IEEE 802.3 Ethernet

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Agenda

IEEE 802.3 Overview

IEEE 802.3 Ethernet Physical Layers

Rate, distance, media

IEEE 802.3 Ethernet emerging technologies

New physical layers, new technologies

Conclusion

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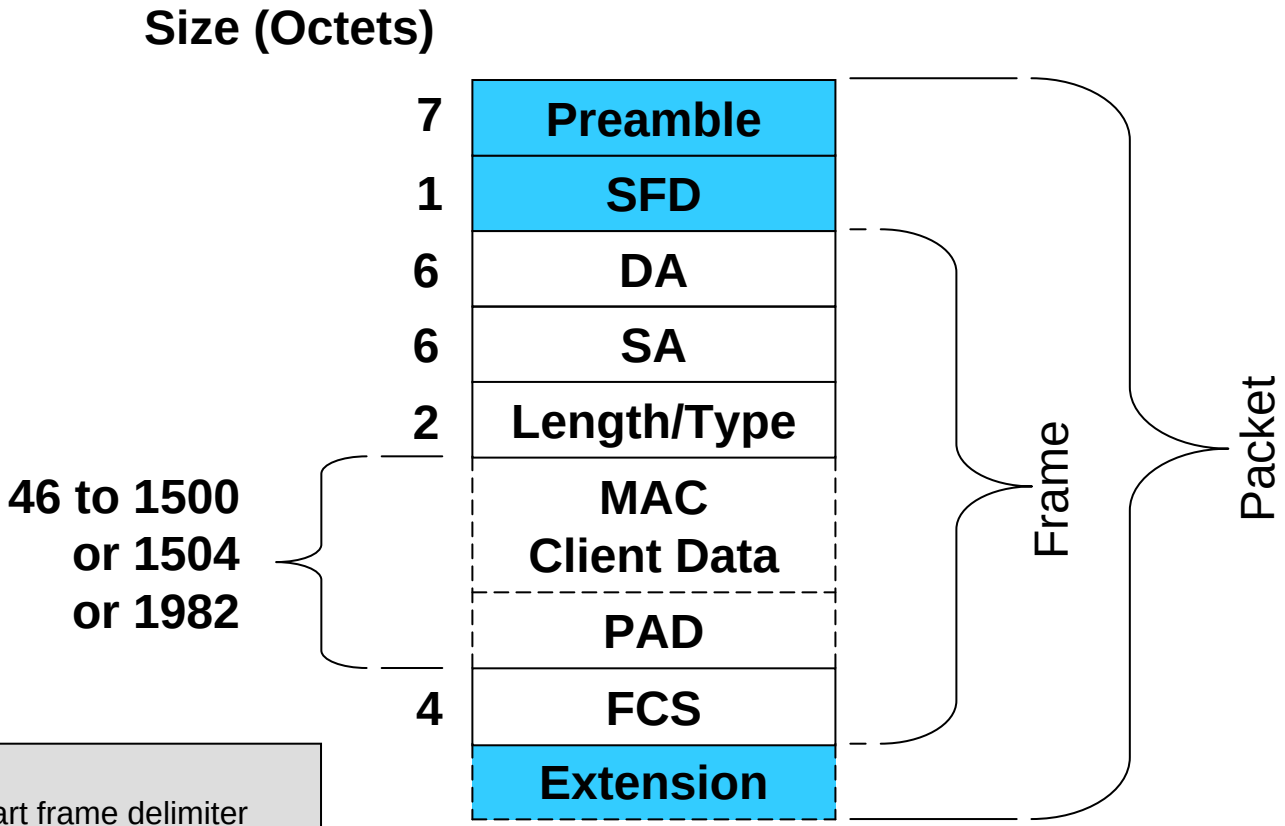
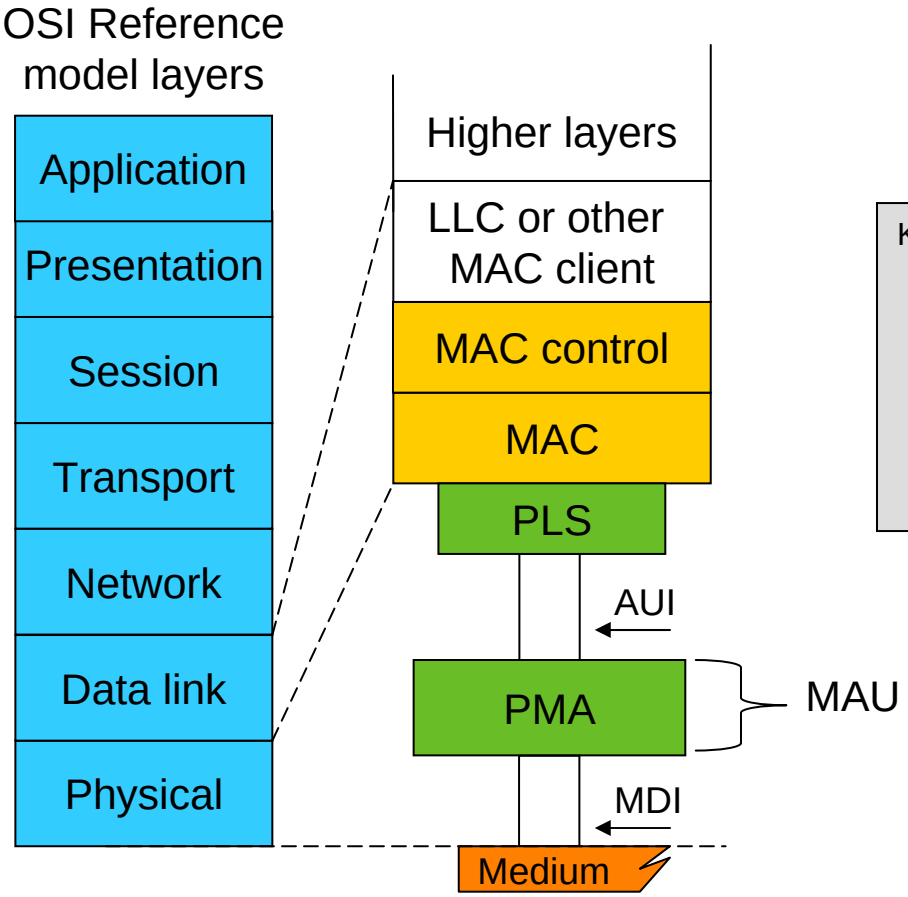
IEEE Std 802.3 Frame format



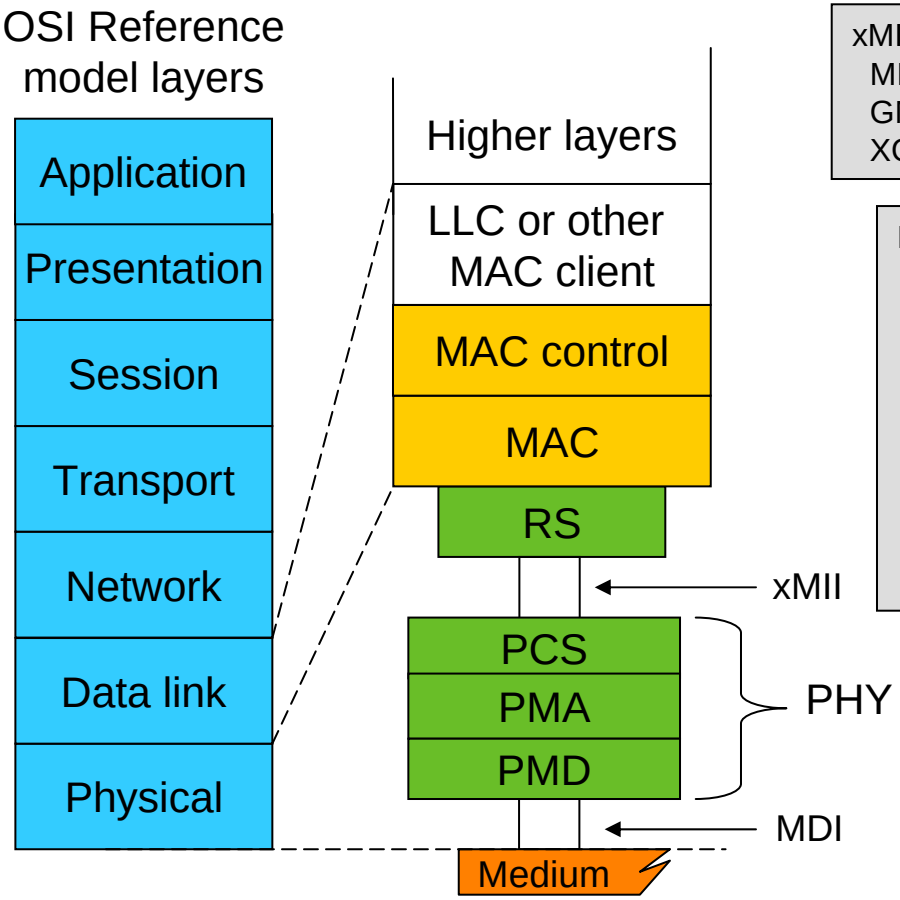
Key:
SFD – Start frame delimiter
DA – Destination address
SA – Source address
MAC – Medium access control
FCS – Frame check sequence

IEEE Std 802.3 layer diagram 1Mb/s and 10Mb/s



Key:
- LLC – Logical link control
- MAC – Medium access control
- PLS – Physical layer signalling
- AUI – Attachment unit interface
- MAU – Medium attachment unit
- PMA – Physical medium attachment
- MDI – Media dependant interface

IEEE Std 802.3 layer diagram 100Mb/s and above



xMII:
- MII – 100Mb/s Medium independent interface
- GMII – 1 Gb/s Medium independent interface
- XGMII – 10 Gb/s Medium independent interface

Key:
- LLC – Logical link control
- MAC – Medium access control
- RS – Reconciliation sublayer
- xMII – Medium independent interface
- PHY – Physical layer device
- PCS – Physical coding sublayer
- PMA – Physical medium attachment
- PMD – Physical medium dependant
- MDI – Media dependant interface

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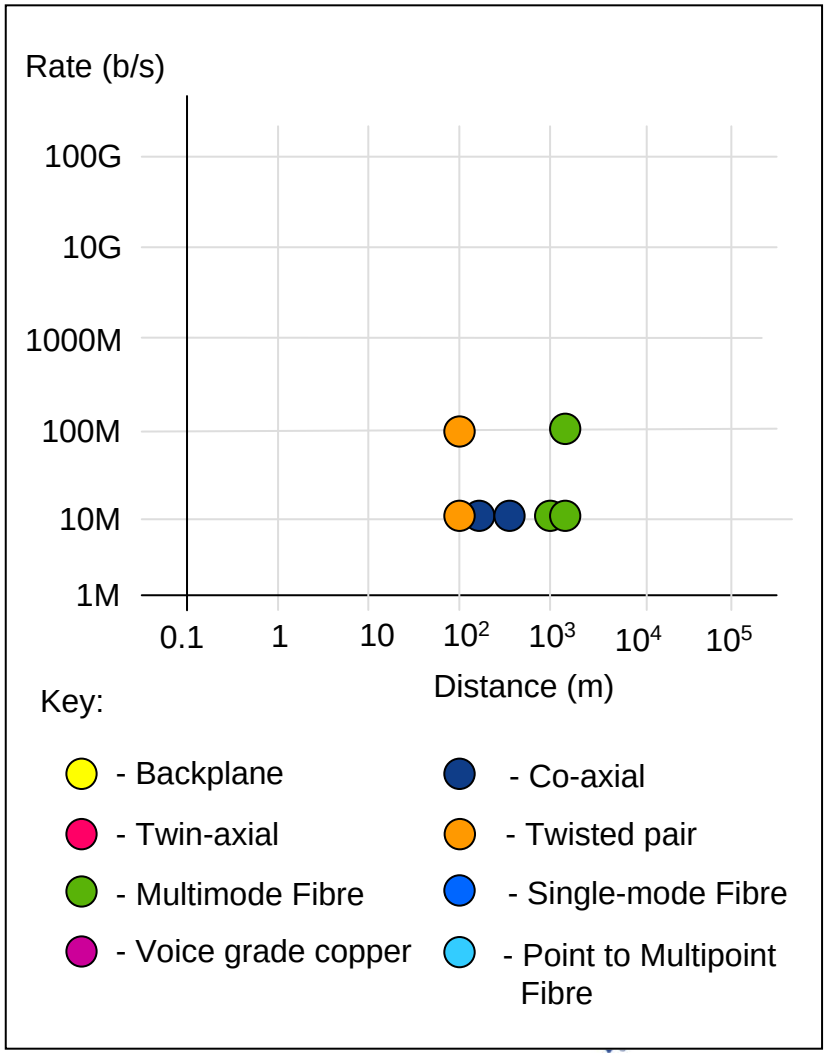
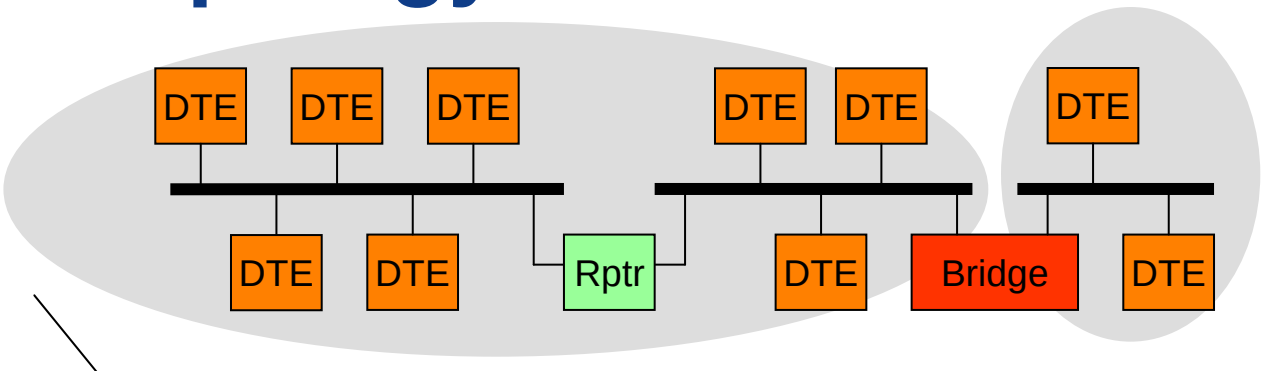
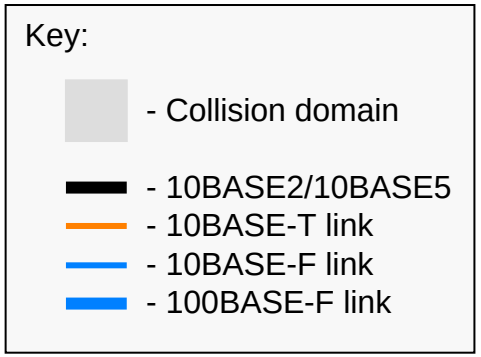
10Mb/s and 100 Mb/s Ethernet

PHY Type	Data rate	Distance	Media
IEEE Std 802.3-1985 Ethernet MAC, 10BASE5			
10BASE5	10Mb/s	500m	Coaxial
IEEE Std 802.3c-1985 Repeater, FOIRL			
FOIRL	10Mb/s	1km	Two multimode
IEEE Std 802.3a-1988 10BASE2			
10BASE2	10Mb/s	185m	Coaxial
IEEE Std 802.i-1990 10BASE-T			
10BASE-T	10Mb/s	100m	Twisted-pair
IEEE Std 802.3j-1993 10BASE-F			
10BASE-FP	10Mb/s	1km	Two multimode
10BASE-FL	10Mb/s	2km	Two multimode
10BASE-FB	10Mb/s	2km	Two multimode
IEEE Std 802.3u-1995 100BASE-T			
100BASE-TX	100Mb/s	100m	2 pair Cat 5
100BASE-T4	100Mb/s	100m	4 pair Cat 3
100BASE-FX	100Mb/s	2Km	Two multimode
IEEE Std 802.3x-1997 Full Duplex			
IEEE Std 802.3y-1997 100BASE-T2			
100BASE-T2	100Mb/s	100m	2 pair Cat 3

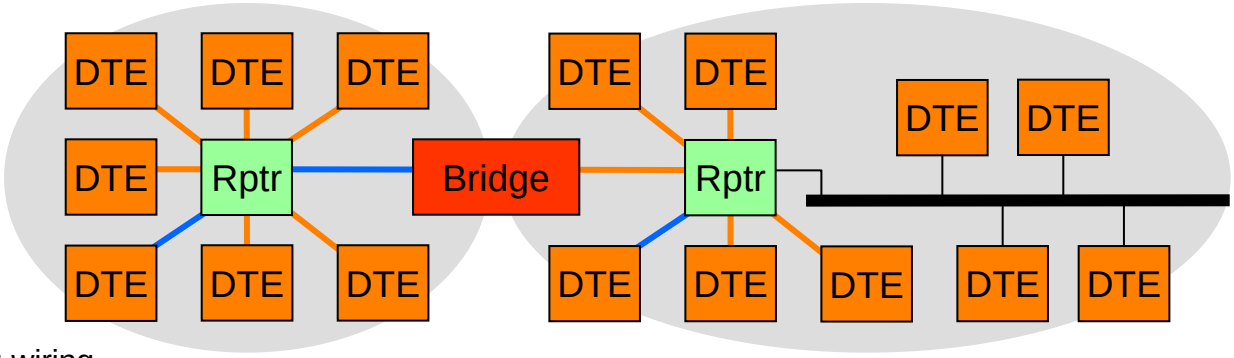


Topology evolution

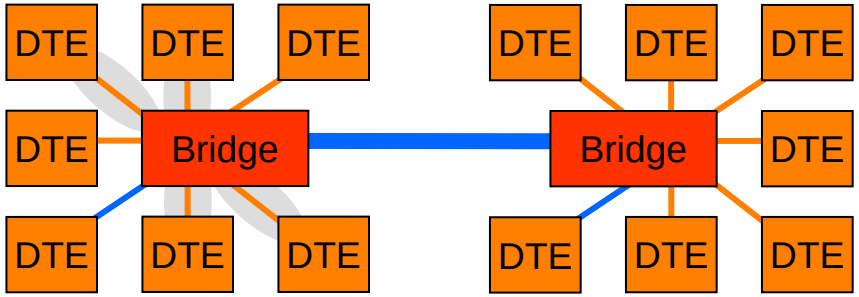




IEEE Std 802.i-1990 10BASE-T
IEEE Std 802.3j-1993 10BASE-F

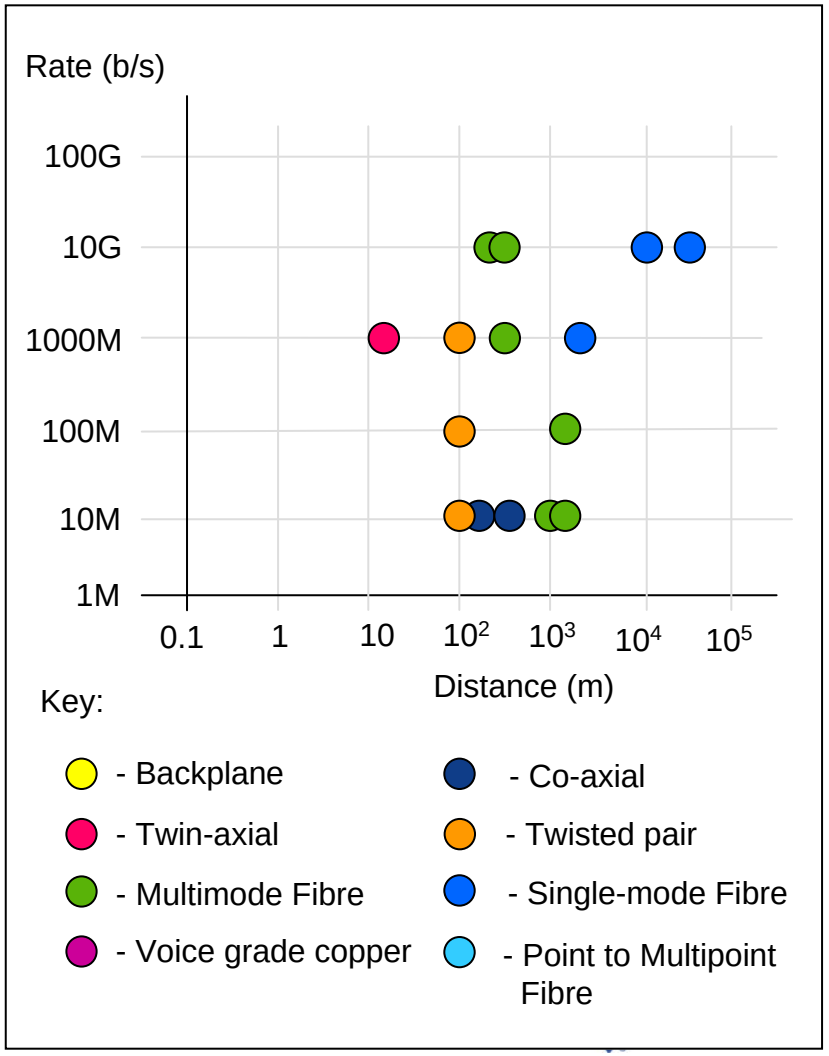


IEEE Std 802.3u-1995 100BASE-T
IEEE Std 802.3x-1997 Full Duplex
TIA/EIA 568:1991 Structured building wiring
ISO/IEC 11801:1995 Structured building wiring



1Gb/s and 10 Gb/s Ethernet

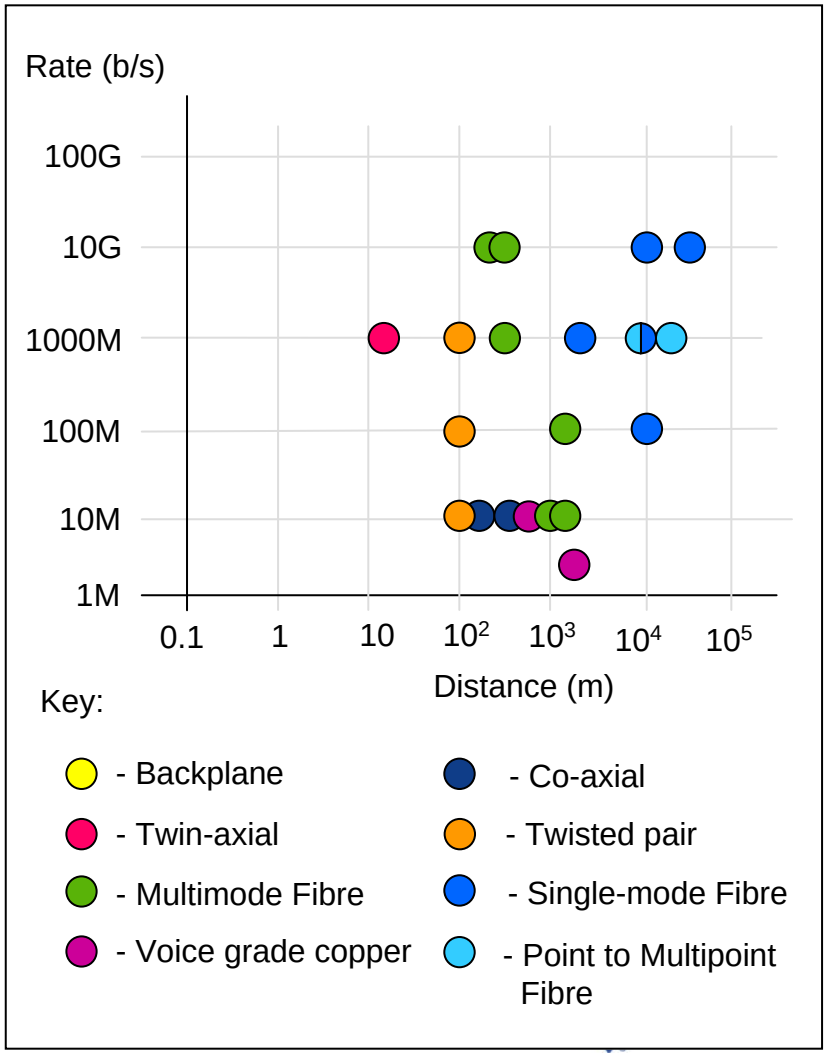
PHY Type	Data rate	Distance	Media
IEEE Std 802.3z-1998 1 Gb/s Operation			
1000BASE-SX	1Gb/s	220m 550m	Two multimode fibres
1000BASE-LX	1Gb/s	5Km 550m	Two single-mode Two multimode
1000BASE-CX	1Gb/s	25m	Copper cable assembly
IEEE Std 802.3ab-1999, 1000BASE-T			
1000BASE-T	1Gb/s	100m	Twisted-pair
IEEE Std 802.3ad-2000 Link Aggregation			
IEEE Std 802.3ae-2002 10 Gb/s Operation			
10GBASE-SR/W	10Gb/s	33m 300m	Two multimode
10GBASE-LX4	10Gb/s	10Km 300m	Two single-mode Two multimode
10GBASE-LR/W	10Gb/s	10Km	Two single-mode
10GBASE-ER/W	10Gb/s	40Km	Two single-mode



Ethernet in the First Mile

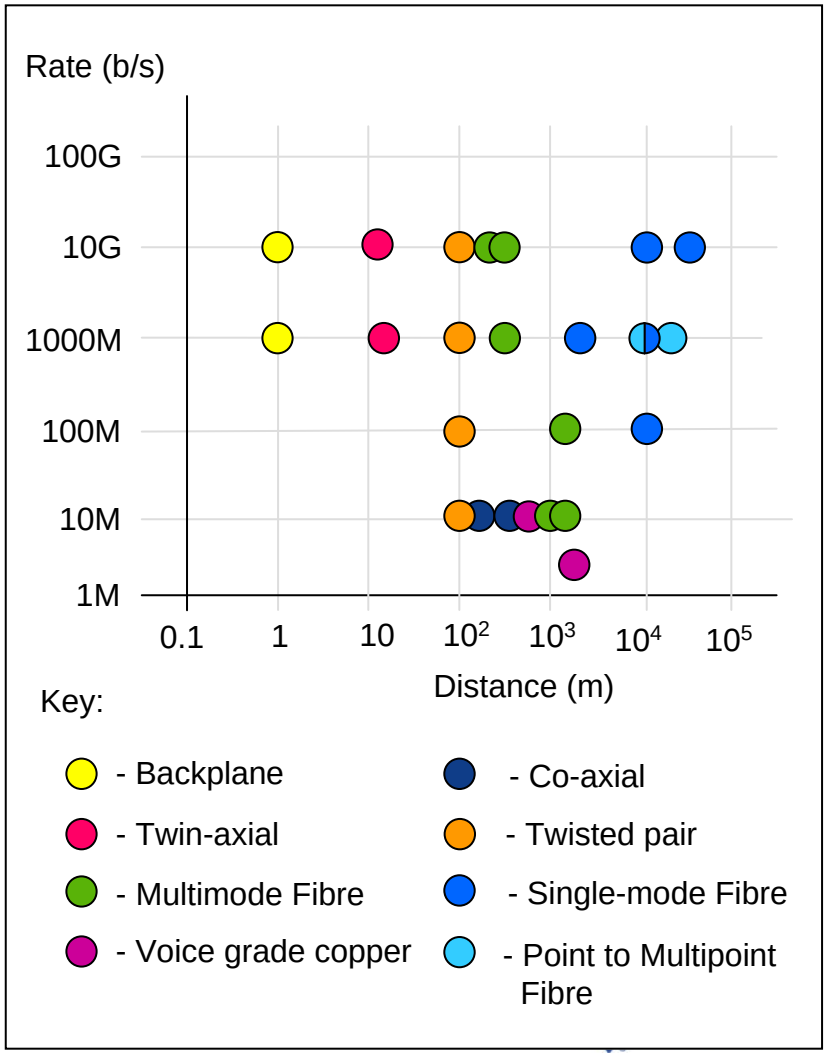
PHY Type	Data rate	Distance	Media
IEEE Std 802.3ah-2004 Ethernet in the First Mile			
100BASE-LX10	100Mb/s	10Km	Two single-mode
100BASE-BX10	100Mb/s	10Km	One single-mode
1000BASE-LX10	1000Mb/s	10Km 550m	Two single-mode Two multimode
1000BASE-BX10	1000Mb/s	10Km	One single-mode
1000BASE-PX10	1000Mb/s	10Km	One single-mode Point to Multipoint
1000BASE-PX20	1000Mb/s	20Km	
10PASS-TS	10Mb/s*	750m*	Voice grade copper
2BASE-TL	2Mb/s*	2Km*	Voice grade copper

* Nominal speed and reach



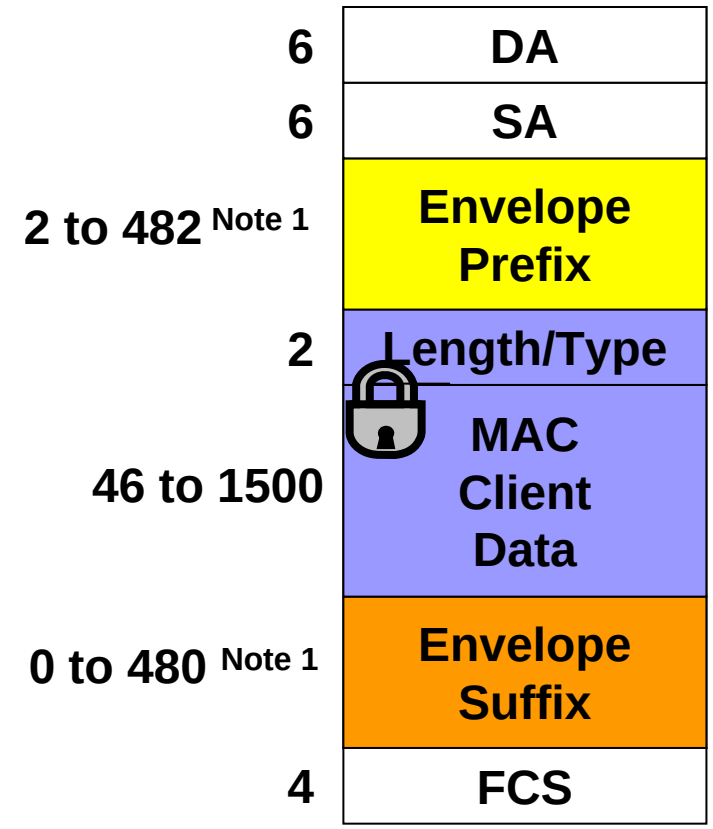
10 Gb/s PHYs, Backplane Ethernet

PHY Type	Data rate	Distance	Media
IEEE Std 802.3ak-2004, 10GBASE-CX4			
10GBASE-CX4	10Gb/s	15m	Copper cable assembly
IEEE Std 802.3an-2006, 10GBASE-T			
10GBASE-T	10Gb/s	100m	Twisted-pair
IEEE Std 802.3ap-2007,Electrical Backplanes			
1000BASE-KX	1000Mb/s	1m	Backplane
10GBASE-KX4	10Gb/s	1m	Backplane
10GBASE-KR	10Gb/s	1m	Backplane
IEEE Std 802.3aq-2006, 10GBASE-LRM			
10GBASE-LRM	10Gb/s	100m 220m	Two multimode



IEEE Std 802.3as-2006 Frame Extension

- Drivers
  - IEEE Std 802.1ad Provider Bridging
    - Tag in Tag
  - IEEE Std 802.1AE MAC Security
    - Cipher block
- Approach
  - Minimal changes
    - Provide for envelope round frame
  - No expansion of MAC Client Data
    - Jumbo frames not supported
- Frame sizes supported
  - 1518 decimal – basic frames
  - 1522 decimal – Q-tagged frames
  - 2000 decimal – envelope frames



Note 1: Envelope prefix + suffix ≤ 482

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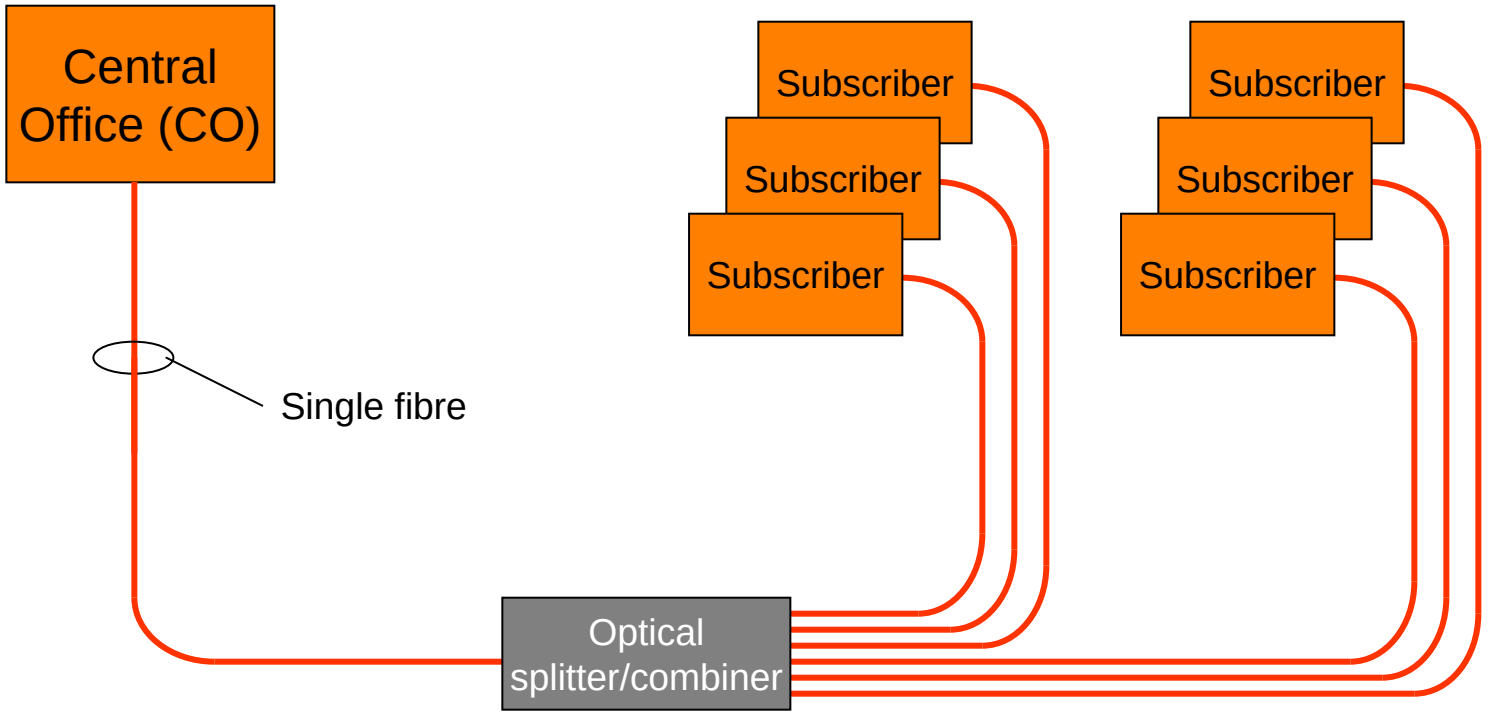
IEEE 802.3 Ethernet emerging technologies

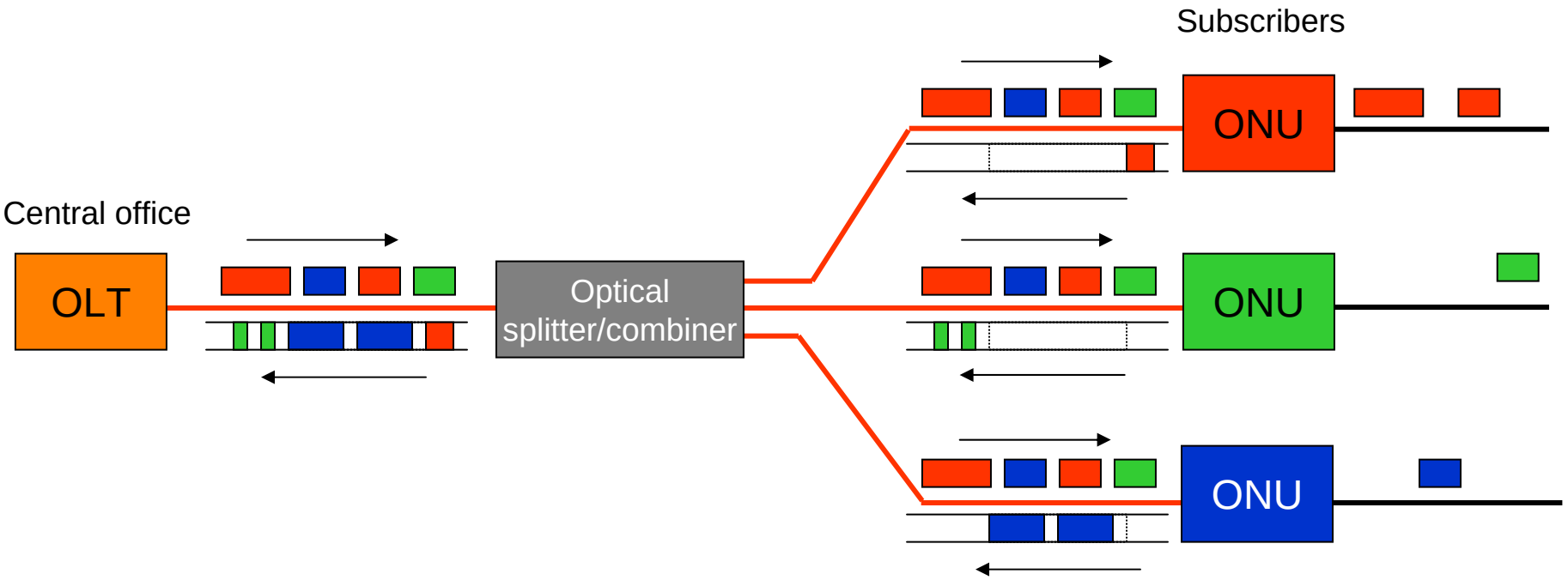
- Demand for increased bandwidth
  - By connected devices
  - By devices aggregating these devices
- Continuing evolution of Ethernet
  - DTE Power via MDI
  - Energy-efficient Ethernet
  - Mapping to OTN
- Convergence around Ethernet
  - Data Centre Bridging (e.g. FCoE, iWARP)
  - Audio/Video Bridging

IEEE Std 802.3 Ethernet Passive Optical Network (EPON) Architecture

- First mile (subscriber access) technology
  - Point to multipoint fibre media



IEEE Std 802.3 Ethernet Passive Optical Network (EPON) Architecture

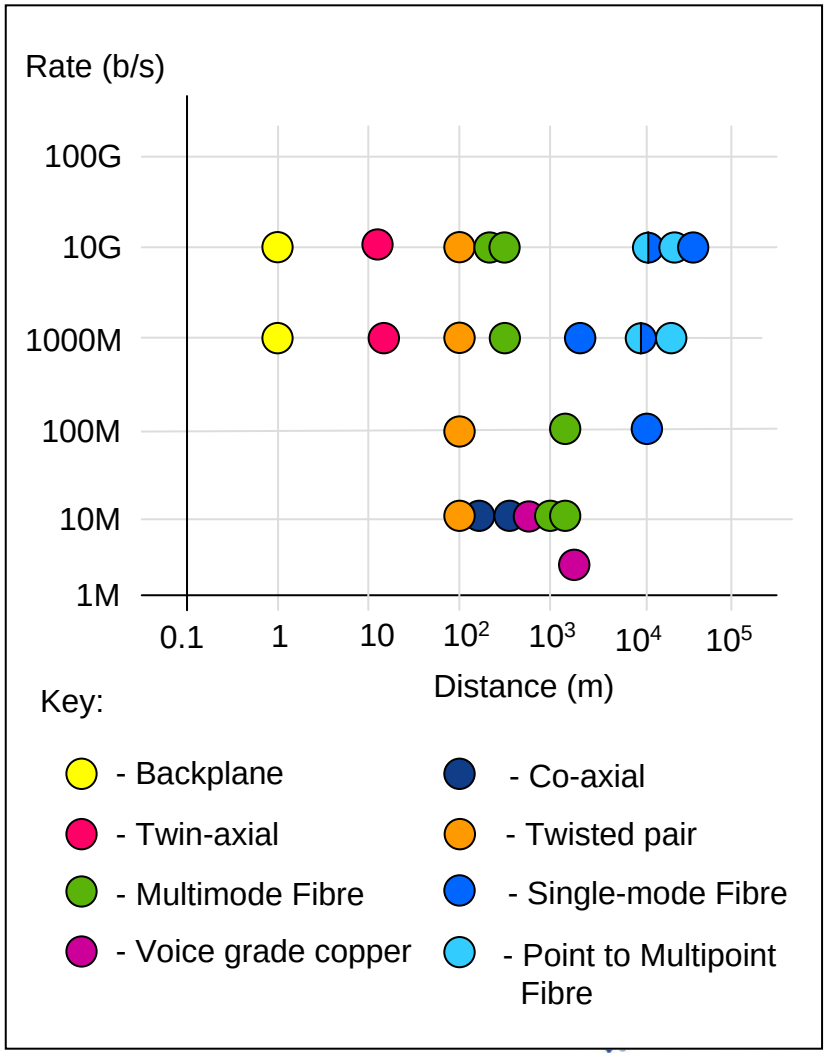


IEEE Std 802.3av-2009 10Gb/s Ethernet Passive Optical Network

- 1Gb/s Passive Optical Networks already supported
  - Included in IEEE Std 802.3ah-2004 Ethernet in First Mile
  - 1 Gb/s downstream and upstream
- Particularly successful in APR
  - Competing standards impediment to wider PONs adoption
    - Both IEEE EPONs and ITU specified GPONs
- Bandwidth demands increasing
  - IPTV, VoD
- IEEE Std 802.3av-2009 10Gb/s EPON
  - Symmetric 10 Gb/s downstream and upstream
  - Asymmetric 10 Gb/s downstream, 1Gb/s upstream

IEEE Std 802.3av-2009 10Gb/s EPON Ethernet PHY Types

PHY Type	Data rate		Split ratio	Distance
	Up	Down		
10/1GBASE-PRX1	1Gb/s	10Gb/s	1:16	10km
10/1GBASE-PRX2	1Gb/s	10Gb/s	1:16	20km
			1:32	10km
10/1GBASE-PRX3	1Gb/s	10Gb/s	1:32	20km
10GBASE-PR1	10Gb/s	10Gb/s	1:16	10km
10GBASE-PR2	10Gb/s	10Gb/s	1:16	20km
			1:32	10km
10GBASE-PR3	10Gb/s	10Gb/s	1:32	20km

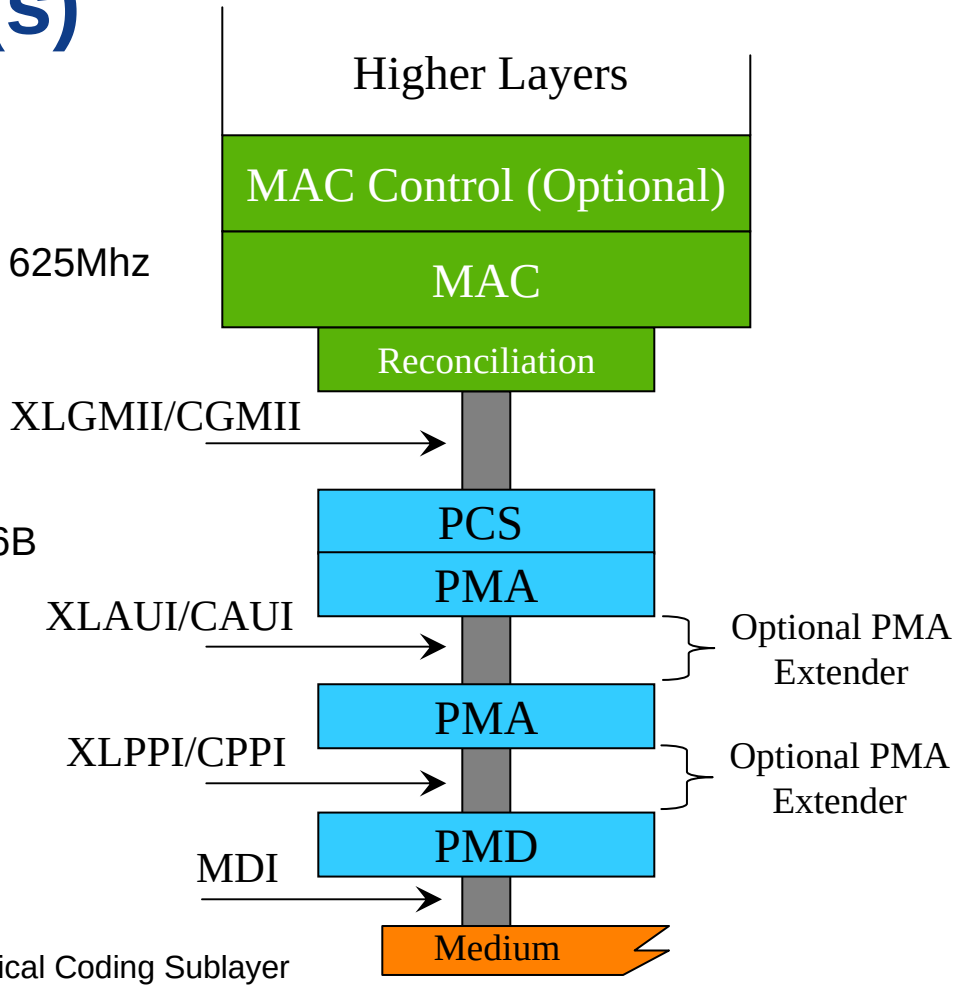


IEEE P802.3ba 40Gb/s and 100Gb/s Ethernet Interface(s)

XLGMII / CGMII
40 / 100 Gigabit **M**edia **I**ndependent **I**nterface
TX and RX data paths
64 data (8 'lanes' of 8 bits), 8 Control, 1 Clock, 625Mhz @ 40Gb/s,1.5625GHz @ 100Gb/s
Logical interface (supports system on a chip)

XLAUI / CAUI
40 / 100 Gb/s **A**ttachment **U**nit **I**nterface
4 (XLAUI) / 10 (CAUI) lanes of 10Gb/s, 64B/66B encoded, 10.3125GBaud/s
To support 25cm FR- 4 PCB traces
Total: XLAUI 16 pins; CAUI 40 pins

XLPPI / CPPI
40 / 100 Gb/s **P**arallel **P**hysical **I**nterface
40GBASE-SR4 or 100GBASE-SR10
Encoding the same as XLAUI/CAUI
No retiming (short distance)



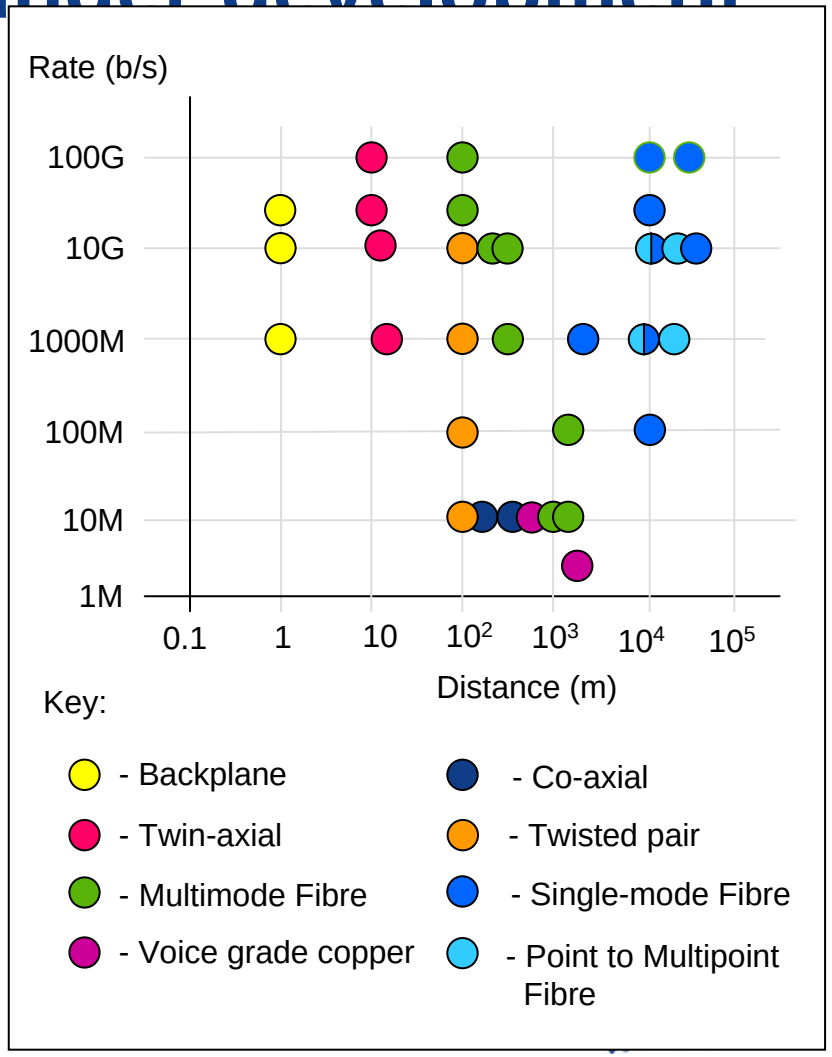
PCS = Physical Coding Sublayer
PMA = Physical Medium Attachment
PMD = Physical Medium Dependent

IEEE P802.3ba 40Gb/s and 100Gb/s Ethernet PHY types

PHY Type	Data rate	Distance	Media	Technology
100GBASE-ER4	100Gb/s	40km	Single Mode Fibre	4 x 25Gb/s (28.78125GBaud) 1310nm DWDM (5nm), SOA
100GBASE-LR4	100Gb/s	10km		4 x 25Gb/s (28.78125GBaud) 1310nm DWDM (5nm)
40GBASE-LR4	40Gb/s			4 x 10Gb/s (10.3125GBaud) 1310nm CWDM (20nm)
100GBASE-SR10	100Gb/s	100m	OM3 multimode fibre	10 x 10Gb/s (10.3125GBaud) 850nm, 10 pairs of fibres
40GBASE-SR4	40Gb/s			4 x 10Gb/s (10.3125GBaud) 850nm, 4 pairs of fibres
100GBASE-CR10	100Gb/s	7m	Copper cable assembly	10 x 10Gb/s (10.3125GBaud) 10 differential pairs
40GBASE-CR4	40Gb/s			4 x 10Gb/s (10.3125GBaud) 4 differential pairs
40GBASE-KR4	40Gb/s	1m	Backplane	4 x 10Gb/s (10.3125GBaud) 4 10GBASE-KR channels

IEEE P802.3ba 40Gb/s and 100Gb/s Ethernet PHY Types under development

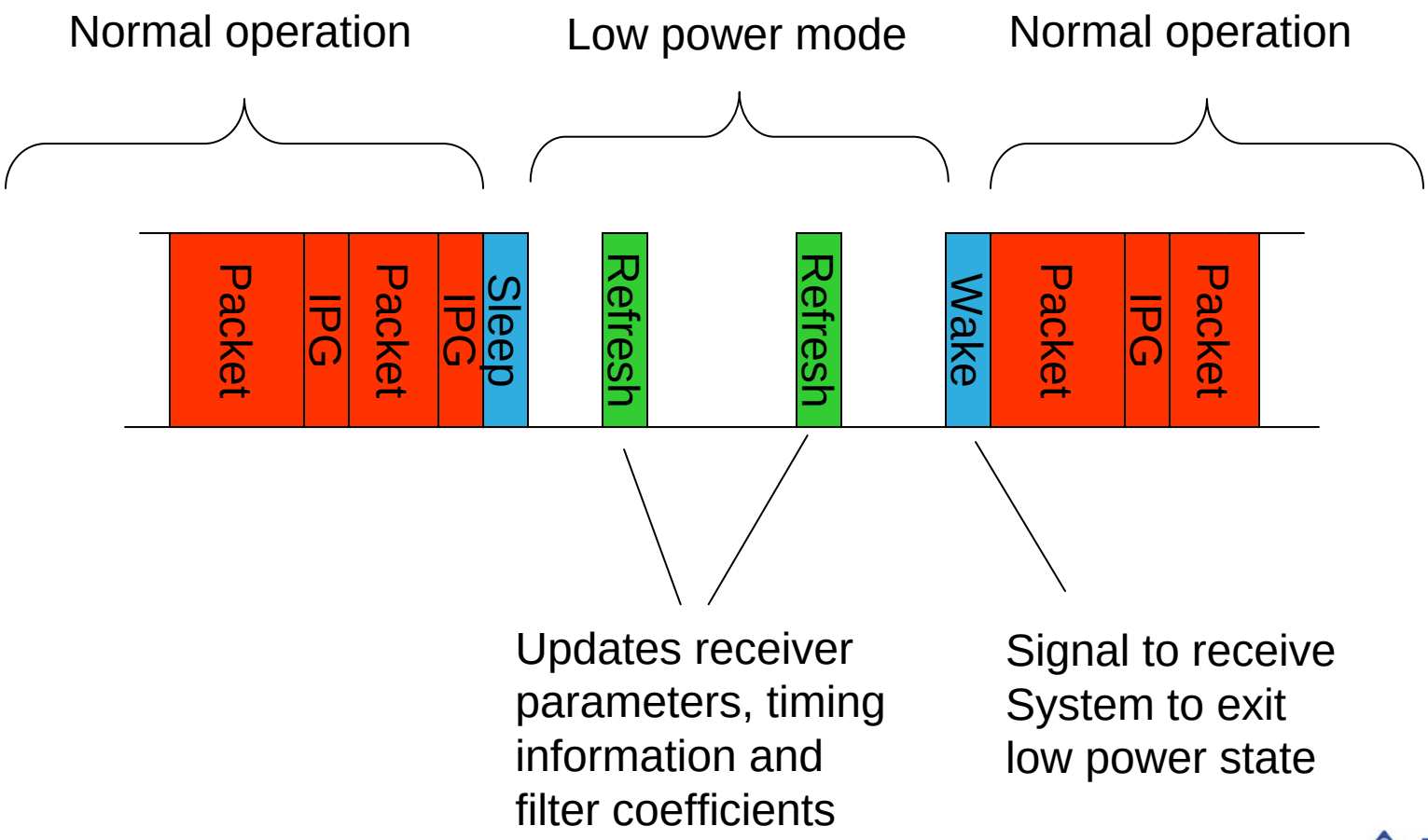
PHY Type	Data rate	Distance	Media
100GBASE-ER4	100Gb/s	40km	Dual Single-mode fibres
100GBASE-LR4	100Gb/s	10km	
40GBASE-LR4	40Gb/s		
100GBASE-SR10	100Gb/s	100m 125m	Multiple multimode fibres
40GBASE-SR4	40Gb/s		
100GBASE-CR10	100Gb/s	7m	Copper cable assembly
40GBASE-CR4	40Gb/s		
40GBASE-KR4	40Gb/s	1m	Backplane



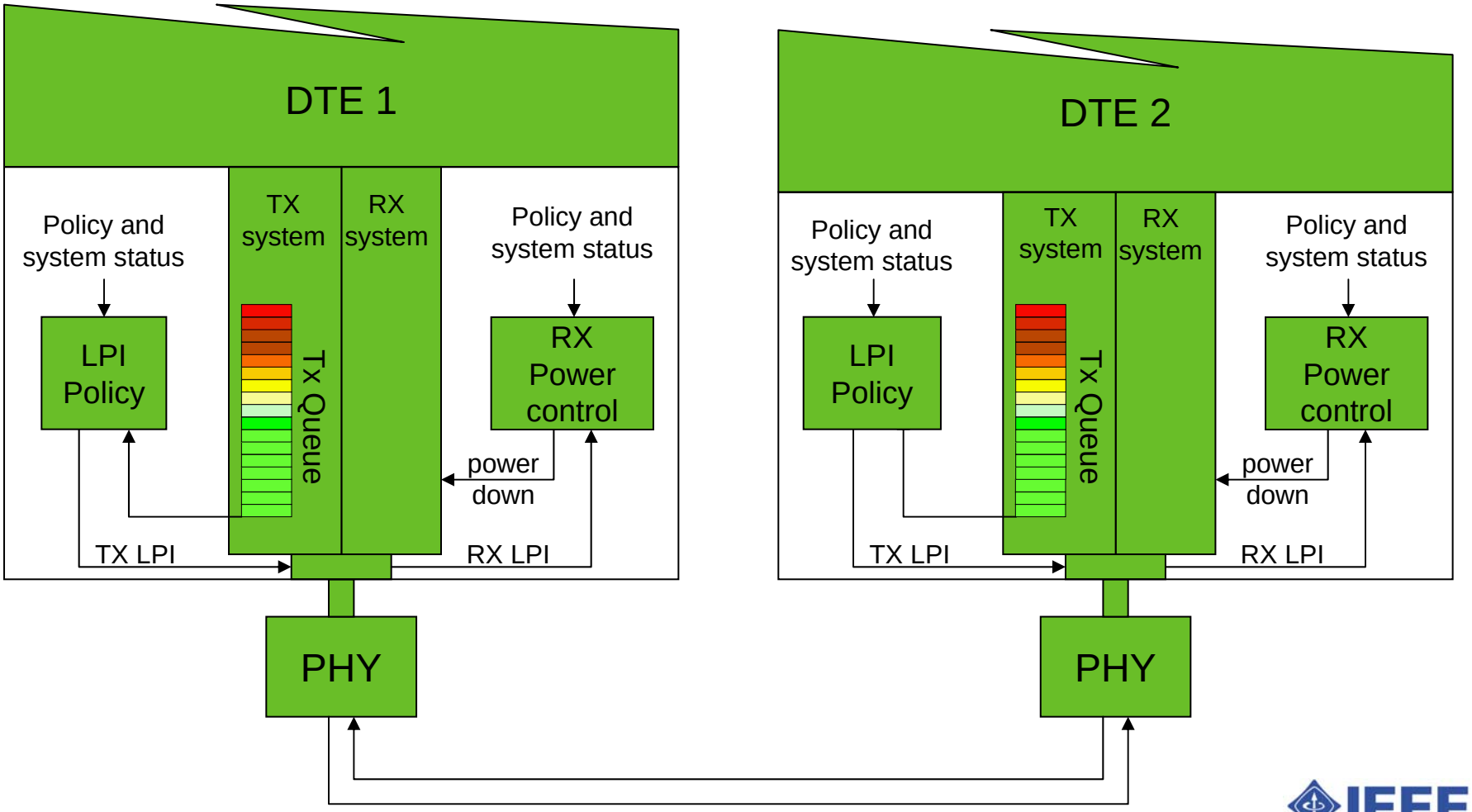
IEEE Std 802.3at-2009 DTE Power Enhancement Overview

- Amendment to IEEE Std 802.3af DTE Power via MDI
  - Interoperation with existing equipment
    - Higher power source will supply existing devices
- Modification to existing standard so need to identify PSE
  - 'Type 1' - Existing IEEE Std 802.3af PSEs and PDs
  - 'Type 2' – New higher power capacity PSEs and PDs
- Cabling
  - 100 meters of ISO/IEC 11801-1995 Class D or better
    - Loop resistance less that 25 Ohms
  - Met by Category 5 or better
    - Under worst case conditions requires a 10C reduction in maximum ambient operating temperature of the cable.
- Supports a 25.5 Watts at PD

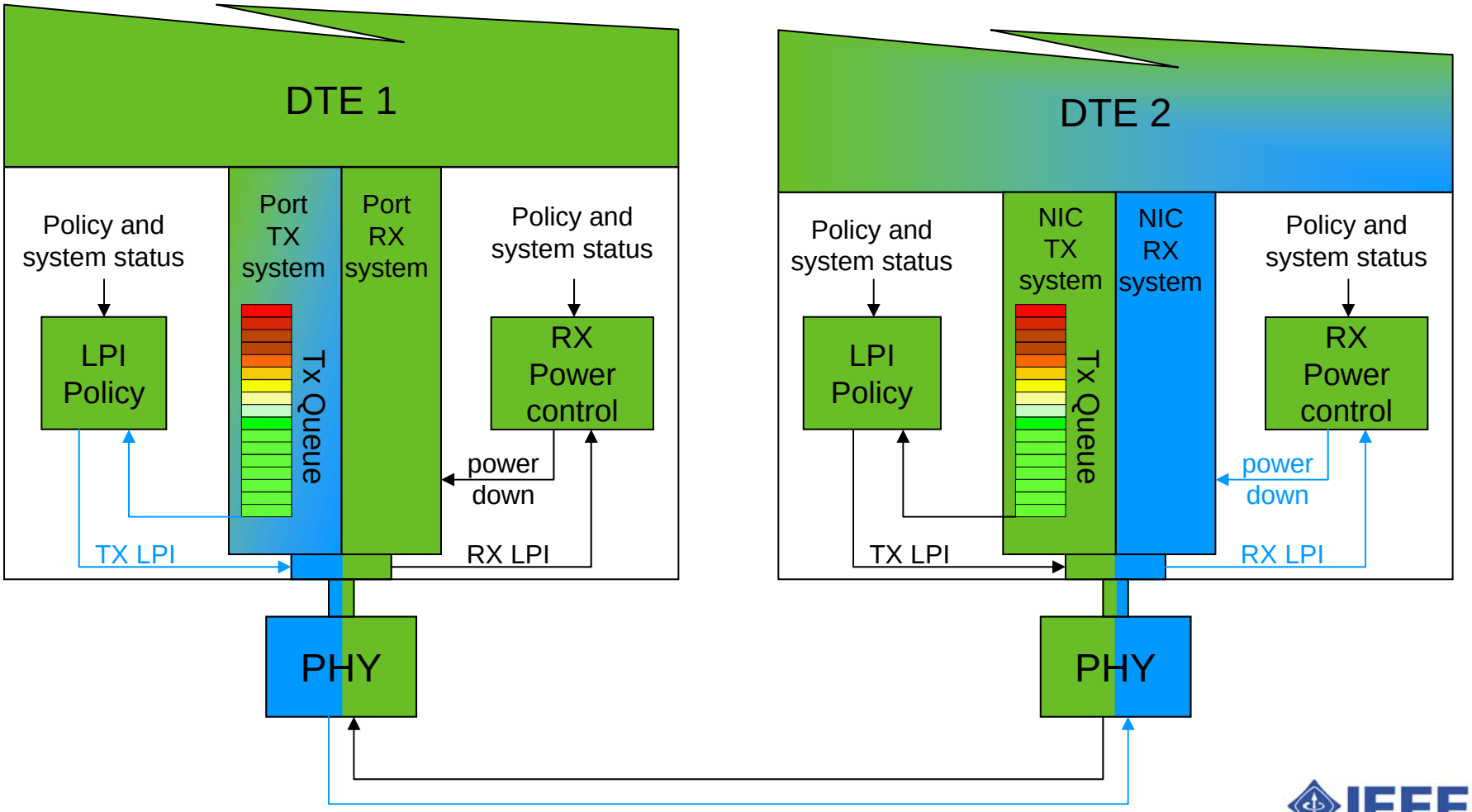
IEEE P802.3az Energy-efficient Ethernet Idle operation overview



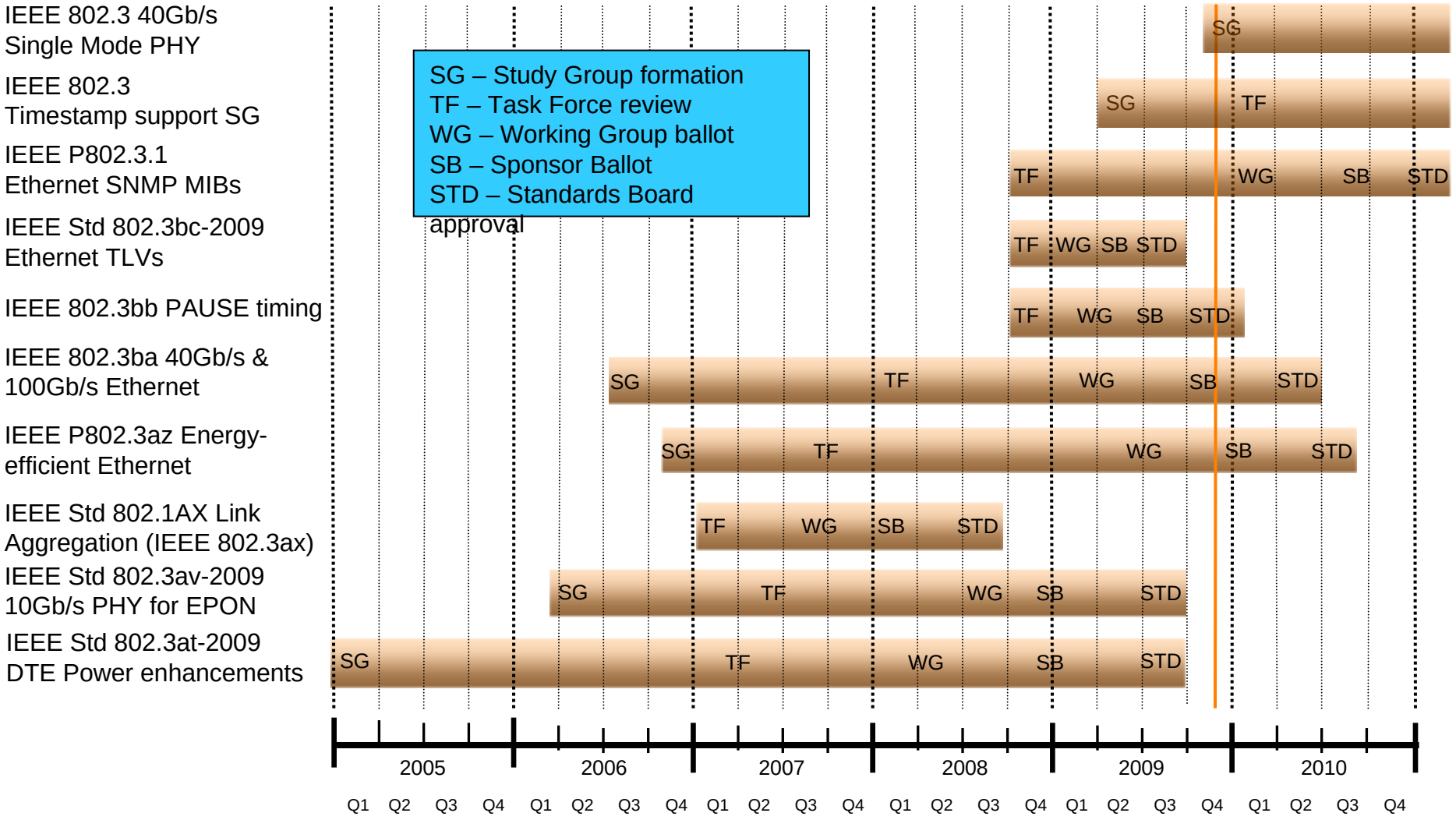
IEEE P802.3az Energy-efficient Ethernet System energy savings



IEEE P802.3az Energy-efficient Ethernet System energy savings, TX queue empty



IEEE 802.3 project status



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Conclusions

- Ethernet is the ubiquitous wired connectivity
  - < 0.01m to 1,000s of kilometres
  - 10Mb/s to 10Gb/s
    - Link Aggregation
  - Backplane to fibre (and everything in between)
- New speeds, media, features and applications reinforce this
  - 40Gb/s and 100Gb/s
  - Energy-efficient Ethernet
- Continued convergence on Ethernet
  - Data Centre Bridging
  - Audio/Video Bridging

IEEE 802.3 Standards

- IEEE Std 802.3™-2008 Ethernet Access Method and Physical Layer Specifications*
  - IEEE Std 802.3av™-2009 10Gb/s EPON
  - IEEE Std 802.3bc™-2009 Ethernet TLVs
  - IEEE Std 802.3at™-2009 DTE Power Enhancements

* Available through Get IEEE 802
http://standards.ieee.org/getieee802/802.3.html

Revision history

Version	Date	Comment
1.0	20th Jan 2010	Initial version based on IEEE Standards Education Committee GlobeCom 2009 Workshop presentation.