WP4: Algorithmic Solutions and Technical Recommendations for Optical Networks I

CRESCCO IST-2001-33135

Critical Resource Sharing for Cooperation in Complex System

presented by Michel Syska, I3S CNRS University of Nice

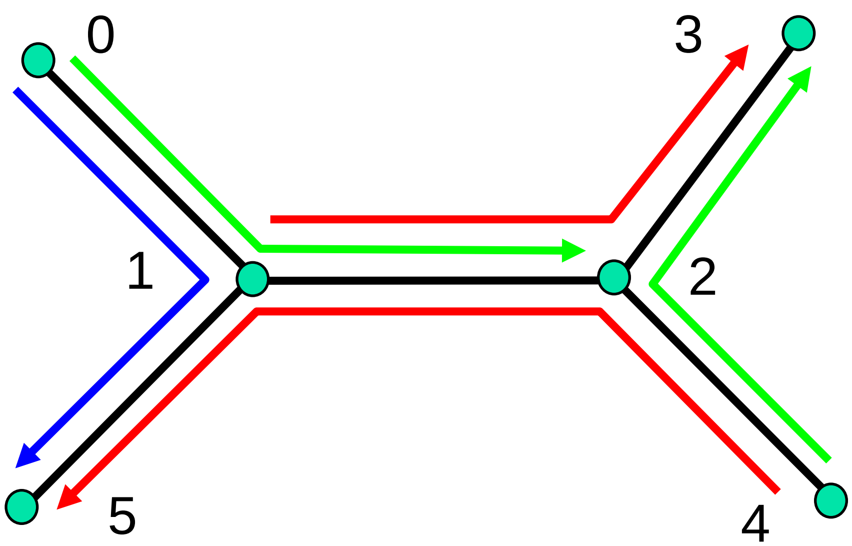
All-Optical Network: Wavelength Assignment Problem

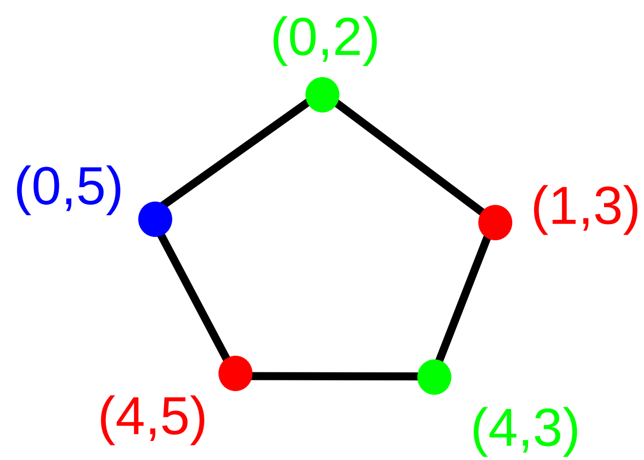
- Communications are routed along color-disjoint *lightpaths*
- Let $\pi(G,I)$ be the minimum load for routing a given set of communication I
- Let $w(G,I)$ be the minimum number of wavelengths for a solution

what is the relation between

$\pi(G,I)$ and $w(G,I)$?

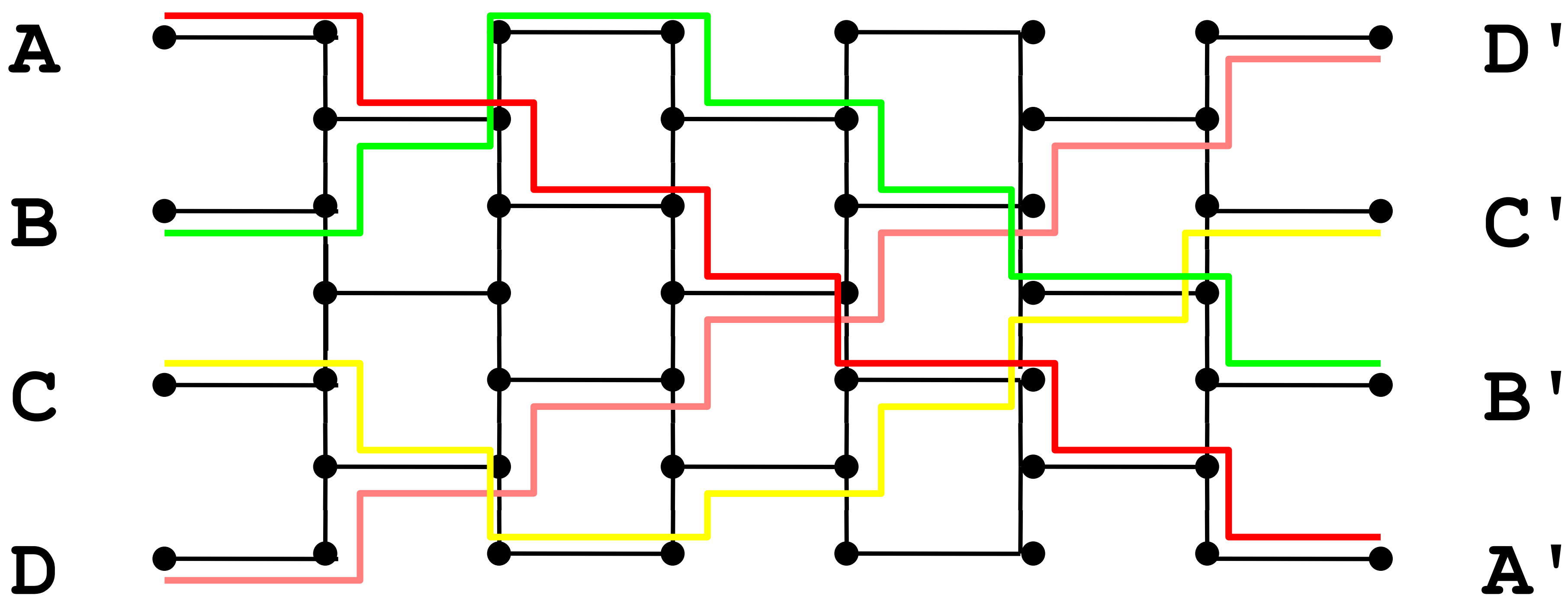
Conflict Graph: coloring problem





Example where $\vec{\mathbf{w}}$ is not equal to $\vec{\pi}$

π =2 and w = |I|



New results for WAP

Design and routing algorithms for multifiber networks

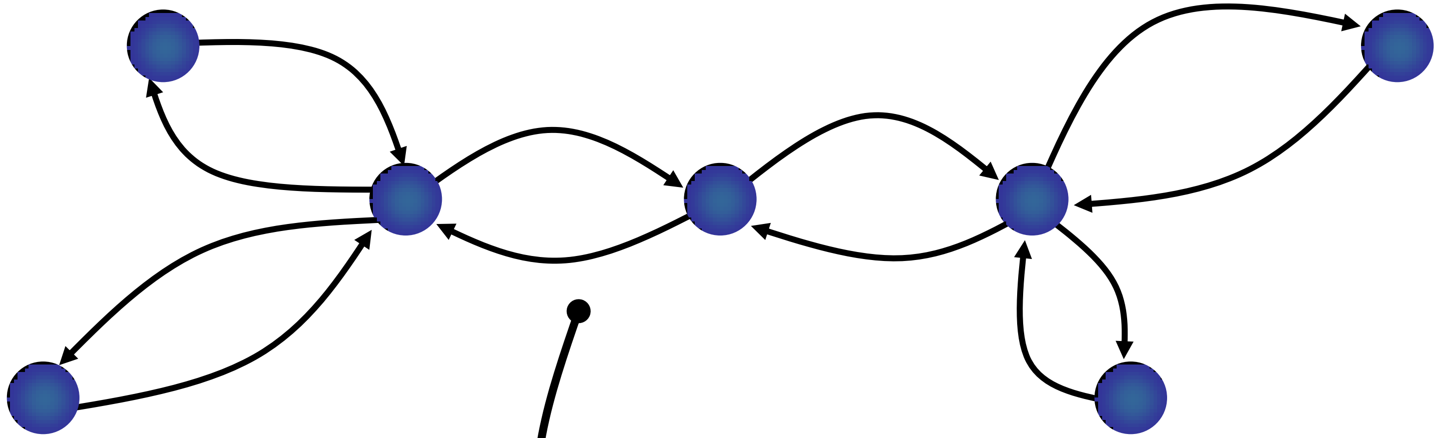
- conflict hypergraphs model
- coloring of hypergraphs (NP-complete)
  - randomized approximation algorithm
  - integer linear programming formulation
- combine routing and wavelength assignment
  - randomized rounding of the fractional multicommodity flow solution

New results for WAP

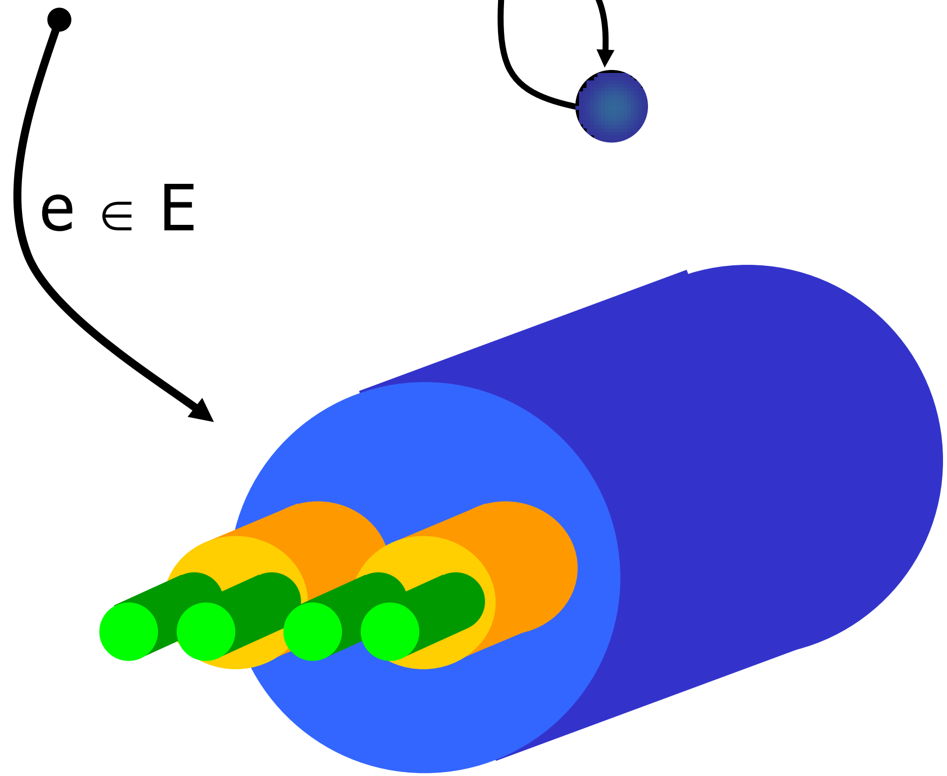
Tree and ring topologies

- class of greedy algorithms using randomization
  - lower bounds and a 7w/5 + o(w) algorithm on binary trees of depth $o(L^{1/3})$ with high probability
- randomized WAP
  - randomized rounding on fractional path coloring
- polynomial time algorithms that compute almost optimal fractional path colorings in bounded degree trees and rings (including multifiber rings)

Traffic Grooming



Network $G=(V,E)$

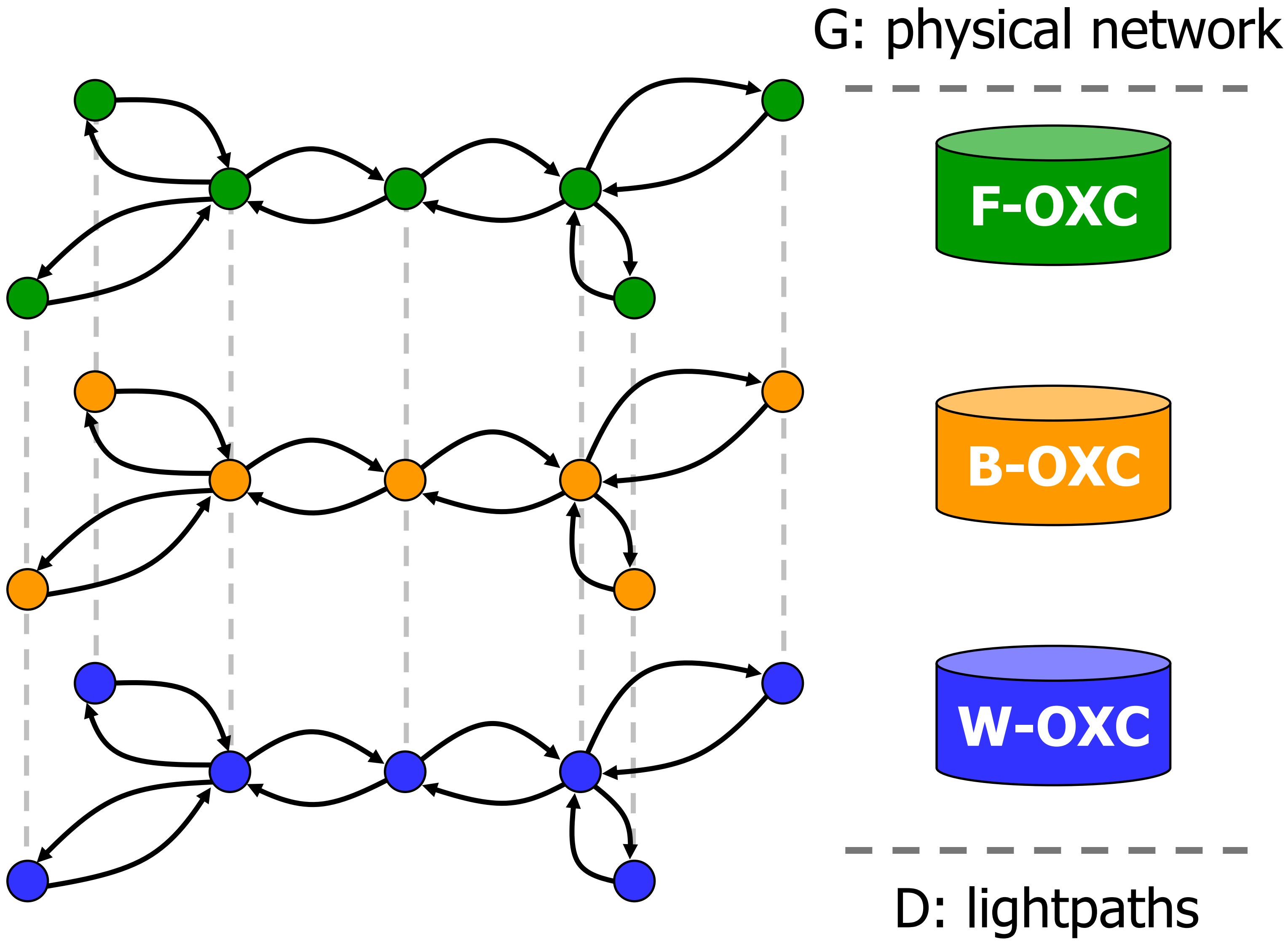


Fibre

Band

Wavelength

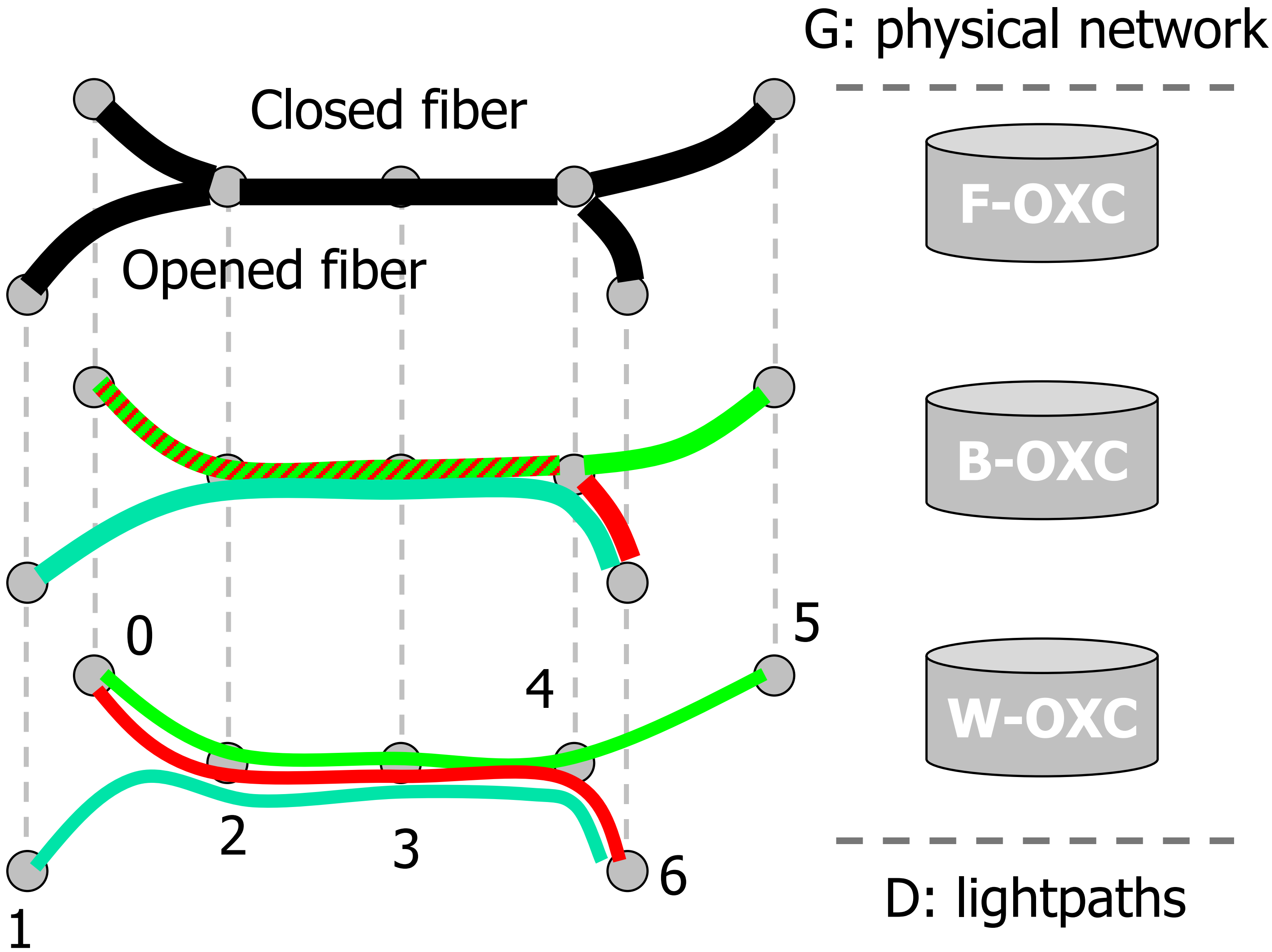
Multi-Layer model



Multi-Layer model

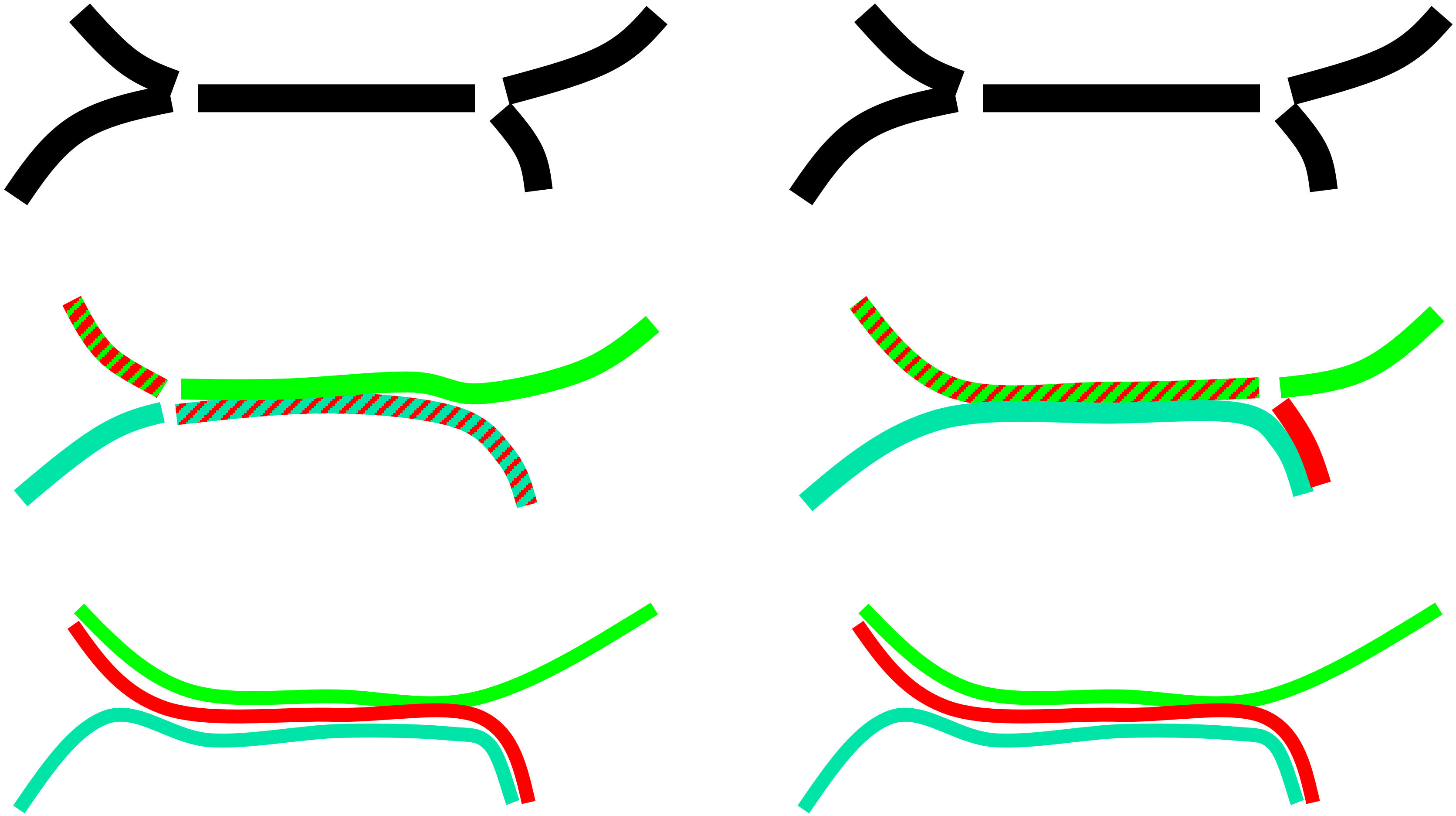
Cost of nodes:
max degree of OXCs

Capacities:
W=1
B=2
F=2



Grooming example

Grooming (b) Grooming (a)



Results

- New model of pipes for multi-layer switches
  - ILP formulation
  - Efficient heuristics with a cost function on pipes
  - Experimental results
- Case for ATA traffic in SDH/SONET rings
  - Some optimal solutions by using results of design theory

    Example: for C=3 the problem consists in covering the ring with triangles

Improved resources allocation algorithms

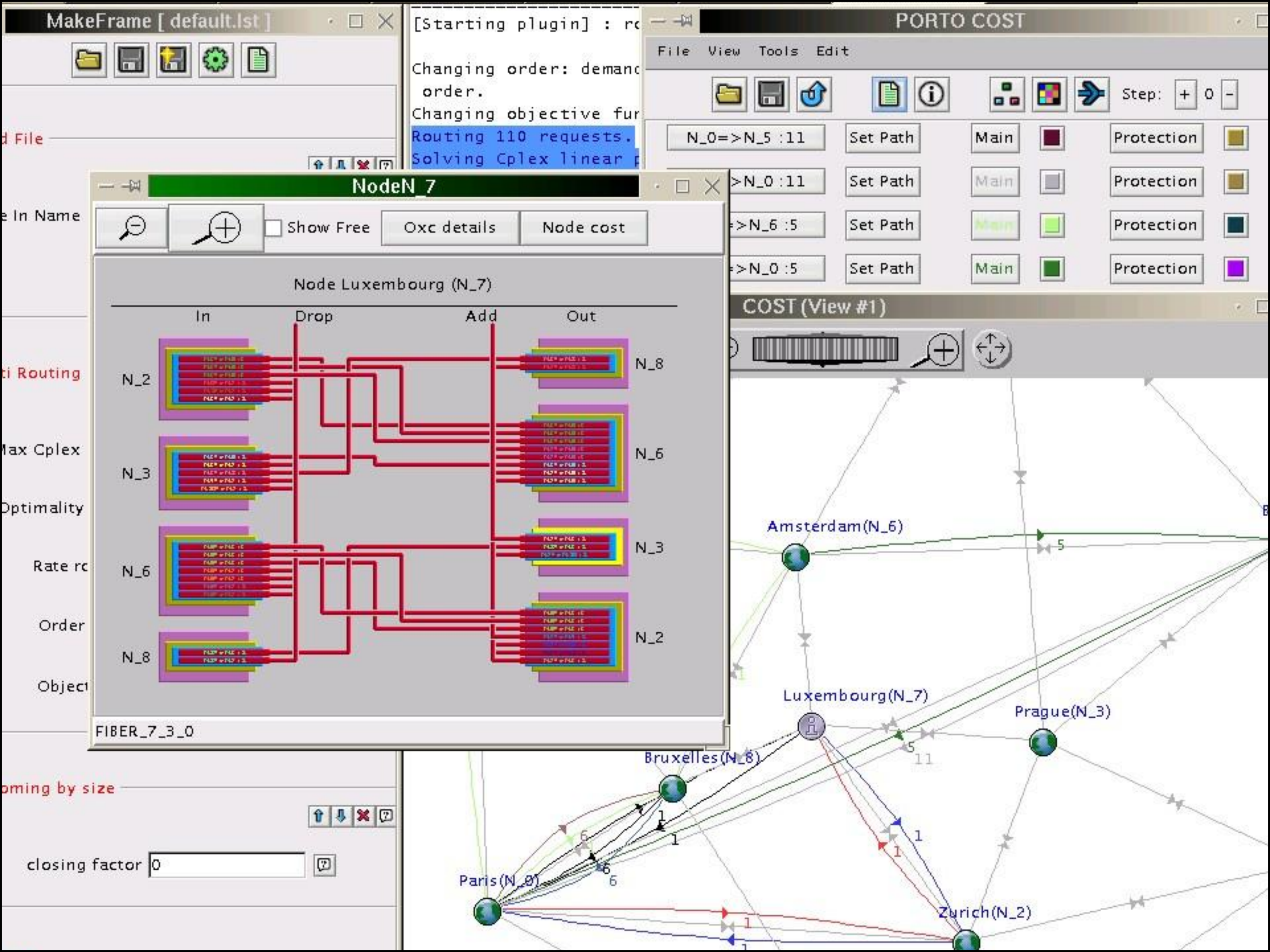
- Packing problem
  - approximation algorithm
  - application to edge congestion problem in multicasting
- Station Placement Problem
  - dynamic programming algorithm (trees) and approximation algorithm : multicast, wavelength converters?
- List coloring problem
  - bounds for bi-partite graph

Conclusion

- Identification of important techniques for allocation problem
  - Graph theory
  - LP-relaxation + randomization
  - Approximation algorithms
- Publications :
  - Theoretical computer science and Networks conferences
- Emergence of a new model: virtual topologies

Future work

- Survivability
  - Protection and restoration
- Dynamic traffic
- Experimentation / validation of algorithms


MakeFrame [default.lst]
[Starting plugin] : ro
Changing order: demand
order.
Changing objective fur
Routing 110 requests.
Solving Cplex linear p
PORTO COST
File View Tools Edit
Step: + 0 -
N_0=>N_5 :11
Set Path
Main
Protection
>N_0 :11
>N_6 :5
>N_0 :5
d File
e In Name
ti Routing
Max Cplex
Optimality
Rate rc
Order
Object
oming by size
closing factor
NodeN_7
Show Free
Oxc details
Node cost
Node Luxembourg (N_7)
In
Drop
Add
Out
N_2
N_3
N_6
N_8
FIBER_7_3_0
COST (View #1)
Amsterdam(N_6)
Luxembourg(N_7)
Prague(N_3)
Bruxelles(N_8)
Paris(N_0)
Zurich(N_2)