10Mb/s Single Twisted Pair Ethernet Call for Interest

IEEE 802.3 Ethernet Working Group

CFI Panel Members

Moderator:	Ludwig Winkel, Siemens
Presenter:	Mick McCarthy, Analog Devices Inc.
Supporters and experts for the Question and Answer session:	David Brandt, Rockwell Automation
	George Zimmerman, CME Consulting, Inc.
	David Hoglund, Johnson Controls
	Kirsten Matheus, BMW
	Chris DiMinico, MC Communications / CU-Test / Panduit

Supporters - Page 1

Ludwig Winkel, Siemens AG (Industrial Automation)

Klaus Wächter, Siemens AG (Building Automation)

Chris DiMinico, MC Communications / Cu-Test / Panduit (Cabling / Test Equipment)

Mick McCarthy, Analog Devices (Semiconductor Supplier)

Matthias Fritsche, HARTING Electronics (Industrial Automation)

Claude Gauthier, OmniPhy (PHY Vendor)

David Hoglund, Johnson Controls (Building Automation)

Oliver Kleineberg, Hirschmann (Industrial Automation)

David Brandt, Rockwell Automation (Industrial Automation)

Mandeep Chadha, Microsemi (PHY Supplier)

Dayin Xu, Rockwell Automation (Industrial Automation)

Laura Schweitz, Turck (Industrial Automation)

Maris Graube, Relcom Inc. (Industrial Automation)

Bob Moskowitz, Consultant (Building Automation)

Jordon Woods, Innovasic, Inc. (Semiconductor Vendor)

Mohammad S. Ahmed TE Connectivity, (Automation Connectivity)

Alan Flatman, LAN Technologies (Cabling)

Hans Lackner, QoSCom (Cabling)

Stephan Kehrer, Hirschmann (Industrial Automation)

Bernd Horrmeyer, Phoenix-Contact (Industrial Automation)

Frank Schewe, Phoenix-Contact (Industrial Automation)

Rubén Pérez de Aranda, KDPOF (PHY Vendor)

Supporters - Page 2

Dr. Joerg Haehniche, Endress+Hauser (Industrial Automation)

Mr. Harald Mueller, Endress+Hauser (Industrial Automation)

Robert Hall, Johnson Controls (Building Automation)

Steve Carlson, High Speed Design (Consultant)

George Zimmerman, CME Consulting (Consultant)

David Doggett , Schneider Electric (Industrial Automation)

Gunther Rogoll, Pepperl+Fuchs (Industrial Automation)

Steffen Grabber, Pepperl+Fuchs (Industrial Automation)

Theodore Brillhart, Fluke Electronics Corp (Test Equipment)

Martin Zielinski, Emerson (Industrial Automation)

Michael Gienke, ABB (Industrial Automation)

Holger Sack, VEGA Grieshaber KG (Industrial Automation)

Jörg Stritzelberger, R. STAHL Schaltgeräte GmbH (Industrial Automation)

Mr. Mark Foltz, ABB (Industrial Automation)

Kirsten Matheus, BMW (Automotive)

Stefano Valle, STMicroelectronics (Semiconductor Supplier)

Christopher A Lupini, Delphi (Automotive)

Laurence Matola, Delphi (Automotive)

Waseem Mir, Delphi (Automotive)

Mike Gardner, Molex (Components and Cable Suppliers)

Eric Scott, Molex (Components and Cable Suppliers)

Supporters - Page 3

Andy Gardner, Linear Technology (Semiconductor Supplier)

Ronald Nordin, Panduit (Cabling and Infrastructure)

Robert Voss, Panduit (Cabling and Infrastructure)

Heath Stewart, Linear Technology (Semiconductor Supplier)

Richard Mei, Commscope (Infrastructure)

Bryan Moffitt, Commscope (Infrastructure)

Masood Shariff, Commscope (Infrastructure)

Kamal Dalmia, Aquantia (Semiconductor Supplier)

Dave Dwelley, Linear Technology (Semiconductor Supplier)

Jinhwa Yun, Hyundai (Automotive)

Dongok Kim, Hyundai (Automotive)

Nobukatsu Kitajima, Renesas (Semiconductor Supplier)

Jeffrey Tsai, Kinnexa (Connectors)

Ramin Farjad, Aquantia (Semiconductor Supplier)

Markus Stark, Würth Elektronik (Component Supplier)

Christian Boiger, b-plus GmbH (Automotive)

Helge Zinner, Continental (Automotive)

Michael Kaindl, BMW (Automotive)

Mike Jones, Microchip (PHY Provider)

David Chalupsky, Intel (Semiconductor Supplier)

Takashi Matsumoto, Nissan (Automotive)

Shehnaz Louvart, Renault (Automotive)

Supporters - Page 4

Julien Duretz, Renault (Automotive)

Josetxo Villanueva, Renault (Automotive)

Yoshifumi Kaku, Denso (Automotive)

Haruka Honda, Denso (Automotive)

Hiroyuki Matsumoto, Continental (Automotive)

Magnus Nigmann, Intedis (Automotive)

Stefan Buntz, Daimler AG (Automotive)

Ali Khan, Corigine Inc. (Semiconductor Supplier)

Hideki Goto, Toyota Motor Corp. (Automotive)

Wael Diab, Huawei (Infrastructure)

Rene Hummen, Belden (Cabling)

Jan Polfliet, On Semiconductor (Semiconductor Supplier)

John D’Ambrosia, FutureWei (Infrastructure)

Albert Kuo, Realtek, (Semiconductor Supplier)

CFI Objective

- To gauge the interest in starting a Study Group for:

10Mb/s Single Twisted Pair Ethernet

- This meeting will NOT:
  - Fully explore the problem
  - Debate strengths and weaknesses of solutions
  - Choose a solution
  - Create a PAR, CSD or Objectives
  - Create a standard or specification

Agenda

- **Market Needs**
- **Solution Requirements**
- **Target Markets**
- **Market Potential**
- **Technical Feasibility**
- **CFI Proposal**
- **Q&A – Please hold until this time**
- **Straw Polls**

Market Needs

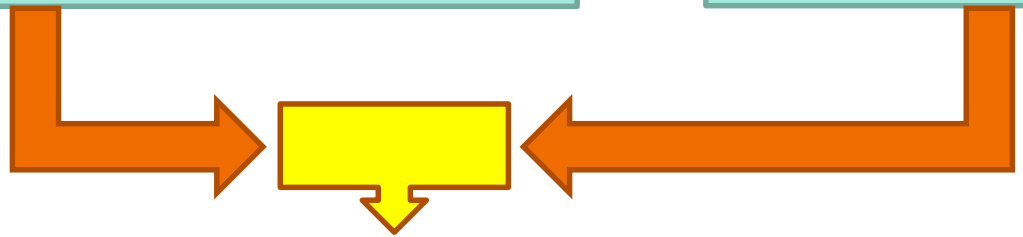
Vision

- Legacy point-to-point & point-to-multipoint
  - 4-20mA
  - HART modem
  - RS-232
  - RS-485
  - CAN
  - FlexRay
  - Proprietary/custom

Existing

- New applications
  - Enabled through this proposed development

Future

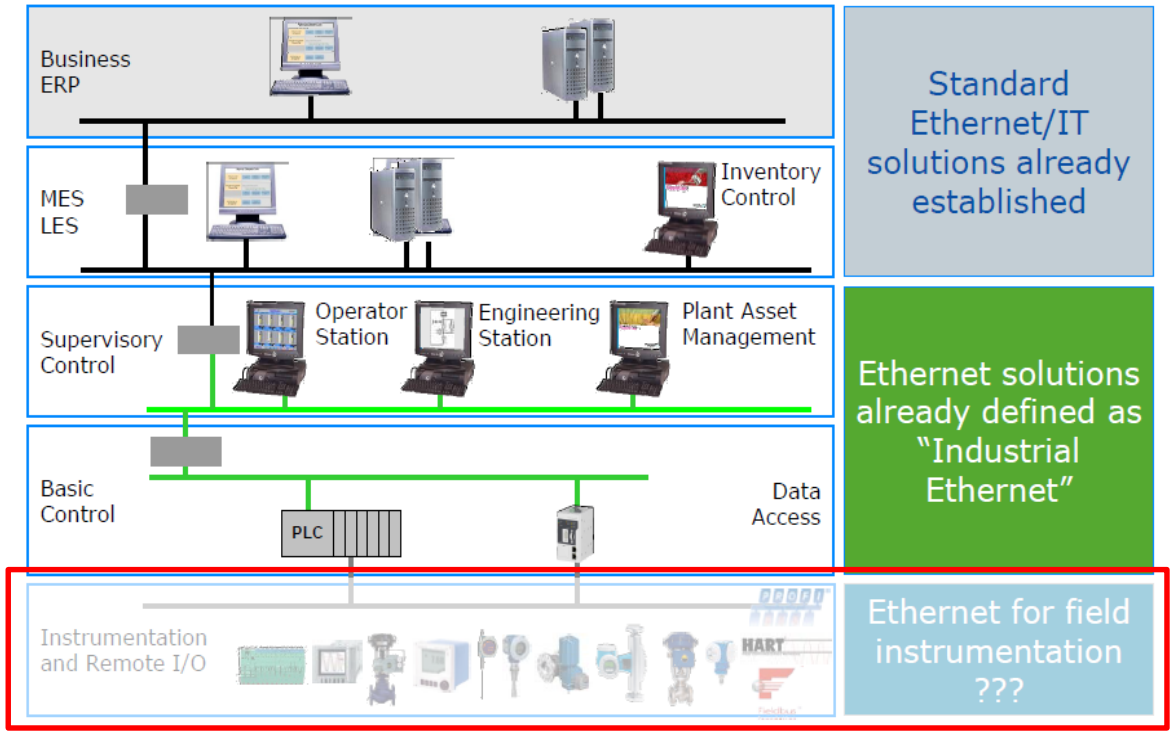


New
IEEE 802.3
Standard

Industrial Automation Market Need

Ethernet Gap in Industrial Networking

- Desire to converge on **one** network type
- Ethernet adoption is happening where technically possible
- Non-Ethernet *fieldbuses* still required to complete communications to the edge
  - Cable lengths > 1km
  - 1200 baud to hundreds of kb/sec
  - Challenges: Combined reach & rate, special environments, cost of operation



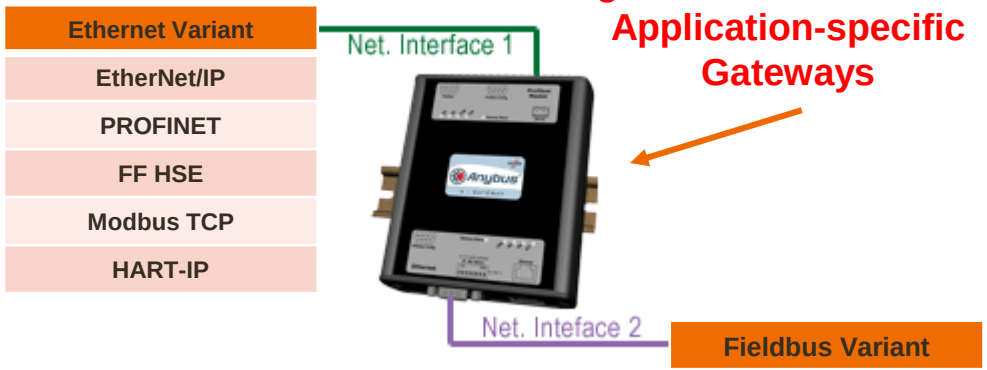
Credit: Dr. Raimund Sommer, Endress + Hauser, ODVA Industry Conference, Oct. 2014.

Ethernet Gap at the 'Edge'

Existing Market Fragmentation

Too Many Fieldbus Variants

- **Big challenges for end users**
  - Sourcing appropriately qualified labor
  - Installation complexity
  - Maintenance complexity
  - Interoperability issues
  - Multiple Standards and Certification Bodies
- **Results in higher OpEx and additional Gateway costs**



Partial list…

Fieldbus Variants	
FOUNDATION Fieldbus H1	PROFIBUS DP
PROFIBUS PA	DeviceNet
HART	CANOpen
IO-Link	Modbus
CompoNet	CC-Link
AS-Interface	INTERBUS

New Requirement: Higher Rates at the Edge

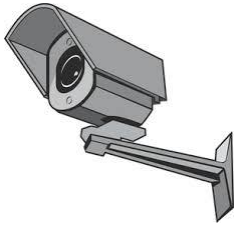
- IIoT, Big Data, and Analytics
  - High-speed data logging
    - Production details, equipment conditions, environment state, energy consumption,…
  - Optimization, maintenance, safety, compliance,…

PLATTFORM INDUSTRIE 4

industrial internet CONSORTIUM

- Embedded web servers
  - Installation and maintenance

- Video
  - Reduced footsteps
  - Safety
  - Product quality sensor
  - Security



Automotive Networking Market Need

Motivation and Use Cases for 10Mb/s Single Twisted Pair Ethernet in Automotive

- The complexity of Electrics & Electronics (E/E) in cars is continuously increasing.
  - More functions, more ECUs, more sensors, more communication.
- There are advantages to a ubiquitous IP communication network:
  - Ensures robustness and flexibility.
- Must be economically viable.
  - Cost is a key determinant of success in Automotive

- A 10Mb/s, appropriately costed Ethernet PHY can be used:
  - For new ECUs or ECU versions, requiring faster communication than CAN(FD)
  - Instead of legacy in-vehicle networking technologies like FlexRay
  - For Ethernet ECUs where 100BASE-T1 is not cost and energy efficient
  - For both simple and redundant sensor networks

ECU: Electronic Control Unit

Solution Requirements:

Why 10Mb/s Single Twisted Pair Ethernet?

Industrial Automation Requirements

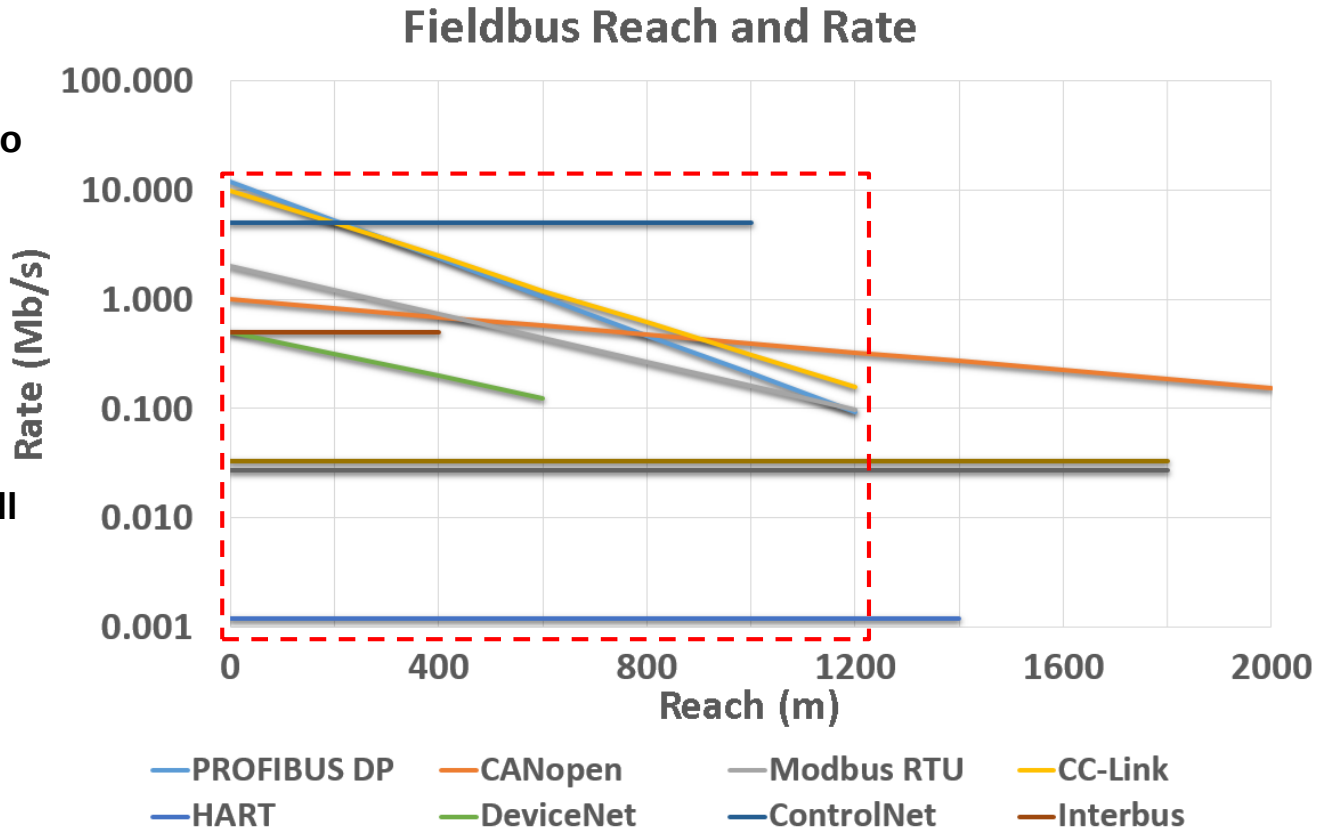
Why Ethernet to the Edge?

- Single network paradigm
  - Transparent connectivity
    - Reduces complex gateways
  - More rapid commissioning
  - More rapid fault diagnosis and repair
- Well-known installation, maintenance and management processes
- Leverage economies of scale for balanced cost approach
  - Higher performance for similar cost
- Ethernet Ecosystem
  - Protocols
  - Security
  - Existing switching technology
  - …

All result in lower Total Cost of Ownership (TCO) and better Return on Investment (RoI) in Network

Why 10Mb/s and Extended Reach?

- A new solution is required to cover a range of reach and rate with a single design
- 10Mb/s (a standard MAC) and 1200m address <u>most</u> fieldbus applications
- Study group will consider, but not expected to cover all extremes/outliers



Why Single Twisted Pair?

- **Enables cable reuse**
  - **Installed base of Single Twisted Pair, usually shielded**
  - **Certain cables are certified**
  - **Lengthy fieldbus cables are expensive to install (often in filled conduit)**
  - **End nodes are easier to replace**
  - **Similar value proposition to 2.5G/5GBASE-T Task Force**
- **Enables constrained form factor applications (sensors etc.)**
  - **Reduced size and cost**

High Cable Reuse Value

Fieldbus	Cable Type	Cable Power
FOUNDATION H1	FF-844 specified	Yes
HART	Various	Yes
PROFIBUS PA	IEC 61158 Type A	Yes
4-20mA	SP-50 instrumentation cable	Yes
CANopen	EIA-485	Yes
Modbus RTU	EIA-485	No
CC-Link	CC-Link, Ver.1.10 specified Shielded, 3- & 5-core	No
DeviceNet	ODVA DeviceNet specified (5-core, various classes)	Yes
ControlNet	RG-6/U Coaxial	No
INTERBUS	3 / 6 no. twisted pairs, various	Yes
PROFIBUS DP	IEC 61158 Type A (22AWG?)	No

What about Power?

- Many devices require power delivery over the same pair
  - Study group topic to determine proportion of devices and requirements
- Existing sensor solutions are often ‘loop powered’
  - Powered from analog current loop/fieldbus cable, e.g. ISA/SP50 Type A
    - Multiple gauges available: 18 AWG sample cable → 43.6 Ohms/km max loop resistance
  - Limited power availability today (~3.2mA @ 18Vdc = ~58mW)
  - Complex Process devices expected to not exceed 500mW total power budget

Intrinsic Safety Considerations

- Industrial Automation has stringent safety standards applied
  - Required where some safety and mission critical systems involved
  - e.g. IEC 60079
- Specific needs for explosion proof systems – Intrinsic Safety
  - Out of IEEE 802 scope
  - Certification is of the networked equipment – not of the IEEE PHY
  - The PHY should not preclude the design of IS networked equipment
    - Usually involves limitation of current, voltage and energy storage capabilities
    - Energy stored in 10/100 transformer exceeds limits

Related Standards and Regulations

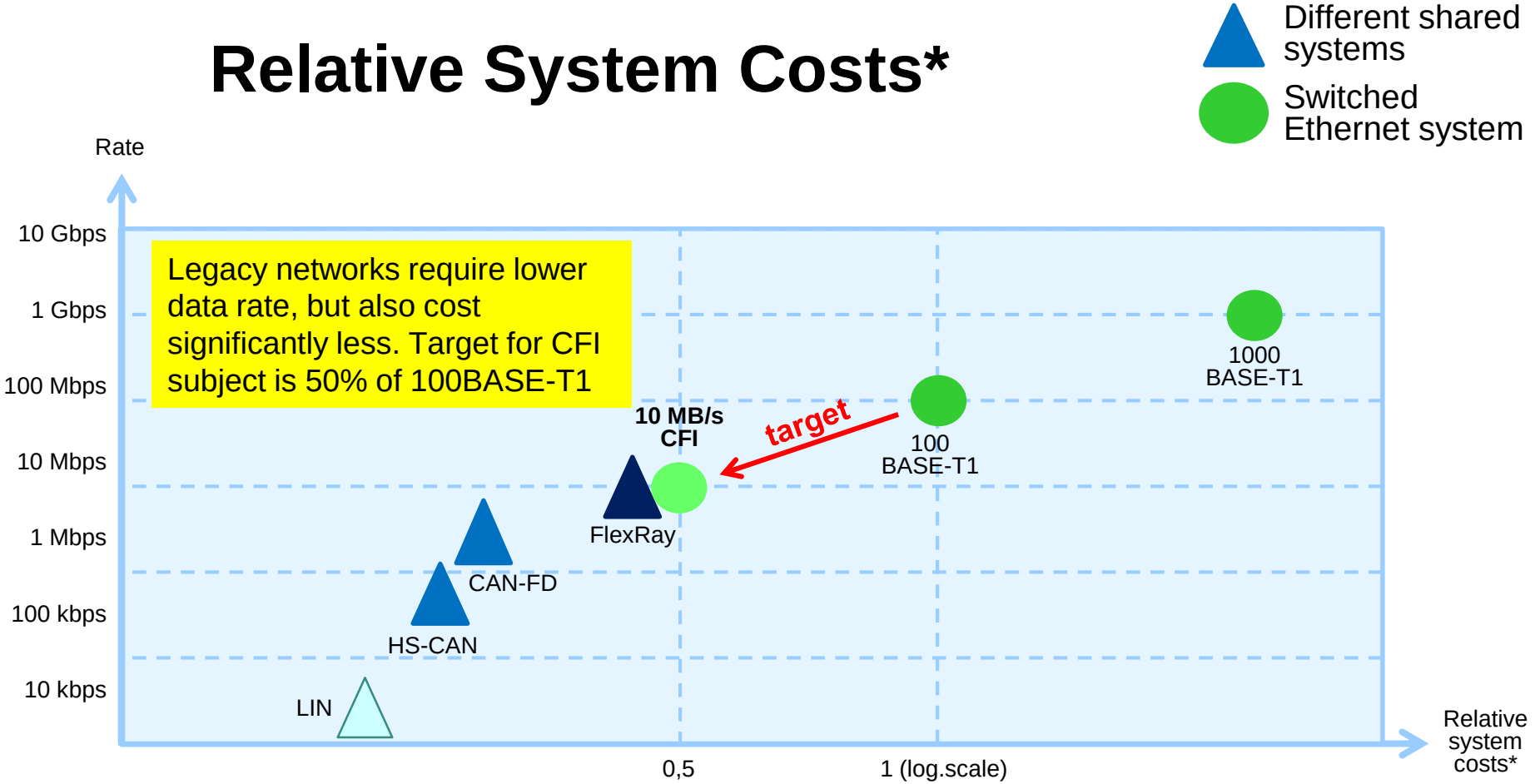
- TIA TR42.9 work on Industrial Cabling
- IEC 60079 Explosive Environments
- NAMUR NE-74
- Electrical safety regulations, e.g., NFPA70, as it relates to powering
- ISO/IEC SC25 WG3 plans to support single-pair applications over structured balanced cabling
- Study group will need to determine what tutorial and liaison information to provide to these groups, and what information to request

Automotive Requirements

Automotive Requirements

- Many legacy in-vehicle networks (IVNs) utilise lower data rates than available with recent single pair Ethernet developments.
- Legacy networks are also lower cost than 100BASE-T1 implementations.
- Enabling the transition to Ethernet from these legacy IVNs requires lower cost, lower data rate capabilities.
- Reducing emissions are a constant goal for the Automotive industry.
  - Lower power communications systems can assist with this challenge.
- A 10Mb/s, single pair solution has the potential to address the technical needs.

Relative System Costs*



* The cost values are very dependent on the exact topology that is being compared, this chart gives an indication only.

Target Markets

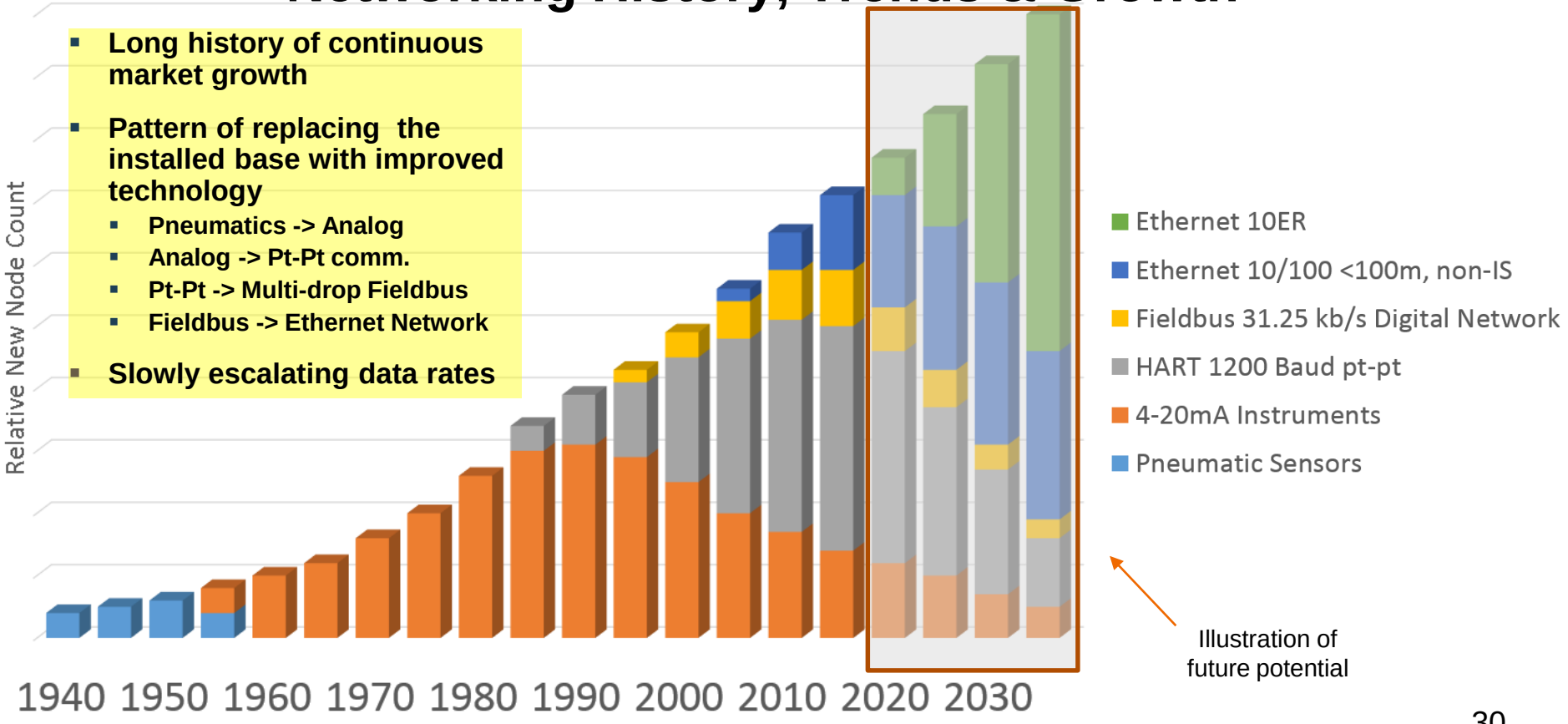
Target Markets

- **Industrial Automation**
  - Process Automation
  - Factory Automation
- **Building Automation[1]**
  - HVAC
  - Security/Access
  - Fire
  - Lighting Control Systems
  - Residential
- **Automotive**
  - Pervasive IP Network
  - Legacy IVN consolidation

[1]Further information see: Carlson/Kennedy, IEEE 802 BoF “I Feel the Need… for Low Speed”, July 2014

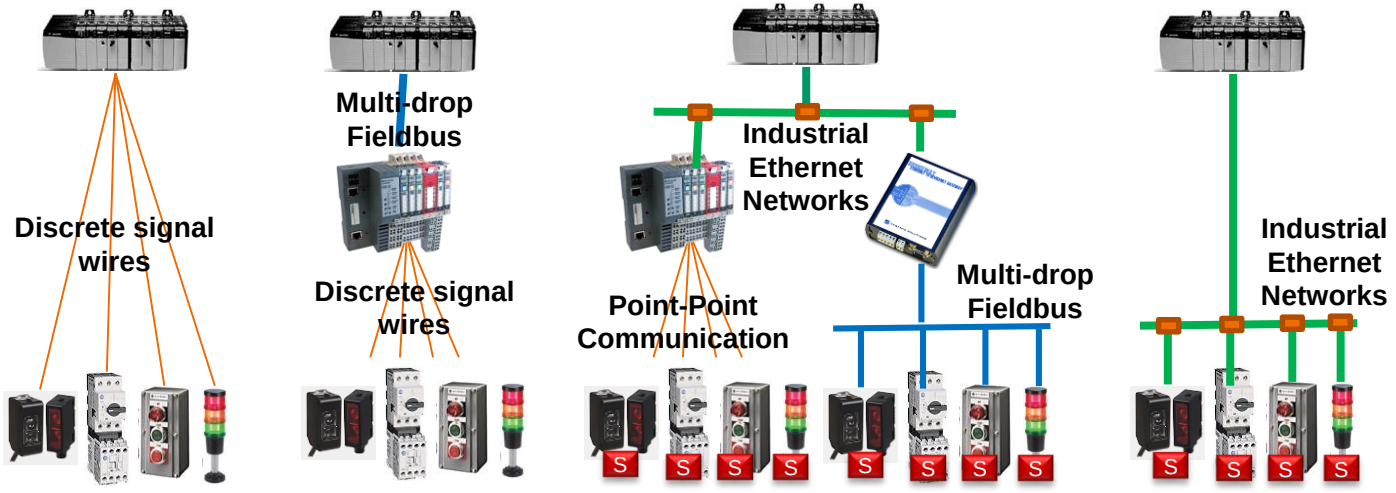
Process Automation
Networking History, Trends & Growth

- **Long history of continuous market growth**
- **Pattern of replacing the installed base with improved technology**
  - **Pneumatics -> Analog**
  - **Analog -> Pt-Pt comm.**
  - **Pt-Pt -> Multi-drop Fieldbus**
  - **Fieldbus -> Ethernet Network**
- **Slowly escalating data rates**



Illustrative graphic based on aggregated sources, including HMS Networks & IHS market surveys, FieldComm published information

Factory Automation: Networking History & Trends



Local I/O **<u>discrete wires,</u>** Dumb devices

Remote I/O **<u>Fieldbus</u>**, Dumb devices

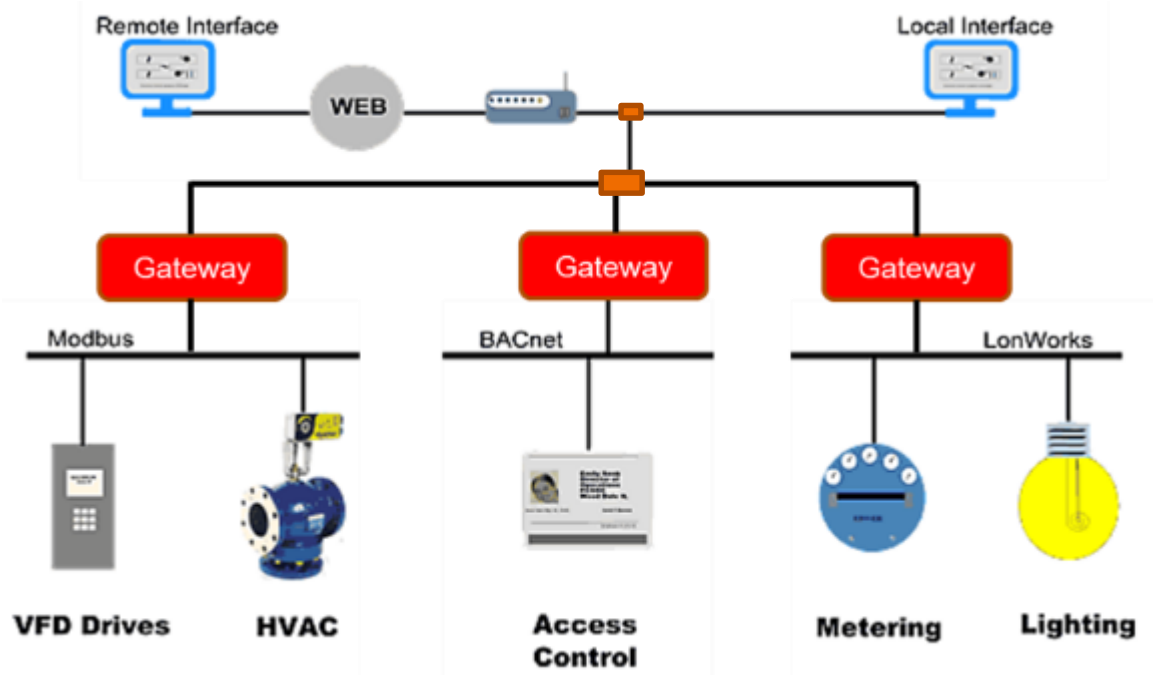
Industrial Ethernet interconnecting multi-drop Fieldbus and point-point for **smart devices**

Native Industrial Ethernet smart devices?

1980s **1990s** **2000s-2010s** **2020s?**

S = Smart Device

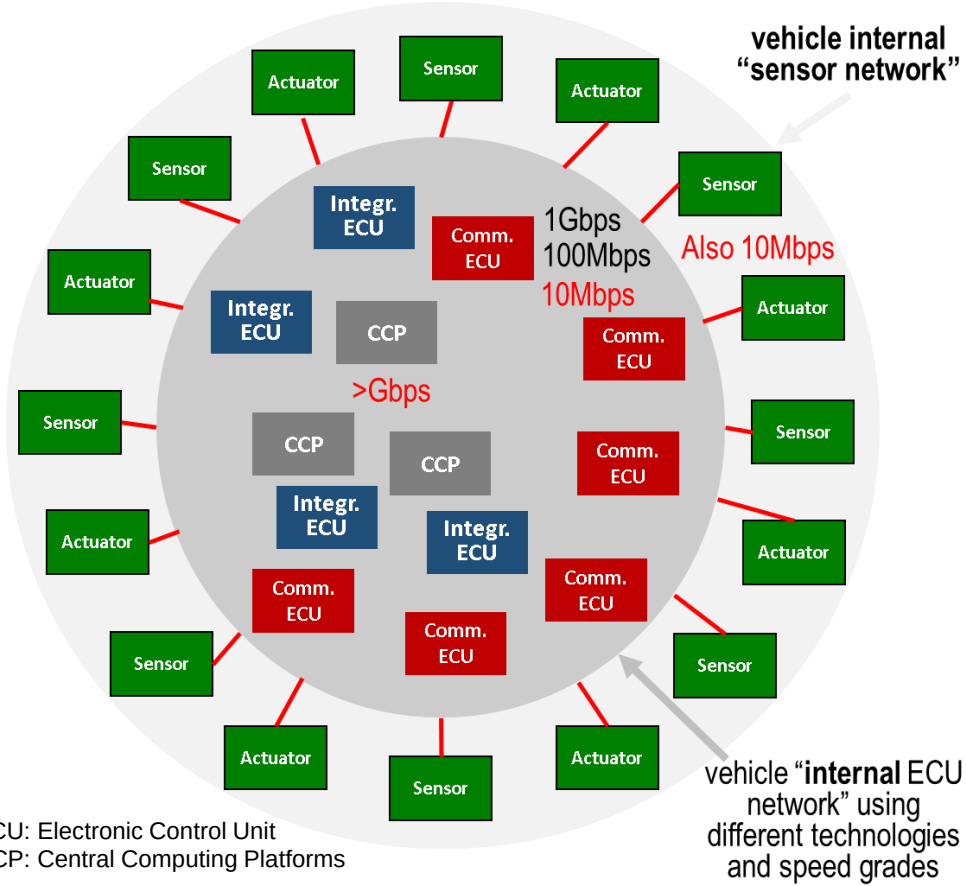
Building Automation Architecture Trends



- The transition to Ethernet is underway
  - BACnet IP
- There is a desire to converge on **one** network type
  - Elimination of fragmentation at the edge…
    - Modbus: RS232/485
    - BACnet: RS485
    - LonWorks: Proprietary
  - Reduction of multiple gateways

Adapted from: Carlson/Kennedy, IEEE 802 BoF "I Feel the Need… for Low Speed", July 2014

Automotive Architecture Trends

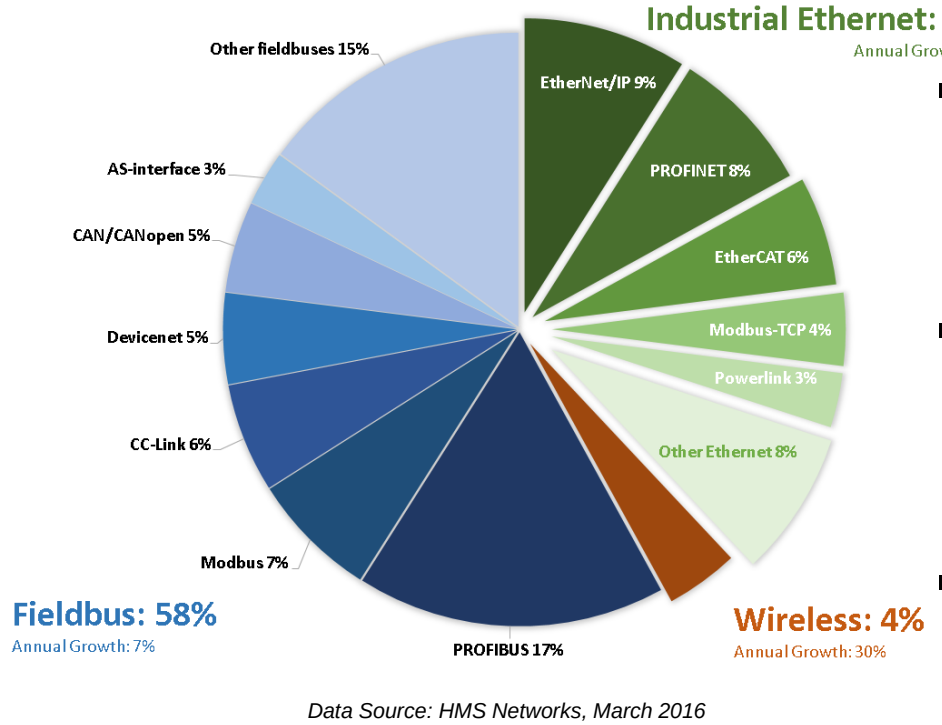


ECU: Electronic Control Unit
CCP: Central Computing Platforms

- The transition to Ethernet is underway.
  - 802.3bp, 802.3bw
- There is a desire to converge towards **one** network type (“Ubiquitous IP”).
  - Independence of physical and logical network.
  - Reduction in number of In-Vehicle Network (IVN) technologies.
    - MOST / FlexRay / …
  - Reduction of multiple gateways.

Market Potential

Current Industrial Network Share



Data Source: HMS Networks, March 2016

- Entire market is growing
  - Fieldbus (58%), 7% growth
  - Ethernet (38%), **20% growth**
  - Limited wireless adoption
- Despite greater growth rate today, Ethernet will hit a roadblock
  - Without this CFI, existing Ethernet cannot match key Fieldbus capabilities
- Significant number of protocols
  - Ethernet protocols can share common hardware
  - Fieldbuses have unique hardware

Industrial Networking Market Size

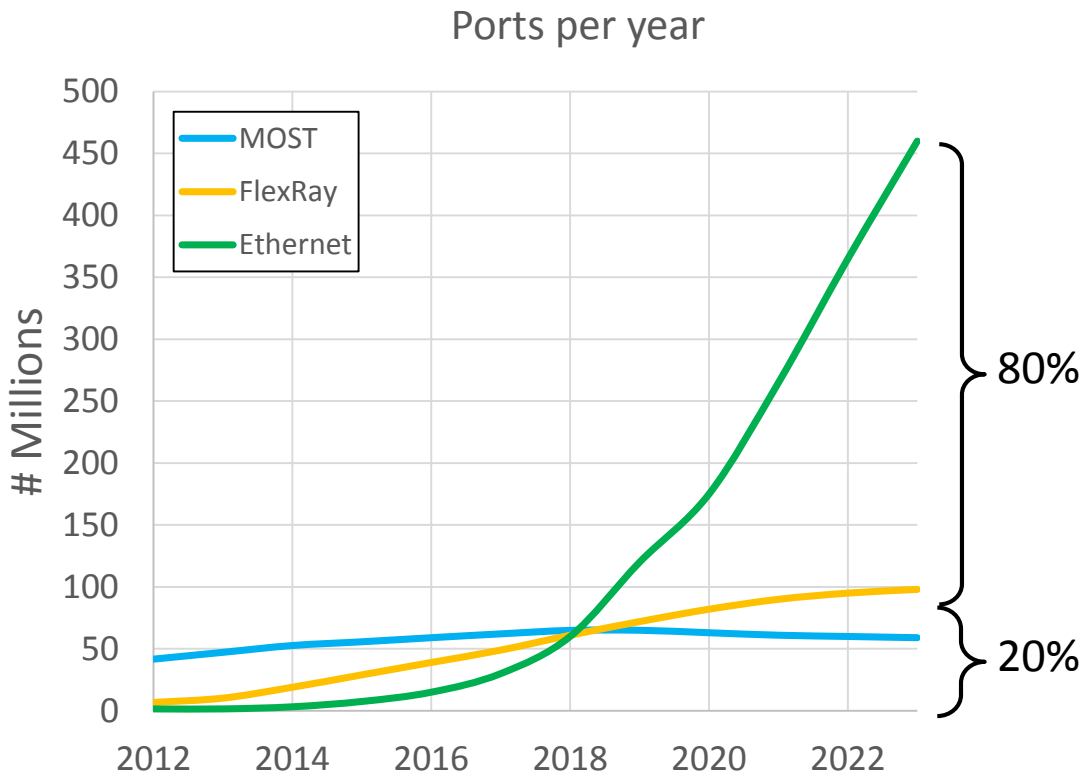
- Converged data is challenging to align
  - Various reporting techniques
    - May or may not include analog only solutions
  - Varying vintage of information
    - May not fully capture recent growth trajectory of Ethernet
  - Potential biases of representative organisations
- Estimate ~50% could be addressed by CFI subject

Source	Vintage	Ports/Year Estimate
IHS	2013	175M
PNO	2015	52M
CLPA	2013	72M
IHS/ARC	2012/2015	136M
	Mean	109M

Building Automation Market Size

- Clear opportunity in HVAC and environmental controls:
  - IHS forecast for 2016 shows ~10 million controllers (20 million ports/year) for Building Automation, growing at 11% per year.
- Estimate ~50% of this market also servable with 10Mb/s, single pair solution.
- Example further potential HVAC opportunity:
  - An average controller interfacing to ~10 sensors/actuators, results in 200 million ports/year.
- Further study group efforts required to dig deeper and discern higher end potential:
  - Security/Access, Fire, Lighting Control Systems have additional opportunity

Automotive Market Size



Sources: Gartner, Strategy Analytics, Others

- ~4 Billion IVN ports in 2019
- Not targeting
  - 2 Billion CAN
  - 1.3 Billion LIN
- 10Mb/s market leveraging from
  - FlexRay
  - New Sensor Applications
  - New ECU developments
  - Where 100Base-T1 exceeds requirements
- Gartner expects an 80:20 ratio between 100Mb/s and 1Gb/s PHYs
- 10Mb/s can expect to be greater or equal to 1Gb/s automotive market

Target Market Size – Summary

- Based on current port count without projected growth, mid-range estimate could suggest a combined opportunity for Industrial and Building Automation of 65M ports/year for new 10Mb/s single twisted pair Ethernet.
- Automotive applications estimate an conservative 100M ports/year served by proposed solution.
- Potential market of **165M** ports/year and growing
- New Ethernet-based technology (CFI subject) can provide greater growth through additional application enablement

Technical Feasibility

Technical Feasibility Example Implementations

- **Recent IEEE Work**
  - **100BASE-T1**
  - **1000BASE-T1**

- **Proprietary PHYs**
  - **Pepperl + Fuchs demonstrator**
    - http://www.pepperl-fuchs.de/germany/downloads_GER/Ethernet_for_Process_Automation___A_Concept_Study.pdf**f**
    - **Up to 10 Mb/s, 1200m, half-duplex, single pair copper**
  - **BroadR-Reach ®**
    - **https://www.broadcom.com/press/release.php?id=1004704**
    - **10 Mb/s, 500m, cable dependent**

- **Relevant past generation IEEE PHYs**
  - **10PASS-TS (IEEE Std 802.3, Clause 61 & Clause 62)**
    - **10 Mb/s, 750 meters, single copper pair, variable rate**
  - **2BASE-TL (IEEE Std 802.3, Clause 61 & Clause 63)**
    - **2 Mb/s, 2.7 km, full-duplex, voice-grade copper wiring, variable rate**

- **ITU-T G.992.2 VDSL2**

® BroadR-Reach is a registered trademark of Broadcom Ltd.

CFI Proposal

High Level Summary

- Clear demand for complete Ethernet-based solution throughout facility/factory/plant/vehicle
  - Legacy Industrial multi-drop fieldbuses and point-to-point digital and analog links need an Ethernet replacement
  - Legacy in-vehicle networking technologies also need an Ethernet replacement
- 10Mb/s Single Pair Ethernet meets the need
  - Consolidate hugely fragmented legacy network market to unified Ethernet-based solutions
  - Enable IoT applications and new markets – e.g. big data analytics, smart sensors, streaming video
  - Single pair for ease of installation and maintenance, enabling cable reuse, reducing cable weight
  - Reduced cost to enable automotive applications
  - Power delivery where applicable
- Large market potential for 10Mb/s Single Pair Ethernet
  - ~55M ports/yr for industrial automation
  - >10M for building automation
  - >100M for Automotive

Why Now and Why in IEEE 802.3?

- Multiple industries are requesting it
- It's Ethernet – it belongs in IEEE 802.3
  - IEEE 802.3 is recognized as the international standard for Ethernet
- The effort should start now to meet the industry adoption timeline
  - Target silicon introduction in 2019

10Mb/s Single Twisted Pair Ethernet Q&A

15 Minutes

Straw Polls

Straw Polls and Counts

- **Room count: 104**

- **Would you support the formation of a Study Group for**
  10Mb/s Single Twisted Pair Ethernet including optional power?
  Y: 83 N: 0 A: 11

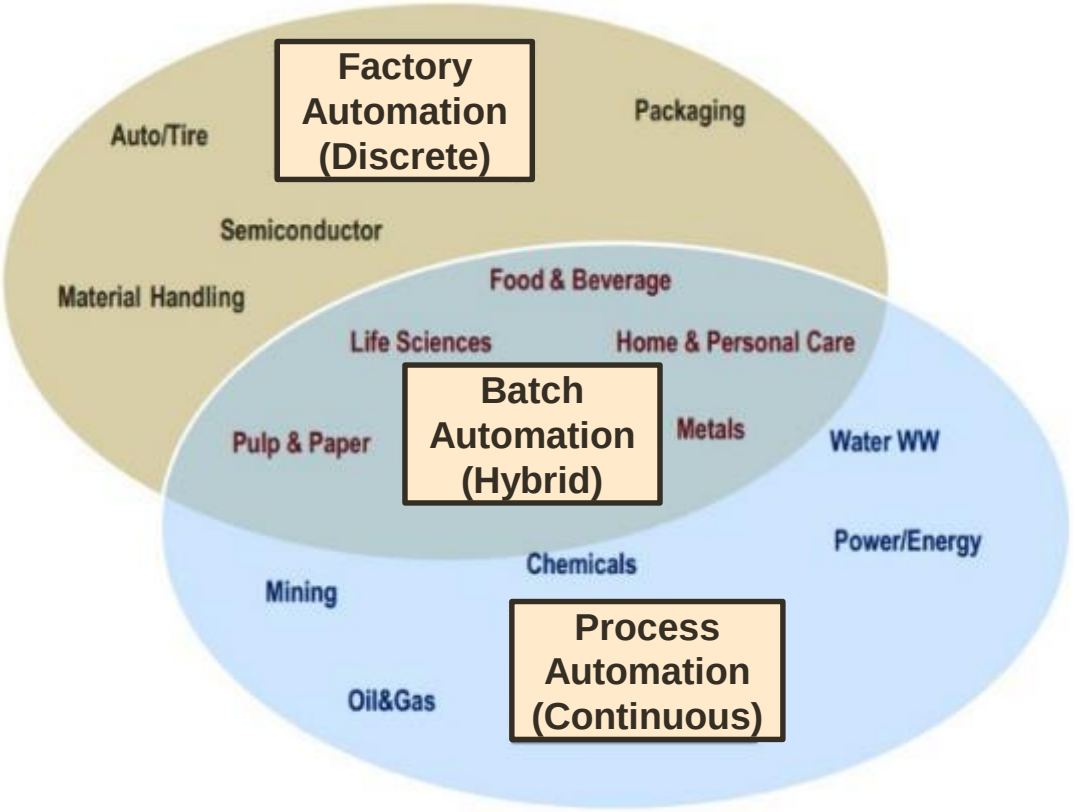
- **Would you attend and contribute to a Study Group for**
  10Mb/s Single Twisted Pair Ethernet including optional power?
  – Tally: 49

- **Would your company support participation in a Study Group for**
  10Mb/s Single Twisted Pair Ethernet including optional power?
  – Tally: 40

Thank you!

Backup Slides

Industrial Automation Landscape



Why 10Mb/s and Extended Reach?

- **Single solution required to simultaneously match both reach and rate**
- **Existing solutions have varied capabilities. Study group will not cover all extremes/outliers**
  - **Common fieldbuses reach 400-5000m**
    - **1200m addresses most fieldbus applications**
  - **Common fieldbuses have rates up to 12Mb/s**
    - **10Mb/s addresses most fieldbus applications**
      - **Enables a standard MAC**

Fieldbus	Longest Reach	Highest Rate
PROFIBUS DP	9.6kb/s @ 1200m	12Mb/s @ 100m
CANopen	10kb/s @ 5000m	1Mb/s @ 20m
Modbus RTU	100kb/s @ 1200m	2Mb/s @ 50m
CC-Link	156kb/s @ 1200m	10Mb/s @ 100m
HART	1200 baud @ 1524m (24AWG) 1200 baud @ 3048m (20AWG)	No enhanced rate
DeviceNet	125kb/s @ 500m	500kb/s @ 100m
ControlNet	5Mb/s @ 1000m	No enhanced rate
INTERBUS	500kb/s @ 400m	No enhanced rate
FOUNDATION H1	31.25kb/s @ 1900m	No enhanced rate
PROFIBUS PA	31.25kb/s @ 1900m	No enhanced rate

Why Limit this CFI to 10Mb/s?

- **Preference for this CFI is to minimize number of PHY developments**
  - **Satisfies immediate pull from market addressing ‘sweet spot’**
  - **Reduces complexity & minimises time to completion**
- **Establishes Ethernet credibility as a true consolidated fieldbus replacement**
- **Future CFI(s) can consider efforts at different rates**
  - **Address certain applications that would benefit from higher rate (>10Mb/s), extended reach, single pair solutions**
    - **NAMUR and Industry vendors body (APL) agree on future need for 100Mb/s**
  - **Distance of existing single pair standards not long enough for some use cases**
  - **Autonegotiation capabilities for future proofing to be considered by Study Group**

Automotive Sensor Classes

Video/Cameras ➔ >>1Gbps ↘

Radar ➔

Radar Type	FarRangeRadar ↘	ShortRangeRadar ↘	HighResolutionRadar ↘	UltraShortRangeRadar ↗
Reach	250m	70m	3-10m	1dim.
Data rate	~130Mbps	>1Gbps	2,5Gbps	<10Mbps

all radars compressed <10Mbps feasible

Lidar ➔ implementation dependent, generally >> 10Mbps

Ultrasound ➔ up to 10Mbps

Microphones ➔ below 10Mbps

Who is NAMUR?

- User Association of Automation Technology in Process Industries
  - http://www.namur.net/en/home.html
- http://www.arcweb.com/events/arc-industry-forum-china/beijing2013presentations/Challenges%20of%20Process%20Automation%20NAMUR%20Provides%20Support.pdf
  - Member companies: 135
  - Experts in member companies: 2000
- “Position paper An Ethernet communication system for the process industry”
  - http://www.namur.net/fileadmin/media_www/Dokumente/Anforderung_Ethernet-NAMUR_2016-02-25_EN.pdf