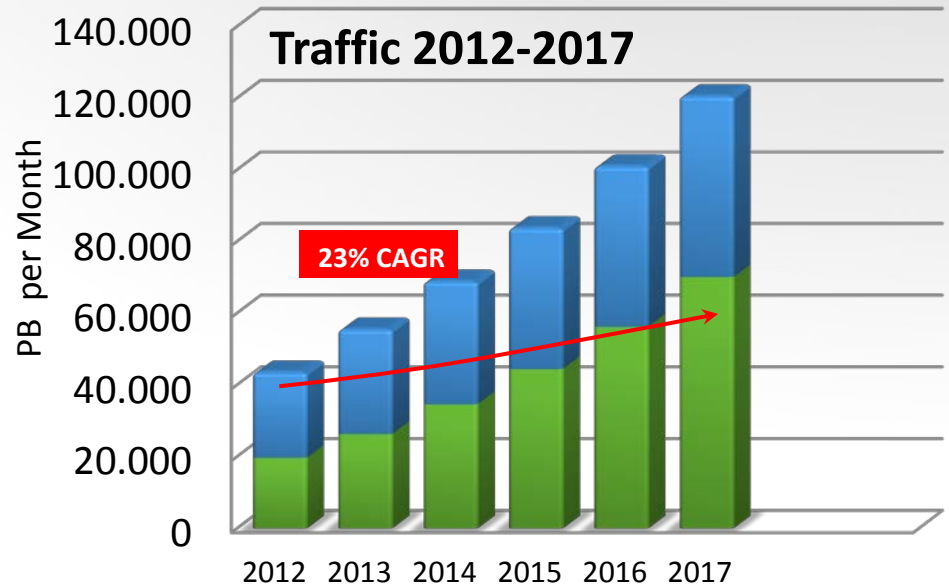


UKNOF29 Metro 100Gig options

Metro traffic to grow 3x over next 5 years...



- Metro-only traffic will surpass long-haul traffic in 2014.
- Metro-only traffic **will grow nearly twice as fast** as long-haul traffic from 2012 to 2017.
- If you have a 40-channel 10G DWDM system filled at 50% capacity (= 200 Gbps) today, **you will need to upgrade that system in the next two years**

Is 100Gbps Today's Solution for Everything?

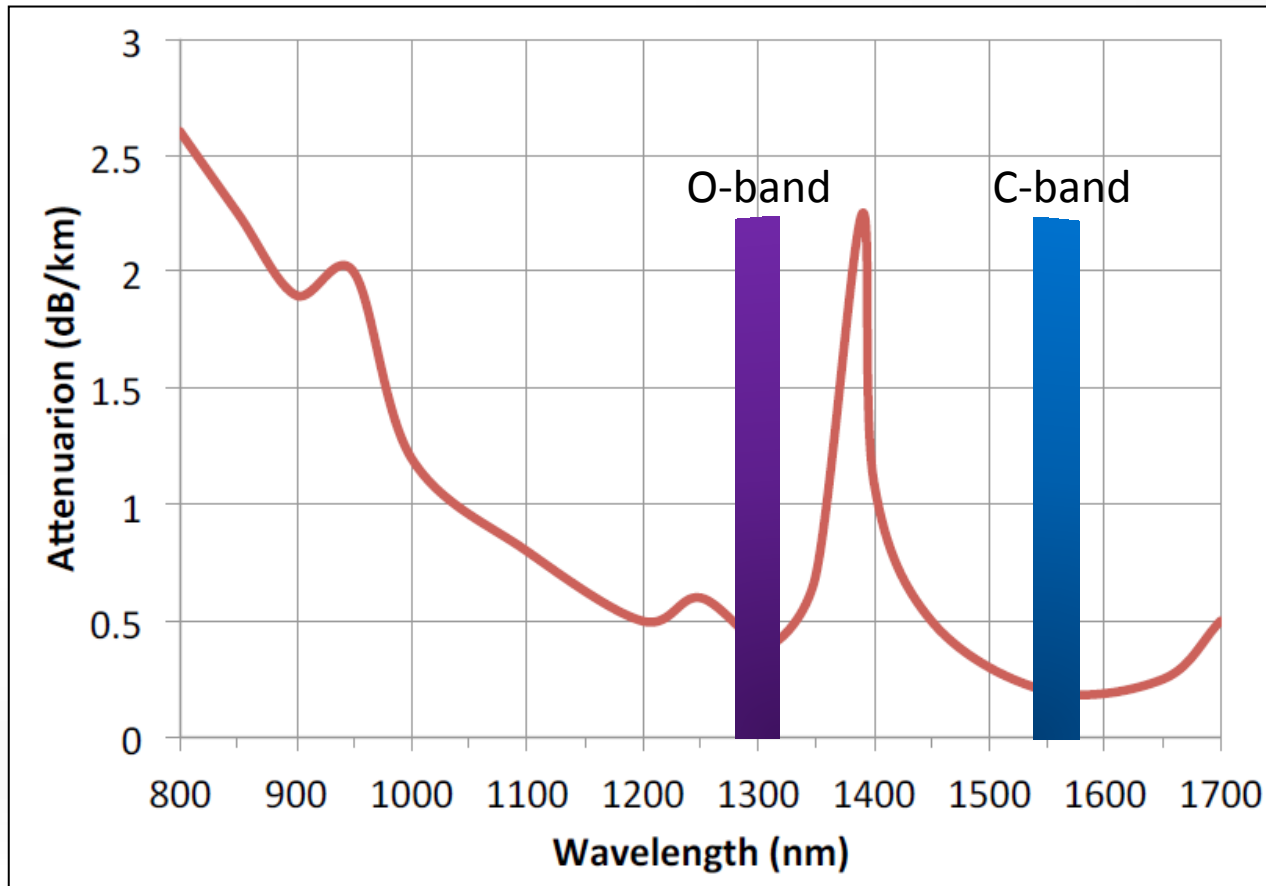
- NO! It depends...
- 100G price / bps is still (and will be for some time) higher than at 1G/10G
- E.g. 100GBase-LR4 roughly 100x 10GBase-LR pricing (“only” ca. 40x at DWDM)
- Higher complexity of 100G transport may add further cost (e.g. DCUs etc)
- So when does it make sense today / nearer term future?

■ Andrew Schmitt from Infonetics, October 2013:

"It is only used (today) when service providers must use it, which means 1 of 2 situations:

- *insufficient fiber (and WDM) capacity to deploy more 10G traffic*
- *a 100G private line service that needs to be delivered – a 100G router port that must be sent across the metro"*

Optical Transmission Windows



100Gig LR4 CFP

- Supported by many vendors
- 100G Ethernet IEEE 802.3ba (103.1Gb/s)
- 4 x 25G LAN-WDM
- Power <24W
- Maximum distance <10km
 - *Can be extended with pre-amplification*

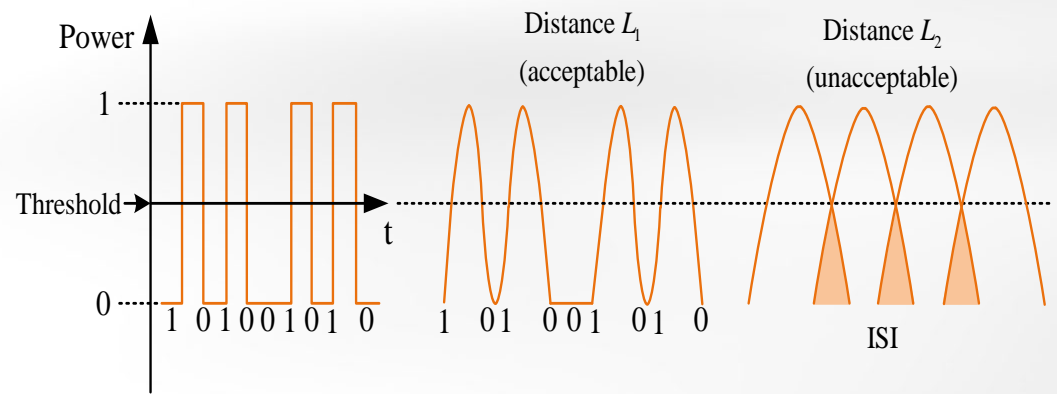


100G Direct Detect or Coherent?

Competing transceiver / transponder technologies

- Coherent versus Direct Detection
- Technical issues:
 - FEC
 - Power
 - Dispersion

What is Dispersion?



100G Coherent

- Developed for Ultra-Long Haul - Adapted for metro
- Complex phase & amp modulation, hence less sensitive to CD & PMD, so wider reach
- 1 lambda per 100G used
- Power 85W
- NOT available as pluggable, “street” availability not before 2015 (cost remains a BIG challenge)
- Price is ~ 3 to 4 times cost of Direct Detect

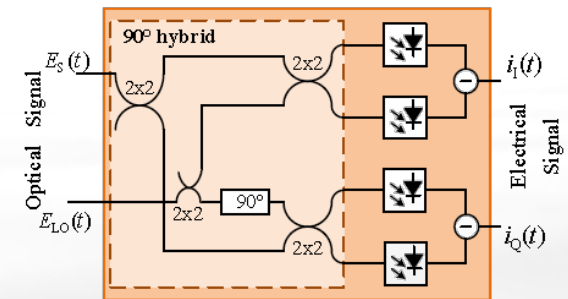
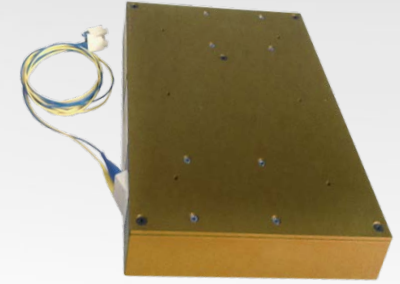


Figure 2: Coherent detection using optical 90° hybrid and balanced photodiodes

100G DWDM Direct Detect

- Based on simpler PDs, reach limited by CD & PMD
 - 4 x 25Gb/s per 100G used
 - 50Ghz or 100Ghz ITU-T grid
 - Fixed
 - Tunable
 - IEEE 803.3ba
 - Power < 24 W
-
- Produced by >5 module makers in 100Ks since 2011
 - *Price ~ 25% - 30% cost of Coherent*



100G Passive Metro Network Architectures

	100G in O Band		100G in C Band	
	Single Circuit 100G	10G DWDM + 100G overlay	10G DWDM + 100G DWDM overlay	100G DWDM
Maximum capacity	100 Gbps (= 1*100G)	500 Gbps (= 1*100G+40*10G)	1.6 Tbps (=12*4*25G+40*10G)	2.4 Tbps (= 24*4*25G)
Number of wavelengths	1	41	88	96
Number of transceivers	1	41 (1*100G, 40*10G)	52 (12*100G, 40x 10G)	24 (24*100G)
Maximum distance	10 kms (no amp) Up to 60 kms (SOA)	< 10 kms (no amp) Up to 60 kms (SOA)	< 100 kms (EDFA)	< 100 kms (EDFA)
Typical transceiver	CFP 100GBASE-LR4	CFP 100GBASE-LR4	CFP DWDM (direct detect)	CFP DWDM (direct detect)

100G DWDM over C-band

■ Requirements 100Gbps DWDM CFP transceiver module

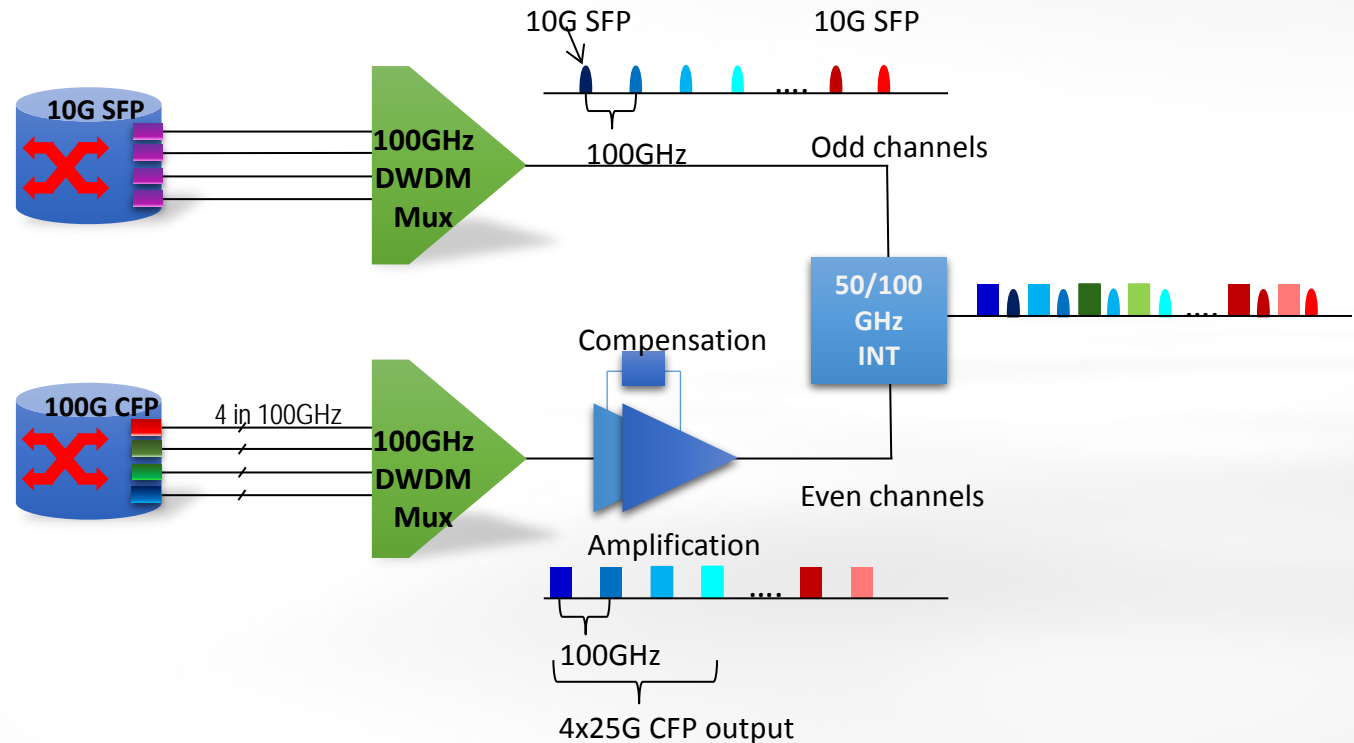
- Transports 4x25Gbps
- Four single mode duplex fibers
- Employs 4 tunable lasers in the 50GHz ITU-T channel grid (DWDM) and 4 receivers



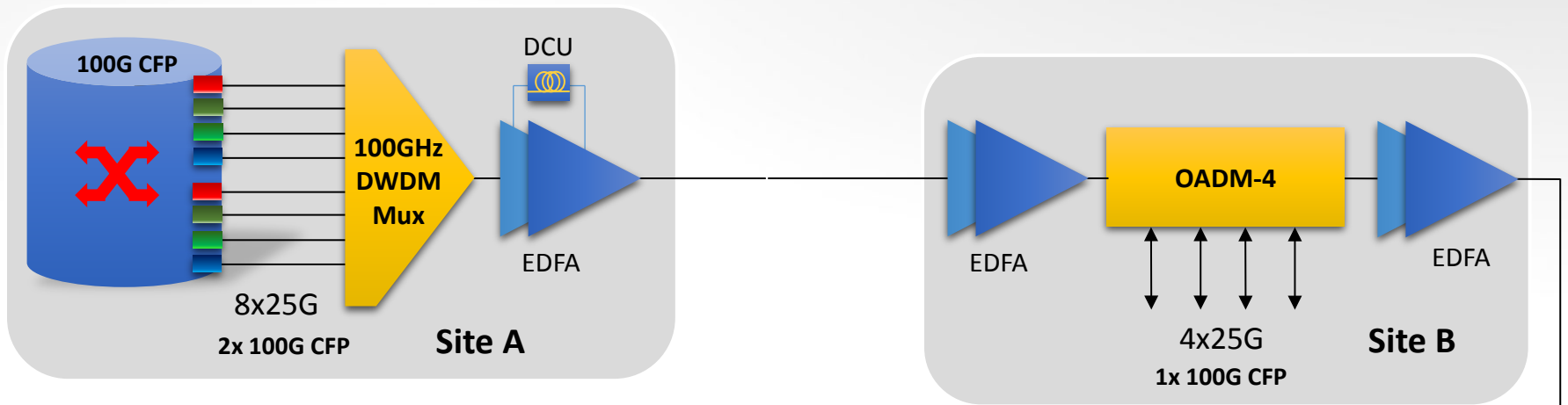
■ Requirements DWDM multiplexers/demultiplexers

- Passive DWDM mux/demux with 50GHz grid over a single mode fiber pair
- Up to 24 "differently colored" 100Gbps DWDM CFP transceivers can be transported via a 96 channel MUX
 - Reach extendable with standard, stand-alone EDFAs to >100kms

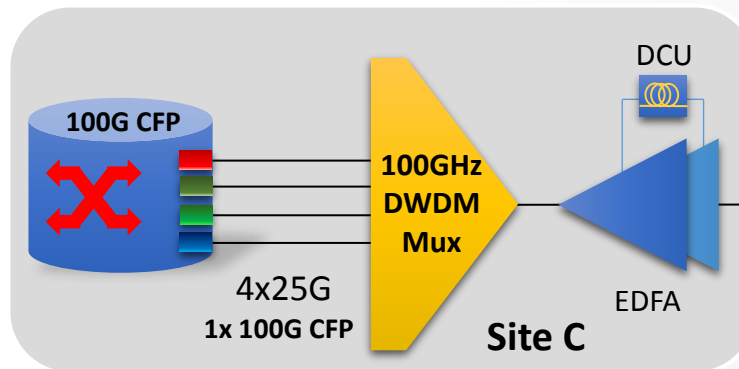
Overlaying 10G DWDM with 100G (C-Band)



Complementing the existing 10Gbps DWDM system with 100Gbps upgrades



100G OADM example scenario



Multiple 100G DWDM in non FEC environment

Vendor	100G DWDM Direct Detect	100G Coherent
Extreme	Q4 2014	? *
Brocade	√	? *
Juniper	√	? *
Alcatel	√	? *

? * - We don't know current status of testing

100Gig DWDM direct detect testing

- 20km, 40km and 60+km - without central location for multiple 100G DWDM services in 100GHz grid
- Proven to work with existing DWDM 10G
- Long term stability over temp 20-50°C (cycled) running stable over 350hrs (2 weeks)

Conclusion

- 100Gbps is still not making sense for all Metro connections but has become a valid solution for fiber constraint areas and native 100G port transport
- 100Gbps Passive Transport has become a powerful, simple and low(er) cost alternative to NEM based Active Transport Solutions



- Coherent Pluggables may become a good alternative to Direct Detect Pluggables, but price remains major issue



Thank you.

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