



# “An Offline Impairment Aware RWA Algorithm with Dedicated Path Protection Consideration”

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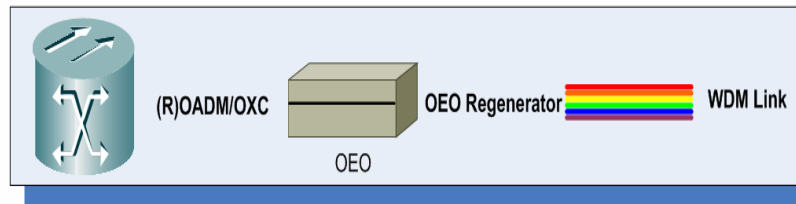
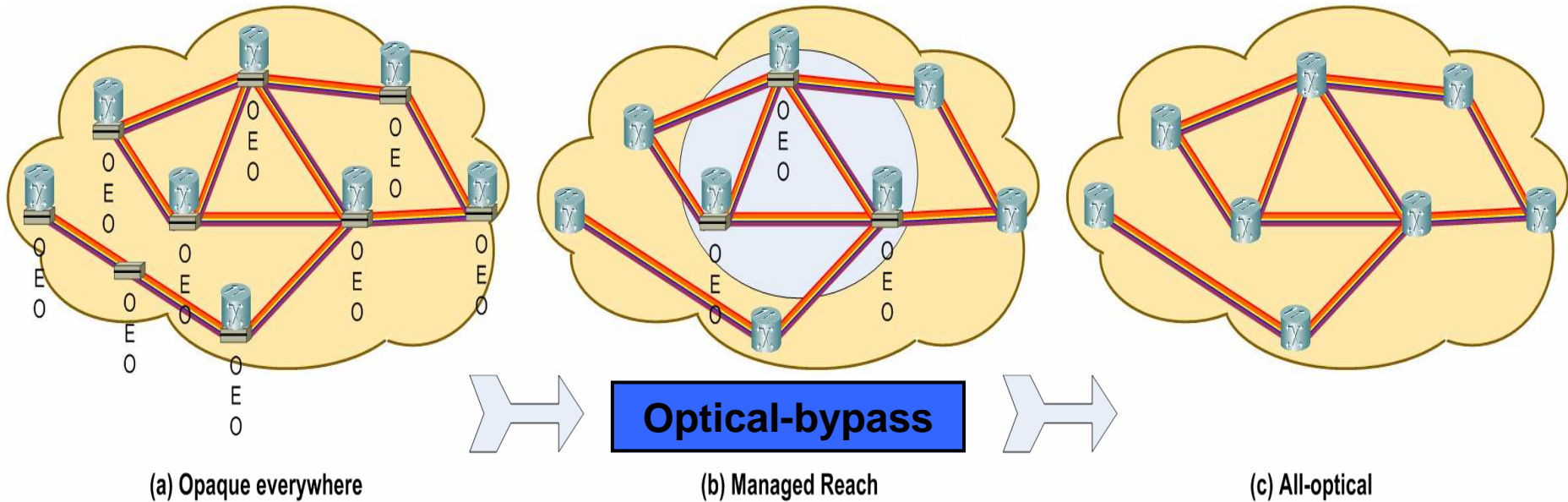




# Outline

- Introduction
- Motivations
- Problem definition
- Proposed framework
- **Offline Impairment Aware RWA algorithm with Dedicated Path Protection**
- Simulation Setup
- Results
- Questions & Answers

- Evolution of core optical networks:
  - Past, Present, Future!





# Key challenges

- **Physical Impairments accumulation**
  - Signal impairments accumulate along a transparent optical path, therefore limiting the system reach and the overall network performance
  - → *Impairment aware routing and wavelength assignment algorithms*
- **Failure localization**
  - Failure propagate in a transparent network environment and they can not be easily localized and isolated.
- **Control plane integration**
  - What to monitor and distribute?
  - What is the best control plane integration model?

- **The network evolution aims at:**
  - **Improved cost economics (less costly electronics)**
    - Cost savings of a transparent solution over and opaque network design of up to 50% could be achieved
      - *Source: M.Gunkel, et. al. "A Cost Model for WDM Layer", Photonics in Switching Conference, 2006.*
  - **Reduced investment and operations Efforts (CAPEX, OPEX)**
  - **Scalability (bit rate independence)**
  - **Suitability to future services (e.g. Grid computing)**
- **The main drivers for network architecture migration:**
  - High bandwidth and end-to-end QoS guaranteed services
  - Dynamic (on demand) technology-independent service provisioning

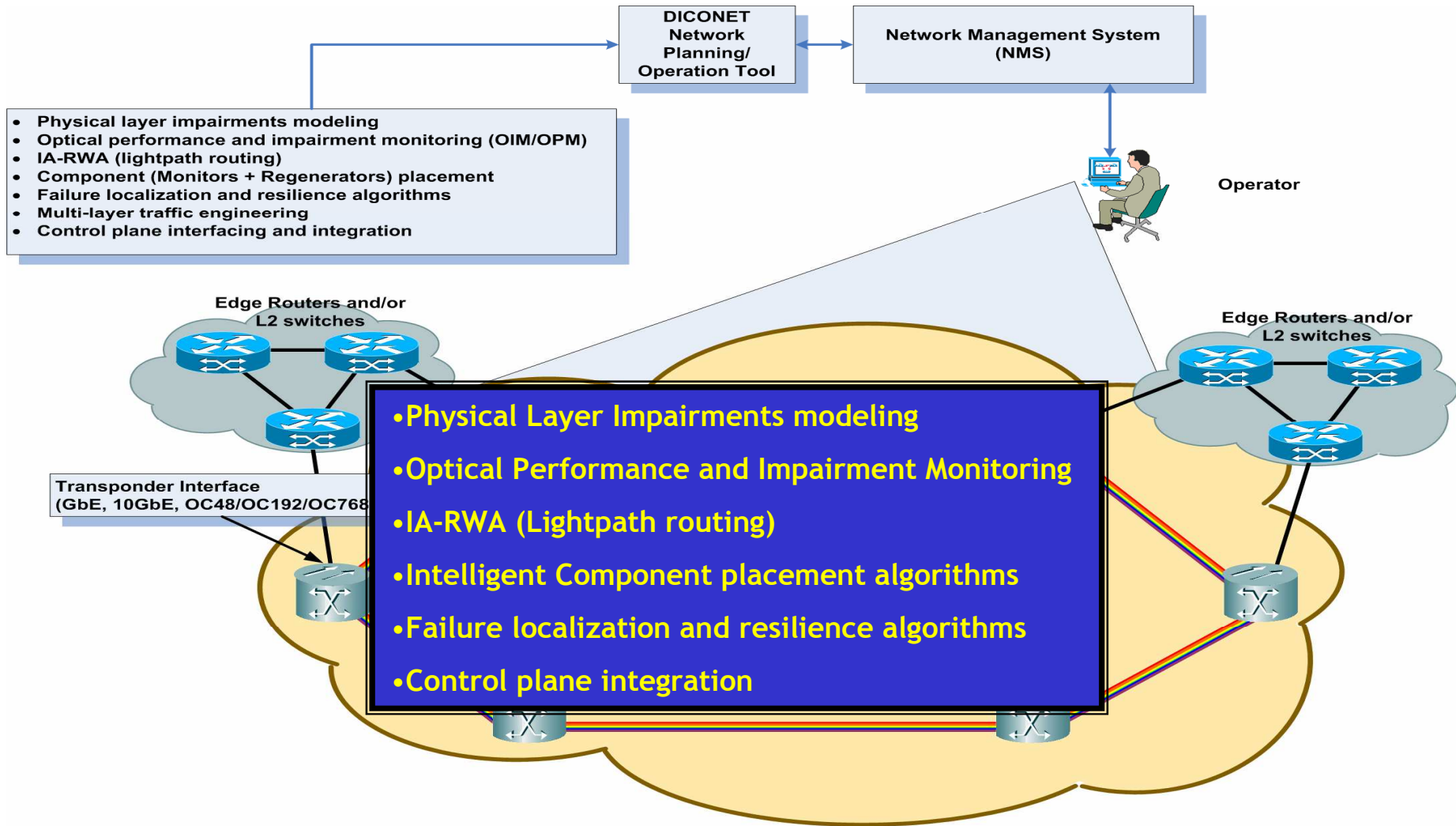


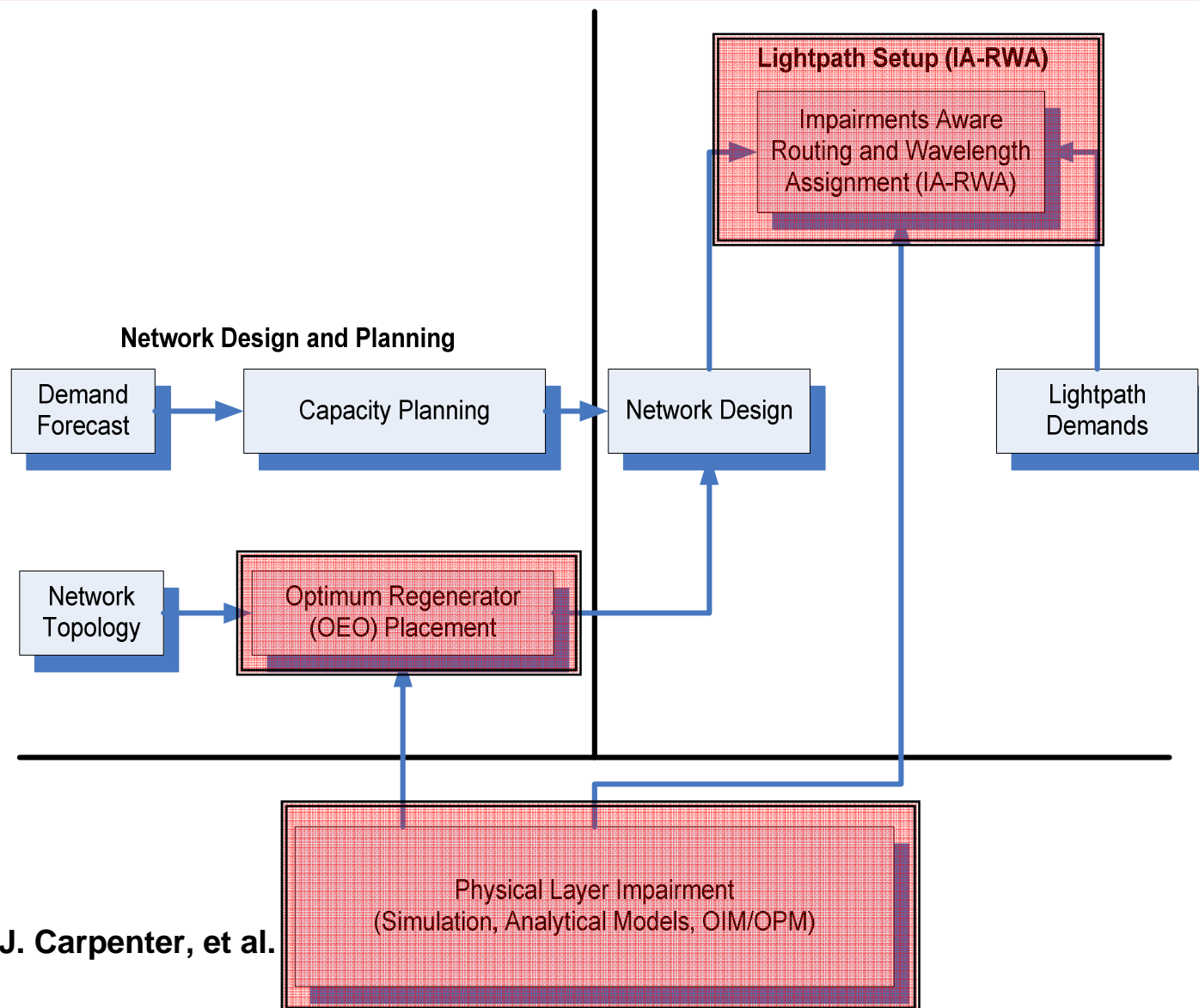
# Proposed framework (1/2)

- Cross-layer optimization
  - Physical layer impairment monitoring/management
  - Impairment Aware Lightpath Routing (a.k.a. IA-RWA)
- The main Idea:
  - The development of a *dynamic network planning/operation tool* residing in the *core network* nodes that incorporates *real-time measurements* of optical layer performance into *IA-RWA algorithms* and is integrated into a unified control plane.



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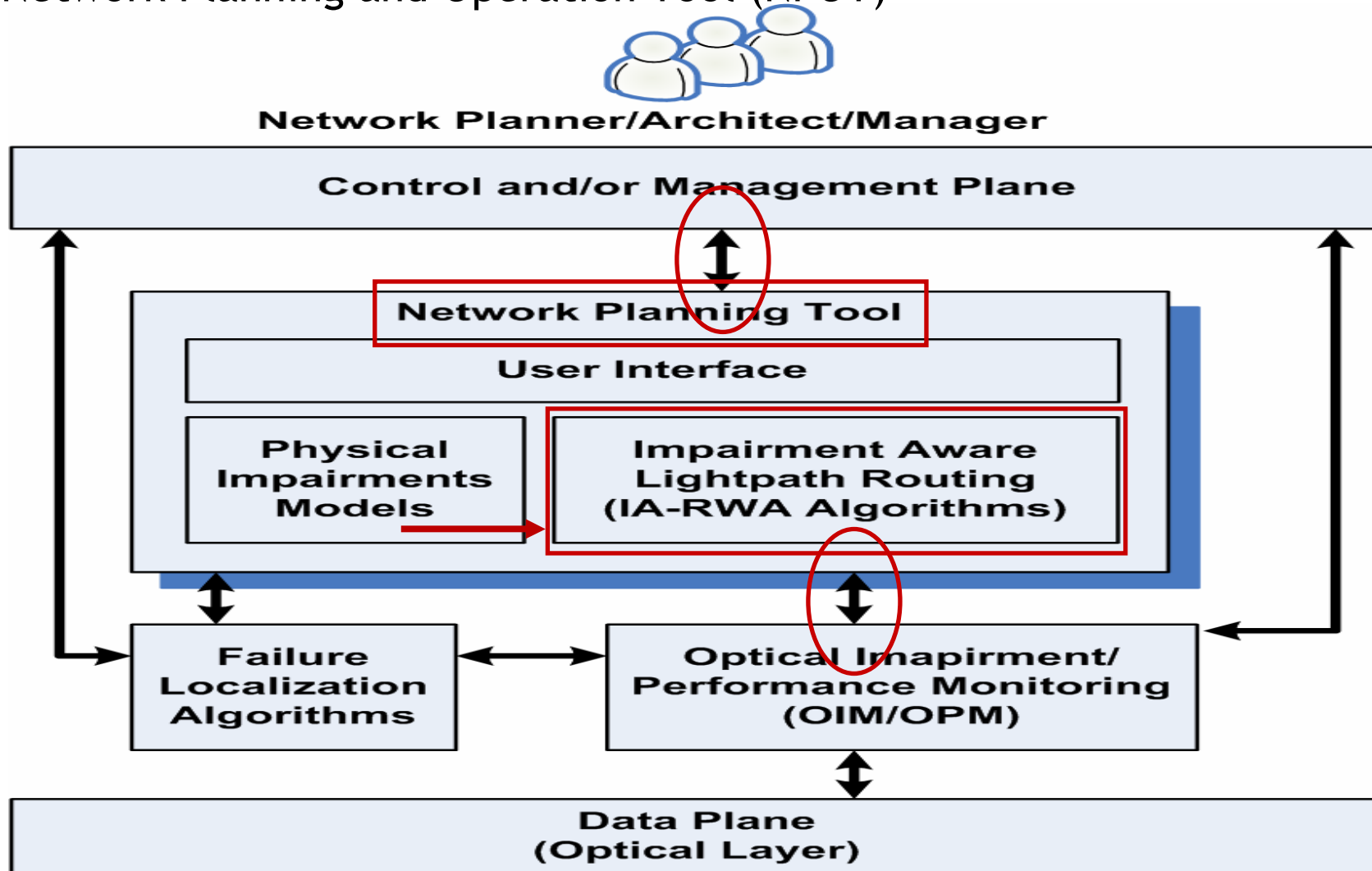


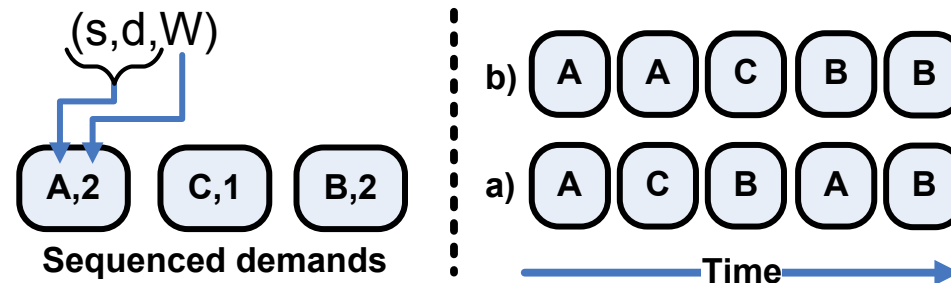
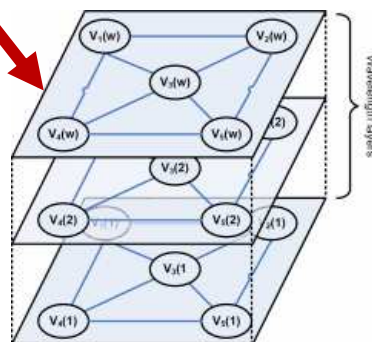
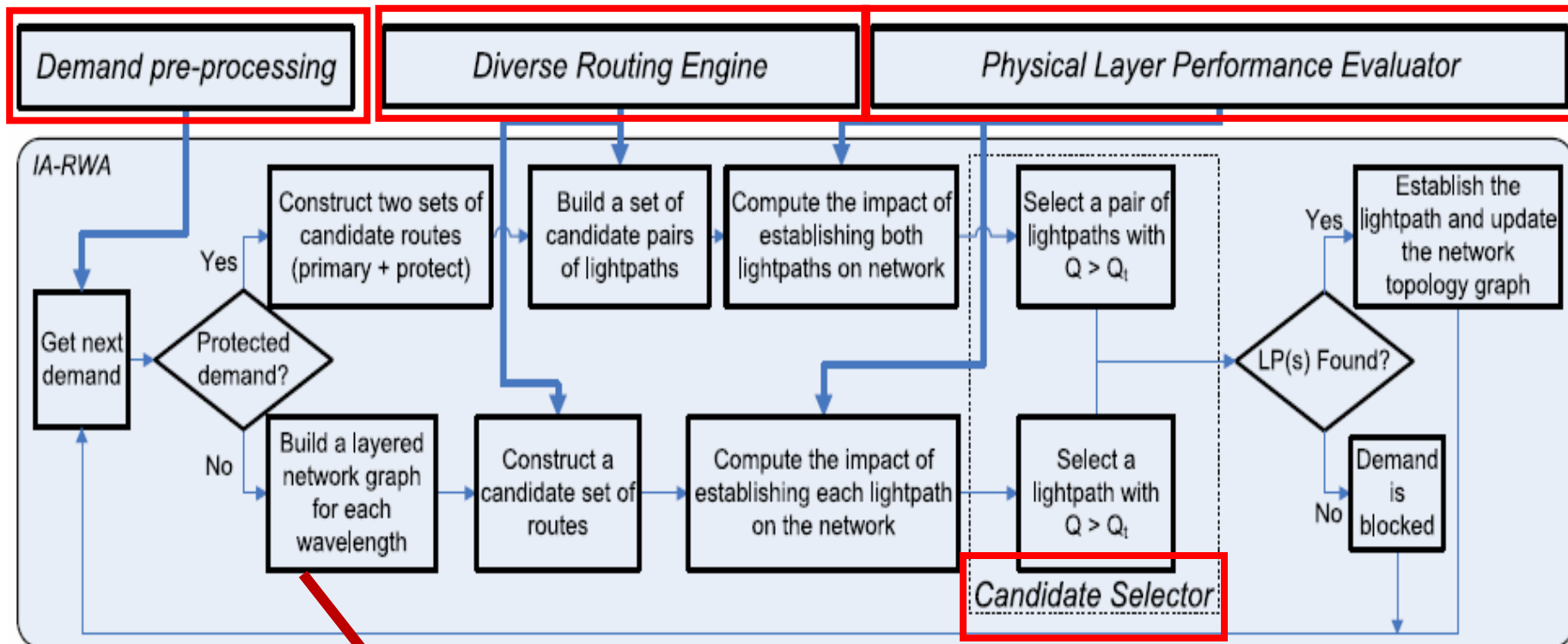


Source: T. J. Carpenter, et al.



- Network Planning and Operation Tool (NPOT)





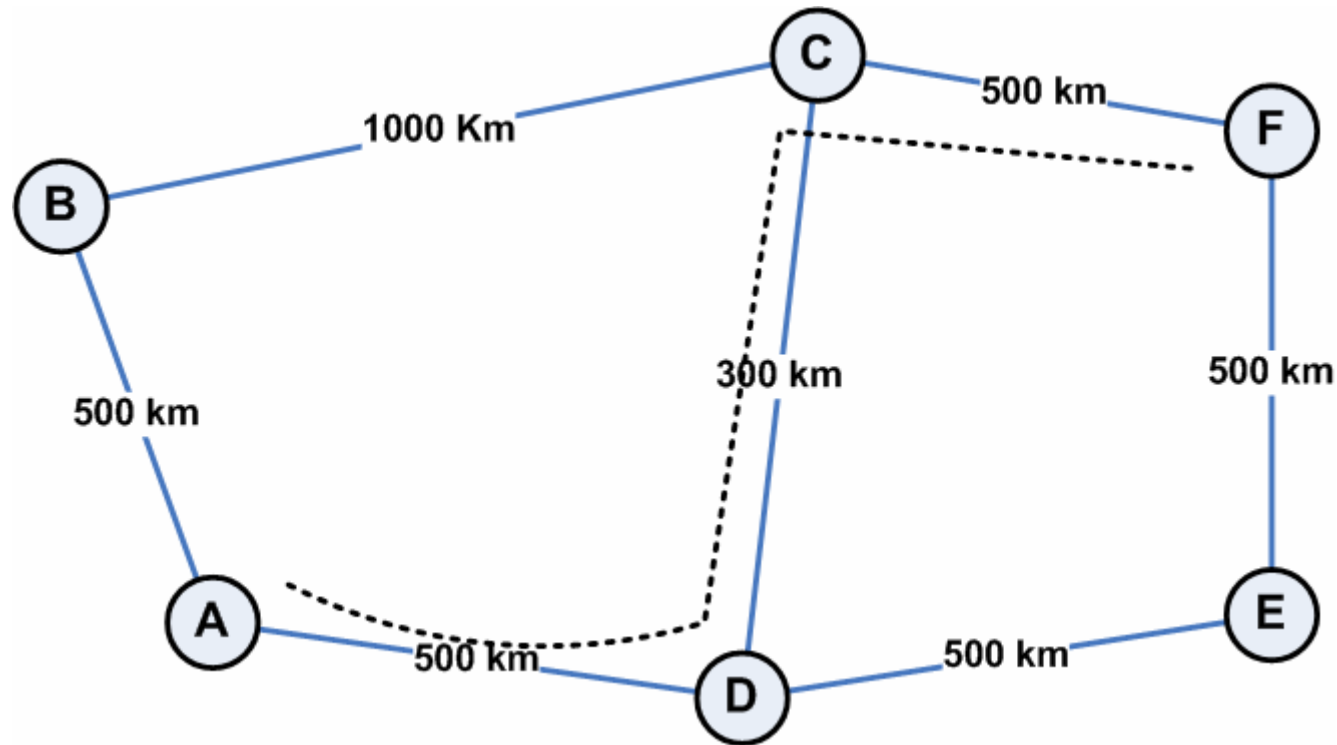


# Algorithm building blocks

- Demand Pre-processing
- Diverse routing engine
  - Breadth-First Search (BFS)
  - K-Shortest path
  - Bhandari algorithm for demands with protection request
- Physical Layer Performance Evaluator
  - Use “Q Factor” as a BER indicator
  - Account for ASE noise, PMD, node crosstalk, XPM, FWM
  - Network status dependent impairments (XPM, FWM)
    - Lengthy computations
    - Valid for 10Gbps, OOK
- Adaptive wavelength assignment

# Diverse Routing Challenge (1/3)

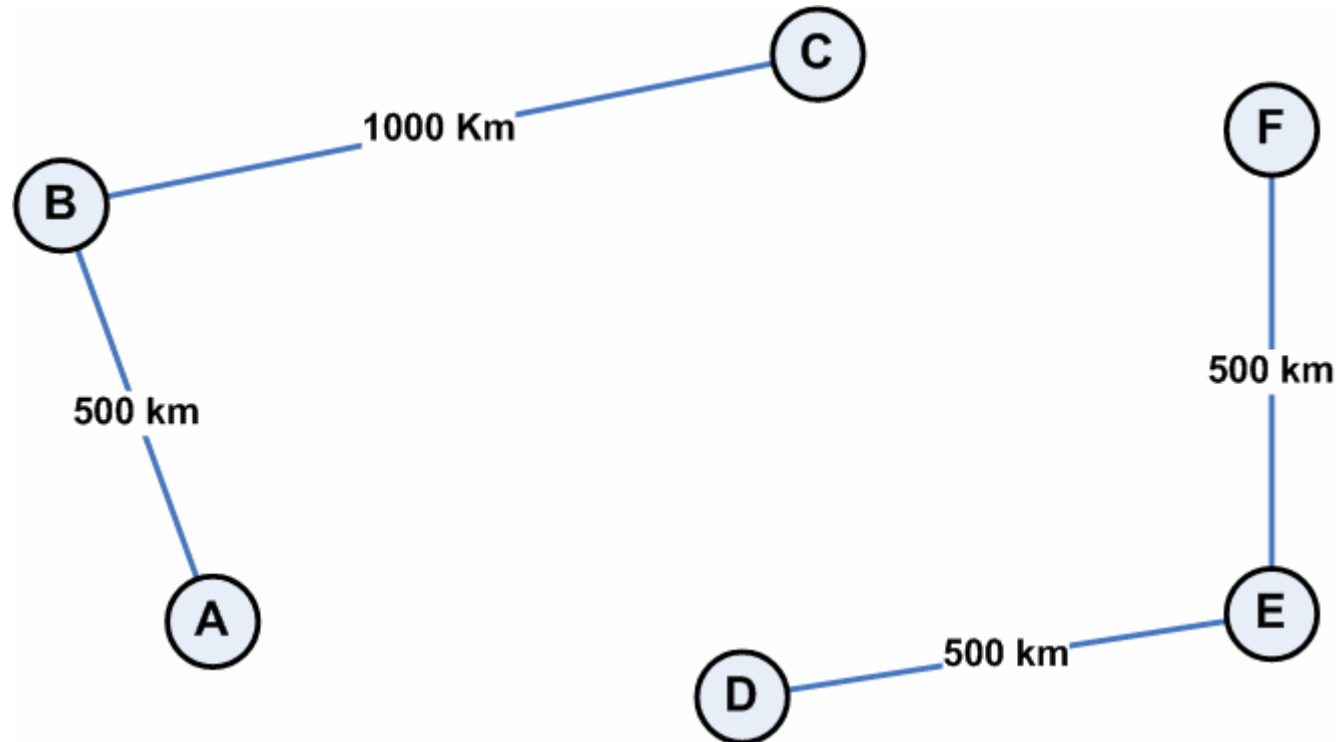
- Find two routes (link and node disjoint) from “A” to “F” (1+1 protection)





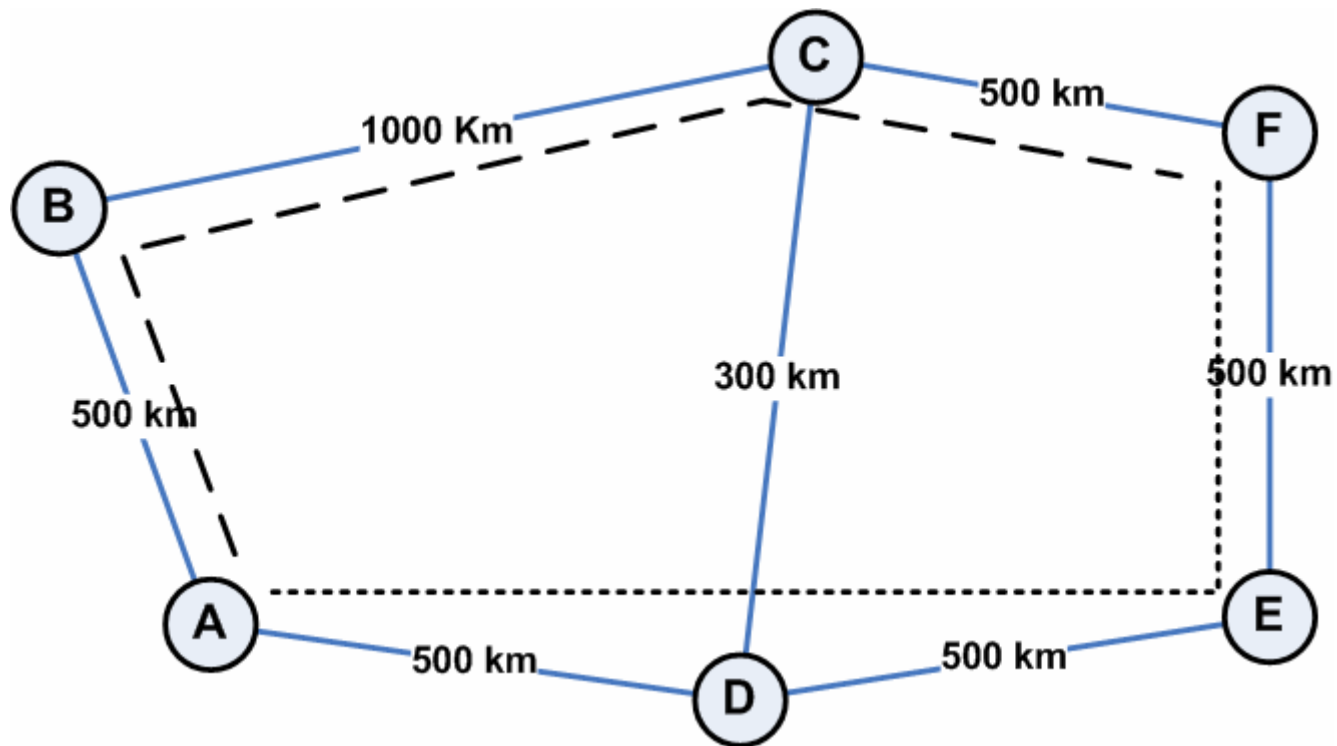
# Diverse Routing Challenge (2/3)

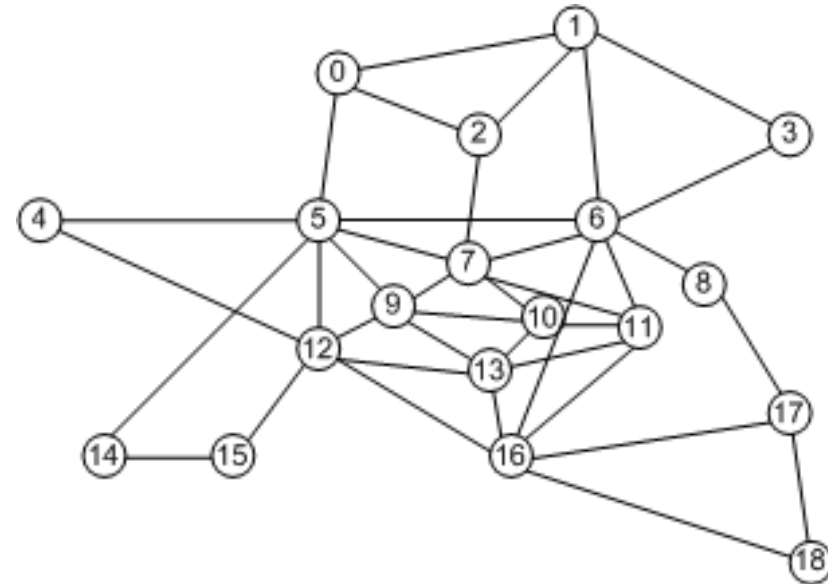
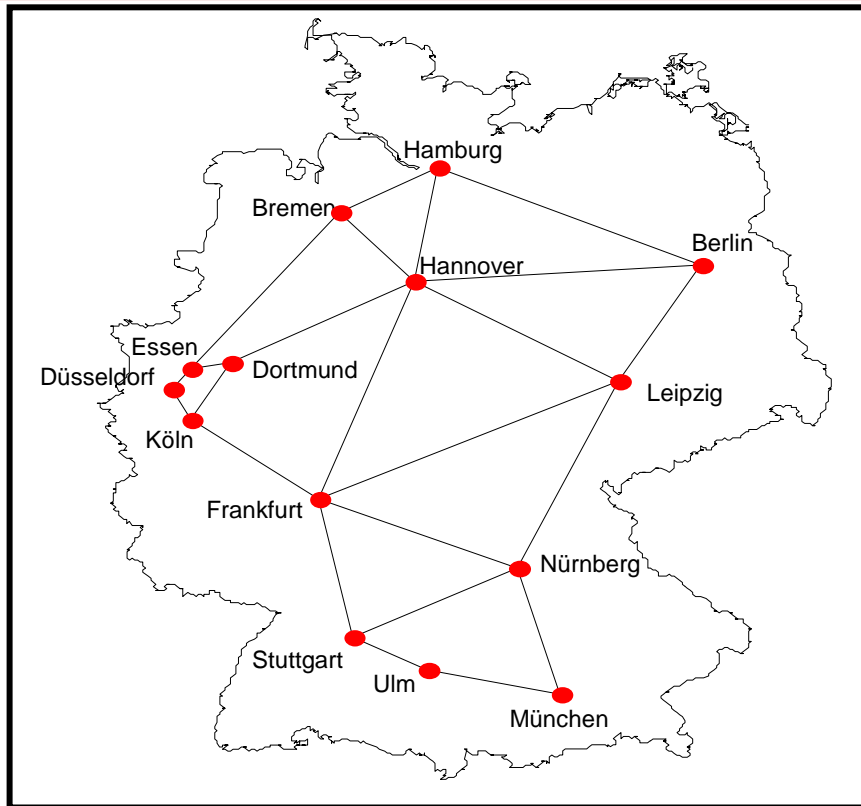
- How to generate diverse path?



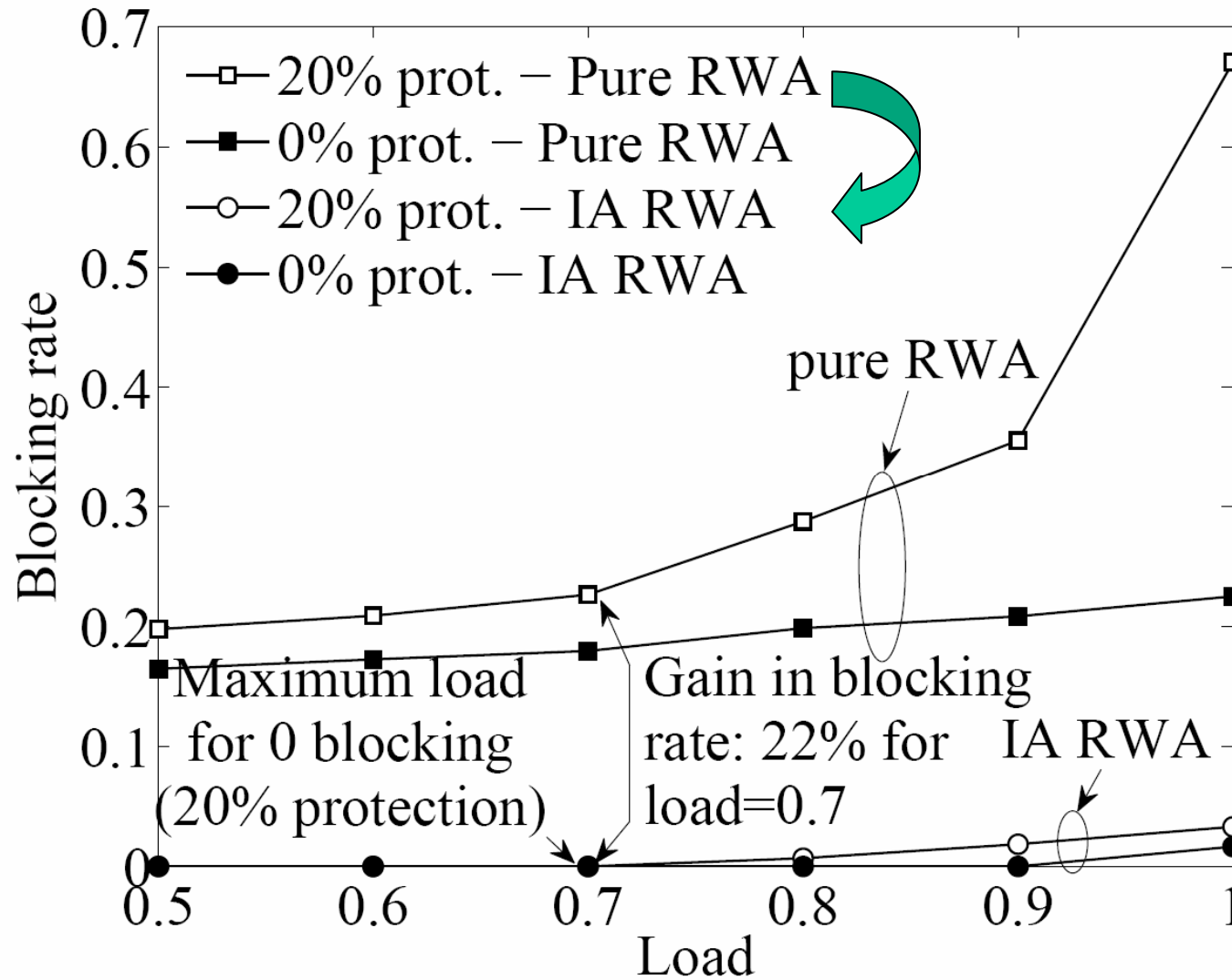
# Diverse Routing Challenge (3/3)

- Diverse Routing Engine (Two routes from “A” to “F”)
- Bhandari Algorithm

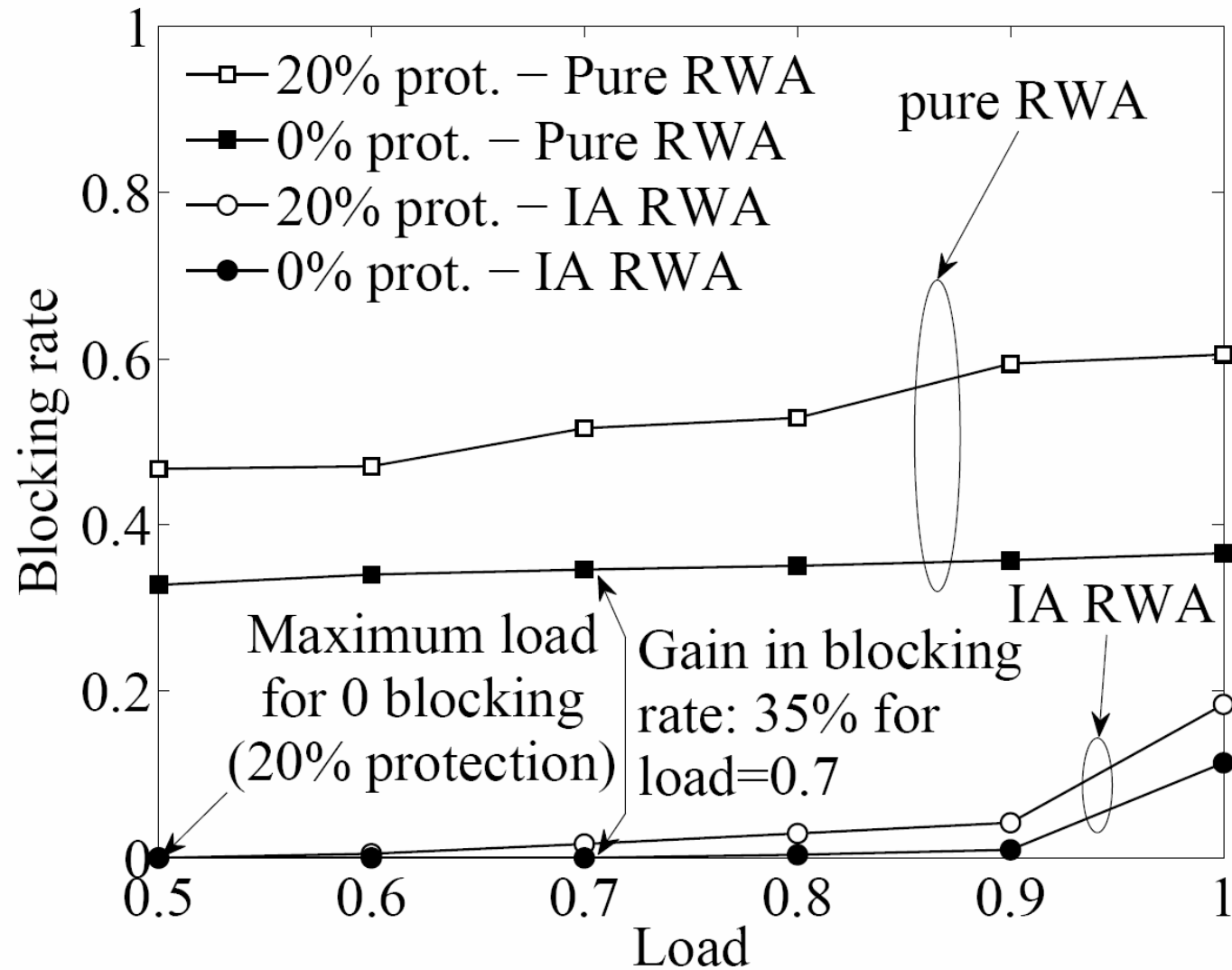


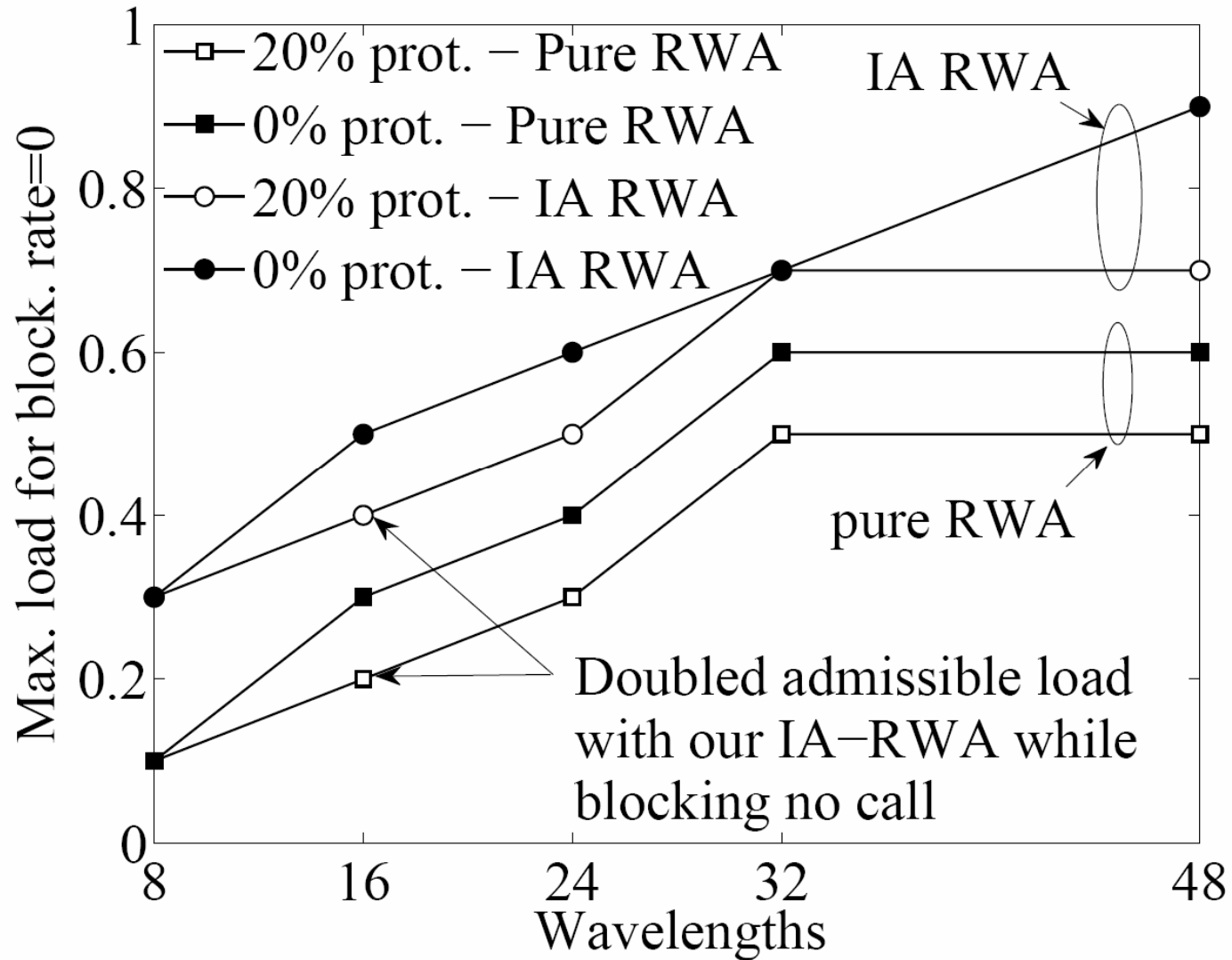


Topology	Scaling factor	Largest shortest path (after scaling)	Nodes	Bidirectional link	Average node degree
DTNet	1.3	1162 km	14	23	3.29
EON	0.4	1658 km	19	74	3.85









- Next Generation Core Optical Networks
  - Many studies around
  - Many problem addressed
  - Not many integrated and comprehensive works
- DICONET → Integrated Network Planning and Operation Tool
  - Presented here: Planning Mode/Offline IA-RWA with dedicated path protection
- Future work/Work in progress:
  - Online IA-RWA multi-constraint algorithms
  - Fault management
  - Control plane design and implementation
  - Integrated Network Planning and operation tool
  - FPGA acceleration
  - Validation with testbed



# Thank you!

- Question & Answers

- Acknowledgements

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