FOUNDRY NETWORKS

10 Gigabit Ethernet Update

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Agenda

Introduction

- 10 Gig Technology and Terminology
- Applications
- Summary



MAN Introduction Concepts & Terminology

- What is a MAN?
 - No precise definition, but here is a general guideline
 - LAN A network within a campus ranging < 2 Km
 - MAN A network ranging from 2 km to 100 km
 - WAN A network ranging > 100 Km
 - Another way to look at:
 - LAN in a campus, MAN in a city to connect the campuses together, WAN to connect the cities together
- What is dark fiber?
 - A fiber that's laid in the ground, but not used yet
 - Lighting a fiber means Use the fiber to transport data



Convergence Drivers



- Evolution of Ethernet
- Exploding Internet Adoption
 - demand for bandwidth
 - next gen applications
- Deregulation
 - availability of dark fiber



Ethernet Technology

- Scalable, High Performance
 - 10 Mb to 100 Mb to 1000 Mb (1G) to 10,000 Mb (10G)
 - Full duplex, symmetrical, easy to use
- Stable, Mature, and Proven
 - 26 years of evolution
 - Over 85% of installed networks worldwide
 - 182 Million ports shipped in 2000 up from 171 M in 1999
 - 98% of all LAN ports shipped in 1999 were Ethernet
 - Rapidly evolving Quality of Service feature set
 - Large pool of trained network professionals
- Wide adoption of standards
 - 802.1q for tagging
 - 802.1p for prioritization
 - 802.3ad for link aggregation
 - 802.1w for rapid spanning tree
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10G Standard Evolution

- IEEE 802.3ae to define two families of physical interfaces
 - LAN PHY at 10 Gbps
 - WAN PHY at data rate compatible with that of OC-192c/SDH (attachment to DWDM or SONET/SDH equipment)
 - Support link distances of at least
 - 100 m over installed MM fiber
 - · 300 m over MM fiber
 - · 2 km, 10km and 40 km over SM fiber
- Standard ratification target: Spring 2002



Fiber: Optical Technology

- Electrons Vs Photons
 - Optical cables provide superior distance range, flexibility and reliability
- Dense Wave Division Multiplexing (DWDM)
 - Multiplies the amount of bandwidth over one fiber
 - Current: 160 lambda x 1 Gb = 160 Gbps per fiber
 - Future: 1024 lambda x 10 Gbps = 10,000 Gbps per fiber



MAN/WAN Technology Evolution



Time

Key Considerations

- Economics of the dark fiber supply, price
- Existing infrastructure leverage it
- Technology considerations and network requirements



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Why 10 Gigabit Ethernet?

- Technology Enhancement
 - Next networking bandwidth evolution
- Cost Effective
 - First networking bandwidth to directly compete against OC-192 SONET - starting at 1/5 the cost
- Highest Return on Investment
 - Leverages the Existing Ethernet Install and Knowledge Base
- Future Ethernet Speeds Will Leave SONET in the Dust



Why 10 Gigabit Ethernet? continuous

- Scales Enterprise and Service Provider LAN backbones
- Extends Ethernet to MAN and WAN, providing seamless connectivity between LAN, MAN and WAN
- Leverages the Ethernet install base Over 300 million Ethernet ports worldwide
- Supports all traffic types Data, voice and video on IP
- Faster, simpler, and cost-effective than other alternatives

 Best in Total Cost of Ownership (TCO)
- Proven paradigm 1 Gigabit Ethernet Vs ATM and FDDI



SONET Simplifies Circuit Networking



Is there a 10 Gig Ethernet Market?



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Economics of Ethernet



Ethernet offers a superior price/performance and TCO over alternative technologies (SONET/ATM)

- Up to 10:1 price advantage in upfront costs
- Up to 5:1 advantage in bandwidth provisioning expenses
- Up to 5:1 advantage in annual maintenance
- Provides bandwidth on demand without costly truck rolls



Pushing The Bandwidth Envelope





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10 Gigabit Ethernet Interfaces and Applications



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IEEE 802.3ae Objectives

- Preserve 802.3 Ethernet frame format
- Preserve 802.3 min/max frame size
- Full duplex operation only
- Fiber cabling only
- 10.0 Gbps at MAC-PHY interface
- LAN PHY data rate of 10 Gbps
- WAN PHY data rate of ~9.29 Gbps



10 Gigabit Ethernet Standards Process IEEE 802.3ae Task Force Milestones



HSSG= Higher Speed Study Group; PAR= project authorization request

802.3ae= the name of the project and the name of the sub-committee of IEEE 802.3 chartered with writing the 10GbE Standard

Working group ballot= task force submits complete draft to larger 802.3 committee for technical review and ballot

LMSC: LAN/MAN Standards Committee ballot. Any member of the superset of 802 committees may vote and comment on draft

* Foundry will replace the product at no cost if the standard changes after a customer purchases the 10 Gigabit Ethernet product. Certain restrictions apply. Check with a Foundry sales office for further details.





Gigabit Ethernet Vs 10 Gigabit Ethernet

10 Gigabit Ethernet – 802.3ae

- Full Duplex Only
- 64 Byte initial
- Throttle (Adjustable) MAC Speed
- Optical Media Only
- 4 New Optical PMD's
- New 64B/66B (Block) Coding Schemes
- Support for LAN up to 40 Km 300m on MMF 10Km on SMF
- LAN / MAN

1 Gigabit Ethernet – 802.3z

- CSMA/CD + Full / Half Duplex
- 512 Byte initial
- Carrier Extension
- Optical and Copper Media
- Leverage Fiber Channel PMD's
- Reuse 8B/10B Coding Support for LAN up to 150 Km 100m on CAT5 550m on MMF (SX) 5Km on SMF (LX)
- LAN / MAN / WAN



Gigabit Ethernet Vs 10 Gigabit Ethernet

The same

- Still Ethernet
 - Leverages features of predecessors
 - No change to Ethernet frames
- Minimizes user learning curve
 - Same management architecture
 - Compatibility with familiar tools
 - No changes above the MAC

Increasing the Ethernet Pipe!





10 Gig Nomenclature and Availability

Reach	PMD (Optical Transceiver)	Type of Fiber Supported	IEEE 802.3ae Description	LAN Or WAN	FCS Availability
200m	850nm Sorial	Multimodo Eibor (MME)	10GBase-SR	LAN	Q4/2001
300m	osonini Seriai		10GBase-SW	WAN	TBD
10km	1310nm Serial	Single Mede Eiber (SME)	10GBase-LR	LAN	Q4/2001
			10GBase-LW	WAN	TBD
40km	1550nm Sorial	Single Mede Fiber (SMF)	10GBase-ER	LAN	Q4/2001
40KM	1550nin Senai	Single Mode Fiber (SMF)	10GBase-EW	WAN	TBD
300m		Multimode Fiber (MMF)			**
10km		Single Mode Fiber (SMF)	IUGDase-LA4	LAN	

CEA* - Currently No Vendor Produces this Optime FOUNDRY

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10 Gbps Fiber Connectivity (Serial)

850nm Serial 10GBase-SR/SW								
Fiber Cable	62.5un	n MMF	50um MMF					
Nominal Wavelength (nanometers)	850 850		850	850	850			
Modal Bandwidth (MHz/km)	160	200	400	500	2000			
Operating Distance (meters)	2 to 28m	2 to 35m	2 to 69m	2 to 86m	2 to 300m			
Link Budget (dB)	7.5	7.5	7.5	7.5	7.5			

	1310nm Serial 10GBase-LR/LW	1550nm Serial 10GBase-ER/EW		
Fiber Cable		SMF		
Nominal Wavelength (nanometers)	1310	1550		
Modal Bandwidth (MHz/km)	n/a	n/a		
Operating Distance (meters)	2 to 10km	2 to 40km		
Link Budget (dB)	10	18		
	•	FOUND		

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10 Gbps Fiber Connectivity (Serial)

	; 10	850nm Serial GBase-SR/SV	N			New MMF
Fiber Cable	62.5um MMF			50um MMF		Optical Multimode
Nominal Wavelength (nanometers)	850	850 850		850	850	OMx
Modal Bandwidth (MHz/km)	160	200	400	500	2000	
Operating Distance (meters)	2 to 28m	2 to 35m	2 to 69m	2 to 86m	2 to 300m	
Link Budget (dB)	7.5	7.5	7.5	7.5	7.5	
				1310nr 10GBas	n Serial e-LR/LW	1550nm Serial 10GBase-ER/EW
OM1 (62 5/125		Fiber Cab	le		-	SMF
OM1 (02.57125)	N	Nominal Wavelength (nanometers)		1310		1550
OM3 (50/125)		Modal Bandwidth (MHz/km)		n/a		n/a
OS1 (~8/125)	(Operating Dis (meters)	ance 2 to 10km		10km	2 to 40km
		Link Budg (dB)	et	ŕ	10	18



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10 Gbps Fiber Connectivity (WWDM)

1310nm WWDM 10GBase-LX4							
Fiber Cable	62.5um MMF	50um	SMF				
Nominal Wavelength (nanometers)	1300	1300	1300	1310			
Modal Bandwidth (MHz/km)	500	400	500	n/a			
Operating Distance (meters)	2m to 300m	2m to 240m	2m to 300m	2m to 10km			
Link Budget (dB)	8	8	8	9			



802.3ae Frame Layer



MDI = Medium Dependent Interface XGMII = 10 Gigabit Media Independent Interface PCS = Physical Coding Sublayer

PMA = Physical Medium Attachment PMD = Physical Medium Dependent WIS = WAN Interface Sublayer



10GBASE-R



10GBASE-W Serial



10GBASE-W WWDM



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64 Bytes

- Output of 64B/66B PCS loaded into the SPE
- Provides attachment to SONET infrastructure



Device Nomenclature

Device	8B/10B PCS	64B/66B PCS	WIS	850nm Serial	1310nm WWDM	1310nm Serial	1550nm Serial
10GBASE-SR		Ľ		K			
10GBASE-SW		K	×	K			
10GBASE-LX4	K.				Ŕ		
10GBASE-LW4		K	×		Ŕ		
10GBASE-LR		Ľ				×	
10GBASE-LW		Æ	×			×	
10GBASE-ER		Ľ					Ł
10GBASE-EW		Æ	×				ĸ



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10 Gig Compared to Optical Transport



Coarse Wavelength Divisional Multiplexing (CWDM)

- Proprietary (Both ends must be from same vendor)
- Using low-cost lasers, wavelengths are spaced farther apart
- Usually limited to about eight "lambdas"

Dense Wavelength Divisional Multiplexing (DWDM)

- DWDM is ITU standards based
- Up to 50 Optical Channels ("lambdas")
- Requires precise and stable laser sources (super-cooled)

10 Gigabit Ethernet

- IEEE 802.3ae Standards Based
- 1 Optical Channel (Serial) providing 10 Gigabits Throughput

• <u>Note: Only 850nm Serial, 1310nm Serial, and 1550nm Serial</u> PMDs can be translated into a CWDM or DWDM lambda



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10 Gigabit Ethernet – Applications

• LAN

- LAN Backbone Scalability Data Center, Building, or Campus
- Server Farm Scalability Gigabit Ethernet to Servers
- MAN
 - High Performance MANs, Metro Ether backbone
 - Multi-Gig Aggregation to 10 Gig Uplinks
 - 10 Gbps as a Lambda in DWDM Transport
 - Metro OC-192 backbone transit
- WAN
 - Internet Router Backbone





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10 GIG For LAN – Data Center and Server Farms

High-Speed Transparent LAN/MAN Services

10 Gigabit Ethernet – MAN Applications

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10 GIG – WAN PHY Applications

The 10G MAN Backbone

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10 Gigabit Ethernet: Summary

- It's Ethernet at 10 Gbps
 - Simple, Cost-effective, Scalable
 - Large pool of trained personnel
 - Same management architecture, no changes above MAC
- Unifies all network infrastructure with Ethernet
 - LAN Scales campus backbones, server farms
 - MAN Extends Ethernet to Metro for broadband connectivity
 - WAN Utilizes the existing SONET infrastructure at a fraction of the cost of OC-192c
- 10 GbE is Here and Available from Vendors NOW!

