100 Mb/s over Dual SM Fiber
Proposed PAR & 5 Criteria

Call for Interest

100BASE-FX over dual single-mode fiber

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Supporters

David Cunningham	Agilent Tech.
Larry Golob	Agilent Tech.
Robert Scharf	Stratos Lightwave
Rooke Sterling	Stratos Lightwave
Erland Sundberg	Telia
Matt Squire	Hatteras Networks
Jerry Radcliffe	Hatteras Networks
Steve Jackson	Hatteras Networks
Dora van Veen	Lucent
Trung Nguyen	NSC
Sergiu Rotenstein	Nbase Xyplex
Craig Easley	Extreme Networks
Lisa Peng	Corning
Hans Mickelsson	Ericsson
Torbjörn Palm	Ericsson
Ulf Jönsson	Ericsson

Proposed PAR for 100Mbps over dual SMF

- Proposal:
  - Specify a dual single-mode fiber extension to 100BASE-X
- Scope:
  - Make amendment to Clause 26, 100BASE-FX, to include a 100Mbps dual SMF PMD
- Purpose:
  - To make the 100Mbps PHY specification complete by including support for operation over dual *single-mode* fiber
  - Meet market requirements for Ethernet 100Mbps SMF as soon as possible (short time to market)
  - Extend the distance reach for Ethernet 100Mbps operation
  - Obtain interoperable equipment (802.3 “compatible” 100Mbps SMF TRx:s available but not always interoperable)
  - Obtain cost efficient applicability of SMF for lots of applications where 100Mbps is adequate

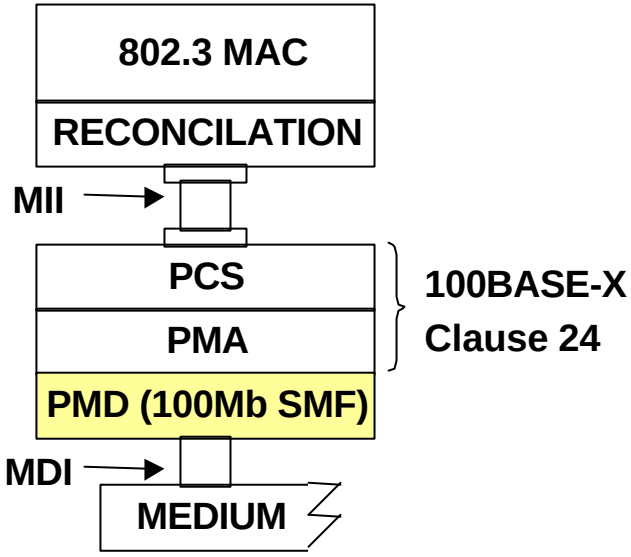
Broad Market Potential

- Market for 100Mbps fiber estimated to >3M installed links in 2-3 years

- Single-mode fiber preferred medium
  - high performance
  - long reach
  - forward compatible
  - low-cost fiber plant
  - only one type of fiber in the network
- 100BASE-X SMF is main candidate for volume applications in:
  - Residential (FTTH)
  - Commercial (SME, Shopping malls, etc.)
  - Industrial (`http://ethernet.industrial-networking.com`)
- Rapid growth anticipated in emerging areas
  - fiber to the radio base stations (FTTR)
  - fiber to WLAN HotSpots (FTTW)
  - fiber links connecting office desktops (FTTD)

Compatibility

- 100BASE-X PCS & PMA assumed, and the 802.3 MAC
  - No changes whatsoever to the MAC
  - PHY identical to current 100Mbps Std except for a new PMD
  - No change to Clause 24
  - Retain all state machines, 4B/5B coding etc. of 100BASE-X
- Only need to extend Clause 26, 100BASE-FX PMD, to include SMF
- Physical medium compatibility through SMF
  - Compatible with existing 1000BASE-LX
  - Provides upgrade paths to higher speeds and multiple wavelengths, with fiber plant untouched



Distinct Identity

- No IEEE 802 standard for 100Mbps over SMF exists

Only PMD missing,
minimum work

	100Mbps		1Gbps		10Gbps	
	MMF	**SMF**	**MMF**	**SMF**	**MMF**	**SMF**
Dual	100BASE-FX	**?**	1000BASE-SX 1000BASE-LX	1000BASE-LX	10GBASE-S 10GBASE-L 10GBASE-LX4	10GBASE-L 10GBASE-E 10GBASE-LX4

Technical Feasibility

- Mature and well proven technology
  - Many years experience with 100Mbps or higher rates on dual SMF
  - 100Mbps optical SMF components exist
  - Vendors can supply components, in volumes, immediately upon Standard completion
  - ‘Pre-standard’ links and systems already in commercial operation
- Minimal work; Base the specification on existing standards
  - FDDI 100Mbps SMF-PMD (ANSI X3.184-1993)
  - SONET OC-3 / STM-1 (ITU-T G.957, S-1.1)
- Possible to make standard that captures a wide range of existing transceivers

Relevant Standards

	Bitrate *(Mbps)*	Wavelength range *(nm)*	Tx: *max* Popt *(dBm)*	Tx: *min* Popt *(dBm)*	Rx: *max* Pin *(dBm)*	Rx: *min* Pin *(dBm)*	Distance *(km)*
100BASE-FX (MMF)	100	1261-1360	-14	-20	-14	-31	2
STM-1*	155						
Intra-office (IO)		1261-1360	- 8	-15	-8	-23	2
Short-haul (SH)		1261-1360 1430-1576	- 8	-15	-8	-28	15
Long-haul (LH)		1261-1360 1430-1576	0	-5	-10	-34	40
FDDI	100						
Cat I		1270-1340	-14	-20	-14	-31	~15
Cat II		1290-1330	0	-4	-15	-37	~60

** Corresponds to SONET OC-3, short reach, intermediate reach and long reach*

Example of “100BASE-FX SMF” Products

	Bitrate *(Mbps)*	Wavelength range *(nm)*	Tx: *max* Popt *(dBm)*	Tx: *min* Popt *(dBm)*	Rx: *max* Pin *(dBm)*	Rx: *min* Pin *(dBm)*	Distance *(km)*
Agilent							
1) Model x1	100	1261-1360	-14	-20	-8	-31	
2) Model x2	155	1261-1360	-8	-15	-8	-31	15
3) Model x3	155	1261-1360/Tx 1261-1580/Rx	-8	-15	-8	-31	15
Stratos							
1) Model y1	10-200	1280-1340/Tx 1260-1380/Rx	-8	-15	-8	-28	15
2) Model y2	155	1266-1360	-8	-15	-8	-23	10
3) Model y3	155	1266-1360	-8	-15	-8	-28	15
Agere							
1) Model z1	155	1261-1360	-8	-15	-8	-28	15
2) Model z2	155	1261-1360	-8	-15	-8	-28	15
Sumitomo							
1) Model k1	155	1261-1360/Tx	-8	-15	-8	-28	15
2) Model k2	155	1261-1580/Rx	-8	-15	-15	-28	15
Luminent							
1) Model l1	155	1261-1360/Tx 1100-1600/Rx	-7	-15	-3	-34	15
2) Model l2	155	1280-1335/Tx 1200-1600/Rx	-8	-15	-3	-34	15

Economic Feasibility - TRx Considerations

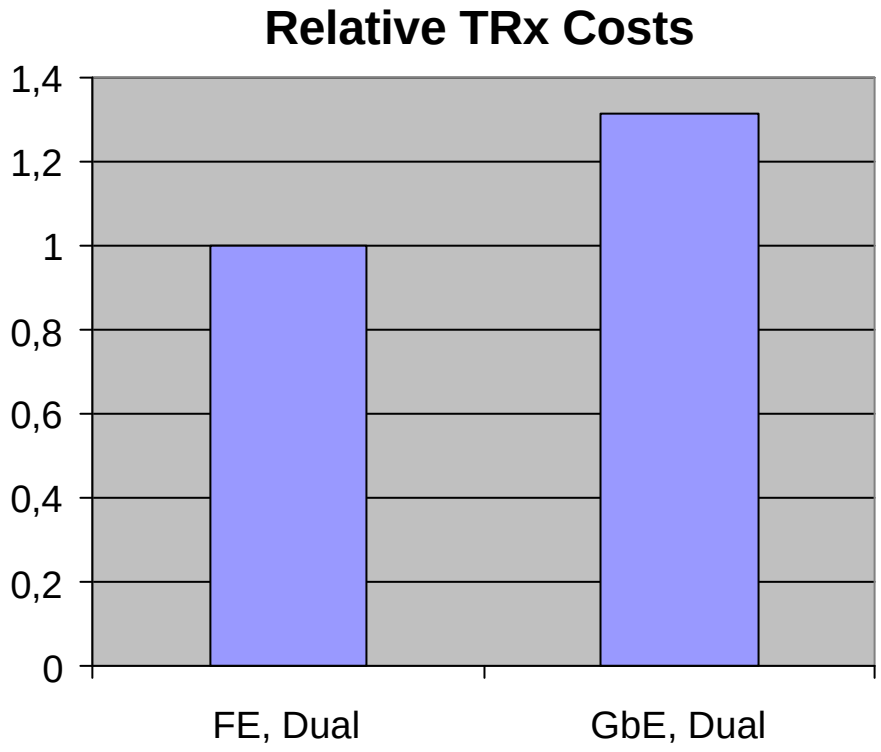
- 100Mbps speed and relaxed link budget facilitates low cost TRx
  - Compared to TRx operating over 1Gbps speed or higher
- Inherently improved receiver sensitivity
  - Supports use of low-cost connectors, mechanical splices etc.
  - Gives low demands on transmitter output power
  - Simplified optical alignment
  - Low assembly costs
- Low power dissipation
  - Low operating power consumption
  - Low heat dissipation – relaxed cooling requirements (fans, AC)
  - Facilitates compact design
- Simple electronic design
  - Reduced electrical crosstalk and transmission line properties
  - Simplified module design and assembly

Economic Feasibility - TRx Considerations

100BASE-X dual SMF has potential to cost considerably less than 1000BASE-LX!

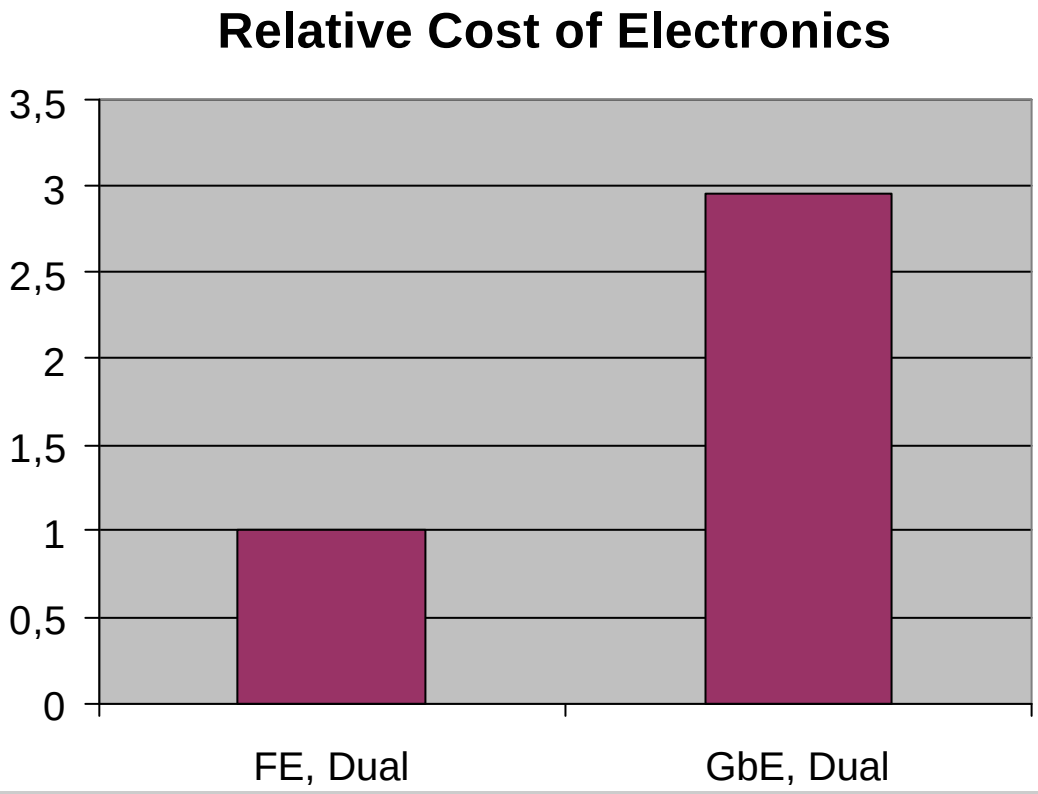
- STM-1 SH (OC-3 IR) specifies 13dB power budget and -28dBm Rx sensitivity
- FDDI specifies 11dB power budget and -31dBm Rx sensitivity
- Relaxed specification makes 1000BASE-LX inexpensive, i.e. 8dB power budget and -19dBm Rx sensitivity

- Relaxing the 100BASE-X dual SMF PMD compared to STM-1/OC-3 and FDDI enables substantial cost savings in volume manufacturing



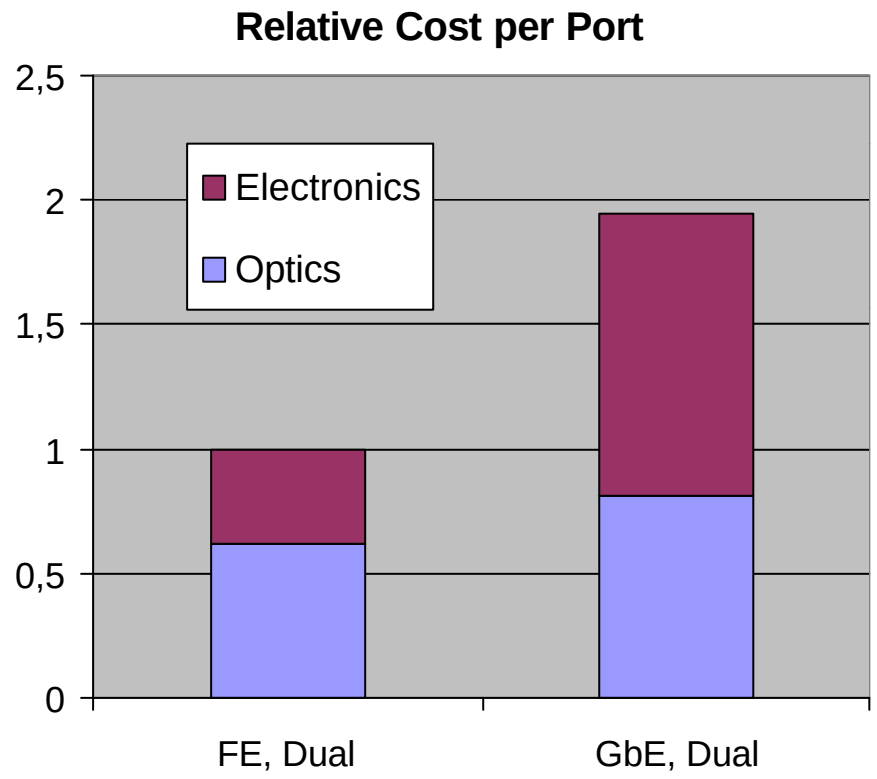
Economic Feasibility - System Perspective

- FE switching components substantially cheaper than GbE
  - Inherent by the lower speed
  - Lower power consumption of switching components
  - Lower cost switch core
  - Less CPU power
  - Less memory required
- Lower cost MAC/PHY (non-PMD part)



Economic Feasibility - System Perspective

Possible to make huge cost savings in the network seen from a system point of view



Sources: Component Vendors, Passive Network Vendors, System Integrators & Dell'Oro Market Report

Economic Feasibility

- Consistent fiber plant throughout the entire access network
  - Only one type of fiber, i.e. SMF
  - Forward compatible fiber installations
  - Easy fiber management
  - Only one type of test and installation equipment

100Mbps and EFM

- EFM deals with major additions to the 802.3 Std
- 100BASE-X dual SMF only requires minimal additions to Clause 26
- 100BASE-X dual SMF is already happening, and will have applicability even outside EFM
- However, 100BASE-X SMF will be used in the public access application space

- 100BASE-X PCS is transparent to EFM OAM
  - Neither “OAM in Frames” nor “OAM on Preamble” require any changes to 100BASE-X PCS

Conclusion

- 100BASE-X dual SMF meets the 5 criteria
- There is a broad market for 100BASE-X dual SMF
- Demand exist for standard, interoperable 100M FE over SMF for multiple applications
- Extended reach expands the application space for 100Mbps Ethernet
- Minimal work to fill gap in specification
- Short time to market
- The 100BASE-X spec may capture existing 100Mbps TRx:s
- Requires no changes to 802.3 MAC or 100BASE-X PCS & PMA
- Only add a new PMD alongside existing 100BASE-TX and -FX
- Huge cost savings in complete system solutions