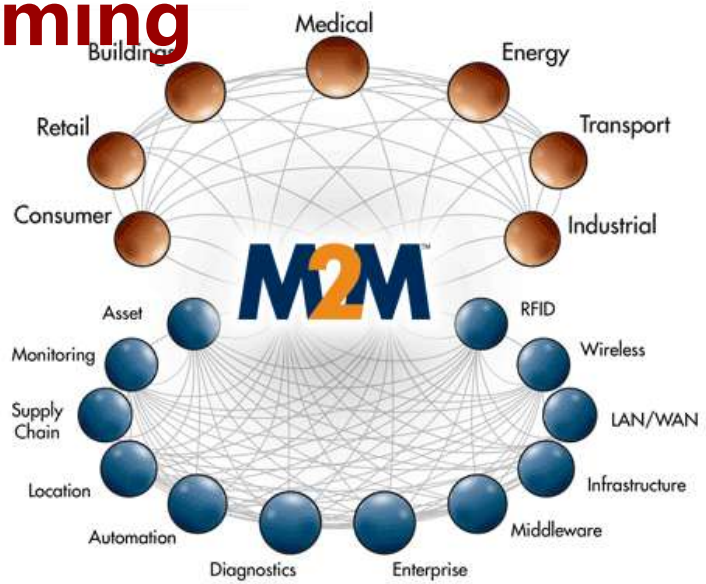
10km PMD
a must for carrier network

Ayla Chang, Huawei
Xiaolu Song, Huawei
Junjie Li, China Telecom

Communications is transforming

One-to-One → Many-to-Many



2000

~700 Million users

2010

5.4 Billion users

Over 5 Billion connections

2020

~7.5 Billion users

10s of Billions connections

User experience is transforming

Generic Apps -> Multiple Personal/Social Apps

2000

~1000 Apps

2010

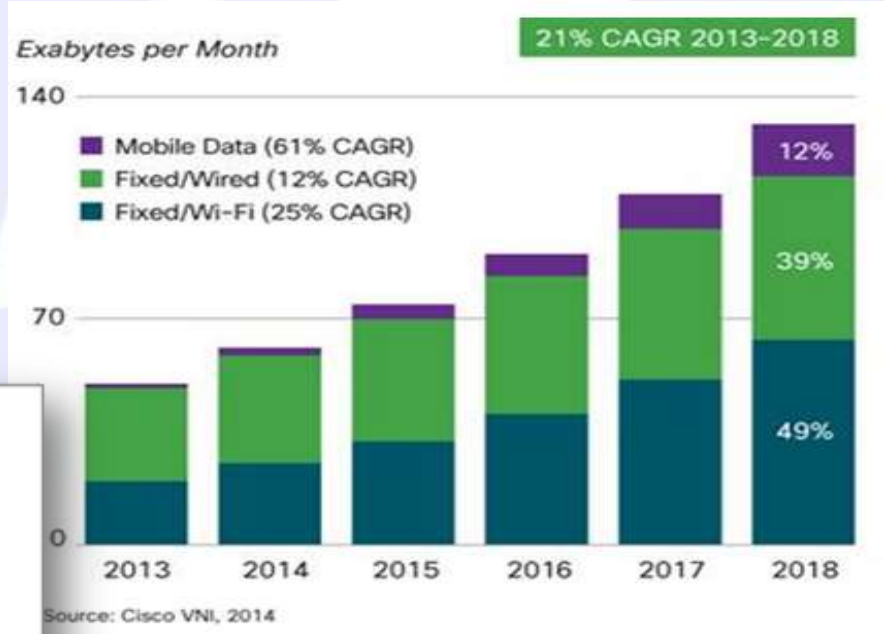
Hundreds of Thousands of Applications

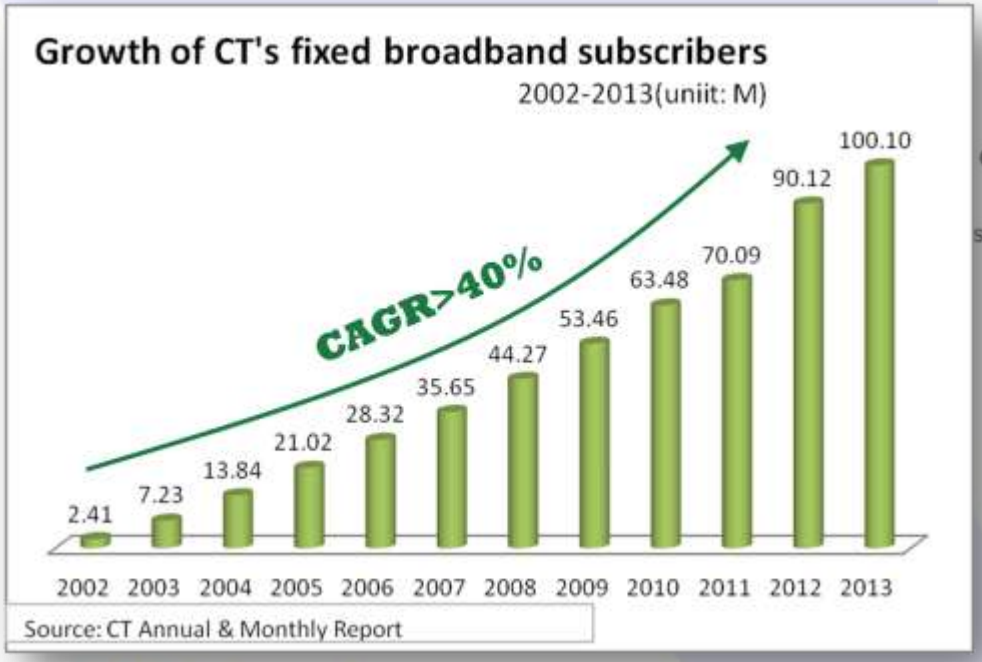
2020

Millions of Applications

Requirement from BB Infrastructure

Increase of IP traffic:
Global CAGR: 21%
2015: Enter ZB era (Z: 10^{21})
China CAGR: >35%



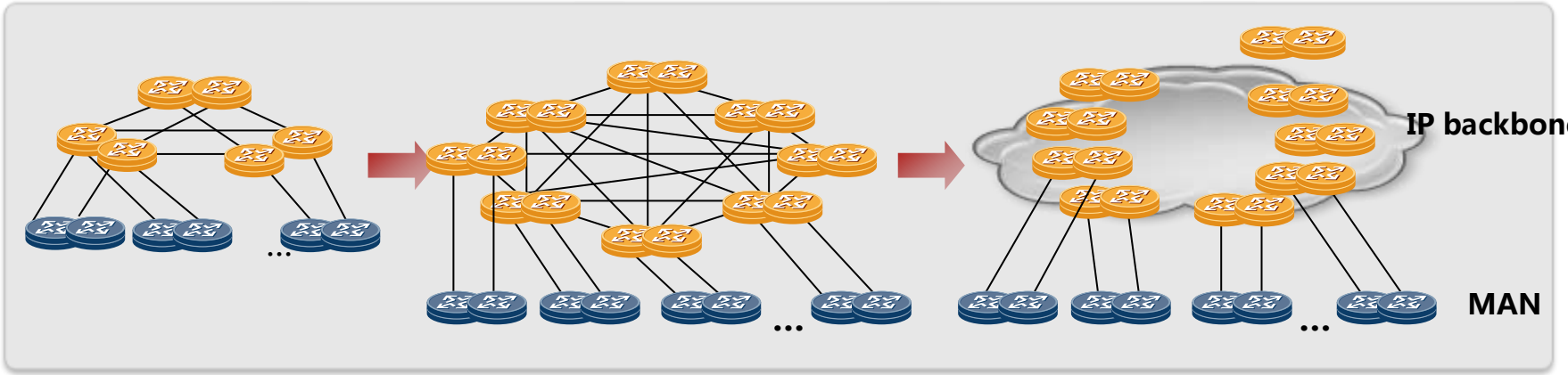


Increase of Users:
CT fixed BB users: reach 100M in 2013, CAGR>40%
Bandwidth per user: typically 2~4M, high end 20~100M

中国电信 CHINA TELECOM

400GE use case in backbone and MAN

- Carriers need to change to meet fast needs of bandwidth after millions of new users, new apps and all kinds of new markets.
- From 2017, there will be some trail in carrier network, from IP backbone and aggregation network.

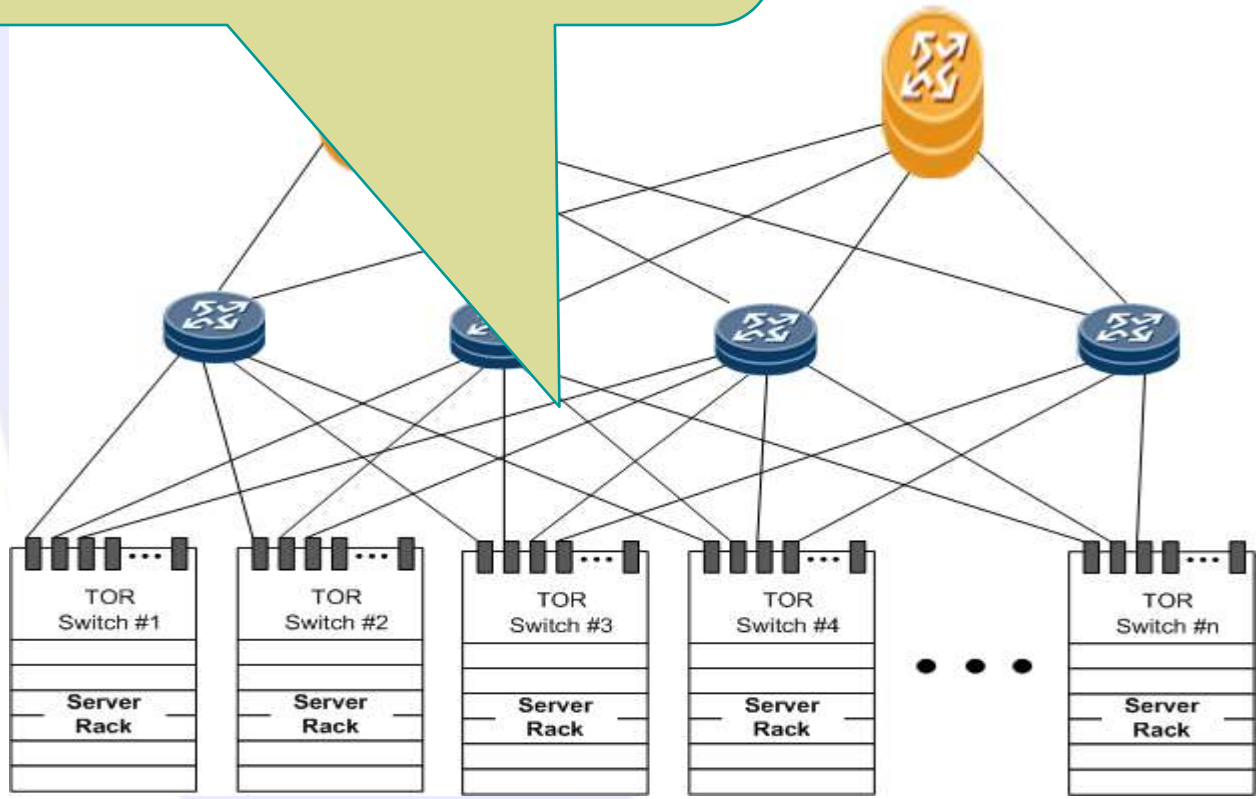


- **Use case in IP backbone**: Core Router to Core Router; MAN up link to Core Router; Core Router to OTN;
- **Emerging uses cases in MAN**: IDC interconnection within MAN/between different MANs; Uplink from IDC to MAN CR; LTE-A/5G Base station Mobile Back haul; MAN: 400GE+400G WDM, including:
  - 400GE Client + 400G WDM Line System
  - 400GE Client over Fiber

400GE Use Case inside IDCs

Emerging Uses Cases for both Carrier and ISPs

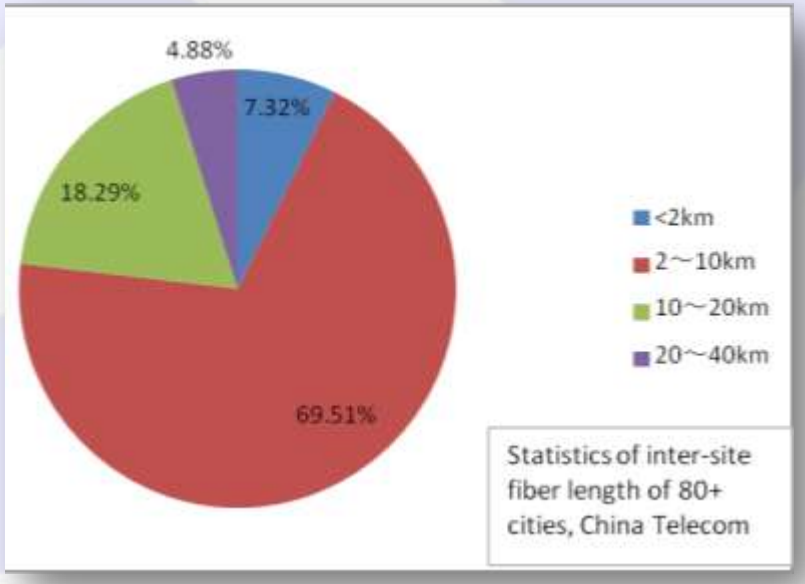
1) Hierarchy IDC Switch Network:
   - Core Switch → Aggregation Switch → TOR Switch
2) 100GE already started; 400GE will come soon
3) In-house connection: 400GE client over Fiber
   - Low Cost, Low Power, High Density



中国电信 CHINA TELECOM

The Distance Requirement

- **Backbone**
  - 400GE over WDM
  - 2km: intra-site
  - 10km/10km+: inter-site
- **MAN**
  - 400GE over Fiber or WDM
  - 2km: intra-site
  - 10km: inter-site
  - 40km/40km+: some inter-site cases
  - Cost balance: 400GE over WDM vs. long reach 400GE
- **Inside IDC**
  - 400GE over Fiber, inter-site
  - 2km is enough
  - Shorter reach is adoptable if with lower cost/power
- **Inter IDC**
  - 10km: inter-IDC connection in the same city, similar to MAN

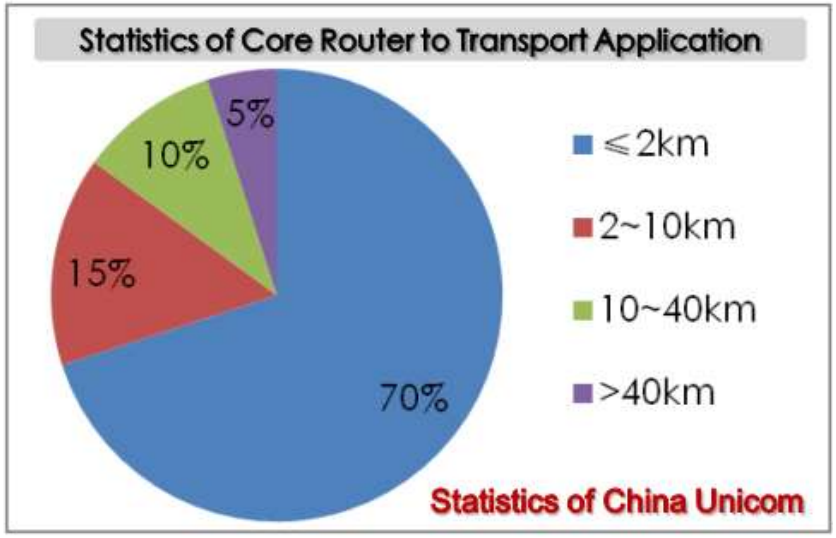


中国电信 CHINA TELECOM

Application Space of 400GbE (Core router to transport application)

- As the infrastructure, the carrier sites are not expected to change with the upgrade of capacity. The modes of 10G / 40G interconnection (especially considering CHINA169 Network) and other carrier sites' information are of great value for reference.
- China Unicom investigated the distance of ~70 sites for the interconnect between CHINA169 backbone transport room and core router room.
  - 2km can cover about 70% of the connections;
  - 10km can cover about 85% of the connections;
  - 40km can cover at least 95% of the connections.

- Notes: Even the router rooms and the transport rooms are in the same location, 500m can cover only <50% applications in the core router to transport scenario, it is not enough for the most of telecom applications, because of considerations on the "between floors" and "between buildings" scenarios.



http://www.ieee802.org/3/400GSG/public/13_11/song_x_400_01a_1113.pdf

Objectives to Support Cloud Scale Data Center Design from Microsoft

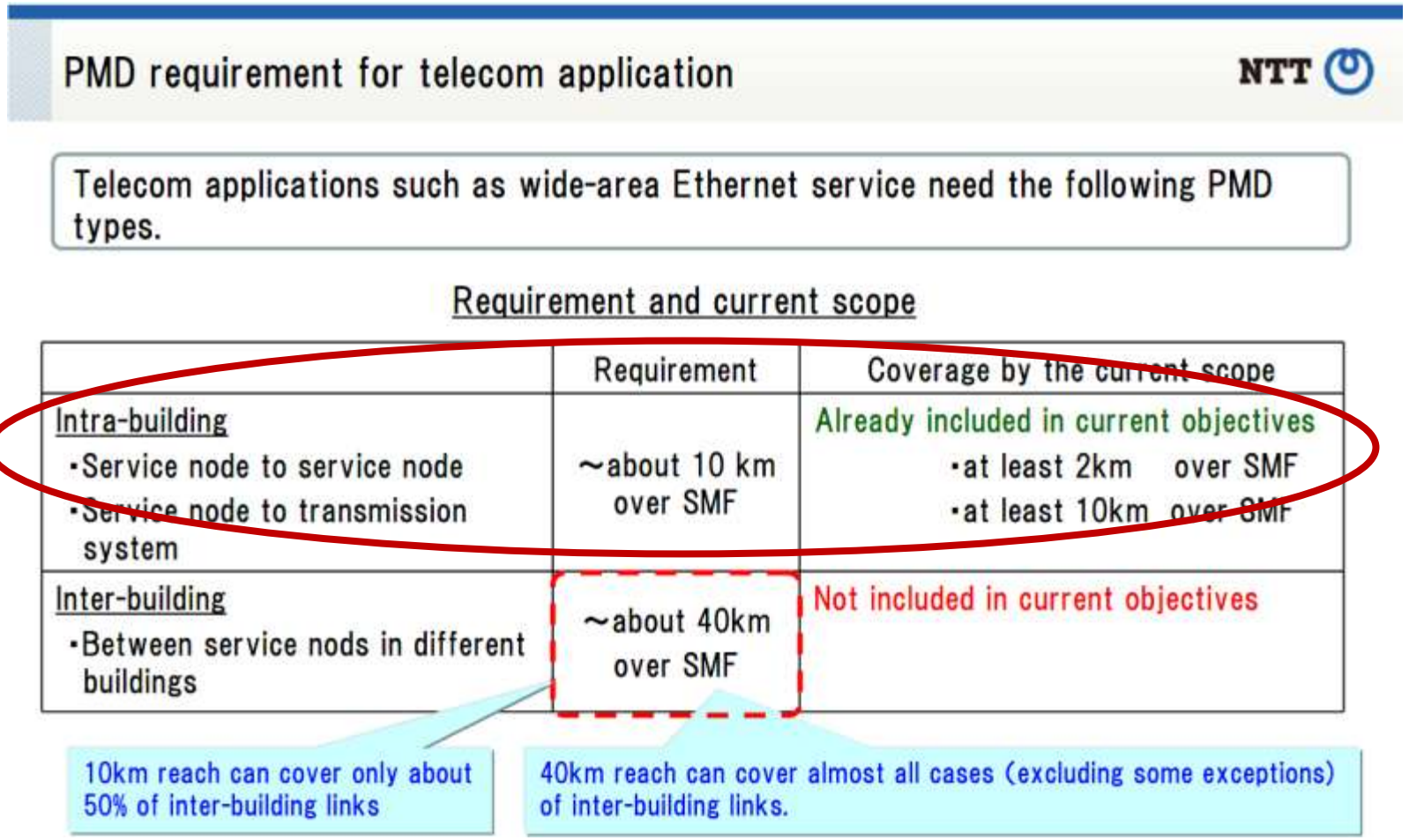
Interconnection Volume

- Four sections per colo & multiple colos (≥ 4) per data center
- Volumes below are per section (except DCR to Metro)

A End	Z End	Volume	Reach (max)	Medium	Cost Sensitivity	Market Space
Server ǂ	TOR	10k – 100k	3 m	Copper	Extreme	LAN
TOR	LEAF	1k – 10k	20 m	Fiber (AOC)	High	
LEAF	SPINE	1k – 10k	400 m	SMF	High	
SPINE	DCR	100 – 1000	1,000 m	SMF	Medium	Campus
DCR	Metro	100 – 300	10 - 80 km	SMF	Low	WAN

http://www.ieee802.org/3/400GSG/public/13_11/booth_400_01a_1113.pdf

Maximizing the cost advantage of Ethernet by considering future generations of 400GE from NTT



http://www.ieee802.org/3/400GSG/public/14_01/sone_400_01_0114.pdf

IEEE 802.3 Working Group Standards Status November 11, 2013

IEEE approved

IEEE 802.3 OM
Approved: Nov-97

IEEE Std 802.3.1-2013 (Ethernet MIB)
14-Jun-13/02-Aug-13*

IEEE Std 802.3bk-2013 (Extended EPON)
23-Aug-13/30-Aug-13*

* Dates are approved/published

SA = Subscriber Access Networks
BPE = Backplane Ethernet

IEEE Std 802.3-2012
6 Books (Sections) Published: 28-Dec-12

Section 1 Clause 1 to 20 Annex A to H, 4A	Section 2 Clause 21 to 33 Annex 22A to 33E	Section 3 Clause 34 to 43 Annex 36A to 43C	Section 4 Clause 44 to 55 Annex 44A to 55B	Section 5 Clause 56 to 77 Annex 57A to 76A	Section 6 Clause 78 to 90 Annex 83A to 86A
CSMA/CD Overview	100 Mb/s Overview	1000 Mb/s Overview	10 Gb/s Overview	SA Overview	EEE
MAC	MII	GMII	MDC/MDIO	OAM	LLDP TLVs
PLS/AUI	100BASE-T2	1000BASE-X AN	XGMII	MPMC	40/100G Overview
10BASE5 MAU	100BASE-T4	1000BASE-SX	XAUI	100BASE-LX10	40GBASE-KR4
10BASE2 MAU	100BASE-TX	1000BASE-LX	XSBI	100BASE-BX10	40GBASE-CR4
10BROAD36 MAU	100BASE-FX	1000BASE-CX	10GBASE-SR	1000BASE-LX10	40GBASE-SR4
10BASE-T MAU	100Mb/s Repeater	1000BASE-T	10GBASE-LR	1000BASE-BX10	40GBASE-FR
10BASE-F MAUs	100Mb/s Topology	1000 Mb/s Repeater	10GBASE-ER	1000BASE-PX10	40GBASE-LR4
10 Mb/s Repeater		1000 Mb/s Topology	10GBASE-SW	1000BASE-PX20	100GBASE-CR10
10 Mb/s Topology	MAC Control		10GBASE-LW	10GBASE-PR	100GBASE-SR10
	Auto-Negotiation (AN)		10GBASE-EW	10/1GBASE-PRX	100GBASE-LR4
10GBASE-Te	Management		10GBASE-LX4	10PASS-TS	100GBASE-ER4
			10GBASE-CX4	2BASE-TL	
1BASE5	DTE Power		10GBASE-T	SA Topology	
DTE & MAU Mgmt				10GBASE-LRM	
Repeater Mgmt				BPE Overview	
				1000BASE-KX	
				10GBASE-KX4	
				10GBASE-KR	
				BPE AN	
				BASE-R FEC	
Maintenance 6 – 10	Maintenance 6 – 10 802.3-2005/Cor 1	Maintenance 6 – 10	Maintenance 7 – 10 802.3-2005/Cor 2	Maintenance 8 – 10	Maintenance 10

http://www.ieee802.org/3/status/1113_state_of_std.pdf

- 10km objective is main objective in IEEE 10/40/100GbE standard.

802.3bs 400GbE Objective

- Support a MAC data rate of 400 Gb/s
- Support a BER of better than or equal to 10^{-13} at the MAC/PLS service interface (or the frame loss ratio equivalent)
- Support full-duplex operation only
- Preserve the Ethernet frame format utilizing the Ethernet MAC
- Preserve minimum and maximum FrameSize of current Ethernet standard
- Provide appropriate support for OTN
- Specify optional Energy Efficient Ethernet (EEE) capability for 400 Gb/s PHYs
- Support optional 400 Gb/s Attachment Unit Interfaces for chip-to-chip and chip-to-module applications
- Provide physical layer specifications which support link distances of:
  - At least 100 m over MMF
  - At least 500 m over SMF
  - At least 2 km over SMF
  - At least 10 km over SMF

10km over duplex SMF is a necessity from a telecom and IDC application perspective!

PMD Economical Perspective

- End User Perspective on 400 Gb/s Ethernet from AMS-IX:
  - Financial costs
    - ≤ 2.5 x 100Gb/s
  - Port density
    - One 400Gb/s port should not replace more than two 100Gb/s ports

http://www.ieee802.org/3/400GSG/public/13_07/vijn_400_01a_0713.pdf

Summary

- Carrier will consider change network node to 400GE in several years, starting from IP backbone and MAN.
- 10km objective is a clear and crucial application for carrier in 400GbE era.
- 10km interconnection not only in Telecom and also for IDC.
- 10km solution will lead to broad market potential for 400GE standard and economical/technical feasibility is ready!


thank you
danke
謝謝
ngiyabonga
teşekkür ederim
gracias
tapadh leat
спасибо
Баярлалаа
рахмат
dank je
obrigado
dziękuję
bedankt
hvala
mauruuru
sukriya
kop khun krap
go raibh maith agat
mochchakkeram
arigatō
takk
dakujem
terima kasih
grazie
merci
мерси
ευχαριστώ
감사합니다
ありがとう
sagolun
köszönöm
mersi
mesi
tack
blagodaram
malondo
paldies
хвала
asante
manana
trugarez
shukriya
dhanyavadagalu
diolch
xiexie
rahmet
tanemirt
najis tuke
kam sah hamnida
didi madloba
dekuji
enkosi
grazie
gracies
sulpay
chnorakaloutioun
vinaka
taafetai lava
kiitos
dankie
nandri
welalin
barka
djiere dieuf
mamnun
misaotra
mahalo
taiku