

Potential MMF objectives and the 5 criteria

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Intent

- Examples of potential MMF objectives are tested against the 5 criteria
 - Not an exhaustive study

1: Single PMD objective for 100G-SR4

“Define a 4-lane 100 Gb/s PHY for operation over OM4 with reach up to at least 100m”

- Broad Market Potential - covers 99% of data centre links
 - 100% of switch to server links, ~90% of switch to switch links
- Compatibility - compatible with IEEE 802.3 standard, 802.3 MAC, ...
- Distinct Identity - Unique 4-lane 100Gb/s PMD for operation on OM4
- Technical Feasibility
 - several low power techniques, including simple Tx and Rx equalization, and FEC, are available to meet 100m reach on OM4
- Economic Feasibility
 - Expected cost factors are lower for a 4-lane PHY than for a 10 lane PHY, given a 4x25G electrical interface. A 4-lane PHY is also expected to need significantly lower power.

2: Single PMD objective for 100G-SR4

“Define a 4-lane 100 Gb/s PHY for operation over **MMF with reach up to at least **100m**”**

- Broad Market Potential - covers 99% of data centre links
 - 100% of switch to server links, ~90% of switch to switch links
- Compatibility - compatible with IEEE 802.3 standard, MAC, ...
- Distinct Identity - Unique 4-lane 100Gb/s PMD for operation on MMF
- Technical Feasibility
 - several low power techniques, including simple Tx and Rx equalization, and FEC, are available to meet 100m reach on OM4; there is higher technical risk for 100m on OM3.
- Economic Feasibility
 - Expected cost factors are lower for a 4-lane PHY than for a 10 lane PHY, given a 4x25G electrical interface. A 4-lane PHY is also expected to need significantly lower power .

3: Dual PMD, dual reach objectives

“Define a 4-lane 100 Gb/s PHY for operation over OM4 with reach up to at least 150m”

“Define a 4-lane 100 Gb/s PHY for operation over OM3 with reach up to at least 50m”

- Broad Market Potential - combined coverage of 99.5 % of data centre links
 - switch to server links:
 - 90 to 95 % covered by 50m OM3 PMD, (5 to 10 % need 150m OM4 PMD)
 - switch to switch links
 - 55 to 75 % covered by 50m OM3 PMD, 20 to 40 % covered by 150m OM4 PMD, 5 % require another longer reach PMD. *The 150m OM4 PMD covers ~ 7 to 14 % of data centre links*
- Compatibility - compatible with IEEE 802.3 standard, 802.3 MAC, ...
- Distinct Identity – overlapping dual 4-lane 100Gb/s PMDs for MMF
- Technical Feasibility – at risk for 150m reach on OM4
 - 150m reach on OM4 is expected to need FEC, Tx equalization and strong Rx equalization. Nothing left in the known, low power toolbox to mitigate technical risks (25G VCSEL performance and MPN).
- Economic Feasibility
 - Expected cost factors are similar for a 150m reach 4-lane PHY and a 150m 10-lane PHY, given a 4x25G electrical interface. A 4-lane PHY is expected to need lower power.
 - Expected cost factors for a 50m OM3 PMD and a 150m OM4 PMD are within ~10%
- *150m and 50m may not be the ideal reach targets for dual PMD objectives (the PMDs would have a lot of overlap).*

4: Single PMD, no reach objectives

“Define a **low power, low cost** 4-lane 100 Gb/s PHY for operation over **MMF**”

- Broad Market Potential
 - unknown coverage of data centre links, or any other application
- Compatibility - compatible with IEEE 802.3 standard, 802.3 MAC, ...
- Distinct Identity - unique 4-lane 100Gb/s PMDs for operation on MMF
 - But unless broad coverage is achieved on MMF, it is implicit that some other MMF PMD will be needed.
- Technical Feasibility
 - no promises made - so by design ?
- Economic Feasibility
 - It's difficult to demonstrate a cost vs performance advantage without a performance target.
- *The lack of a reach objective means Broad Market Potential and Economic Feasibility are difficult to demonstrate.*

5: Single PMD, dual reach objectives

“Define a 4-lane 100 Gb/s PHY for operation over 100m on OM4 & 70m on OM3”

- Broad Market Potential- covers 99% of data centre links
 - 100% of switch to server links, ~90% of switch to switch links
- Compatibility - compatible with IEEE 802.3 standard, 802.3 MAC, ...
- Distinct Identity - unique 4-lane 100Gb/s PMD for operation on MMF
- Technical Feasibility
 - several low power techniques, including simple Tx and Rx equalization, and FEC, are available to meet 100m reach on OM4
 - If two reaches on different fibres are specified, it is difficult to tell which will be the limiting application. We are likely to end up with added constraints on the prime reach objective in order to meet the second.
- Economic Feasibility
 - Expected cost factors are lower for a 4-lane PHY than for a 10 lane PHY, given a 4x25G electrical interface. A 4-lane PHY is also expected to need significantly lower power.
- *The dual reach objective risks adding constraints (cost) to the prime reach objective in order to meet the second. Better to let the second reach fall out of the task force technical work.*

6: Notes on an objective for Active Optical Cable

- An electrical interface definition is sufficient
 - no accessible optical interface for an AOC
- Nothing more for IEEE to do !

7: Notes on an MMF objective for un-retimed modules

Needs an electrical objective:

“Define an **un-retimed 4-lane 100Gb/s electrical interface for chip to module applications”**

- Broad Market Potential – possibly ... what can be plugged into it ?
 - Compatibility - compatible with IEEE 802.3 standard, 802.3 MAC, ...
 - Distinct Identity - unique 4-lane 100Gb/s un-retimed interface
 - Technical Feasibility - not demonstrated
 - Economic Feasibility – possibly ...what can be plugged into it ?
- *Technical feasibility needs to be demonstrated.*
 - *Link budgets for un-retimed modules with expected 25G VCSEL and Rx performance (power and jitter) do not close unless TP1 and TP4 jitter specs are significantly tighter than 802.3ba.*
 - *The optical interface specs for the retimed and un-retimed modules would differ.*

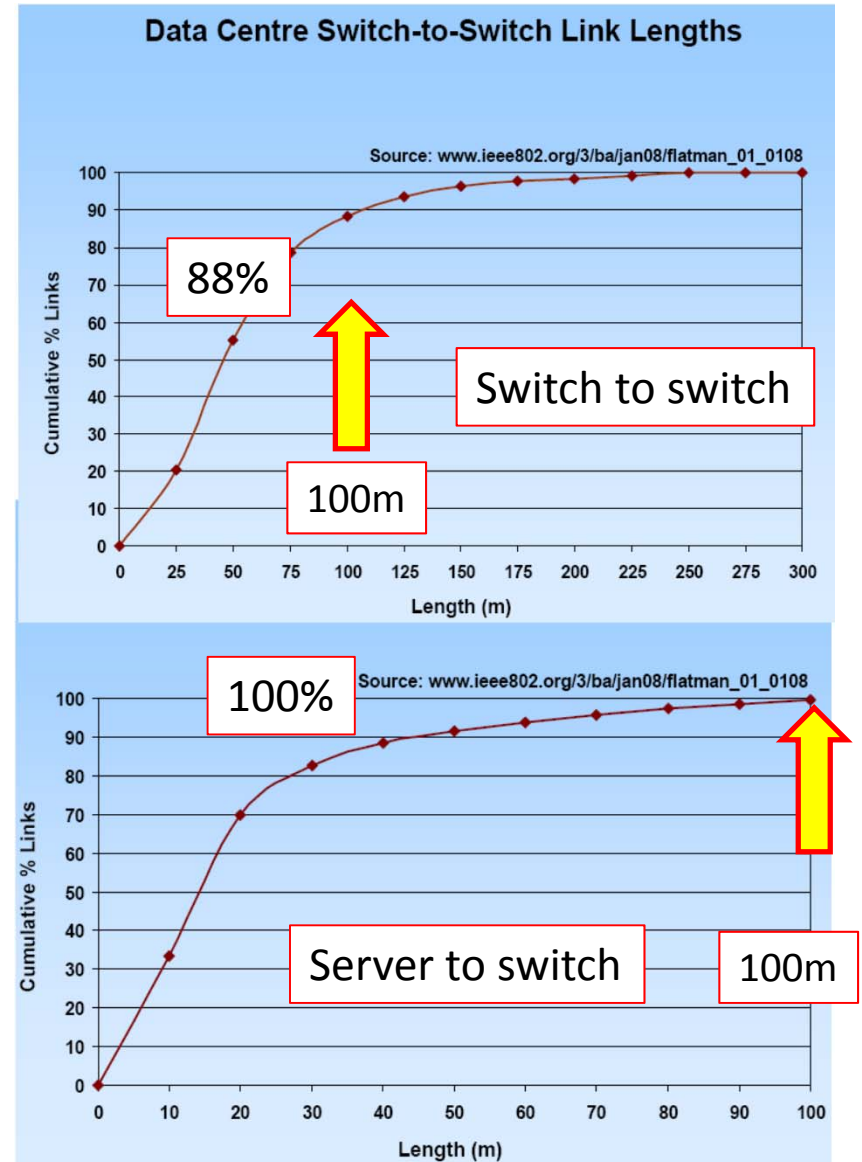
Summary

- A single PMD, single reach MMF objective meets all 5 criteria:
“Define a 4-lane 100 Gb/s PHY for operation over OM4 with reach up to at least 100m”
 - Equivalent reach on OM3 will fall out of the task force process.
 - If FEC were to be required to meet the objective, then reach with and without FEC will fall out of the task force process.
- An un-retimed MMF objective is lacking technical feasibility
- Active Optical Cables need only an electrical interface spec
 - Nothing more to be done here.
- Dual PMD, dual reach objectives may split the market without significant cost savings.

- Back up

Broad Market Potential

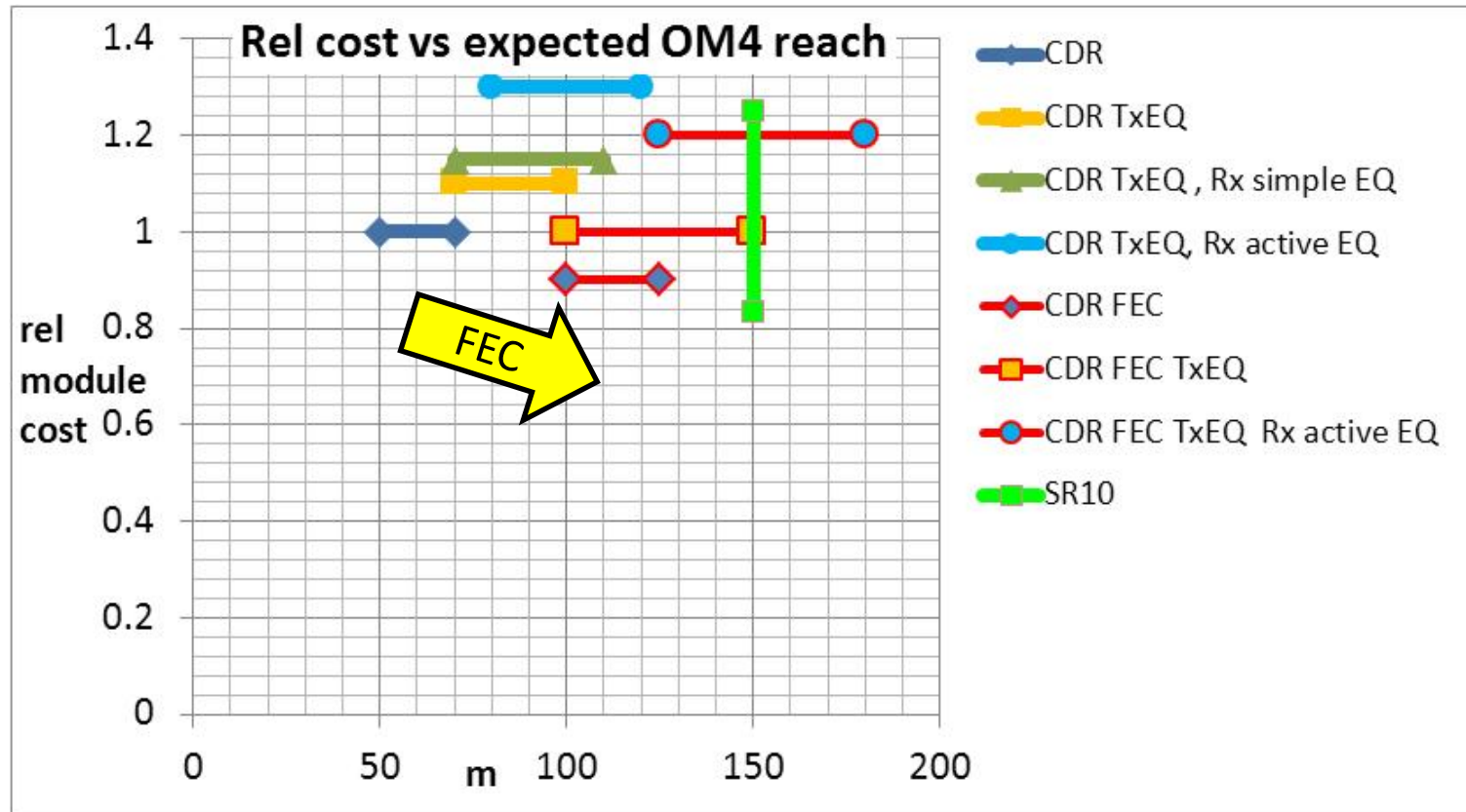
- Data Center link lengths
 - 100 m covers ~90% of switch to switch links
 - 100% of server to switch links
 - **Flatman_01_0911**
 - **Kolesar_01_0911**: good agreement for single link length distribution
 - Andy Moorwood, Infinera: “10’s of metres, weighted to low end... 100m reach on MMF may be good enough”
 - **From “Intra and Inter Rack Connectivity Requirements”, OIF Workshop January 16th 2012**
 - Mark Nowell, Cisco: “... at least 100m on latest multi-mode fibre”
 - Q&A after presentation of **Nowell_01_0911**
- HPC/server environment: <50-75m
 - **Pepeljugoski_01_1111**



Technical feasibility of retimed 4 x 25G optics

- VCSEL and receiver performance
 - 25Gb/s and 28Gb/s VCSELs and receivers have been demonstrated by several organizations
 - Most recently, OFC 2012
 - Expected performance for a fully retimed module
 - with FEC: 100m to 150m on OM4
 - without FEC: from 50 to 70m on OM4 for a simple retimed module
 - Up to 70 to 100m on OM4 with simple Tx and Rx EQ, with added cost and power compared to a FEC enabled module
 - Refs: *King_01_1111* and *Petrilla_01_0112*
 - Technical risk associated with high speed VCSEL characteristics and MPN can be mitigated by FEC and other known, low power (~30mW/channel) performance enhancements inside the module:
 - Mild equalization of optical Tx
 - Mild Rx chain equalization

Economic Feasibility: module cost vs OM4 reach



- Reach and relative cost numbers based on *King_01_1111* , range of reach values plotted for slow to fast VCSEL rise times)
- Relative cost of 100G-SR10 added, max/min consistent with *Petrilla_01_0112* and *King_02_0112*