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

Supporters - Page 1

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Supporters - Page 2

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George Zimmerman, CME Consulting (Consultant)

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Gunther Rogoll, Pepperl+Fuchs (Industrial Automation)

Steffen Grabber, Pepperl+Fuchs (Industrial Automation)

Theodore Brillhart, Fluke Electronics Corp (Test Equipment)

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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)

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Laurence Matola, Delphi (Automotive)

Waseem Mir, Delphi (Automotive)

Mike Gardner, Molex (Components and Cable Suppliers)

Eric Scott, Molex (Industrial Automation Industry)

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

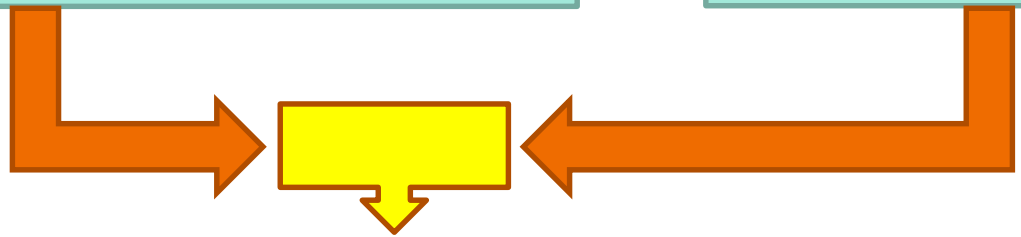
Vision

- 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

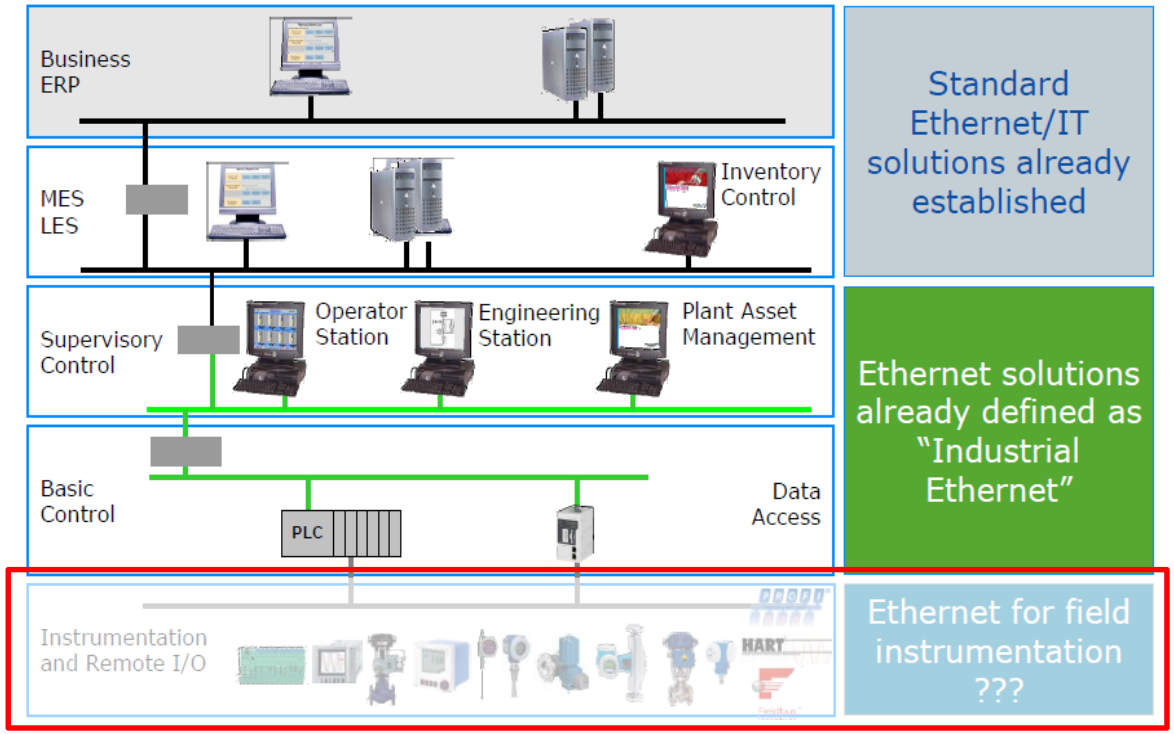


New
IEEE 802.3
Standard

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



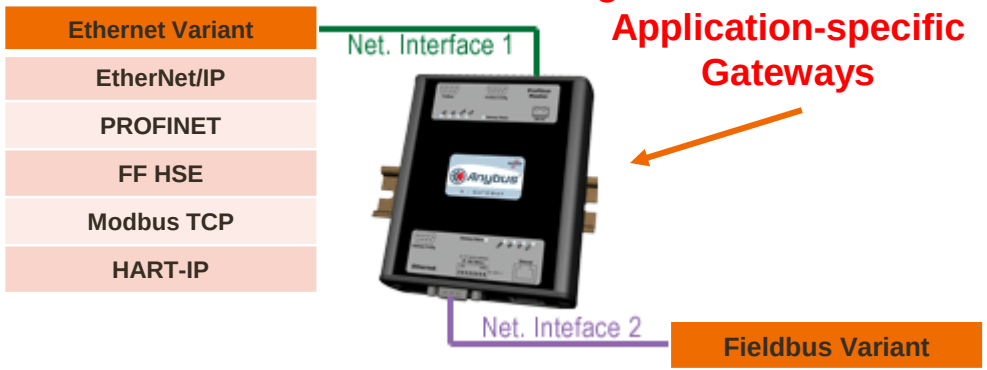
Credit: Dr. Raimund Sommer, Endress + Hauser, ODVA Industry Conference, Oct. 2014.

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

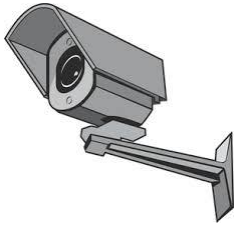
- IIoT, Big Data, and Analytics
  - High-speed data logging
    - Production details, equipment conditions, environment state, energy consumption,…
  - Optimization, maintenance, safety, compliance,…

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

Solution Requirements:

Why 10Mb/s Single Twisted Pair Ethernet?

Industrial Automation Requirements

Why Ethernet to the Edge?

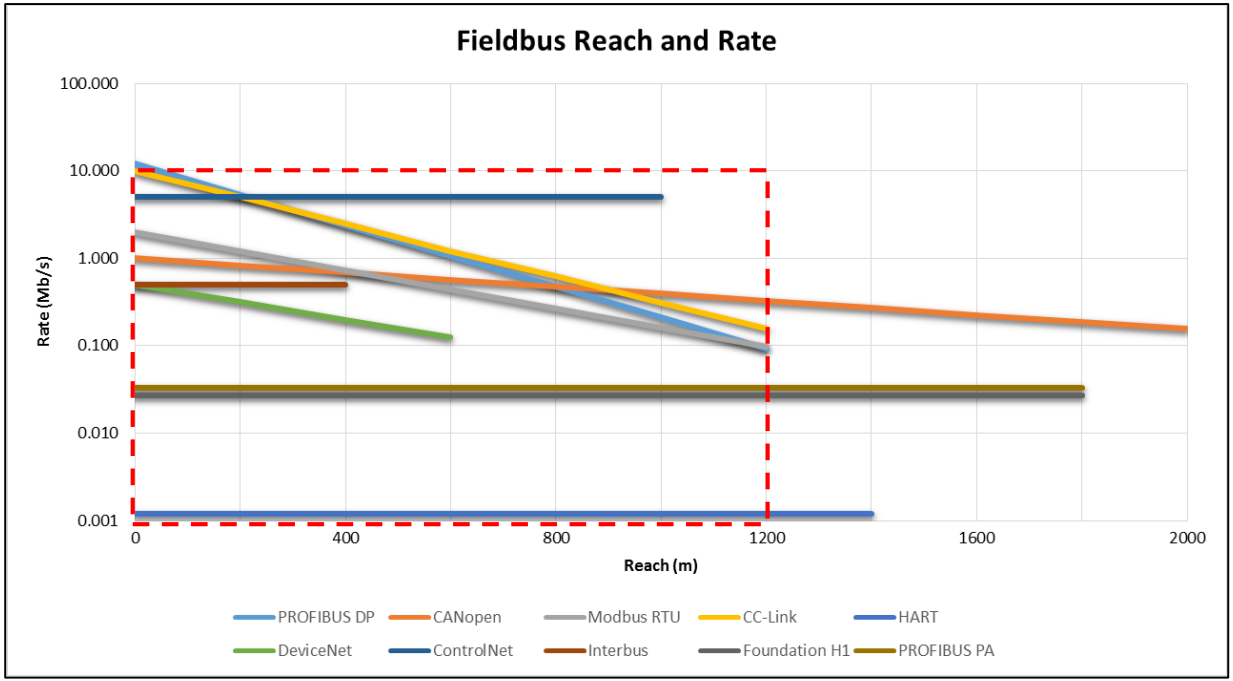
- Single network paradigm
  - Transparent connectivity
    - Reduces complex gateways
  - More rapid commissioning
  - More rapid fault diagnosis and repair
- Well-known installation, maintenance and management processes

- 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)

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 most 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
  - Enhancement of PoDL for extended reach to be considered
- 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

- IEEE 802.3bu PoDL
- 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

- Study group will need to determine what tutorial and liaison information to provide to these groups, and what information to request

Why Limit this CFI to 10Mb/s?

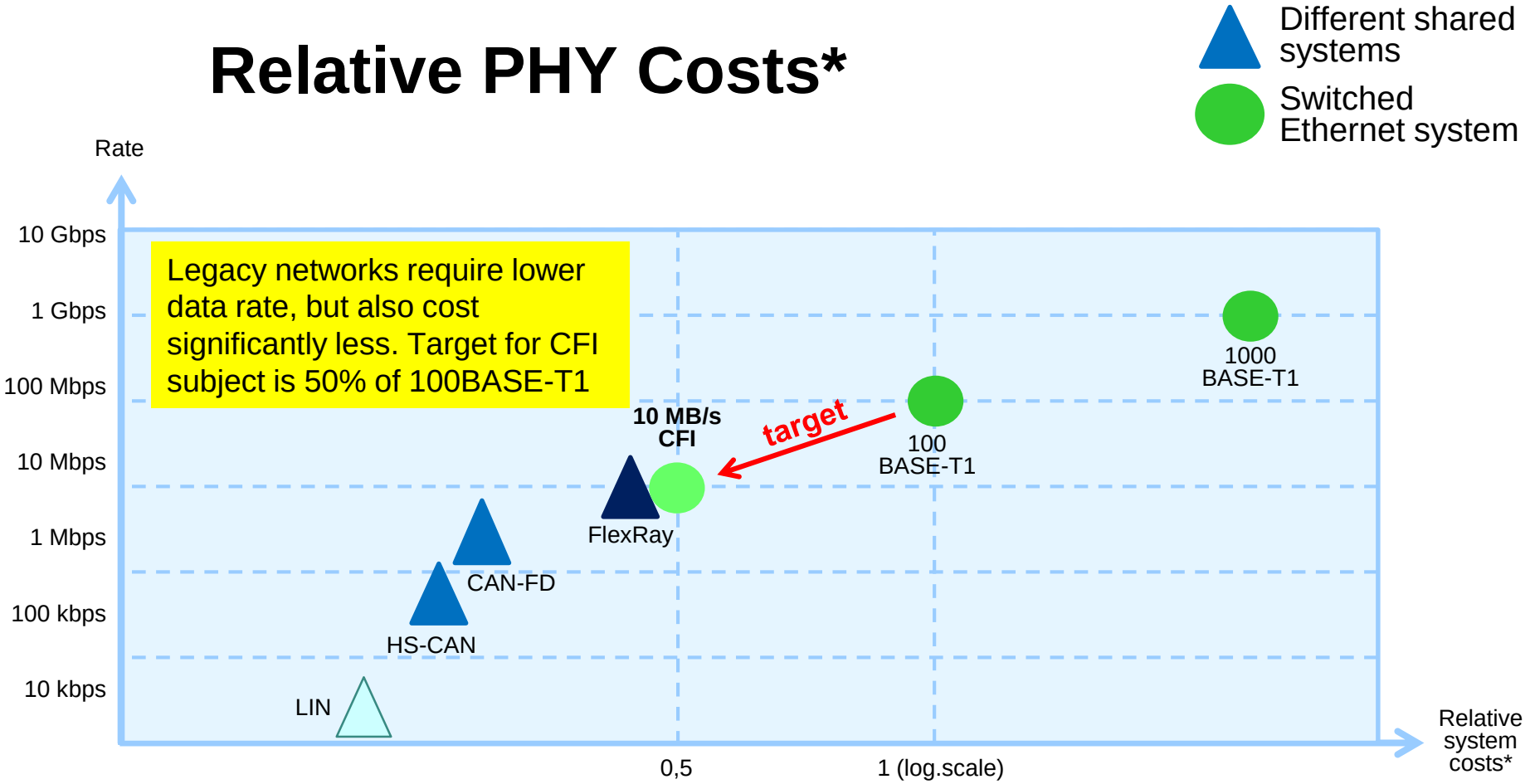
- **Preference for this CFI is to minimize number of PHY developments**
  - **Satisfies immediate pull from market addressing ‘sweet spot’**
  - **Reduces complexity & minimises time to completion**
- **Establishes Ethernet credibility as a true consolidated fieldbus replacement**
- **Future CFI(s) can 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 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 PHY 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 (**The dominant driving market for this CFI)
  - Process Automation
  - Factory Automation

- **Building Automation[1]**
  - HVAC
  - Security/Access
  - Fire
  - Lighting Control Systems
  - Residential

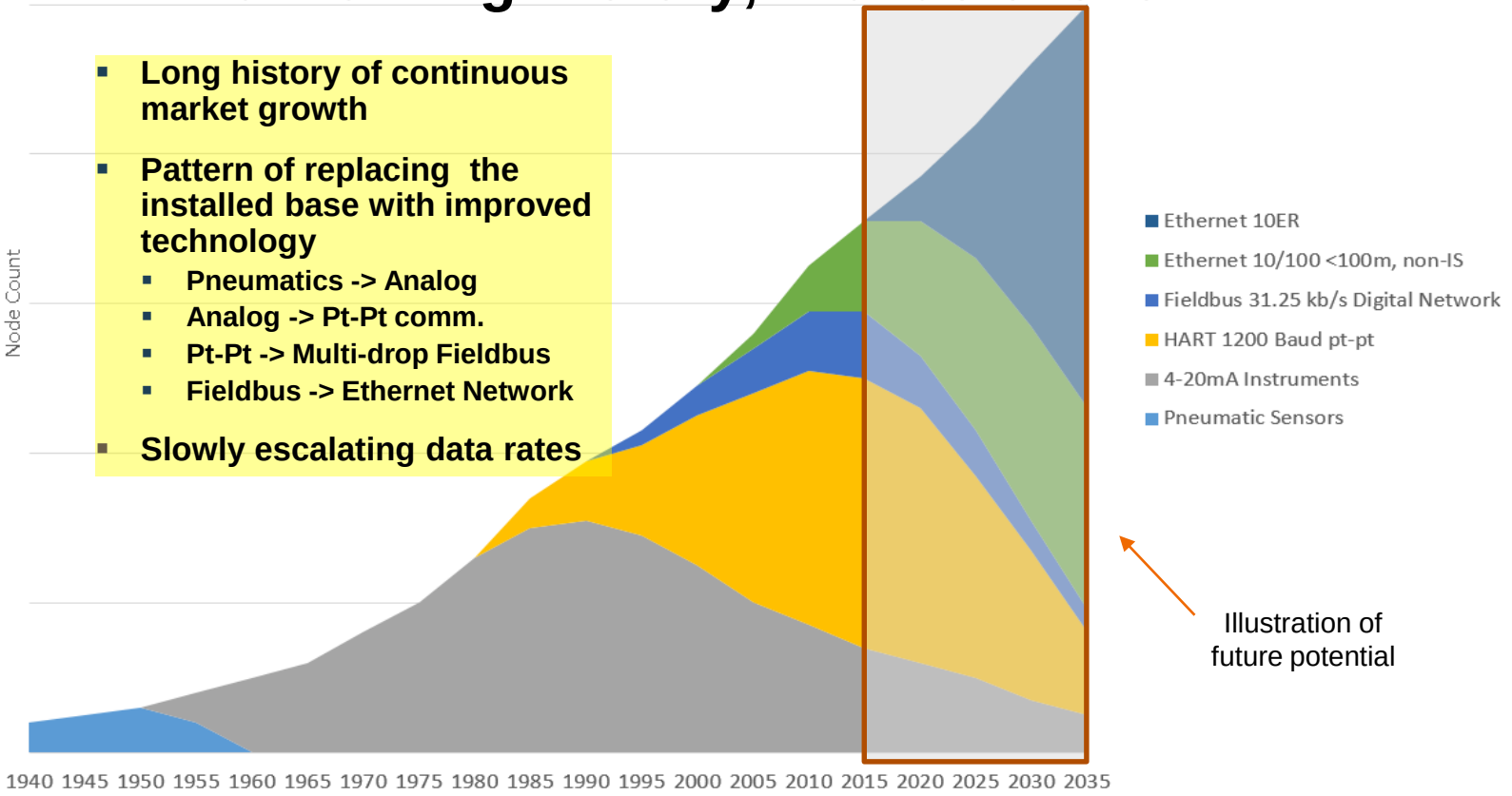
- **Automotive**
  - Legacy IVN consolidation

- **New Applications**

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

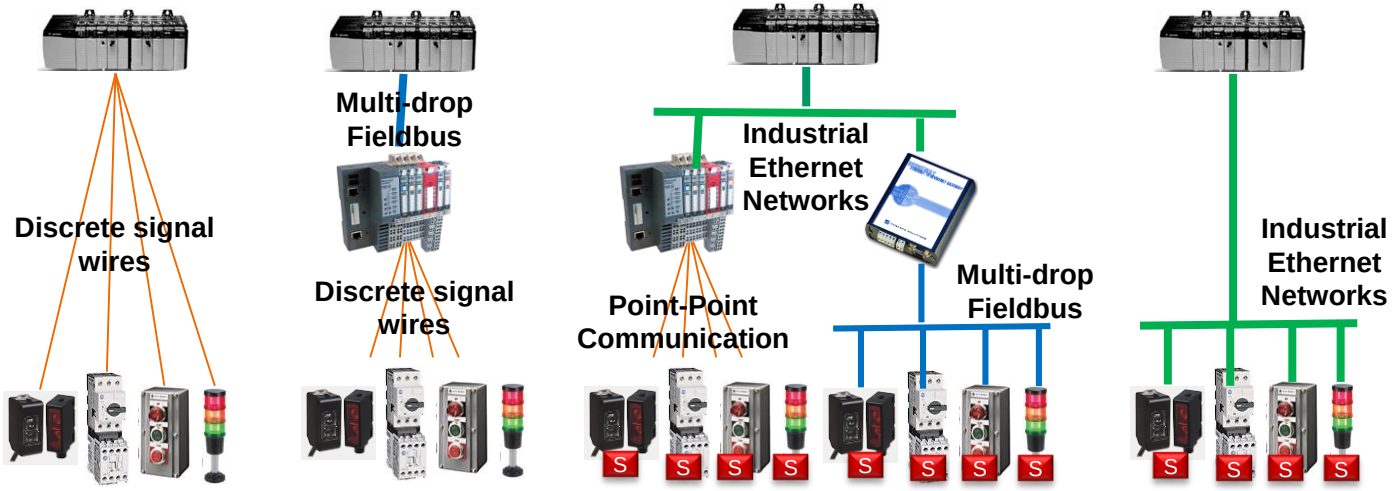
Process Automation
Networking History, Trends & Growth

- **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 **discrete wires,** Dumb devices

Remote I/O **Fieldbus**, Dumb devices

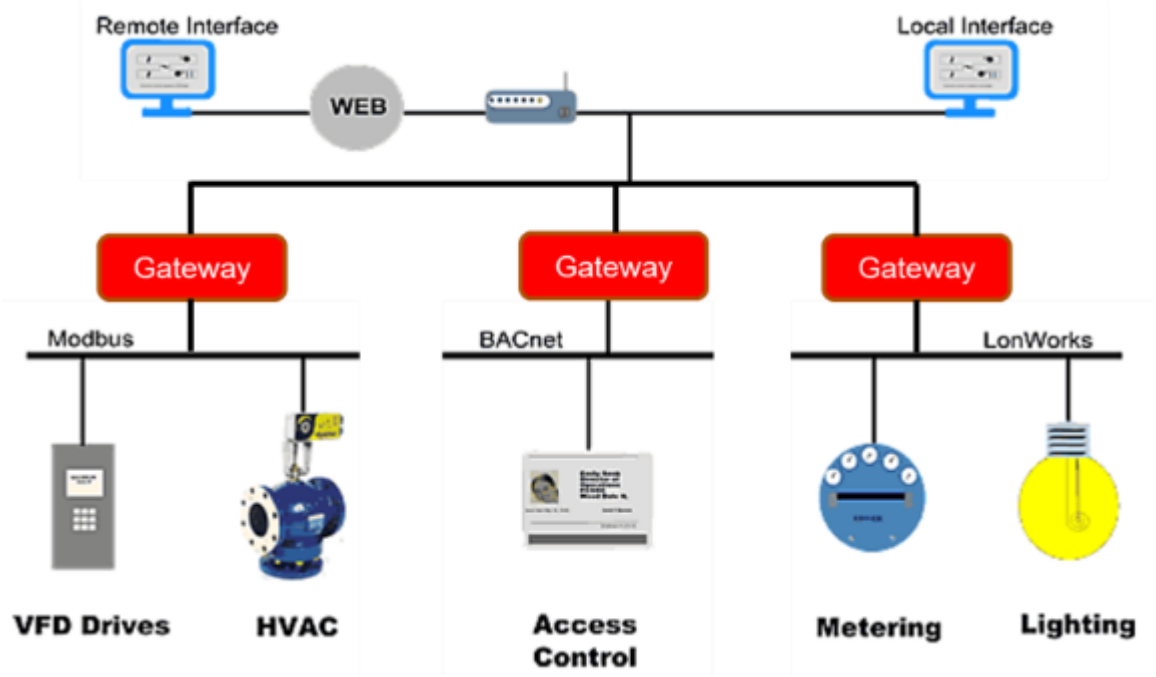
Industrial Ethernet interconnecting multi-drop Fieldbus and point-point for **smart devices**

Native Industrial Ethernet smart devices?

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

S = Smart Device

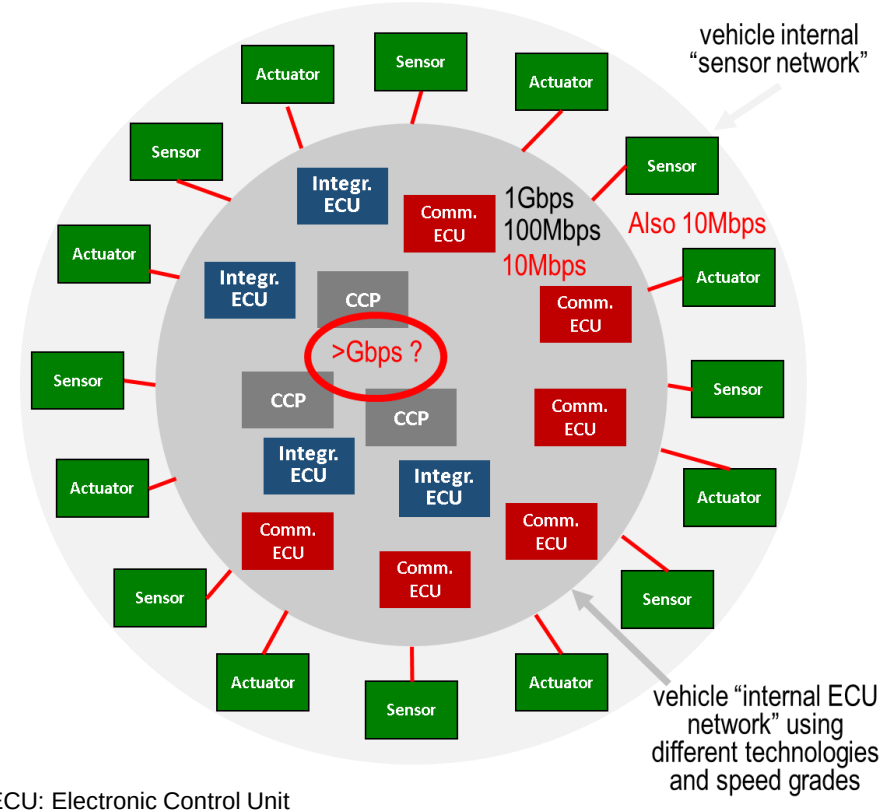
Building Automation Architecture Trends



- 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

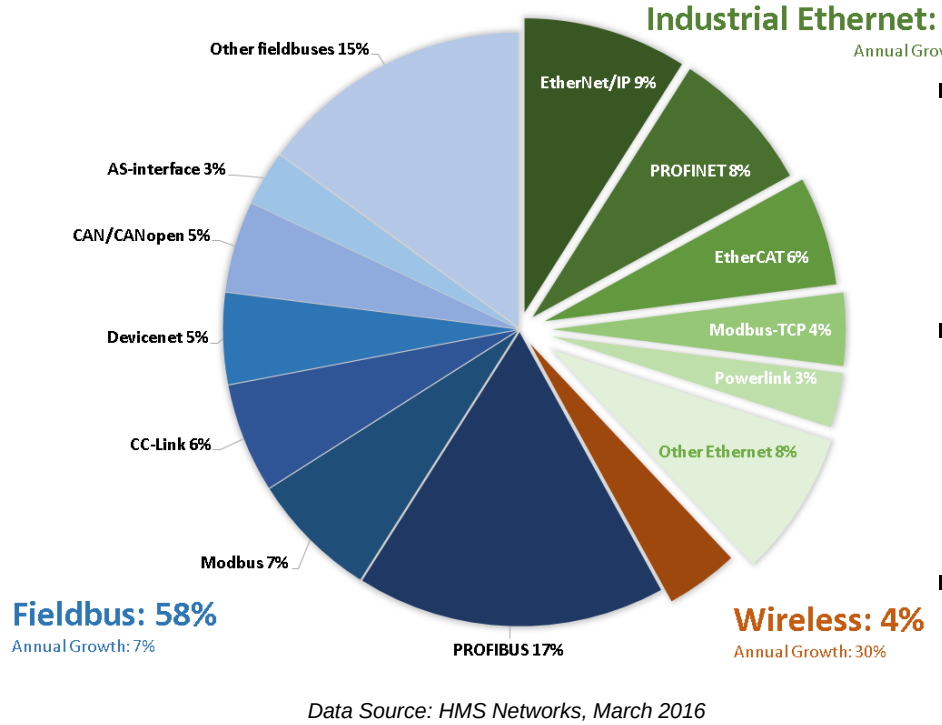


ECU: Electronic Control Unit
CCP: Central Computing Platforms

- 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 / LIN / …
  - 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

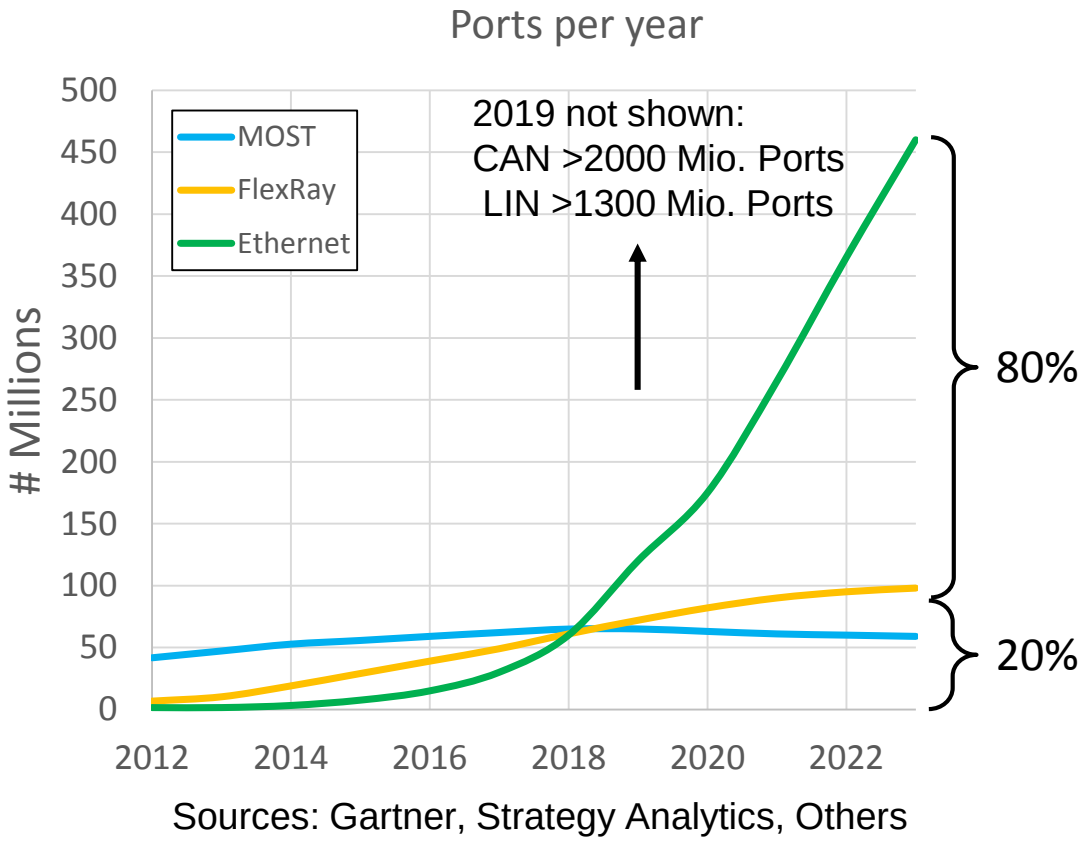
- Converged data is challenging to align
  - Various reporting techniques
    - May or may not include analog only solutions
  - Varying vintage of information
    - May not fully capture recent growth trajectory of Ethernet
  - Potential biases of representative organisations

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

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.
- Further potential HVAC opportunity:
  - An average controller example interfacing to ~10 sensors/actuators, results in 200 million ports/year.
- Further study group efforts required to dig deeper and discern higher end potential of this market.
  - Security/Access, Fire, Lighting Control Systems have additional opportunity

Automotive Market Size



Sources: Gartner, Strategy Analytics, Others

The analysts currently consider only 100Mb/s and 1Gb/s.

Gartner expects a ratio of 80% 100Mb/s to 20% 1Gb/s PHYs.

The 10Mb/s market will leverage from:

- FlexRay
- New Sensor applications
- Where 100BASE-T1 exceeds requirements
- New ECU developments

It can expected to be minimum as large as 1Gb/s automotive market

2019: ~4 Billion total IVN Ports

Target Market Size – Summary

- Based on current port count without projected growth, mid-range estimate could suggest a combined Industrial and Building Automation (IBA) 130Mio ports/year
- Estimate 50% of IBA ports can be served by new 10Mb/s single twisted pair Ethernet PHY, multiple legacy solutions will not fully disappear.
- Automotive applications estimate an additional 100Mio ports/year served by proposed solution.
- Potential market of **165Mio** 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**
  - **PoDL**

- **Proprietary PHYs**
  - **Pepperl + Fuchs demonstrator**
    - **http://www.pepperl-fuchs.com/global/downloads_ENU/PR-2016-23023PA-ENG.pdf**
    - **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**

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
- Other efforts imply the technical feasibility

Why Now and Why in IEEE 802.3?

- The industry is requesting it
- It's Ethernet – it belongs in IEEE 802.3
  - IEEE 802.3 is recognized as the international standard for Ethernet
  - Responsible for Ethernet physical layers
- 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 Poll

xxx Number of people in the room

Would you support the formation of a:

10Mb/s Single Twisted Pair Ethernet Study Group?

Y/N/A

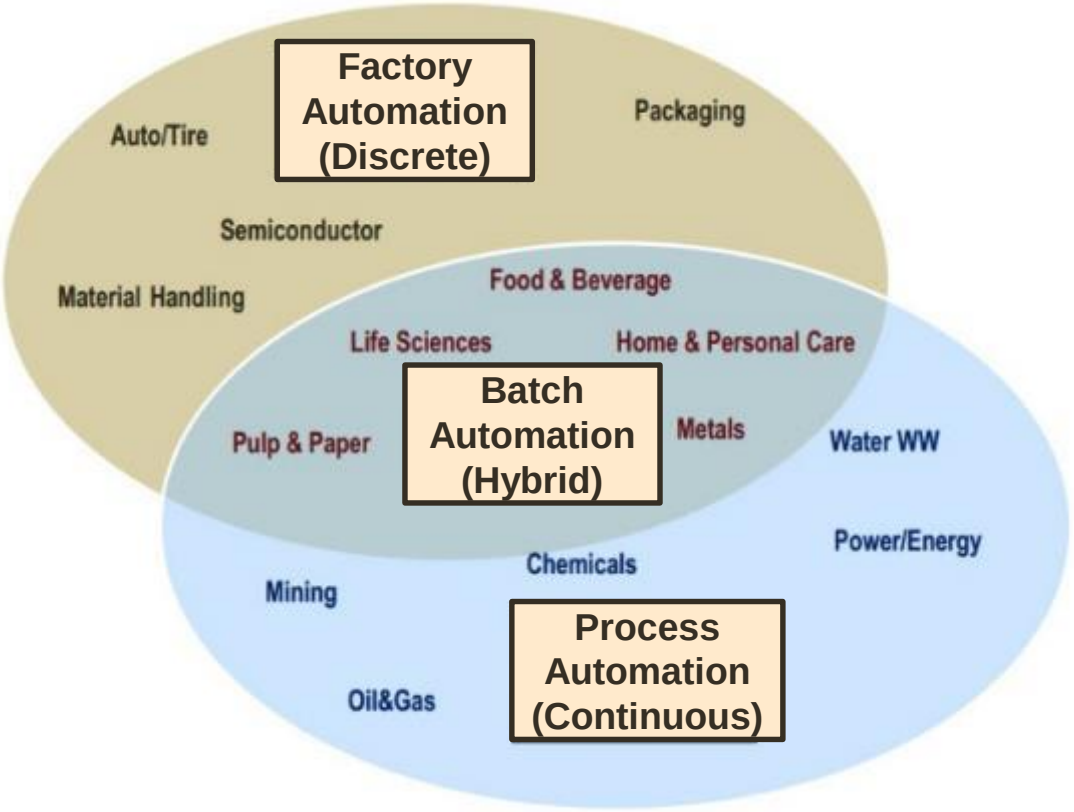
Would you attend and contribute to a:

10Mb/s Single Twisted Pair Ethernet Study Group?

Y/N/A

Thank you!

Industrial Automation Landscape



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

Lidar ➔ implementation dependent, generally >> 10Mbps ↘

Ultrasound ➔ up to 10Mbps ↗

Microphones ➔ below 10Mbps ↗

Topology

- A half-duplex option may provide some cost reduction, but full-duplex is required for deterministic industrial applications
- Many links and installed cables are already point to point
- Some multi-drop installations add electrical switch like devices to split the cable into pieces electronically to allow rapid maintenance
- Existing Ethernet adopts:
  - Star topology, a trunk and spurs through a switch
    - Process Automation expectation
  - Linear with 2 PHYs in each device
  - Redundancy is sometimes required
    - Parallel star
    - Ring

- This is a topic the study group could consider.

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