Next steps in single-pair ecosystem - consideration of extended reach

IEEE 802.3 NEA Ad hoc

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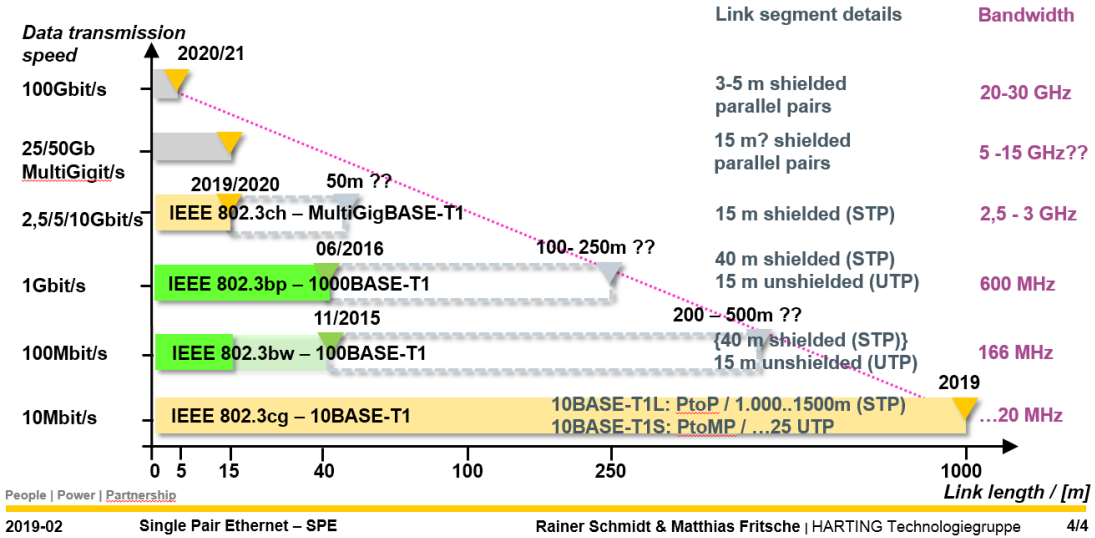
Scope

- This is NOT a CFI
- This is NOT the typical NEA consensus building around a mature pre-CFI proposal
- This is an initial discussion of one possible extension of the single-pair ecosystem:

Extended Reach Single Pair Ethernet

Extended Reach Concept

- The single pair eco-system has to a large degree been defined with automotive distances in mind
- There are a range of rates that are not believed to have met their potential for reach
- Unsatisfied applications are believed to exist across a wide range of markets



Agenda

- **Market Needs**  **We primarily focus here**
- Solution Requirements
- Target Markets
- Market Potential
- Technical Feasibility
- **Q&A – Please hold until this time**

Market Needs

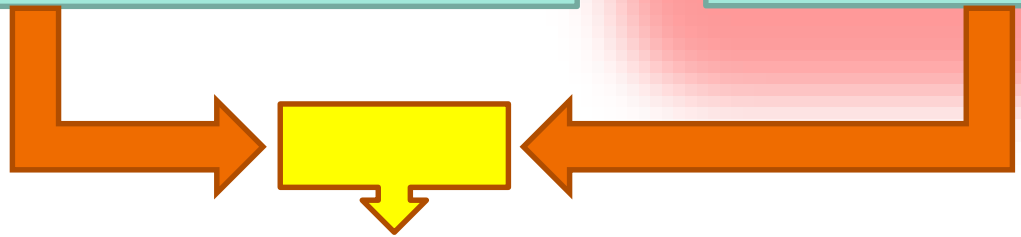
Vision from IEEE P802.3cg

- 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

New Requirement: Higher Rates at the Edge

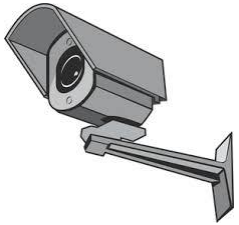
- IIoT, Big Data, and Analytics
  - High-speed data logging
    - Production details, equipment conditions, environment state, energy consumption,…
  - Optimization, maintenance, safety, compliance,…
- Digital Twin

PLATTFORM INDUSTRIE 4

industrial internet CONSORTIUM

- Embedded web servers
  - Installation and maintenance

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



Video Bandwidth

Resolution	Uncompressed (30 fps)	Motion JPEG (HQ – 30 fps)	YouTube H.264 (30 fps + audio)	YouTube H.264 (60 fps + audio)	H.265 HVEC (HQ – 30 fps)	H.265 HVEC (HQ – 60 fps)
426 x 240 (240p)	74 Mb/s	---	500 kb/s	---	---	---
640 x 360 (360p)	166 Mb/s	10.5 Mb/s	700 kb/s	---	400 kb/s	700 kb/s
854 x 480 (480p)	295 Mb/s	---	1.50 Mb/s	---	---	---
1280 x 720 (720p)	664 Mb/s	42.2 Mb/s	2.75 Mb/s	4.13 Mb/s	1.5 Mb/s	3.0 Mb/s
1920 x 1080 (1080p)	1.49 Gb/s	94.9 Mb/s	4.50 Mb/s	6.75 Mb/s	3.4 Mb/s	6.7 Mb/s
3840 x 2160 (4k)	5.97 Gb/s	378 Mb/s	23.5 Mb/s	35.5 Mb/s	13.4 Mb/s	26.8 Mb/s

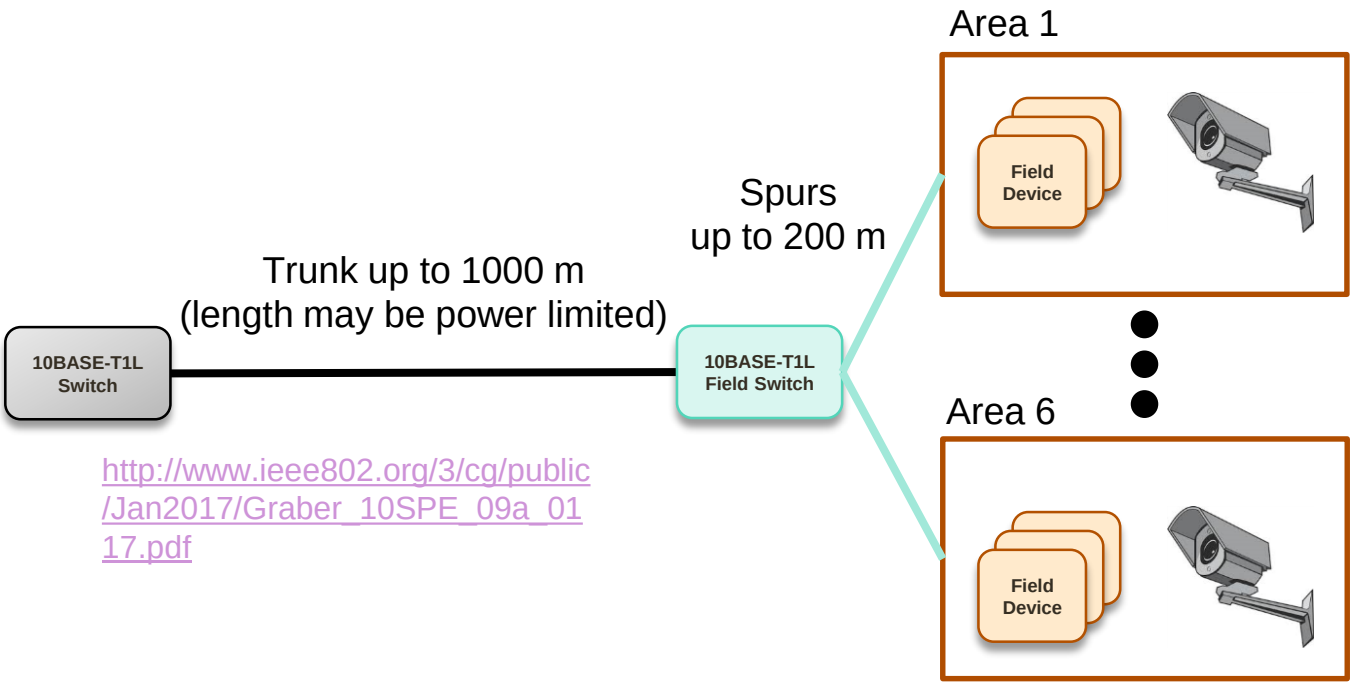
- **Uncompressed video**
  - **data rate = color depth * vertical resolution * horizontal resolution * refresh frequency**
- **YouTube H.264 data: https://support.google.com/youtube/answer/2853702?hl=en**
- **Motion JPEG and H.265 data: https://www.cctvcalculator.net/en/calculations/bandwidth-calculator/**

Further Video Considerations

- Lossless video, low latency, and high frame rates are required for some applications
  - Parts inspection
  - Incident analysis
- Low power is required for some applications

- Reference:
  - http://www.cast-inc.com/ip-cores/video/index.html

Process Automation Video Example

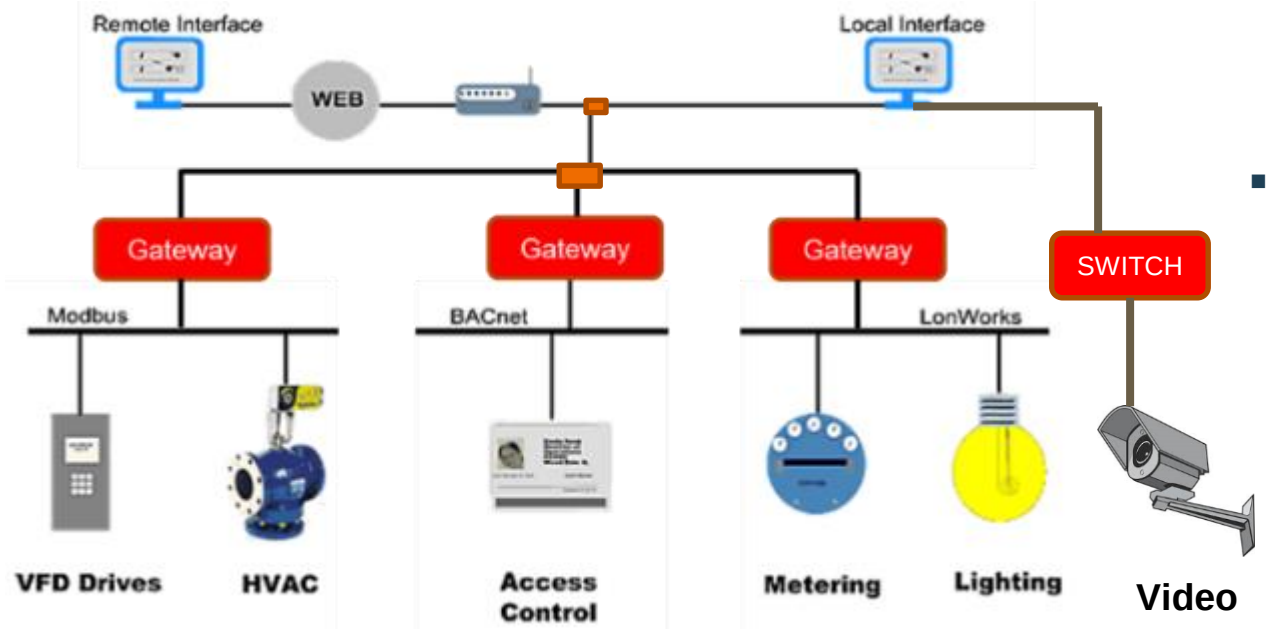


http://www.ieee802.org/3/cg/public/Jan2017/Graber_10SPE_09a_0117.pdf

<u>Applications</u>
Security
Safety
Maintenance
Incident Analysis
Product Inspection

The core automation function is met by 10BASE-T1L
Future streaming video applications may exceeds the trunk capacity

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

Wind mills and wind parks

- **Big wind turbines have towers higher than 100m and because of this fact Ethernet based on copper is not possible.**
- **With 100BASE-T1L up to 500m link segment length a market potential about 100.000 ports for connections from ground to the top of the tower and between wind mills (wind parks) per year is possible.**
- **In addition for shorter link segments up to 50m SPE can be used inside the wind mills to and a potential of approx. 2-3 Million .p.a. ports is possible**

→ **Advantage for this use case:** More robust and cost effective connections

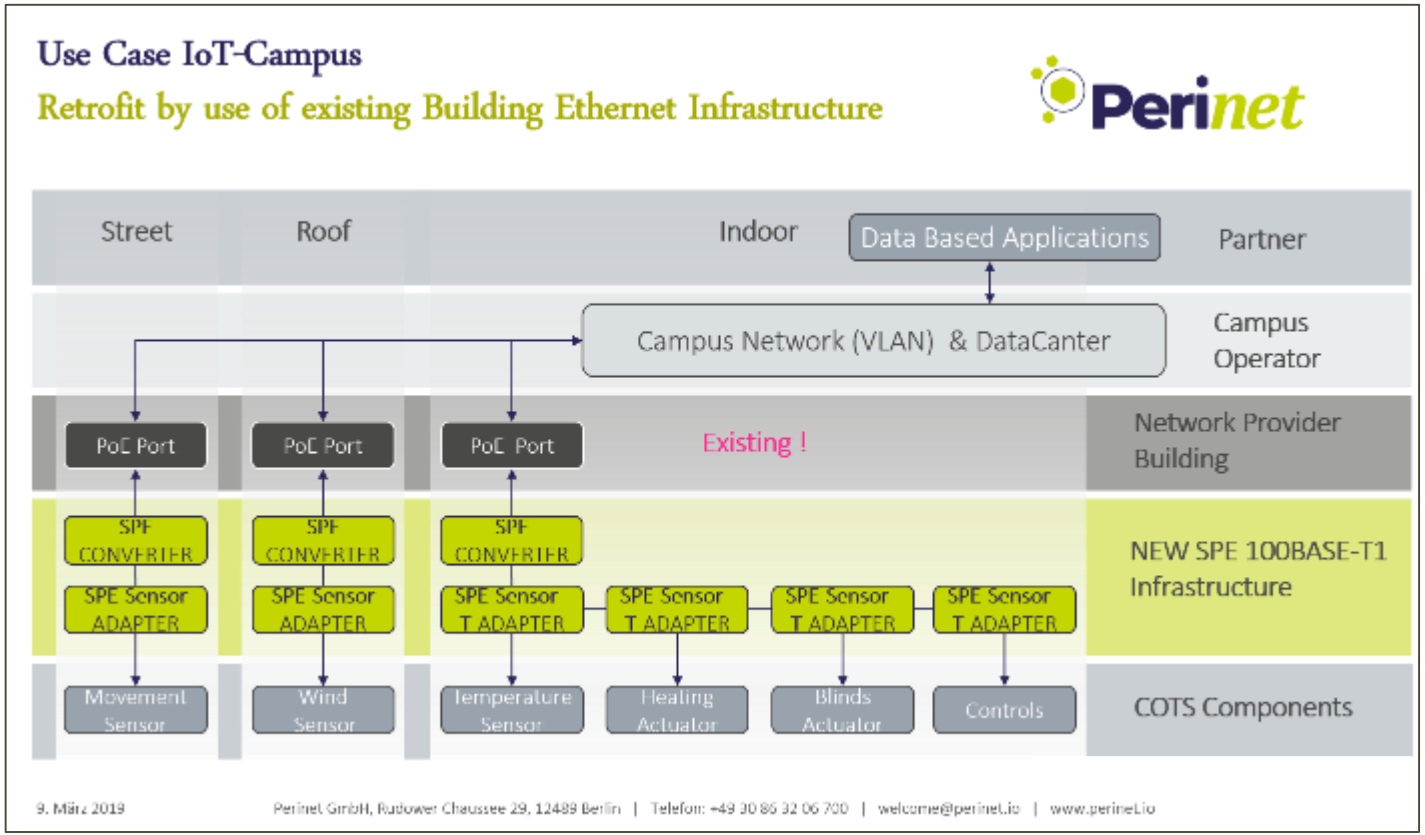
Solar energy plants

- **Solar plants are installed at huge areas and between the solar converters the distances usually are bigger than 100m and 100BASE-T1L will be a very good solution with a big market potential.**

Retro Fit Smart Building

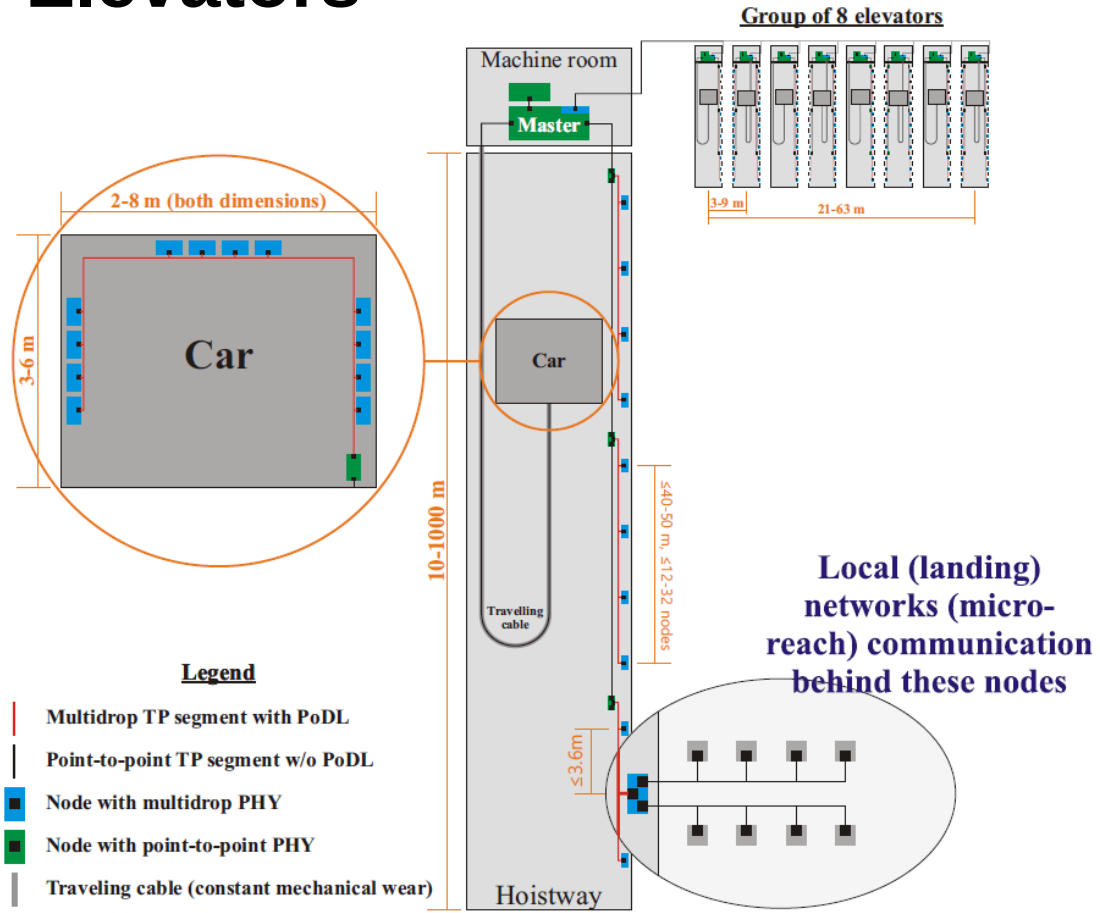
100BASE-T1L…

- support the installation of new sensors, cameras, LiFi-LED lamps to make existing buildings smart
- cost and space reduction compared to 4-pair cabling
- re-use of existing data networks
- just one cable for power and data



Elevators

- Worldwide market:
  - 2020: ≈1.000.000 new installations / year
- Requirements of near-future systems include:
  - voice and video streaming
- References:
  - http://www.ieee802.org/3/cg/public/Sept2017/huszak_3cg_01a_0917.pdf
  - http://www.ieee802.org/3/cg/public/Sept2017/Huszak_3cg_02a_0917.pdf
  - http://www.ieee802.org/3/cg/public/Nov2017/kattainen_huszak_3cg_01a_0117.pdf



Other application areas to consider

- Video Surveillance
  - Airports
  - Harbors
  - Government facilities
  - Military Areas
- Large buildings
- Ships
- Mines
- ???

Solution Requirements

Requirements for each Use Case

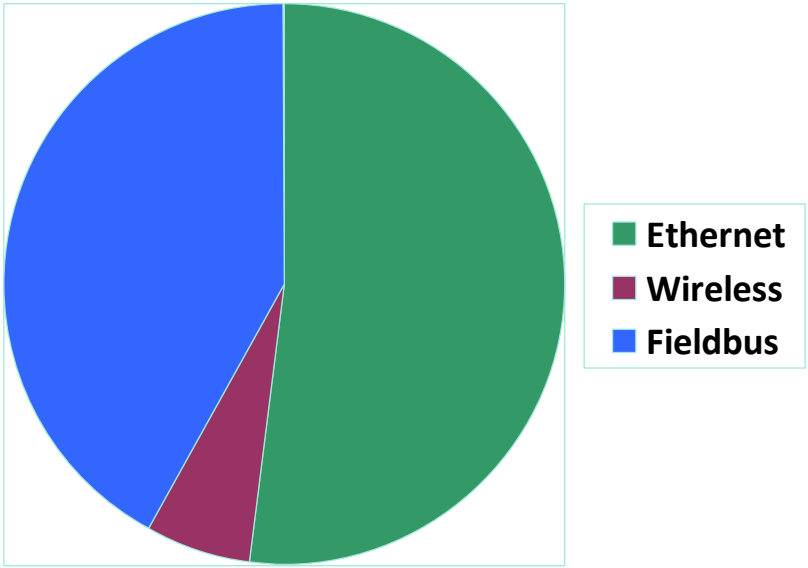
- Rate and reach requirement
  - Application(s) exceeding the next lower rate
  - Reach requirement exceeding the existing solutions
- Requirement for single-pair Ethernet
  - Why Ethernet?
  - Why not a wireless, fiber, or multi-pair solutions?

Example: 100 Mb/s for Process Automation

- Between 200 m and 1000 m @ 100 Mb/s
  - Streaming video for security, safety, and maintenance
  - 100BASE-T1 only reaches 15 m (officially)
- Full Ethernet solution is the trend in Process Automation. 10BASE-T1L is expected to complete the transition at the edge.
- Wireless has safety and security concerns.
- Expectation of power and communication. Fiber does not carry power.
- Expectation set for re-use of existing cables, which are not multi-pair. Existing cables support intrinsic safety option.

Market Potential

Industrial Network Trend



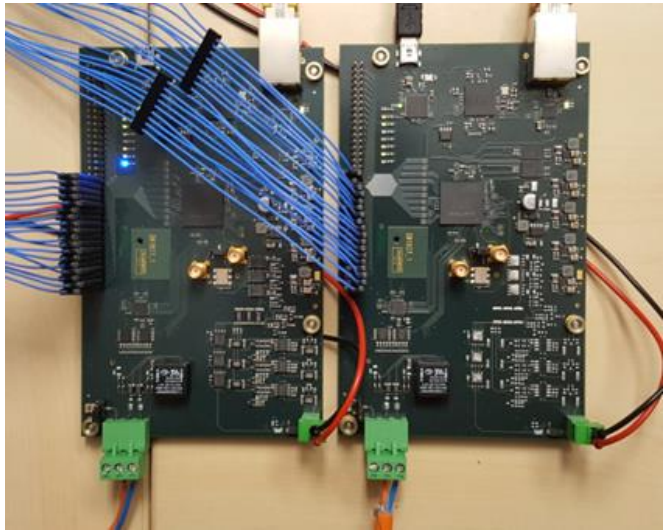
Data Source: HMS Networks, 2018

- Entire market is growing
  - Ethernet (52% share @ 22% growth)
  - Fieldbus (42% share @ 6% growth)
- Industrial Ethernet leads the market (2017)
- 10M Single Pair Ethernet will emerge to displace more fieldbuses
- New applications are expected to drive future demand for increased distances at each rate
  - Existing Single Pair Ethernet cannot match key use cases with higher bandwidth

Technical Feasibility

Example: 100 Mb/s for Process Automation

- Endress + Hauser initiative
- University collaboration
- Sponsored by APL



- Working FPGA-based prototype completed
- 100 Mb/s @ 200 m
- Uses “poor quality” Fieldbus Type A Cable

Summary

Extended Reach Single Pair Ethernet

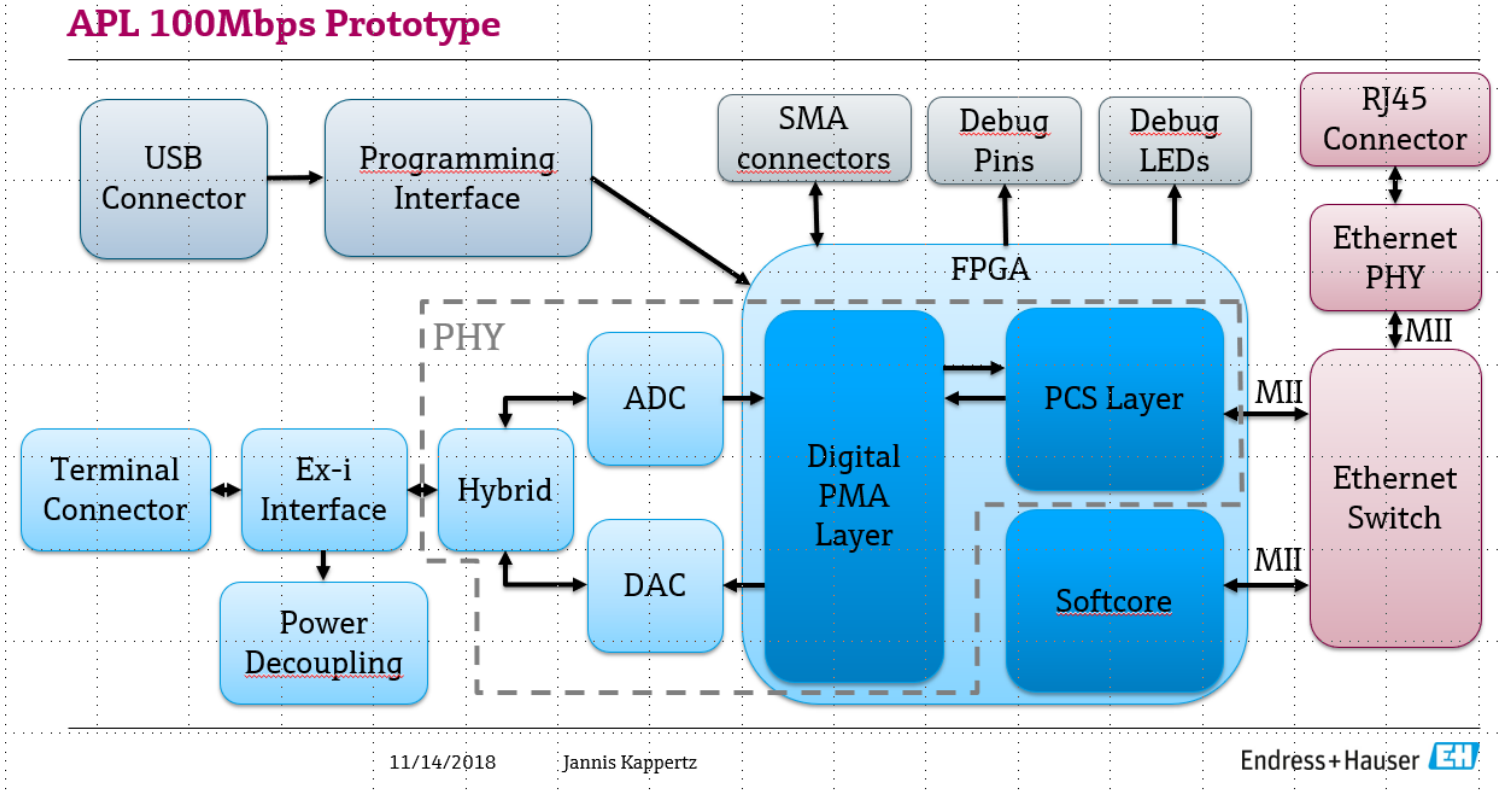
- The single pair eco-system has to a large degree been defined with automotive distances in mind
- There are a range of rates that are not believed to have met their potential for reach
- Unsatisfied applications are believed to exist across a wide range of markets
- One example application (100M in Process Automation) is described and shown to be feasible

Extended Reach Single Pair Ethernet Q&A

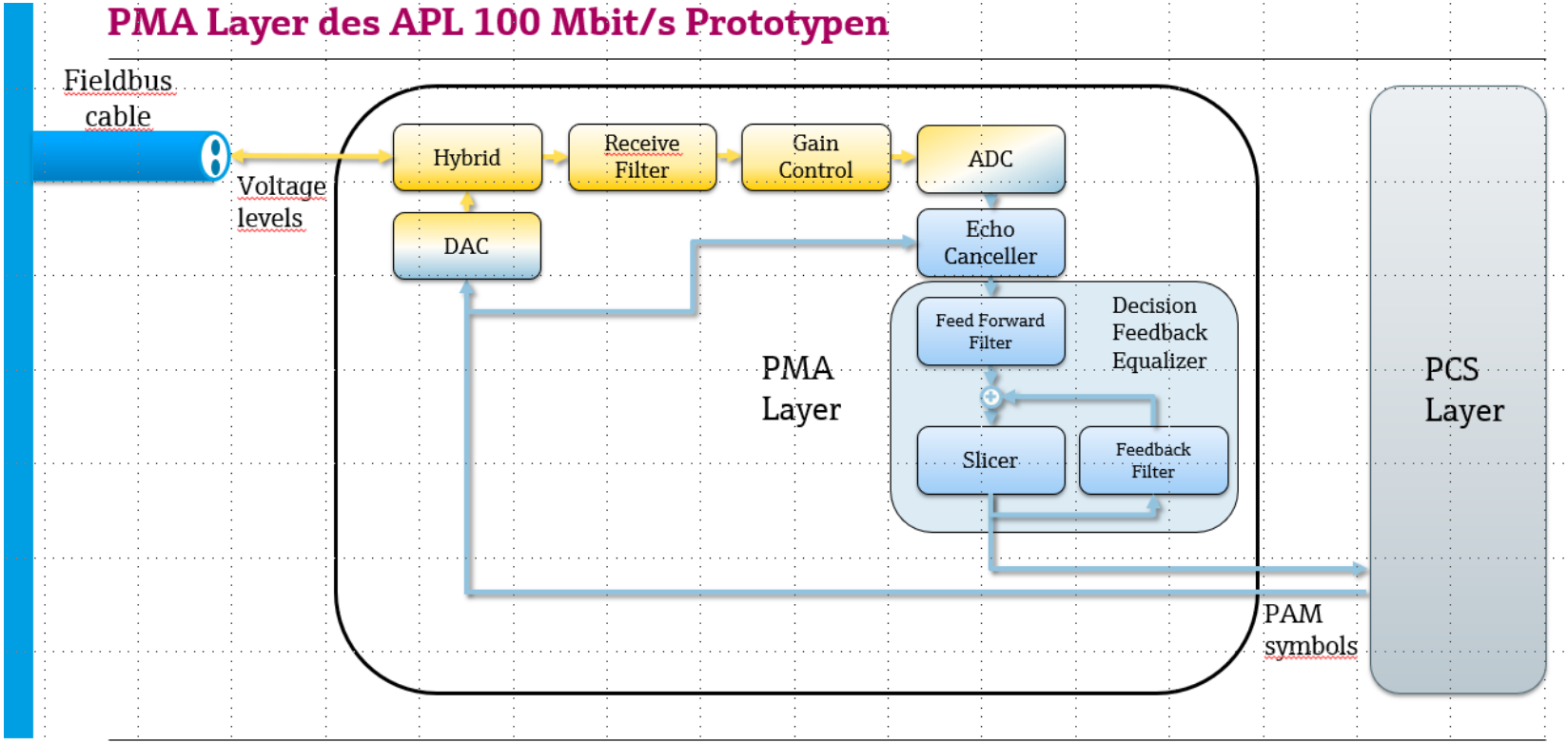
Thank you!

Backup Slides

Technical Feasibility Implementations

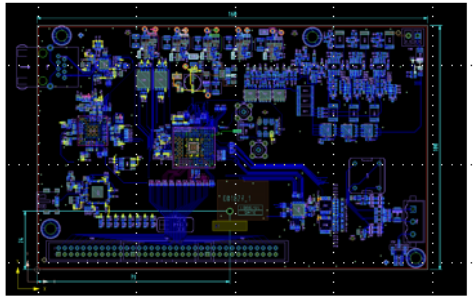


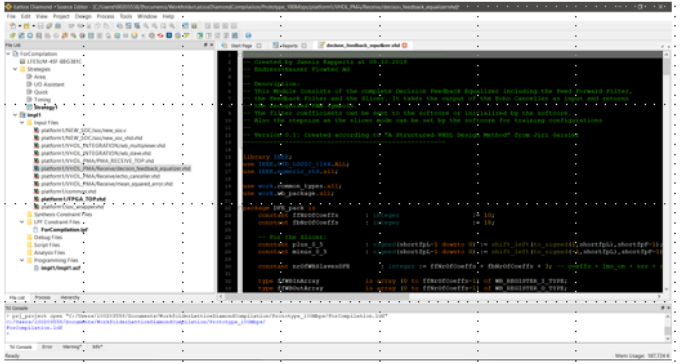
Technical Feasibility Implementations



Technical Feasibility Implementations

HW Sample 2 and FPGA LATTICE Work Bench Project for “APL 100 Mbps”

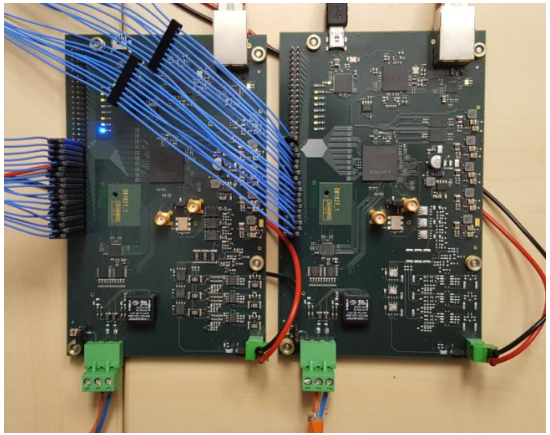


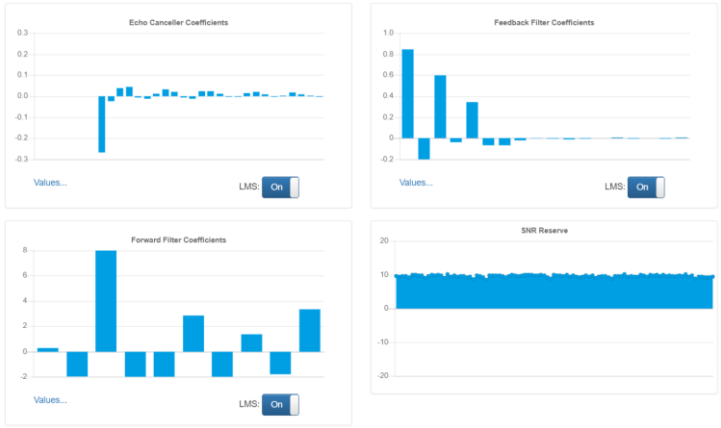


LATTICE DIAMOND DESIGN SOFTWARE

• PCBA HW Sample	done
• Delivery PCBA HW Sample	Dec. 2018
• SW FPGA Implementation 70%	done
• First Version without PCS – Layer (Physical Coding Sublayer)	until Dec 2018
• 1. Version	Feb. 2019

Technical Feasibility Implementations





APL Phase2 Project :

Working Prototype 200 m
Fieldbus Type A Cable
@ 100Mbps / PAM 3