10Mb/s Extended Reach Single Twisted Pair Ethernet PHY 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

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David Hoglund, Johnson Controls

Supporters - Page 1

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Supporters - Page 4

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

Mr. Mark Foltz, ABB (Industrial Automation)

CFI Objective

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

10Mb/s Extended Reach Single Twisted Pair Ethernet PHY

- 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

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

Industrial Networking Market Need

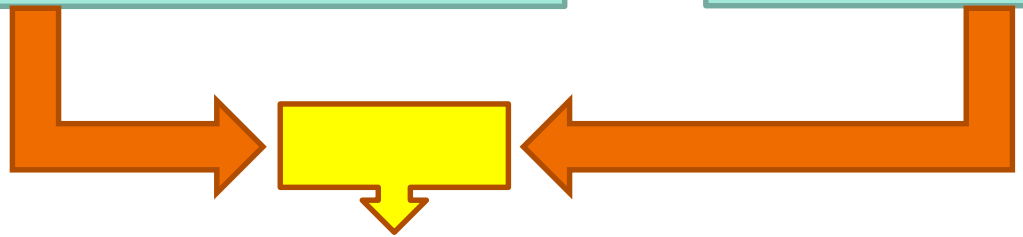
Vision

- Point-point
  - 4-20mA
  - HART modem
  - RS-232
  - Proprietary/custom
- Multi-drop
  - RS-485
  - HART modem
  - CAN
  - Proprietary/custom

Existing

- New applications
  - Enabled through this proposed PHY development

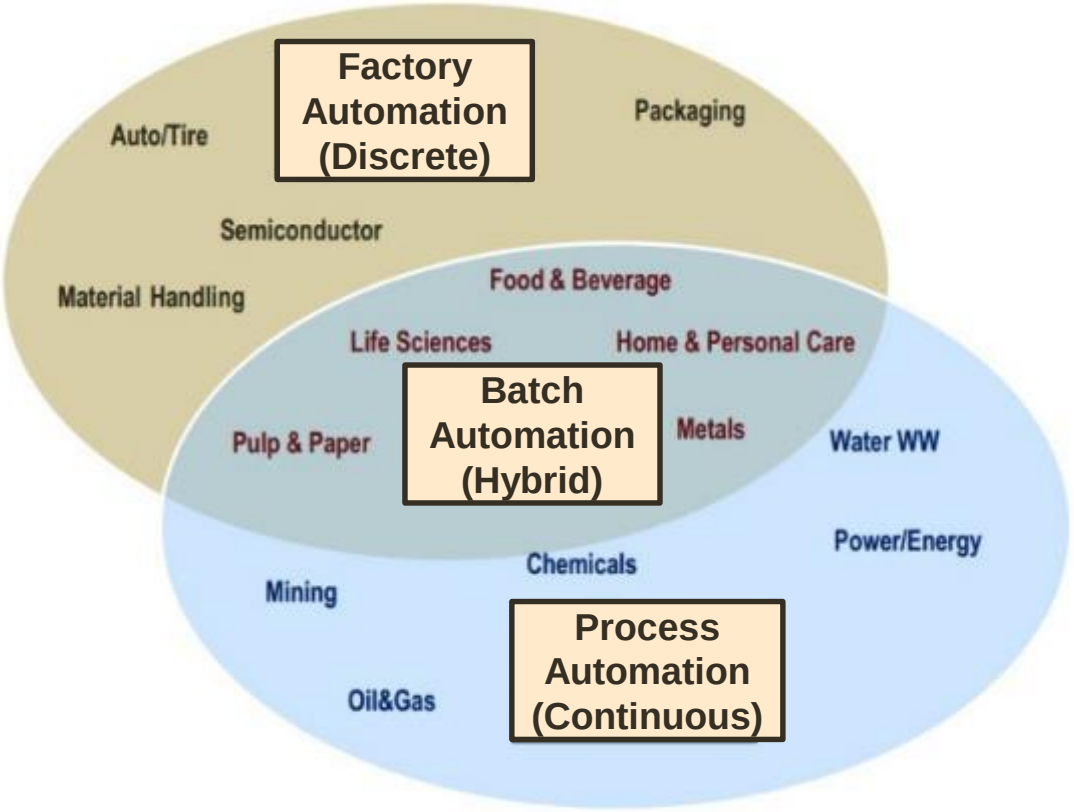
Future



New
IEEE 802.3
Standard

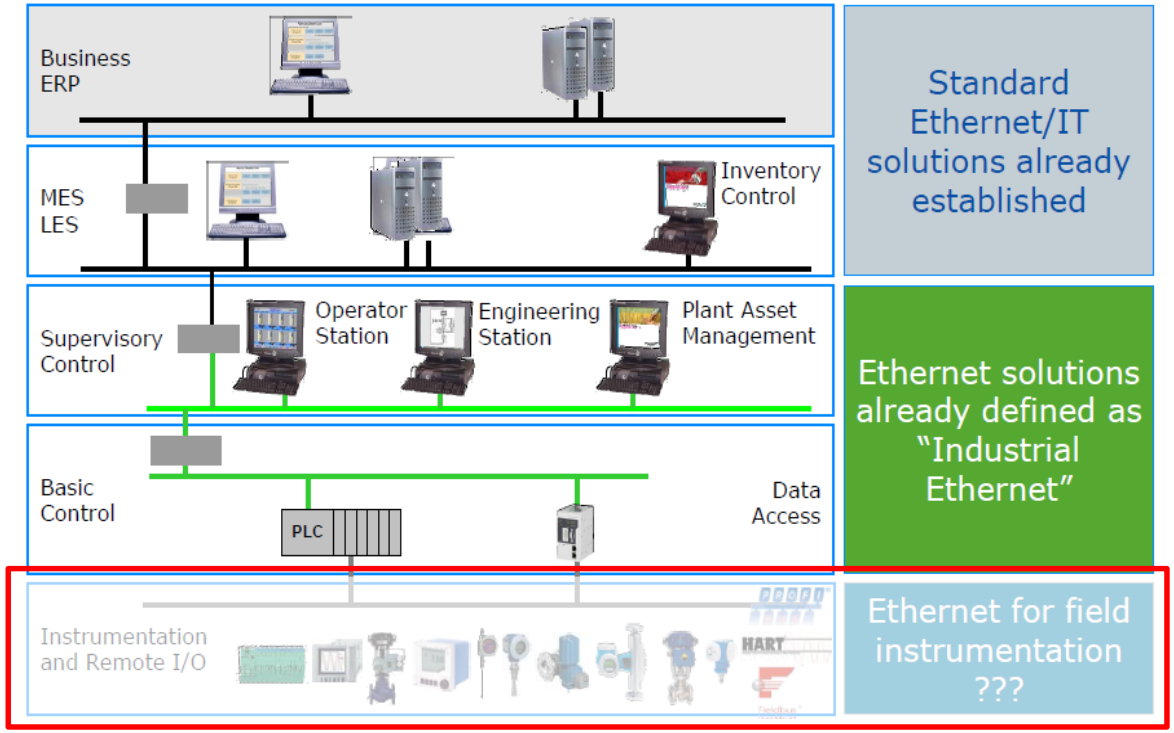
Point to Point, Single Pair, Long Reach, ‘Intrinsically Safe’ (e.g., IEC 60079), Power Delivery

Industrial Automation Landscape



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



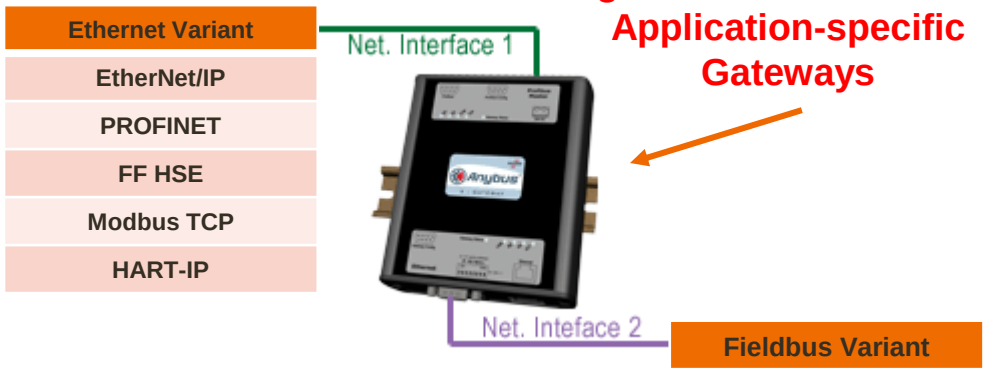
Credit: Dr. Raimund Sommer, Endress + Hauser, ODVA Industry Conference, Oct. 2014.

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

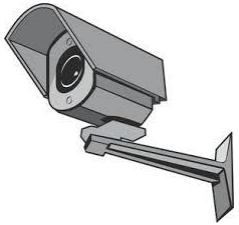
- **IIoT, Big Data, and Analytics**
  - **High-speed data logging**
    - **Production details, equipment conditions, environment state, energy consumption,…**
  - **Optimization, maintenance, safety, compliance,…**

PLATTFORM INDUSTRIE 4

industrial internet CONSORTIUM

- **Embedded web servers**
  - **Installation and maintenance**

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



Solution Requirements:

Why 10Mb/s Extended Reach Single Twisted Pair Ethernet PHY?

Why Ethernet to the Edge?

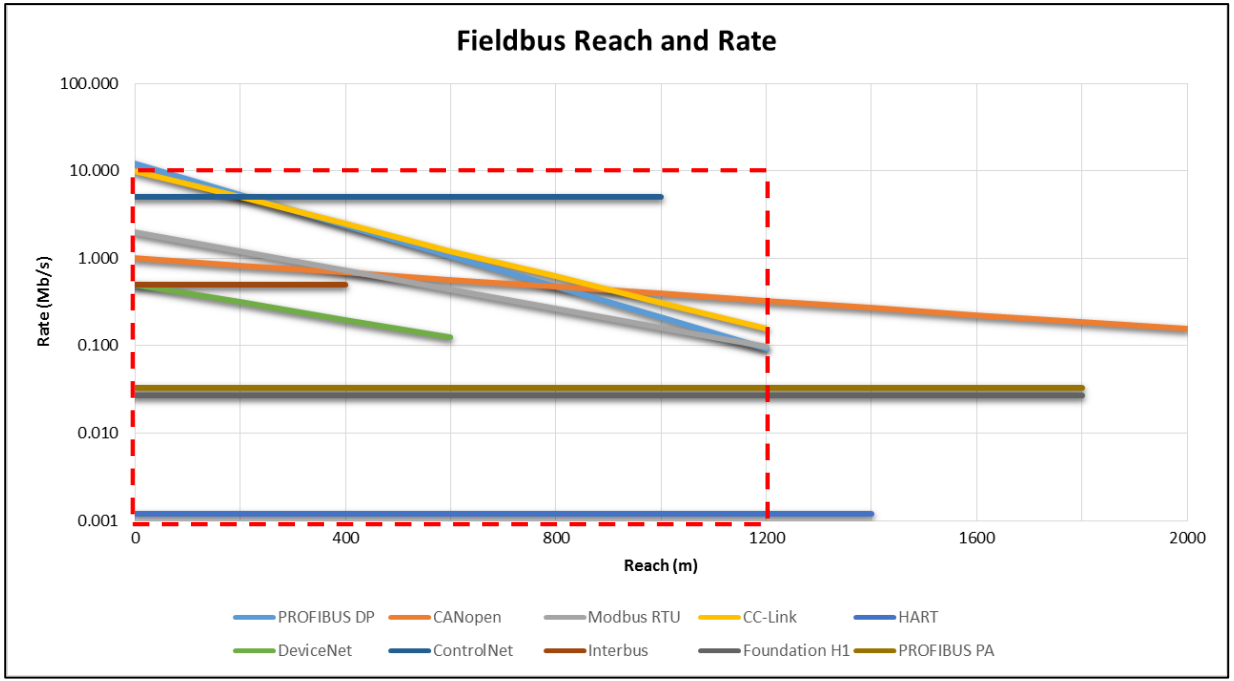
- Single network paradigm
  - Transparent connectivity
    - Reduces complex gateways
  - More rapid commissioning
  - More rapid fault diagnosis and repair
- Well-known installation, maintenance and management processes

- 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?

- Low power operation is required
- 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 include one PHY development**
  - **Satisfies immediate pull from market addressing ‘sweet spot’**
  - **Reduces complexity & minimises time to completion**
- **Establishes credibility in Ethernet as true consolidated fieldbus replacement**

Y/N/A

- **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 to be considered by Study Group**

Target Markets

Target Markets

- **Industrial Automation (**The dominant driving market for this CFI)
  - Process Automation
  - Factory Automation

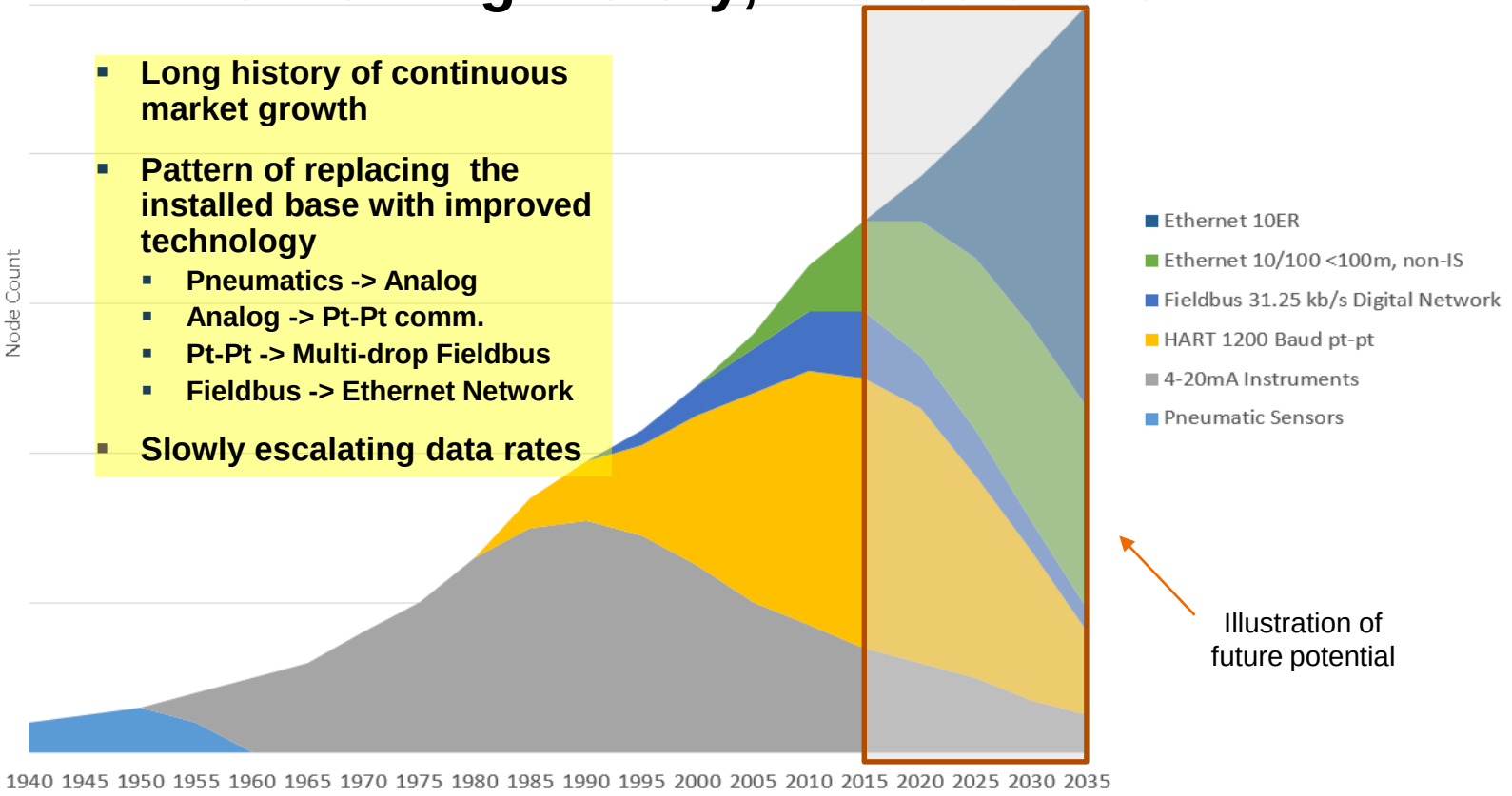
- **Building Automation[1]**
  - HVAC
  - Security/Access
  - Fire
  - Lighting Control Systems
  - Residential

- **New Applications**

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

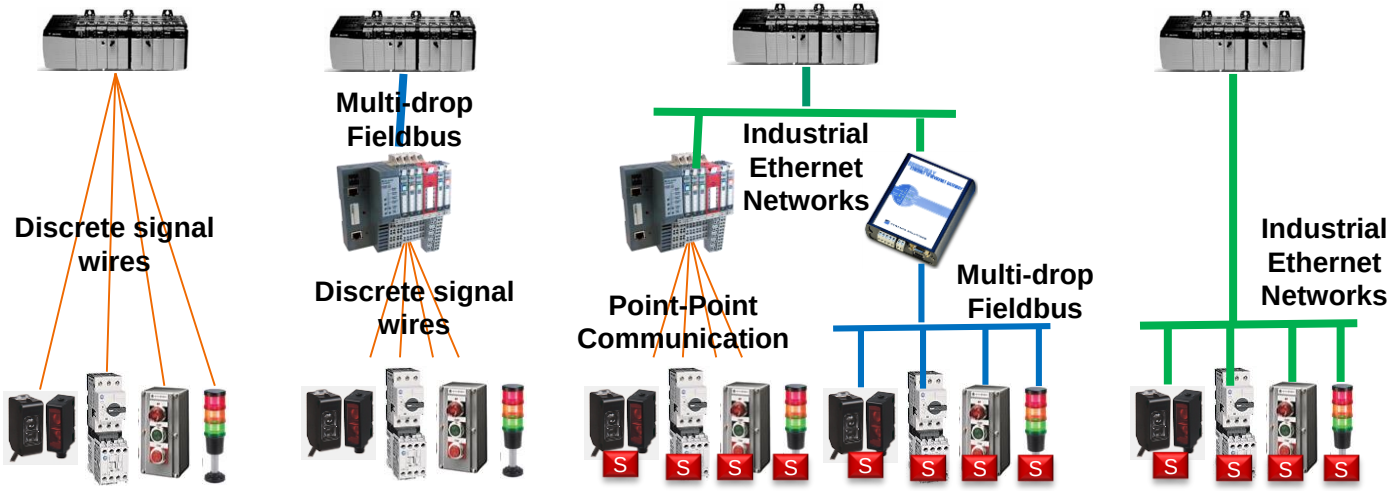
Process Automation
Networking History, Trends & Growth

- **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
<u>discrete wires,</u>
Dumb devices

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

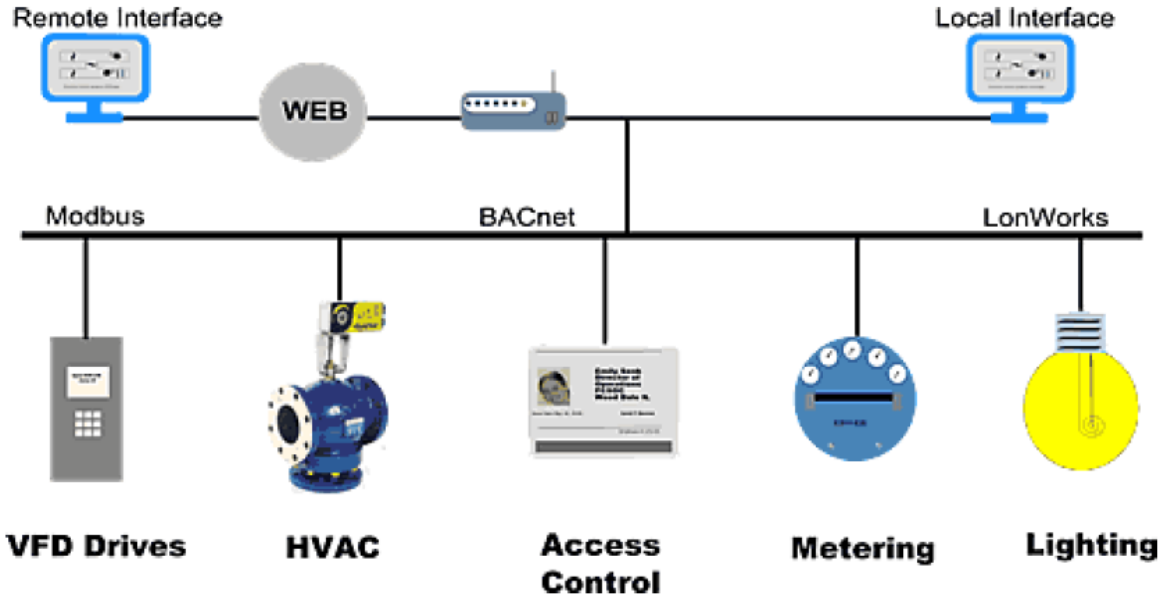
Industrial Ethernet interconnecting multi-drop Fieldbus and point-point for **smart devices**

Native Industrial Ethernet smart devices?

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

S = Smart Device

Building Automation Architecture

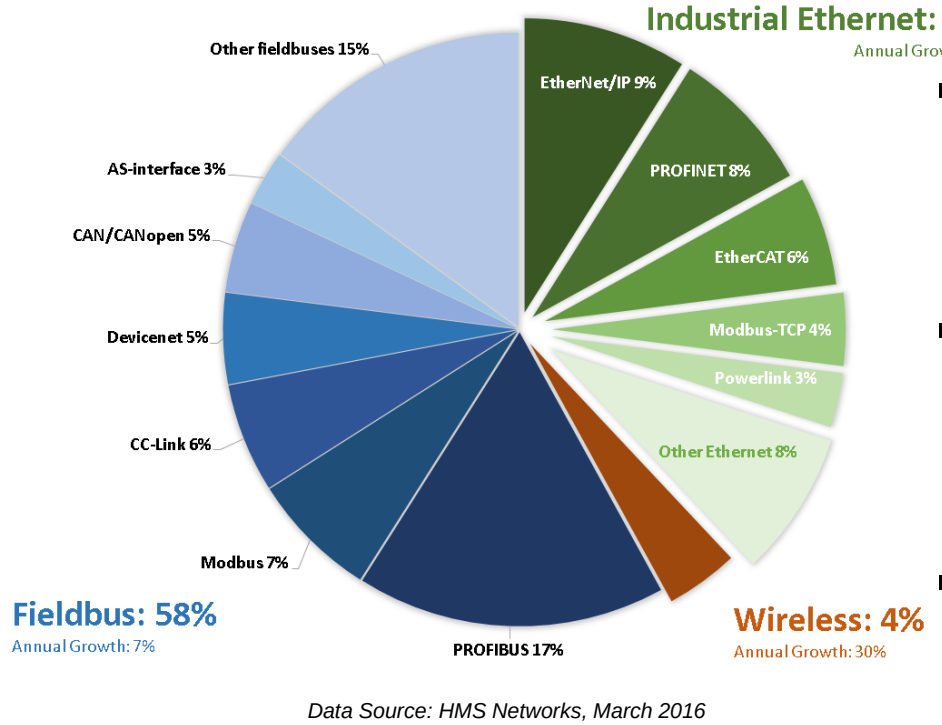


Credit: Carlson/Kennedy, IEEE 802 BoF "I Feel the Need… for Low Speed", July 2014

- Fragmentation…
  - Modbus: RS232/485
  - BACnet: RS485
  - LonWorks: Proprietary
- Multiple gateways needed
- Desire to converge on **one** network type

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	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.
- Further potential HVAC opportunity:
  - The average controller interfaces to ~10 sensors/actuators, this 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

Target Market Size – Summary

- Based on current port count without projected growth, mid-range estimate could suggest a combined 130M ports/year.
  - Further opportunities exist
- Estimate 50% can be served by new Ethernet PHY
- Potential market of **65M** ports/year and growing
- New Ethernet-based technology (CFI subject) can provide greater growth through additional application enablement

Technical Feasibility

Technical Feasibility Example Implementations

- **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**

® 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
  - Multi-drop fieldbuses and point-to-point digital and analog links need an Ethernet replacement
- 10Mb/s Extended Reach Single Pair Ethernet meets the need
  - Consolidate hugely fragmented fieldbus market to unified Ethernet-based solution
  - Enable Industrial IoT applications and new markets – e.g. big data analytics, smart sensors, streaming video
  - Single pair for ease of install and enabling cable reuse
  - Power delivery for applicable portion of market
- Large market potential for 10Mb/s extended reach single pair Ethernet
  - 55M+ ports/yr for industrial automation
  - >10M for building automation
- 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 market introduction in 2019

10Mb/s Extended Reach Single Twisted Pair Ethernet PHY Q&A

15 Minutes

Straw Polls

Straw Poll

xxx Number of people in the room

Would you support the formation of a:

10Mb/s Extended Reach Single Twisted Pair Ethernet PHY Study Group?

Y/N/A

Would you attend and contribute to a:

10Mb/s Extended Reach Single Twisted Pair Ethernet PHY Study Group?

Y/N/A

Thank you!

Topology

- A half-duplex option may be lowest cost, but full-duplex is anticipated
- Many links and installed cables are already point to point
- Some multidrop installations add electrical switch like devices to split the cable into pieces electronically to allow rapid maintainance
- 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 question for the Study Group

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