Ethernet: why does it always win?

TECHDAY 2019

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Disclaimer

Steve's Industry Involvement

– Consultant, High Speed Design, Inc.
– Consulting Member, Ethernet Alliance
– Chair, IEEE P802.3ch Multi-Gigabit Automotive Ethernet PHY Task Force
– Chair, IEEE802.3 Greater than 10 Gb/s Automotive Ethernet Electrical PHYs Study Group
– Executive Secretary, IEEE 802.3 Working Group

The views I am expressing on IEEE standards and related products should NOT be considered the position, explanation, or interpretation of the Ethernet Alliance.

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"At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE. "

Who I am

- 45+ years in the entertainment industry

- High-tech lighting and control systems*

- Designed Ethernet into systems starting in 1992

- Co-founder of ESTA ANSI-E1-Entertainment Technology

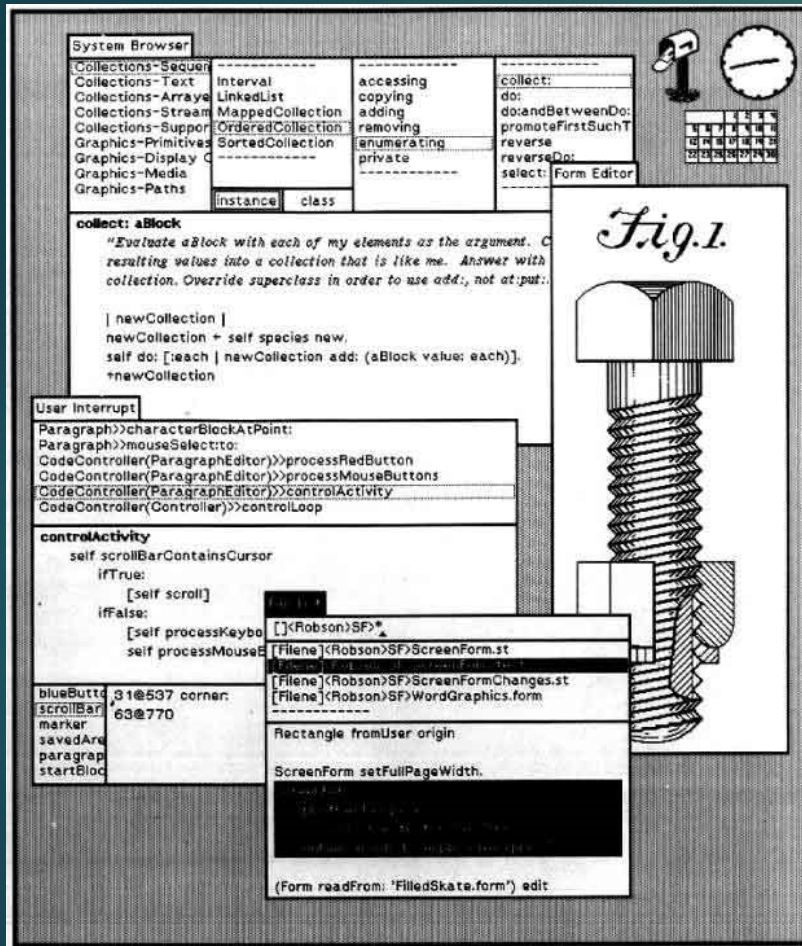- Started in IEEE 802.3 in 1999

- Ethernet user-just like you

*Designing theme parks is fun!

"Ethernet does not in theory work, only in practice."

-Ethernet co-inventor Dr. David R. Boggs
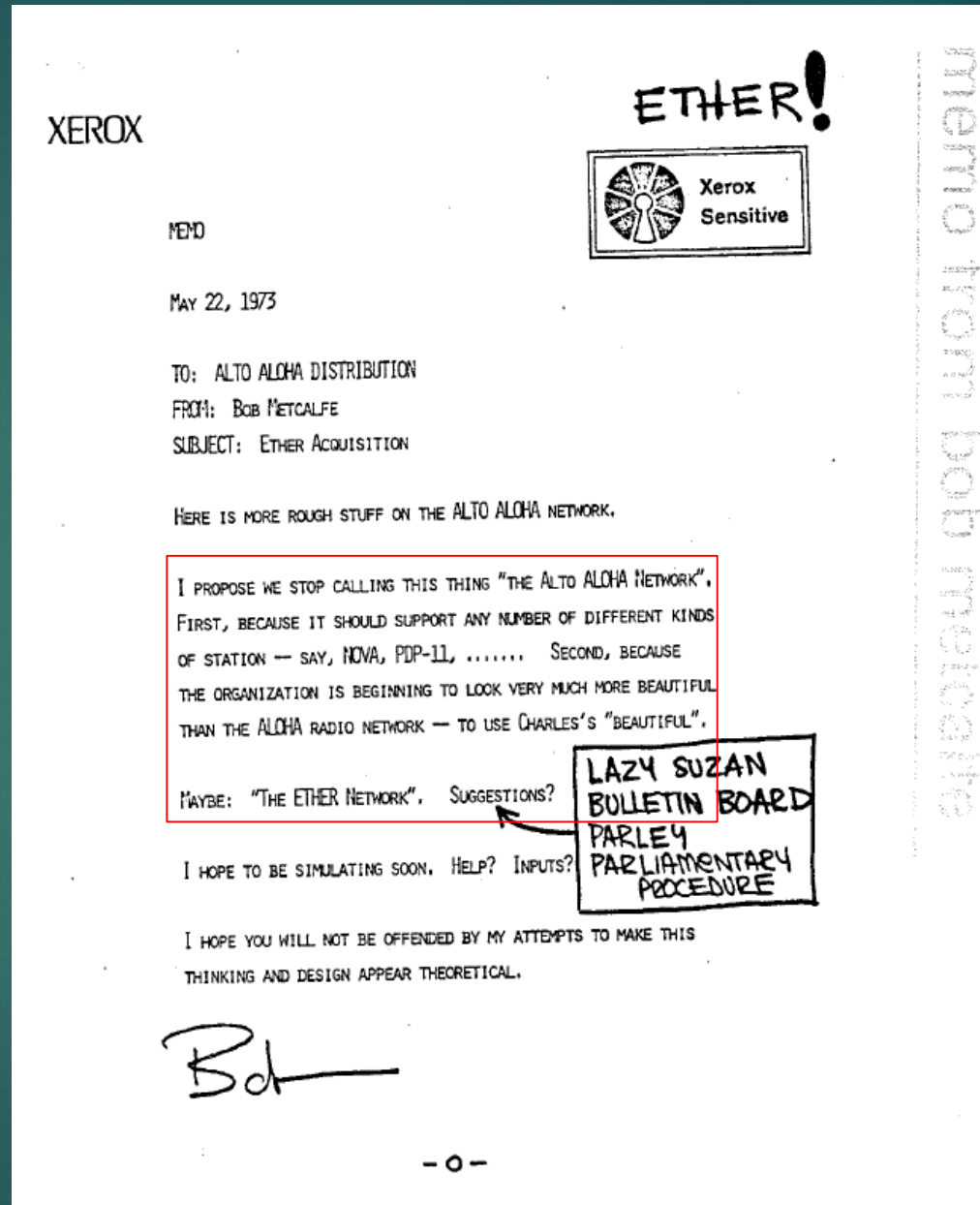
Project ALTO – June 1972

Xerox PARC ALTO Personal Computer

▶ Bit-mapped display

▶ GUI

▶ Mouse

▶ WYSIWYG

▶ Document preparation/typesetting

▶ High-speed LAN

▶ Networked laser printing

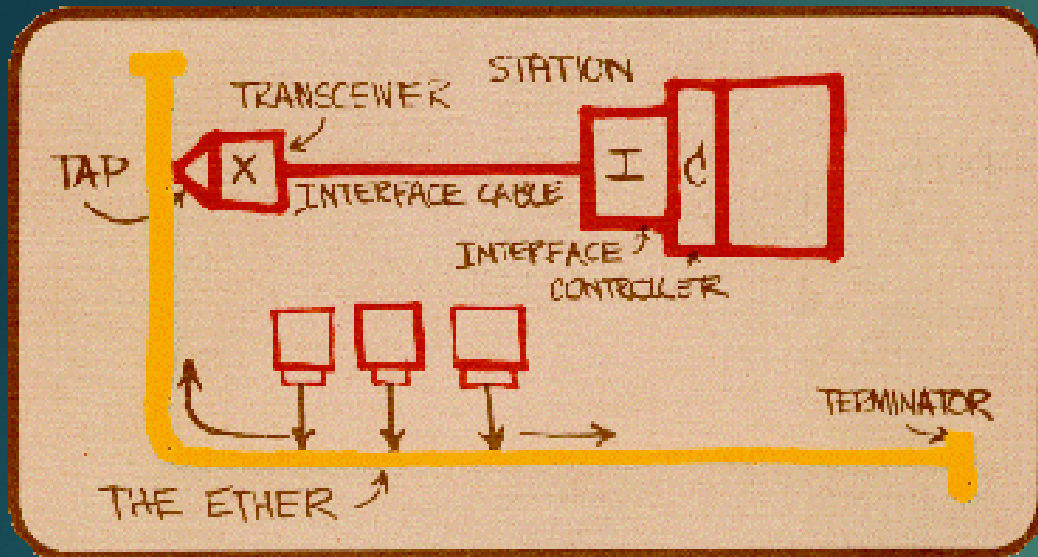▶ Networked file sharing

▶ Email

The Memo
May 22, 1973

Bob Metcalfe and Dave Boggs "The Bobbsey Twins"

- 27- year old Bob Metcalfe was charged with networking the new Xerox Alto personal workstation and the new Xerox laser printer

- Metcalfe took concepts like Internet packet switching from the Advanced Research Projects Agency Network (ARPANET) and multi-access randomized retransmission from ALOHAnet to create Ethernet (CSMA/CD)

- 23 - year old Dave Boggs worked with Metcalfe to realize the actual Ethernet hardware and considers November 11, 1973 as the birth of Ethernet---the day the system first functioned.

- In 1976, after 18 months in the writing, they published "Ethernet: Distributed Packet Switching for Local Computer Networks", Ethernet's seminal paper.

September 2019

A <u>Local</u> Area Network

- The ARPANET was a Wide Area Network (WAN) designed to connect remote computers over slow telephone lines
- Ethernet was a fast (~3Mb/s) Local Area Network designed to connect hundreds of computers, printers, and file servers together within a building or campus.
- Nobody ever had hundreds of computers in one building before
- Nobody had a laser printer that consumed data at the rate of Mb/s
- Peer-to-peer network with no central controller
- Stations could be added and removed from the network without disruption
- Only Layer 1 and Layer 2 are defined
- In 1980 DEC, Intel and Xerox published the DIX V1.0 Ethernet spec that increased the speed to 10Mb/s

http://ieee802.org/3/ethernet_diag.html

Reboot

- Bob Metcalfe leaves Xerox PARC in 1979 to found 3Com, which makes Ethernet cards for DEC computers and MultiBus systems, among others
- 3Com becomes a dominant player in the new computer networking business
- 3Com was the major supplier of Ethernet interface cards in the 1980s

IEEE 802 Standards—the Dots: 1980

- ▶ IEEE Project 802 is formed in February 1980 to standardize local and metropolitan area networks (LANMAN)

- ▶ In 1982 DIX V2.0 is published-Ethernet II

- ▶ Xerox gives up the rights to the "Ethernet" name in 1982

- ▶ Two other LAN technologies are brought to 802

- ▶ Token Ring from IBM

- ▶ Token Bus

- ▶ There was no agreement on which one to standardize, so different working groups under 802 were created:

    - ▶ 802.3 for Ethernet (CSMA/CD)

    - ▶ 802.4 Token Bus

    - ▶ 802.5 Token Ring

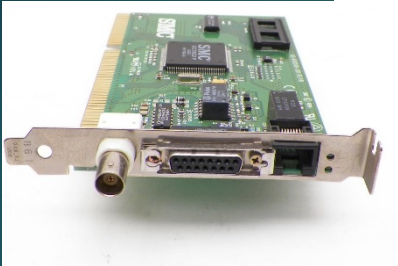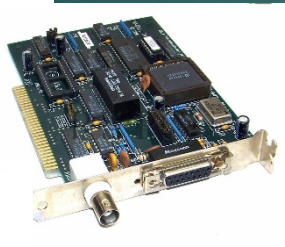- ▶ Standardization work begins for all three "dots" under the IEEE open, consensus-based process

- In 1983 IEEE Std 802.3™-1983 is published: 10BASE5
  - 10-speed in Mb/s
  - BASE-baseband signaling
  - 5-500 meters RG/8 coax
- In 1985 IEEE Std 802.5™-1985 is published
  - 4Mb/s over IBM Type 1 or Type 2 STP cable
  - IBM hermaphroditic connectors 3 x 3cm
  - Passive concentrator with relays to create the ring
- IBM introduces Token Ring products for the IBM PC and other IBM systems
- The IBM structured wiring system is extremely expensive, and the wiring and connectors are fragile
- Even though IEEE Std 802.5™-1985 standardized Token Ring, IBM still has proprietary "hooks" that prevent 100% interoperability

Ethernet vs. Token Ring

- By the mid 1980's, there were over 200 companies making Ethernet networking equipment based on the IEEE standards.

- Because no one company controlled the Ethernet standards, the playing field was level and there was opportunity for all

- At the same time, there were about 20 companies making Token Ring networking equipment, and IBM dominated the market
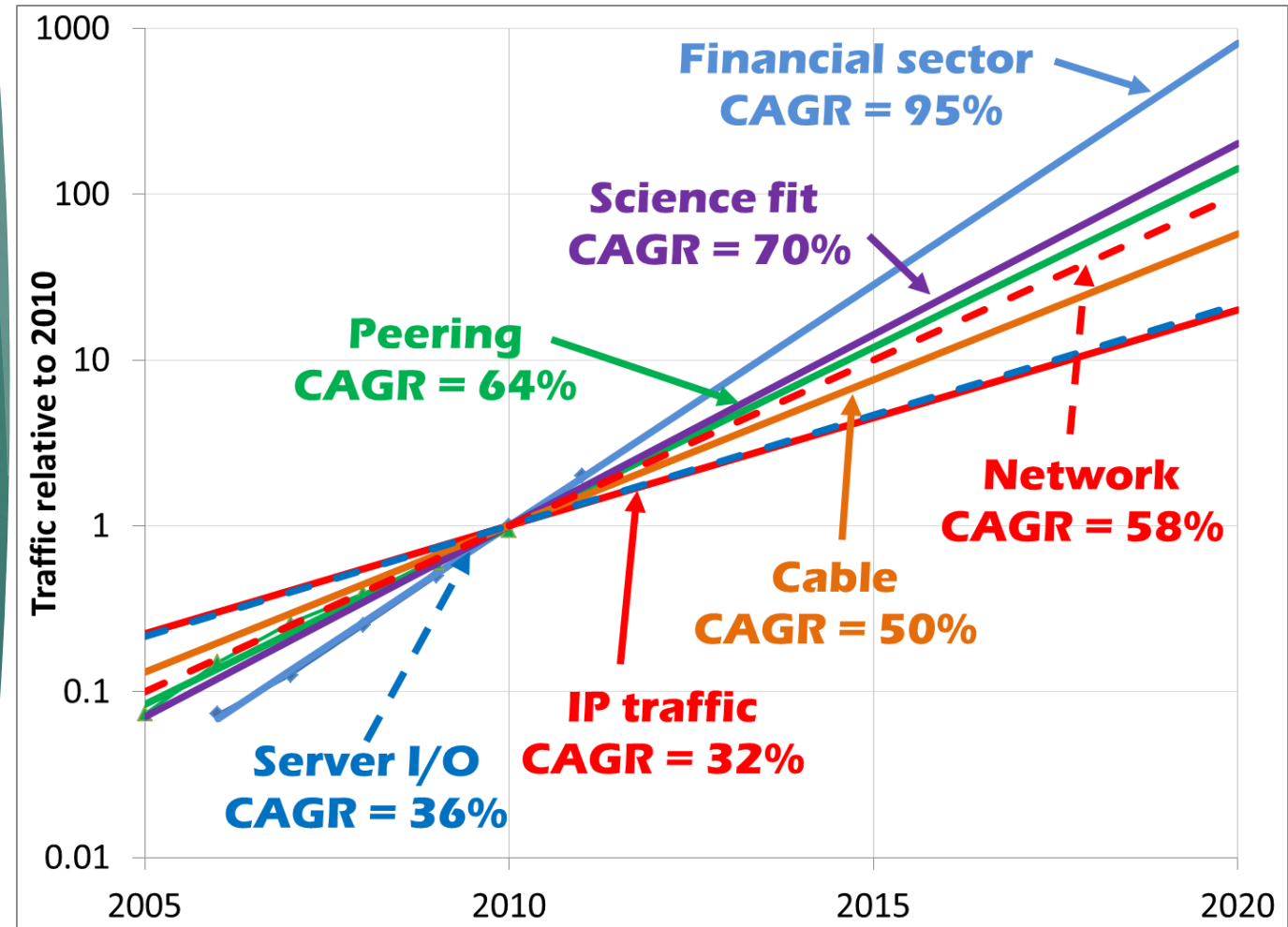
Connections

1995: End of the LAN Wars

▶Since 1995, Ethernet has become the ubiquitous wired network*:

- ▶ < 0.01m to 1,000s of kilometres
- ▶ 10 Mb/s to 400 Gb/s
- ▶ Backplane to fibre (and everything in between)
- ▶ Power Over Ethernet/PoDL
- ▶ Energy-Efficient Ethernet
- ▶ Application-specific Ethernet
- ▶ Billions of Ethernet ports ship per year
- ▶ Bandwidth needs keep rising
- ▶ All traffic (wireless 802.11, cellular, microwave, etc.) eventually is carried by wired Ethernet
- ▶ There's no end in sight!

*David Law, 802.3 Chair

IEEE-SA and IEEE 802

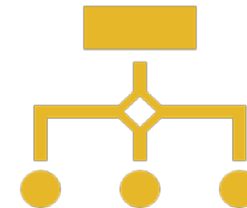## IEEE-SA Standards process

Open, consensus-based

IPR Policy

Rigorous process checks with appeals

IEEE 802

Adds to the SA process

Individual, not entity process

Working Groups cross-check each other

Approval at the 802 Executive

IEEE 802.3 Ethernet Working Group

- IEEE 802.3
  - Adds to the 802 process
  - Set a high bar for project starts - CFI
  - Sets high expectation for projects - objectives
  - Interoperability standards
    - NOT product specifications
    - Demands compatibility
    - Plug and play (in some areas)
    - Adaptable
      - Power
      - Application-specific
      - Timing support
  - Open, consensus-based process
  - Anyone may participate
  - RESPECT, give it, get it

IEEE 802.3 Ethernet Working Group

- IEEE 802.3
  - Tradition of excellence since 1983
  - Tribal knowledge
    - "If all else fails, follow the process"
    - Conversely, "Never let process stand in the way of doing what's right"
    - Pass on the ethos to new people
  - Rigorous timelines
    - Good idea how long a project should take
  - Dream team!

Ethernet's DNA

Fast
- Don't let the network be the bottleneck

Simple
- Layer 1 and layer 2 only
- System agnostic from the start

Reliable
- Interoperable
- Leaves data reliability to higher layers

Cheap
- Built with standard manufacturing techniques

Ethernet's infrastructure

TCP/IP
- Ethernet and TCP/IP – yin and yang

"U*IX"
- TCP/IP - language of the ARPANET (Internet)

Standards
- Pre-standard multivendor spec
- IEEE 802 -not aligned with any vendor
- IEEE 802.3 Ethernet Working Group

"Ethernet began as a very high-speed packet-switching local area network (LAN) for extending the Internet into buildings to reach personal computers and their servers. However, Ethernet has been **evolving** and **re-invented** for some 40 years, making it so much more than just a networking technology or a means for connecting computers together.

At its heart, Ethernet is a brand – an innovation brand.

Brands make promises, so it's entirely appropriate to ask what promises Ethernet makes…such as the promise of **openness, interoperability**, and **higher speeds** at **lower costs**. Ethernet's promises also come in the form of **open** jure **standards**; owned rather than open source implementations; and fierce competition but interoperability among competing products. It also means preservation and backward compatibility with the installed base and the rapid evolution of **IEEE standards** based on market engagement. Long live Ethernet!"

---**Dr. Robert Metcalfe**, inventor of Ethernet, Ethernet Alliance interview, 2013

Epilogue

▶ Dr. Robert Metcalfe is Professor of Innovation, fellow of the Clint W. Murchison, Sr. Chair of Free Enterprise and Professor of Electrical and Computer Engineering at the University of Texas in Austin

▶ Dr. David Boggs is quietly retired in the San Francisco Bay area. He is still an amateur radio operator.

Acknowledgments

Jim Lawlis of Ford for the conversation that started all this.

David Law of HPE, Chair of IEEE 802.3, for his support, assistance and friendship over the last 20 years

Geoff Thompson, 802 Member Emeritus, past Chair of 802.3, who, while at Xerox and SynOptics, worked on laser printing, Ethernet, the Alto and many of the other technologies that make up the modern digital world

Dr. Jim Carlo, past 802 Chair, Texas Instruments Fellow, and manager of TI's Token Ring group for his insights into the LAN wars of the 1980s.

Dr. Robert Metcalfe for sharing his insights, and for his tireless support of IEEE 802.3 Ethernet, and **Dr. David Boggs**, for making Ethernet work, and the late **Ron Crane** for commercializing Ethernet at 3Com.

And finally, to all my colleagues in the IEEE 802.3 Ethernet working group for sharing their tremendous knowledge, dedication to the open consensus-based standards process and warm friendship throughout so many projects

Thank you!