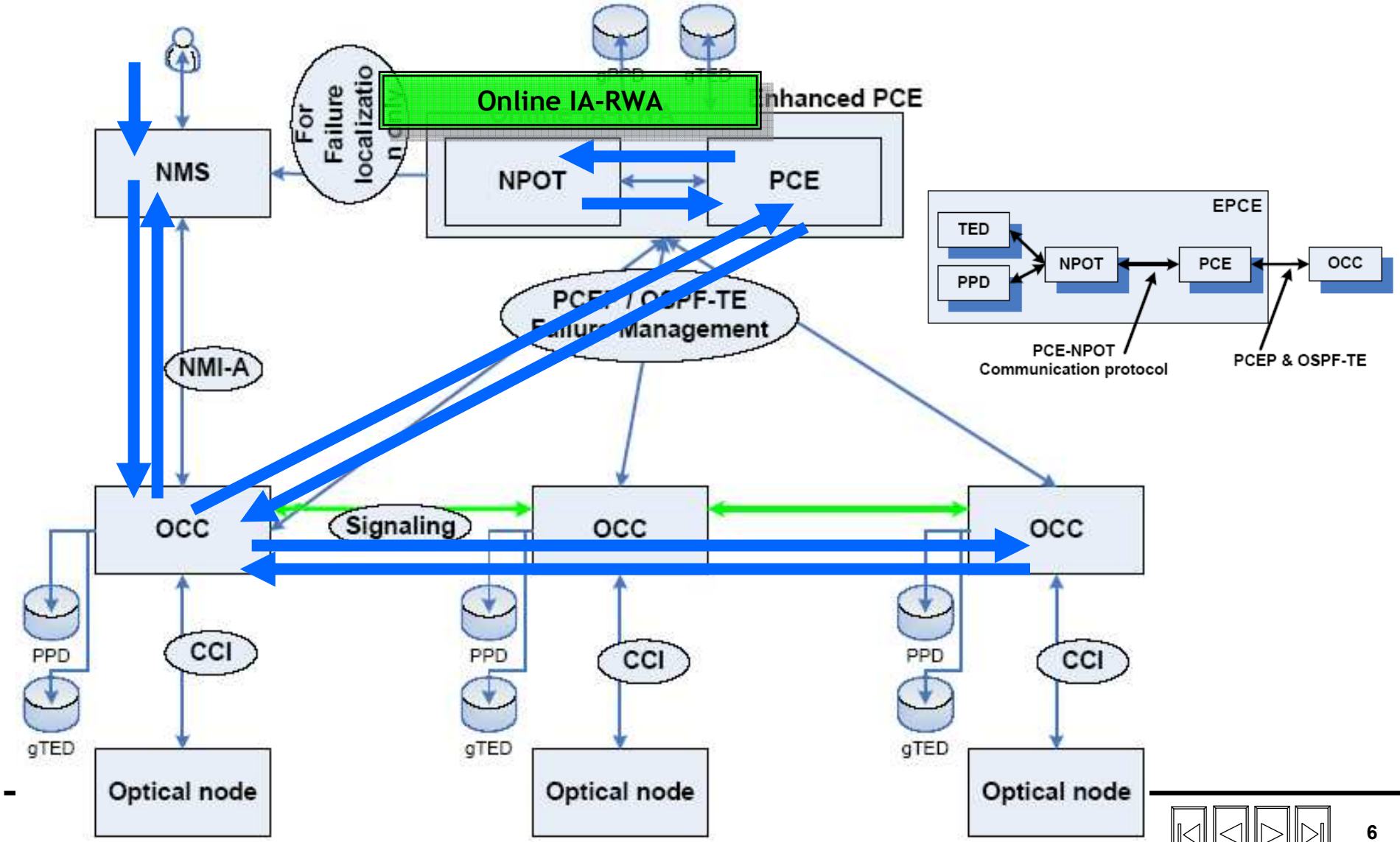
✓**Approaches for impairment dissemination:**

a) ROUTING, b) SIGNALING, c) DISTRIBUTED (HYBRID ROUTING - SIGNALING) and d) CENTRALIZED (PCE)

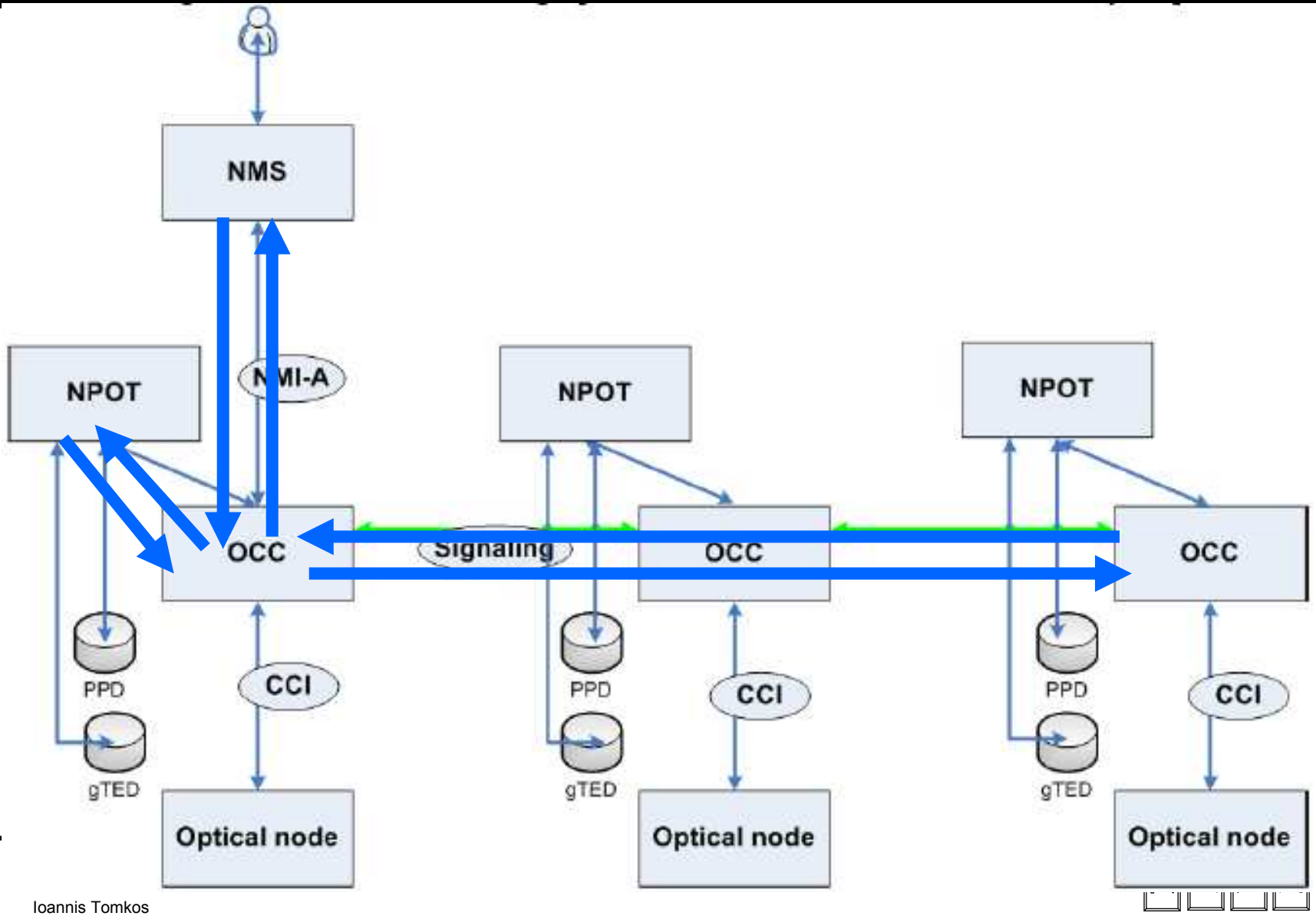


Metrics	Signaling based approach	Routing based approach	Hybrid approach	PCE approach
Blocking probability	High	Medium	Low	Low
Average number of attempts	High	Medium	Low	Low
LSP set-up time	High	Medium	Low	Low
Path computational complexity	Low	High	Very high	Very high

Centralized Integration - Lightpath establishment

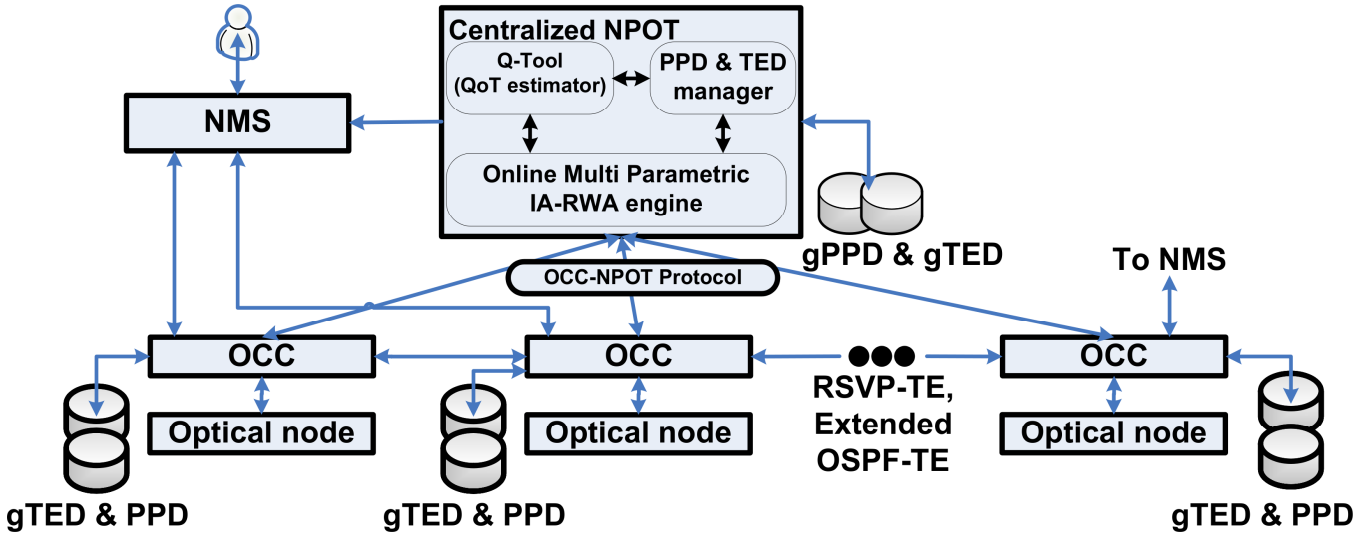


Distributed Integration – Lightpath establishment

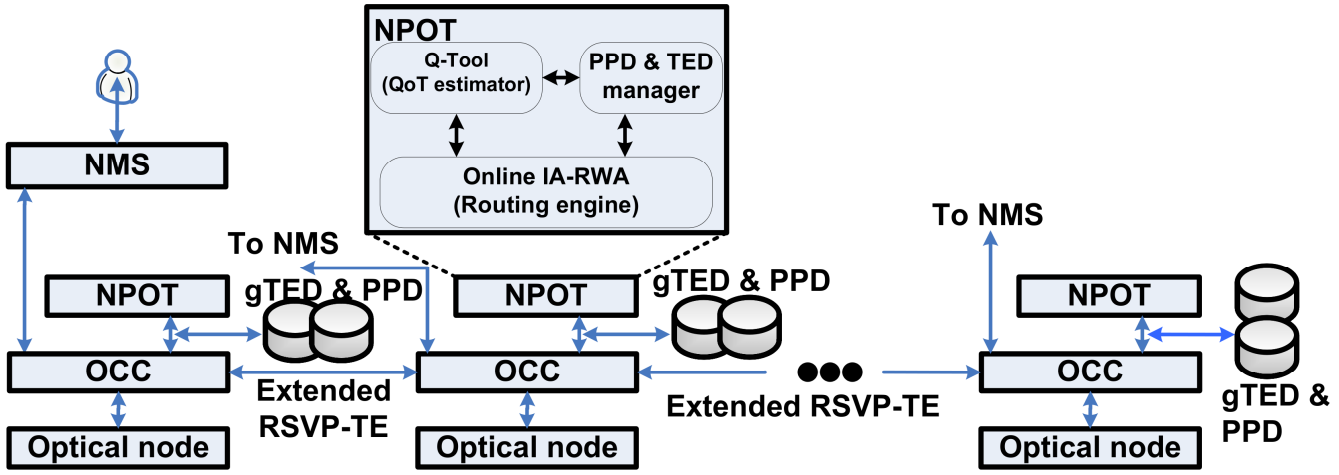


Control plane implementations

Centralized approach

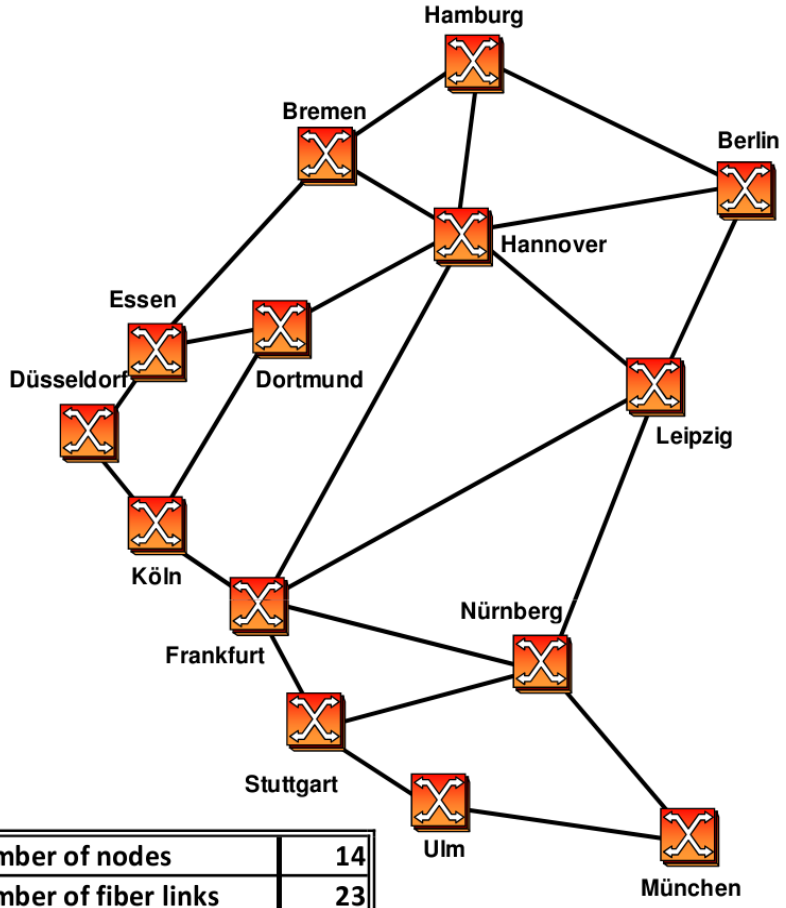


Distributed approach



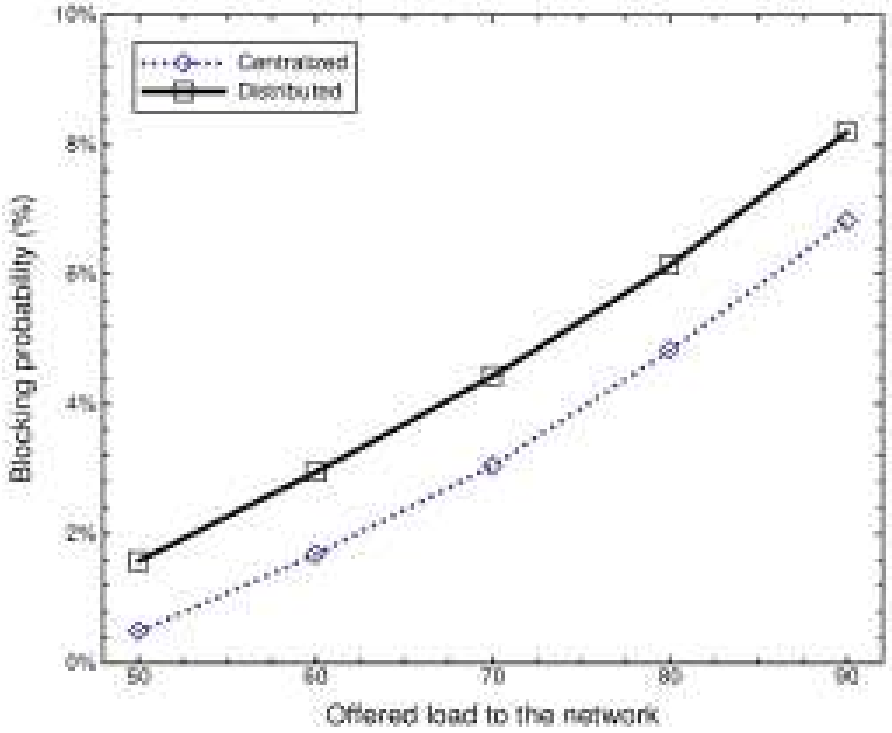
Experimental conditions

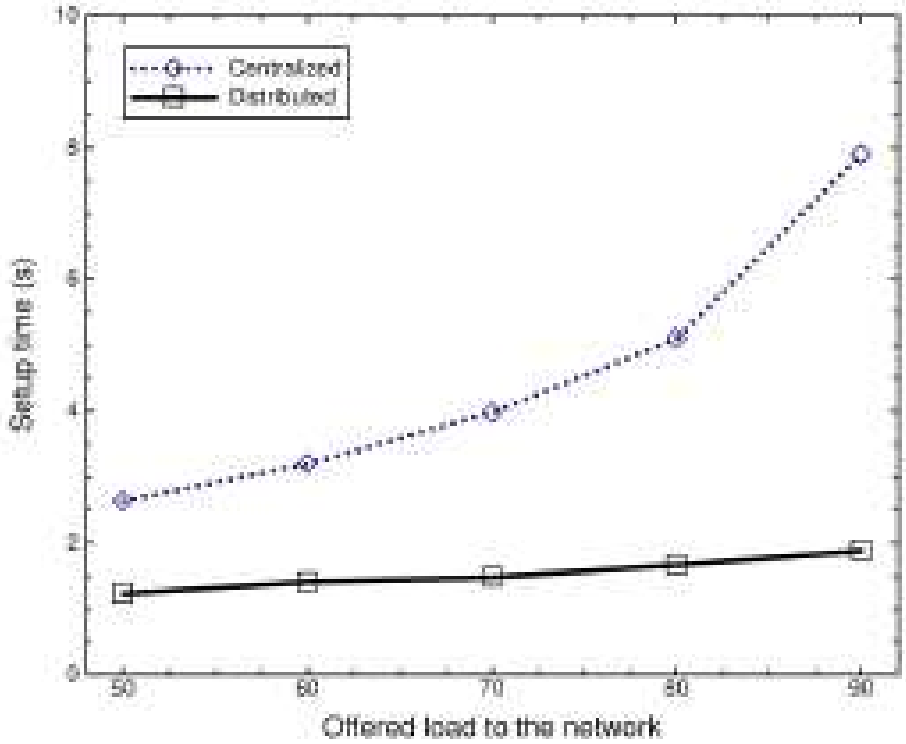
- The performance of the proposed approaches has been validated on a 14-node network test-bed that emulates the same topology as the Deutsche Telekom (DT) network
- Each network node is composed of an Optical Communication Controller (OCC) and a WSS
- Dynamic traffic: The emulated traffic characteristics are uniformly distributed lightpath requests that arrive to the network following a Poisson process and have holding times (HTs) are exponentially distributed with mean 600s.
- The offered loads are thus varied by modifying the connection inter-arrival times (IATs) accordingly (load = HT/IAT).



Number of nodes	14		
Number of fiber links	23		
Mean node degree	3.29	Mean path length (Km)	410
Wavelengths per link	10	Offered load range (Er)	50-90
Mean link length (Km)	186	Traffic distribution	uniform

Experimenting with the Impairment aware control plane implementations





- The distributed case shows lower setup times (due to parallel lightpath set-up)
- The centralized approach is slower (requires one route computation at the same time and is affected by the time required to keep updated the PLI information in the global databases). However, it achieves slightly lower blocking as it uses more complete/updated information.

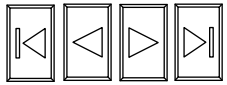
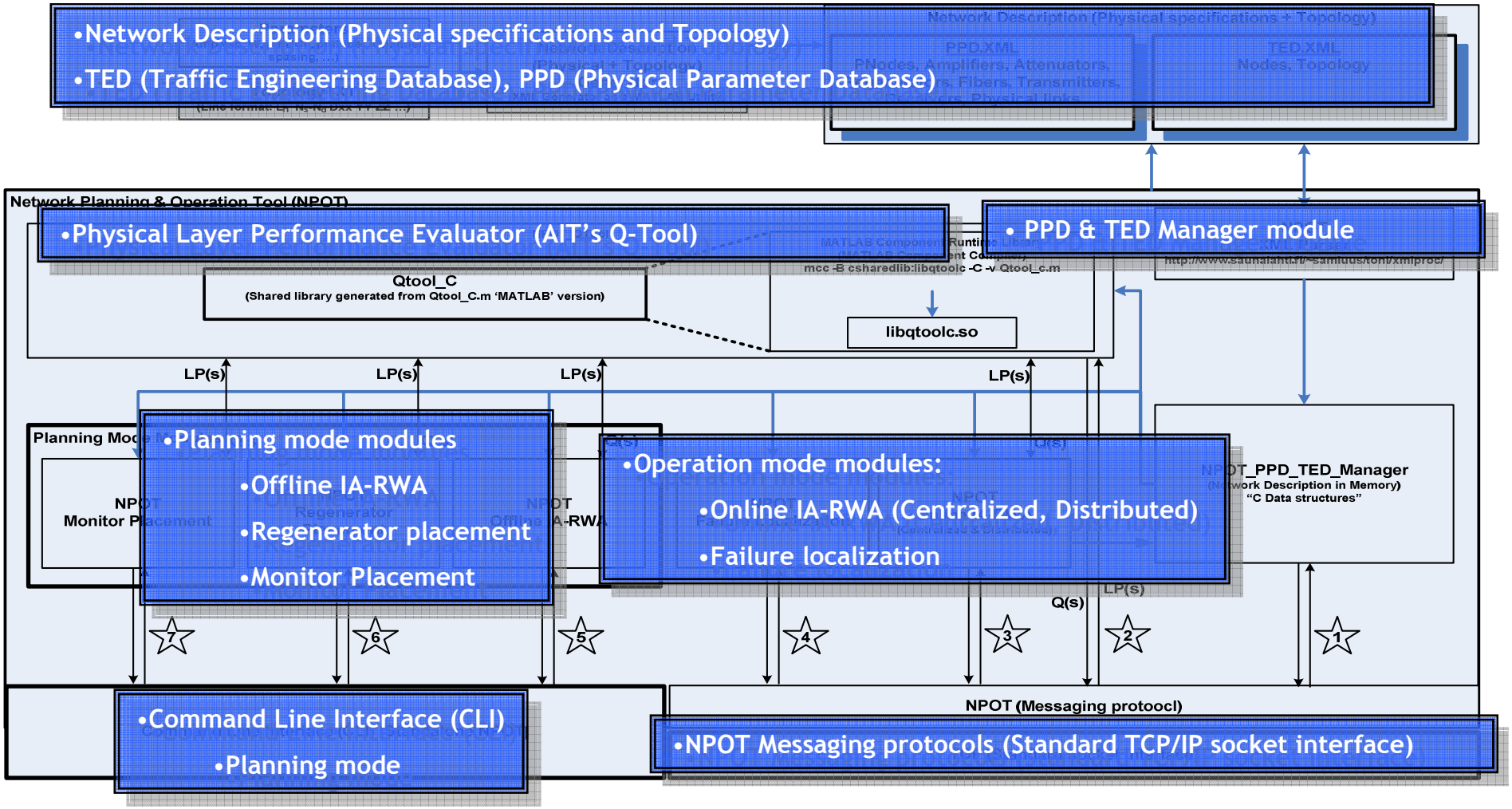
Summary - Conclusions

- We demonstrated experimentally the performance of centralized and distributed impairment-aware control implementations
- A realistic 14-node experimental test-bed under dynamic traffic conditions was emulated.
- The test-bed integrates the developed NPOT engine, the extended GMPLS control protocols required for supporting the innovative DICONET solutions and the communication protocols to allow all DICONET building blocks run in an orchestrated fashion.
- To the best of our knowledge, this is the first time that both approaches are experimentally investigated and their performance reported under such conditions.
- The results show that our novel hybrid distributed scheme yields five-times lower setup times than other reported alternatives

Questions?

- DICONET – Dynamic Impairment Constraint Optical Networking
  - www.diconet.eu

Back-up slides



Anatomy of NPOT