Ethernet nodes in terabit backbones

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Typical (small) IP/MPLS backbone network

Service Site

Service Site

PE   P

P   PE

Service Site

Service Site

S

PE   P

PE

PE
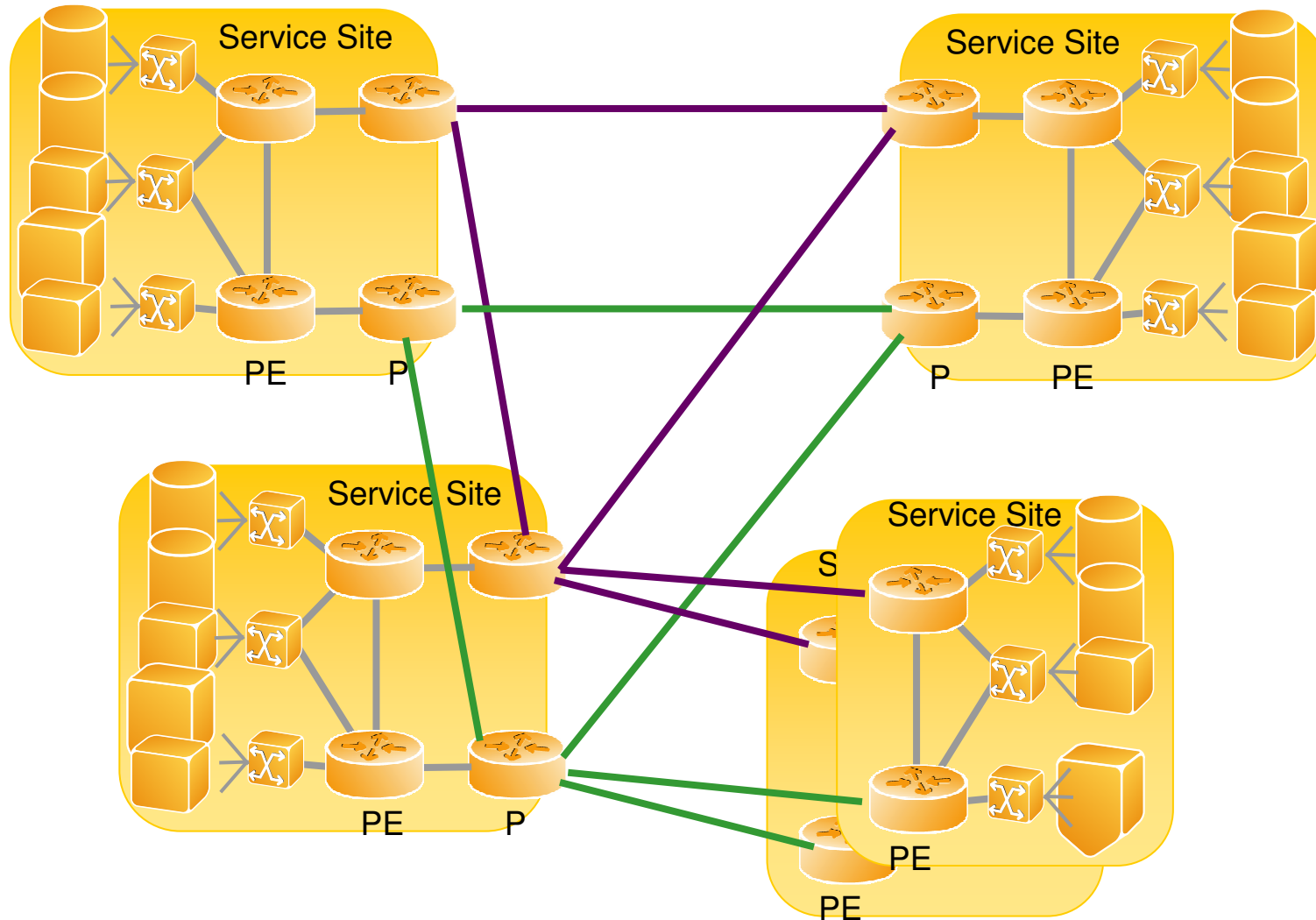
Typical (Carrier) Ethernet backbone network ?

Service Site

Service Site
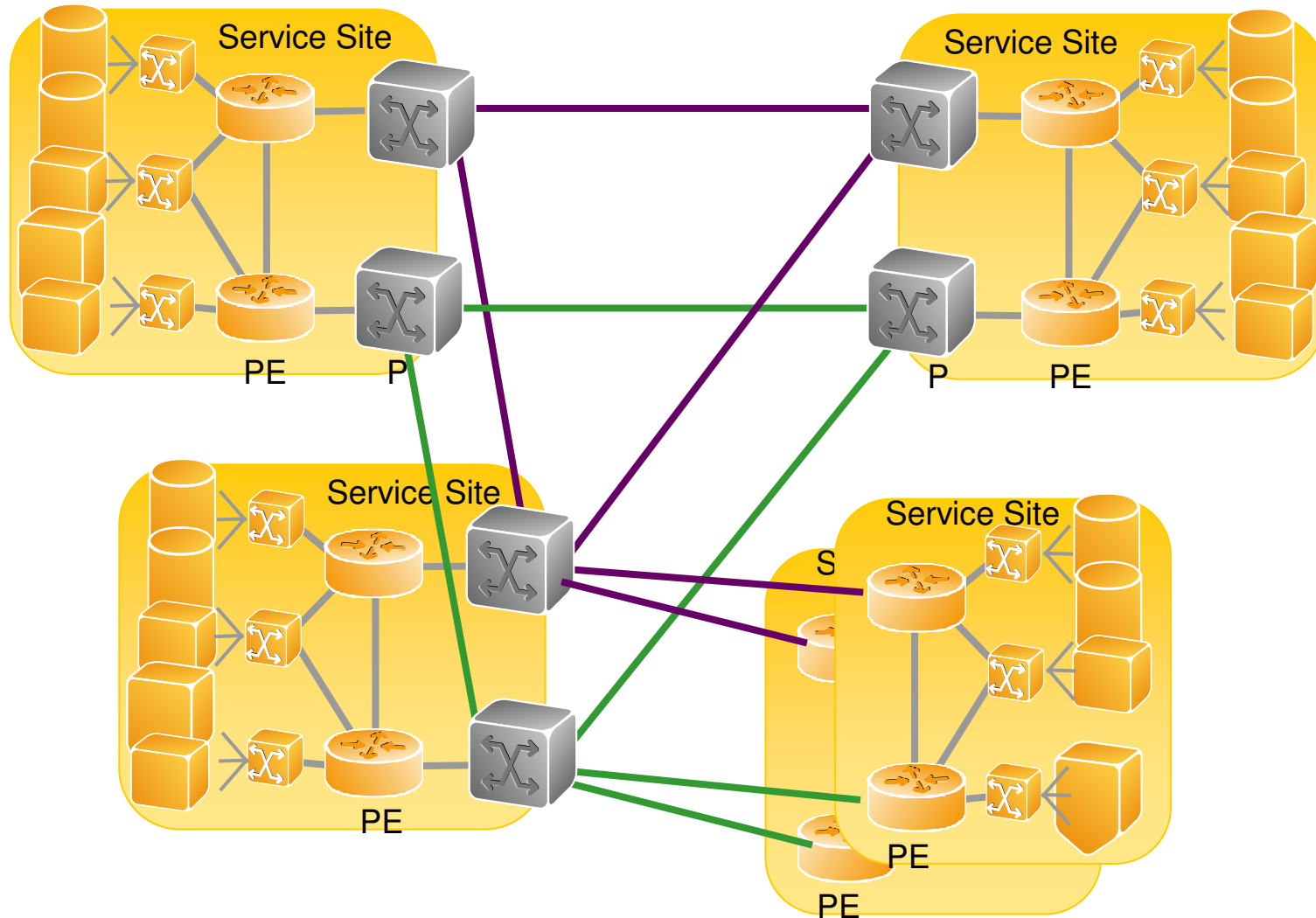
Service Site

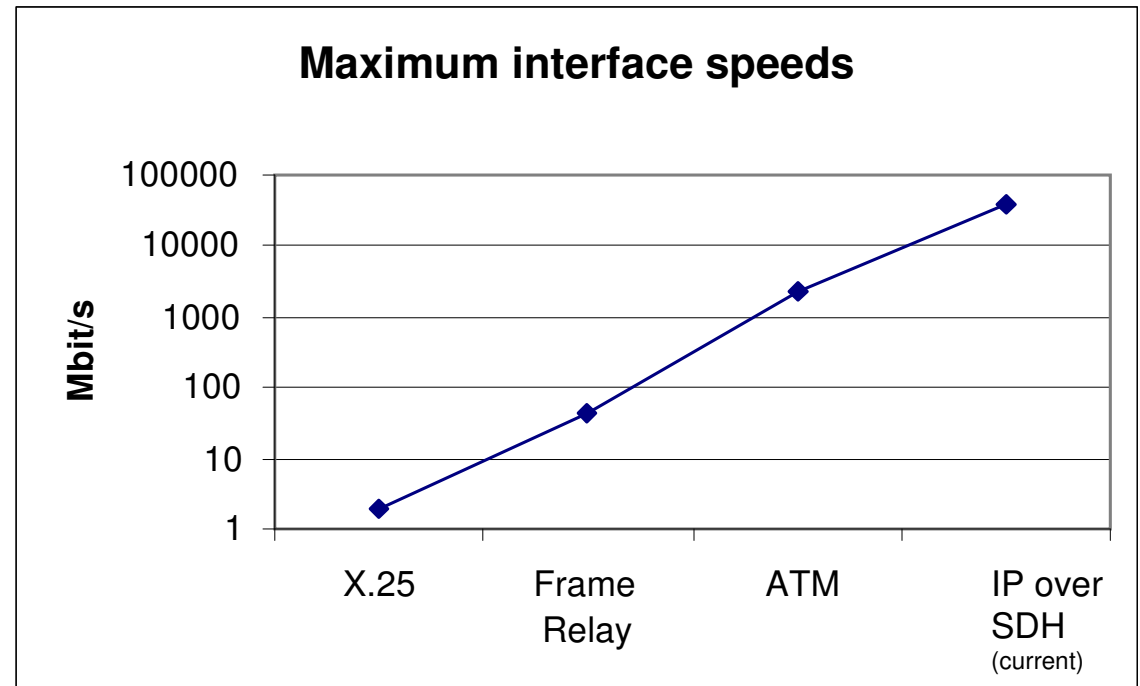Service Site

PE

P

P

PE

S

PE

PE

PE

Ethernet nodes in terabit backbones

- Are Ethernet switches and cross connects likely to replace core routers in the backbone networks the same way ATM replaced Frame Relay and IP replaced ATM?

- What features and capabilities are required from Ethernet switches or cross-connects when they are introduced to the terabit backbone?

- Under what circumstances is it justified to use Ethernet switches or cross-connects as building blocks of a terabit backbone?

# Backbone technology evolution since the 1980's

- From X.25 to Frame Relay
  - Link speeds (no ack)
  - Optical networks, low BER
- From Frame Relay to ATM
  - Link speed, DLCI space
  - B-ISDN
- From ATM to IP over SDH
  - Link speed
  - Data is now IP
- From IP over SDH to …
  - Link speed should be nx100Gbit/s
  - Should outperform current solution (price ?)
  - Breaking current L1 - L3 functional division

Maximum interface speeds

	Mbit/s
	100000
	10000
	1000
	100
	10
	1

X.25   Frame Relay   ATM   IP over SDH (current)

- Currently high end platforms carry 40 Gbit/s per slot
  - Routers and Switch/Routers
  - 4 x 10GE and STM-256
- No higher speed interfaces standardised yet

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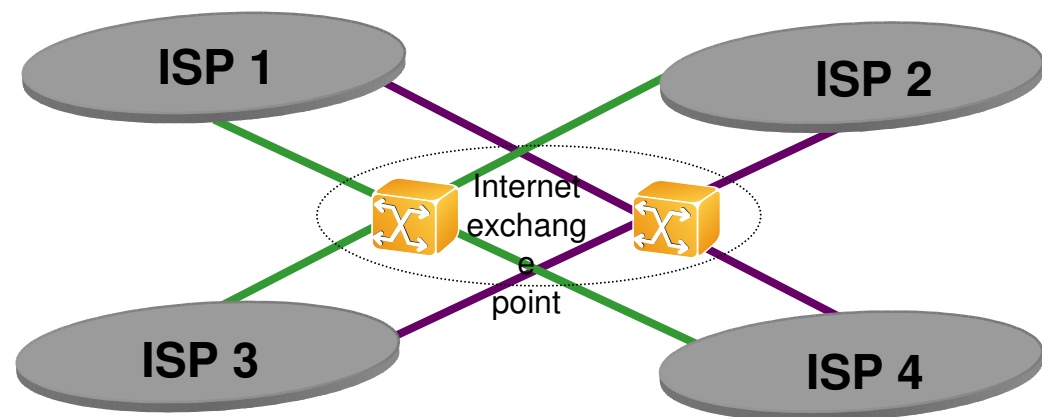
Cost of Ethernet and IP over SDH

- Ethernet interfaces are much lower priced than SDH (or PDH)
- Cost difference between Ethernet switching and routing is unclear
  - Cost of route processor vs cost of central management (for Carrier Ethernet)
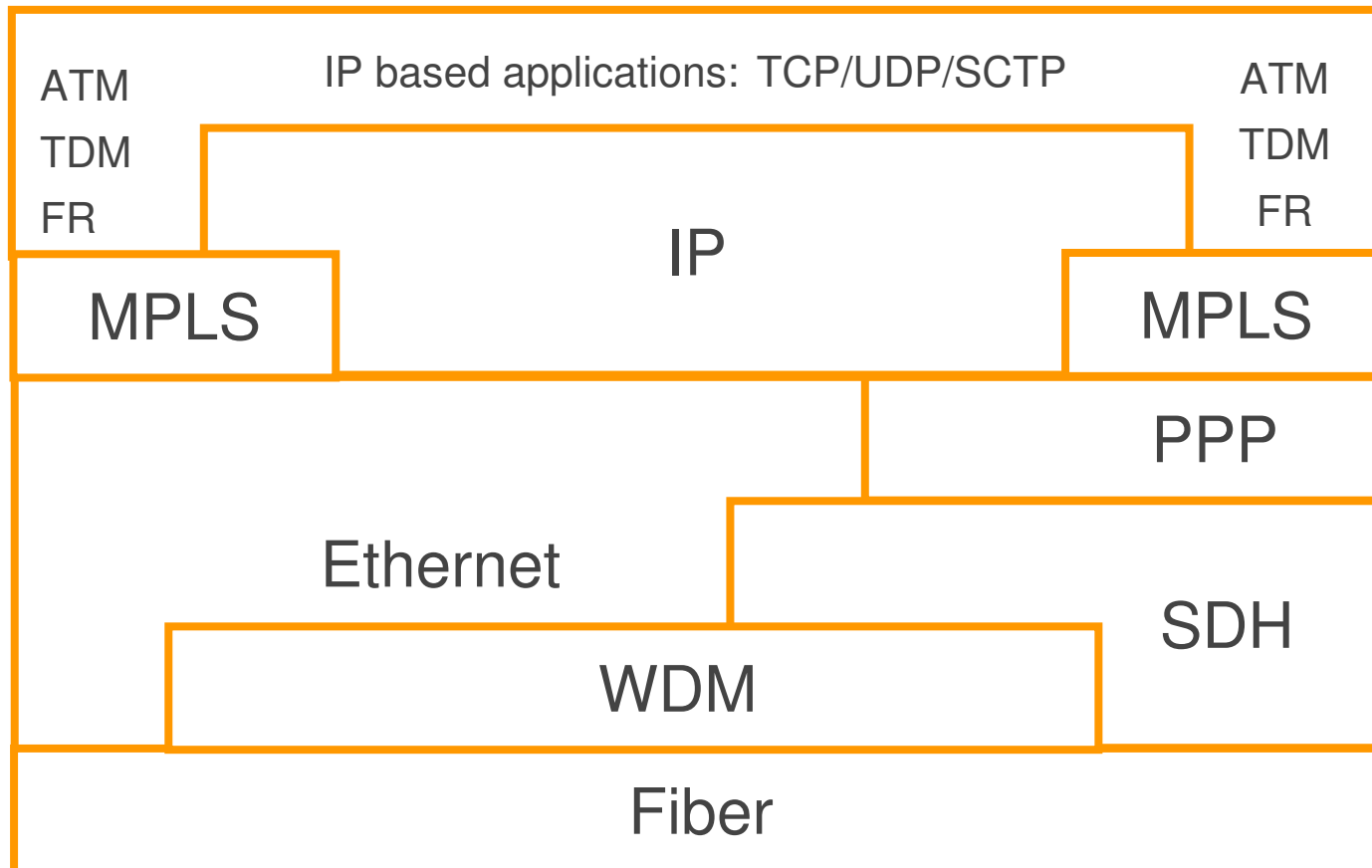- Backbone router vendors enjoy great margins today
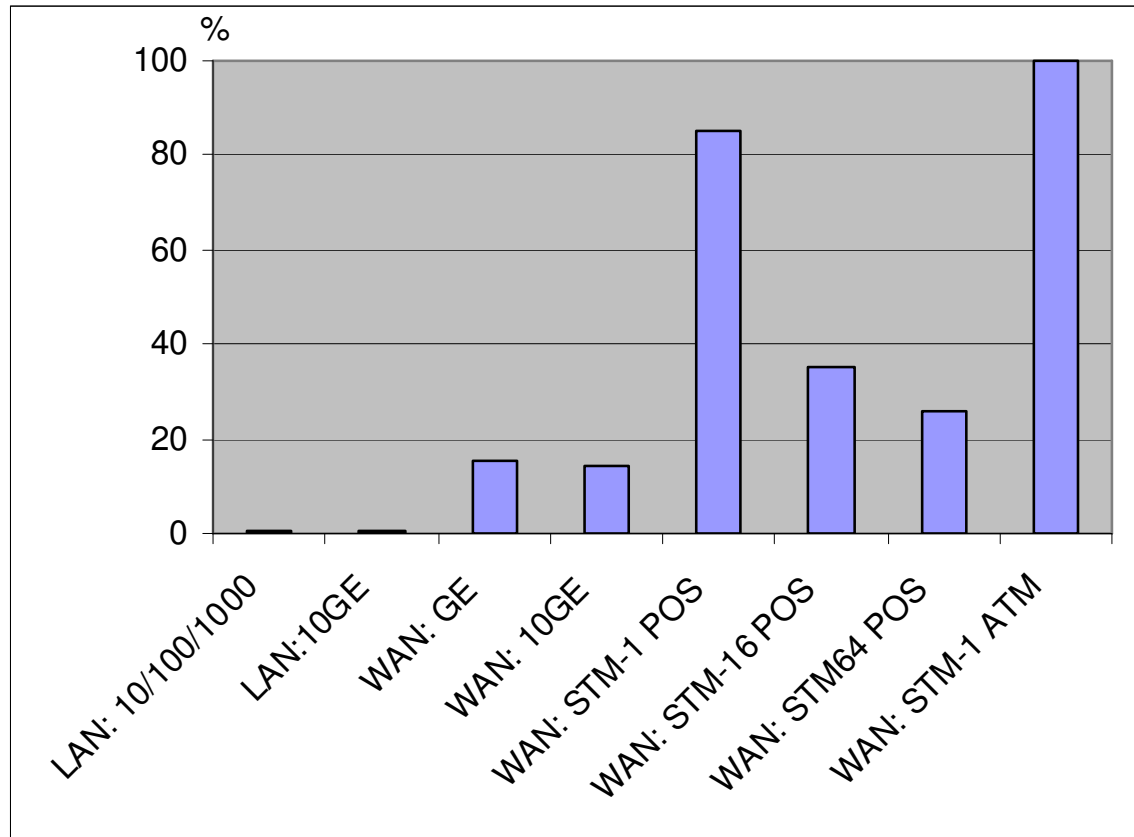
Relative prices of different interface technologies in a switch/router

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Are Ethernet switches and cross connects likely to replace core routers in the backbone networks the same way ATM replaced Frame Relay and IP replaced ATM?

- Not because of capacity or interface speed. Switches and routers have currently same restrictions.
- Price may be a reason for network operators to select switches instead of routers.
  - Cost difference is clear
  - Router vendors do have the possibility to adopt their pricing
- There are examples of backbone like applications implemented with Ethernet switches

ISP 1

ISP 2

Internet exchange point

ISP 3

ISP 4

Protocol options in a fiber based backbone

ATM
TDM
FR

IP based applications: TCP/UDP/SCTP

ATM
TDM
FR

IP

MPLS

MPLS

PPP

Ethernet

SDH

WDM

Fiber

What features and capabilities are required from Ethernet switches or cross-connects when they are introduced to the terabit backbone?

- With existing Ethernet switch features / planned PBB-TE features
  - Can be built using current Ethernet Switches but the solution will not scale
    - Spanning tree size
    - Multicast domain
  - Can be built using Carrier Ethernet (PBB-TE) but the solution is not mature
    - Provisioning (manual provisioning does not scale)
    - Topology changes (resilience of management and management connections)
    - Loop protection (if you can have a loop you will eventually have one)

- Additional requirements (mostly because of missing TDM network)
  - Fast failover (can be implemented with BFD in PE routers)
  - Link quality monitoring (in PE router or Ethernet nodes)
  - Clocking (needed by some applications)

Under what circumstances is it justified to use Ethernet switches or cross-connects as building blocks of a terabit backbone?

- WDM, dark fiber or NG-SDH is available for Ethernet wide area transport

- Number of adjacent routers does not grow too big (additional requirements)

- Price
  - Price per bit for Ethernet transport interfaces is significantly lower than for SDH
  - The cost differences between switching and routing unclear

- Expansion of established wireline service provider backbones
  - High capacity needs
  - Own fiber and WDM
  - Technical skills
- Small greenfield backbone
  - Transport capacity from other players?
  - Competences?

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Additional thoughts

- Ethernet will replace SDH first
  - This will take a long time
  - SDH … dead but growing
  - Over time functionality redistributed over L1 - L3

- Clear technology transition happening
  - like C. Christensen described for disk drive industry
  - But more complex with many technologies involved

- Further work
  - technology transitions in multilayer networks