Nuts and Bolts (NaB) of the Internet of Things
IEEE 802 Plenary March 2014
Beijing, China

Contributors

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- John D'Ambrosia - Dell
- Chris DiMinico - MC Communications/Panduit/PHY-SI LLC
- Dave Dwelley – Linear Technologies
- Howard Frazier - Broadcom
- James Gilb - Chair IEEE 802.24 TAG
- Thomas Hogenmüller - Robert Bosch GmbH
- Jeremy Hulse – OTM Consulting for SIIS
- David Law – Chair 802.3
- Robert Lounsbury/Dayin Xu - Rockwell Automation
- Harshang Pandya, Arvin Patel – Psiber Data Pte. Ltd.
- Paul Nikolich - Chair 802
- Robert Wagner, Ronald Nordin – Panduit
- Bob Heile - Zigbee Alliance

Agenda – NaB IoT session

- Introduction
    - James Gilb gilb@ieee.org, Chair IEEE 802.24 TAG - restatement of meeting announcement
    - Chris DiMinico - Present agenda
- Agenda -
    - Paul Nikolich Chair 802 -(5 min) Paul's perspective/expectations of this effort
    - Hugh Barrass – Concept of IoT nuts and bolts – MIB - Common management
    - Case studies:
        1. Subsea Cabling/link Segments/testing (instrumentation standardization –Chris DiMinico http://www.siis-jip.com
            - Ethernet and Ecosystem
        2. Industrial automation/Broadcast –
            - Panduit - Bob Wagner, Rockwell Automation – Bob Lounsbury/Dayin Xu
        3. Automotive - Thomas Hogenmüller - Robert Bosch GmbH
    - Capabilities:
        1. PoE- PoDL (RTPGE) and 4-pair higher power - Dave Dwelley/ Koussalya Balasubramanian
        2. Channel characterization and testing – under Subsea case study
        3. Wireless –802.15, 802.11 - Bob Heile - Zigbee Alliance
- Next steps - Paul Nikolich

Paul Nikolich Chair 802

- Paul's perspective/expectations of this effort

- "the NaB of IoT" discussions we are having today represent an opportunity for the entire 802 community to gather and organize efforts for an application that spans multiple 802 WGs/TAGs, not just today, but on an ongoing basis.

Hugh Barrass

- Concept of IoT nuts and bolts

IoT raises new networking problems…

… but many "new" problems are really "old" problems re-stated

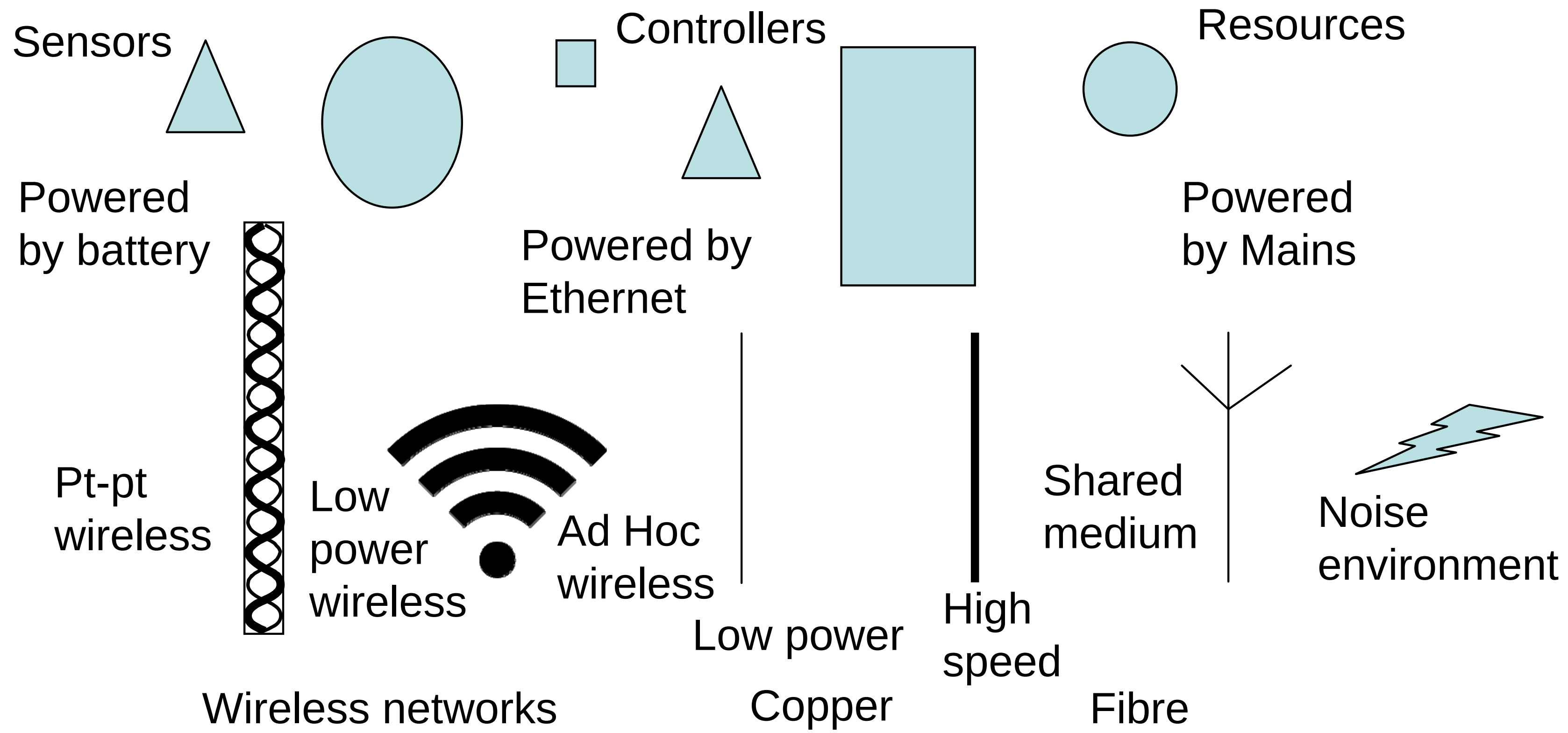
Oftentimes the nuts and bolts needed to solve the problem are already available.

↕

Applications are consumer, business, industrial and commercial.

The Nuts and Bolts of Networking Things

Things come in all shapes & sizes



Different connection requirements

Networked together

Bridged LAN

Time-sensitive

Differentiated traffic

Audio/Video service

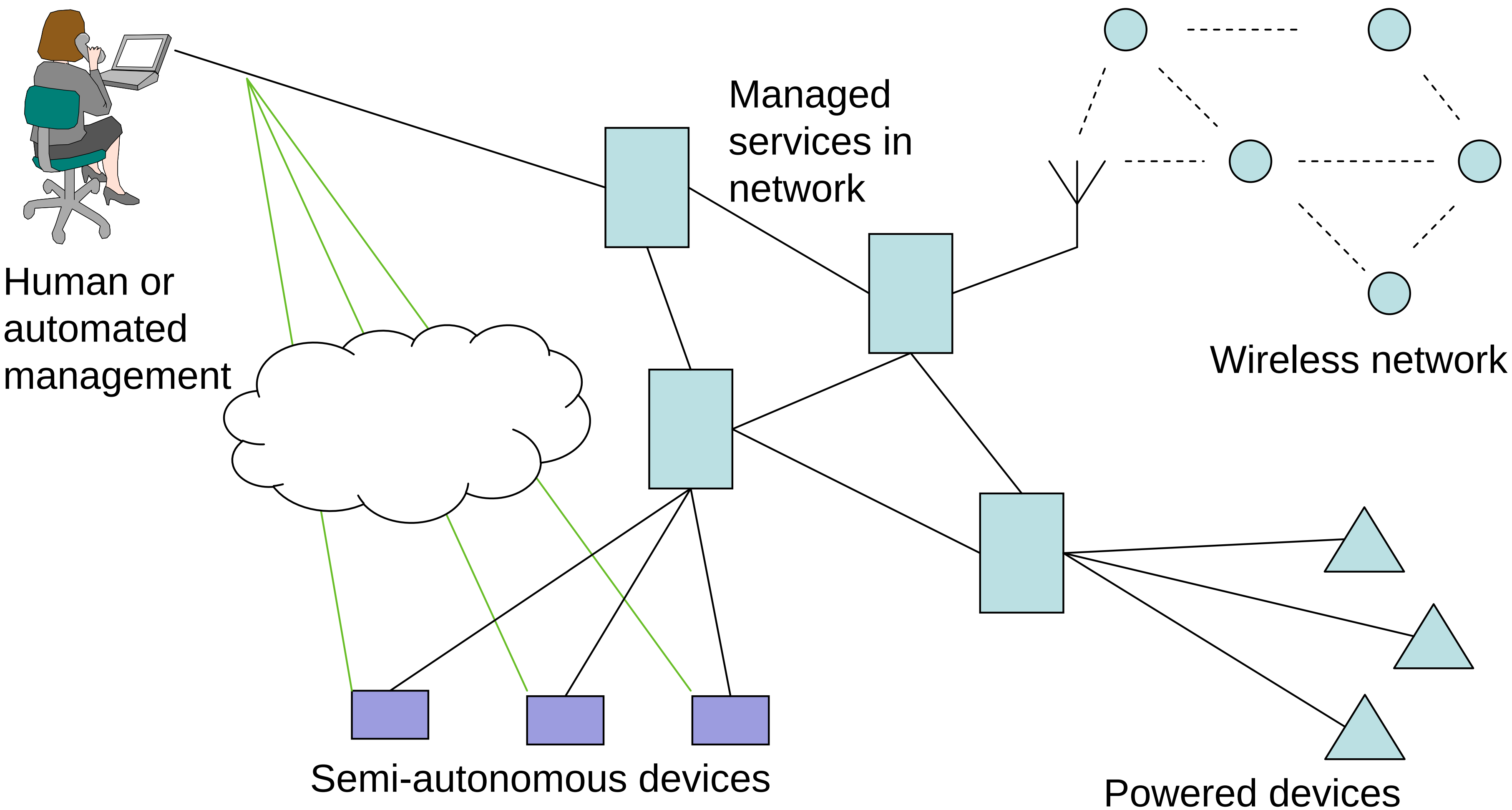
Link security

Robust delivery

Connected to the world

Common management structure

All elements are managed through a common infrastructure – in-band and out-of-band



Subsea instrumentation standardization

- Chris DiMinico – MC Communications

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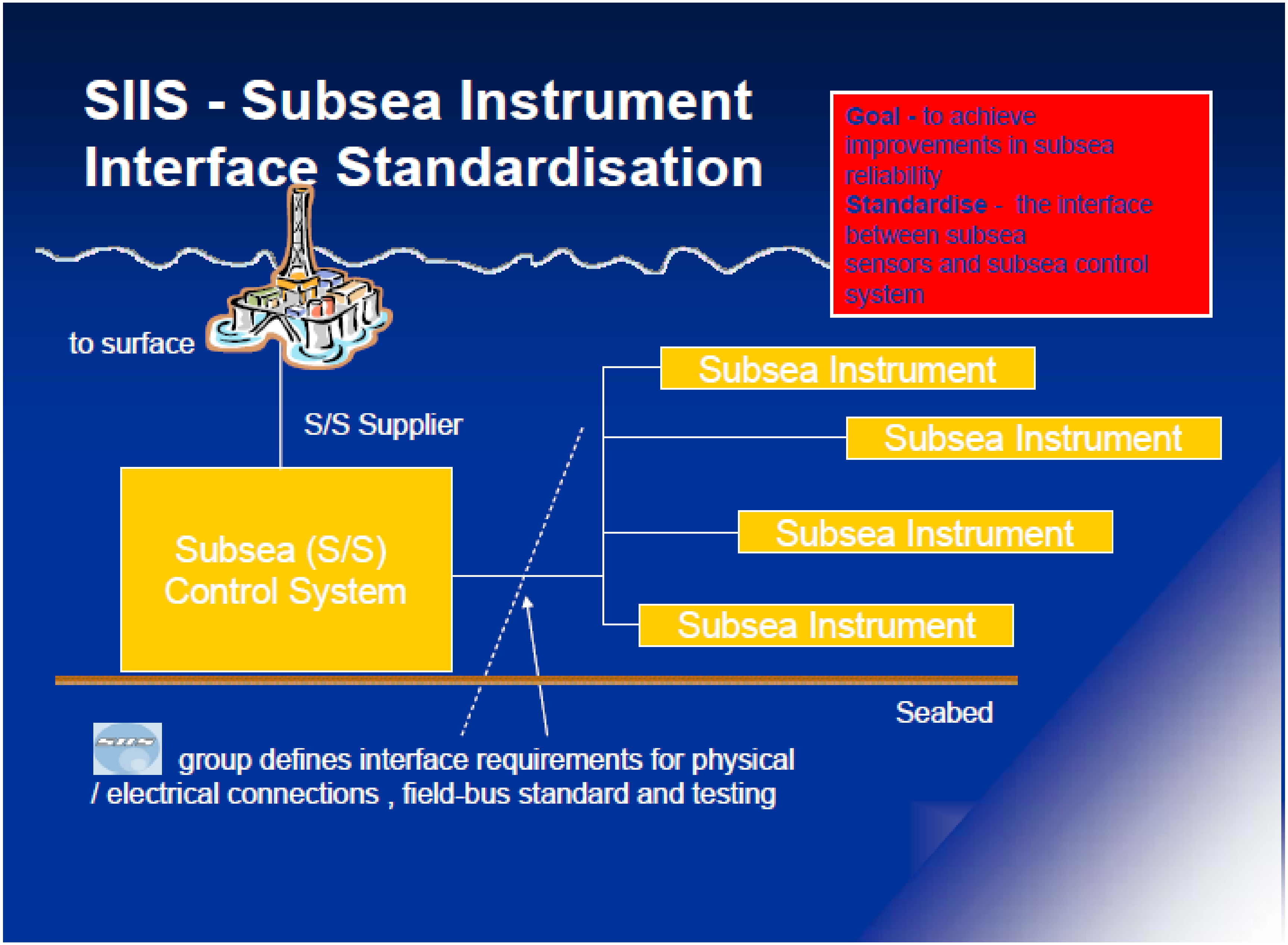
Subsea Instrumentation Interface Standardization (SIIS)

- SIIS is a Joint Industry Project with its goal to achieve improvements in subsea reliability. The aim is to standardise the interface between subsea sensors and the subsea control system.
- The historic problems with subsea sensor interfaces
  - multiple standards
  - Incompatibility (project cost)
  - extended project lead times
  - repeated onetime engineering cost
  - reliability issues

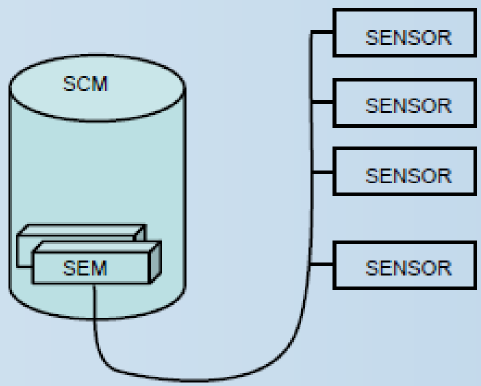
http://www.siis-jip.com/

Standard interfaces



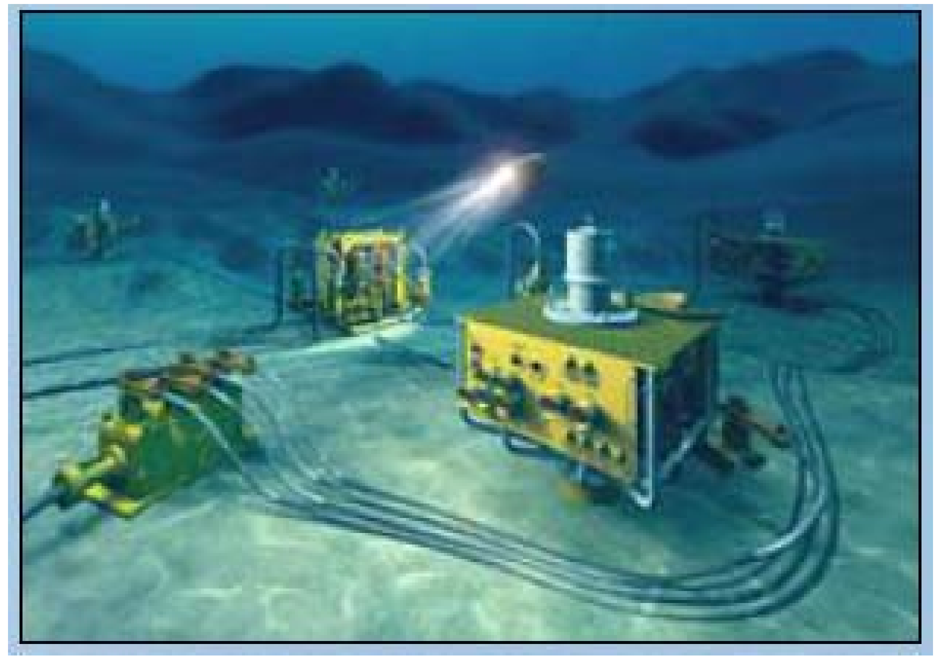
Standard interfaces – Open Standard

- Standard interface between the subsea control module and subsea sensors



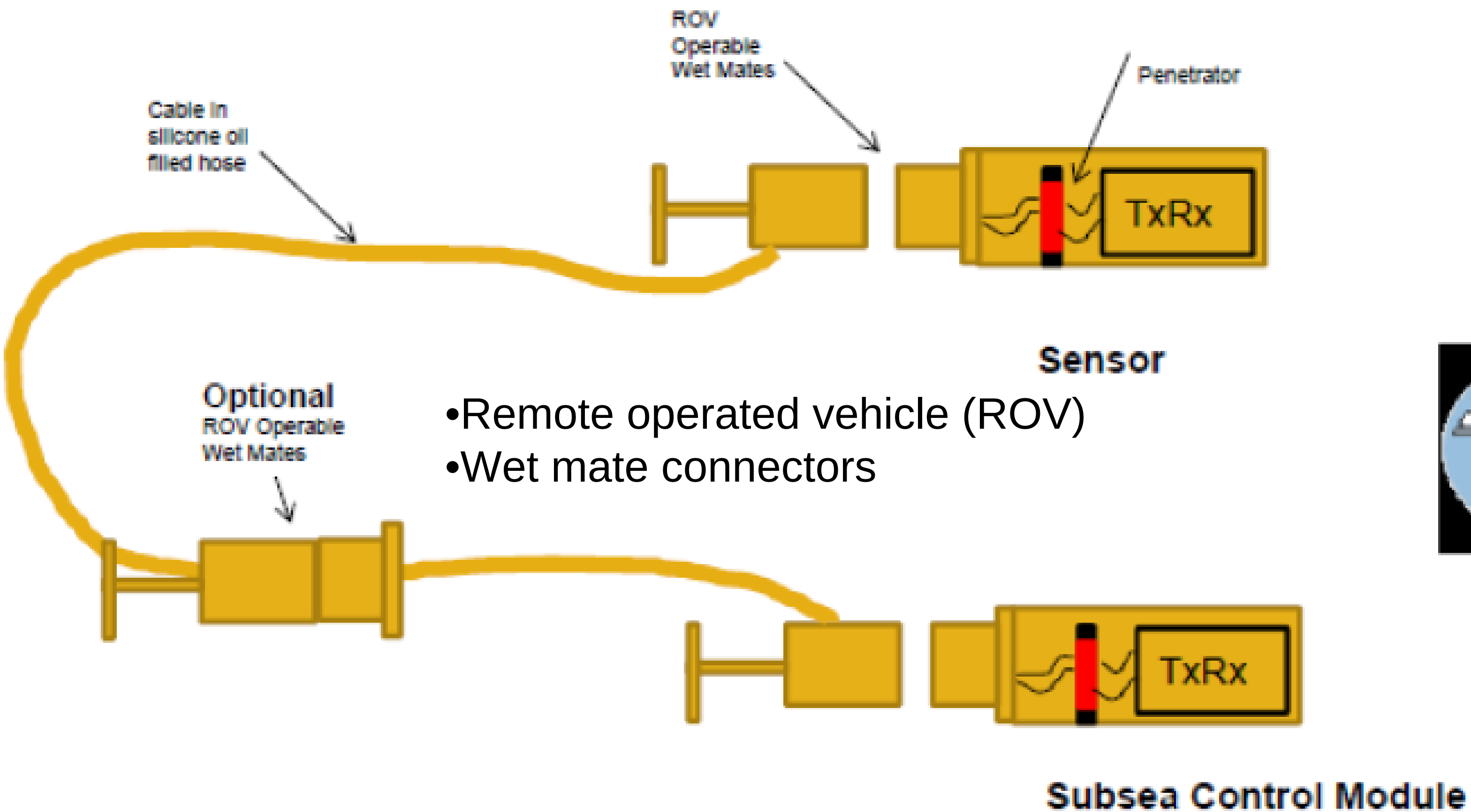
SIIS has developed a tri-level classification system for control system to sensor interfaces:

Level 1 – Simple instrument loops (4-20 mA)
Level 2 – CANbus (Fault tolerant) CANOPEN
Level 3 – Ethernet TCP/IP



- From ten industry protocols considered, SIIS chose three based on cost comparisons and levels of support across industry.

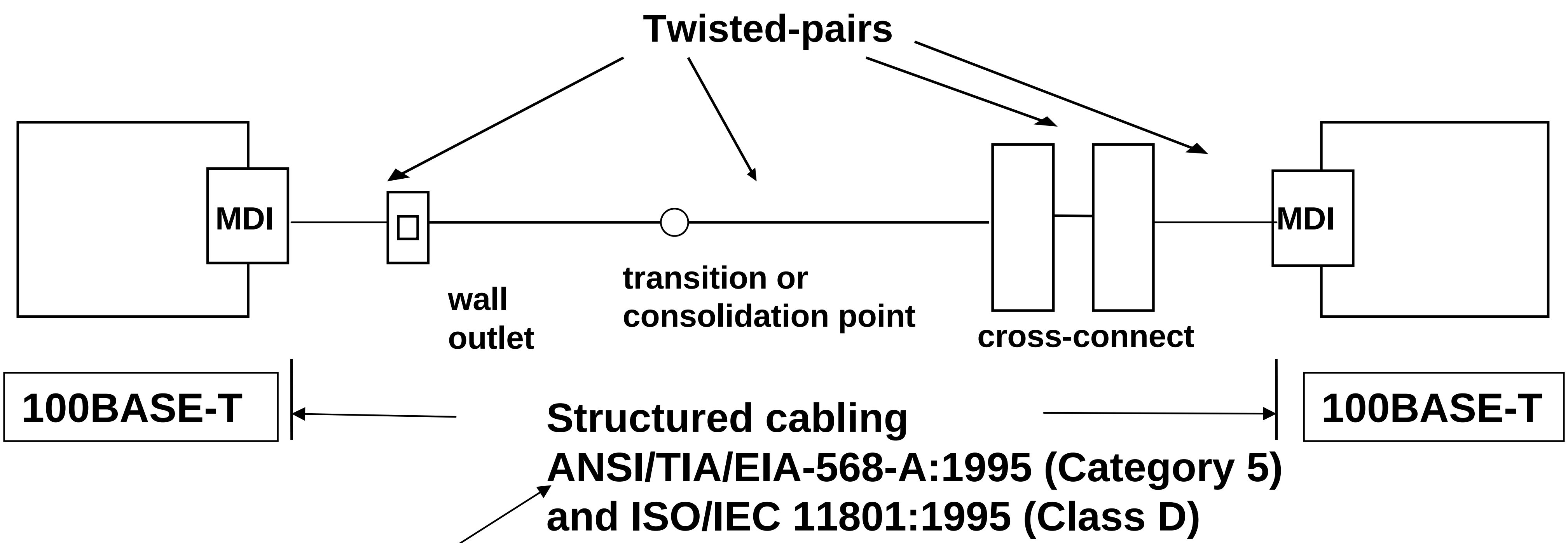
Ethernet jumper link (copper)



- Remote operated vehicle (ROV)
- Wet mate connectors

- Ethernet performance for bandwidths of 100Mb (or better).

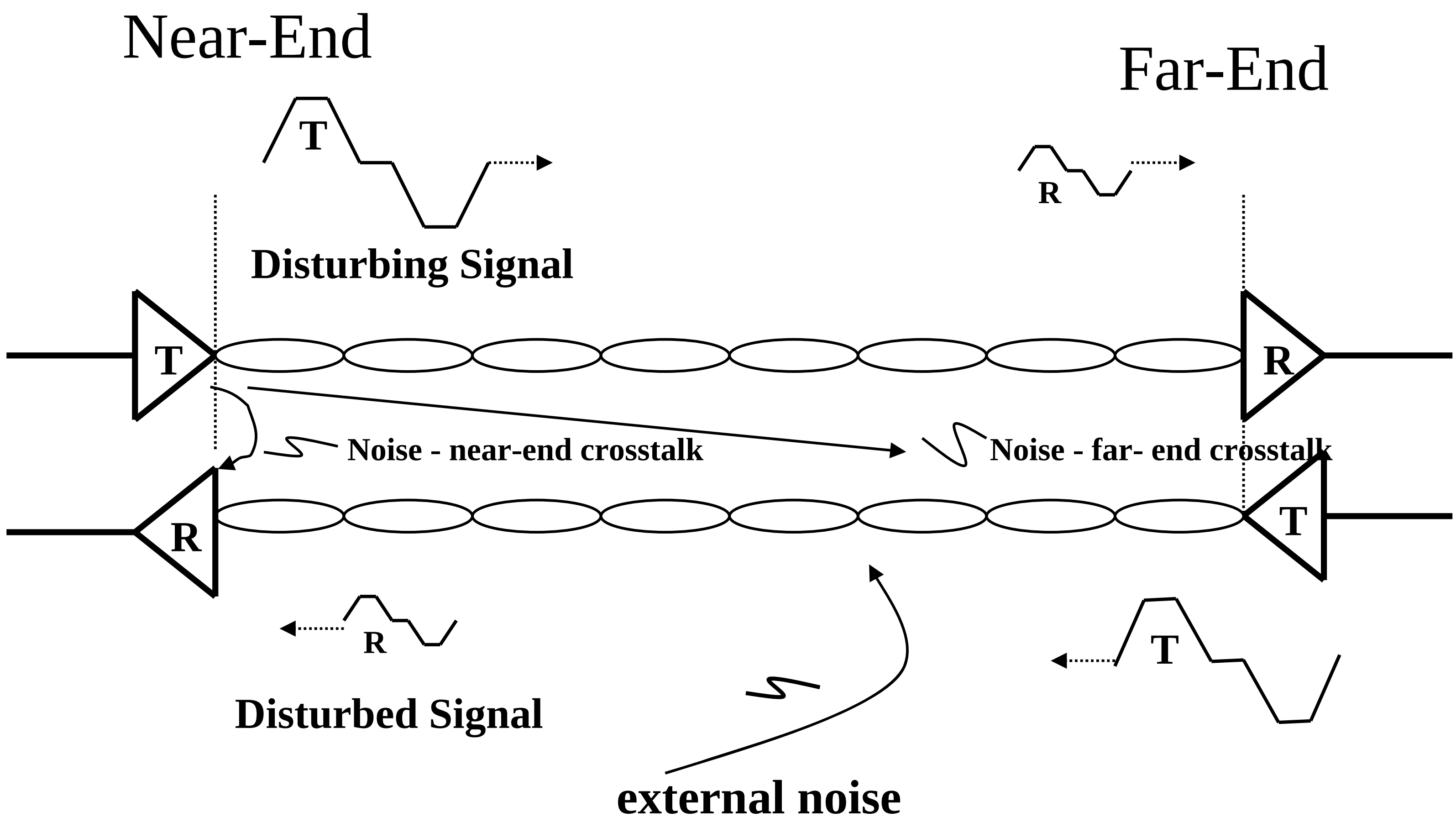
100BASE-T Twisted Pair Link Segment



100BASE-T Link transmission and coupling parameters (Category 5)

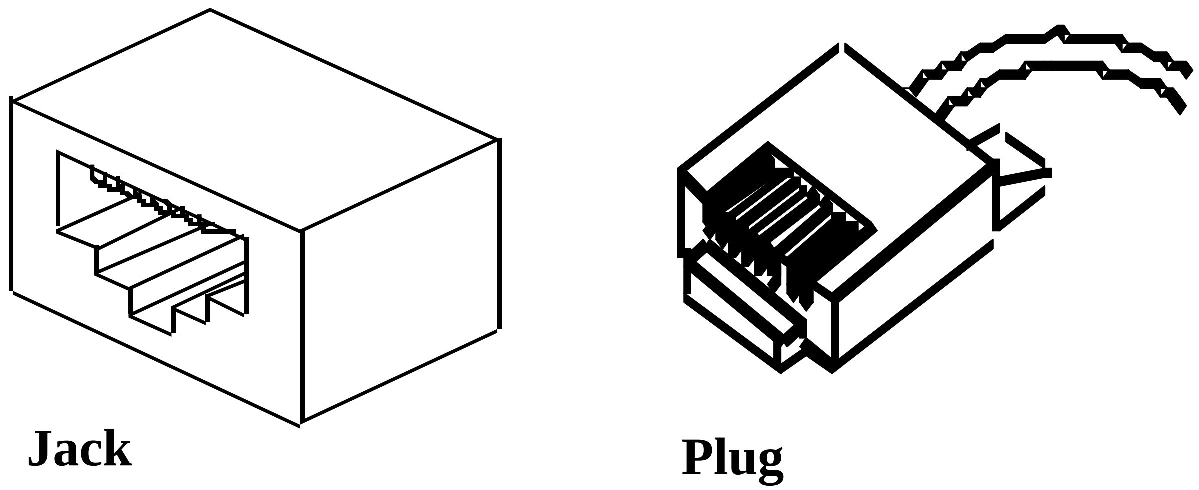
- **25.4.7.1 Cabling system characteristics**
- **Insertion loss, Differential characteristic impedance, Return loss**
- **Near End crosstalk (NEXT)**

100BASE-T Signal Impairments



Full duplex

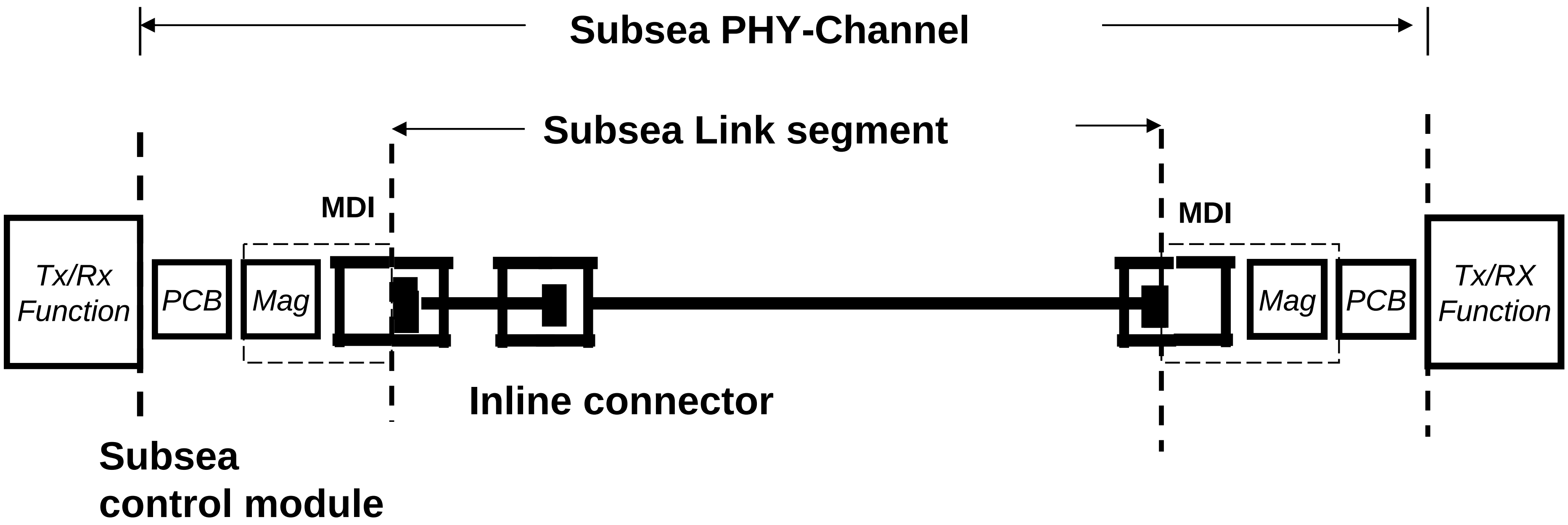
MDI Connector



The MDI Connector (jack) when mated with a specified balanced cabling connector (plug) shall meet the electrical requirements. Specified in FDDI TP-PMD; electrical requirements…

- Insertion Loss – EIA/TIA TSB 40:1992 Section 4.1
- Near-end crosstalk – EIA/TIA TSB 40:1992 Section 4.2

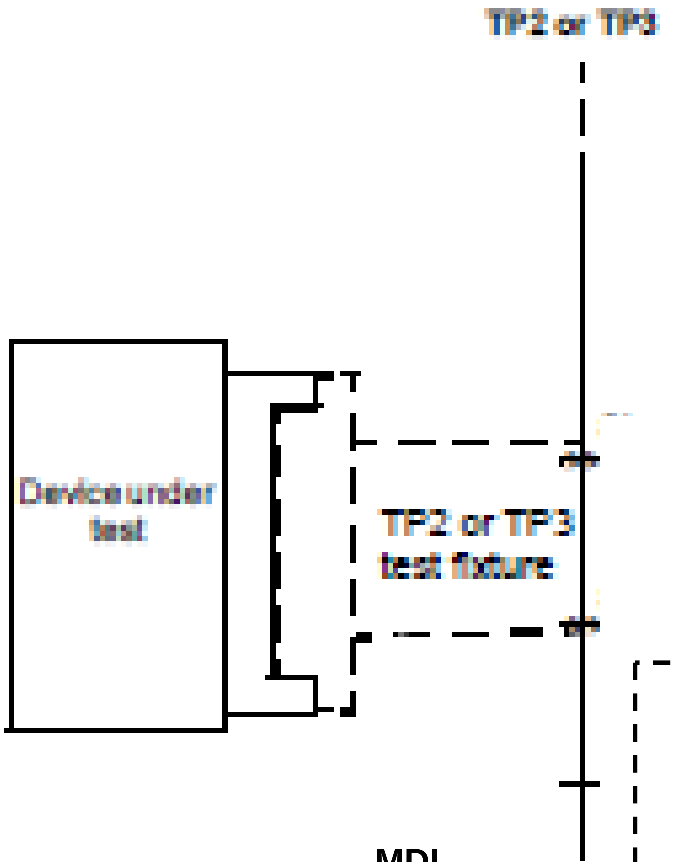
Subsea PHY- Channel



PHY-Channel

- •MDI/Magnetics
- •Host PCB
- •Link segment – 100BASETX - 25.4.7.1 Cabling system characteristics - based upon copper media specified by ISO/IEC JTC1/SC25/WG3 and TIA TR42.7
  - –2 pair, balanced twisted-pair copper cabling (Category 5e)
  - –Up to 1 connector
  - –Up to at least TBD meters

Test Points and Test Fixture



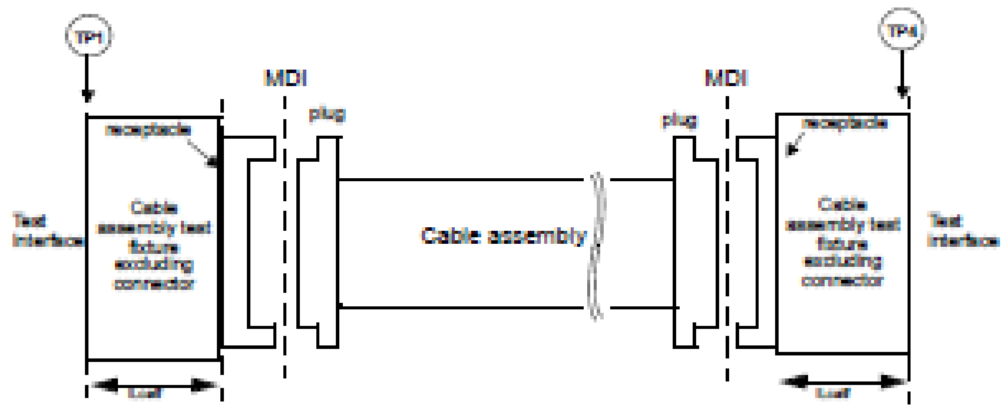
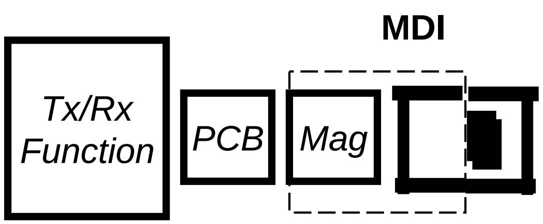
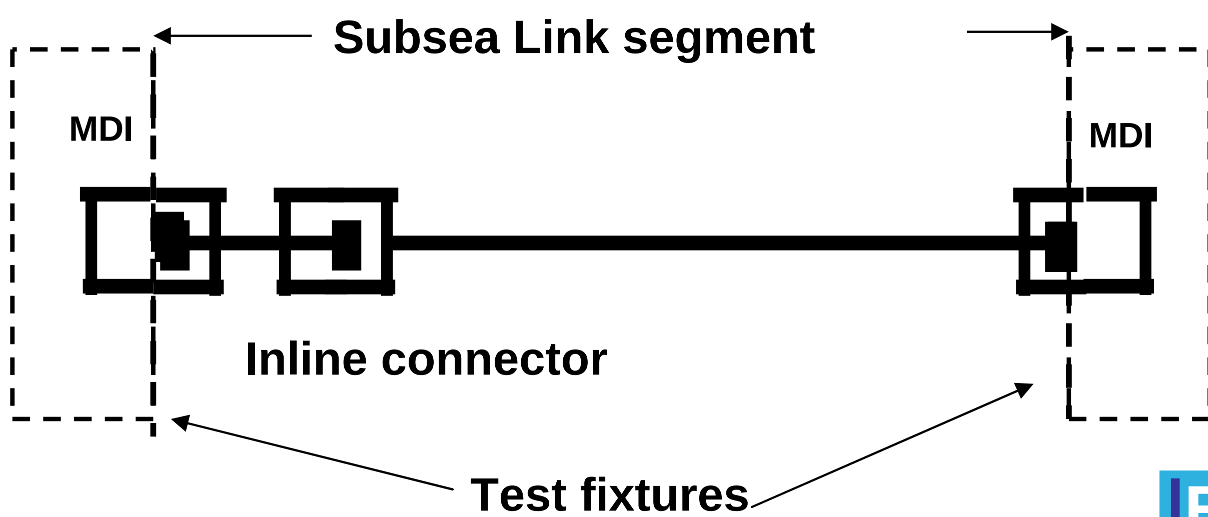


Figure 82–18—Cable assembly test fixtures





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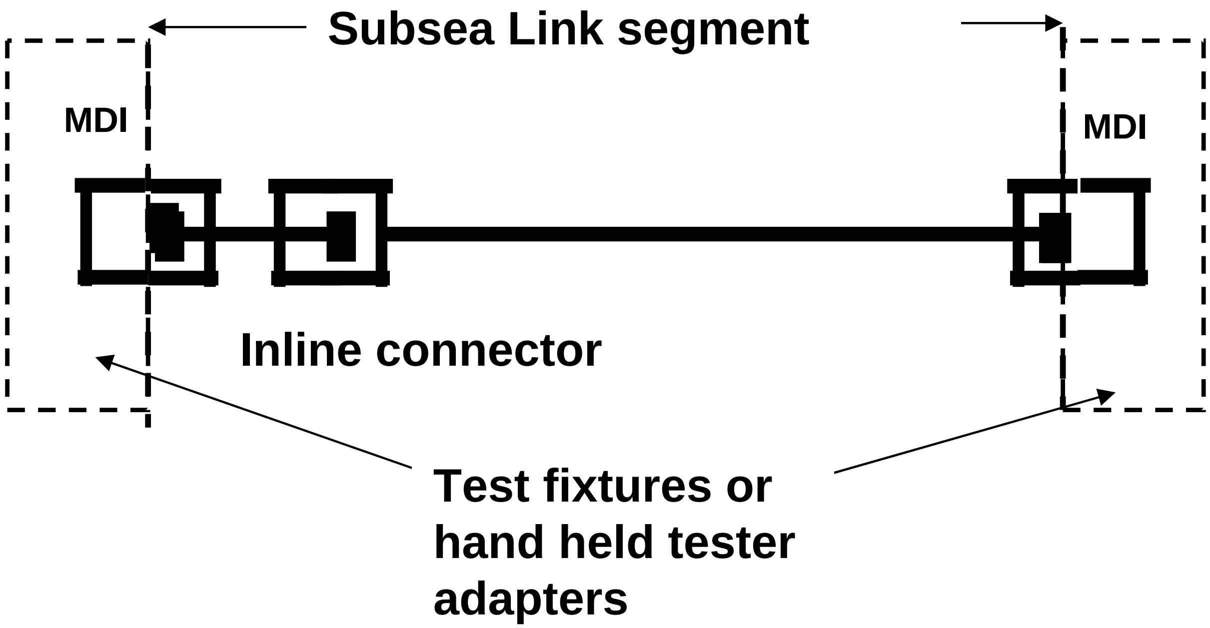
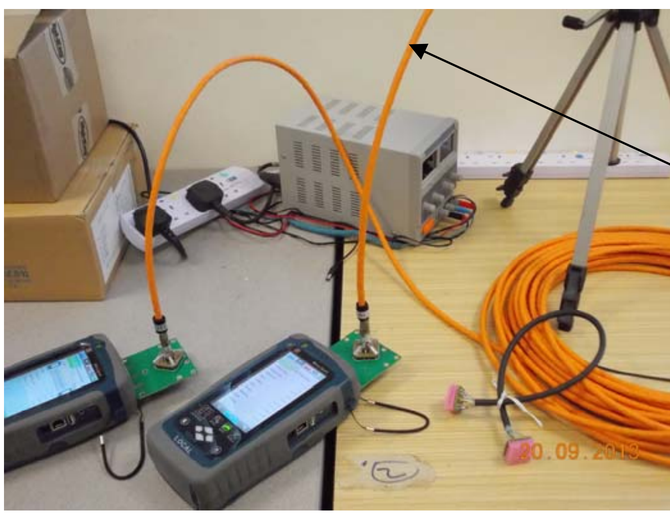
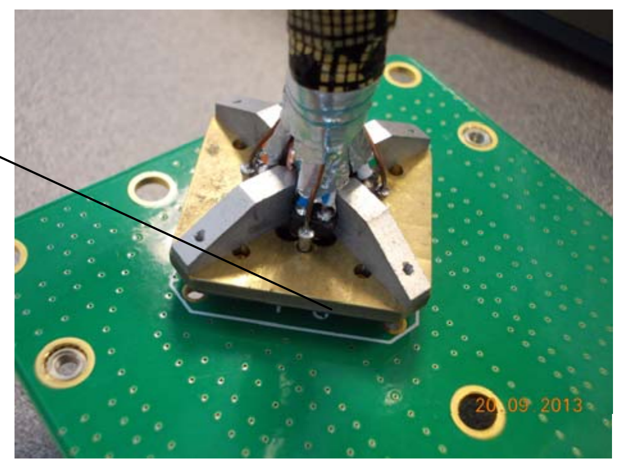
Subsea Link Segment and Component Testing





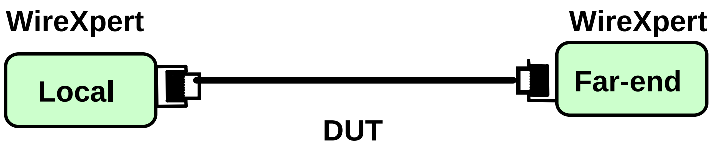
Bare wire adapters



Cable or connector testing

Link segment measurement parameters

- All measurement parameters - 4 differential pairs in < 11 seconds
- One button autotest to programmed limits – pass/fail – diagnostics - database



  - Wire map, including shield connection if present
  - Insertion loss
  - Length
  - Propagation delay
  - Delay skew
  - DC resistance
  - NEXT loss, pair-to-pair, measured from local end and far-end
  - NEXT loss, power sum, local end and far-end
  - FEXT loss, pair-to-pair, measured from local end and far-end
  - FEXT loss, power sum, local end and far-end
  - ELFEXT, pair-to-pair, local-end and far-end
  - ELFEXT, power sum, local-end and far-end
  - Return loss, measured from local end and far-end

Ethernet and Ecosystem

- Plug and play interoperability
  - Link segment, Tx, Rx,

- Significant supplier base
  - Equipment
  - Components
  - Test and measurement
    - Standardized accuracy requirements TIA-1152

- Interoperability Test Laboratories
  - UNH-IOL

Industrial/Building Automation

- Robert Wagner - Panduit
- Bob Lounsbury/Dayin Xu – Rockwell Automation

Connecting the things…

•IoT is about putting things on the Internet….. door locks, appliances, smart meters, video surveillance, health care devices, thermostats…sensors…

•Structured cabling and pathway standards continue to evolve to address connectivity between network devices;

•Industrial

•Broadcast

•Building automation

•Health care

•Educational facilities

•“Intelligent Building” technologies

•Data centers

Industrial Automation and Broadcast

IP Convergence in Broadcast

- Users have changed how they view media
  - Digital recording of shows (DVR)
  - Streaming video (Hulu)
  - Online services (NetFlix)
  - Surfing the internet for news
  - Using phones and tablets
- Providers are using HD to differentiate
  - 4K is new higher video resolution
  - Requires more bandwidth (coax to fiber)

Courtesy of Gepco, A General Cable Company

Industrial Automation Networking

- 55% of sensors “internet things” in plants use an automation protocol[1]
- 78% of the top 50 automation companies offer EtherNet/IP devices[2]
- 51% of packaging machines and equipment builders prefer EtherNet/IP[3]
- 75% reduction in the cabling costs by simplifying integration from device to IT level[4]

1 – HIS Industrial Ethernet & Fieldbus Technologies 2012

2 – ARC/Control Magazine

3 – Machinery Communications – Trends & challenges, 2011 p18-19

4 – Rockwell Automation, consumer Ref http://biy.ly/1heowvs

Growth Industrial Consortia

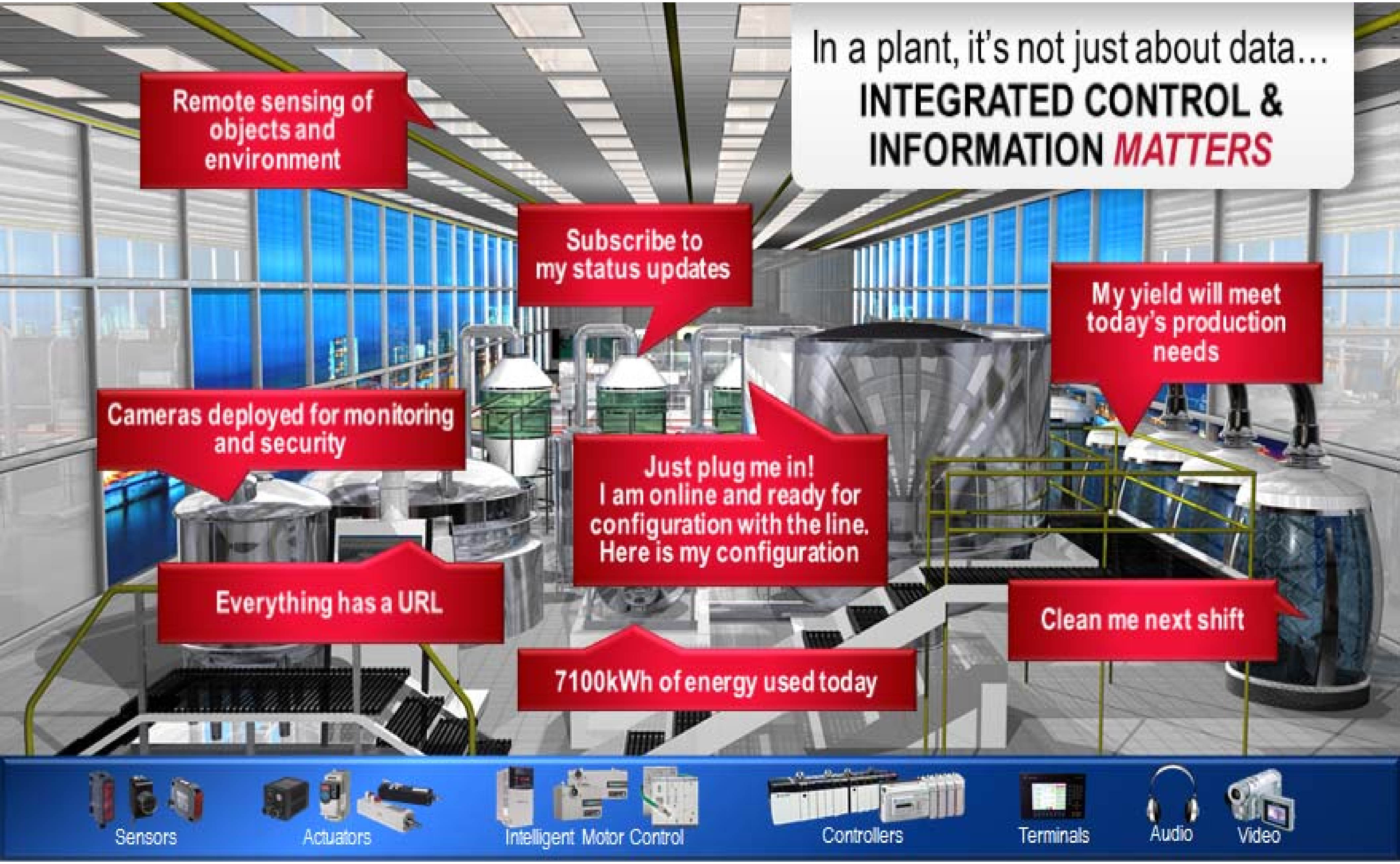
- About 23% of the 31.3 million industrial networked nodes in 2011 were based on Ethernet or an Ethernet variant, reported by John Morse, senior analyst at IMS research.
- This will grow to 26% by 2015 or just short of 12 million nodes.
- Currently (2011) 42.8% of the Ethernet nodes are Industrial with standard TCP/IP nodes consisting of 42.4% in industrial installations.

Source: INDUSTRIAL CABLING
Bob Lounsbury, Principal Engineer, Rockwell Automation, IEEE 802.3BP, EMC Task Group, 2-May, 2013

EtherNet/IP Advantages for Industrial Automation

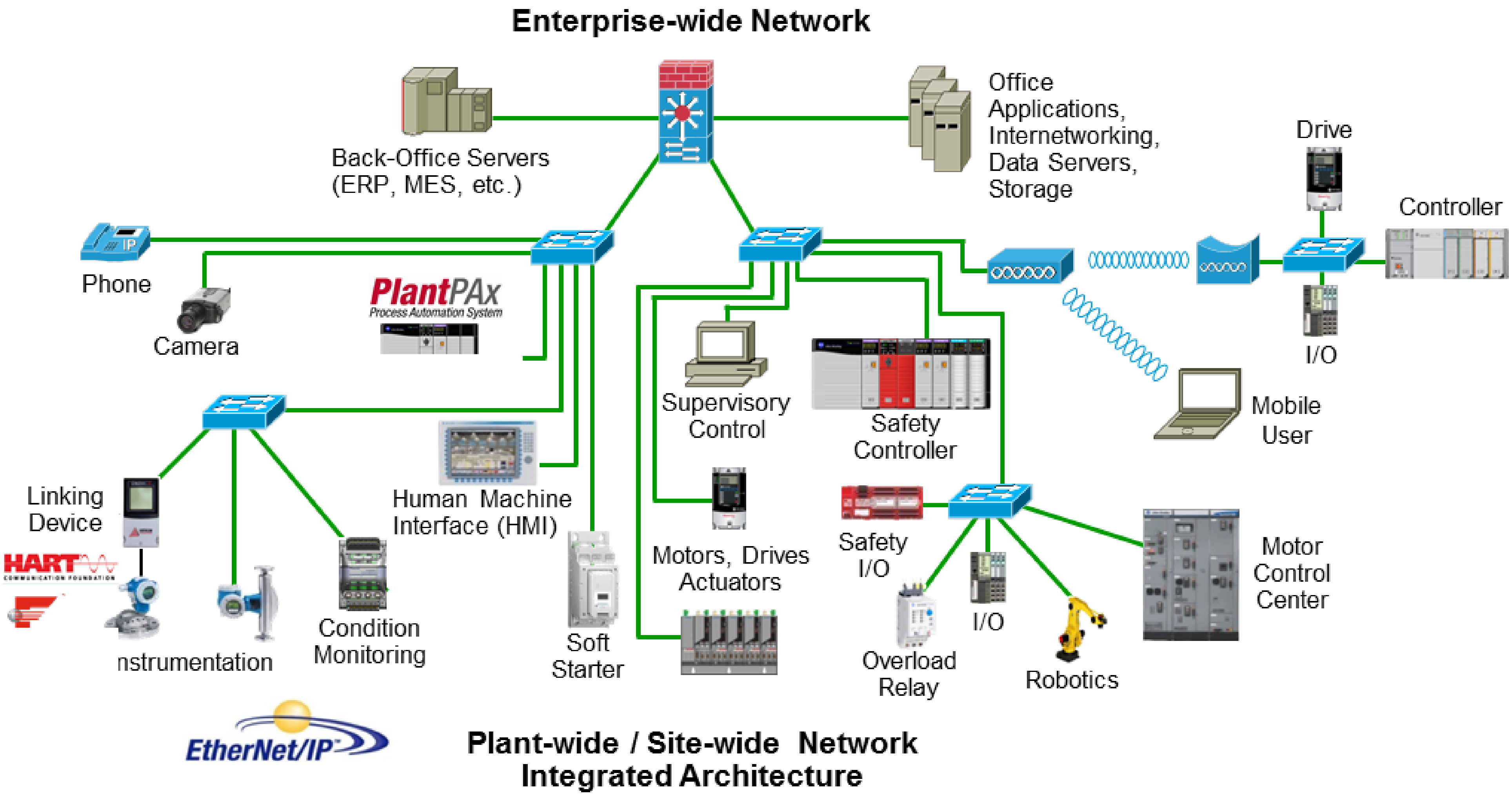
- **Open scalable networks are in demand**
  - Broad availability of products, applications and vendor support
  - Network standards for interoperability of industrial devices
- **Convergence of network technologies**
  - Reduce the number of disparate networks
  - Seamless information sharing throughout the plant
- **Lower Development costs (IT friendly)**
  - Reduce training, support, and inventory for different networking technologies
  - Use of common network design, deployment and troubleshooting tools
- **Robust Network**
  - Secure even over remote access
  - Defined QoS priority values
- **Future-ready – maximizing investments / minimizing risks**
  - Support new technologies and features without a network forklift upgrade

Reduce Risk **Simplify Design** **Speed Deployment**

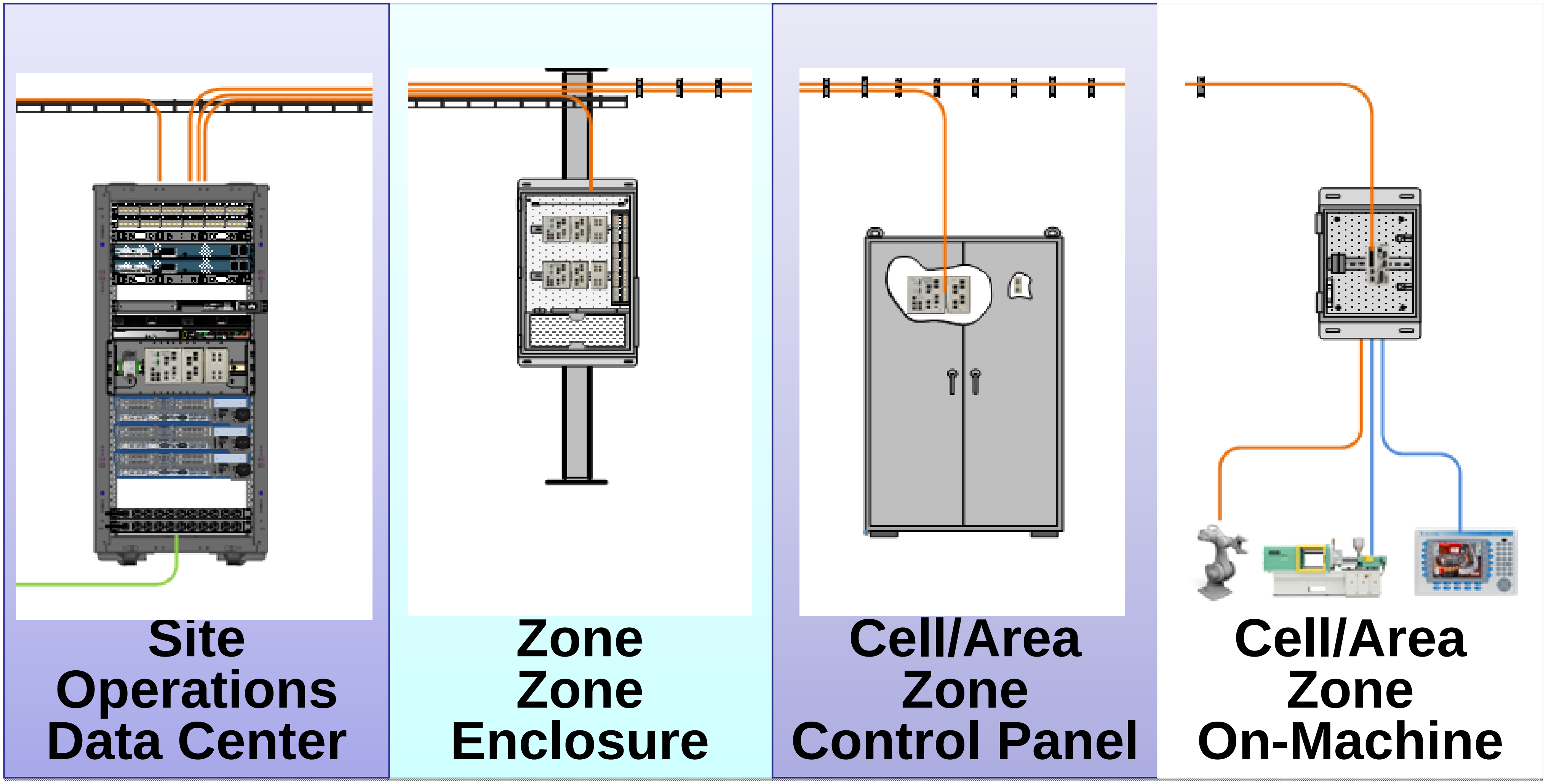


Use Cases for the Connected Industrial Enterprise

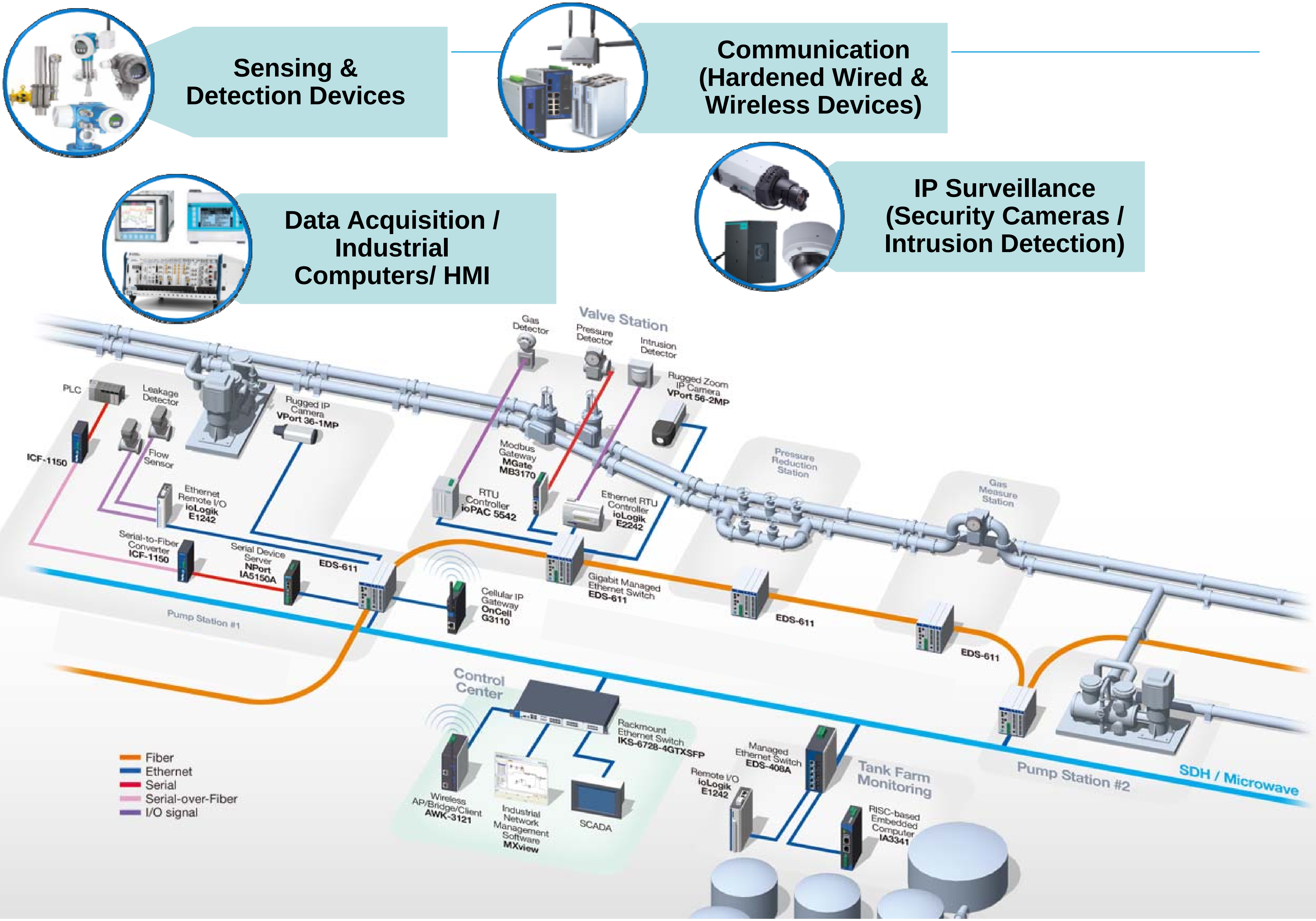
Integrated Architecture – connecting things



One Network from Data Center to Machine



Remote Monitoring (Pipeline)



Industrial IoT versus Consumer IoT

- Consumer IoT
  - User experience, user interaction, new devices and services
  - Examples: IP Cameras, switches, lights, thermostats, wore sensors, smart appliances

- Industrial IoT
  - Real-time, automatic control, reliability, safety and security, large installed base of fieldbus devices
  - Examples: programmable logic or automation controllers (PLCs/PACs), drives, human-machine interfaces (HMIs), distributed input/output (I/O) devices, sensors, actuators, and process instruments

What Industrial Automation Needs

- Standardized MAC and PHY technology
- Wired and wireless IP-enabled devices at the edge of the industrial network
  - Discrete sensors (e.g., proximity sensors)
  - Analog sensors (e.g., temperature sensors)
  - Actuators (e.g., motor control devices)
  - Meters (e.g., power monitors)
- Meeting harsh industrial environmental conditions
  - Wide temperature range (typical -45°C to +85°C; up to +105°C)
  - Severe electromagnetic interference
  - Long wire/cable lengths or wireless distances (>100m)
  - Shock and vibration
  - Dust and humidity
  - Sulphurous environment

Convergence of Standards for IA

- ODVA
  - Common Industrial Protocol (CIP)
- ANSI/TIA -1005 and 862-A
- ISO/IEC - 61158 and TR 29106
- MICE – Mechanical Ingress Climatic Electromagnetic
- IETF – Internet Engineering Task Force
- IEEE 802.3 / 802.1
  - IEEE 1588 Precision Time Protocol
  - POE
  - RTGPE – 100 Mbps and Gigabit Ethernet over single pair
  - PoDL – Power over data Lines for power enabled end points
  - Options for trunked (multiple pair) and single pair for improved cable routing and management

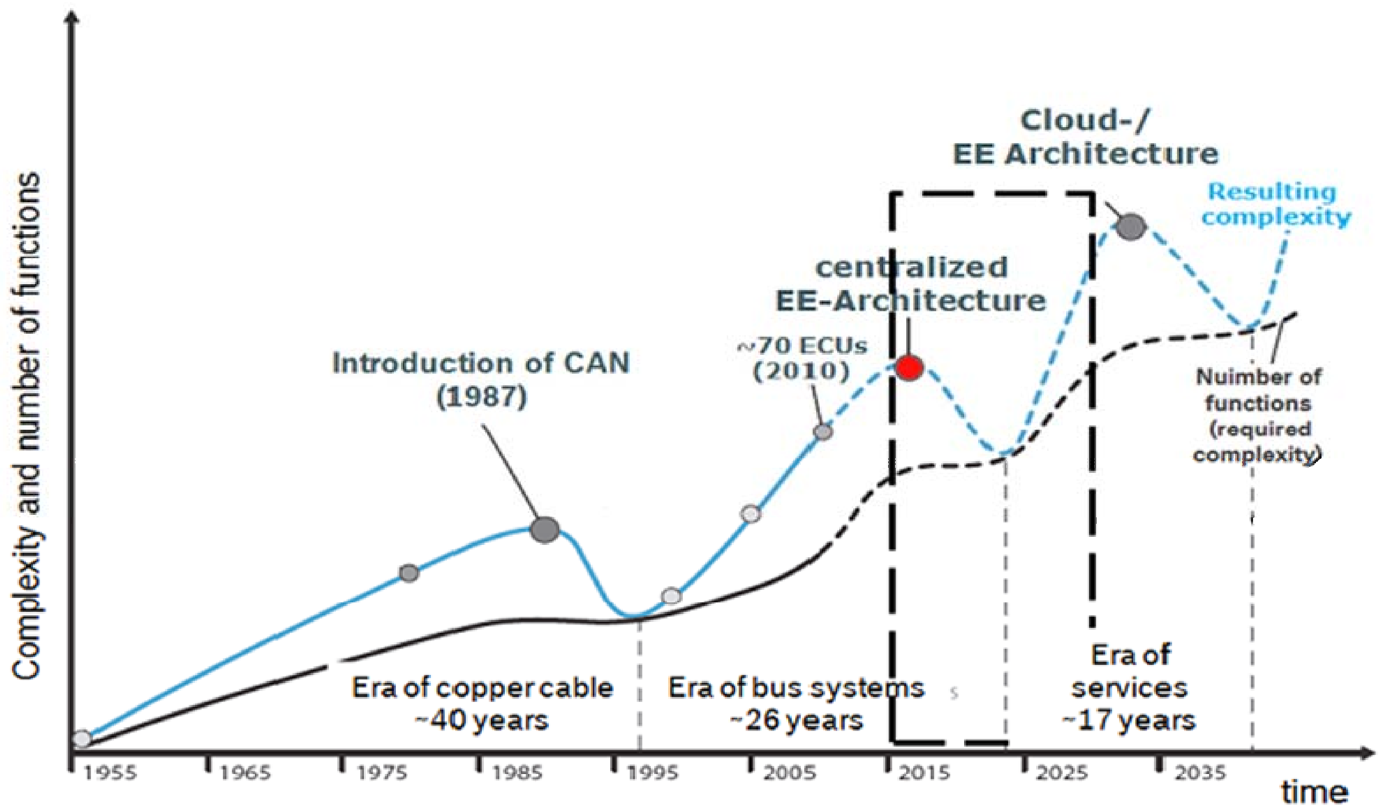
What IEEE 802 Impacts

- IEEE 802.3 (Ethernet)
  - Industrial Ethernet uses this technology
- IEEE 802.11 (Wi-Fi)
  - Complement of Industrial Ethernet, Gradually adopted into movable, rotatable, unreachable industrial applications
- IEEE 802.15.4 (WPAN)
  - 6LoWPAN
  - Wireless Process Instrument network (ISA100.11a, Wireless HART, WIA-PA) based on this technology

Automotive

- Automotive - Thomas Hogenmüller - Robert Bosch GmbH

Electronic/Electric Architecture Cycles in Automotive



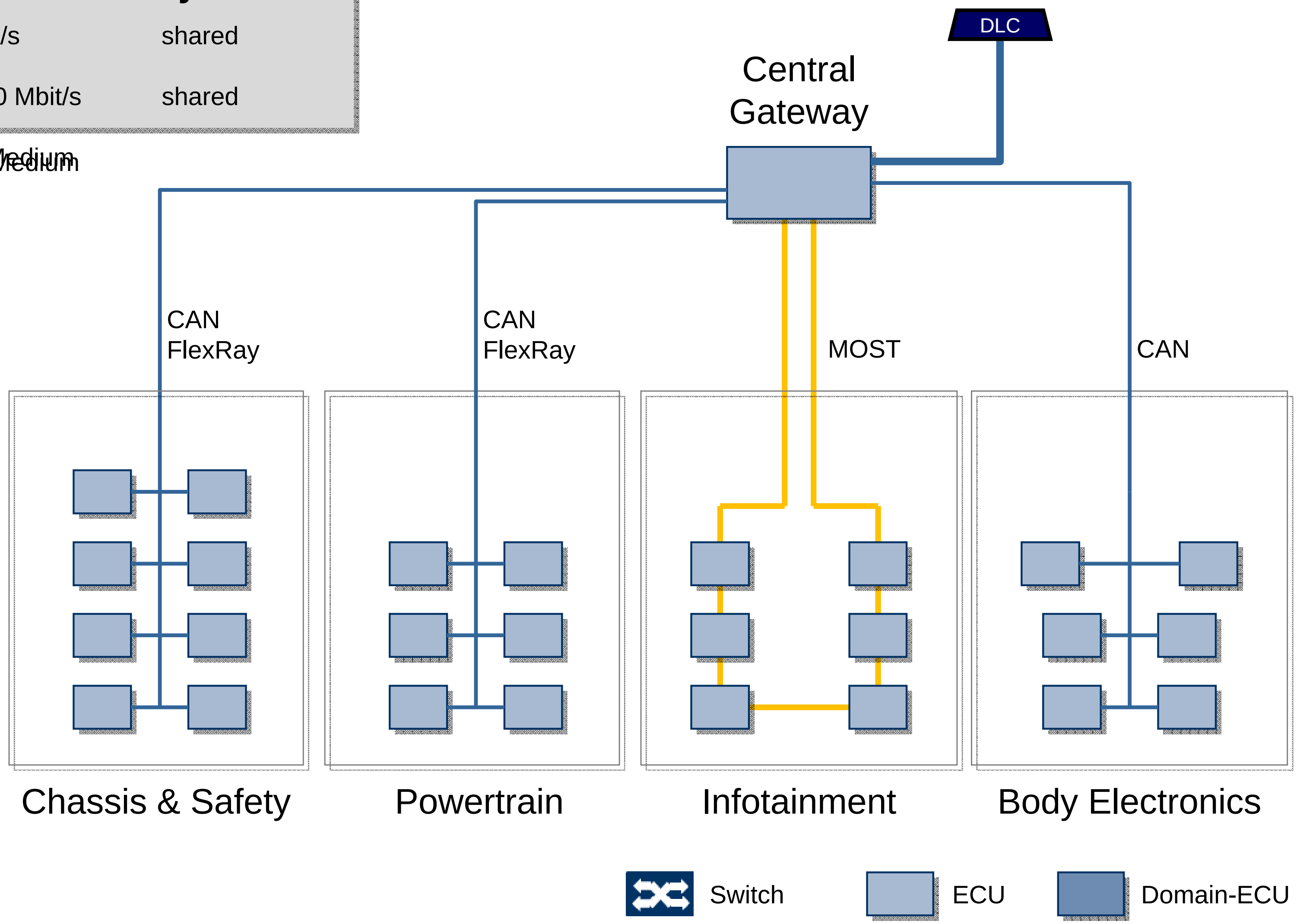
- CAN dominated E-/E-Architectures for the last three decades with very flexible design paradigm
- CAN can't fulfill all needs of future E-/E-Architectures:
  - New Advanced Driver Assistant Systems and Multimedia Systems demand for more speed and QoS
  - Reduction of complexity and preparation in future leads to domain based, centralized and backbone driven Architectures

Scenario of current E/E Architecture

Legend typical Automotive Bus-Systems

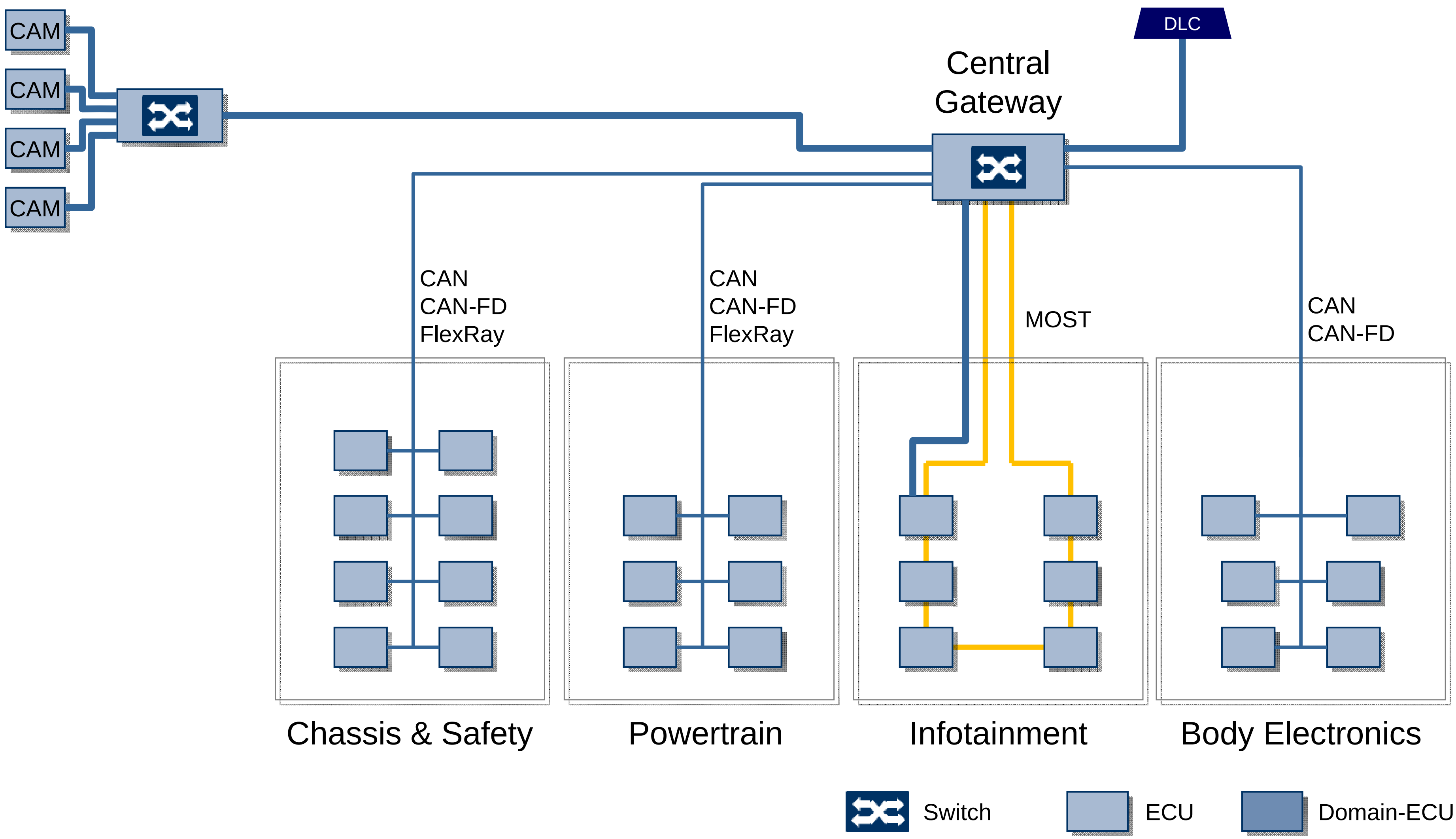
CAN ISO11898 till 1 Mbit/s shared Medium
FlexRay ISO 17458 10 Mbit/s shared Medium
MOST till 150 Mbit/s shared Medium

Ethernet
Bus-Systems



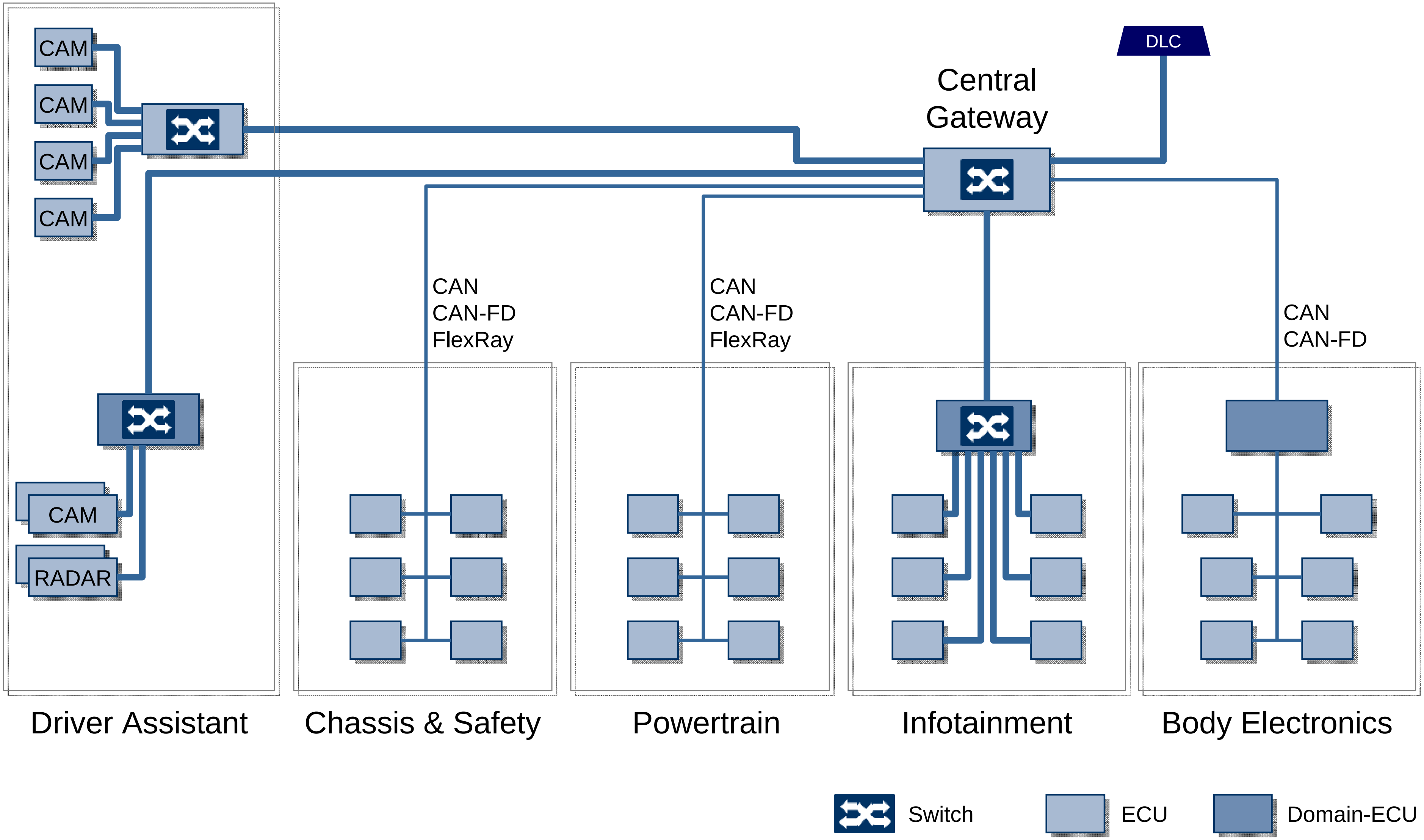
Diversity of bus systems - a direct migration to an „Ethernet Backbone“ is very unlikely

First steps - Automotive Ethernet in 2015



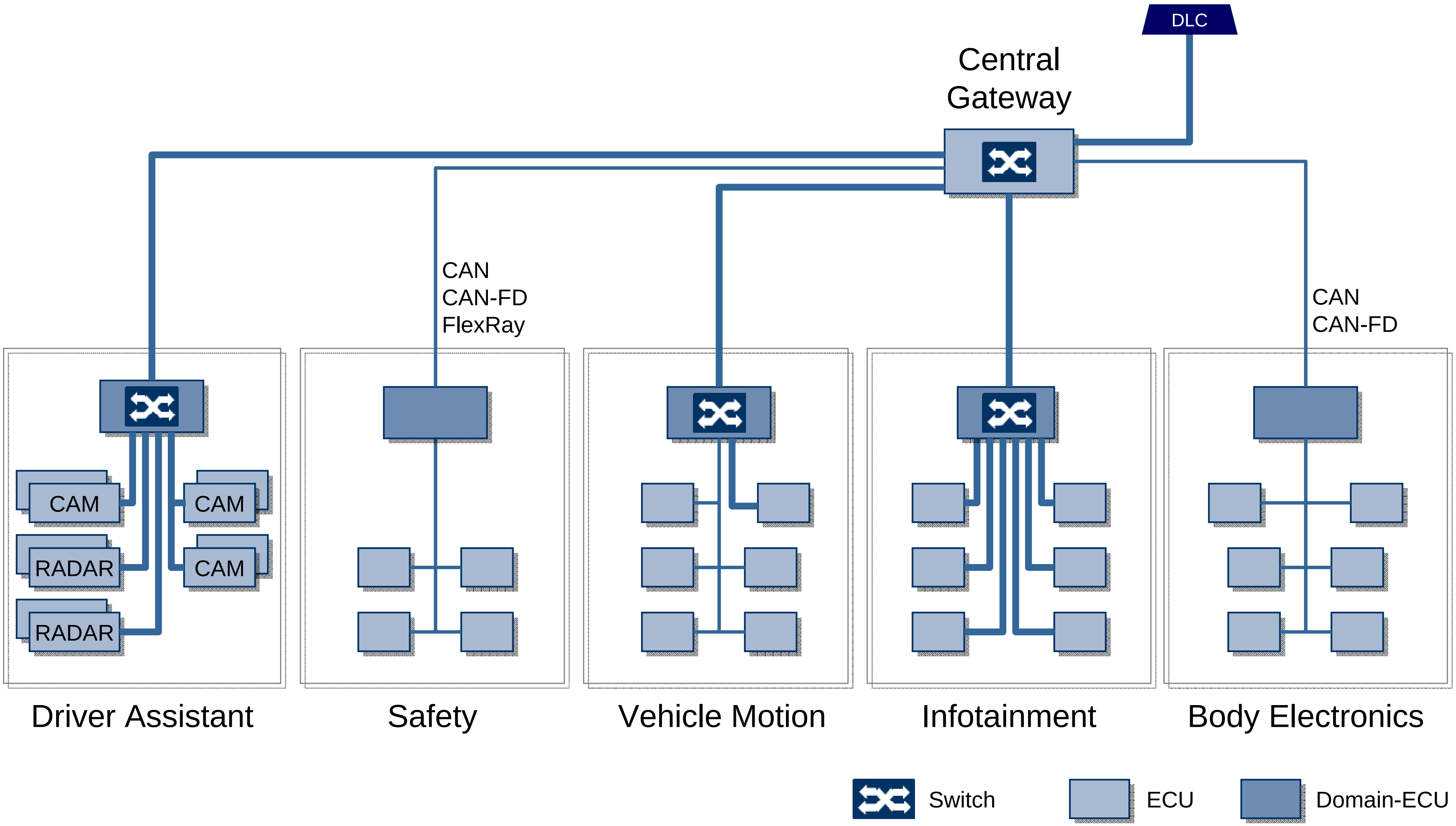
First Ethernet approach: Near Range Camera Systems for "Top View"

Scenario Automotive Ethernet - 2015…2017



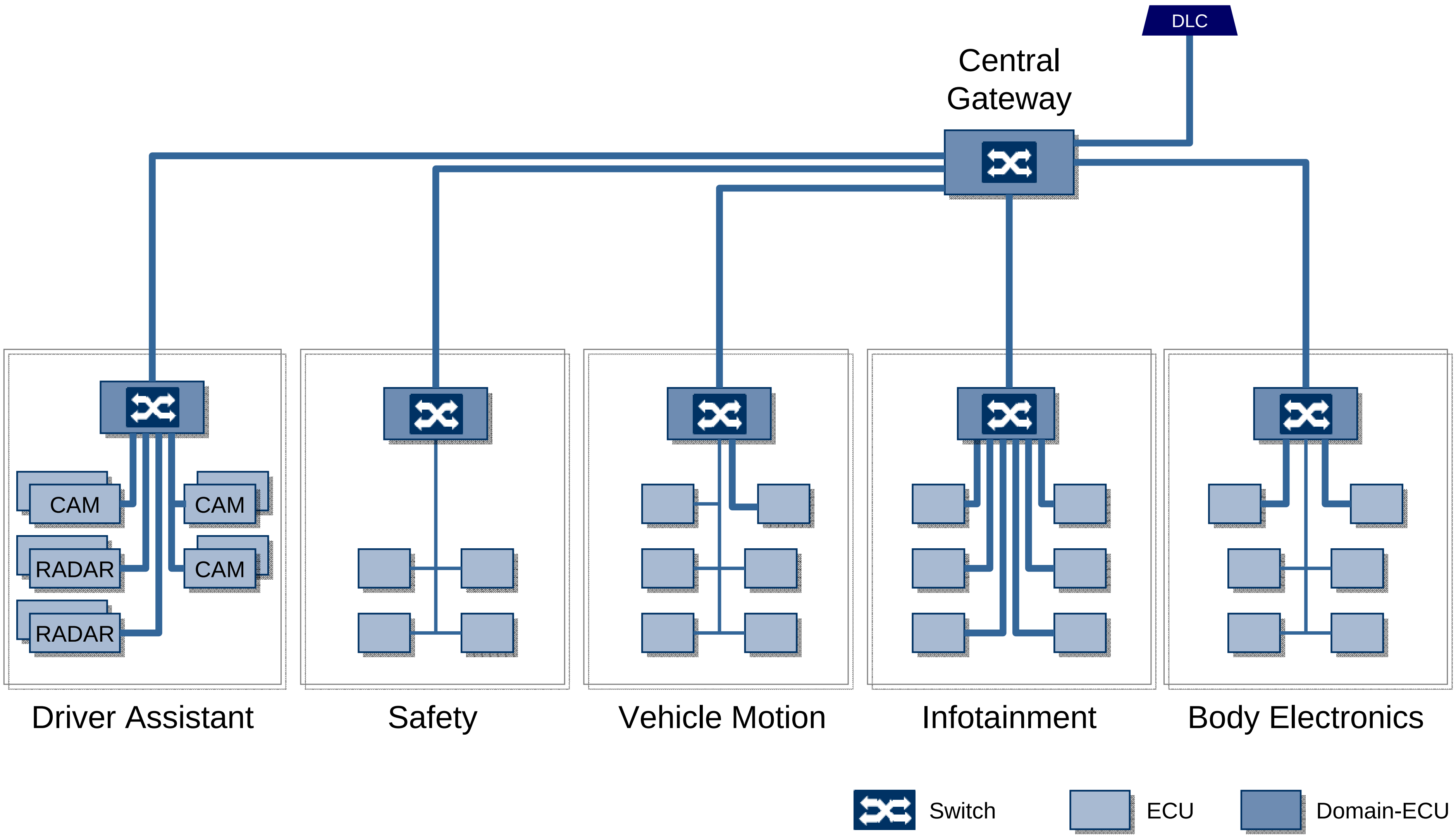
Higher bandwidth requirements for ADAS and Infotainment System

Hybrid Backbone with Domain-ECU in ~2018ff



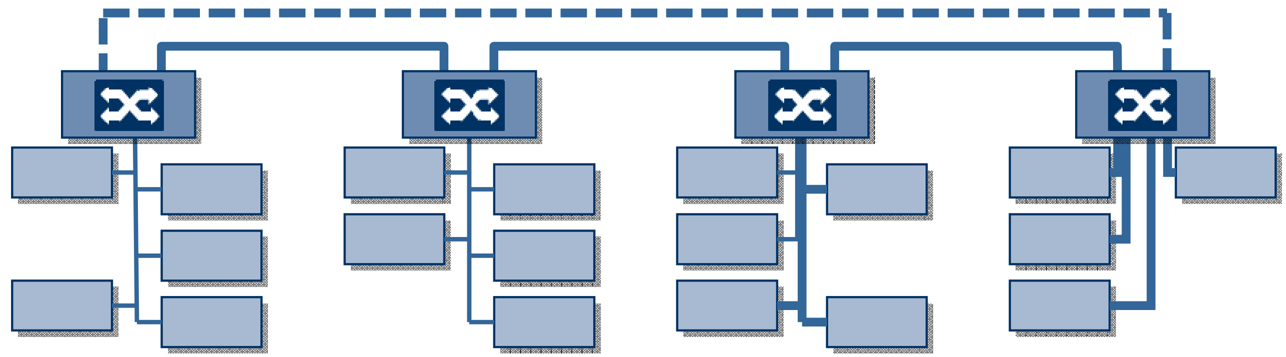
Hybrid Backbone - Ethernet, CAN / CAN-FD and FlexRay on one Central Gateway

Domain-ECUs & Ethernet-Backbone

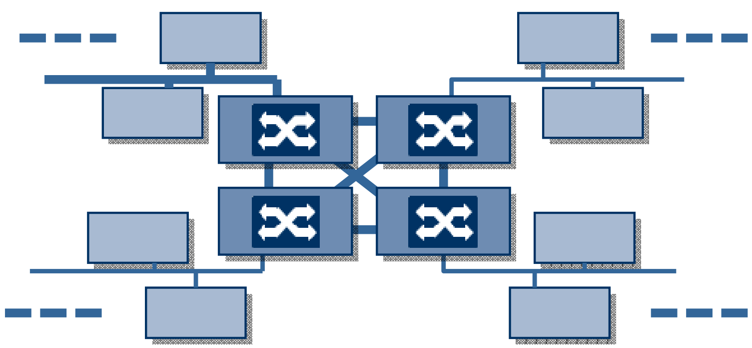


Approach towards a "logical" Ethernet Backbone

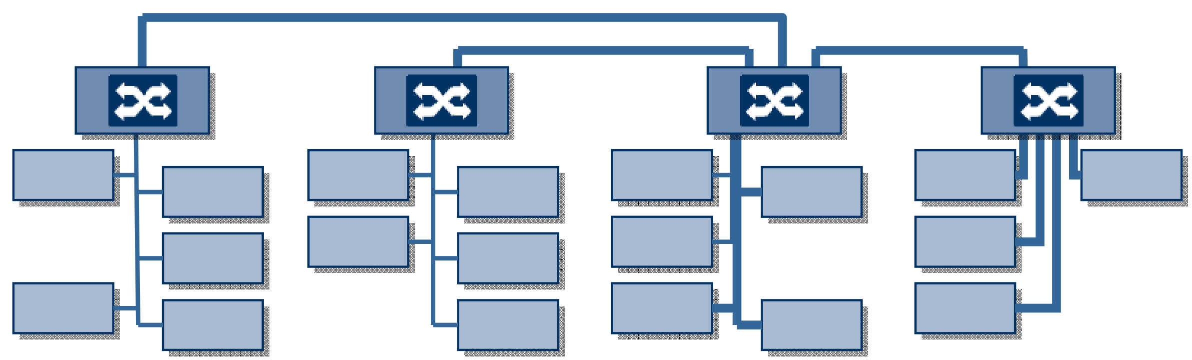
Variants of Backbone Architecture



Daisy Chain with optional redundant path



Full Meshed redundant Backbone

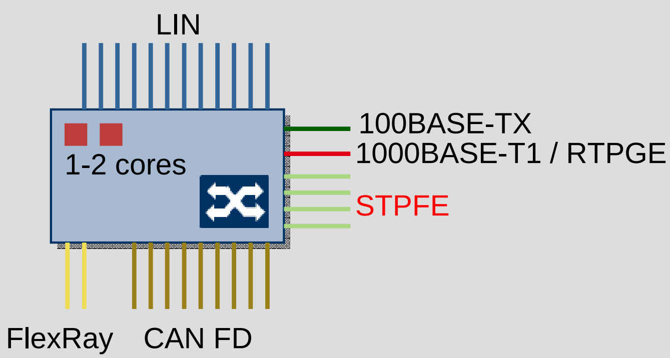


Switched Architecture CGW inspired

Switch ECU Domain-ECU

Use Case: Typical Gateway Requirements (2018-20)

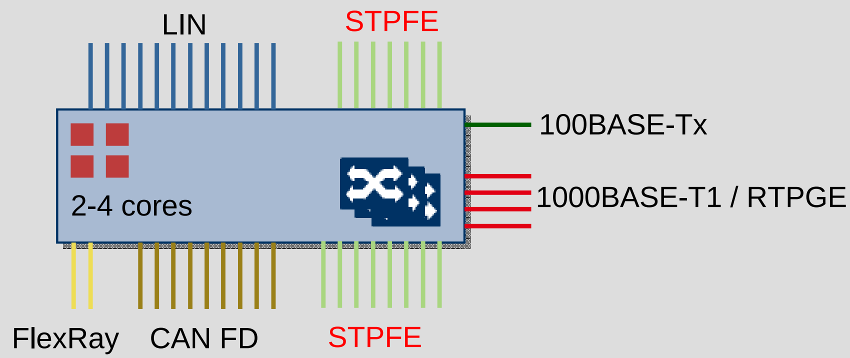
Volume segment cars



Number of ports / busses

- 4 - 10 x CAN FD
- 0 - 2 x FlexRay
- 8 - 16 x LIN
- 1 x 100BASE-TX
- 2 - 6 x STPFE
- 0 - 2 x 1000BASE-T1 / RTPGE

Premium segment cars



Number of Ports / Busses

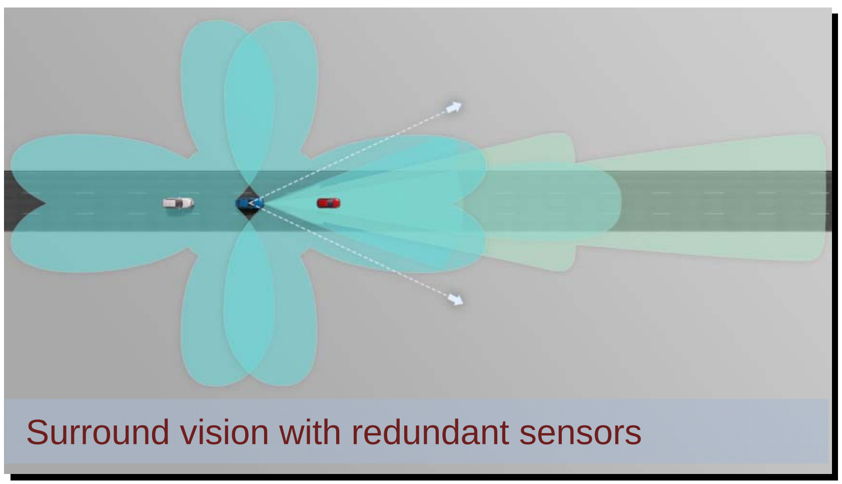
- 6 - 10 x CAN FD
- 0 - 2 x FlexRay
- 8 - 16 x LIN
- 1 x 100BASE-TX
- 5 - 15 x STPFE
- 0 - 4 x 1000BASE-T1 / RTPGE

Remark: Automotive gateways work on all 7 OSI-Layers. There is no unified network layer for typical automotive bus-systems. Routers in IT work on Layer 3 (Internet Protocol).

Use Case: Advanced Driver Assistance Systems

- 4-6 Mono Cameras
- 1-2 Stereo Cameras
- 2-4 Mid-Range Radar
- 2 Long Range Radar
- 8-16 Ultrasonic Sensors, 4 Wheel Speed Sensors
- Redundant Data Center
  - Number Crunchers for Data Fusion
  - ABS, ESP, …
  - Some ECUs we can’t tell you details today ☺
- Interaction with Powertrain, Body Domain, Navigation, Airbag, CAR2CAR, CAR2Infrastructure

Automated Driving is leaving the Research Labs.
Soon it will be in mass production.



Surround vision with redundant sensors

Does this look familiar to data centers?

Market Communication Systems View

Likely to phase out

		2010	2015	2020
Vehicle Domains	Power Train	CAN, (FR)	CAN, FR	CAN, CAN FD, FR, Ethernet
	Body	CAN	CAN	CAN, CAN FD, Ethernet
	Infotainment	CAN, MOST	CAN, MOST, Ethernet	CAN, CAN FD, MOST, Ethernet
	Vehicle Motion & Safety	CAN, (FR)	CAN, FR	CAN, CAN FD, FR, Ethernet
Specific Apps	Camera Systems	LVDS, Analog	LVDS, Ethernet	LVDS, Ethernet
	Diagnostics*	CAN	CAN, Ethernet	CAN, Ethernet
	DCU Backbone**			Ethernet

* via Gateway ** with introduction of domain control units

PoDL (RTPGE) and 4-pair PoE

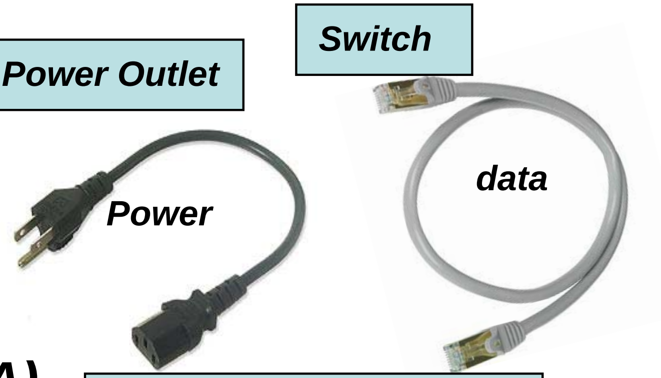
- Dave Dwelley/ Koussalya Balasubramanian

Power Over Ethernet – The easy & Robust Power Distribution

A)

Power Outlet

Switch



End User

"Reduced cable architecture" - One Cable for Power and Data

Power + Switch

End User

B)

End Equipment	
End Equipment - 1	Battery Backup
.	
.	
End Equipment - n	Battery Backup

Backup Power Consolidation

Active Power Management

End Equipment - 1

.

.

End Equipment - n

Switch

Backup Power Supply

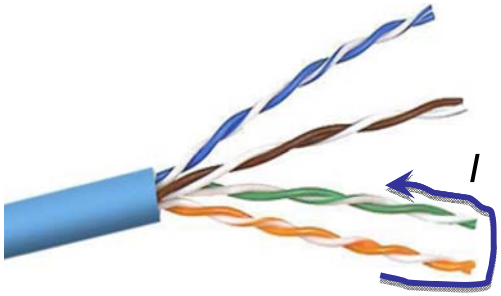
C)

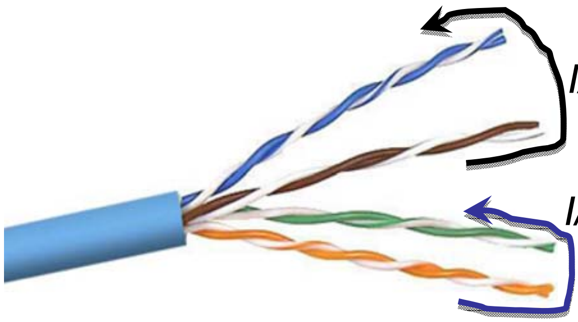
Ease of Installation

"broad adoption"

4-Pair PoE - Higher Efficiency and Bandwidth

- *4Pair for low power applications → Higher efficiency than 2pair*





- *10G support with PoE → Enabling future APs and some new applications which need higher BW*

IEEE 802

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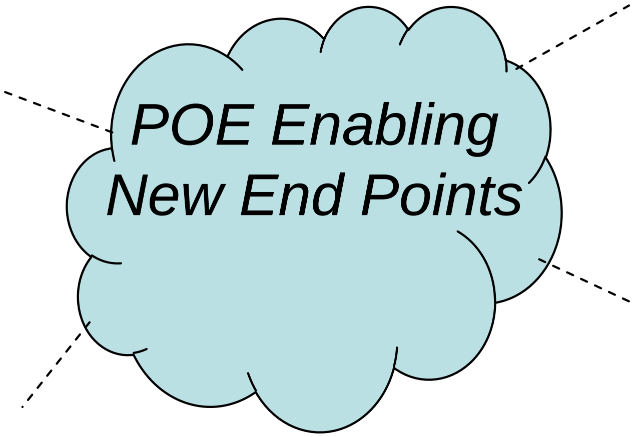
Enabling New Endpoints - 4-Pair PoE

Trading Floor Phones

Video Conferencing

HealthCare – Nurse Call System



Lighting

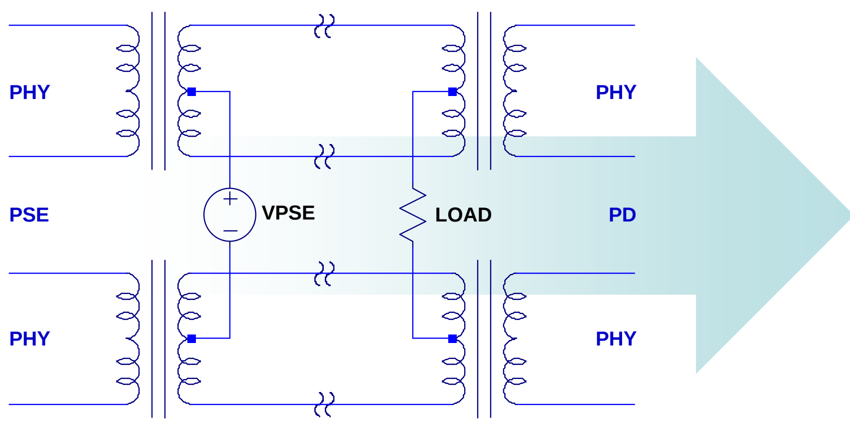
Physical Security Gateways

Thin Clients

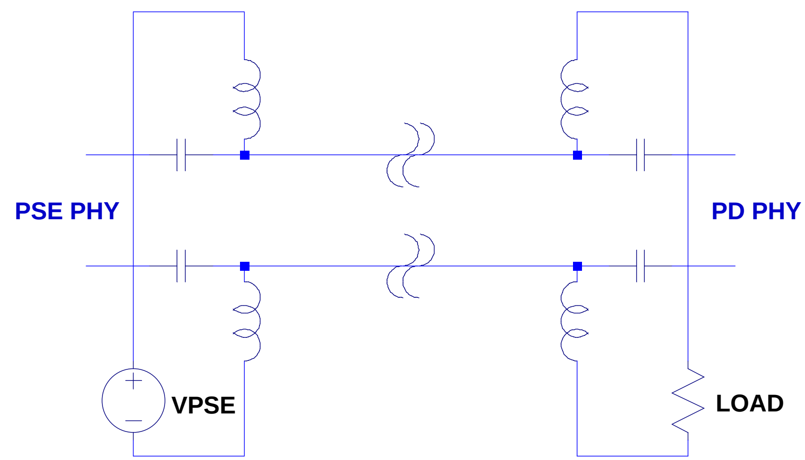
P802.3bu PoDL: PoE for Single Pair Links

- Single Pair Ethernet (1000Base-T1) in development
  - Aimed at vehicle and other weight sensitive applications

- PoDL extends PoE technology to single-pair links
  - PoE requires at least two pairs



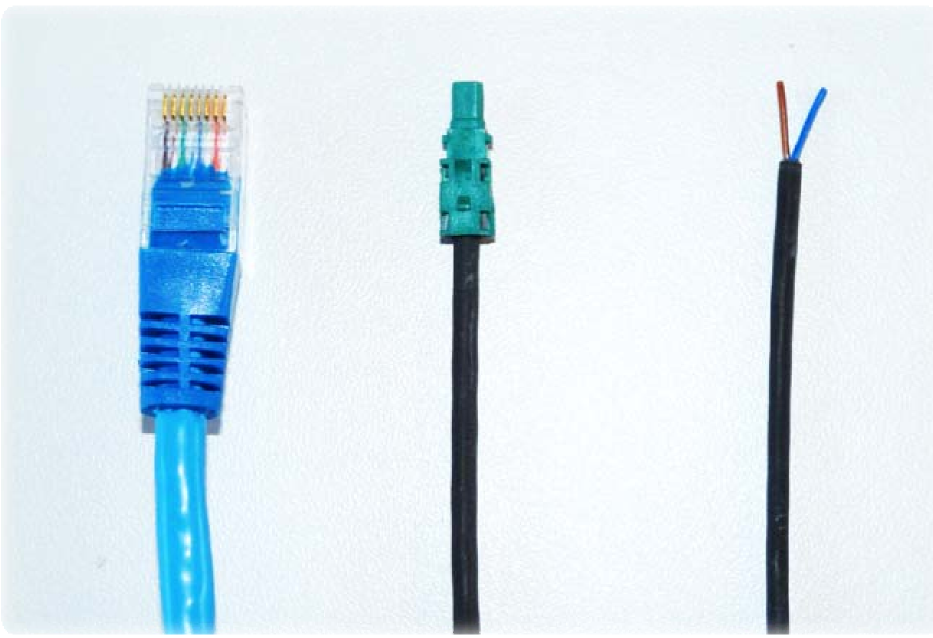
Existing PoE



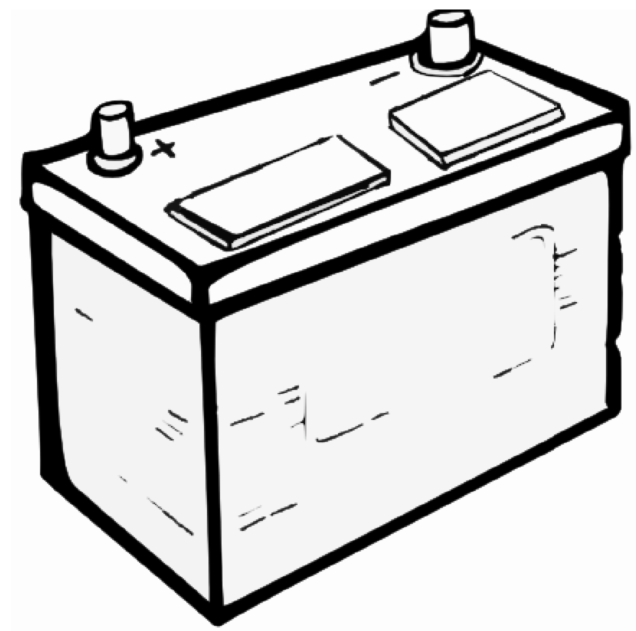
Power over Data Lines (PoDL)

PoDL: All the Benefits of PoE, plus…

- Weight and cost savings
- Works with automotive voltages (12V)
- Complements upcoming single-pair data schemes



PoE PoDL



PoDL Applications

- Backup cameras
- Cruise control sensors/Driver assistance sensors
- RF antenna modules
- Anything that can benefit from power and data over just two conductors…

Wireless – 802.15, 802.11

- Bob Heile - Zigbee Alliance

WSNs in Retail

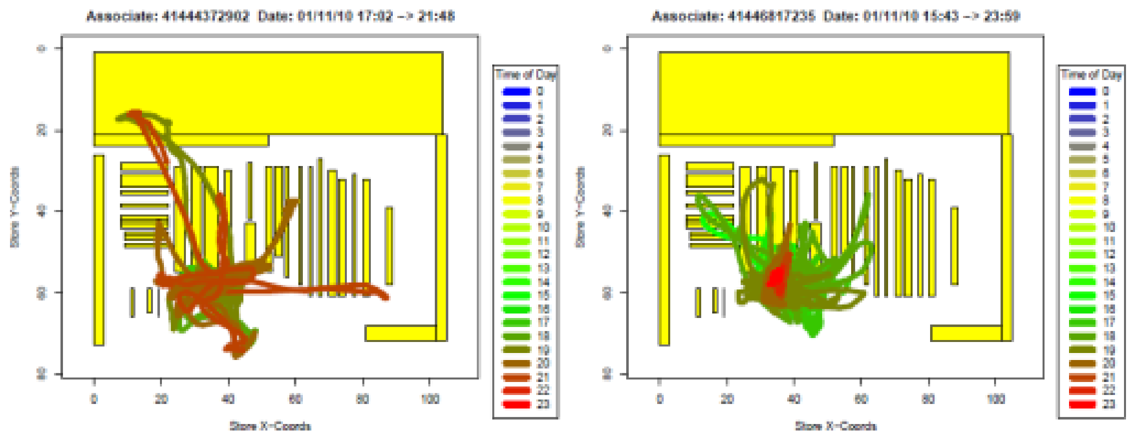
ZigBee Retail Service Applications

Being developed by multiple major players:

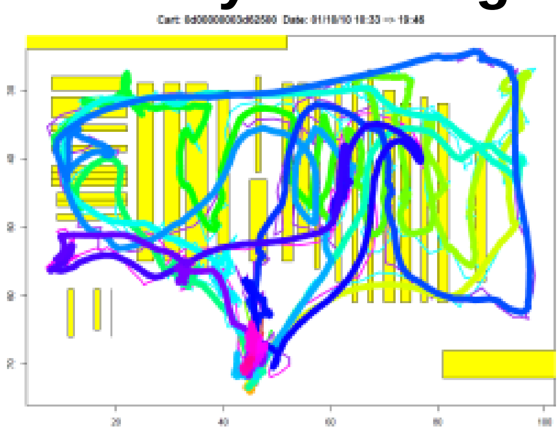
ZigBee Retail Service Information

Real-time Information

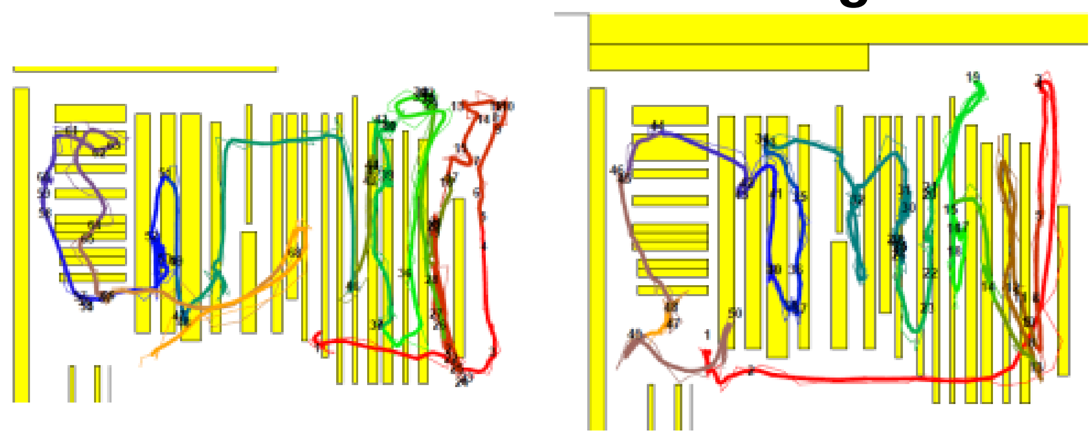
Associate Tracking



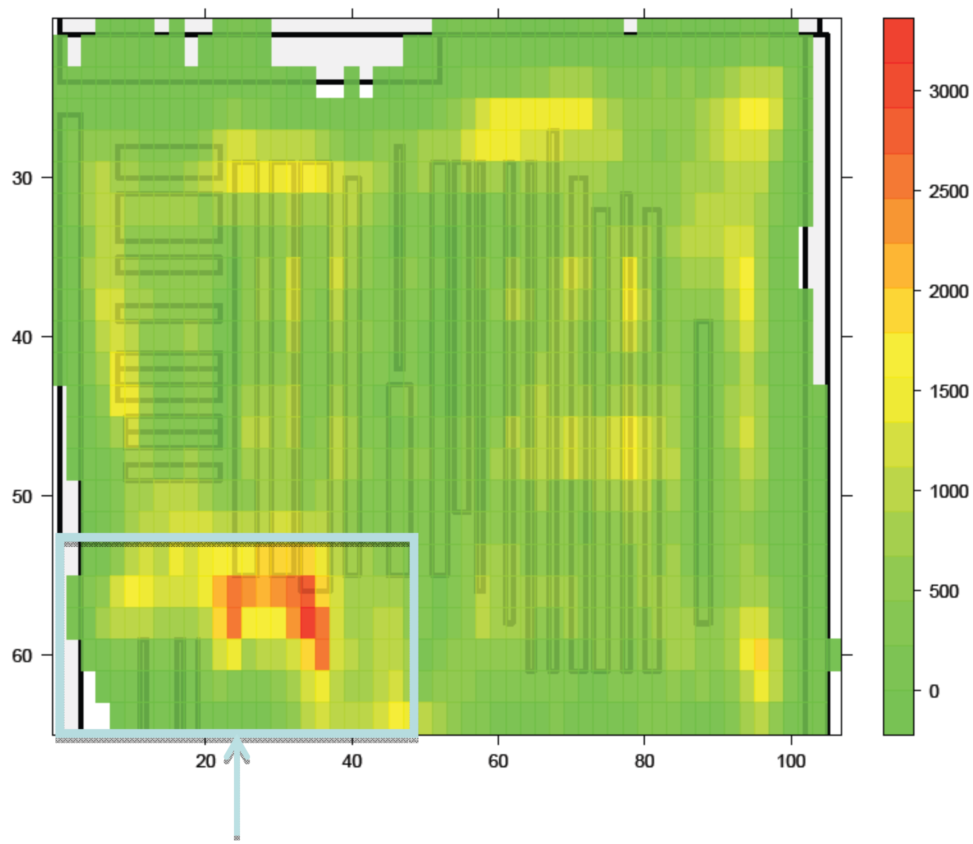
Trolley Tracking



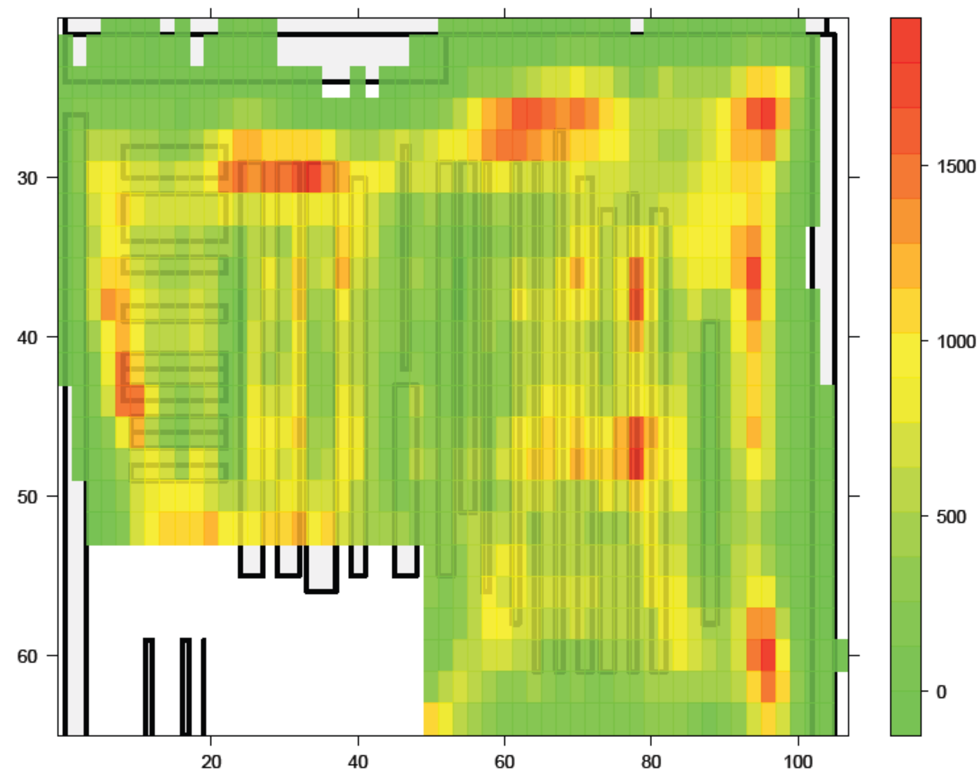
Customer Tracking



Store Heat Maps



Checkout Area



Göteborg: ”The ZigBee City”

500 000 Citizens

260 000 meters < 63 A

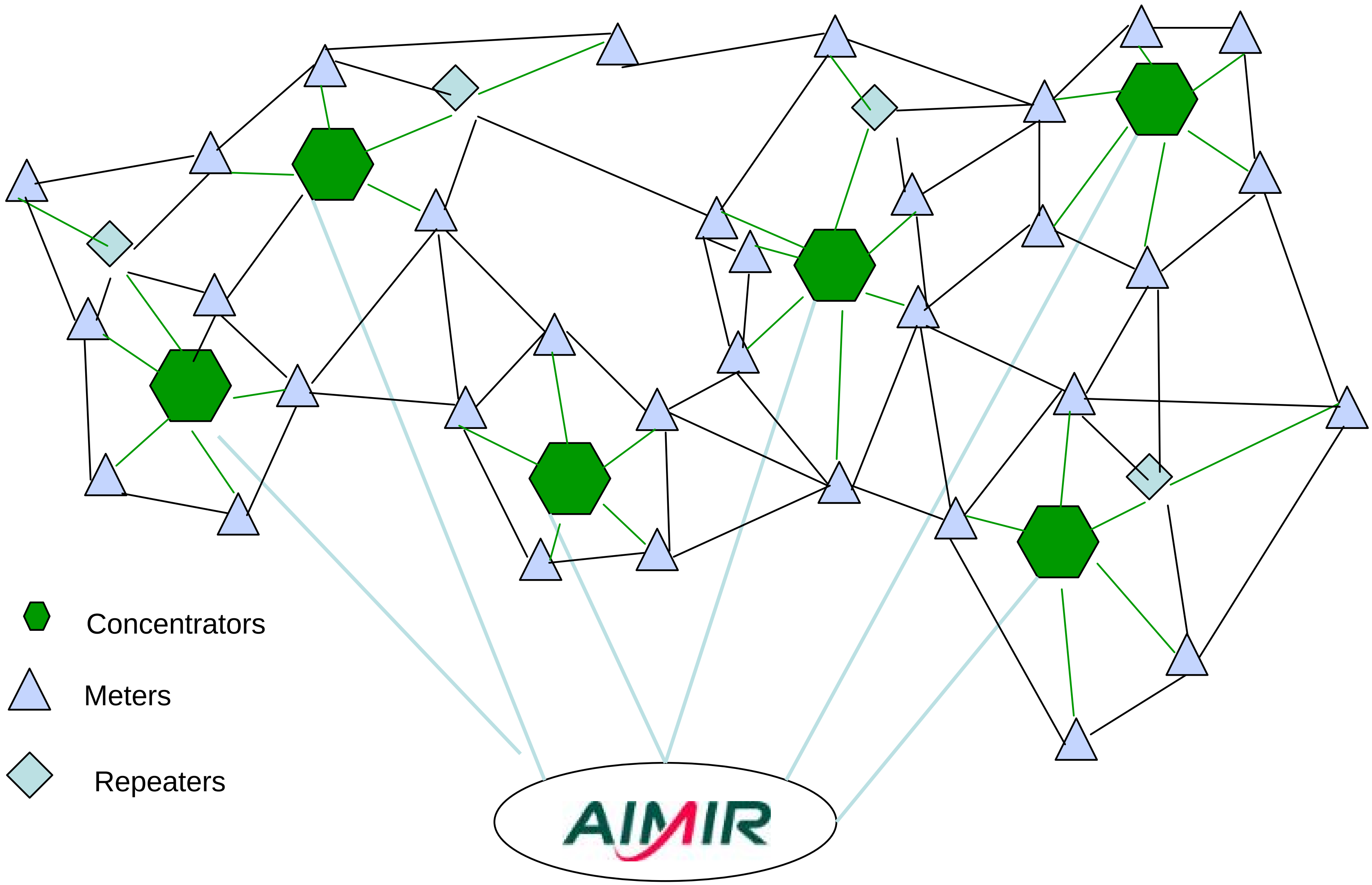
42 000 meters indoors

180 000 in metering-rooms

+ Rural area including 15 000 metering points

IEEE 802

Building the ZigBee NAN



Göteborg Energi

- Immediate Focus:
  - Power Quality and Failure alarms
    - Smart Grid foundation
  - Multimetering – Gas, District Heating, Water
  - Advanced Meter Management implementation of processes
- New Services (among others)
  - Individual metering (heat, water)
  - Security Alarm
  - ZigBee locks
  - Control of street lamps

Paul Nikolich Chair 802 – Next Steps

•Developers and end-users of NaB IoT applications need a location where 802 standards and expert guidance on how these standards can be applied to solve their problems.

•We need a group that represents all that IEEE 802 has to offer regarding NaB of IoT such as:

- Respond to enquiries
- Develop white papers and application notes
- Catalogue of NaB IoT standards
- Direct deeper level questions/activities to the appropriate Working Groups.

•Now we need to identify the best way to continue the NaB of IoT discussion. Some options are--expand the scope of 802.24 to NaB IoT applications to act as a host regular cross-802 discussions on this topic.

•The group will meet on an ongoing basis to focus on the “nuts and bolts” of IoT i.e., understanding individual and developers IoT requirements.

•Chris DiMinico and Hugh Barrass volunteered to co-chair this effort under 802.24.

- 2 hour meeting during Plenary sessions (more if necessary)
- Teleconference calls