

2008 BICSI Winter Conference

January 14-17, Orlando, Florida



Bicsi[®]

Exchange. Engage. Expand.

On the Road to 100 Gigabit Ethernet Transmission: Setting the Standard for Next-Generation Enterprise Networks

Andrew Oliviero
OFS

aoliviero@ofsoptics.com

770-798-2212



2008 BICSI Winter Conference
January, 2008

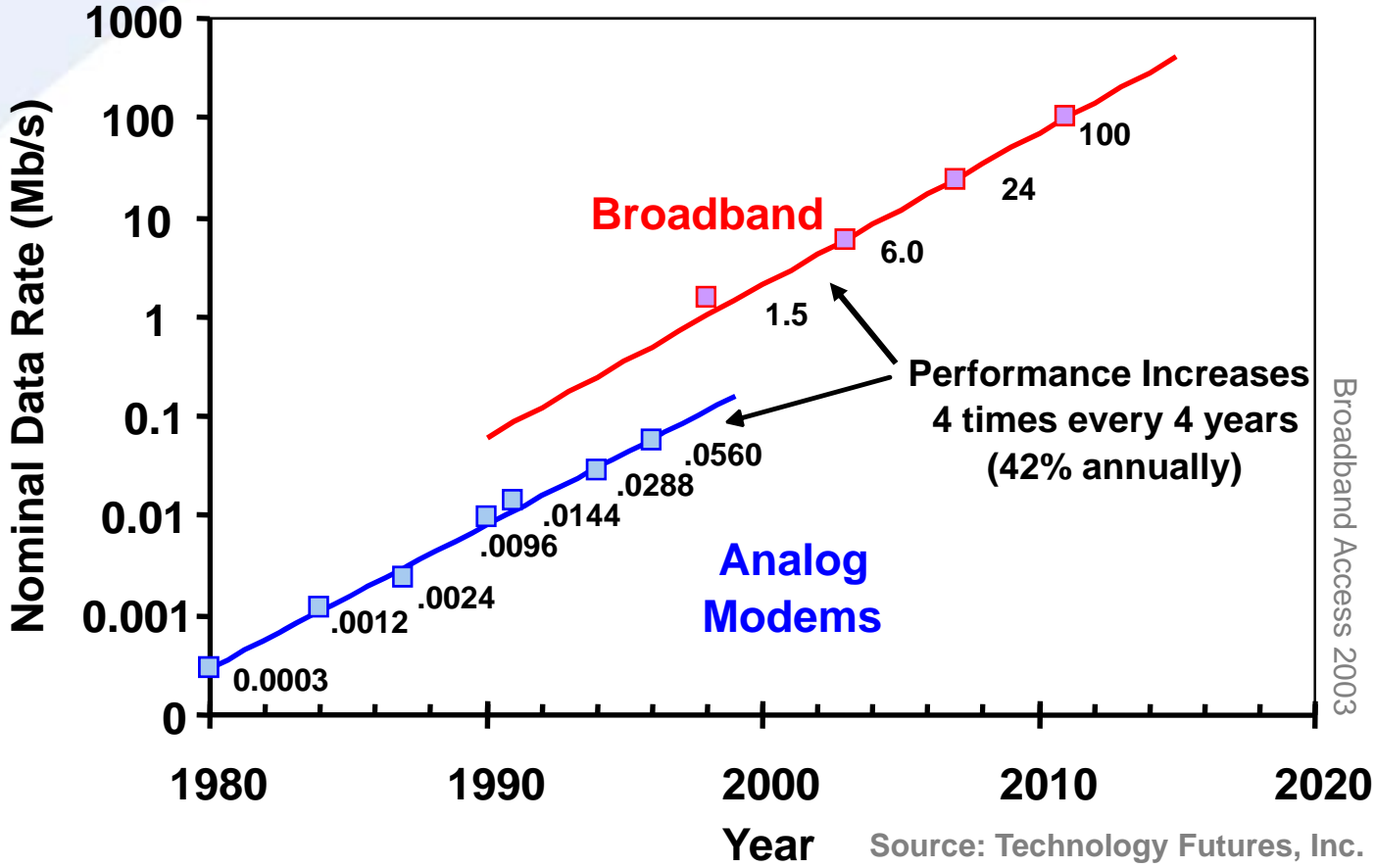


IEEE 802.3 Evolution...will it end?

- 03/1983 802.3 10Base5 10Mb/s over “thick” coax
- 03/1985 802.3a 10Base2 10Mb/s over “thin” coax (thinnet, cheapernet)
- 09/1985 802.3b 10Broad36 10Mb/s over CATV
- 12/1985 802.3c 10Mb/s repeater specifications•
- 12/1987 802.3d FOIRL Fiber Optic Inter-Repeater Link
- 06/1987 802.3e 1Base5 1Mb/s over twisted-pair (StarLAN)
- 09/1990 802.3i 10BaseT 10Mb/s over UTP
- 09/1993 802.3j 10BaseF 10Mb/s over fiber optic
- 06/1995 802.3u 100Base 100Mb/s over TX:2-pair, T4:4-pair, FX: fiber optic
- 03/1997 802.3x Full-duplex operation and flow-control
- 05/1997 802.3y 100BaseT2 100Mb/s over 2-pairs of Cat-3 UTP
- 06/1998 802.3z 1000BaseX GigE over fiber
- 06/1999 802.3ab 1000BaseT GigE over twisted-pair
- 03/2000 802.3ad Link Aggregation
- 06/2002 802.3ae 10GBase 10Gb/s over fiber (SR, LR, ER, SW, LW, EW)
- 06/2003 802.3af Power over Ethernet
- 06/2004 802.3ah Ethernet in the First Mile (EPON)
- 02/2004 802.3ak 10GBaseCX4 10Gb/s over twin-axial cable - 15m
- 06/2006 802.3an 10GBaseT 10Gb/s over UTP - 100m
- 09/2006 802.3aq 10GBaseLRM 10Gb/s over MMF – 220m
- 802.3av 10Gb/s over Passive Optical Networks



Heading to 1 Gb/s per Home by 2020



High Revenue Services

- Entertainment
- Tele-medicine
- Virtual Meetings
- Distance Learning
- Others we can't imagine..

Require High Bandwidth



Outline

- Market Drivers
- Ethernet Standards Development
 - IEEE
 - HSSG
 - 802.3ba Task Force
- Fiber Considerations
- Opto-electronic Considerations
- Summary



Market Drivers



Drivers for 40 and 100 Gb/s Speeds

Rapid growth of network and internet traffic has placed high demand on the existing infrastructure

- Consumers
 - Increasing penetration of Triple Play services
 - Increasing bandwidth demand
 - Personalized Content
- Content
 - Increasing bandwidth requirements
- Networking
 - Carriers
 - Service Providers
 - Internet eXchanges
- Private Users
 - Supercomputing / High Performance Computing (HPC)
 - Data Centers
 - Research & Development
 - Medical

The text "Digital Photos" is rendered in a 3D, blocky font with a light beige color and a dark shadow underneath, giving it a three-dimensional appearance.

HDTV // IPTV // Video-on-Demand

The text "MySpace, YouTube" is written in a large, bold, blue font with a red outline and a slight 3D effect.

The text "Gaming ofS" features the word "Gaming" in a multi-colored font (pink, orange, yellow, green, blue) and "ofS" in red below it. A red swoosh underline is under "ofS".

The logo for Bicsi, featuring the word "Bicsi" in a bold, italicized, grey font with a yellow arc above the "i".

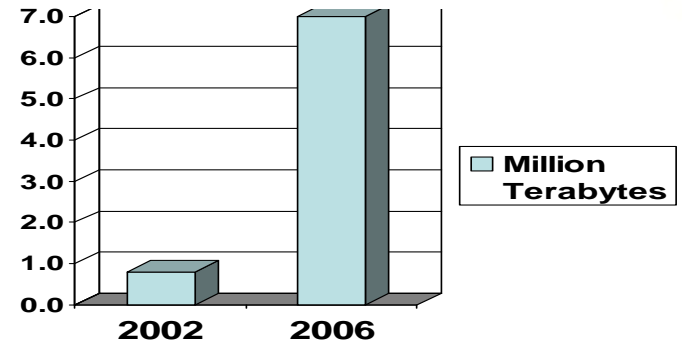
Key Network Points for 40 and 100 Gb/s Speeds

- Early deployment of 40 Gb/s Ethernet will support Data Center Servers
 - Interconnection links
 - Data center servers
 - Storage Area Networks
 - Corporate, video, medical, R&D Enterprises
- Early deployment of 100 Gb/s Ethernet will be driven by high-bandwidth switching, routing, and aggregation interconnect points
 - Metro, core, carrier/service provider networks
 - Internet exchanges and aggregation points
 - Will drive growth of Content Provider applications such as:
 - Video on demand/IPTV/HDTV
 - Gaming
 - Interconnects for high performance super computing environments
- Not intended for riser or horizontal building cabling

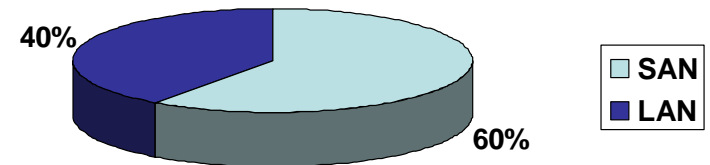


Enterprise Data Storage Leading the Way

- 30% annual growth
 - Last 3 years
 - Predicted for next 5 years
 - ~\$5.3 billion market
- Largest component of hardware budget
 - 18% of total I.T. budget
 - 60% of hardware budget
- Separate LAN/SAN spending strategies



Enterprise Storage Growth



Percent of Hardware Budget



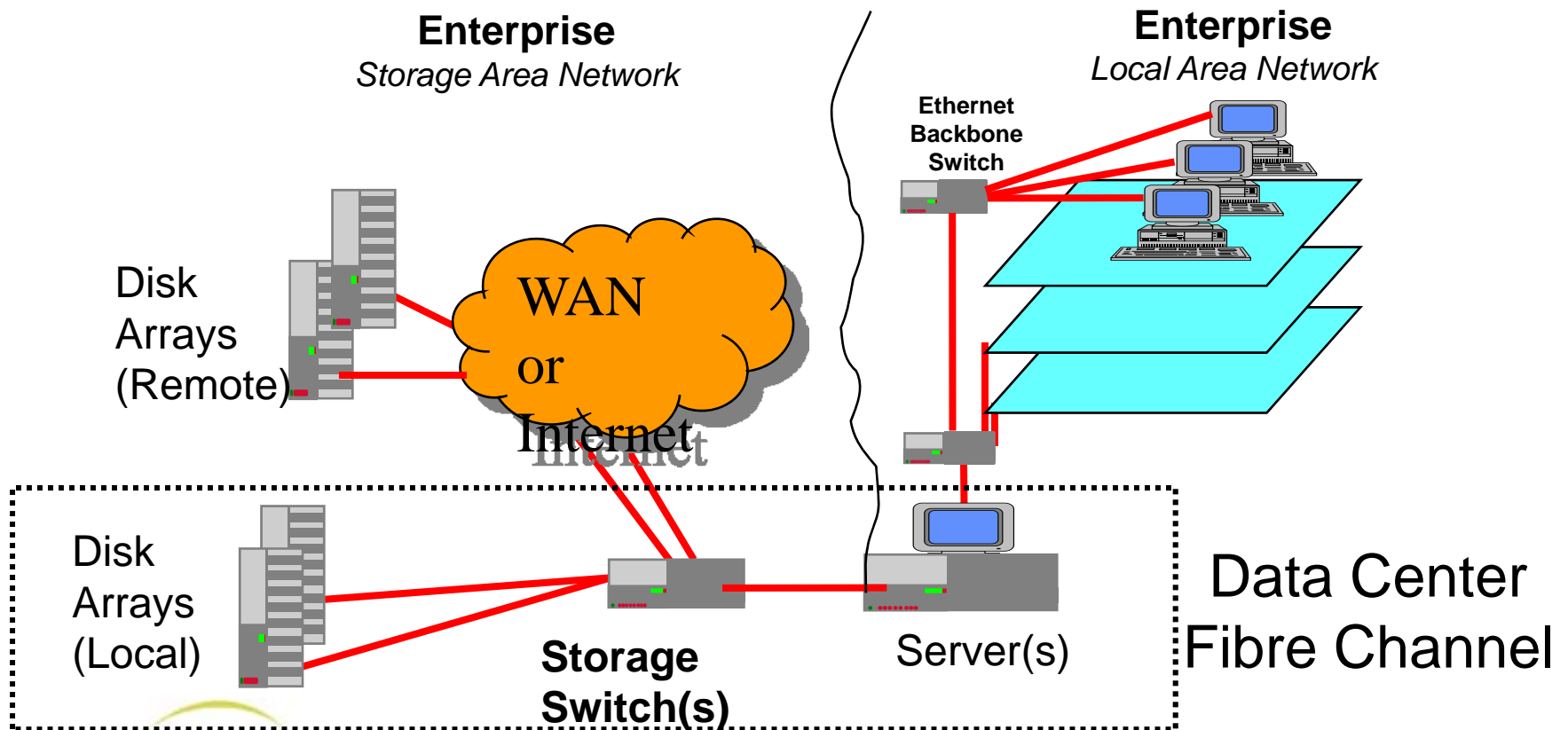
Source: iSuppli Corporation Press Release,



Storage Applications

Fibre Channel

- Most widely deployed storage interconnect technology



Fibre Channel SAN Technology Roadmap

Fibre Channel Speed Chart-Base2*

Product Naming	Throughput (MBps)	Line Rate (Gbaud)	T11 Spec Completed (Year)	Market Availability (Year)
1GFC	200	1.065	1996	1997
2GFC	400	2.125	2000	2001
4GFC	800	4.25	2003	2005
8GFC	1,600	8.5	2006	2008
16GFC	3200	17	2009	2011
32GFC	6400	34	2012	Market Demand
64GFC	12800	68	2016	Market Demand
128GFC	25600	136	2020	Market Demand

*Base2 used throughout all applications for Fibre Channel infrastructure and devices.

Fibre Channel Speed Chart-Base10**

Product Naming	Throughput (MBps)	Line Rate (Gbaud)	T11 Spec Completed (Year)	Market Availability (Year)
10GFC	2400	10.52	2003	2004
20GFC	4800	10.52	2007	2008
40GFC	9600	21.04	TBD	Market Demand
80GFC	19200	84.16	TBD	Market Demand
160GFC	38400	168.32	TBD	Market Demand

**Base10 commonly used for ISLs, core connections, and other high speed applications demanding maximum bandwidth. Each Base10 speed maintains backward compatibility at least two previous generations (i.e., 40GFC backward compatible to 20GFC and 10GFC)



Expected Demand

- Unlike the higher volume end system application typical for 10/100/1000 Mb/s Ethernet
- Initial volumes for 40 and 100 Gb/s Ethernet are anticipated to be more modest
- This does not imply a reduction in the need or value of 40 and 100 Gb/s Ethernet to address the stated applications
- 40 and 100 Gb/s provides a solution for applications that have been demonstrated to need bandwidth beyond existing capabilities



40 and 100 Gb/s Ethernet Standards Development



IEEE-High Speed Study Group (HSSG)

- HSSG formed by IEEE 802.3 in 2006
 - Supported by Fiber Optic and Reach ad hoc committees
 - International representation
 - Component, switch and cabling manufactures
 - End users in public and private sectors
- Investigated the need for next Ethernet Speed and recommended objectives for a task force
- Validate 5 Criteria
 - Broad Market Potential
 - Compatibility
 - Distinct Identity
 - Technical Feasibility
 - Economic Feasibility
- Submitted PAR (Project Authorization Request)



HSSG – 40 and 100 Gb/s Options

- IEEE HSSG (Higher Speed Study Group) voted in July '07 to adopt the following objectives:
 - Support a MAC data rate of 40 Gb/s
 - Provide Physical Layer specifications which support 40 Gb/s operation over:
 - at least 100m on OM3 MMF
 - at least 10m over a copper cable assembly
 - at least 1m over a backplane
 - Support a MAC data rate of 100 Gb/s
 - Provide Physical Layer specifications which support 100 Gb/s operation over:
 - at least 40km on SMF
 - at least 10km on SMF
 - at least 100m on OM3 MMF
 - at least 10m over a copper cable assembly



IEEE 802.3ba Task Force Formed

- Write the standard
 - 2-year effort expected
- Publication of standard by mid-2010
- Set fiber reach
- Set channel specifications
- Set transceiver specifications



Fiber Considerations



Industry Standard Multimode Fiber Sub-types

Fiber type	Wavelength (nm)	Max Loss (dB/km)	Min Bandwidth (MHz·km)		1 Gb/s Reach (meters)	10 Gb/s Reach (meters)
			OFL	EMB		
62.5 μm (OM1)	850	3.5	200	n.s.	275	33
	1300	1.5	500	n.s.	550	300
50 μm (OM2)	850	3.5	500	n.s.	550	82
	1300	1.5	500	n.s.	550	300
850-nm 10G Laser- Optimized 50 μm (OM3)	850	3.5	1500	2000	1000	300
	1300	1.5	500	n.s.	600	300

OM1, OM2, OM3 =
ISO/IEC 11801 designations

OFL = Overfilled Launch

EMB = Effective Modal Bandwidth
(also known as "Laser" BW)

EMB met by meeting a) DMD
specifications, or b) EMBc, as
outlined in TIA 492 AAAC-A



Other Multimode Fiber Sub-Types

Fiber Type	Wavelength (nm)	Max Loss (dB/km)	Min Bandwidth (MHz·km)		1 Gb/s Reach (meters)	10 Gb/s Reach (meters)
			OFL	EMB		
50 μm (OM2+)	850	3.5	700	950	750	150
	1300	1.5	500	n.s.	600	300
50 μm (OM3+)	850	3.5	3500	4700	1040	550
	1300	1.5	500	n.s.	600	300

DMD specifications determined
by scaling rules outlined in
TIA 492 AAAC-A

OFL = Overfilled Launch

EMB = Effective Modal Bandwidth
(also known as "Laser" BW)



Considerations

- **Short Reach OM3-Multimode Applications**
 - **Short Term → Data Centers**
 - **At least 100 m over OM3 is the present objective**
 - **Typical length between data center panels 60-90 m**
 - **However, there is along tail in distribution which shows that lengths of 150-250 m should be supported**
 - **Seeing demand for 200m reach target**
 - **Further work in the 802.3ba Task Force will finalize lengths**
 - **Long Term → Riser backbones (300m requirement)**
 - **OM3+ being considered to support up to 300 m**
 - **ISO could establish an OM4 standard allowing IEEE to reference a new fiber to support longer distances**



Opto-electronic Considerations



Considerations

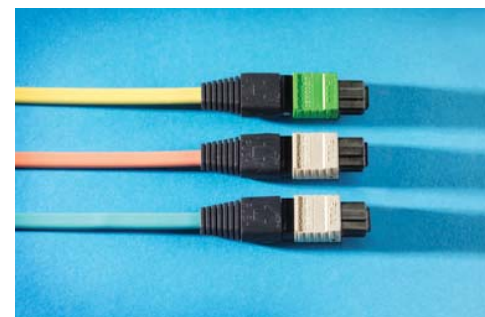
- **Short Reach Applications**
 - **Short Term → Data Centers, HPC's (at least 100m requirement)**
 - Tx mfr's focused on creating lower-cost 850 nm based transceiver arrays for these applications
 - Increase mfg yield by relaxation of spectral width, encircled flux requirements
 - Reduces OM3 length despite readiness of OM3 to support 300m with standard 850nm 10 Gb/s VCSELs



Considerations



- **Transceiver Considerations**
 - **Will leverage existing fiber and transceiver technologies**
 - 850nm Parallel VCSEL Arrays
 - 1310 nm CWDM Transceivers
 - Recommend reading TIA TSB-172
- **Connectivity Considerations**
 - **MPO cable terminations**
 - **SNAP12 Tx connections**



HSSG Fiber Optic Ad Hoc Proposals

OM3 Multimode

10 Gb/s each over

Multiple Fibers (SDM)

and / or

Multiple Wavelengths (WDM)

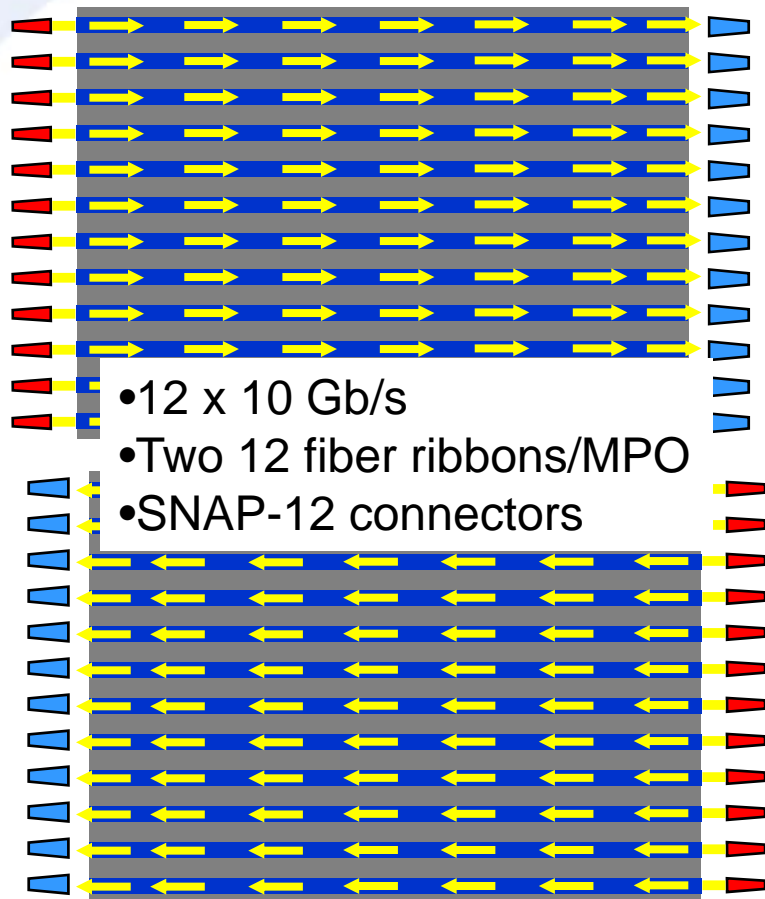
Wavelengths (nm)	# Cables x # Fibers
850	2 x 12
850	2 x 10
840 / 860	1 x 12
840 / 860	1 x 10
835 / 850 / 865	1 x 8



Parallel Systems Technology

Using 850 nm VCSEL arrays for Future Speeds

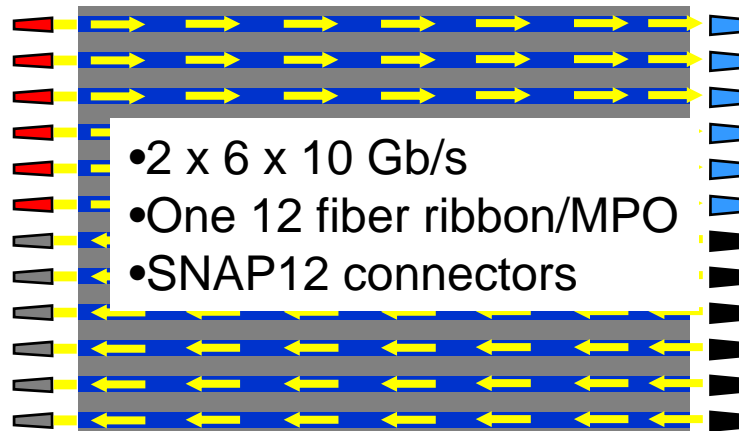
12 Channel Duplex 100 Gb/s 850 VCSEL Array



Bicsi

Andrew Oliviero

12 Channel Duplex 2 Lambda



- Ribbon or loose tube cable
- MPO Connectors
- SNAP12 Tx connectors
- Ideal for Data Center Trunk cabling

*Makes sense to increase density
in Data Center applications.*

HSSG Fiber Optic Ad Hoc Considerations

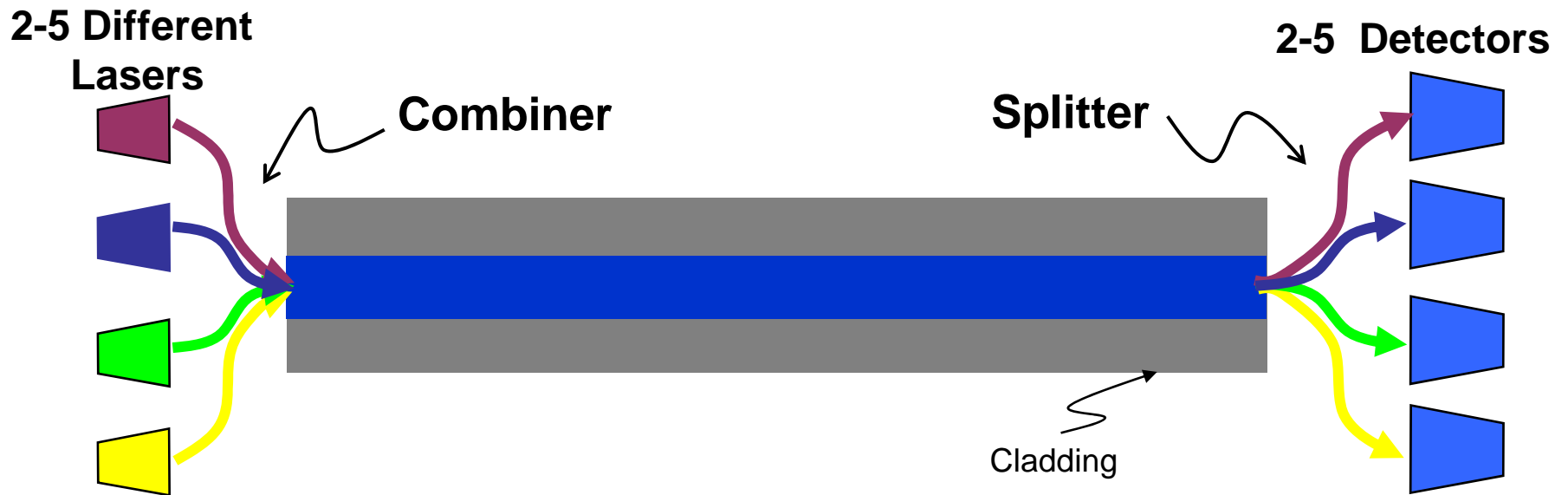
Single-mode

Multiple Wavelengths (WDM)

Wavelength Window (nm)	# of Wavelength Channels	Rate (Gb/s)
1550	10	10
1310	5	20
1310	4	25
1310	2	50



CWDM (Coarse Wavelength Division Multiplexing)



- High cost SM packaging, plus more parts and complexity

Cost Implications

- Single Mode CWDM Systems

Work continues to define technical and economic feasibility of designs being considered

- Pro: Low cable cost

- Con: High Transceiver cost & development required

- OM3 Multimode Parallel Systems

10 Gb/s VCSELS and fiber are already available

- Pro: Low cost, readily available parts

- Con: High cable cost and sensitivity to length

- Traditionally, cost of electronics drive cost comparisons between MM and SM

- Preliminary cost analysis for MM suggests lower cost up to ~200 meters



Summary



Conclusions

- High bandwidth applications and FTTx/CATV triple-play penetration driving need for higher speeds
- Will support key switching, routing and aggregation interconnect points
- OM3 multimode will support short reach applications using 850nm based parallel array systems
- Single-mode will support long reach systems using CWDM technology
- Multimode anticipated to be lower cost for short reach applications
- Publication of 40 and 100 Gb/s Ethernet standard expected by mid-2010



Thank you.....



ofs

Leading Optical Innovations

To learn more about optical fiber, subscribe to our free email newsletter, **Fiber Topics**, by visiting www.ofsoptics.com



2008 BICSI Winter Conference

January 14-17, Orlando, Florida



Bicsi[®]

Exchange. Engage. Expand.