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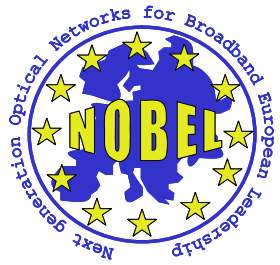
The economic benefits of all-optical core networks around Europe

Outline

- Acknowledgements
- Rationale for an all optical network
- Designing all-optical networks
- Economics
- Conclusions

Acknowledgments

- Nobel EU collaborative project funding much of this work

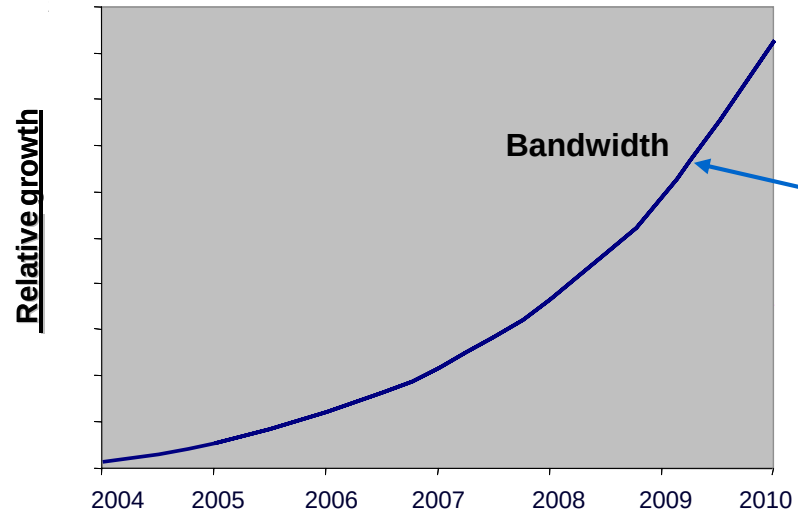


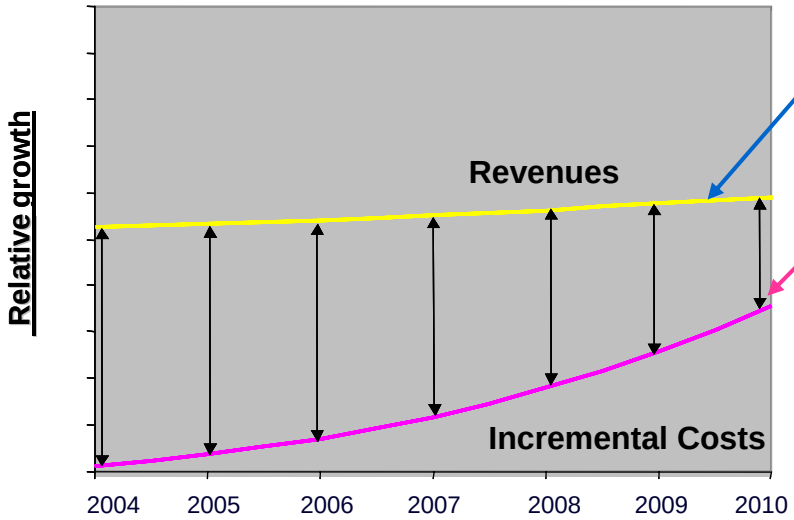
- Economic modelling in conjunction with Polatis
  (Many thanks to Richard Jensen)

(Booth 1940 in exhibition)

BT

Bandwidth Growth – The Margin Challenge





Greater bandwidths
- New services
- Maintain/grow revenues

But costs rise faster

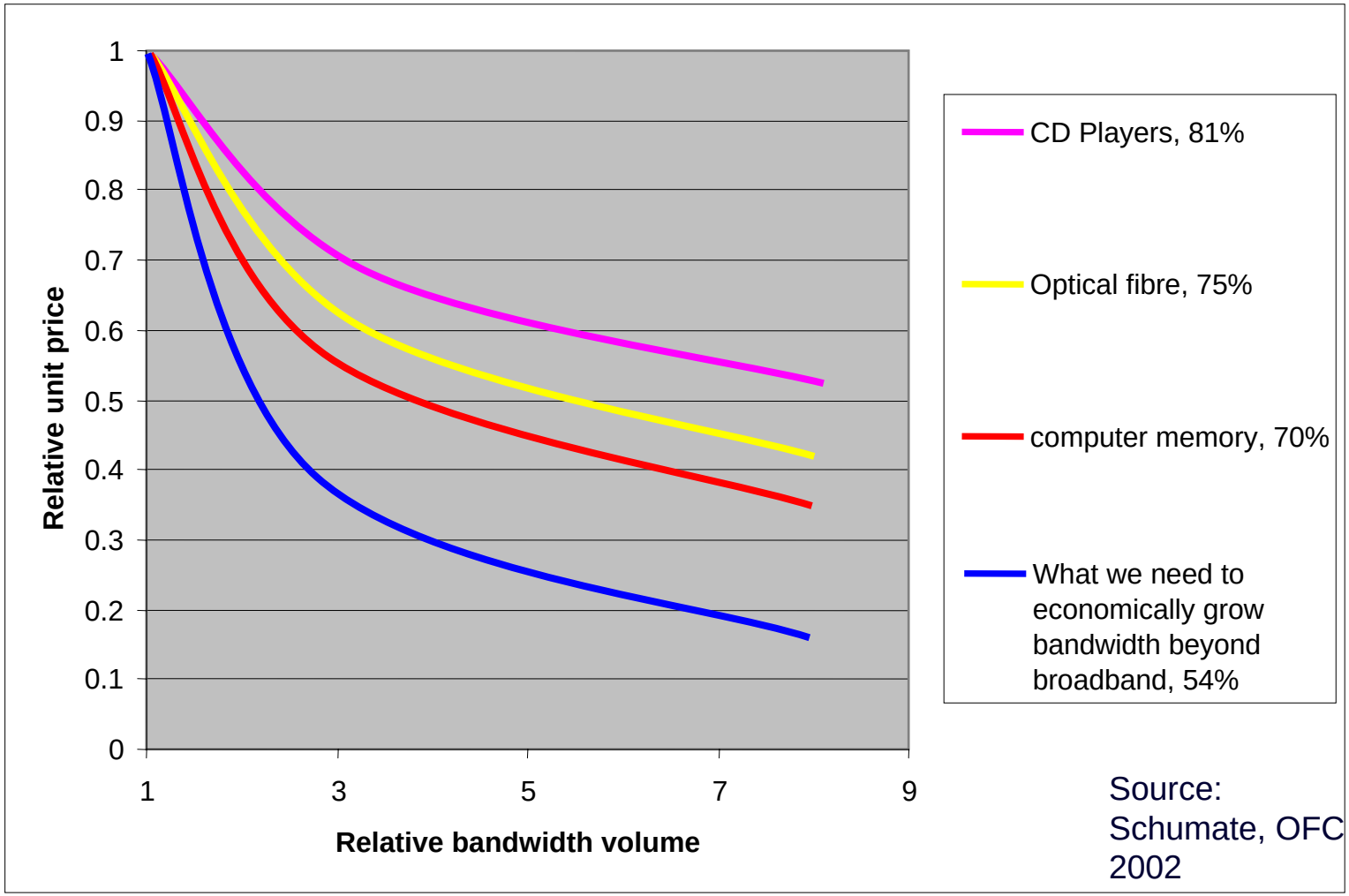
… Margins are eroded

How do we sustain revenue growth?

- As bandwidth demand increases
- More equipment is purchased
- Higher sales volumes leads to cheaper equipment

How quickly does the equipment price need to fall to maintain revenue growth?

Price Reductions with Volume



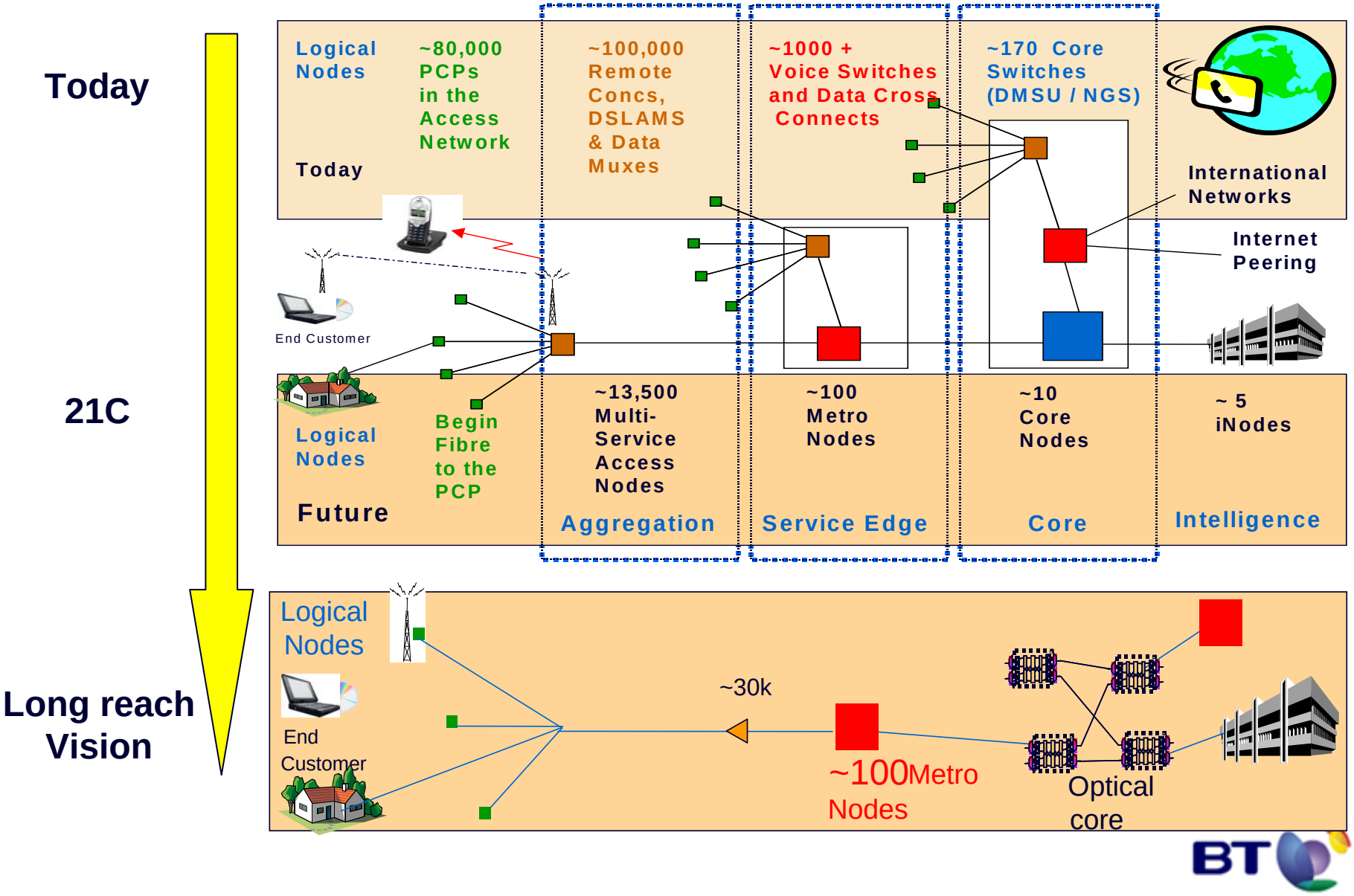
So how do we achieve required cost reduction?

- Optical components (lasers, fibre etc) follow ~75% volume price reduction
- We need ~54% volume price reduction to economically grow bandwidth beyond today's broadband
- Answer is to eliminate equipment, interfaces and nodes from the network

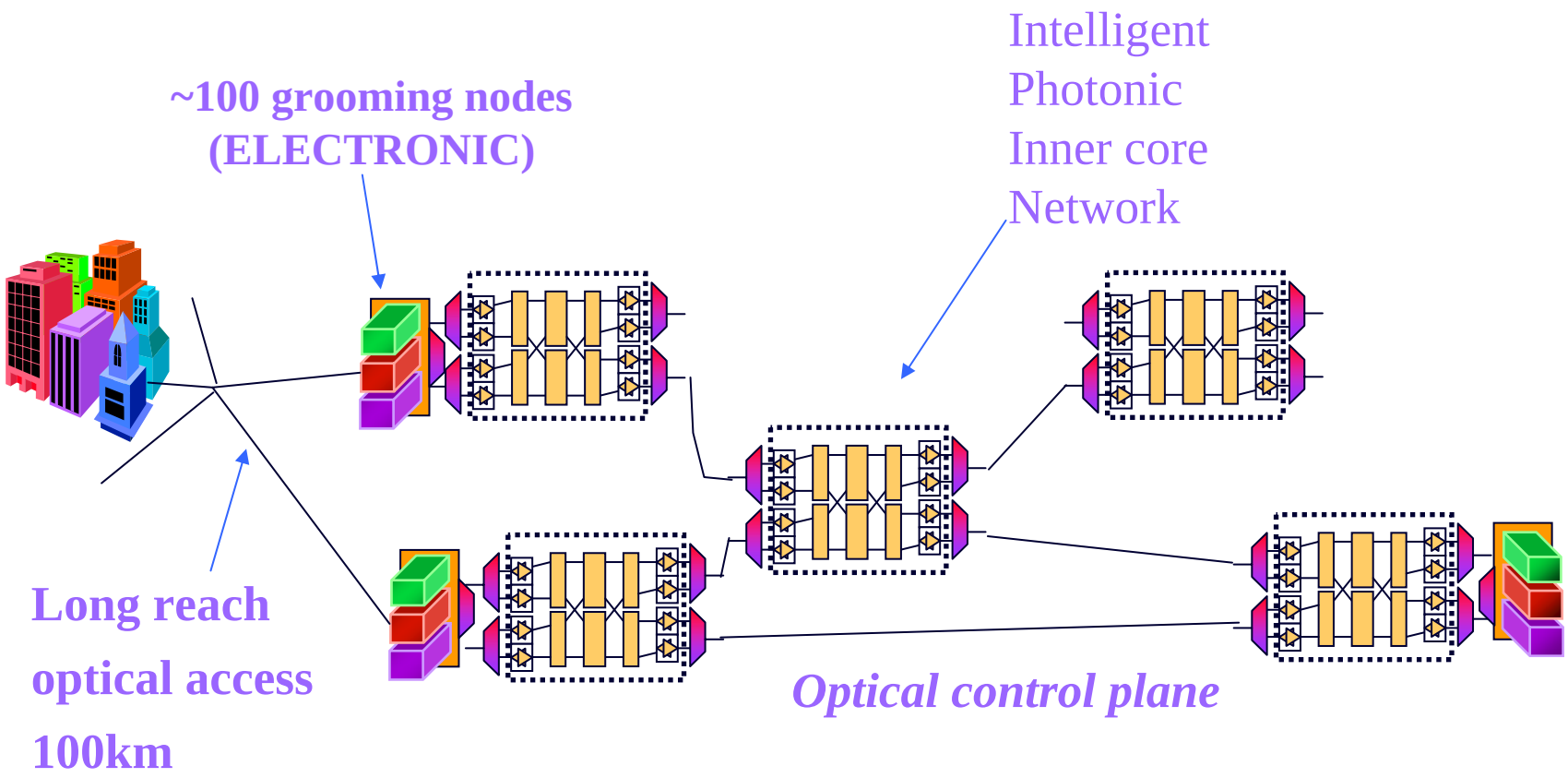
Two Components:

1. Integrate access and metro using long reach PON
2. Optical inner core network

Network evolution

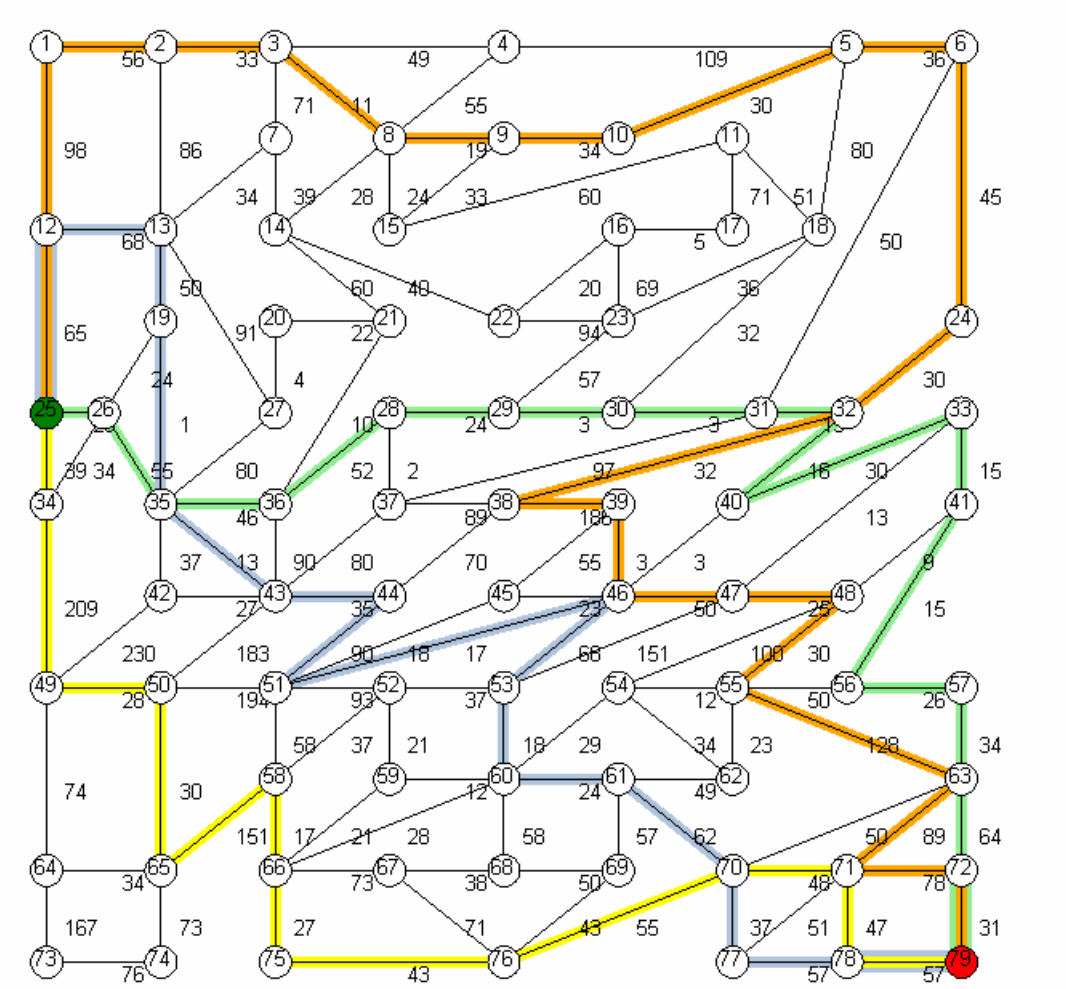


Core optical layer

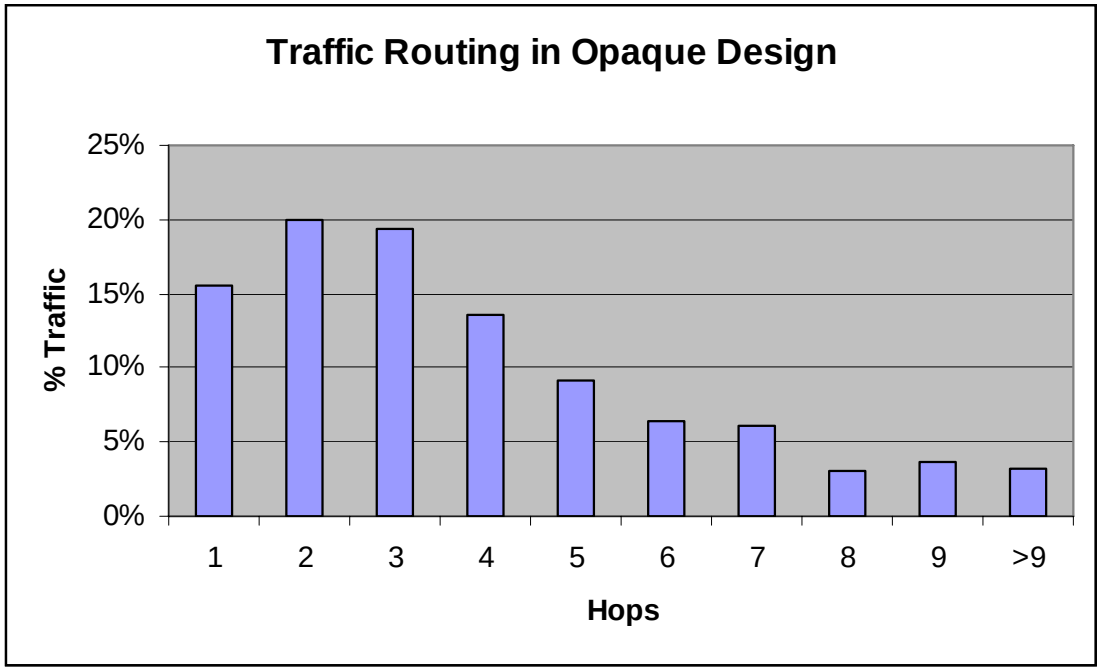


Ultimate aim: Reduce BT network to ~100 exchanges

BT Core network schematic



Traffic bypassing core nodes

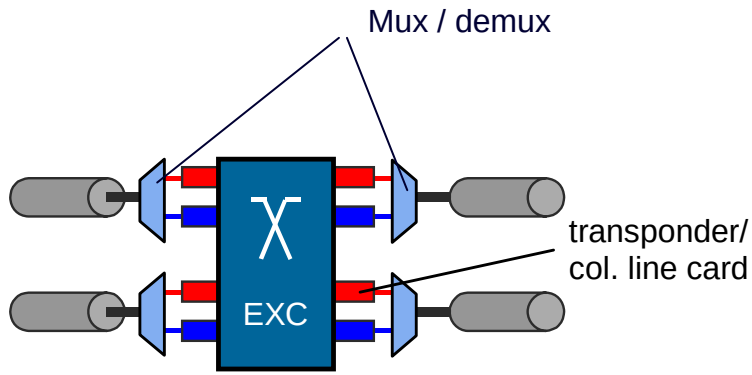


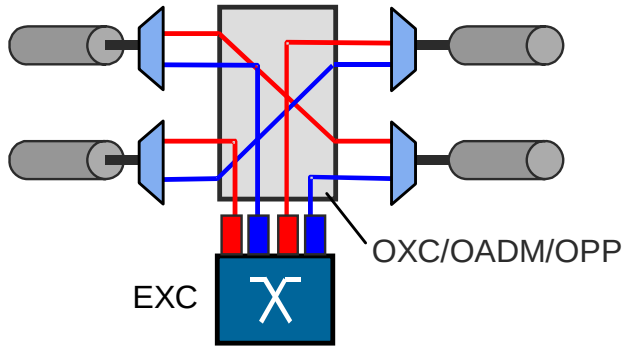
- **BT Core network 79 node model**
- **Assumes minimum hop routing**
- **No optical protection paths**
- **Therefore a LOW estimate of bypass traffic**

- Large future traffic entering core from broadband access network
- High % traffic will bypass core nodes en-route to destination
- 74% transponders used for transit traffic

Opaque vs transparent?

- opaque
  - intermediate grooming using electrical cross-connect (EXC)
  - no optical bypass
- transparent (hybrid)
  - intermediate grooming in EXC
  - optical bypass using all-optical cross-connect (OXC) or optical patch panel (OPP)



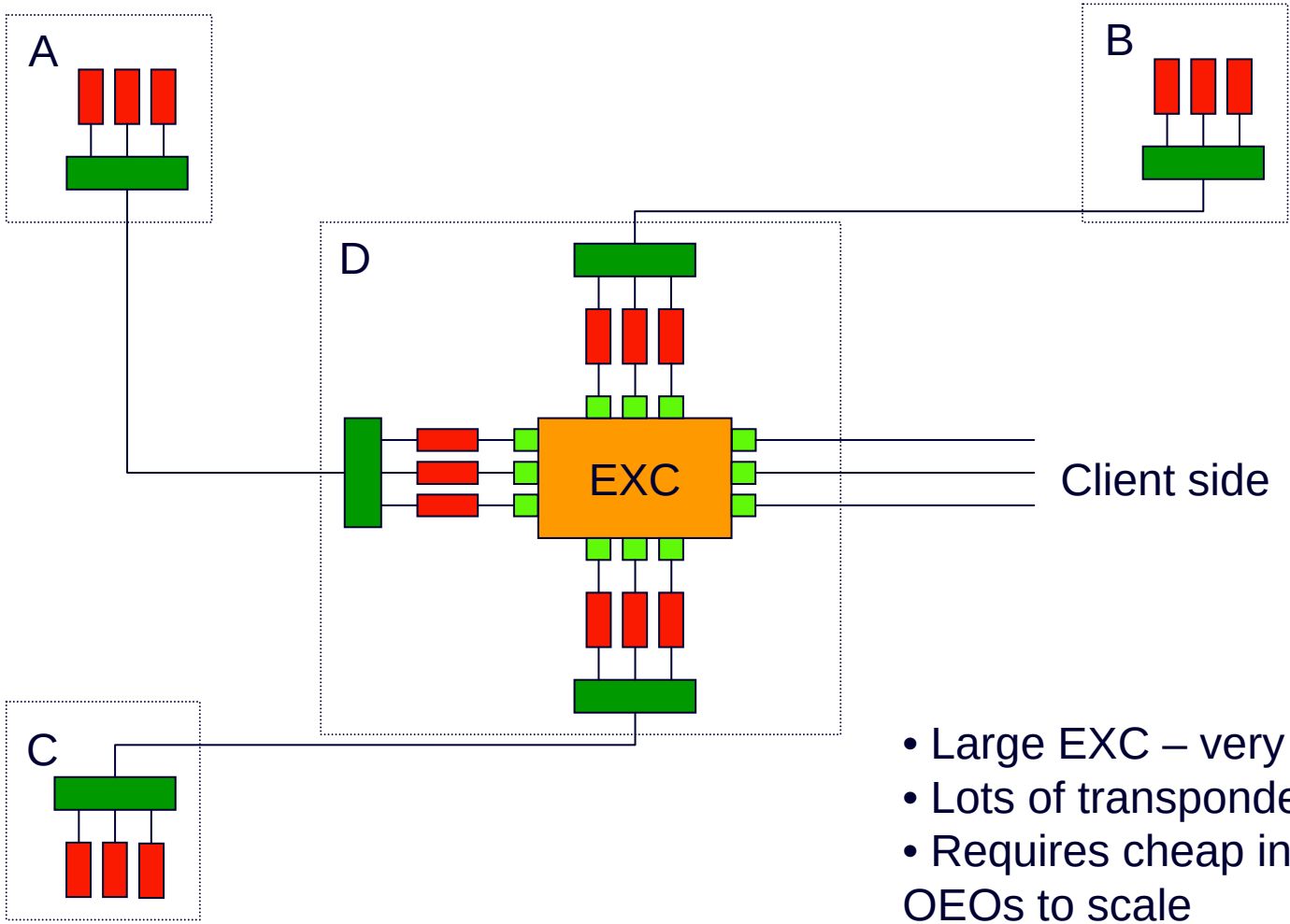


Optical node design

- Range of technologies, each giving different architectures
- 3D MEMs switches
- Wavelength selective switches
  - Simplest example is degree 2 ROADM
  - Higher degree components available this year
- Technologies include MEMs, piezo-mechanical, planar waveguide

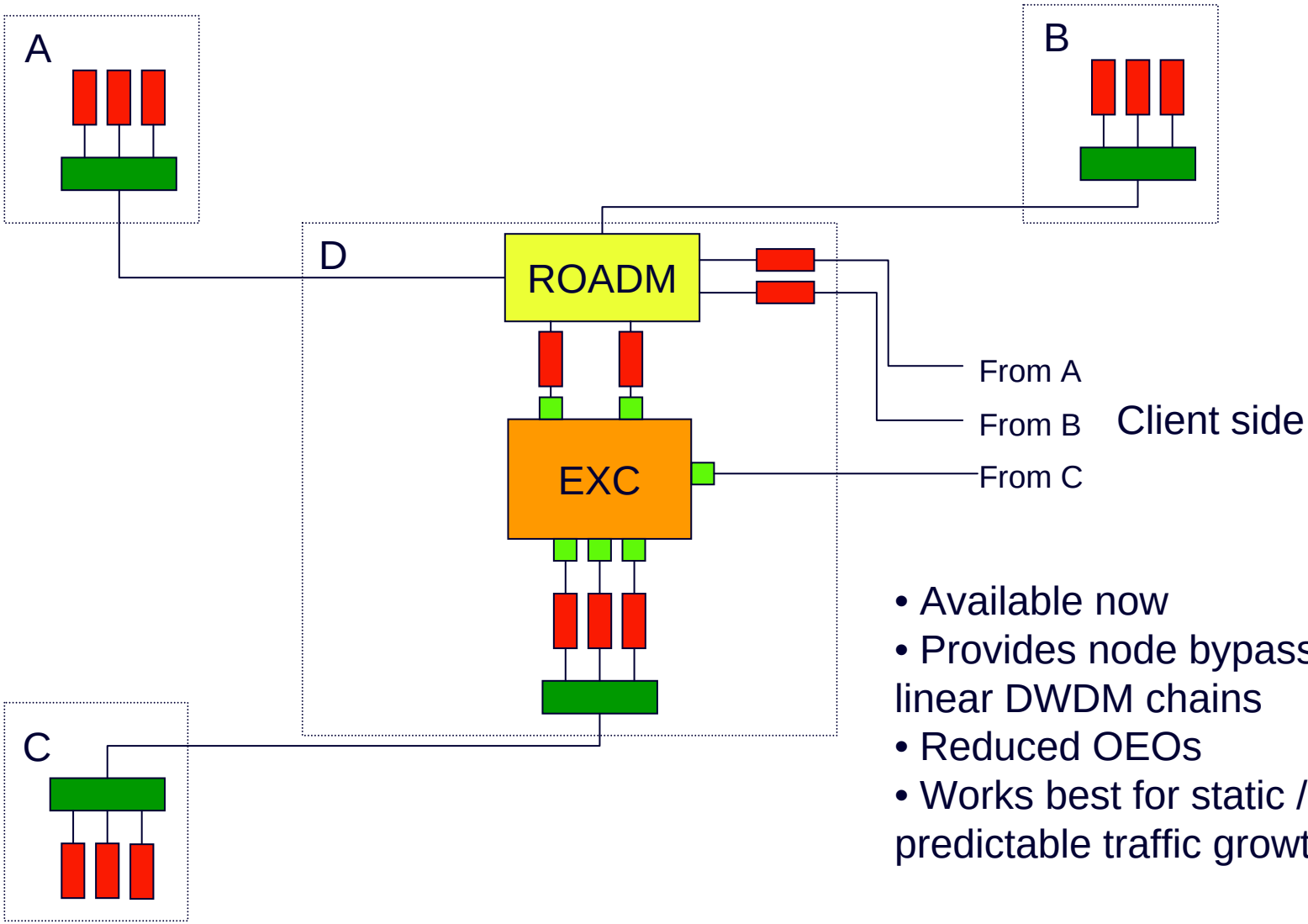
Alternatively reduce the cost of OEO transponder technology

OEO



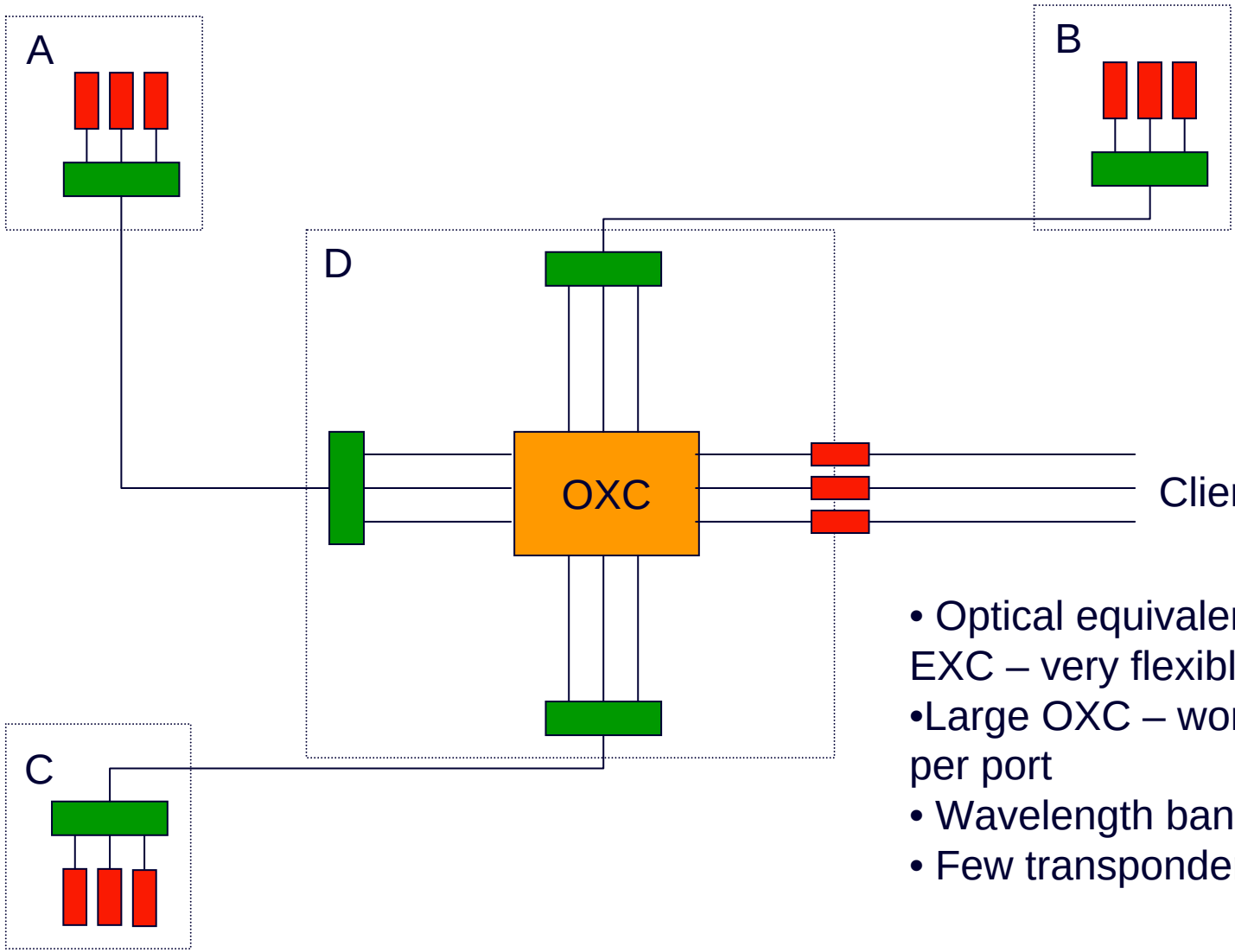
- Large EXC – very flexible
- Lots of transponders (OEOs)
- Requires cheap integrated OEOs to scale

ROADM



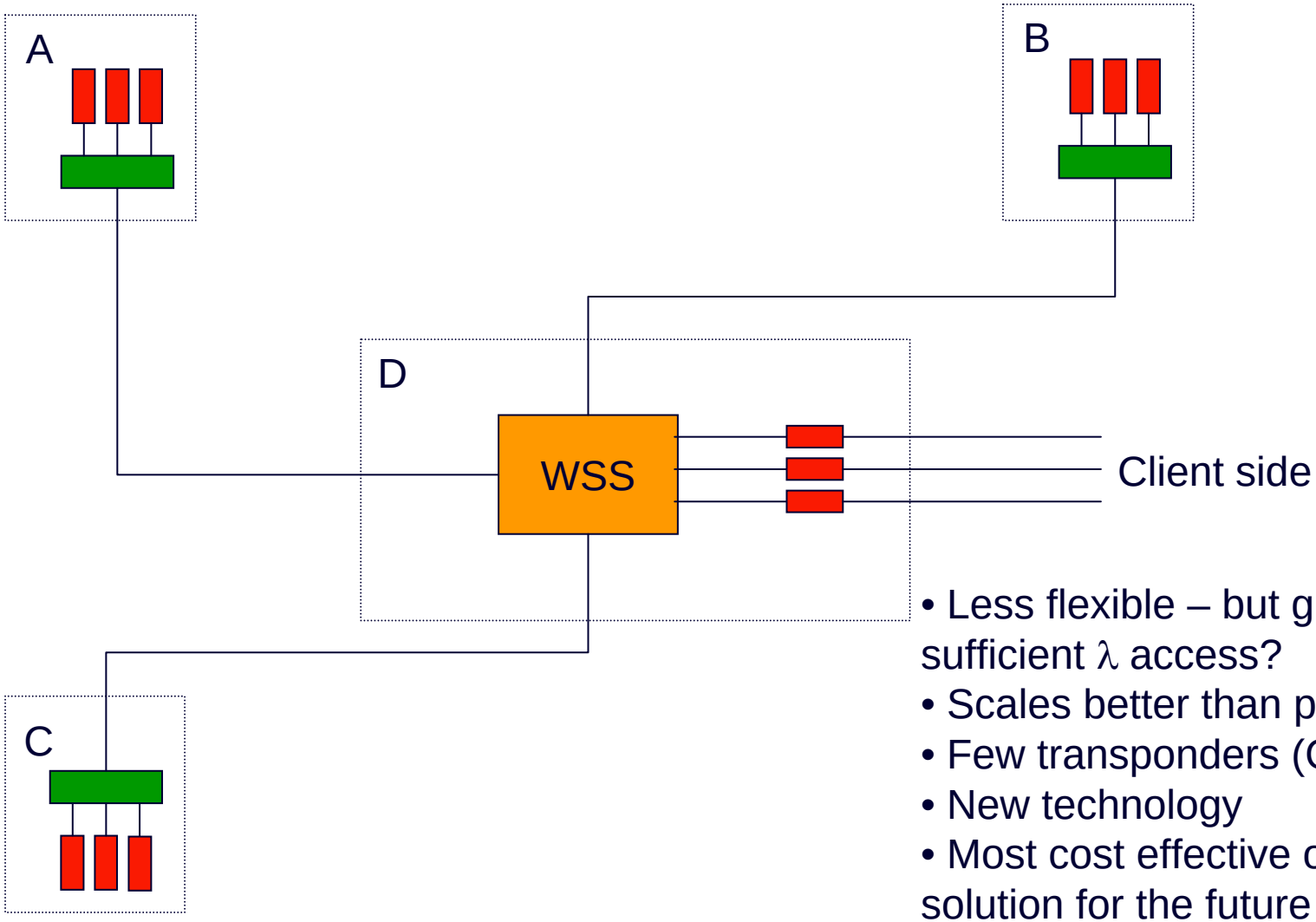
- Available now
- Provides node bypass for linear DWDM chains
- Reduced OEOs
- Works best for static / predictable traffic growth

Matrix OXC



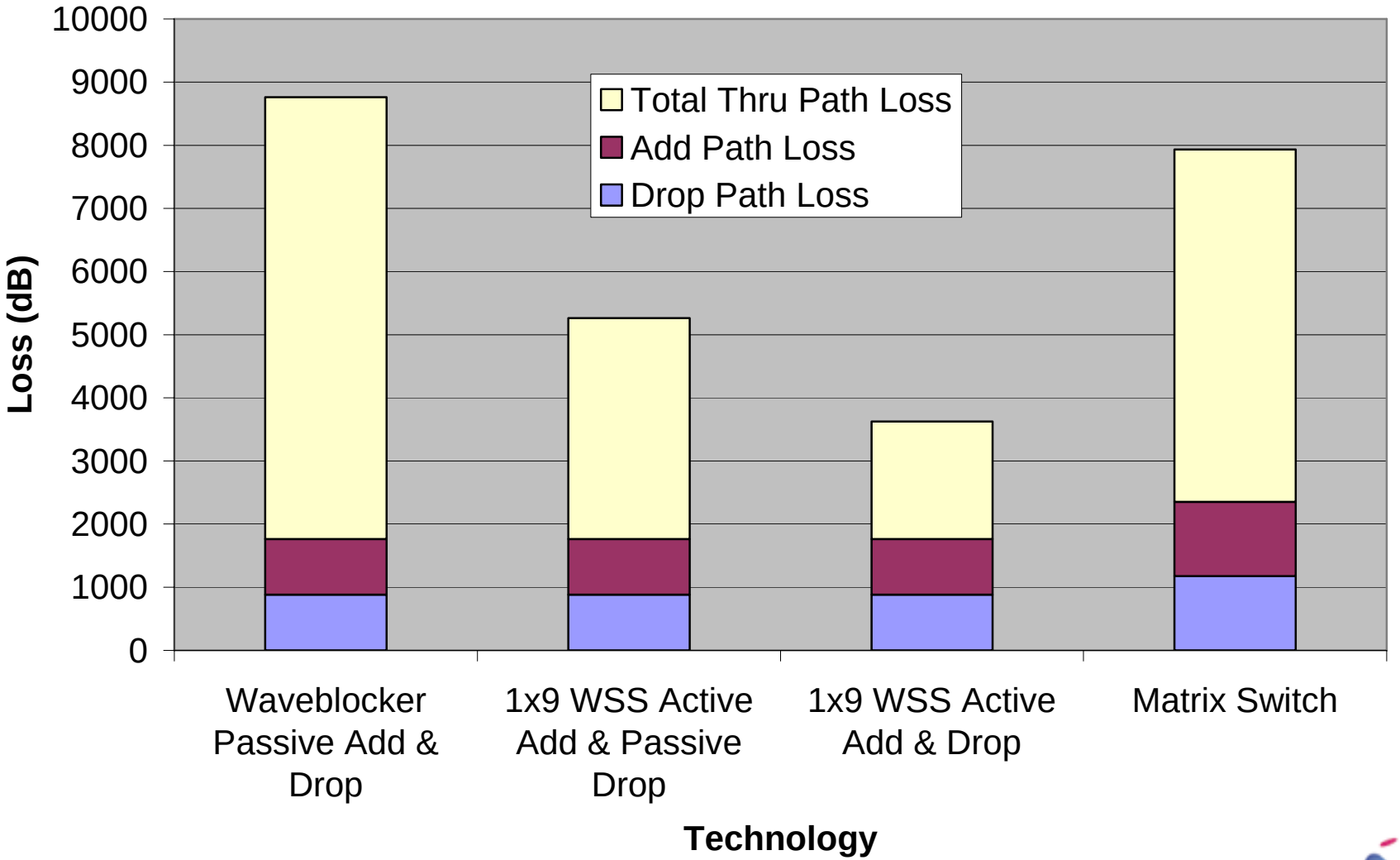
- Optical equivalent of trad EXC – very flexible
- Large OXC – won't scale if 1 λ per port
- Wavelength banding helps
- Few transponders (OEOs)

WSS



- Less flexible – but gives sufficient λ access?
- Scales better than previous
- Few transponders (OEOs)
- New technology
- Most cost effective optics solution for the future (?)

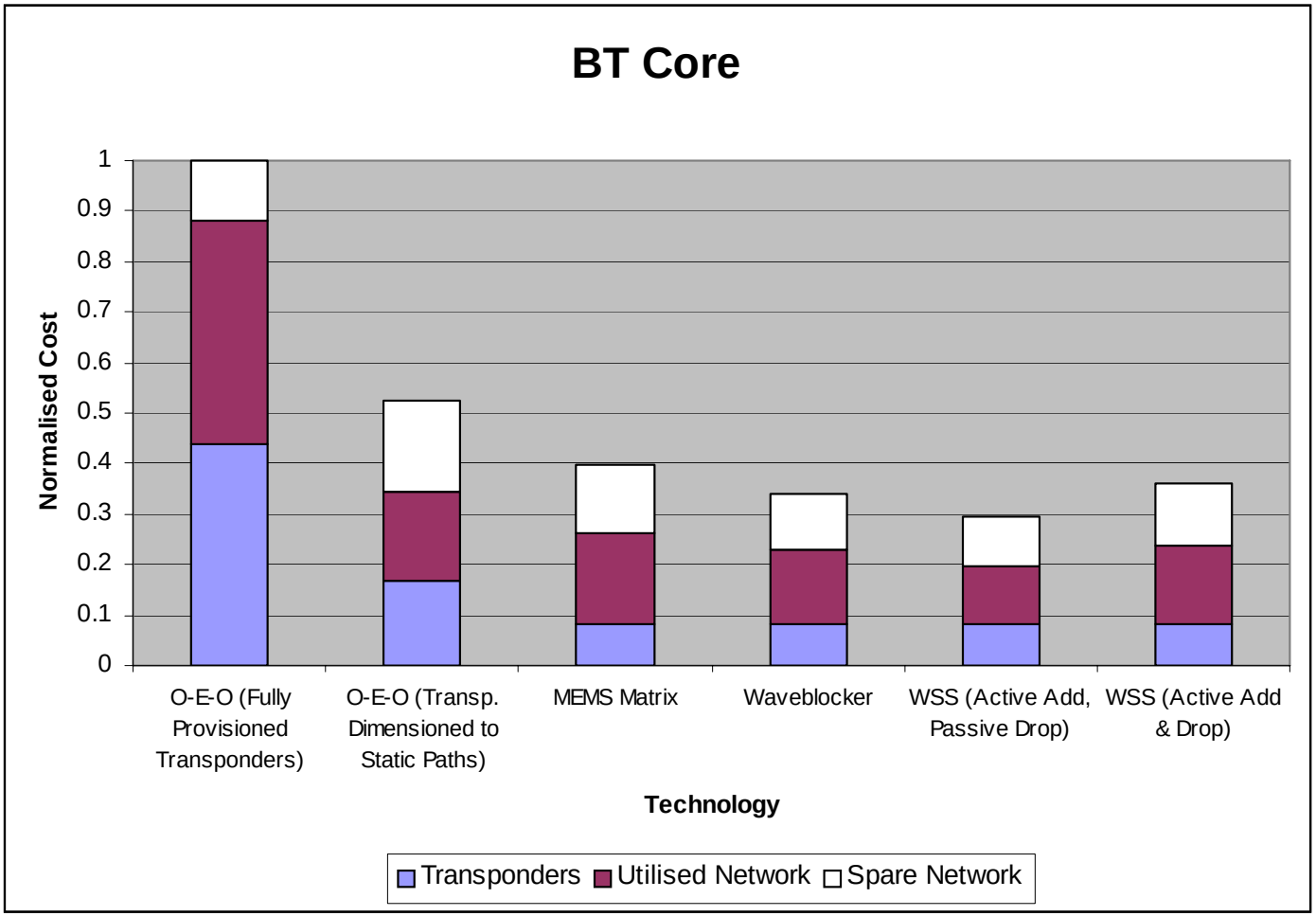
BT Metro Network Study Technology Loss Comparison



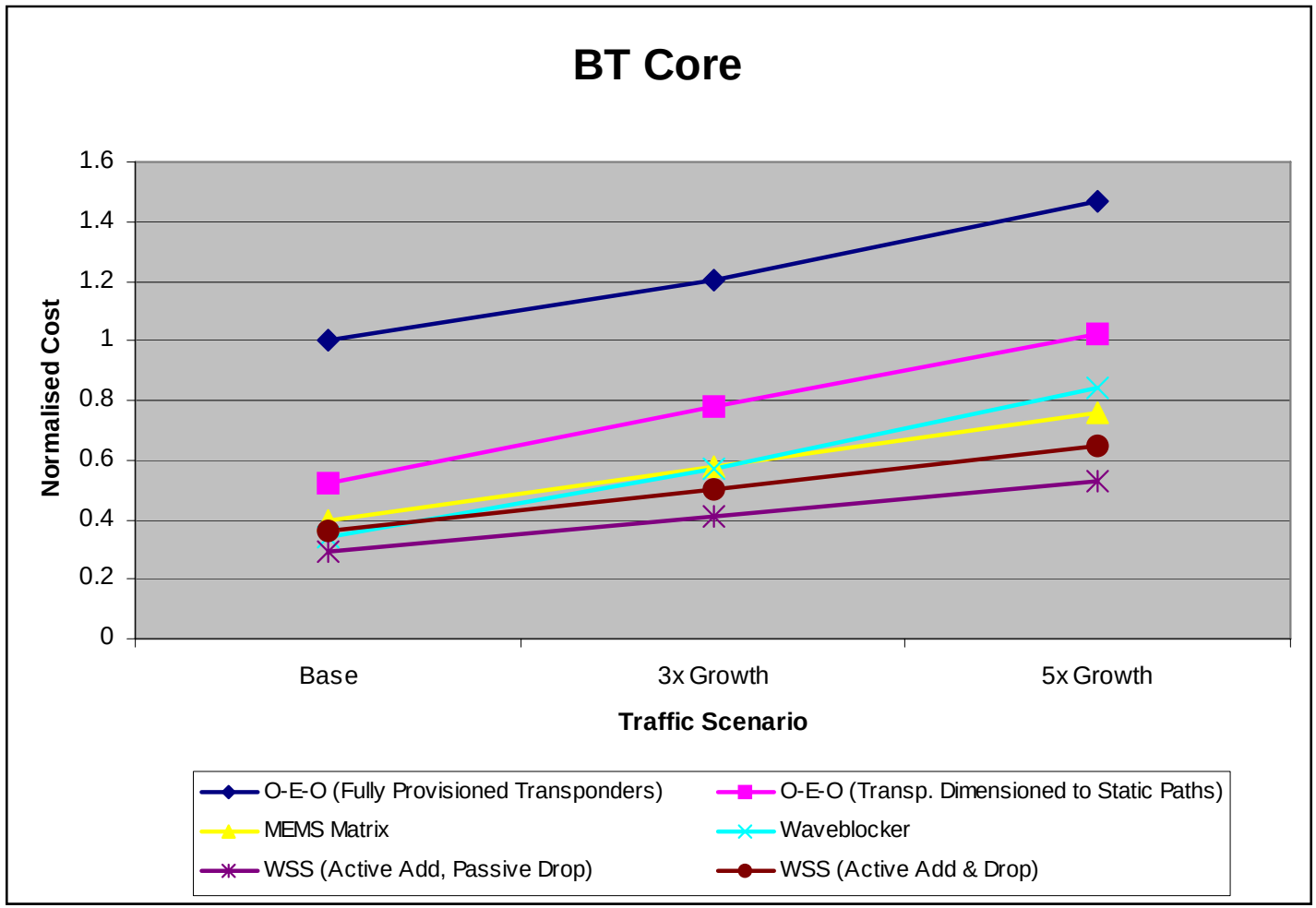
Dynamic traffic

- If traffic static and growth predictable we can design network perfectly tailored in advance – no need for flexible all-optical network
- How dynamic will the real network become?
  - Traffic growth unpredictable but if we build static network infrastructure, growth will economically be driven the same way
  - As traffic volume grows there will be large numbers of wavelengths in the core, and the need to switch them quickly and flexibly will increase
  - Flexible network can provide wavelength services anywhere
  - Any time instant provision allows ‘time of day’ services (e.g. large back up of company data)
  - Fast response to multiple network failures. Far less required protection bandwidth (optical mesh restoration)

Network Design Cost Analysis (1)



Network Design Cost Analysis (3)



Conclusions

- Two key advantages for all-optical core networks:
  - Economic savings – CAPEX and possibly OPEX
  - Increased network flexibility
- But for static (or slowly growing) traffic ROADMs deliver most of the node bypass savings
- And we can have greater flexibility from electronics (e.g. sub rate grooming)
  - OEO costs could potentially reduce via photonic integrated circuits
- And all-optical networks are all-analogue networks
  - Problems with optical transients, optical performance monitoring, channel set-up…
- So – will we need dynamic traffic at the wavelength level?
  - If so there are a range of architectures worth considering
  - Wavelength Selective Switches appear to be the cheapest and most easily scalable

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Network Design Cost Analysis (2)