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# An Efficient and Practical Layer-preference Policy for Routing in GMPLS Networks

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# Multi-layer networks

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- Multilayer network
  - Multiple network technologies
  - GMPLS

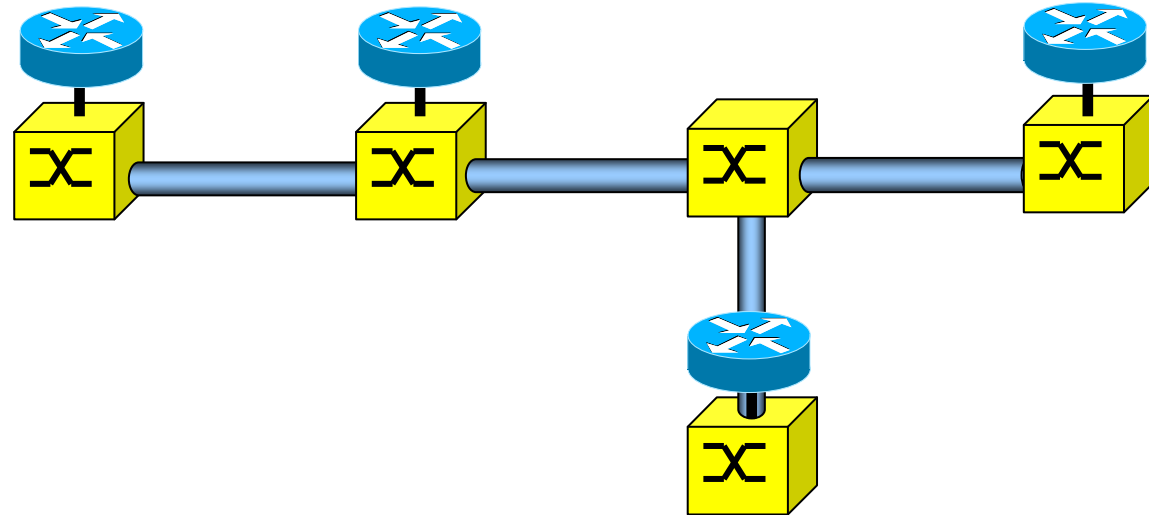
Packet switching
Time division multiplexing
$\lambda$ switching
Fiber switching





# Multi-layer networks

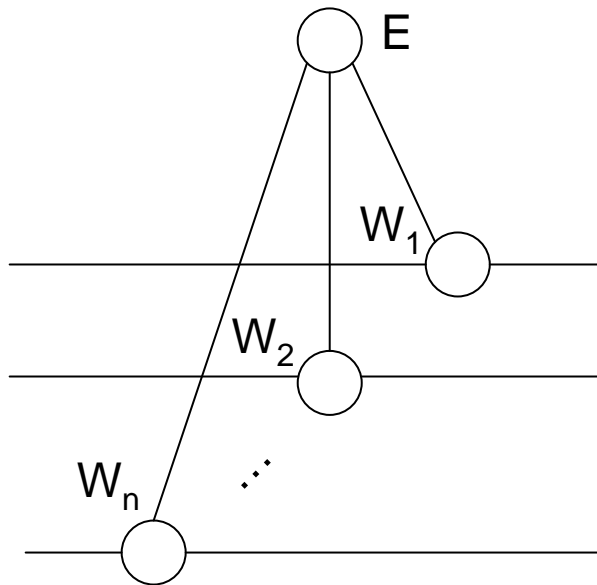
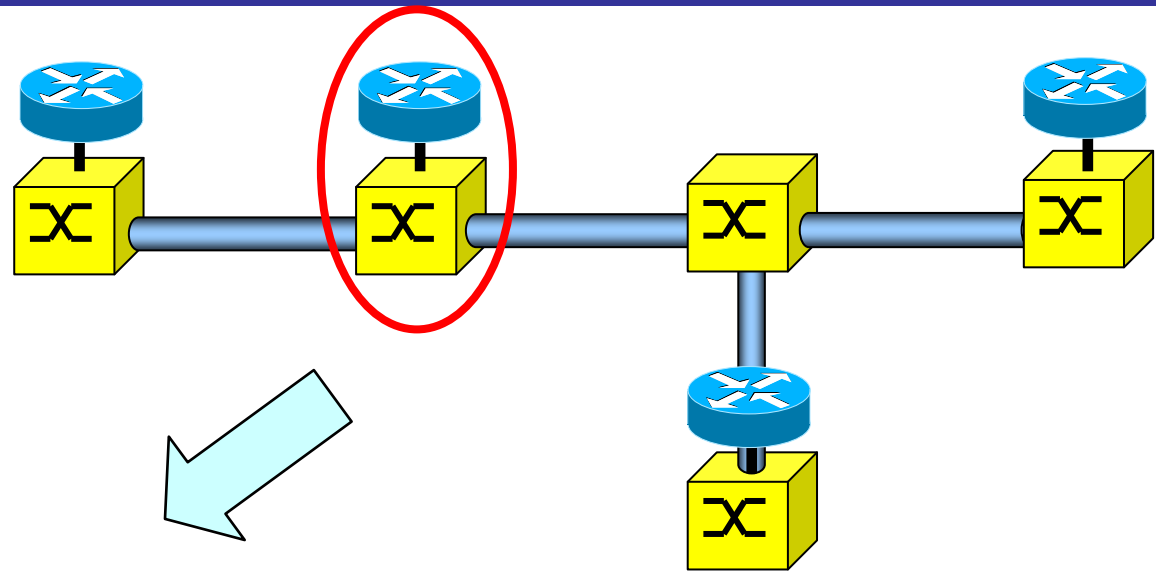
Physical Network





# Multi-layer networks

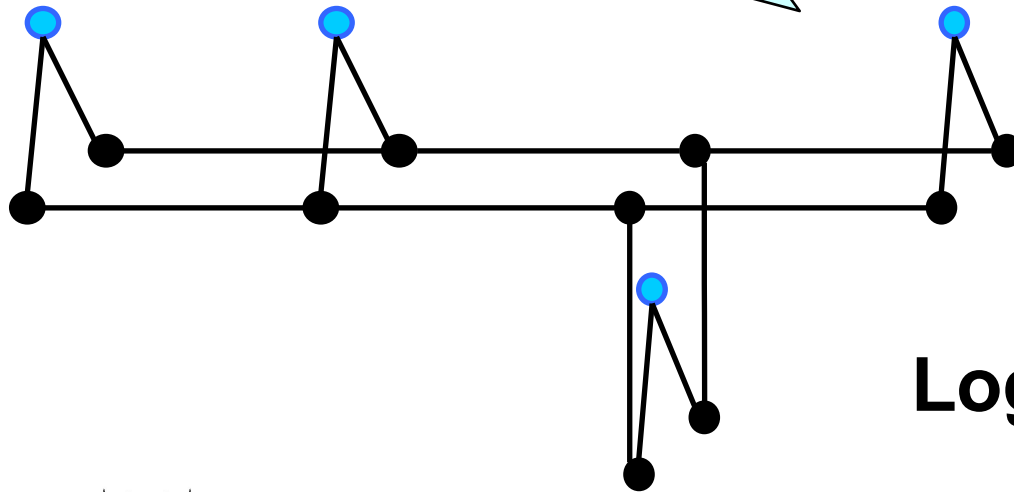
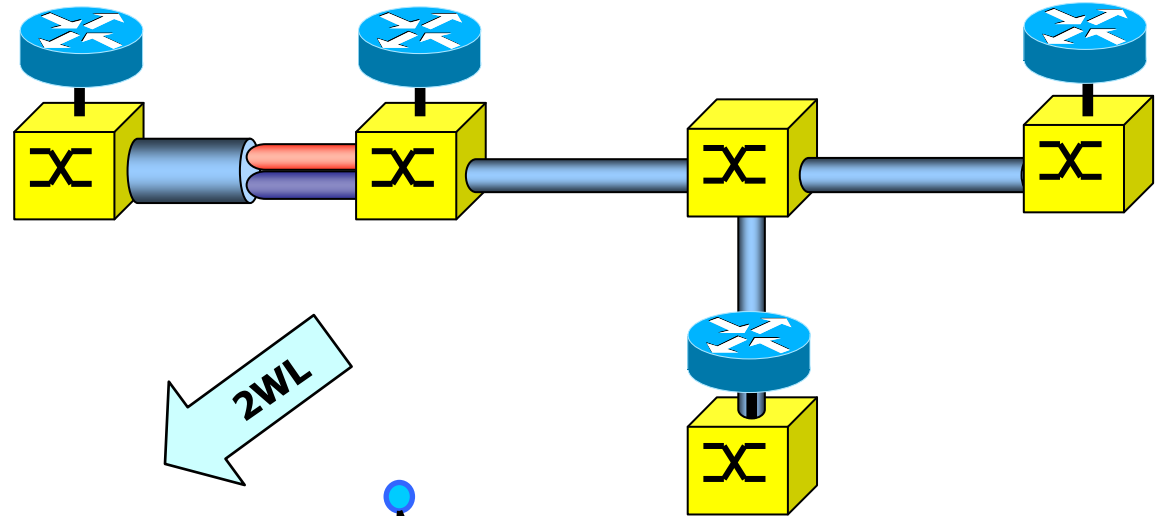
Physical Network





# Multi-layer networks

Physical Network



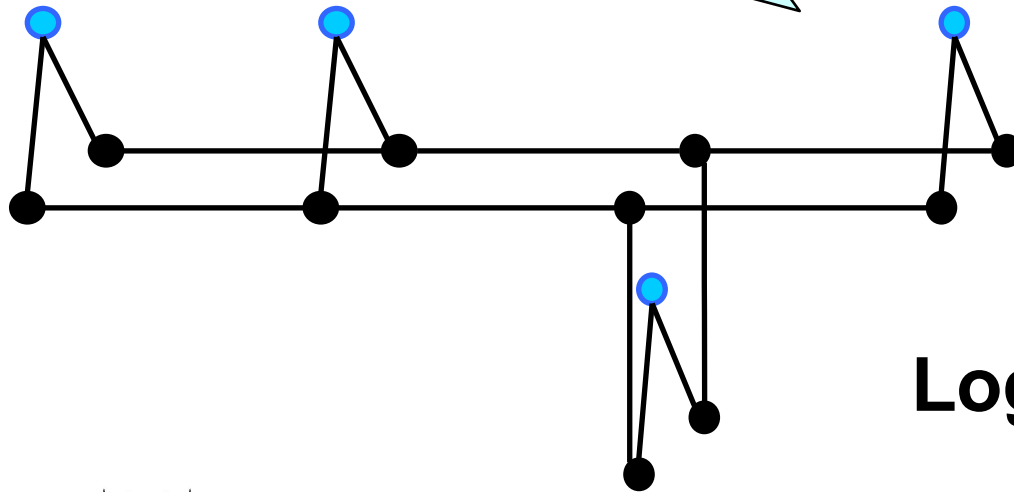
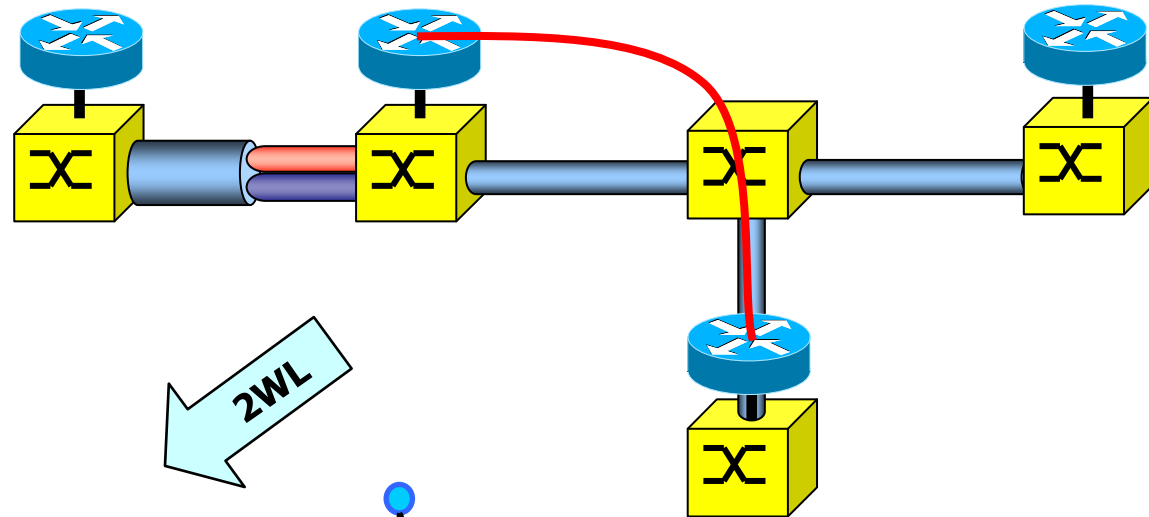
Logical Network





# Multi-layer networks

Physical Network

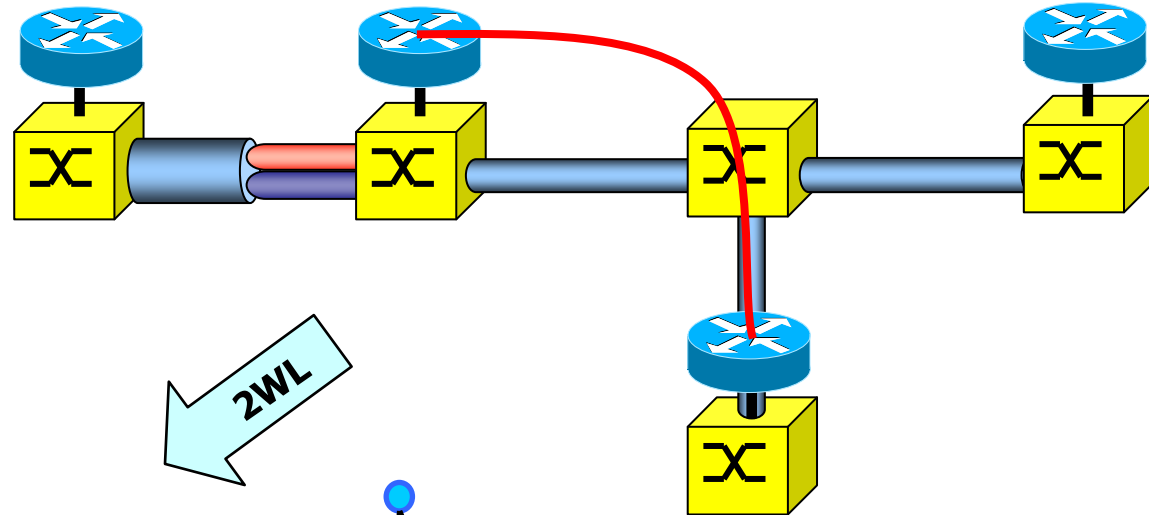


Logical Network

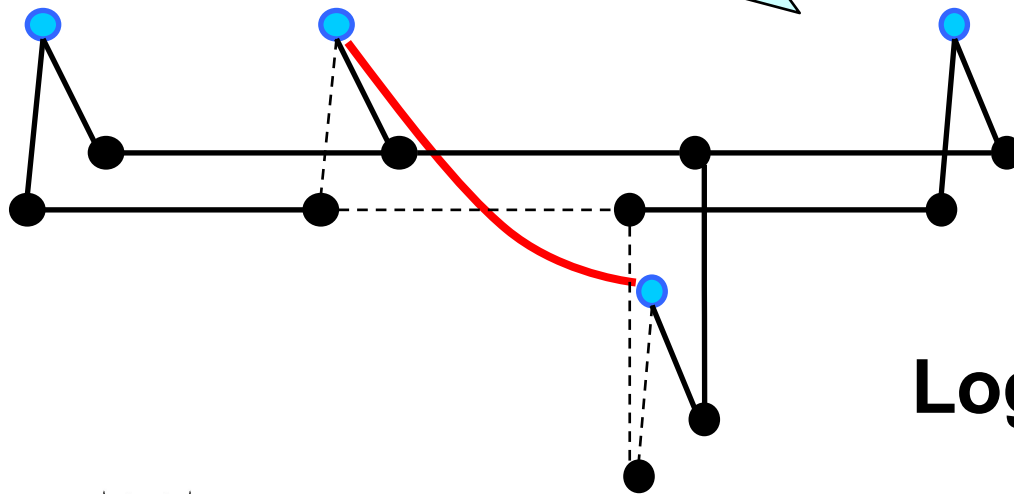


# Multi-layer networks

Physical Network



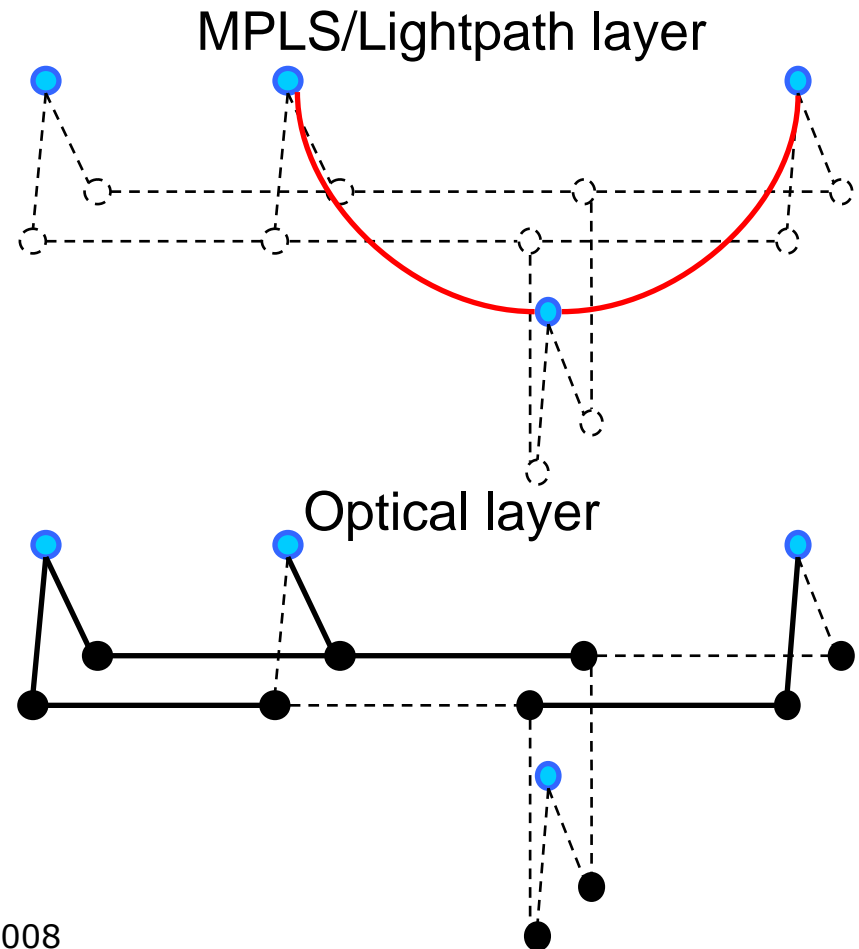
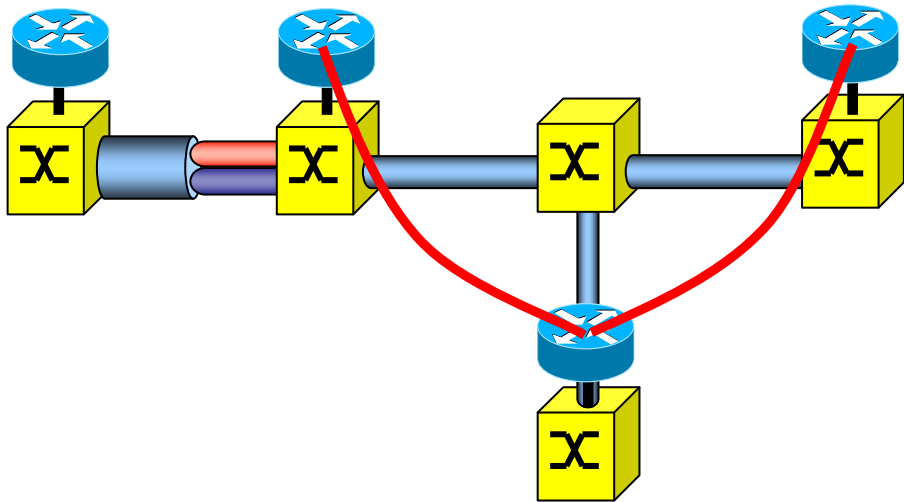
2WL



Logical Network

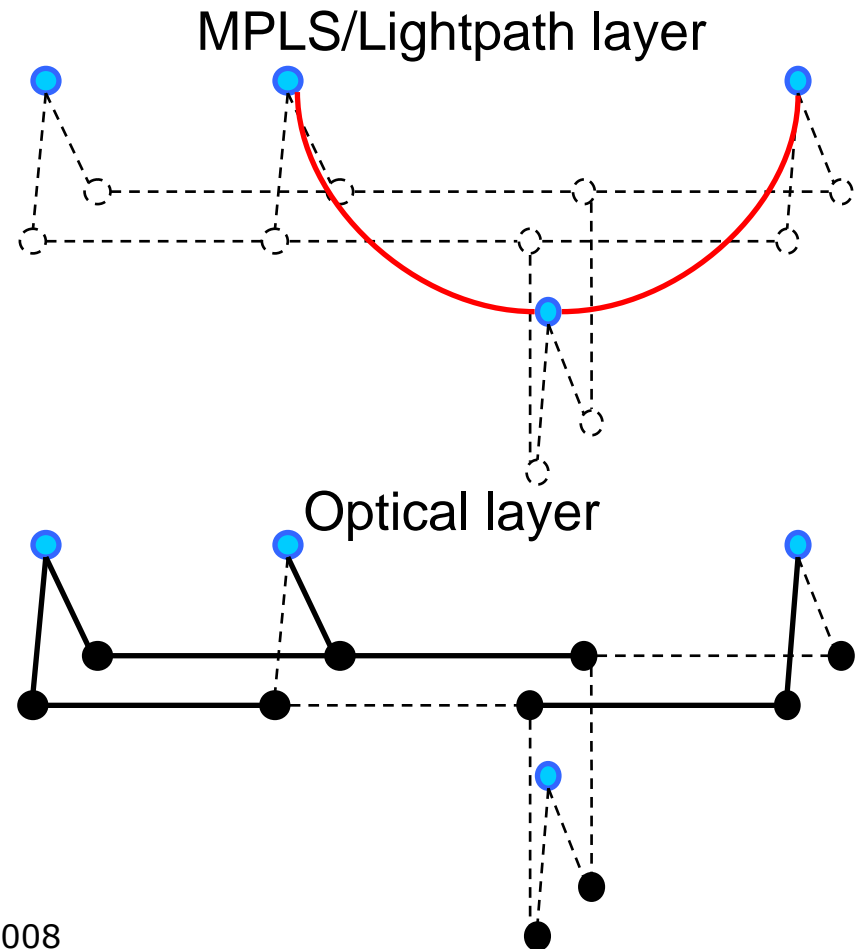
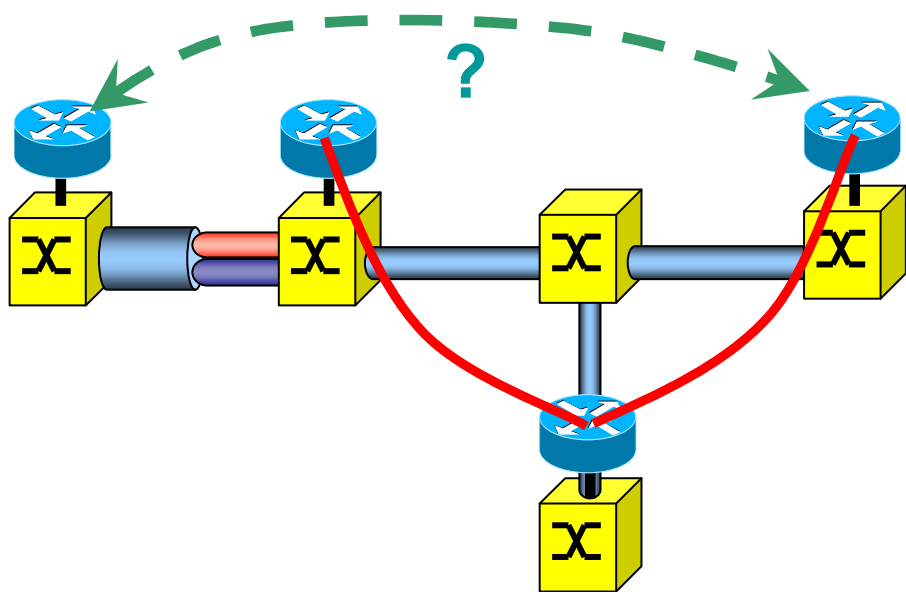
# Overlay model

- Layers differentiated
- Find route in a single layer



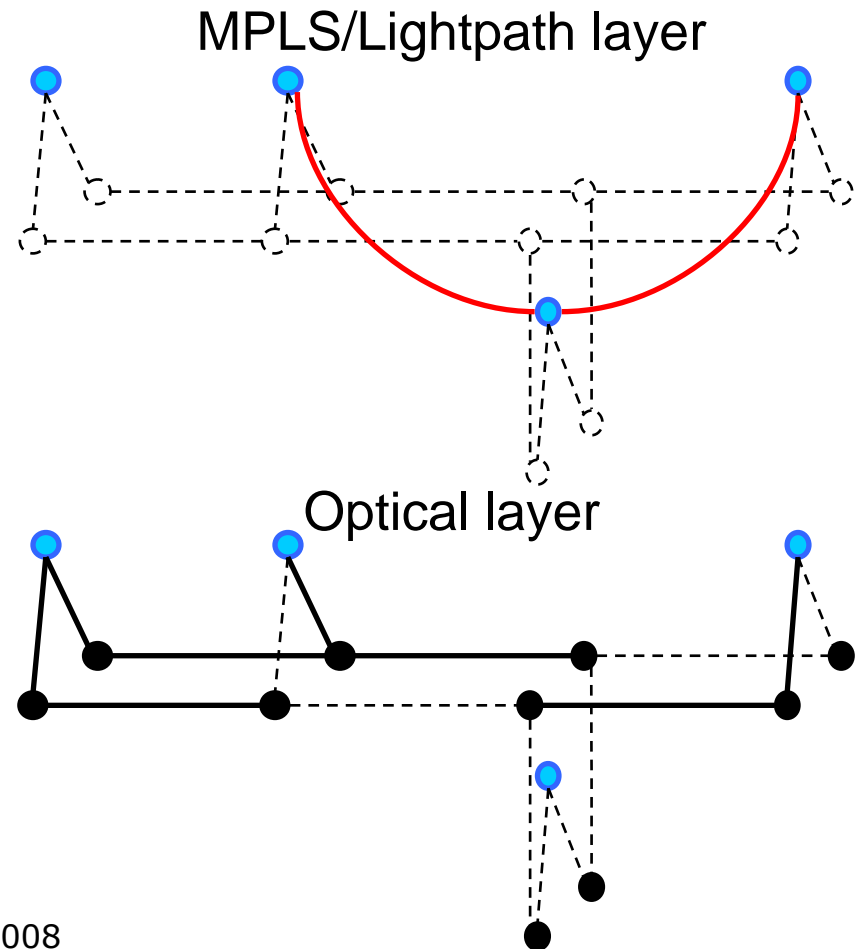
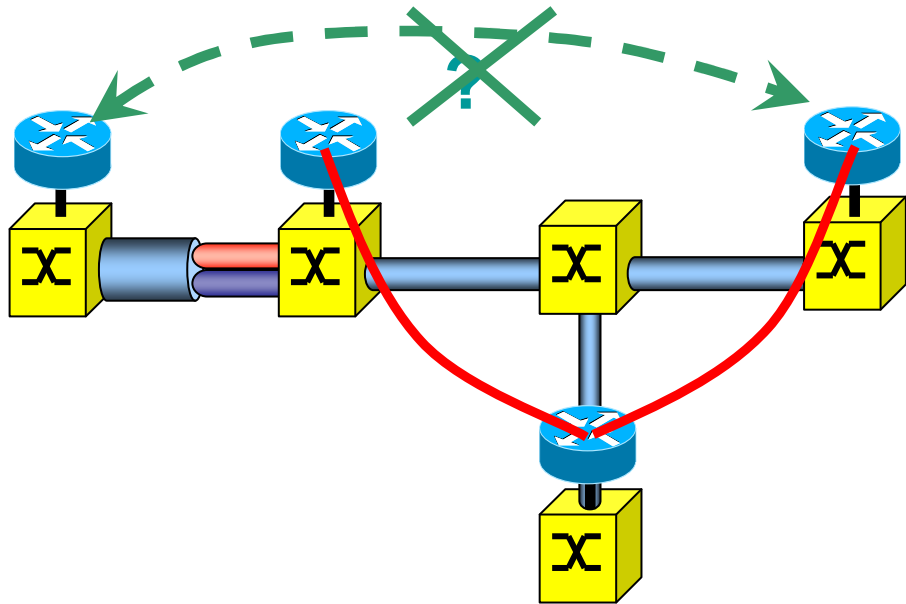
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# Overlay model

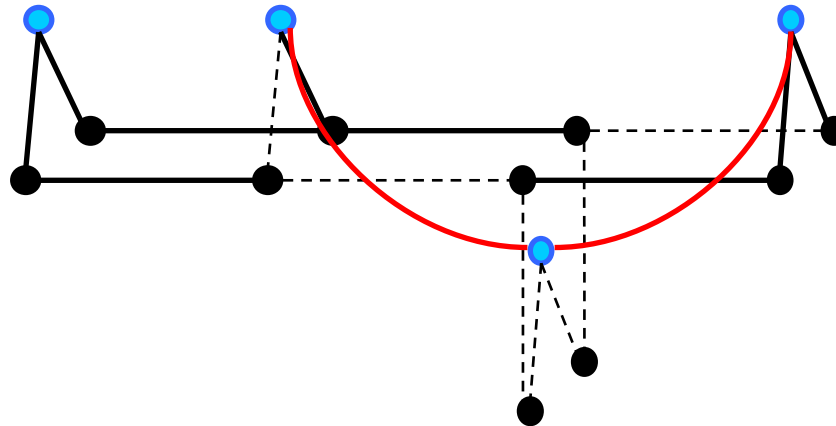
- Layers differentiated
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# Peer Model

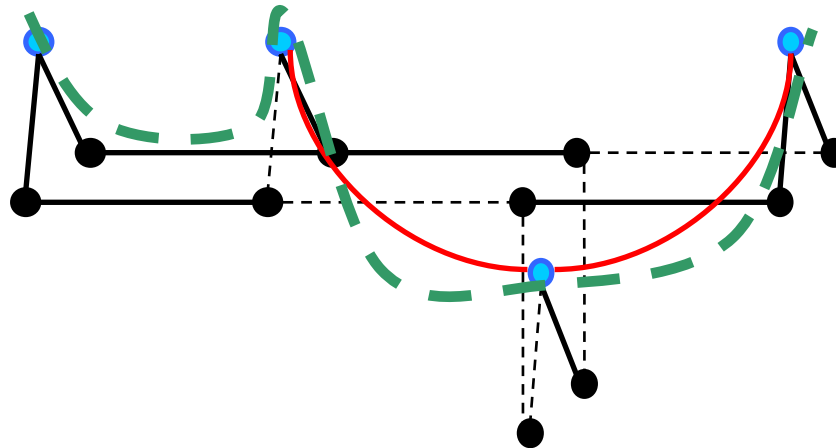
- Both layers considered together → GMPLS
- Finding route on this combined graph model
- We investigate this model





# Peer Model

- Both layers considered together → GMPLS
- Finding route on this combined graph model
- We investigate this model





# Fundamental Question

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## Routing:

1. Routing on a direct lightpath, if exist



2. Routing in the optical layer?
3. Routing in the MPLS/lightpath layer?

2. Routing in the MPLS/lightpath layer?
3. Routing in the optical layer?

**In which layer to route new connection requests?**





# Routing in the Optical Layer

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- Always set up new lightpath (direct lightpath or combination of new and existing lightpaths)
- Advantages:
  - Paths reserve minimal resources
- Disadvantages:
  - Frequent reconfiguration of the optical devices
  - Wavelength fragmentation: free wavelengths decrease



# Routing in the MPLS/Lightpath Layer

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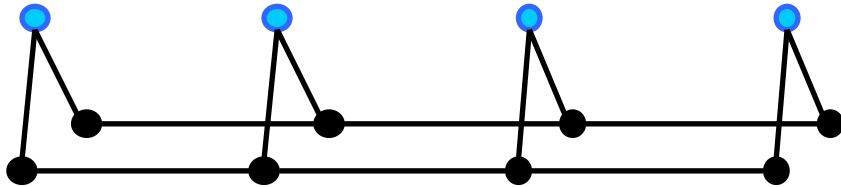
- Uses only existing lightpaths as long as possible
- Advantages
  - Rare reconfiguration of optical devices
  - Less wavelength fragmentation
- Disadvantages
  - Loop can often occur in the physical network
  - Long paths in the physical network
- Loop free path on physical network is NP-Complete





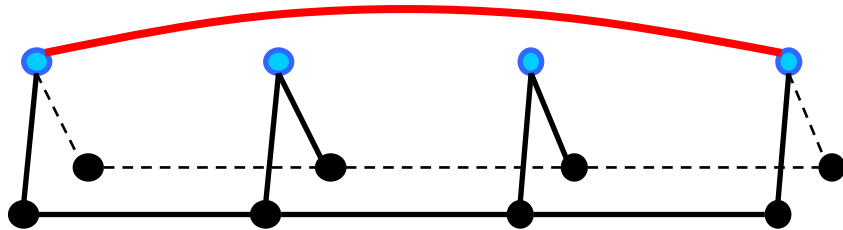
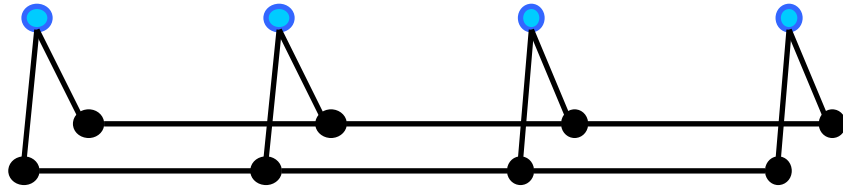
# Loop

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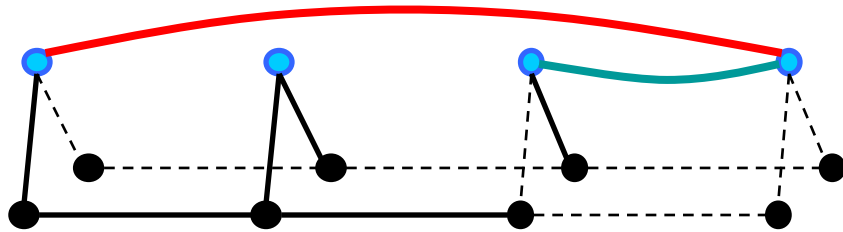
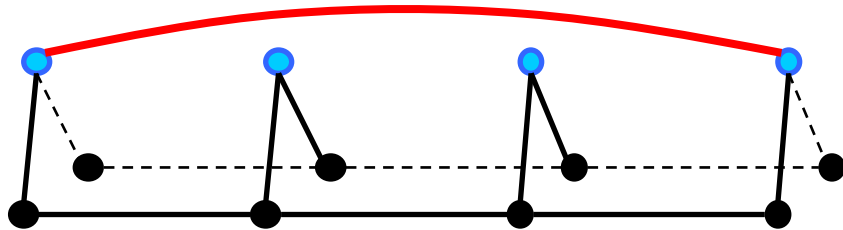
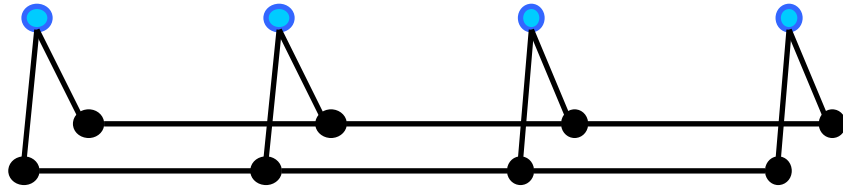


# Loop



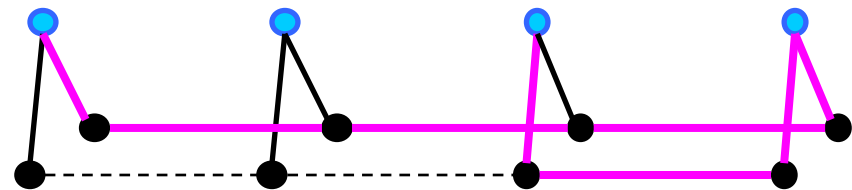
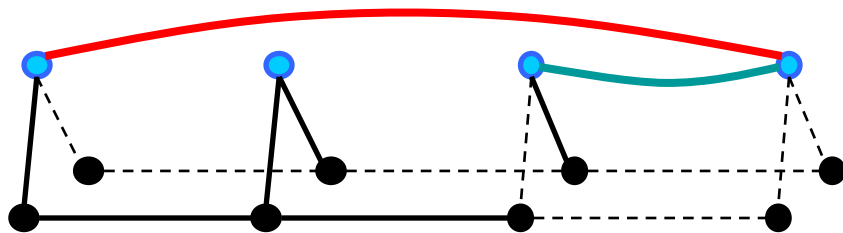
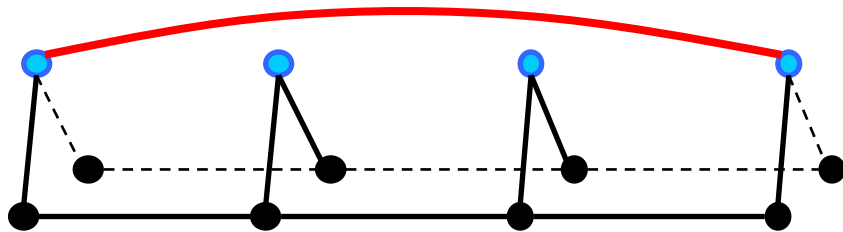
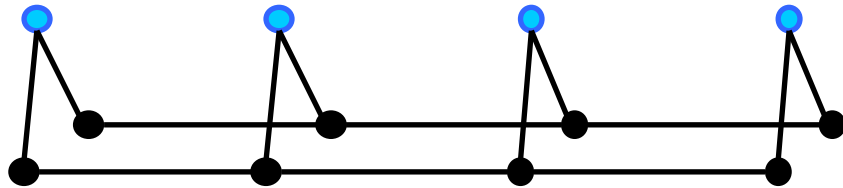


# Loop

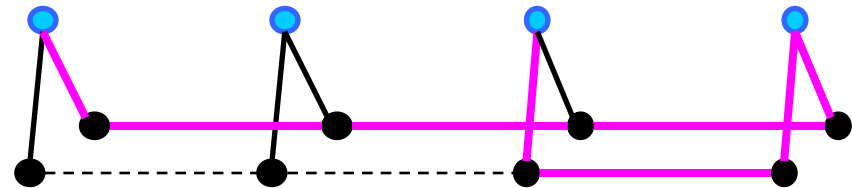
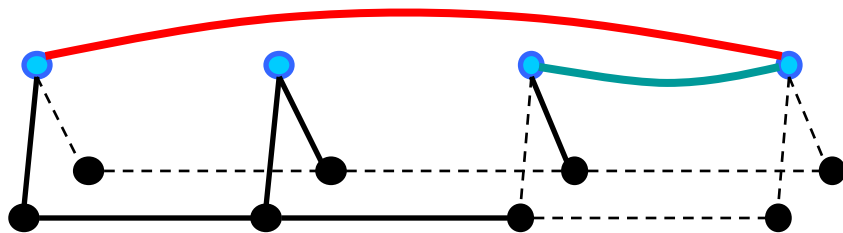
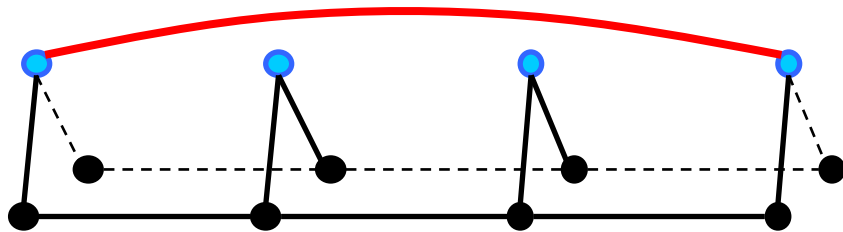
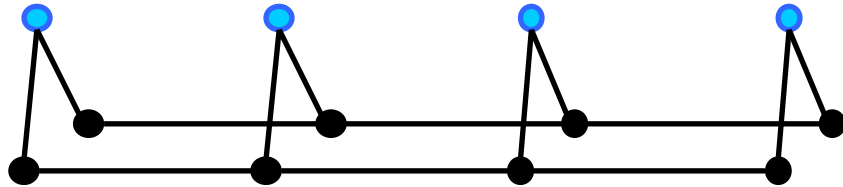




# Loop



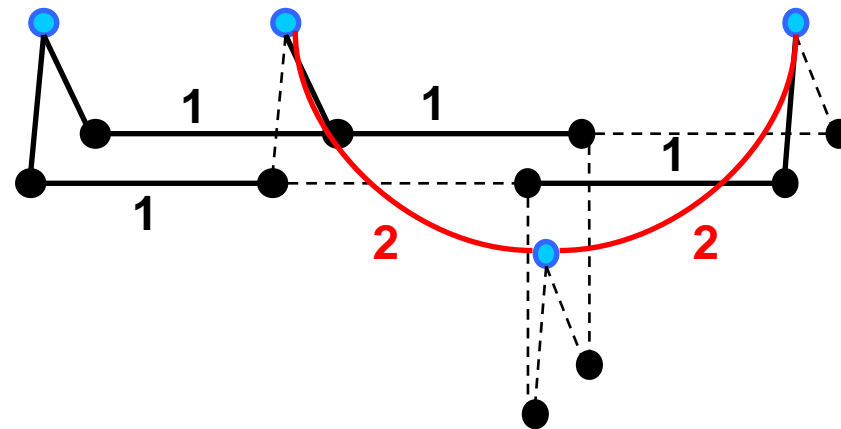
# Loop





# Min-phys-hop routing

- Avoid creating very long paths
- Avoid creating loops as long as possible
- The length of MPLS/lightpath layer path is the length of the optical layer



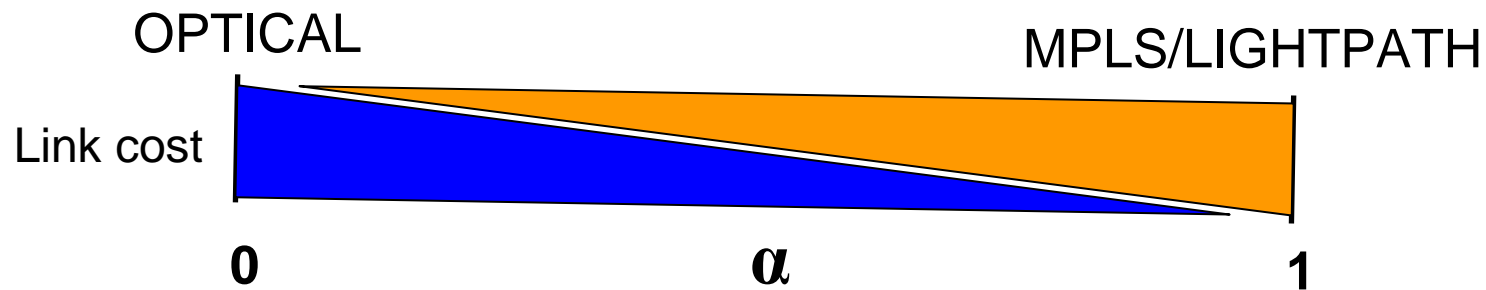


# Weight setting policy between the layers

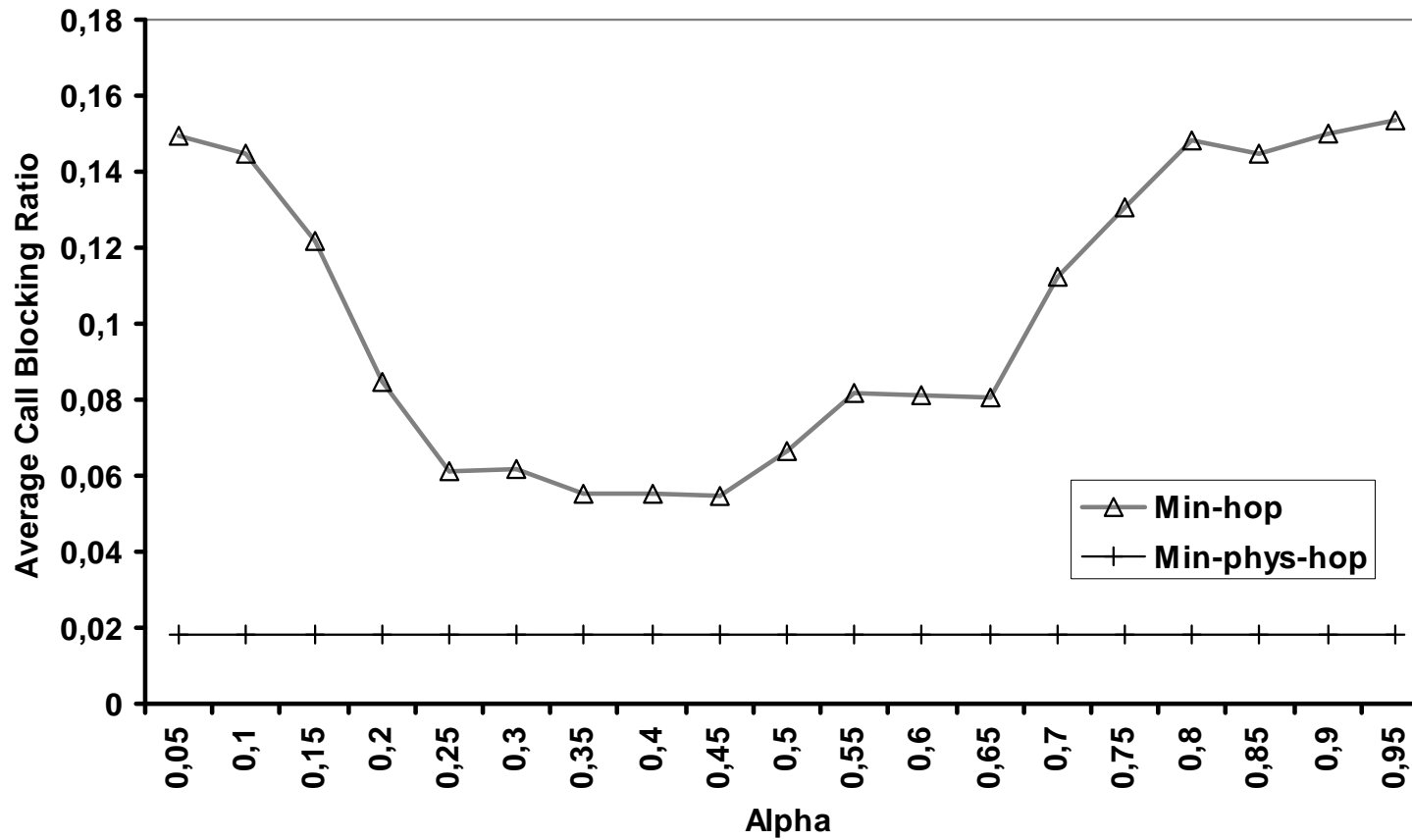
- Calculating link weights on the peer graph
- Multiplying the link lengths of the MPLS/lightpath layer by

$$\frac{1}{1-\alpha}$$

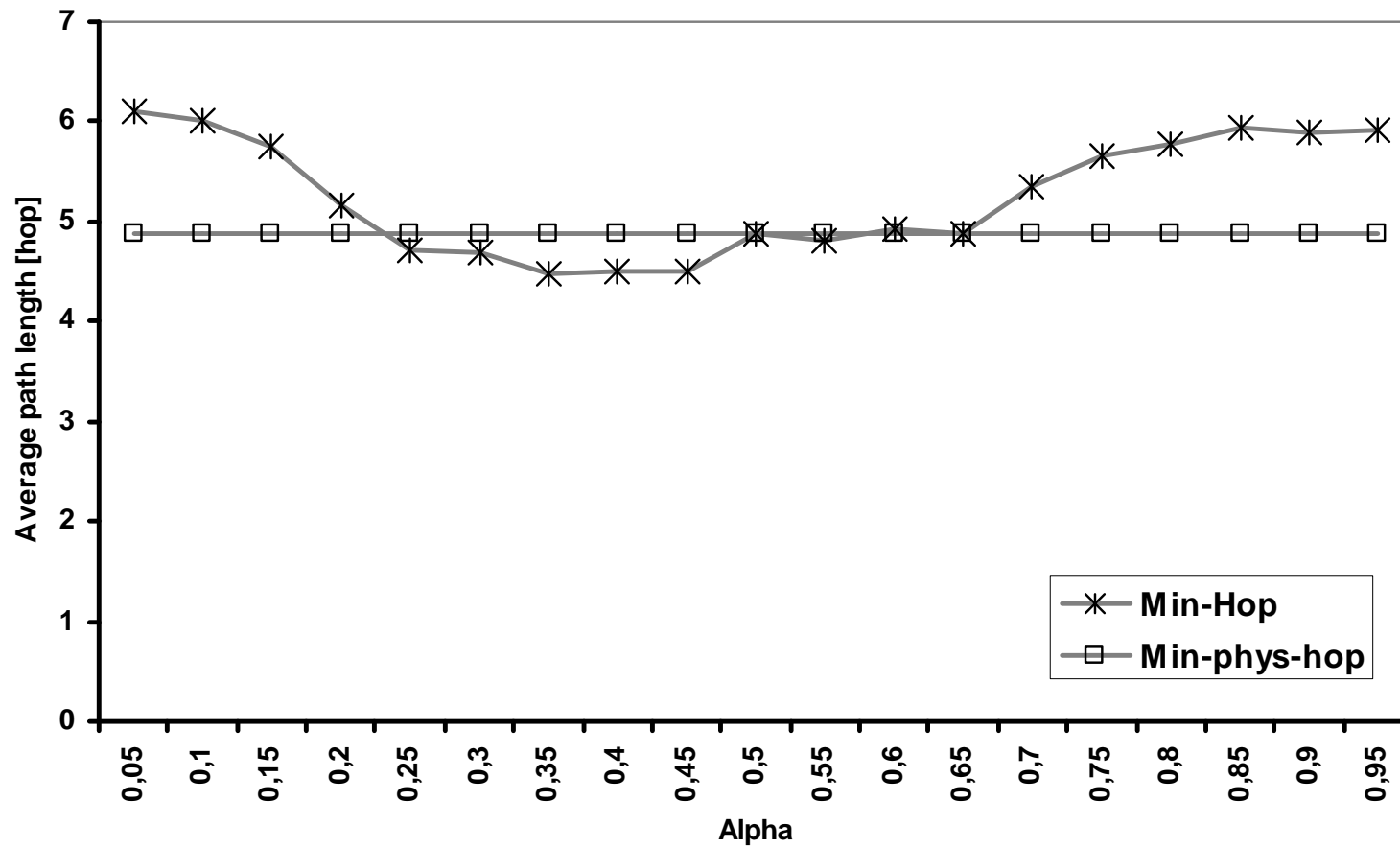
- Multiplying the link lengths of the optical layer by  $\frac{1}{\alpha}$
- Where  $\alpha$  is (0..1)



# Simulation results



# Simulation results





# Conclusion

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- We have dealt with routing using GMPLS peer model
- MPLS/lightpath layer preferred
  - Too long paths
  - Large number of loops
- Optical layer preferred
  - Short paths, until all wavelengths used up, then the length of the paths increases
  - Wavelength fragmentation
- Min-phys-length
  - Trade-off between these policies
  - Avoids routing loops, short paths, fewer blocked calls





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*Thanks for the attention.*



Networks 2008