10SPE Multidrop Enhancements
Call For Interest
Consensus Presentation

CFI Objectives

- To gauge the interest in studying 10SPE Multidrop Enhancements
- We do not need to:
  - Fully explore the problem
  - Debate strengths and weaknesses of solutions
  - Choose a solution
  - Create project documentation (e.g., PAR)
  - Write the standard

- Anyone in the room may vote or speak

10SPM CFI Motivation

- Target applications include
  - Building Automation
  - Industrial Automation
- Topics to address
  - Plug-and-play power distribution over mixing segments
  - Mixing segments longer than 25m
  - Improved energy efficiency
  - Mixing segments with more than 8 nodes
  - PTP (e.g., 802.1AS, IEEE 1588) and TSN over mixing segment

Draft Agenda

• Overview	Peter Jones	Cisco
• Presentations		
– Market Drivers	Peter Jones	Cisco
– Technical Feasibility - Power	Chad Jones	Cisco
– Technical Feasibility - Data	George Zimmerman	CME Consulting
– Why Now?	George Zimmerman	CME Consulting
• Q&A		
Expert Panel	David Brandt	Rockwell Automation
	David Tremblay	HPE
	Lennart Yseboodt	Signify
• Straw Polls		

Why Multidrop?

- Common design pattern in many target use cases
- Matches “natural” layout of systems
- Reduction in cabling and switch ports reduces cost compared to point to point.

Multidrop in P802.3cg

- Motion from 802.3cg TF Charlotte meeting (September 2017):

  Define a multi drop PHY using Clause 4 half duplex operation supporting up to at least 25m of balanced pair cabling in passive linear topologies.

- Objectives:

  A mixing segment with a single balanced pair of conductors supporting up to at least 8 nodes, for up to at least 25 m reach.

  Optionally supporting half-duplex multi-drop operation over the 25 m mixing segment.

- TF did not take up requests to address:

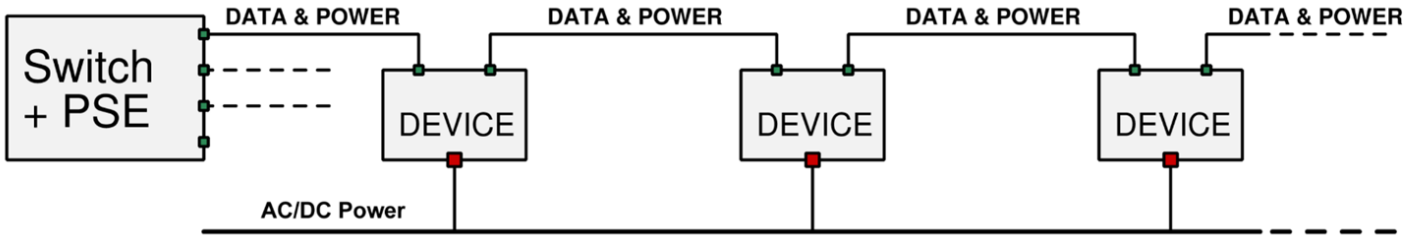
  Extended reach and node count

  Power over mixing segment

Market Drivers

Peter Jones Cisco

Multidrop Automation



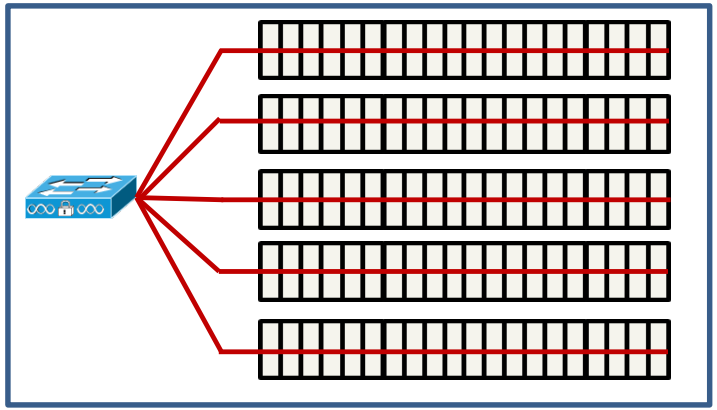
- Many of today's industrial and building automation systems use multidrop topologies for data or data+power.
- Data+power
  - High power devices use bus power for the control system, AC or DC to power the main load.
  - Low power devices use bus power only.
- Moving to Ethernet (incl. Ethernet diagnostics), will significantly improve user experience and network value

Industrial In-cabinet: Today

- Components are snapped into place in rows on DIN rails
- Component wiring is placed in channels
- Discrete wiring is the most common practice

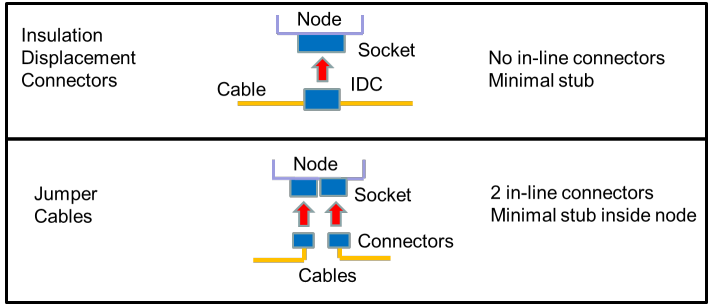
Industrial In-cabinet: Tomorrow

- A typical cabinet might contain 5 rows of 20 devices
- Low port count switch serves the segments.
- Replace 100 wires with 5 multidrop modular connections
- Reduces material costs, cabinet size, assembly time, etc.



Example logical topology

- Low voltage contactor 2020 market projection - $5B
  - technology.ihs.com/581715/contactors-database-2017
- Overload protection device 2020 market projection - $1B
  - technology.ihs.com/515493/overload-protection-devices-database-2017
- Industrial Edge Networking (Source: IHSMarkit)
  - Ethernet connected nodes CAGR 2016-2021: 15.4%
  - L2 Managed Switches CAGR 2018-2024: 13.9%

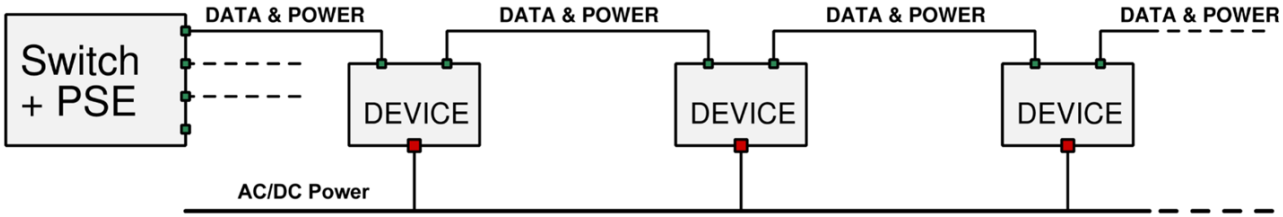


Example connectivity options

Lighting Automation - DALI

- DALI (IEC 62386) is a widely used protocol for digital lighting control
  - DALI supports up to 64 devices over up to 300m (16 AWG) at 1200b/s with power (≤ 250 mA at 16 V DC).
    https://en.wikipedia.org/wiki/Digital_Addressable_Lighting_Interface
    https://www.digitalilluminationinterface.org/dali/
- To address this market with 10SPE Multidrop
  - Reach: > 25m
  - Nodes: 16-24
  - Power per node: 0.5W

Lighting Automation with 10SPE



Devices (luminaires, sensors, …) are connected in passive linear topology, key requirements:

1. **Fault isolation:** Device fault doesn't interrupt control data & power flow
2. **Power:** Mains failure doesn't interrupt control data & power flow
3. **Topology:** Linear wiring possible

Global lighting node shipments are expected to exceed 210 million by 2021

Navigant Research, Smart Buildings and Communications, 2014

Global IoT for intelligent buildings market expected to grow $6.3 billion to $22.2 billion 2017-2026.

https://www.navigantresearch.com/reports/iot-for-intelligent-buildings

PTP, TSN and 10SPE Multidrop

- Precision Time Protocol (e.g. IEEE 1588, 802.1AS) on 10SPE Multidrop.
  - PTP on half-duplex Ethernet links is not supported in 802.1 or 802.3
  - One use case for PTP is to resolve time sequence of a set of related events
- 802.1 TSN on 10SPE Multidrop. TSN is made up of a number of standards, including the following:
  - 802.1AS Timing and Synchronization
  - 802.1Qbv Scheduled traffic
  - 802.1Qci Per-Stream Filtering and Policing
- TSN requires PTP
- Work with 802.1 TSN TG to support PTP and TSN on 10SPE multidrop

Summary

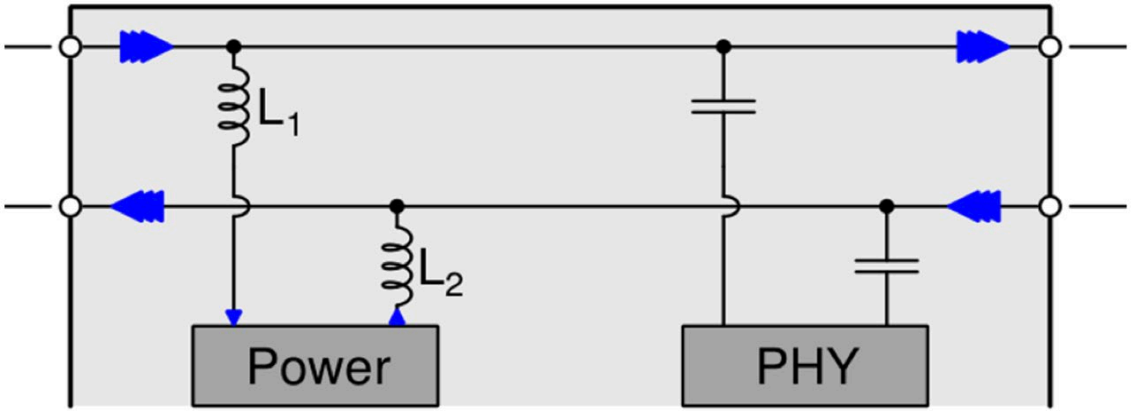
- 10SPE is the natural successor to a wide range of “fieldbus” technologies
- 10SPE multidrop does not address
  - Mixing segments longer than 25m
  - Mixing segments with more than 8 nodes
  - Power over the mixing segment
- PTP and 802.1 TSN is a key emerging technology to enable automation applications on Ethernet.
  - TSN has not addressed multidrop Ethernet yet.

10SPE needs to support these features

Technology Feasibility - Power

Chad Jones, Cisco

Power Injection/Extraction



- 802.3 powering does not support multidrop
- Power pass thru concepts have been discussed in the 802.3cg TF
- 802.3cg compliant devices are required to withstand 60V even if they do not support a PD function.

Voltage

- Multiple voltage levels discussed in 802.3cg
- Interest expressed for 24V and <60V
  - Low voltage for specific environments, e.g. damp locations
  - High voltage provides max power to PD and increased energy efficiency

Possible Power Allocation Scheme

- When PD is first connected, must stay within a specific power draw (e.g., 1W)
- PD negotiates additional power allocation via LLDP
- PSE grants power: PD moves to full power
- PSE denies power: PD moves to sleep state (e.g. 0.1W)

Technology Feasibility - Data

George Zimmerman, CME Consulting

Mixing Segment

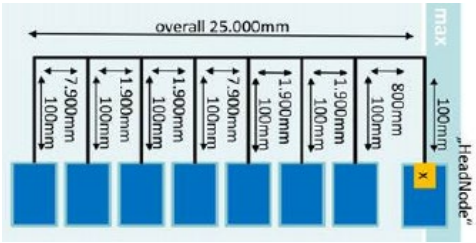
- For an example application (e.g., 75m and 32 powered nodes), we need to consider the following:
  - Insertion loss
  - Impulsive noise due to adding/changing nodes or power transients
  - Increased tap mismatches

NOTE: Reach and powering both affect the mixing segment specification.

Extending the Mixing Segment

- Build on the analysis in 802.3cg
- Linear topology w/stubs
  - See, e.g., (excerpt at right)
    Or: analysis/measurements in
- # of nodes limited by capacitance & stub performance
  - Higher node count = lower capacitance/node
- Reach limited mainly by wire gauge, connector losses

	24AWG	22AWG	18AWG	16AWG	14 AWG
No-connector reach (m)	38	47	75	97	123
Reach w/connectors (m)	25	31	50	64	82



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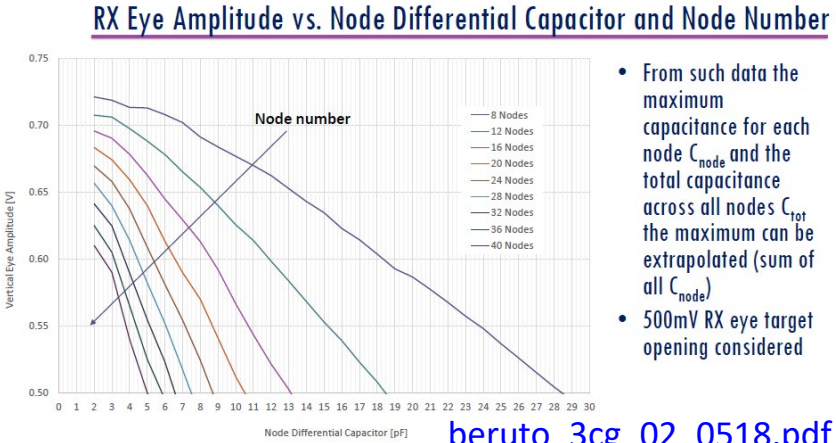

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Coding

- It would be preferable not to change line coding (e.g., Clause 147 DME / 4B5B encoding)
- An optional FEC sublayer, similar to Clause 108 RS-FEC, is a possible approach both to extend reach and deal with power transients

Energy Efficiency

- To support lighting and extended applications, enabling better system level energy efficiency should be considered
  - 802.3cg d3p1 clause 147 PHY goes silent, so the PHY doesn't need LPI signaling
  - BUT – not signaling an LPI mode beyond the PHY limits system power savings, AND widespread applications require < 0.5 W/node total
- These may be addressed by modifications to signal EEE low power idle modes in Clause 147
- Also related to voltage levels used when delivering power over the mixing segment

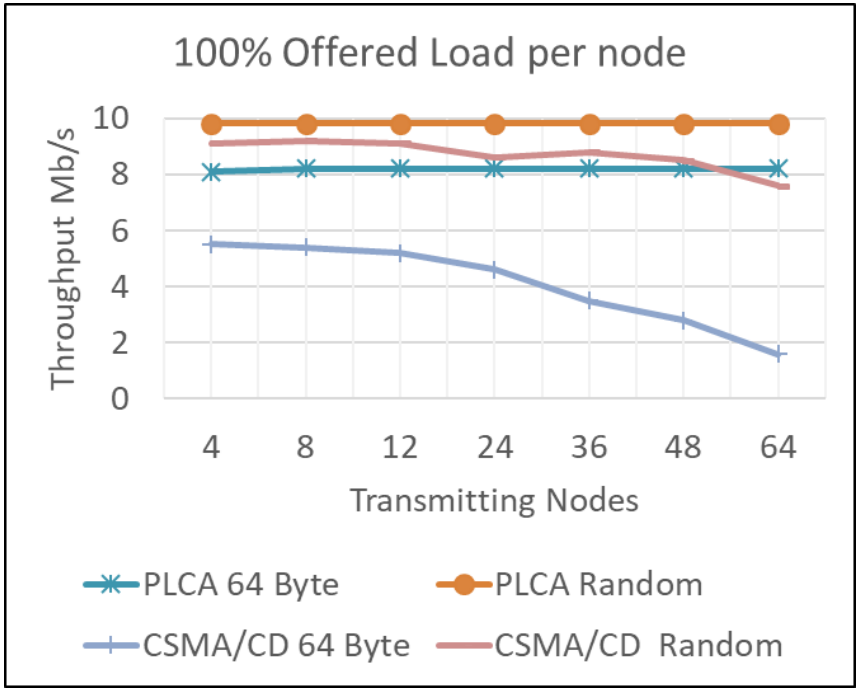
Increased Node Count

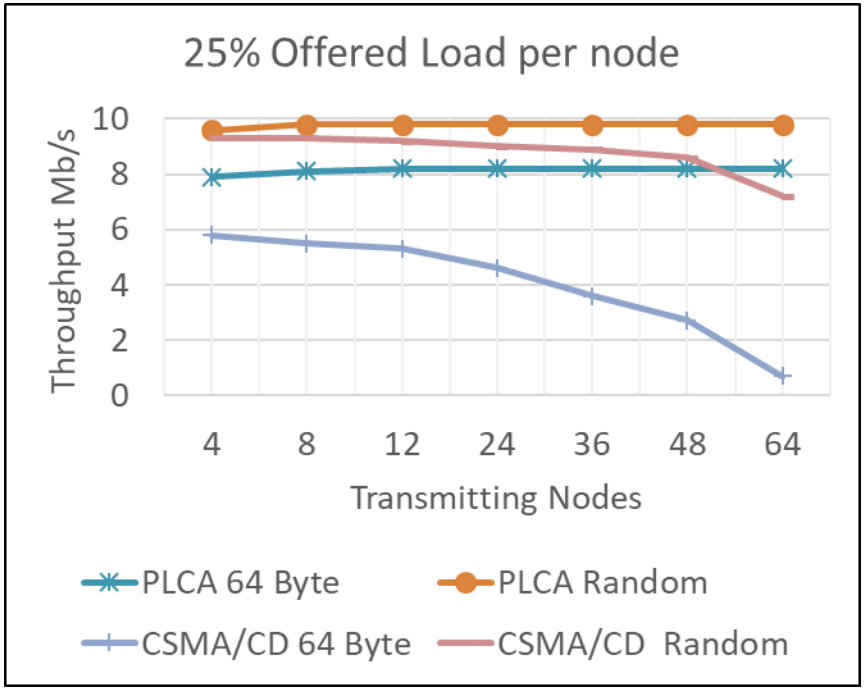
- 802.3cg objective was

  "A mixing segment with a single balanced pair of conductors supporting up to at least 8 nodes."

- Both CSMA/CD, and CSMA/CD with the PLCA RS support higher node counts, with known performance characteristics.

Performance with increased node count





PTP support – TSSI

- Clause 90 specifies:
  - the optional Time Synchronization Service Interface (TSSI)
  - This is an extension to other Reconciliation Sublayers
  - The service interface provided to the TimeSync Client
    - Definition of TimeSync Client is out of scope for IEEE Std 802.3
  - TS_TX.indication & TS_RX.indication primitives

Figure 90–1 depicts the TimeSync Client and the RS interlayer service interfaces.

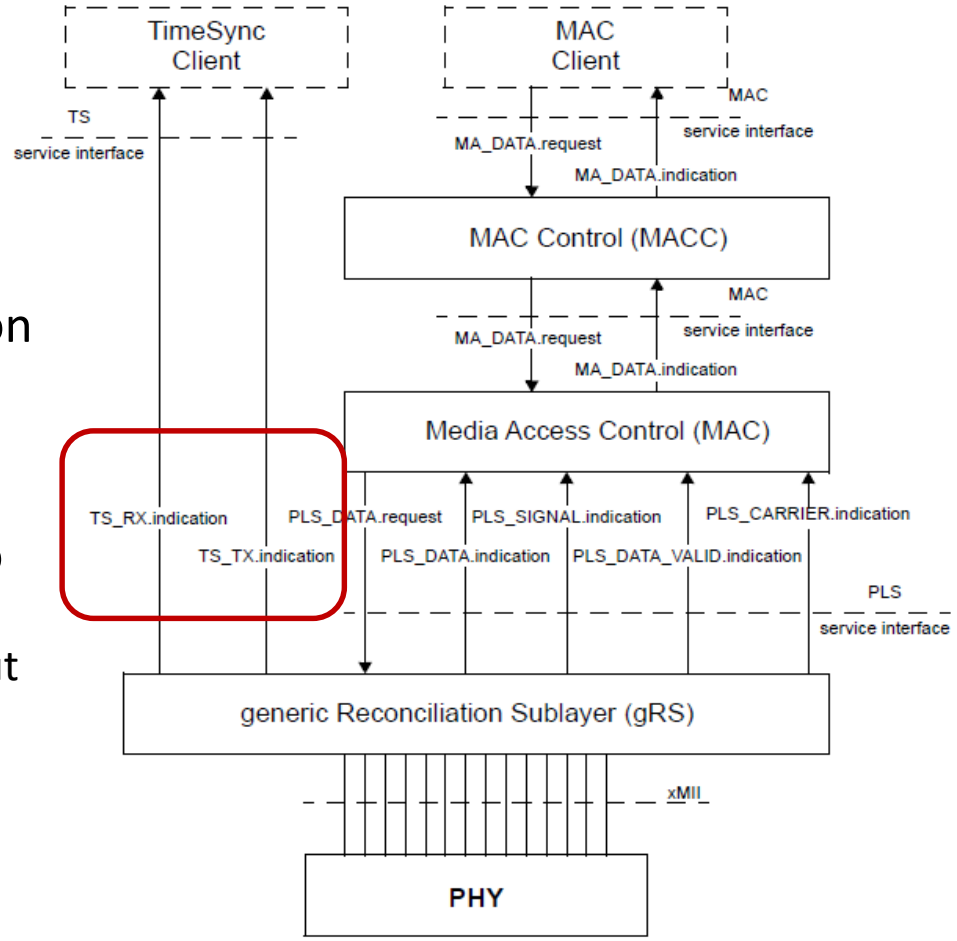


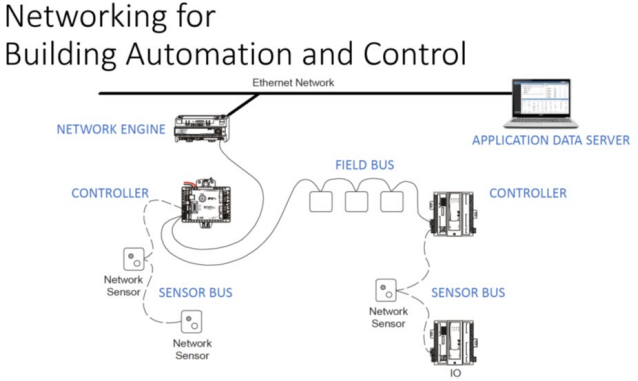
Figure 90–1—Relationship of the TimeSync Client, TSSI and gRS sublayer relative to MAC and MAC Client and associated interfaces

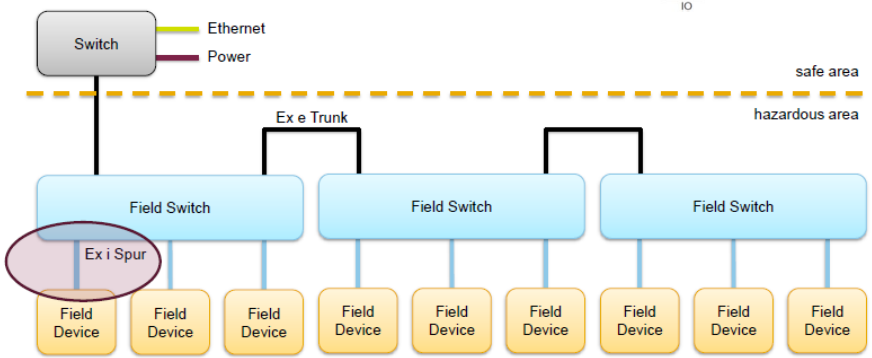
Why Now?

George Zimmerman, CME Consulting

Use cases already in 802.3cg

- Short:
  - In-cabinet, chassis
  - Vehicles
  - Multipoint topologies
- Medium:
  - Industrial pods (5-40m)
  - Building control networks (50-100m)
  - Process control “spurs” (200m)
- Long:
  - Process control trunks (1km)
  - Building automation trunks (500m)
  - Elevator shafts

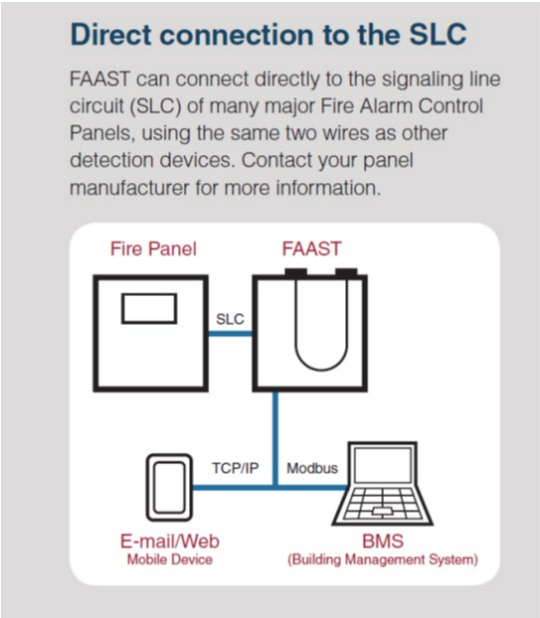


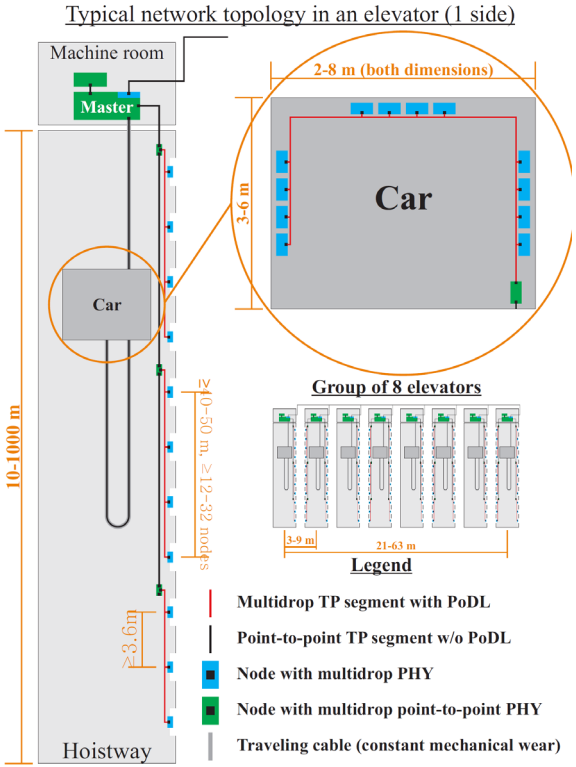


PROJECT NEEDED TO ACTIVELY SAY NO MORE TO NEW USE CASES, BUT…

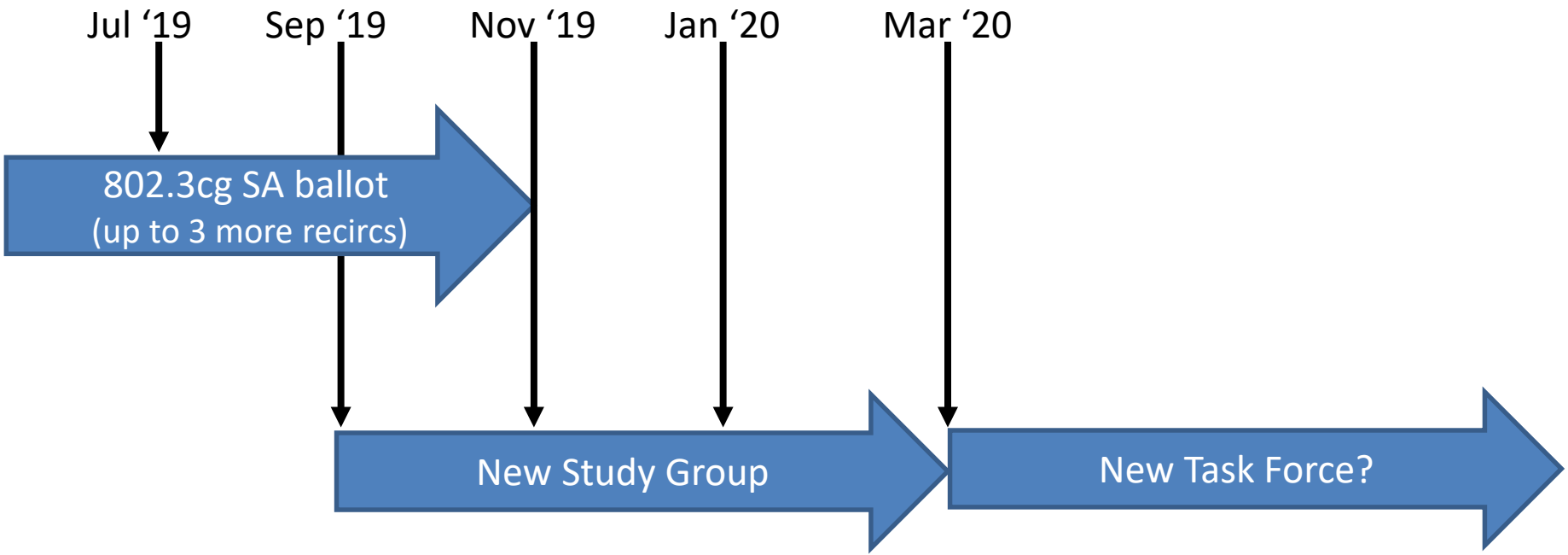
With success comes more success…

- Every time I turn around, someone has a new use….
  - Elevators
  - COPS?, Alarms?
- Managed power and data on OT cabling grew interest from New Ethernet users





Timeline Dovetails with 802.3cg



Summary

- It’s time
  - 802.3cg is expected to complete SA ballot by November 2019
  - Key 802.3 participants are available
  - Multidrop use cases better understood
  - Interest in multidrop from industry has only grown

Q&A

Presenters

Chad Jones	Cisco
George Zimmerman	CME Consulting
Peter Jones	Cisco

Expert Panel

David Brandt	Rockwell Automation
David Tremblay	HPE
Lennart Yseboodt	Signify

57 Supporters
38 Organizations

Contributors and Supporters

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Bernd Horrmeyer, Phoenix Contact
Bob Noseworthy, UNH-IOL
Bob Voss, Panduit
Brett McClellan, Marvell
Brian Franchuk, Emerson
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Chad Jones, Cisco
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Christopher Pohl, Beckhoff Automation
Claude Gauthier, NXP
Craig Gunther, Bosch
Curtis Donahue, UNH-IOL
Dave Hess, CordData
David Abramson, TI
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David Hoglund, Johnson Controls
David Tremblay, HPE
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Steve Sedio, TDK
Theo Brillhart, Fluke
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Tim Baggett, Microchip
Venkat Iyer, Microchip
Wojciech Koczwara, Rockwell Automation
Yair Darshan, Microchip
Zhuangyan (Yan) Zhuang, Huawei

Straw Polls

Call-for-Interest Consensus

- Should a study group be formed for “10SPE Multidrop Enhancements”?
- Y: 53 N: 3 A: 17
- Room count: 79

Participation

- I would participate in a “10SPE Multidrop Enhancements” study group in IEEE 802.3
  - Tally: 31

- My company would support participation in a “10SPE Multidrop Enhancements” study group
  - Tally: 19

Future Work

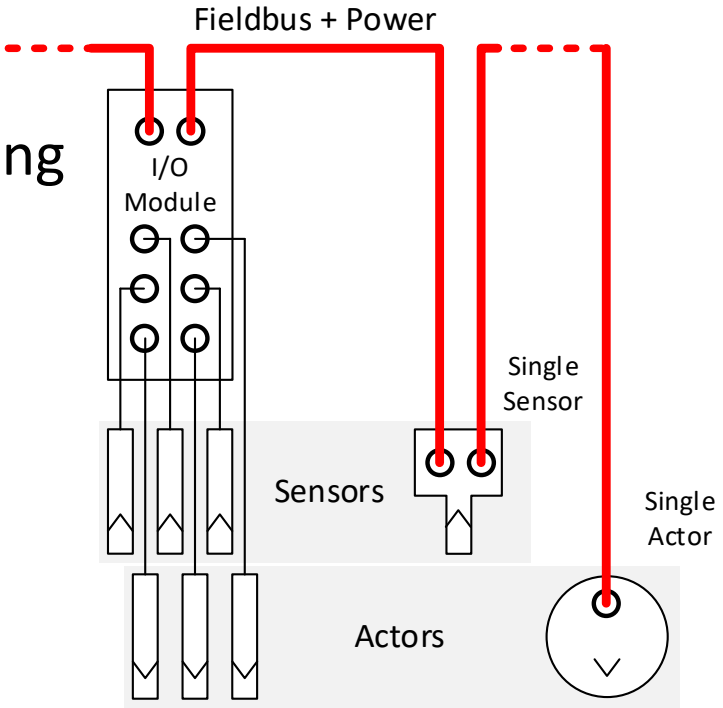
- Ask 802.3 at Thursday's closing meeting to form a "10SPE Multidrop Enhancements" Study Group
- If approved by 802.3:
  - Request 802 EC to approve the formation of the Study Group
  - If approved by the EC, the first Study Group meeting will be at the September 2019 in Indianapolis.

Thank You

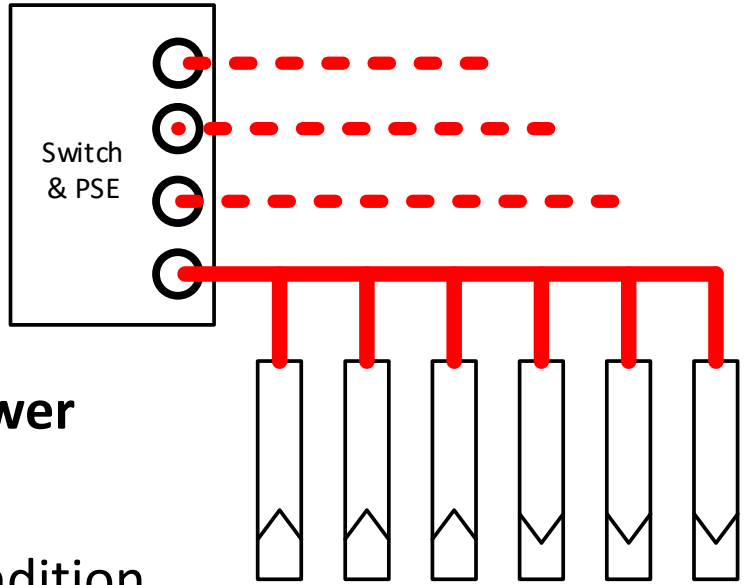
Additional Use Cases

Industrial In-Field Today

- EtherCAT-P as an effort to reduce cabling
- Ethernet based
- Power coupling via inductors
- Daisy chained power
- Unsuitable for small I/Os
- Overkill for single low end I/Os



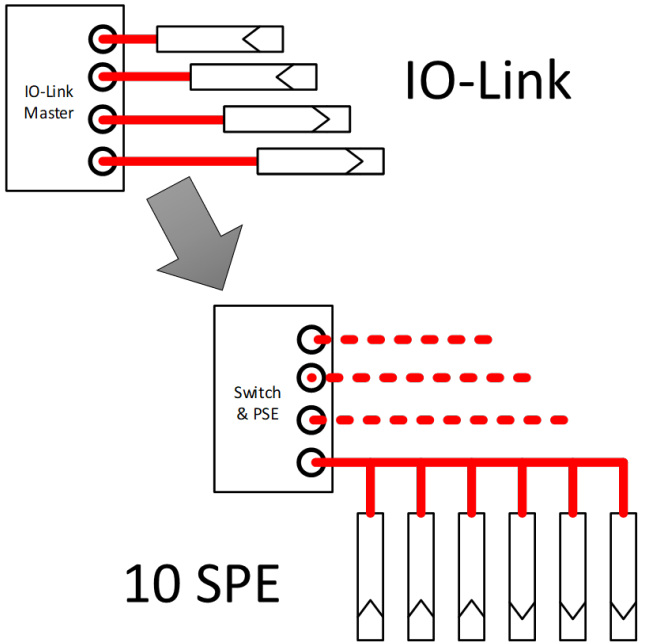
Industrial In-Field Requirements



- Easy to wire in the field
- Small footprint
- Lower end multidrop bus **including power**
- Significantly reduce wiring cost,
- Allow for more sensors in the field (condition monitoring, predictive maintenance, IIOT, …)

Application Example: IO-Link

- IO-Link is a low cost, P2P, Master/Slave industrial fieldbus
- End points may have high complexity but low communication requirements
- Limited bandwidth (<=230 kBaud), 3-5 wires per device
- Market share 2018 $3.5bn
  - Devices ~$2bn
  - Masters ~$1.5bn
- Expected growth 2019: 12%



drivesncontrols.com/news/fullstory.php/aid/5951/IO-Link_revenues_hit_$3.5bn_in_2018_and_are_booming.html

Outdoor light poles

Newest generation pole heads come with two sockets → the top socket makes an uplink.

The bottom socket can be used for sensors or for another wireless radio to create a mesh network.

Power needs of these devices differ and the current technology does not offer any power management.

Additionally, we envision further sockets on the pole itself for sensor modules (e.g. gun shot detection) which require data and power.

A bus design meets this very well, provided (managed) power is available.

Multidrop and Nanogrids

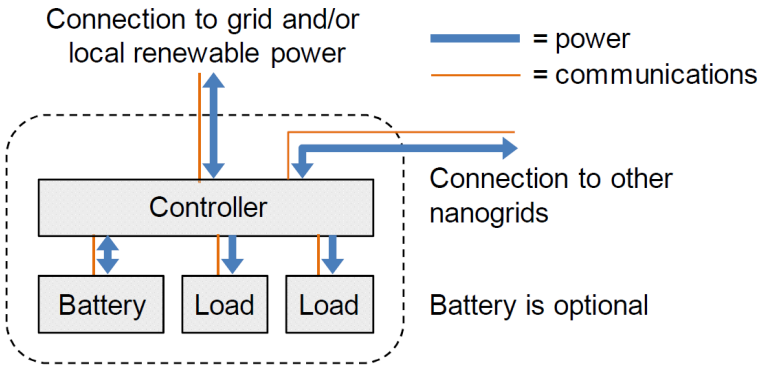


Fig. 1. Conceptual diagram of a nanogrid

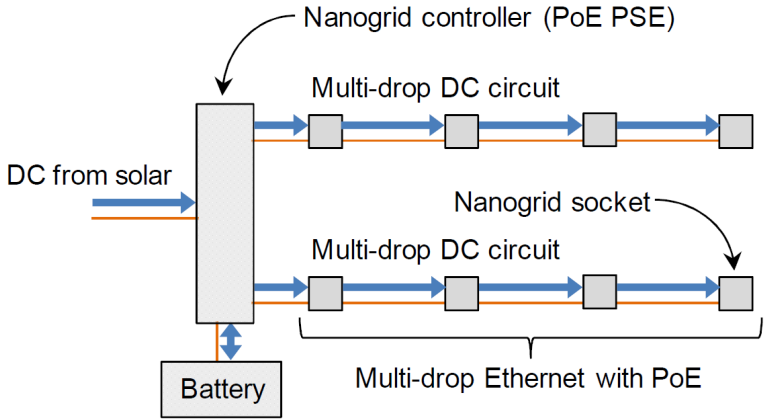


Fig. 2. PoE-based nanogrid with two DC multi-drop circuits and a battery

Back to the Future: A Need for Multi-Drop Ethernet for Cost-Effective Power Distribution

Abstract: Local renewable DC electricity sources, such as solar, have become cost competitive. In this position paper, we argue that an Ethernet LAN with Power-over-Ethernet (PoE) is a nanogrid where the physical layer infrastructure is used for DC electricity distribution and the link-layer capabilities can be used to match electricity supply and demand. To be cost effective with respect to wiring, many of these nanogrids must be multi-drop where each drop may be a power socket. Open challenges to employing PoE as a multi-drop managed nanogrid include 1) extending LLDP for multi-drop, 2) adapting LLDP to support the use of price signals for modulating power demand, 3) achieving efficient PoE power flow in a multi-drop circuit, and 4) implementing low-cost and fair scheduling for packet transmission. We explore how multi-drop Ethernet can be implemented with fair access to all devices by employing at each drop a mini-switch with packet scheduling.

Kenneth J. Christensen, Bruce Nordman: https://ieeexplore.ieee.org/abstract/document/6925796

Multidrop and Nanogrids (cont.)

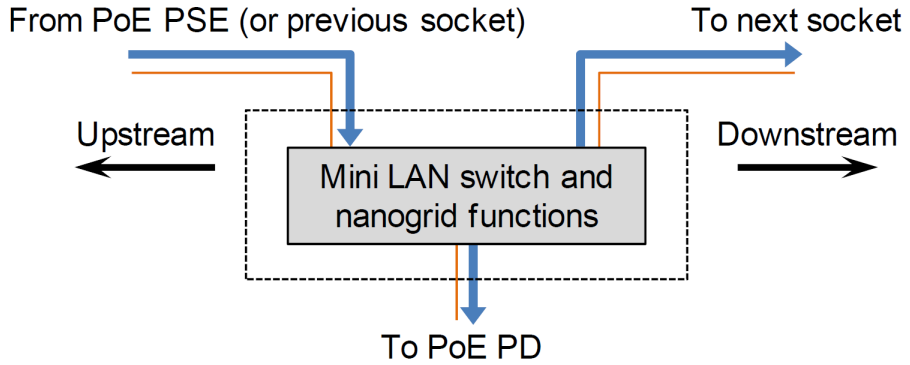


Fig. 3. Schematic of a nanogrid socket for a multi-drop PoE circuit

Back to the Future: A Need for Multi-Drop Ethernet for Cost-Effective Power Distribution

SUMMARY AND FUTURE WORK: In this short position paper, we have defined the need for multi-drop Ethernet. Such a network with PoE and LLDP modified to support notification of power availability and price is a managed nanogrid. The multi-drop Ethernet is a daisy chained configuration of mini-switches. We see future work in addressing the four challenges described in this paper. LLDP changes to support both multi-drop and nanogrid functions need to be explored. Very importantly, the ability for PoE to efficiently (that is, without significant power loss) support multi-drop configurations must be studied Our experimental results showed the need for packet scheduling at each drop for fair access to the network in high utilization scenarios. Threshold-based schemes appear to be promising. There is future work to be done in light-weight fair scheduling schemes for multi-drop Ethernet with daisy-chained switches. Our preliminary work in this paper shows that ensuring fair access by all devices to available bandwidth in a daisy-chained network of switches is a challenging problem. Other future work should address USB as a possible multidrop communications and power distribution technology. Similar to PoE, USB is increasing the amount of power that can be delivered currently up to 100 W.

Kenneth J. Christensen, Bruce Nordman: https://ieeexplore.ieee.org/abstract/document/6925796

Industrial Outside-cabinet:

- Applications:
  - Machinery
  - Robots
  - Conveyer belts
  - Printing machines
  - Etc.
- Nodes:
  - IoT
  - Sensors
  - Actuators
- Topology:
  - Multidrop
  - <30 nodes
  - <100m
- Environmental:
  - M3 I3 C3 E3

Further possible applications

- Traffic control
- Railway cars
- Ships, Ferries, Vessels
- Agriculture and construction machinery
- Power plants, Substations, PV-plants
- Let your fantasy play around..

30 Nodes, 100m, MICE2-3 seems a good target

End