



> BUSINESS MADE **SIMPLE**

ESCC/Internet 2 Joint Techs Workshop

40/100G-What is best next line rate after 10G?
Are we ready to hear the answer?

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Why a higher line rate system?

1. High capacity

- > Wavelength plan 70% occupied: increase spectral efficiency
- > Additional capacity is required rapidly and/or with Low IFC
 - Delay lighting new fibre pair

2. Service rate > line rate

- > Quality of service and operation not compatible with Inverse -Muxing
- > Service cost lower than cost of N X Lower Rate

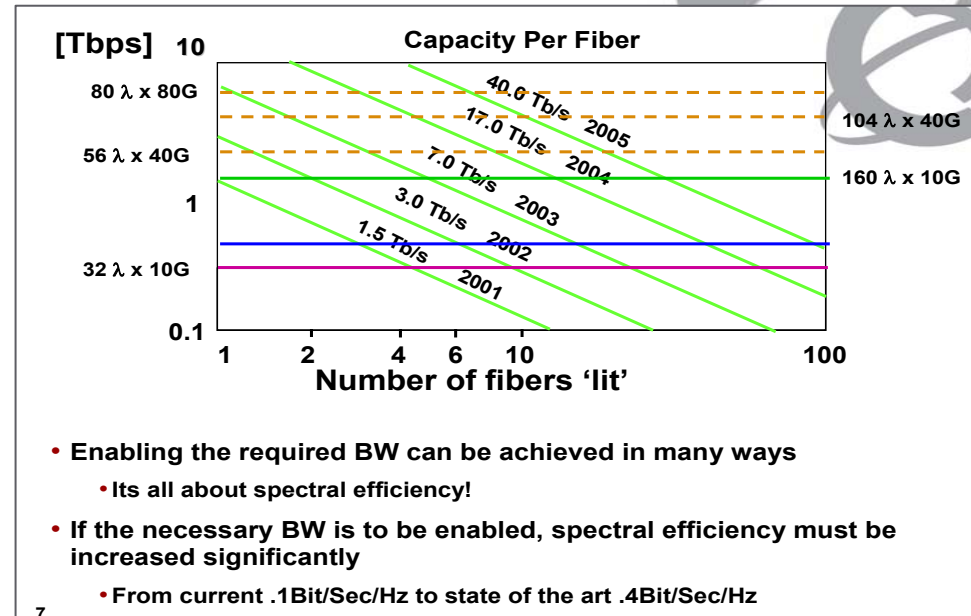
3. Technology discontinuity is changing the cost/service landscape

- > Existing service cost reduction
- > New services become possible

4. New service whose better served with higher line rate

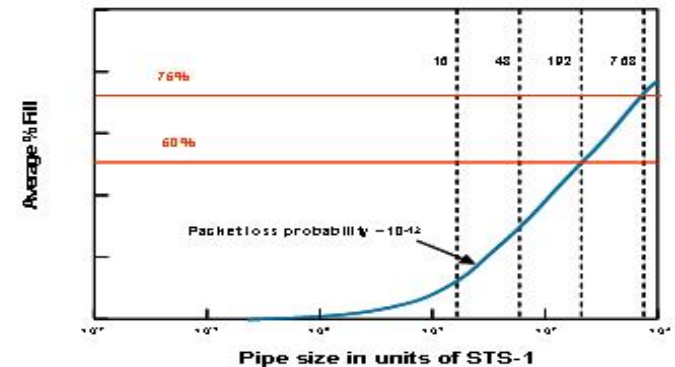
- > Cheaper implementation

Today what is the main driver?



Aggregation statistics & Packet Loss:

$$1 \times 40G = 6 \times 10G @ 10E-12 \text{ loss}$$





On Service side of platform

- > 10G is an industry workhorse
 - General use
 - Mature mechanical and interface standards
 - Commodity cost

- > 40G is another story
 - Very few suppliers on board
 - Tentative standards
 - Existing 300 Pin MSA 40G serial SR agreement
 - Questionable interoperability (need inter-op testing)
 - Component suppliers in “*wait and see*’ mode
 - Costs are far from being competitive
 - System houses seek workarounds
 - Avoid deploying costly SR interfaces

- > 100G
 - Open to invention!

System House Service Side Wish List



- > **Stable mechanical and interface standards**
 - No need for inter-op testing
 - Volume pricing

- > **Single fibre access for 40G and 100G (as opposed to ribbon)**
 - Ease of CO operation (fibre routing, splicing, etc)
 - Fibre management in system common equipment

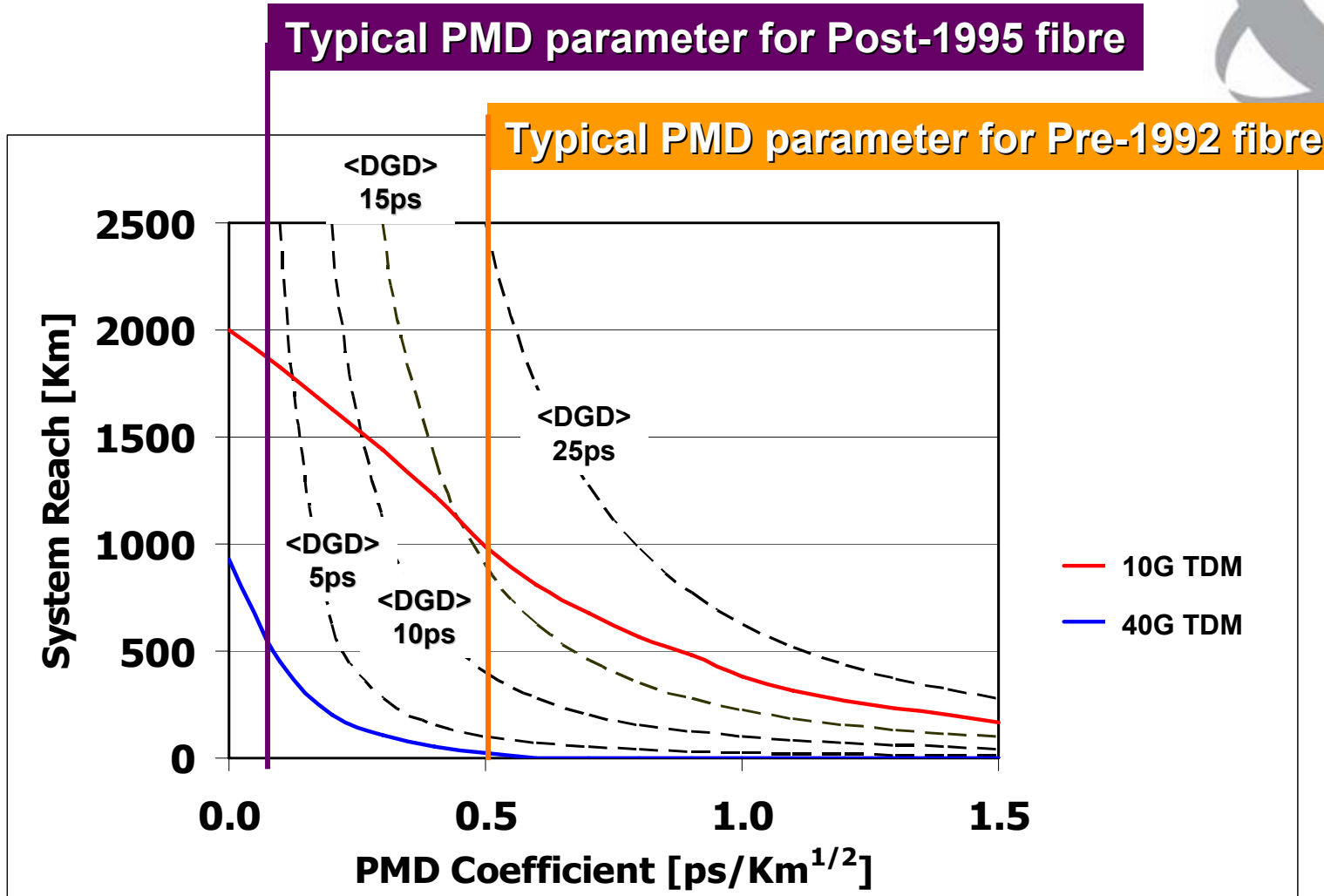
- > **No line buildout up to distances of at least ~2km**
 - Ideally ~40 km “campus wide”
 - Parallel implementation
 - **N** lanes at **Y** Gbps/lane
 - Ideally **Y** should be common for 40G and 100G
 - Low cost enough per **Y** Gbps such that no requirements for changing **N** in the field
 - Technology should survive a few generation of service interface
 - No discontinuity as today with 40G
 - Compatible with future service requirements

Fiber related line rate constraints

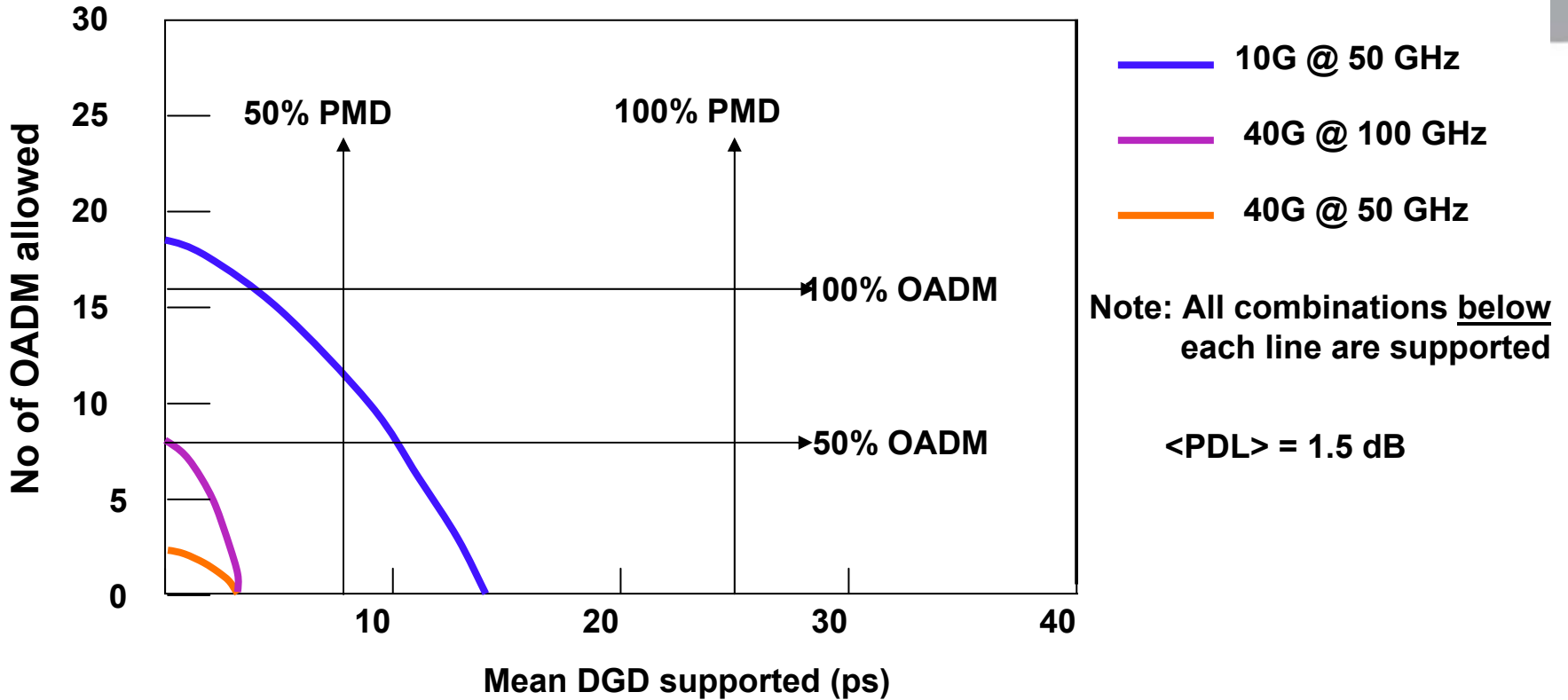
	10G	40G	100G	
Bit interval reduction	100ps	25ps	10ps	Increased system impact of optical filters Constraints on Line ingress/egress
Electrical BW increase	1	4	10	
Optical Spectrum occupancy	1	~4	~10	
Chromatic dispersion tolerance	1	1/16	1/100	More stringent dispersion map Increased installation difficulties Need to be engineered day one May need active CD compensators
PMD tolerance	1	1/4	1/10	Practical solution requires active compensator Special fibre
Noise margin	0dB	-6dB	-10dB	Generalized Raman deployment Shorter amplifier spacing

Significant optical challenges

PMD impact on Reach



Metro & Regional PMD and OADM coverage



> 40G TDM can barely meet practical network transport conditions

- No room to maneuver and do margin trade off
- Severe impact in practical engineering conditions



Addition to the system tool box for 40G/100G TDM

1. Higher Speed electronics and opto-electronics
2. Optical filters with tighter specs
3. Tunable Chromatic Dispersion compensation
4. Tunable PMD compensation

40G TDM enabling technologies



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6. New fibre plant

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100G TDM enabling technologies

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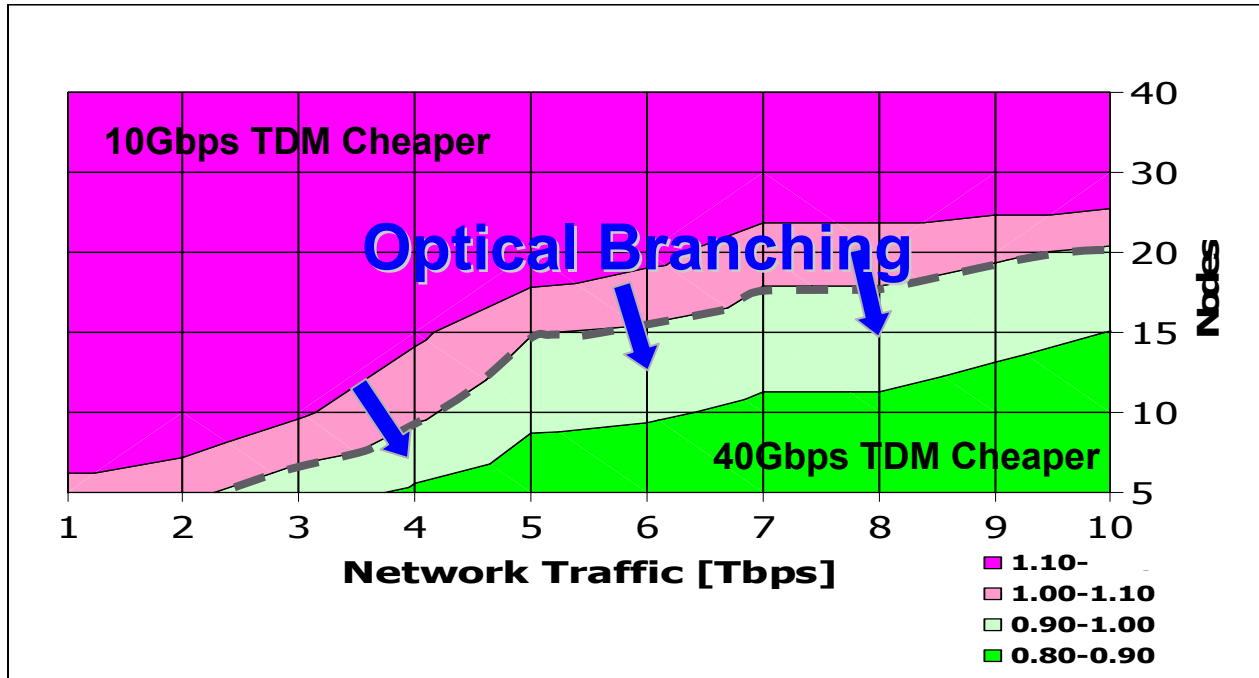
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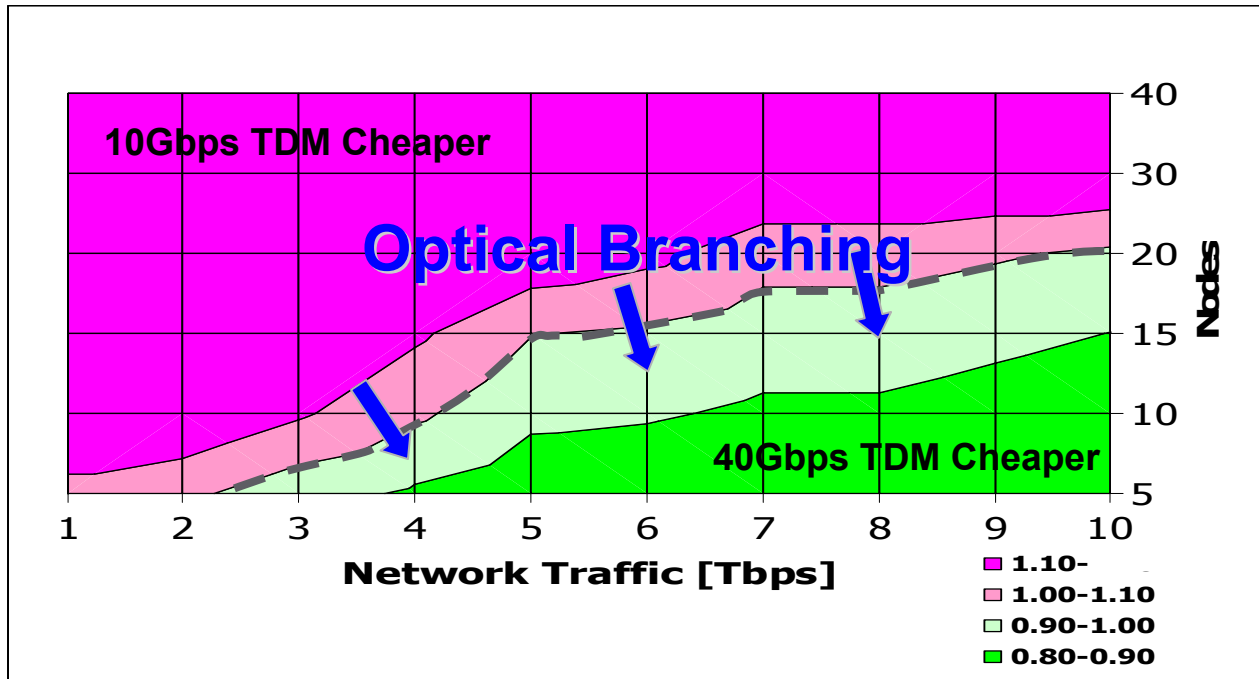
TDM technologies are hard pressed to meet 40G and 100G system requirements

Is 40G or 100G TDM expected to enable similar network to that of 10Gbps?

Network Economics

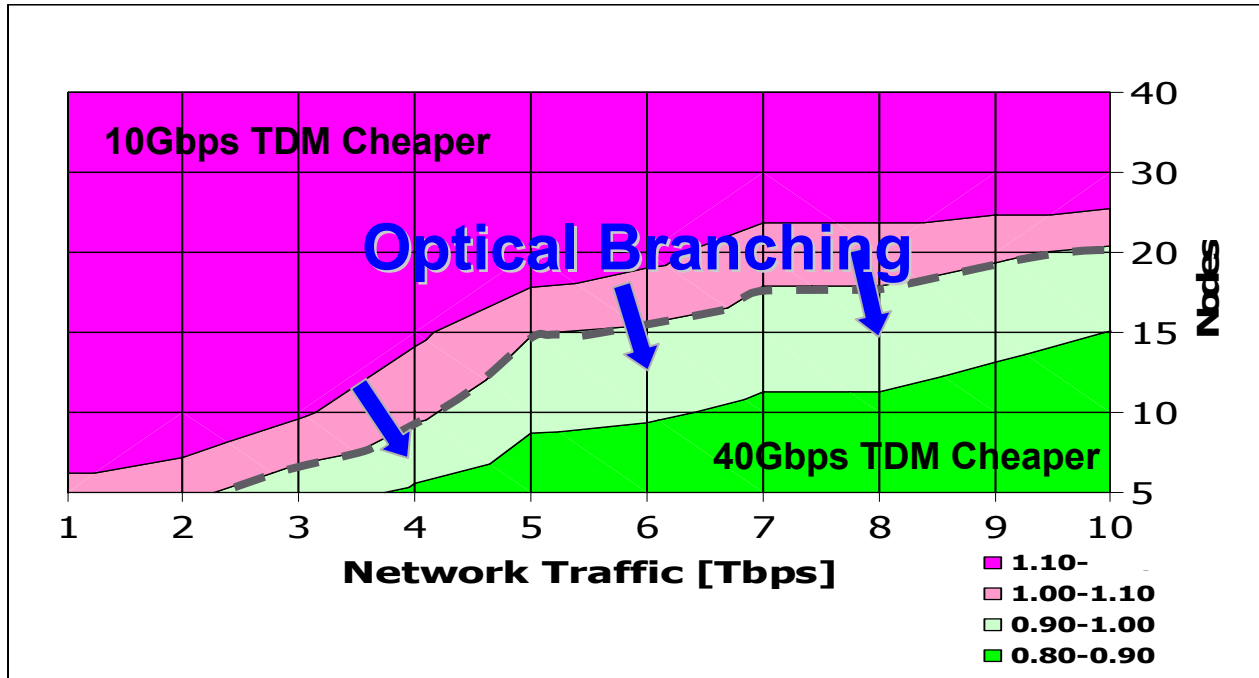


Network Economics



- > The majority of applications have better economics at 10Gbps (65%)
 - Optical features such as branching increases 10Gbps prove in!

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> 40Gbps TDM does not allow the construction of the same network

- Is this a problem?



Statement of Work for a Mainstream Transport Solution

> Transport cost reduction of existing services

> **BUT** fully compatible with a 10 Gbps line design

- Use same deployed amplifier system as 10Gbps
- Same reach as 10G system
- Have same OADM and Branching capability
 - *All routes always possible!*
- Have PMD/PDL specifications at least as tolerant as 10Gbps
- Use same platform as 10Gbps

10Gbps performance at less than 10Gbps cost



Requirements for a Mainstream Transport Solution

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Are these requirements valid?

Comments



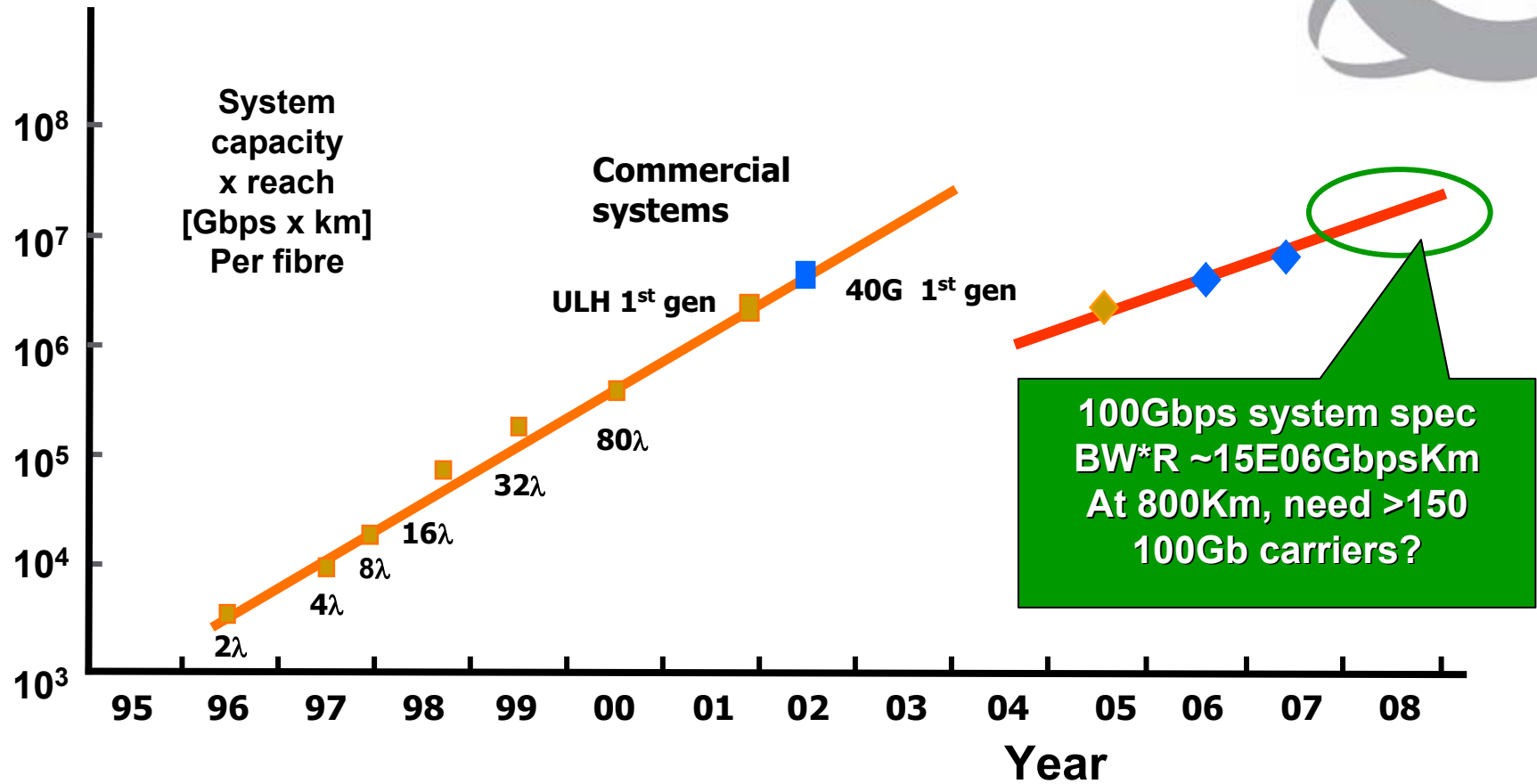
> 40G will happen

- Already deployed by carriers
- Key element still missing is SR 40G interface with suitable economics WRT 10G equivalent

> At 100G, industry still in infancy, but few statements can be made

- Too early choices may be ruling out significant technical discontinuity
- 100G will push further the separation Service Rate-Line Rate
- Several requirements need to be modified
 - Line Ingress/Egress, Impairment mitigation, Optical routing, Amp spacing, etc
- Economics may not allow a novel fibre plant for accommodating transmission at an higher line rate
 - What will be the transport technology of choice?

High-capacity Transport Evolution



To keep up technical discontinuity is required

