



BROCADE

CORNING



LOW COST 100GBE LINKS

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Total Cost of Links

- This presentation explores the total cost of links including the connectivity cost (connectors, fiber, and hardware like fanout cassettes) and the module costs
- The connectivity cost has become more significant at 100GbE since we aren't using duplex fiber pairs for all links
 - 24-fiber ribbon connectivity is more costly than 2 duplex fibers, but by how much more?
- The module cost estimates are based on LightCounting data when it is available, but the new variants are not part of their forecasts
- The connectivity cost estimates are based on Corning Cabling System costs
- The costs are estimated for 2014 when these second gen 100GbE systems should be available.

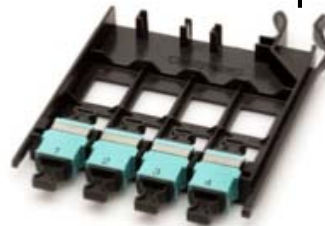
The Link Model

- The link that we have calculated is based on the double link channel which should be used as worst case and is shown below:

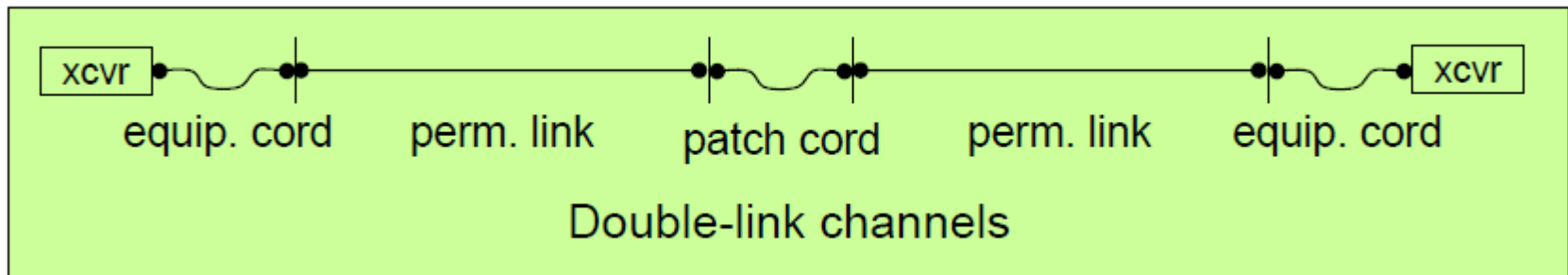
LC to MTP Converter



MTP to MTP Adapter



3 MTP to 2MTP Converter



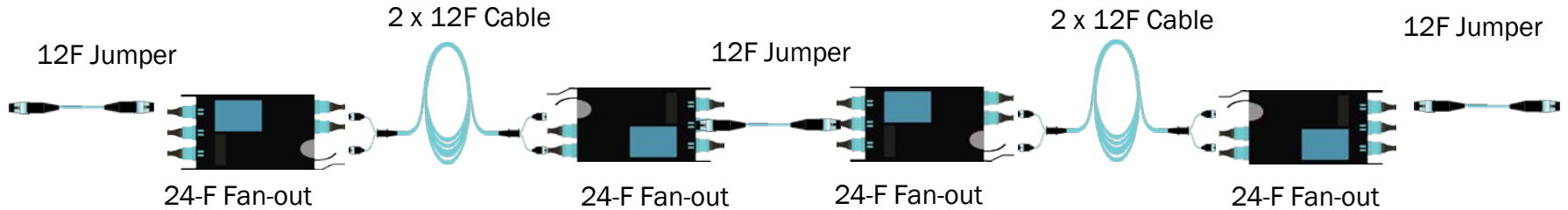
Source: Kolesar_02_0911_NG100GOPTX.pdf

3 Link Scenarios

2 Channel Model for 100GBASE-LR4 and NR4 with WDM



8 Channel Model for 100GBASE-SR4 and 100GBASE-NR4 no WDM



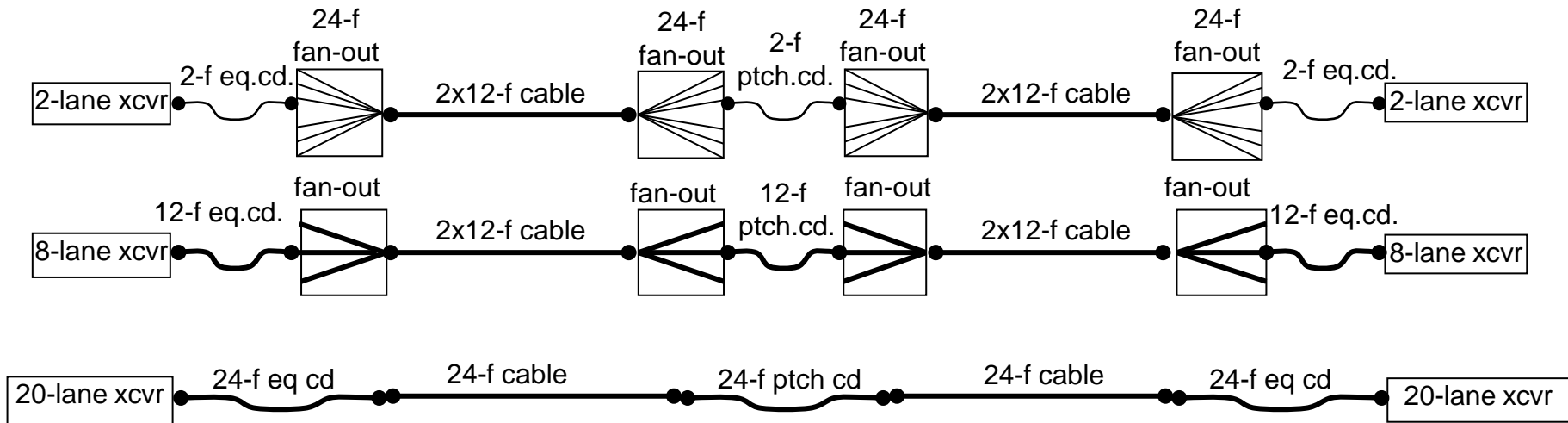
10 Channel Model for 100GBASE-SR10



3 Scenarios

NR4 is a new SM PMD between 500m and 2km. We evaluate two flavors “with WDM” or “no WDM”.

PMD	Fiber Needed	Fibers in the Model
100GBASE-SR10	20	24
100GBASE-SR4	8	8
100GBASE-NR4-SM no WDM	8	8
100GBASE-NR4-SM with WDM	2	2
100GBASE-NR4-PAM	2	2
100GBASE-LR4	2	2



Source: Kolesar_02_0911_NG100GOPTX.pdf

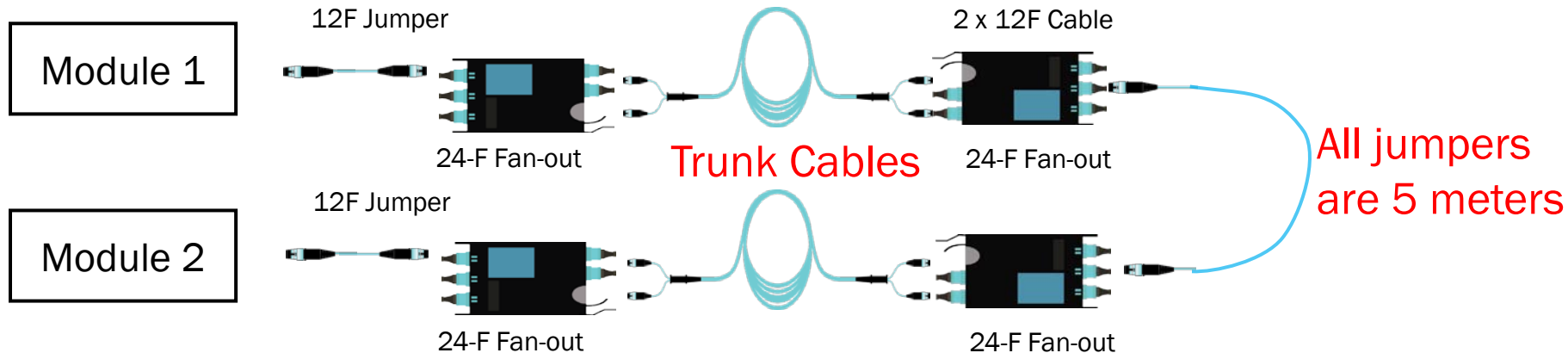
Connectivity Costs in Detail

Link Cost = Connectivity Cost + Cost of 2 modules

Connectivity cost = hardware cost + (fiber cost/m) * link distance (m)

Hardware cost is constant for a given PMD and the fiber cost varies with the distance of the link that varies from 25m up to 1000m where appropriate

We varied the length of trunk cables to see how the costs changed with distance



The module and hardware cost is fixed for a given PMD

Model Assumptions

NR4 is the new SM PMD

PMD	Max Distance (m)	Fiber Count	Relative Connectivity Cost /Circuit at 100m
100GBASE-SR10-OM3	100	24	1.53
100GBASE-SR10-OM4	150	24	1.78
100GBASE-SR4-OM3	100	8	1
100GBASE-SR4-OM4	150	8	1.13
100GBASE-NR4-SM no WDM	2000	8	0.81
100GBASE-NR4-SM with WDM	2000	2	0.24
100GBASE-LR4-SM CFP2	10000	2	0.24
100GBASE-LR4-SM CFP	10000	2	0.24

The connectivity values were normalized to this value which is not the same as the cost of SR4 on slide 9

Single-mode connectivity very cost effective

Module Assumptions

Cost Normalized to SR10

SR4 and SR10 Assumed to be the same cost in 2014

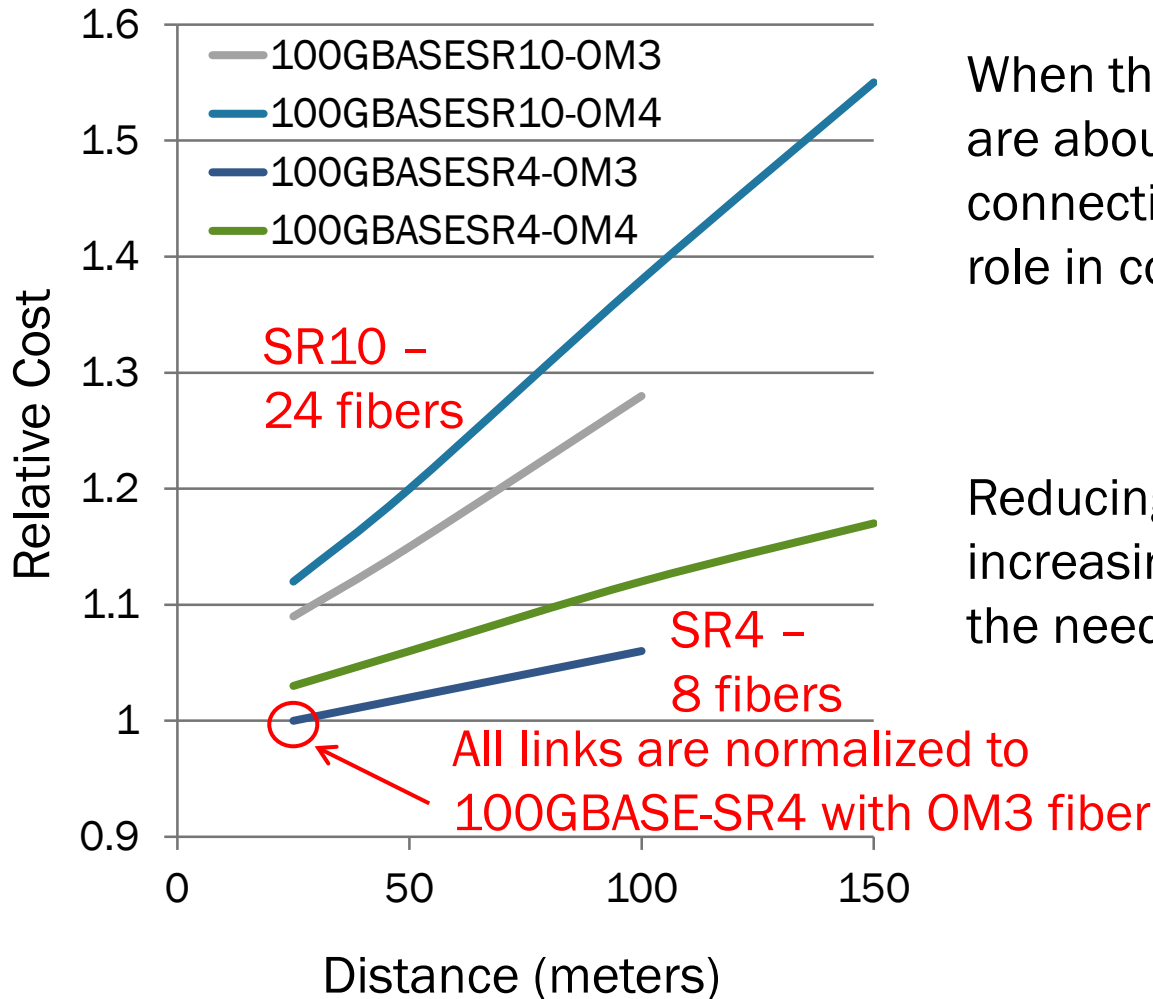
PMD	Max Distance (m)	Relative Module Cost	Range
100GBASE-SR10	150	1	1
100GBASE-SR4	100	1	0.8, 1.2, 1.6
100GBASE-NR4 no WDM	2000	5	1, 3 - 6
100GBASE-NR4 with WDM	2000	6	5-8
100GBASE-LR4-SM CFP2	10000	25	5-25
100GBASE-LR4-SM CFP	10000	32	15-32

Slide 11 shows this

Slide 13 shows this

Based on 2010 LightCounting Forecasts

Multimode Link Cost Analysis



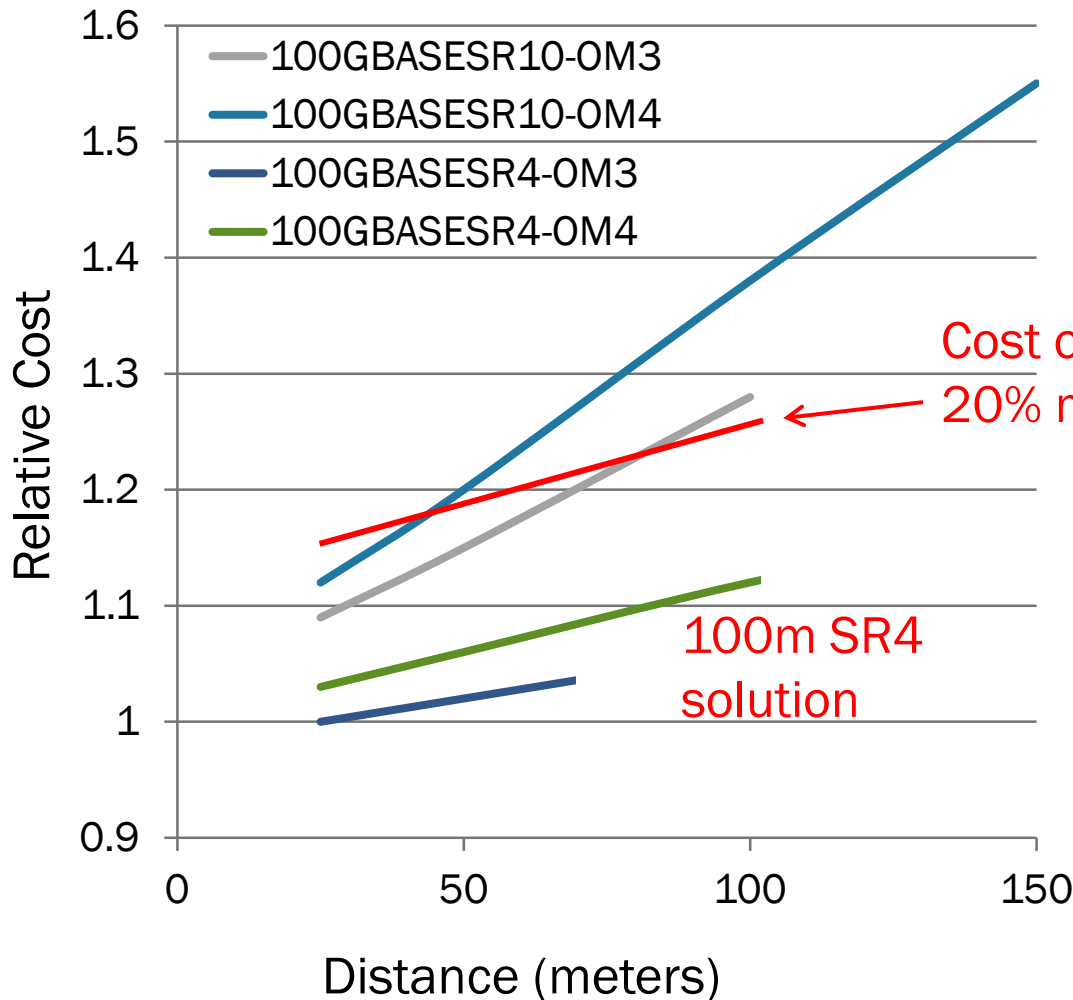
When the SR10 and SR4 modules are about the same cost, the connectivity costs play a significant role in cost of the link.

Reducing the fiber count and increasing the port density drive the need for an SR4 solution

Will SR4 only go 100 meters on OM4?

Optics is significant cost of link

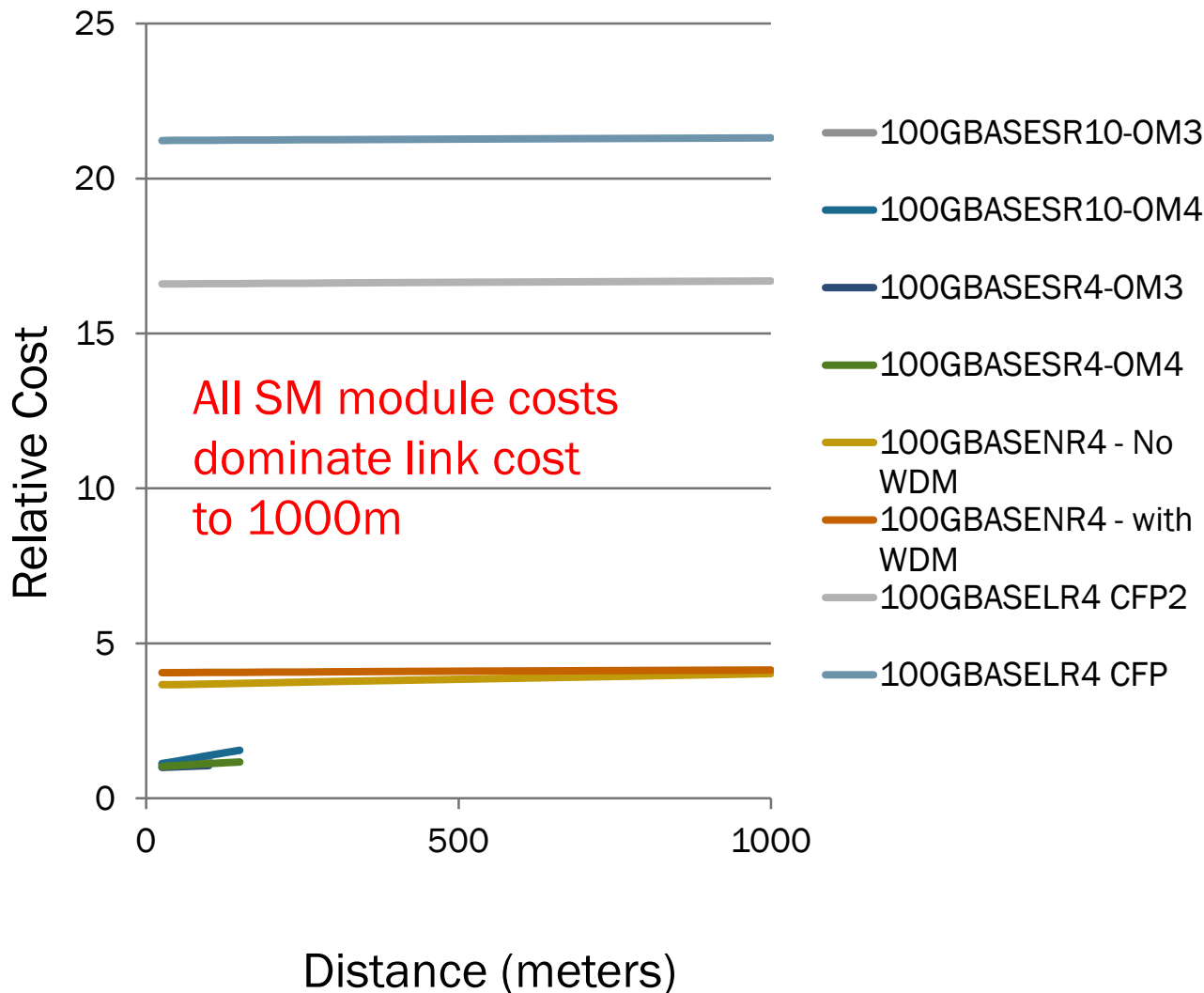
SR4 will likely only go 100 meters if it wants to be cost competitive with SR10 – the previous slide assumes the same cost for SR4 and SR10.



Cost of SR4-OM4 link if SR4 module is 20% more costly than SR10 module

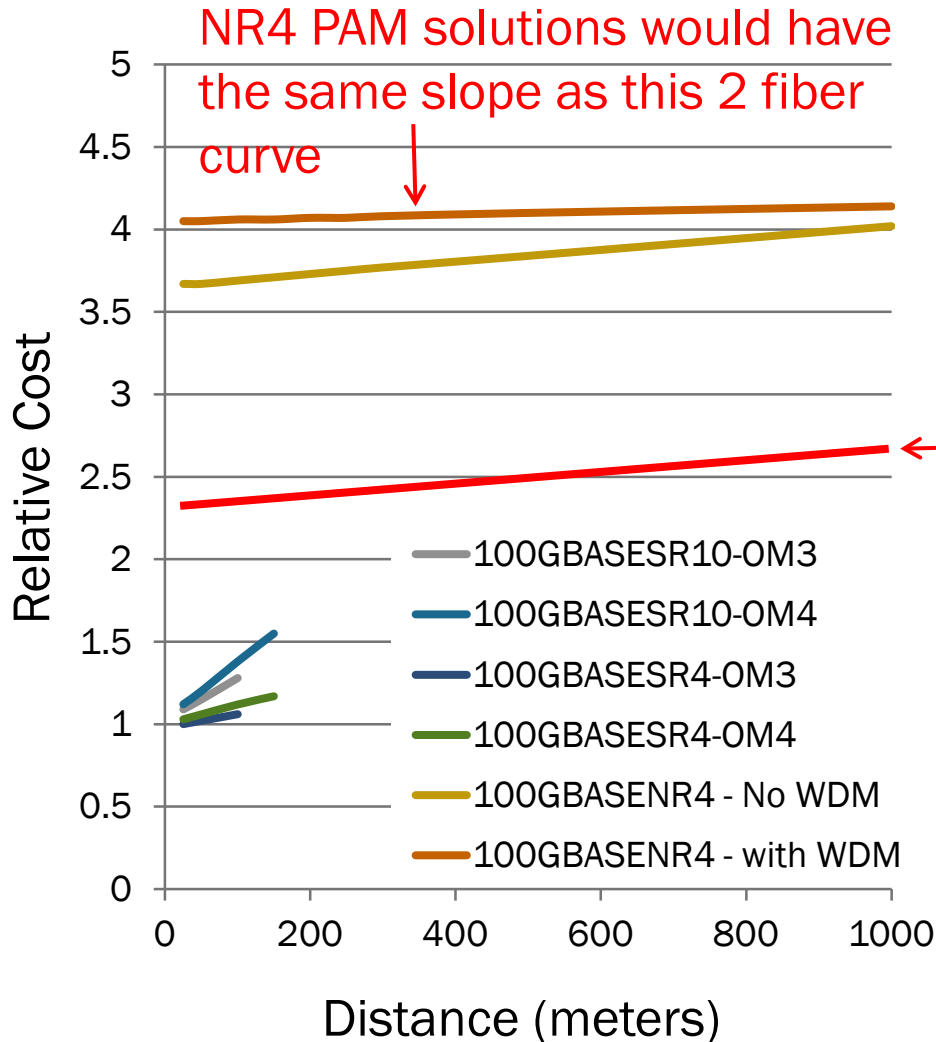
If longer distance is supported in SR4, the cost will likely exceed the cost of SR10 and then we'd have conflicts in what solution is lowest cost depending on distance?

Single-mode Link Cost Analysis



The connectivity costs don't play a significant role in single-mode links. The link cost is dominated by the module cost.

NR4 WDM vs No WDM for 100GBASE-NR4



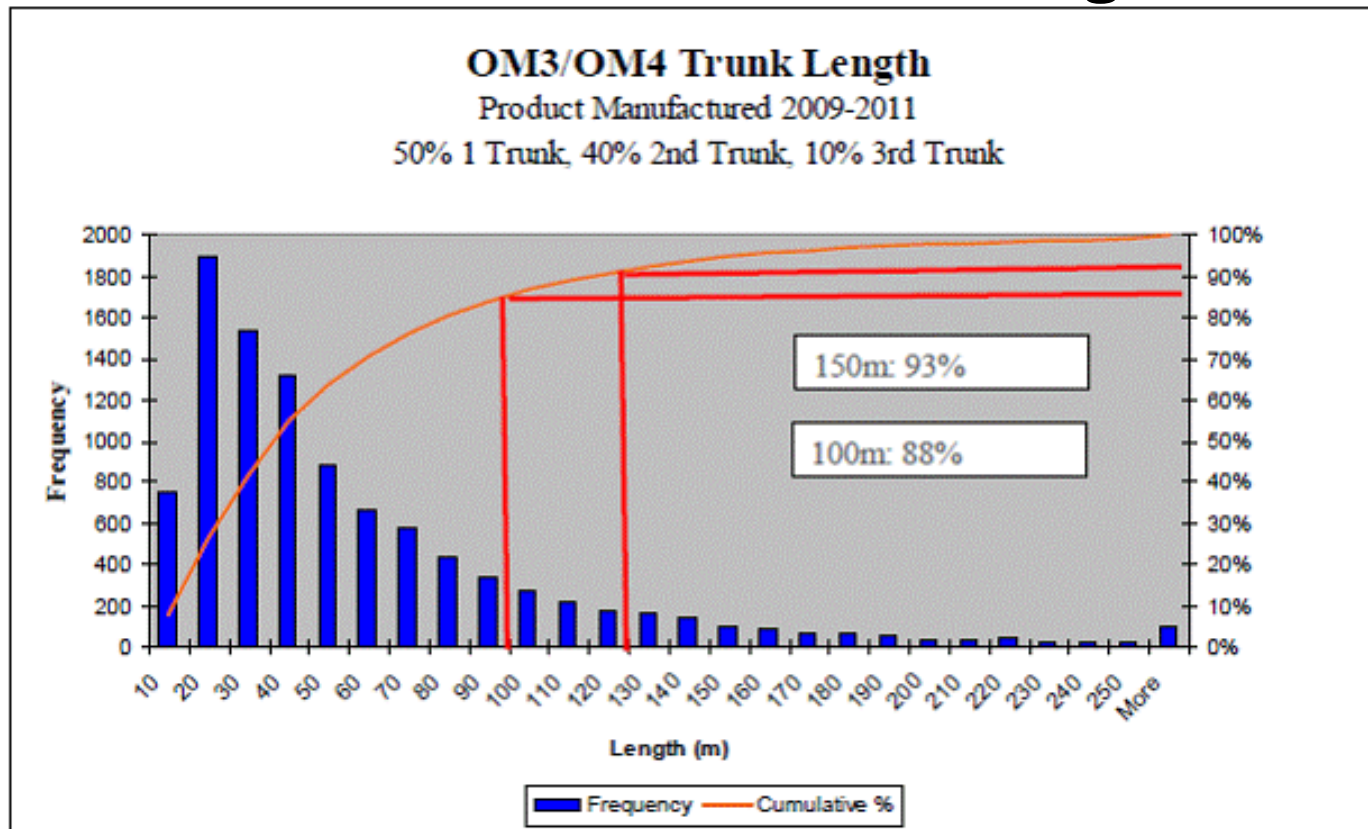
NR4 no WDM (8 fibers) is assumed to be 20% less cost than NR4 with WDM (2 fibers). The NR4 no WDM is less cost up to 1000m.

← This line shows where the cost of the link would be when NR4 no WDM is about half the cost of NR4 with WDM or 3X the cost of SR4 modules.

Link Distributions

Links are only getting longer

- If SR4 link only goes 100 meters, the market will drive about 12% of the market to SR10 or single-mode



Source: Corning

The Main Gap That Needs a Solution

Links over 150 meters within the data center

- For MM links, the module cost and the connectivity costs are significant because they are close in value and the fiber is expensive
- For SM links, the cost is driven by the module
 - Fiber cost doesn't vary much from 2 or 8 fibers but hardware cost does
- The main gap that needs to be filled in this 100G Optics project is the need for a low cost solution beyond 150 meters in the data center
- From the Kolesar Calculator, 4-15% of links in 2010 were longer than 150m
 - Between cells Q19 and S20
- By 2015, the percentage of 100GbE links in the data center that go beyond 150 meters will be significant – probably 10%
- We need the following objectives:
 - Define a 100 Gb/s PHY for operation over at least 100m of MMF
 - Define a 100 Gb/s PHY for operation over at least 1 km of SMF



Thank You

