

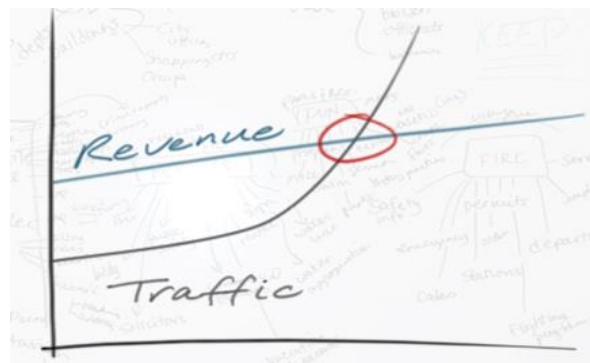
Converged IP and Optical layers

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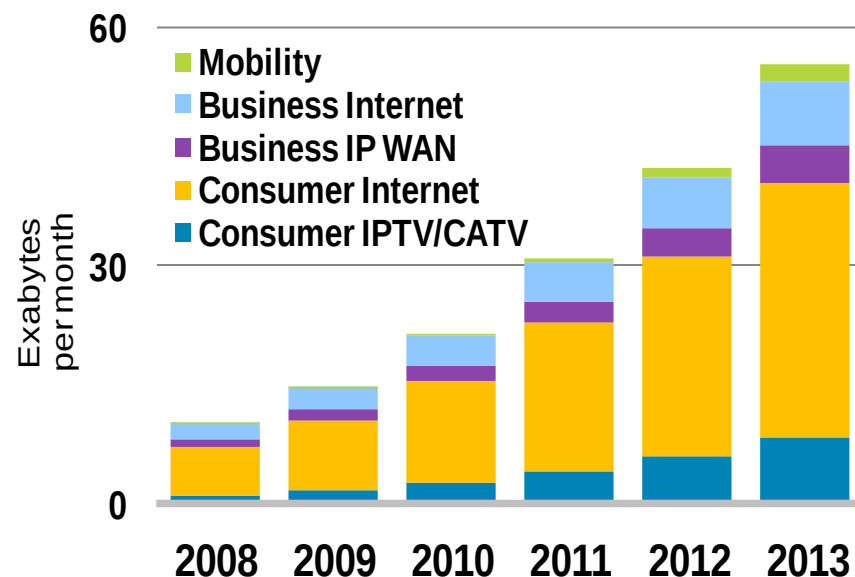
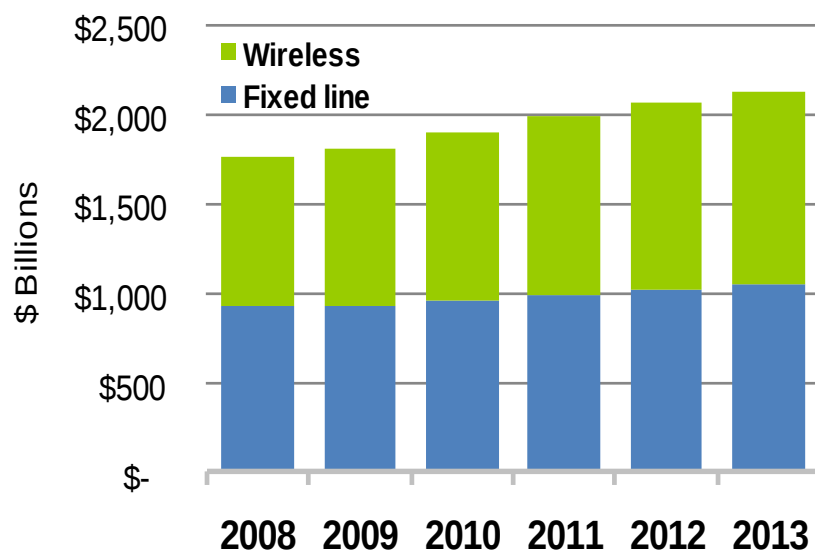
- Challenges
 - The shrinking gap between network cost and revenues
 - Are we approaching the limit of fiber capacity?
 - Lack of Moore's law for optics
 - The reducing accuracy of traffic forecasts
- Solution components
 - Elastic optical networking
 - DWDM aware IP layer
 - Cross layer collaboration
 - Centralized intelligence
- Implications → IP-DWDM convergence

Challenge 1: Network Operator ROI

Telecom Revenue growth is limited (GDP based)

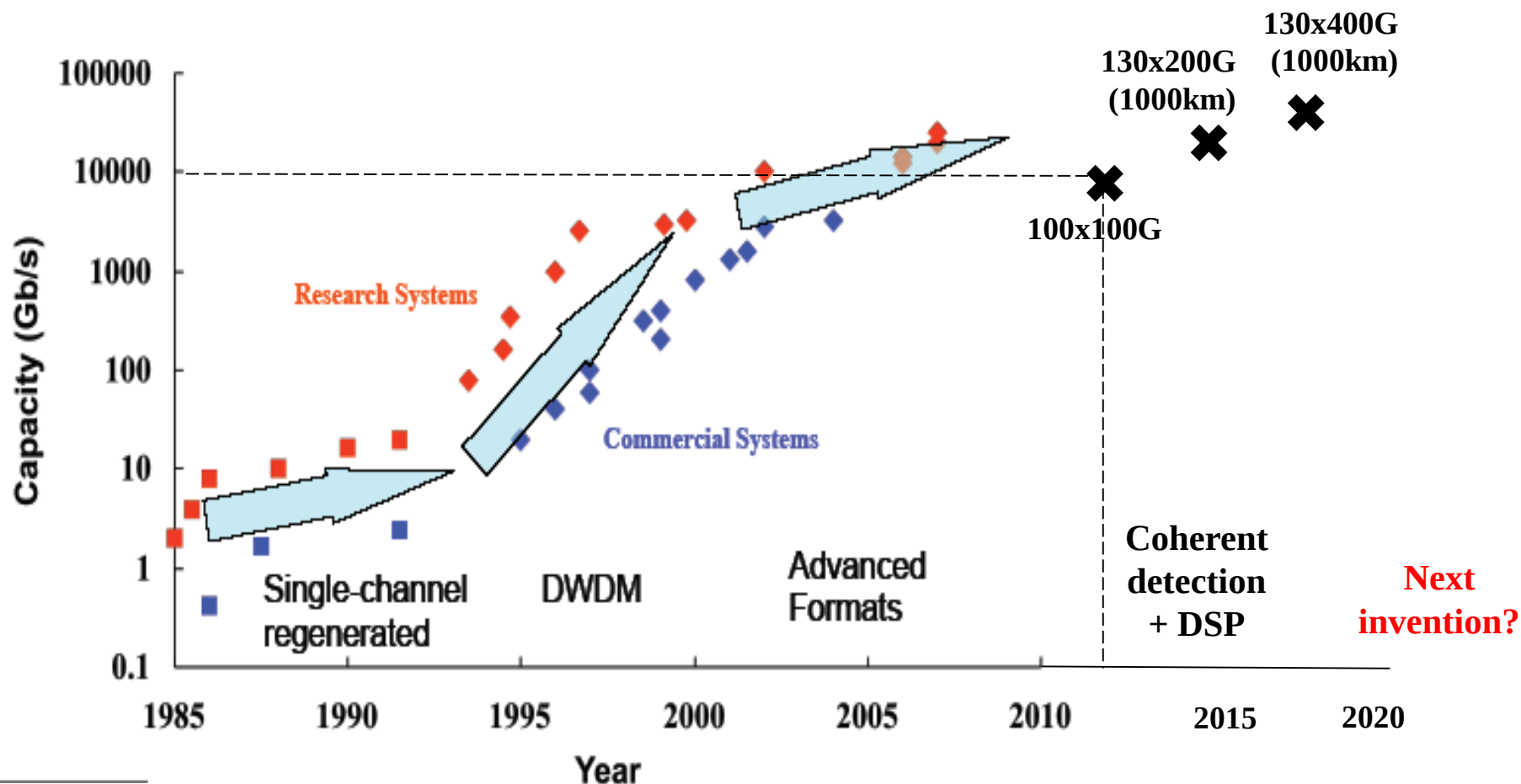


Internet traffic growth is high (30-100% CAGR)



Source: Independent Analyst Research and Cisco Analysis; Cisco Visual Networking Index

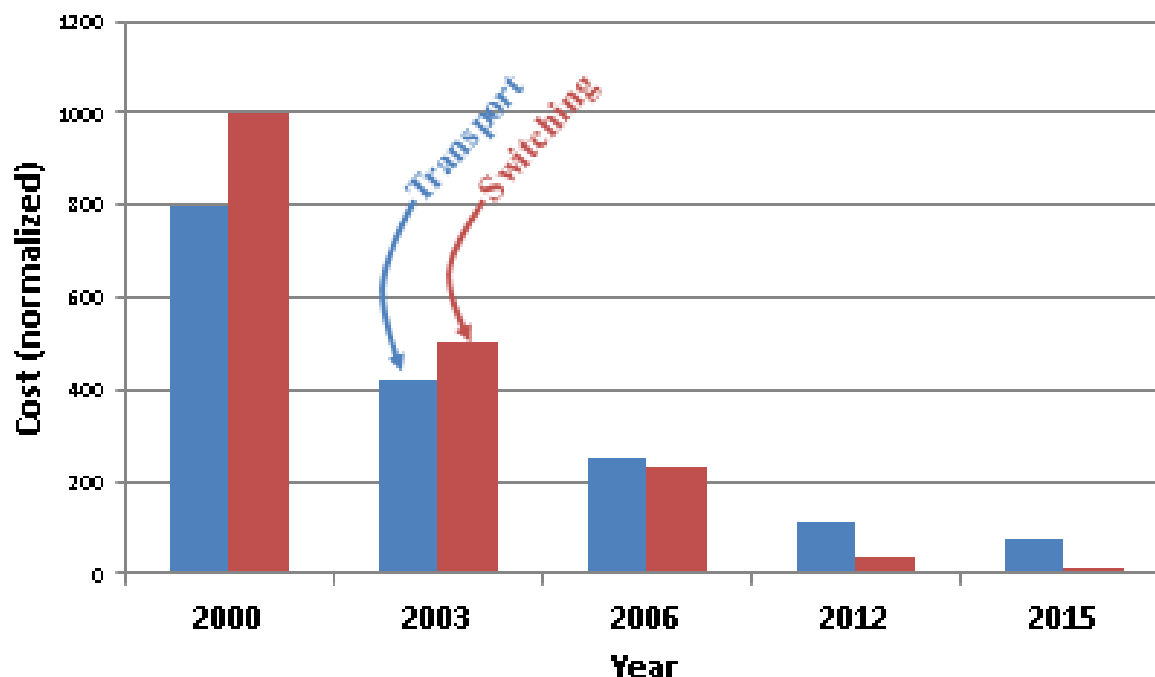
Challenge 2: how to achieve 10x capacity in 10 years?



Challenge 3: optics does not follow Moore's law

What are cost trends over the past 15 years?

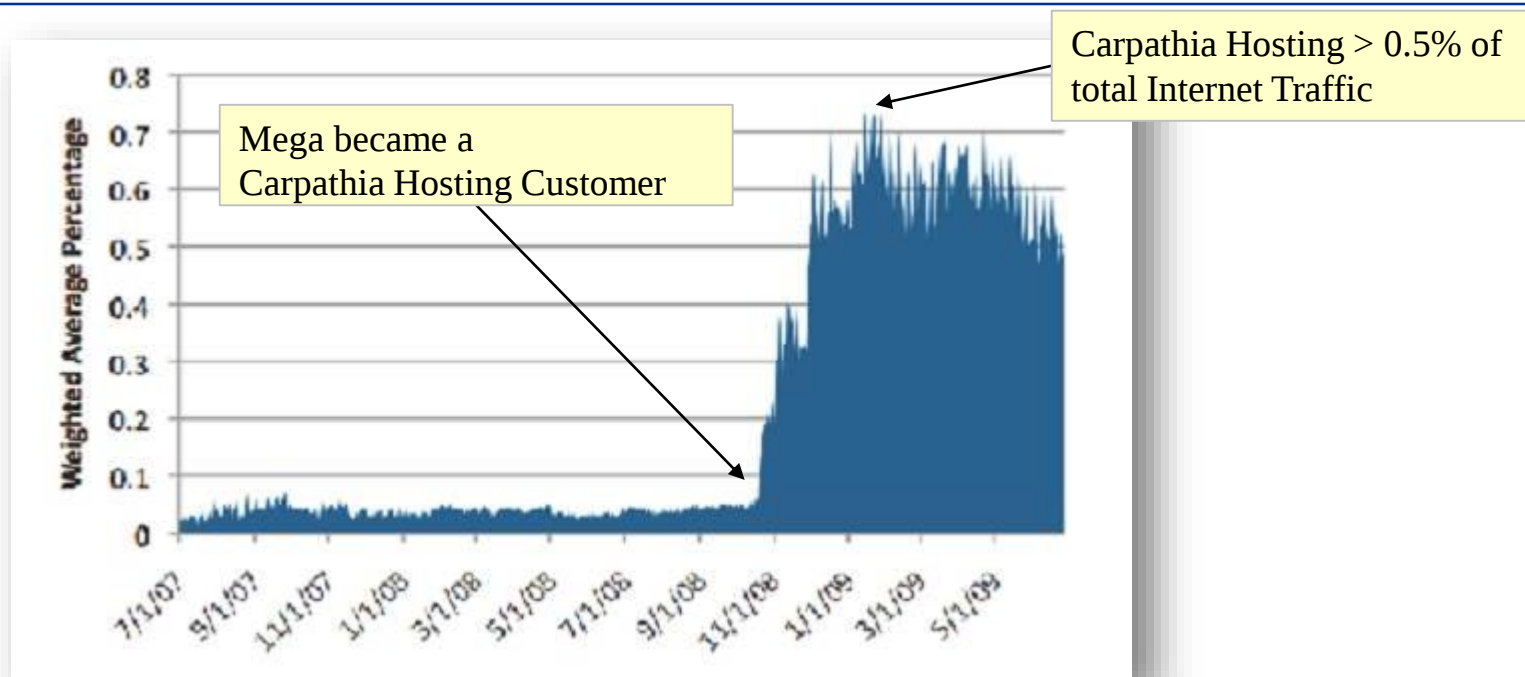
Cost of 10 Gb/s-equivalent 1000km link
(two switch ports and circuit transport)



Fraction of total cost for electronic switching has been shrinking



Challenge 4: Growing forecast uncertainty



Graph source : ATLAS Internet Observatory 2009 Annual Report

- New content or changes in hosting arrangements
- Changes in peering / transit set-up in the wider Internet
- Failures in the wider Internet – changes entry points into SP network
- Data Center workload shift internal / external to the Service Provider

Interim summary

- Challenges

- The shrinking gap between network cost and revenues 
- Are we approaching the limit of fiber capacity? 
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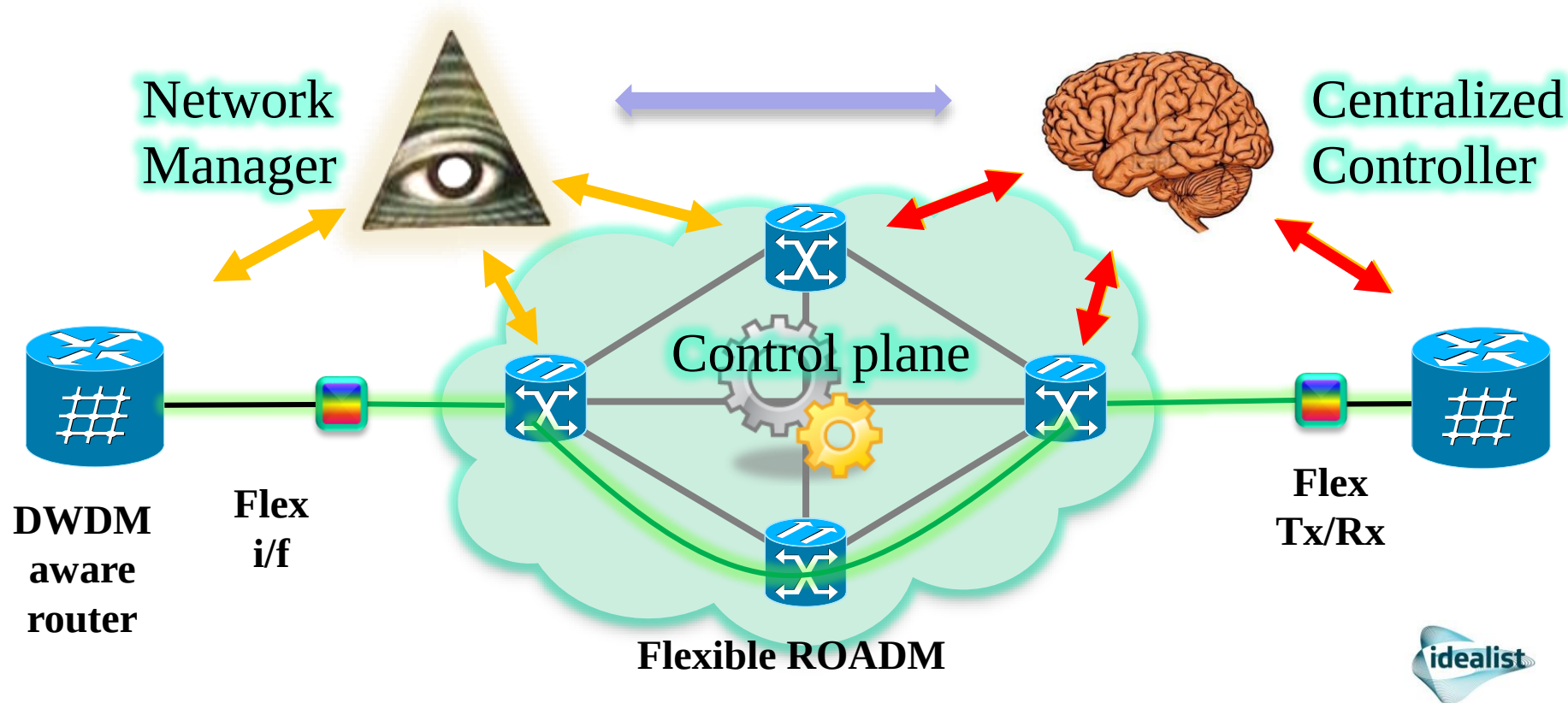
- Conclusion: current rigid optical layer and lack of cross-layer intelligence will not get us there

How can this be fixed?

- Elastic DWDM layer → flexible spectrum, modulation, ...
- Client layer designed to help → DWDM aware IP
- Inter-layer collaboration → IP-DWDM control plane
- Centralized intelligence → Multi-layer PCE/SDN

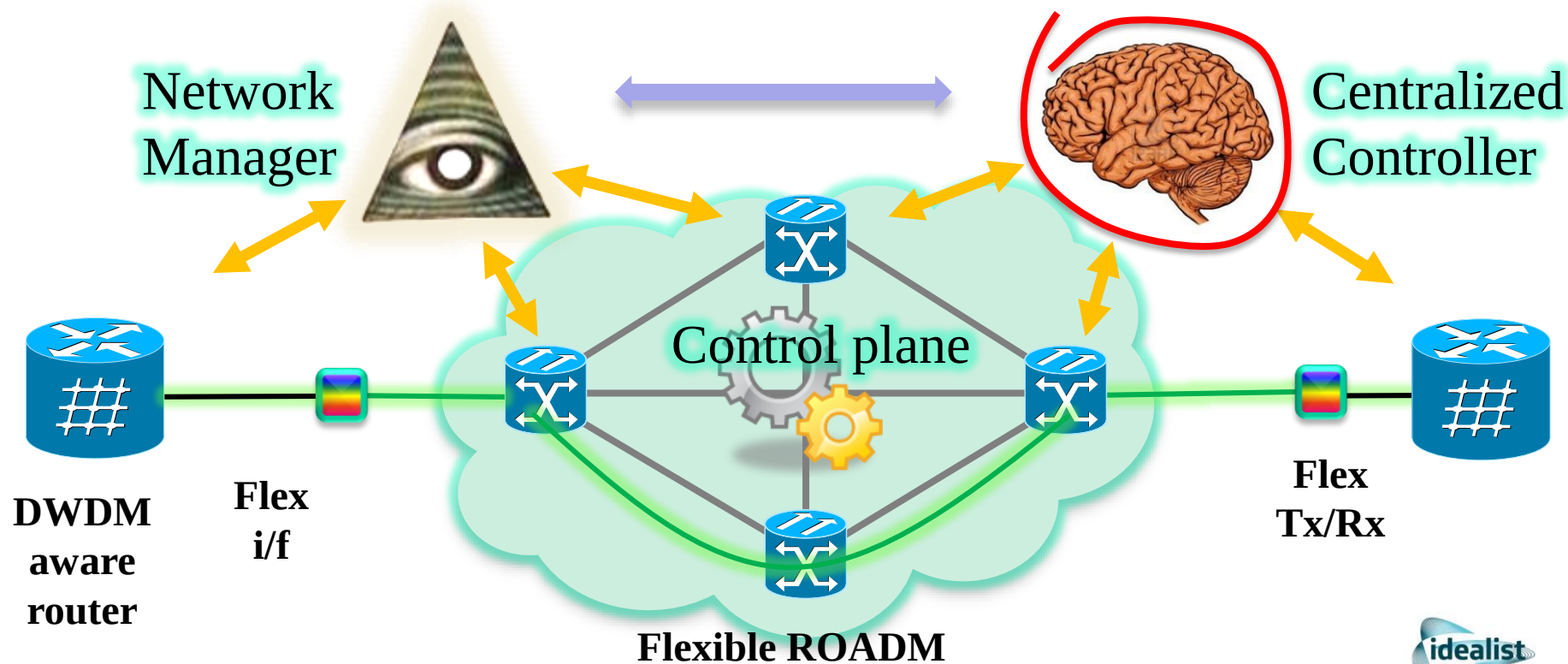
The ideal converged network of the future

- The network is constantly looking for opportunities to optimize the use of optical resources



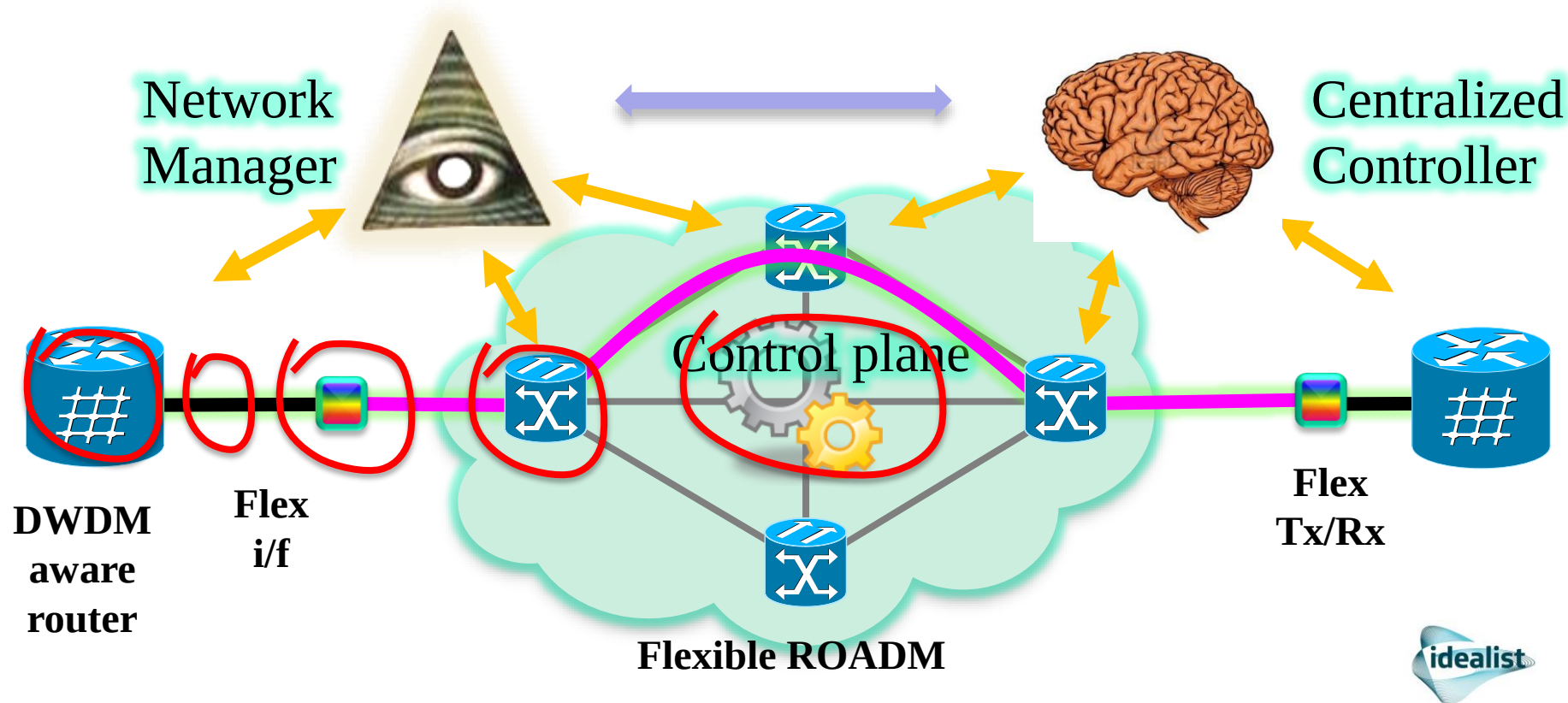
The ideal converged network of the future

- When an opportunity is identified, it's impact is analyzed by central control
- This requires understanding of both layers



The ideal converged network of the future

- Applying the change requires adjustment of the use of spectrum, wavelength, modulation, interface to the router, and router configuration – using the control plane



Thank you