The Ethernet Story

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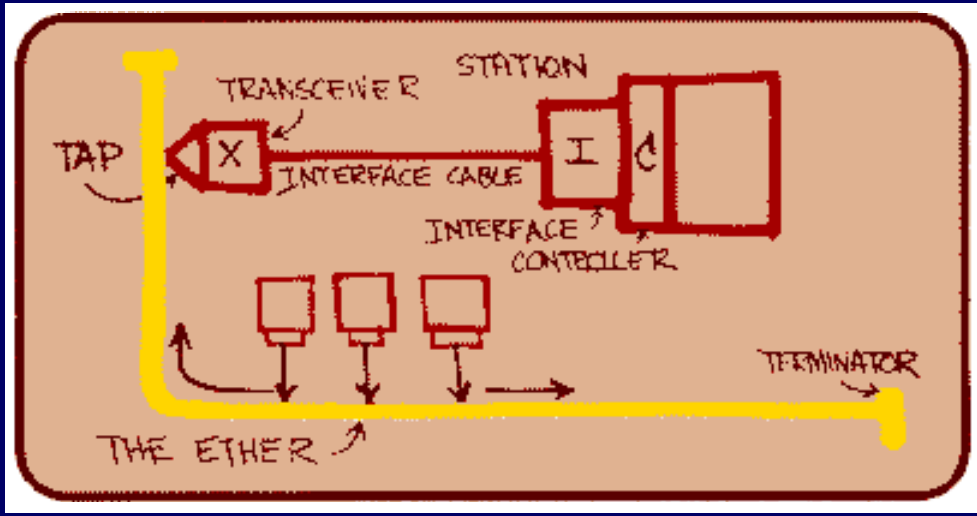
Agenda

- Bob Metcalfe's Vision - the early years
- IEEE – its role and the process
- Ethernet Fundamentals
- Ethernet (r)Evolution
- Related Standards
- Trends
- References

Bob Metcalfe's Vision

June 1976 National Computer Conference



Historical Note

INTEL had just developed the 8080

Running at an unbelievable speed of 4.77 MHz

When did it begin?

- May 22 1973 - Metcalfe wrote a memo at Xerox Parc on ethernet's potential.
- However, Metcalfe claims ethernet was actually invented gradually over a period of several years (U.S. Patent #4,063,220 issued Dec 13, 1977).
- July 1976 - Robert Metcalfe and David Boggs published the paper in the Communications of ACM:

"Ethernet: Distributed Packet-Switching For Local Computer Networks"

- IEEE 802 Committee celebrated 30th Birthday in July 2003

Motivation for Ethernet

- Robert Metcalfe was a member of the research staff at the famous Xerox PARC (Palo Alto Research Center).
- He was asked to build a networking system for PARC's computers.
- Xerox's motivation for the computer network was that they were also building the world's first laser printer and wanted all of the PARC's computers to be able to print with this printer.

Industry Standard

- Metcalfe left Xerox in 1979 to promote the use of personal computers and Local Area Networks (LANs).
- He convinced Digital Equipment, Intel, and Xerox Corporations to work together and promote ethernet as a standard.
- Today, ethernet is the most widely installed LAN protocol.
- Ethernet is no longer limited to LANs.

Early History

1973 Xerox PARC begins development of bus topology LAN

1976 Successful CSMA/CD system to connect 100 workstations on 1 km cable

1980 Digital Equipment Corp, Intel Corp, and Xerox release de-facto Ethernet DIX standard

1980 IEEE 802 Standardization process begins

1983 IEEE 802.3 Standard Published

IEEE and IETF

- Internationally accepted bodies for Data Communications Standardization
  - Open to all practicing engineers
  - Driven by engineers
  - Members are individuals
- IEEE/IETF standards have driven the phenomenal growth in Data Comm

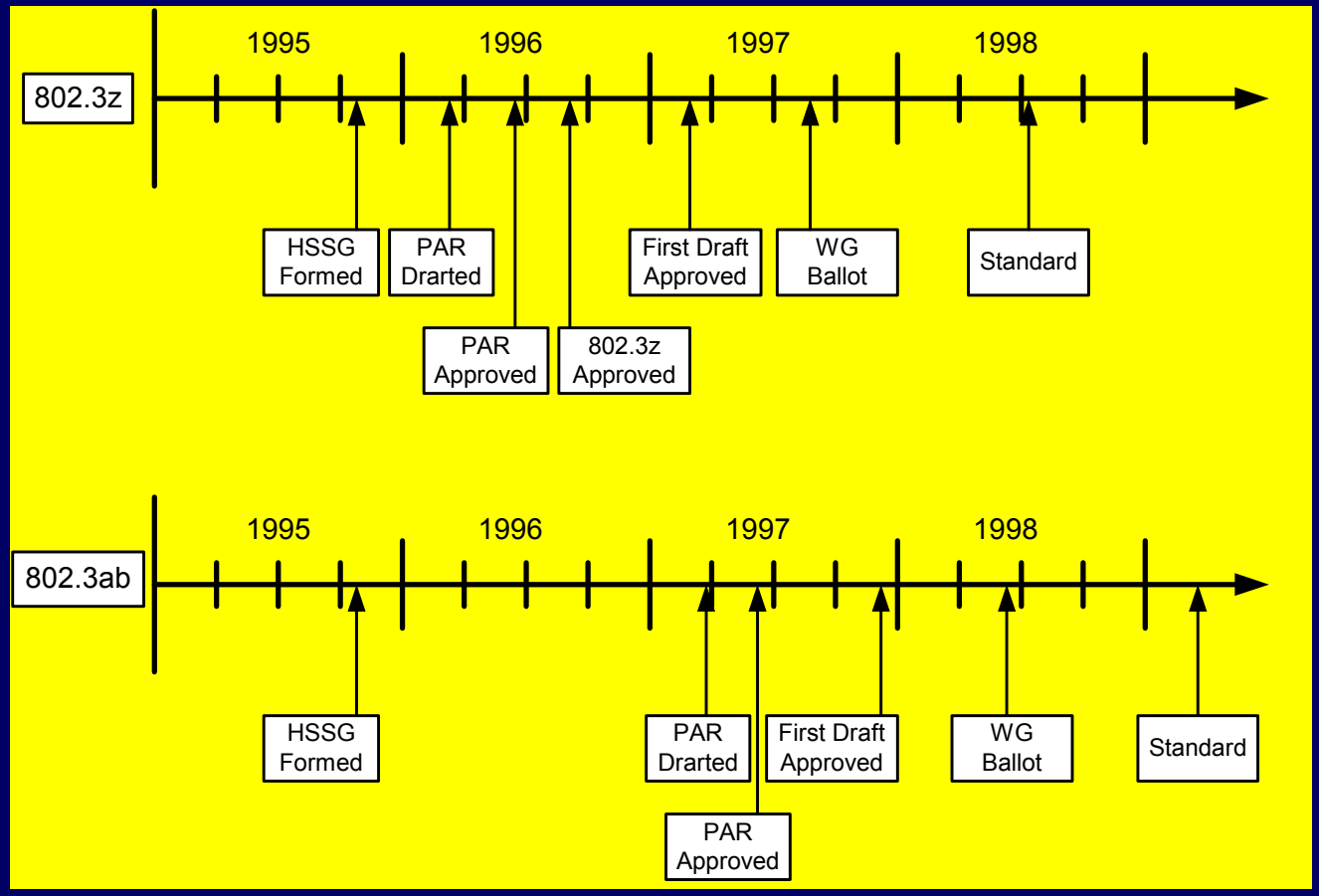
Note: Telecom Standardization has historically been driven by National or Regional bodies (e.g. ANSI, ITU) whose members are generally companies and governments.

IEEE 802® Process

- Call for Contributions
  - Specific topics for discussion at next meeting
- Receive and post written contributions
- Discuss and debate at meeting
- Create draft by 75% vote
- Working Group Ballot
- IEEE "Sponsor Ballot"
- Ballot Responses:
  - "Approve" (can include comments)
  - "Disapprove": indicate what needs to be changed to bring about an "Approve" vote

Example Timelines for Standard

802.3z – 1000Base-X



802.3ab – 1000Base-T

IEEE 802

The LAN/MAN Standards Committee

Wired:

- 802.3 (Ethernet)
- 802.17 (Resilient Packet Ring)

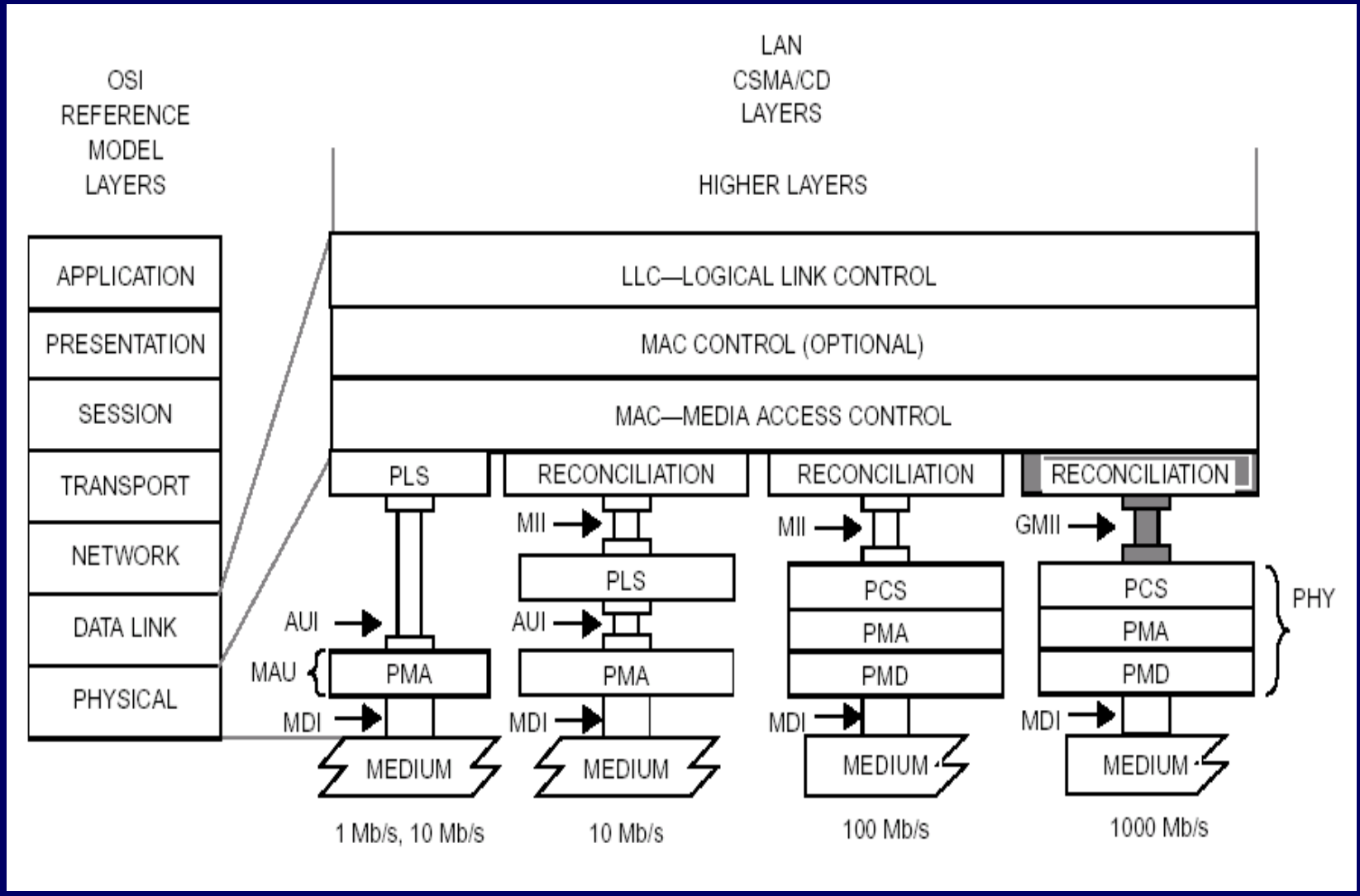
Wireless:

- 802.11 Wireless LAN (Local Area Networks)
- 802.15 Wireless PAN (Personal Area Networks) {inc. Bluetooth}
- 802.16 WirelessMAN™ (Metro Area Networks)
- 802.20 Mobile Wireless Access (new in March 2003)

Common Activities

- 802.1 HILI (High Level Interface)
- 802.18 Radio Regulatory Technical Advisory Group

Ethernet 101



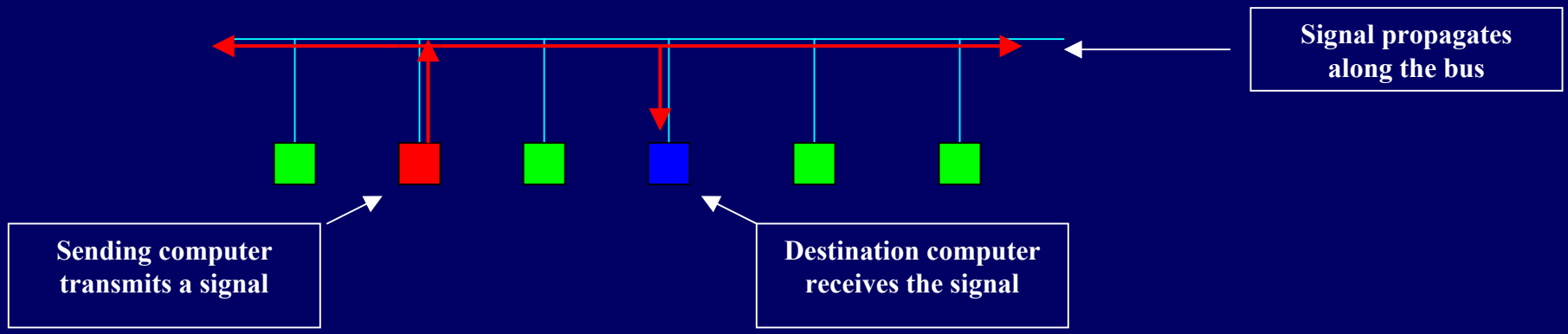
802.1

802.2

802.3

Lost in history (Obsolete) 802.4 (Token Bus) & 802.5 (Token Ring)

CSMA/CD Protocol



- Original Ethernet used shared bus topology
- Frame is transmitted only when bus (i.e. carrier) is sensed as idle
- Bus is monitored for round trip duration for Collision Detection (CD)
- Retransmissions follow exponential backoff algorithm
- Throughput limited by physical round trip delay

Ethernet Frame

- Preamble for receiver synchronization (7 bytes) – alternating 1/0 combination produces 10 MHz square wave for 5.6 Micro Sec.
- Start of Frame (1 byte) – 10101011
- Header (14 bytes)
  - Destination MAC Address (6 bytes – 48 bits)
  - Source MAC Address (6 bytes)
  - Type/length (2 byte overloaded field)
- Variable Length Data (46-1500 bytes)
- CRC (4 bytes)
- Minimum Frame Length 64 bytes (512 bits)

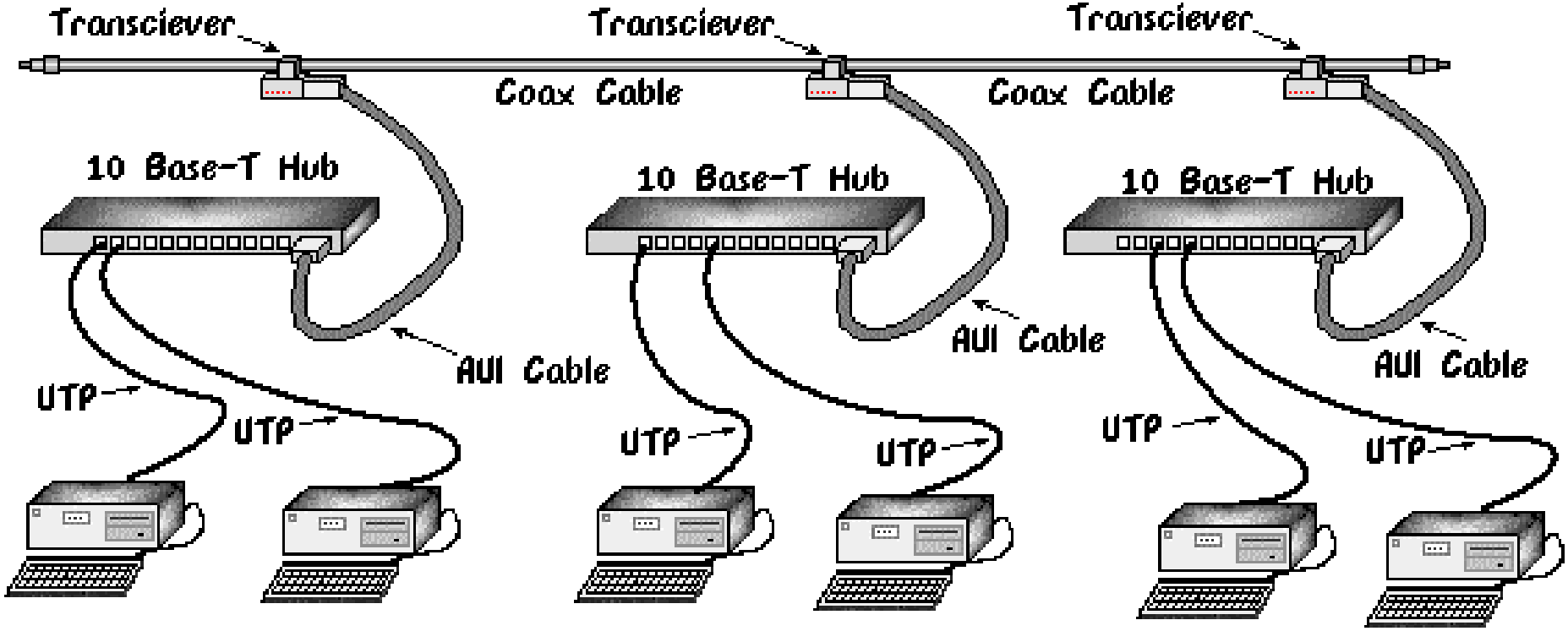
Frame vs. Bus Length

- 802.3 standard at 10 Mb/s specifies maximum bus length of 2.5km with repeaters
- This is equivalent to 50 μs or 500 bits (512 with safety margin)
- Fast Ethernet (100 Mb/s) standard uses 200m maximum length allowing use of same 512 bit minimum frame length and other features of 802.3
- Hence collision probability and throughput are similar to 10 Mb/s but frames need to be longer (by factor of 10) in bits to obtain similar performance. However, max frame size is same as 802.3 for compatibility in interconnected networks

Hubs, Bridges, Switches

- Hubs
  - Central device (usually in wiring closet) that each computer connects to via twisted pair and RJ-45 jack
  - Functions as single segment or collision domain
- Bridges
  - Forwards Ethernet frames between segments
  - Performs frame filtering
  - Distributed Spanning Tree algorithm prevents looping
- Switches
  - Each port is one segment & connects to one computer
  - Effectively provides bridging between segments
  - Multiple computers transmit and receive simultaneously

Using Hubs to enlarge a LAN



Courtesy of Jon Dron (http://edtech.it.bton.ac.uk/ism05-01/index.html)

Ethernet Transceiver

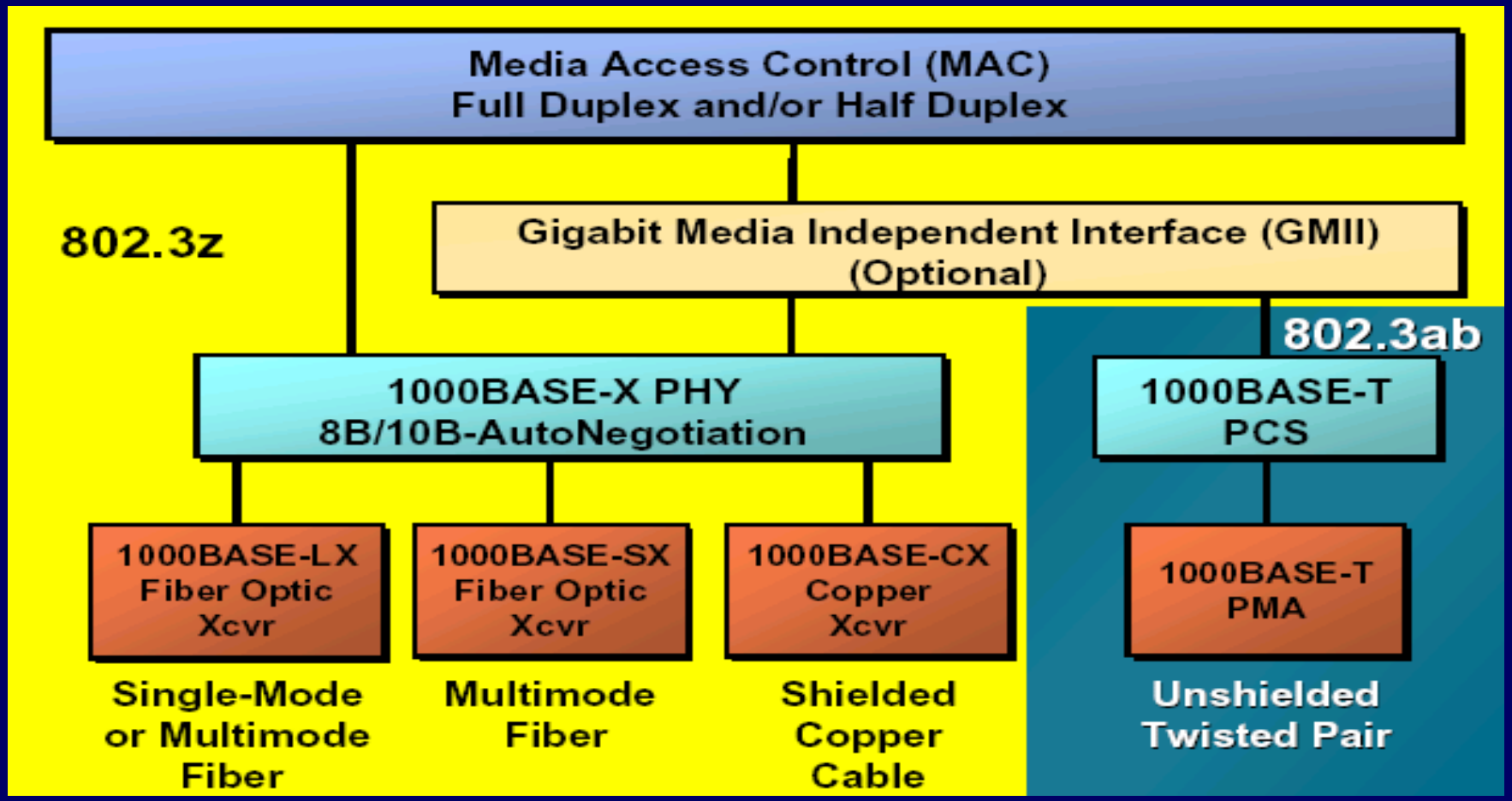
802.3 (r)Evolution

1983	802.3	Ethernet (10 Mbps)	Thick Coax
1986	802.3a	Ethernet	Thin Coax
1991	802.3i	Ethernet	Twisted Pair
1995	802.3u	Fast Ethernet (100 Mbps)	Fiber, Twisted Pair
1998	802.3z	Gig Ethernet (1 Gbps)	Fiber
1999	802.3ab	Gig Ethernet	Twisted Pair
2002	802.3ae	10G Ethernet (10 Gbps)	Fiber
Ongoing	P802.3an	10G Ethernet	Twisted Pair

Ethernet Cabling Types

Name	Type	Distance	Name	Type	Distance
10Base-5	Thick Coax	500m	1000Base-SX 850nm	62.5u MMF 50.0u MMF	300m 500m
10Base-2	Thin Coax	200m	1000Base-LX 1330nm	62.5u MMF 50.0u MMF SMF	500m 500m 3000m
10Base-T	Twisted Pair	100m	1000Base-T	Cat5 UTP 4pr	100m
100Base-T4	Cat 3 UTP 4pr	100m	10GBase-SR 850nm	MMF	300m
100Base-TX	Cat 5 UTP	100m	10GBase-LR 1310nm	SMF	10 km
100Base-FX	MM Fiber	2000m	10GBase-T	Cat 5, 5e ? Cat 6, 7 ?	100m ? 50m ?

GigE Wired LAN Media Types



Trends

- Converged Enterprise Voice and Data Networks
  - Replaces separate PBX voice and LAN data networks
  - Provides cost savings and new services
  - Voice over IP (VoIP) must provide same quality and reliability as PBXs
  - Related specs: 802.1p/Q (priority), 802.3af (powering)
- Ethernet beyond the LAN
  - Ethernet First Mile (EFM) access networks
  - IEEE Task Force 802.3ah and www.efmalliance.org
  - Local Loop objectives:
    - Short Haul: >10 Mbps for > 750m; based on VDSL
    - Long Haul: > 2 Mbps for > 2700m; based on SHDSL

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- Just GOOGLE it