802.3 NEA
Possible CFI for 10SPE Multidrop Enhancements

Peter Jones – Cisco

May 2019 – Salt Lake City

Overview

- Some of the applications previously presented
  - Industrial in-cabinet
  - Lighting
  - Elevators
- We need
  - Mixing segments longer than 25m
  - Mixing segments with more than 8 nodes
  - Mixing segments with power distribution

Example use cases

In-Cabinet

Typical panel assembly

- Components are snapped into place in rows on DIN rails
- Component wiring is placed in channels
  - Load connections
  - Device power
  - Communication or wired logic

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From www.ieee802.org/3/cg/public/Mar2017/brandt_cg_01_0317.pdf

In-Cabinet

Wiring practice - discrete

- Discrete wiring is the most common practice

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From www.ieee802.org/3/cg/public/Mar2017/brandt_cg_01_0317.pdf

In-Cabinet

Wiring practice - networking

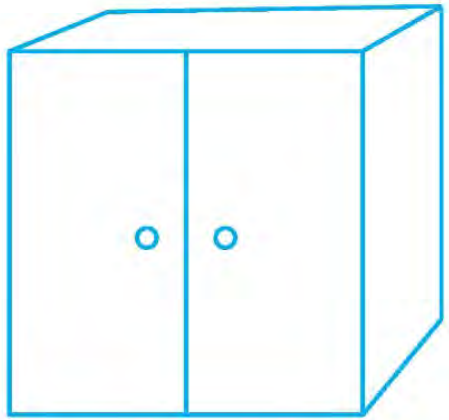
- High-end components have already adopted Ethernet
- For the bulk of the devices, dual-port Ethernet exceeds the cost of the discrete wired device

From www.ieee802.org/3/cg/public/Mar2017/brandt_cg_01_0317.pdf

In-Cabinet

Enclosures

- Typical enclosures
  - https://www.pentairprotect.com/wcsstore/AuroraStorefrontAssetStore/UserDownloads/Downloads/Bro-00218.pdf
- Large
  - Height = 2.2 m
  - Width = 1.8 m
  - Depth = 1 m



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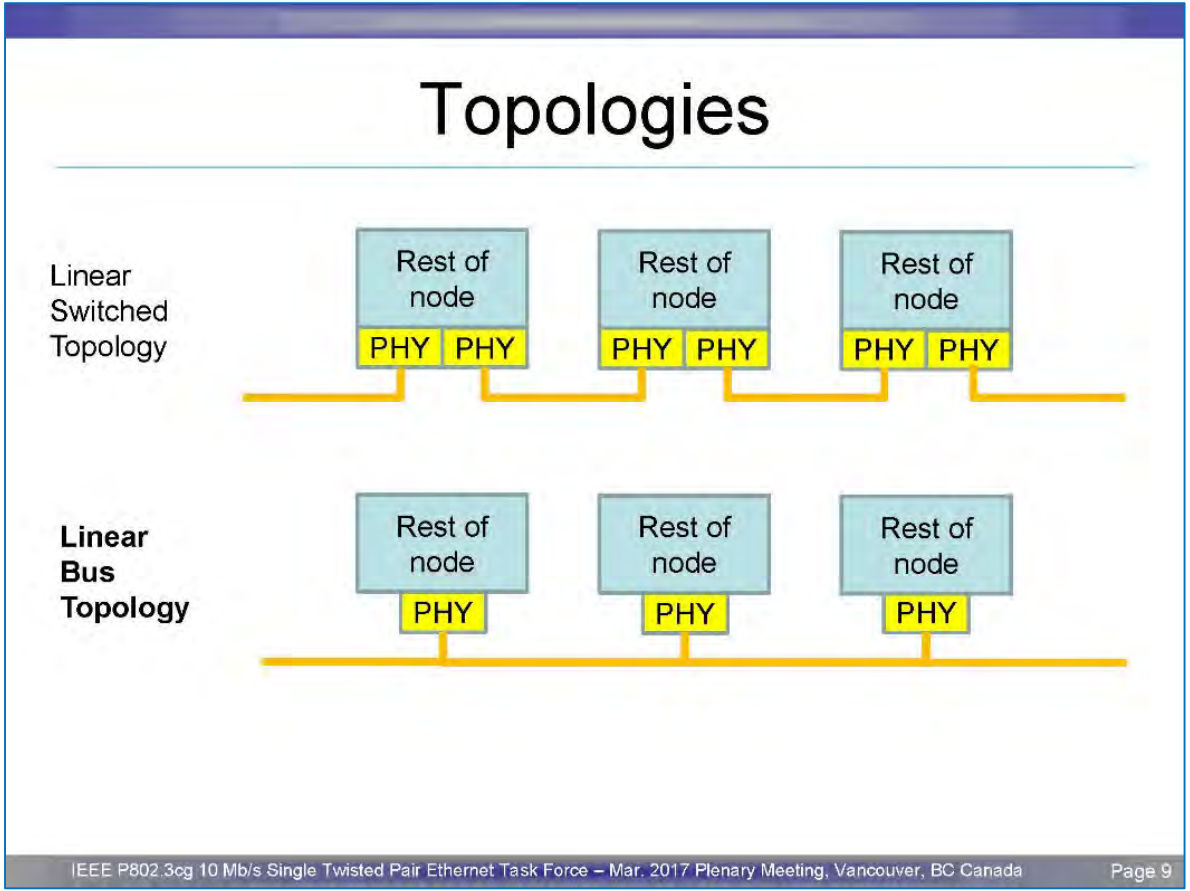
In-Cabinet


Topologies
Linear Switched Topology
Rest of node
PHY
PHY
Rest of node
PHY
PHY
Rest of node
PHY
PHY
Linear Bus Topology
Rest of node
PHY
Rest of node
PHY
Rest of node
PHY
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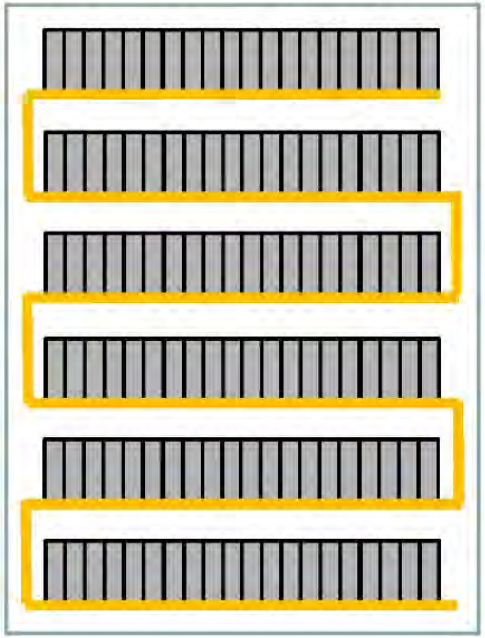
In-Cabinet

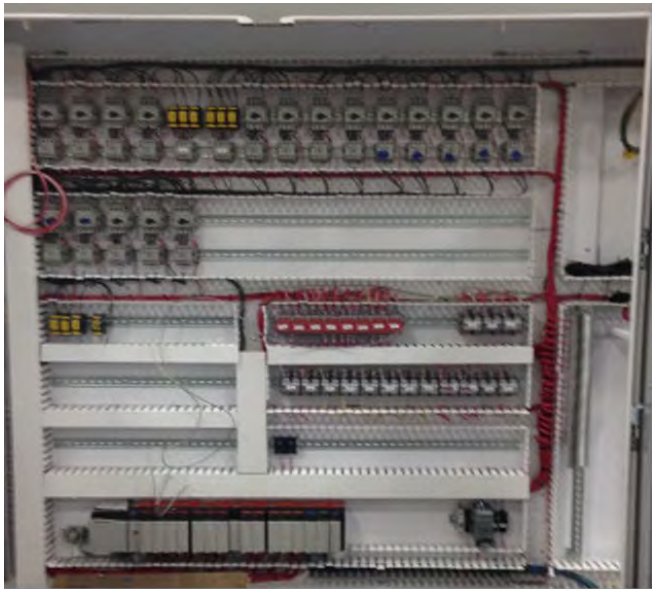
Estimates for linear bus topology

- A single bus covers back panel and doors
- Length
  - 6 rows @ 1.8 m
  - 2.2 m height
  - 2 m to doors + 1.8 m backtracking
  - 6 rows @ 1.8 m on door
  - Total > 27.6 m
- Nodes
  - 20 across * 5 rows
  - Total > 100 nodes



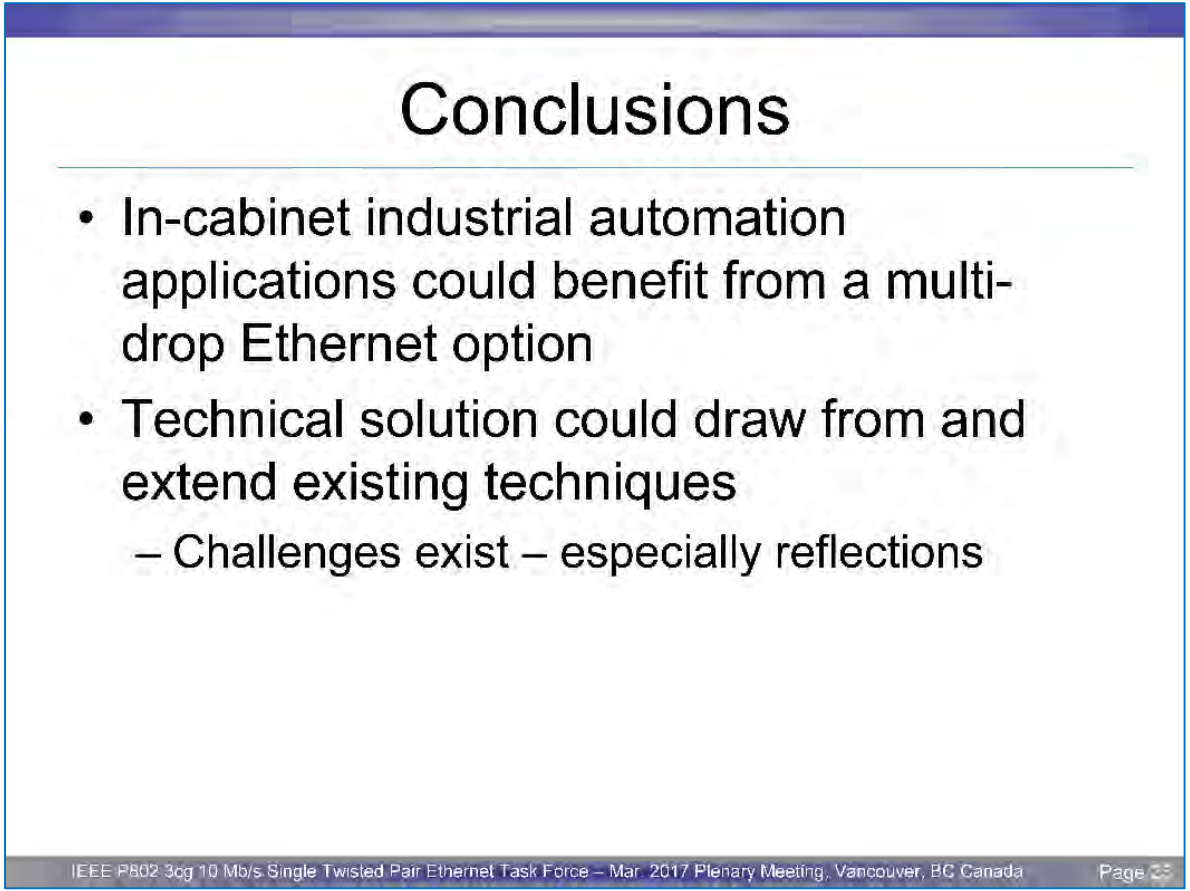
From www.ieee802.org/3/cg/public/Mar2017/brandt_cg_01_0317.pdf

In-Cabinet - Customer Applications



- **Hundreds of wires in a typical customer application**
- **Hardwired with limited intelligent information**

In-Cabinet



From www.ieee802.org/3/cg/public/Mar2017/brandt_cg_01_0317.pdf

Lighting

DALI – Digital Addressable Lighting Interface

DALI covers OSI layers from Physical to Application and is extensively used in lighting controls. See ➠wendt_10SPE_01_0916.pdf

- 1200 bit/s, two wire communication
- Manchester endoded with voltage swing up to 16V±6.5V
- Nearly any cable can be used (mains cable, twisted pair, …)
- Free topology – possible due to the extremely low data rate

With 10BASE-T1 is is not expected that mains cabling can still be used, nor will it be possible/desired to use a completely free cabling topology.

3 November 3, 2016 Philips Lighting – Research

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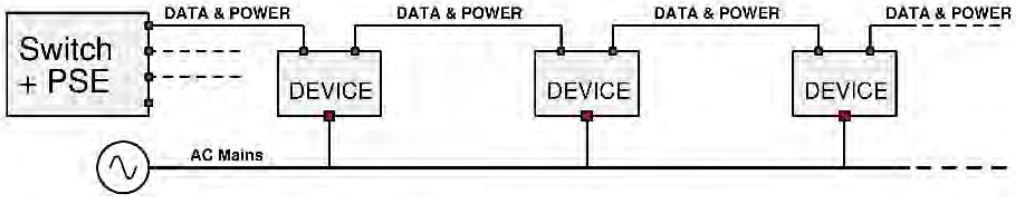
From http://www.ieee802.org/3/10SPE/public/Nov2016/yseboodt_10spe_01_1116.pdf

Lighting

Architecture for Lighting



Devices (luminaires, sensors, …) are connected in passive linear topology. DALI carries a limited amount of power, and offers bus based data at very low data rate.

Requirements for 10BASE-T1:

1. **Redundancy:** Device fault doesn't interrupt data & power flow
2. **Power:** Mains failure doesn't interrupt data & power flow
3. **Topology:** Linear wiring possible (active or passive)

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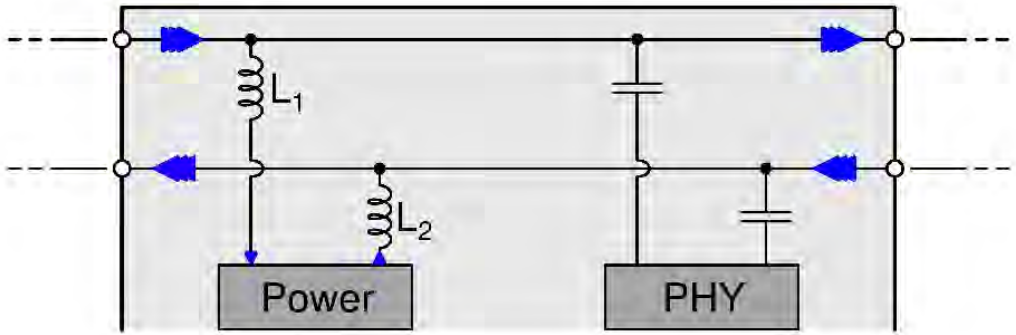
Lighting

Multidrop 10SPE powering



The total current of all downstream devices flows through the device. No series components are required. Power is tapped through inductors L_1 and L_2, which only need to be sized according to the PD consumption. A large amount of pass-through current can be specified with minimal cost impact.

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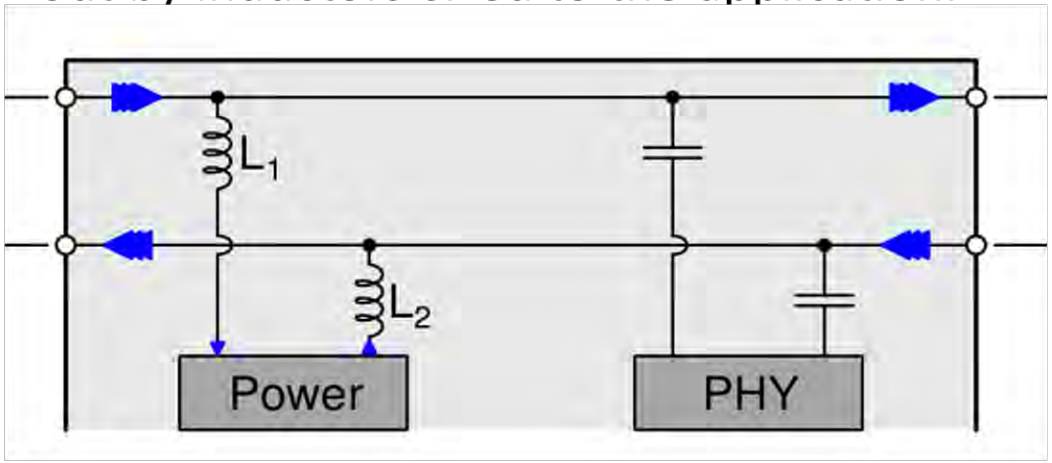
From http://www.ieee802.org/3/10SPE/public/Nov2016/yseboodt_10spe_01_1116.pdf

Lighting

- In a multidrop system, current can be tapped out by inductors sized to the application.



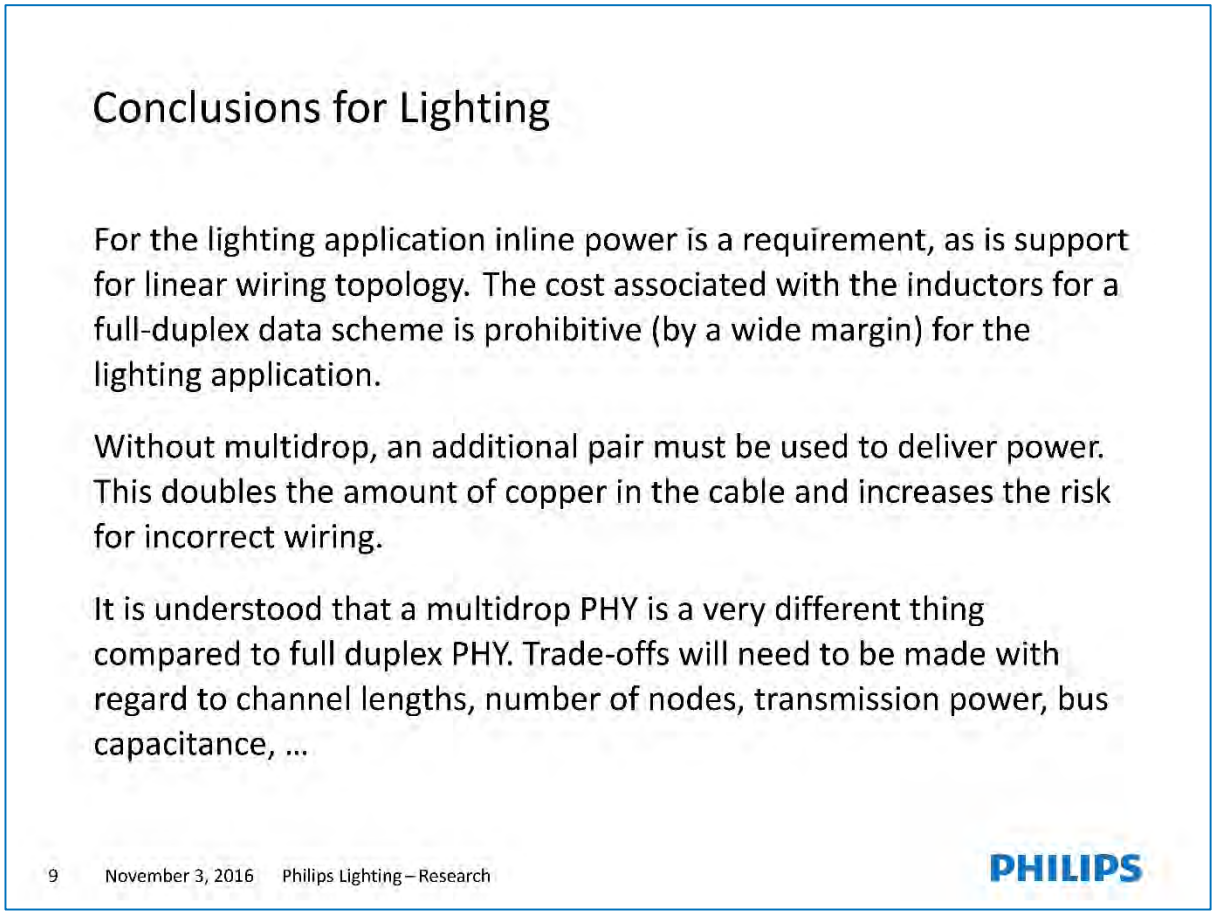
From http://www.ieee802.org/3/10SPE/public/Nov2016/yseboodt_10spe_01_1116.pdf

Lighting

Current outdoor pole heads come with two sockets. The top socket makes an uplink and the bottom socket can be used for sensors, wireless radios, etc. SPE multidrop with supports this application

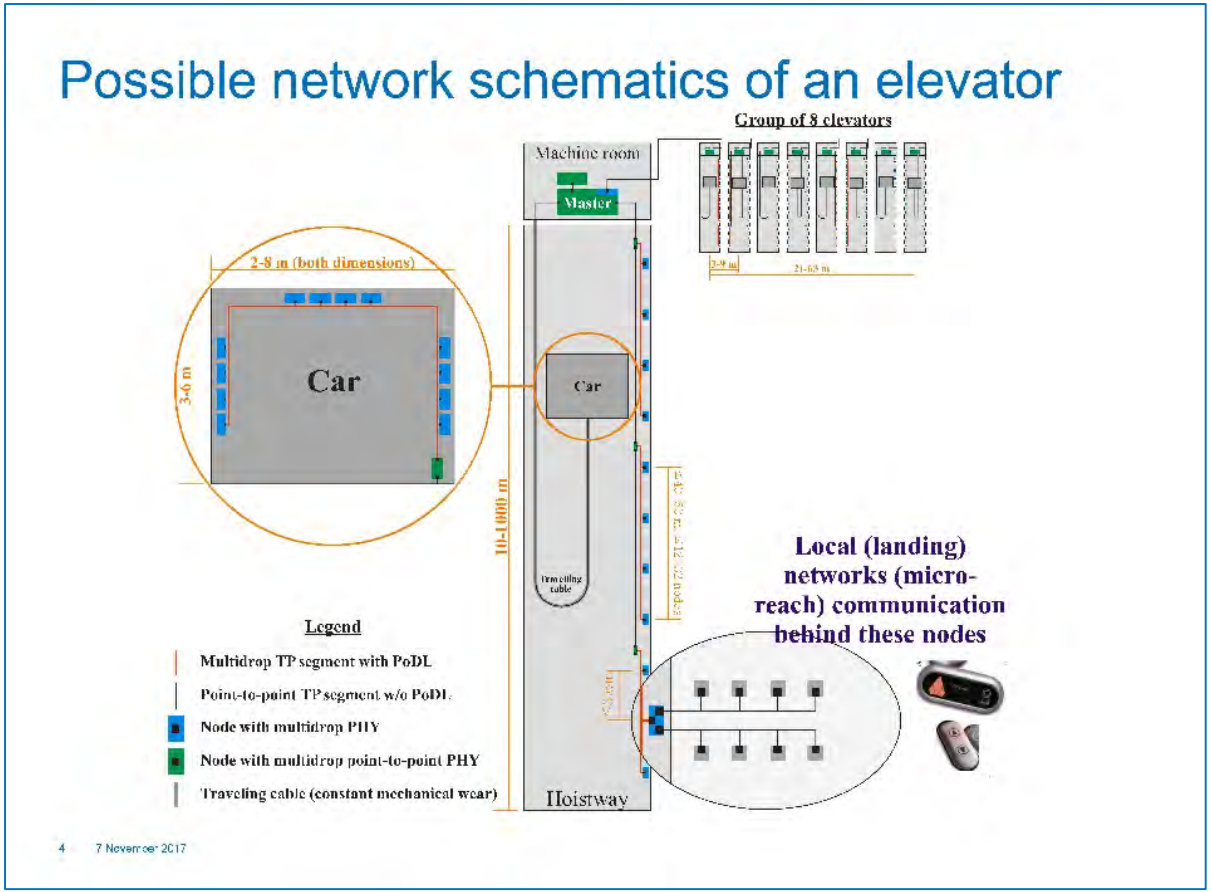
From http://www.ieee802.org/3/10SPE/public/Nov2016/yseboodt_10spe_01_1116.pdf

Lighting



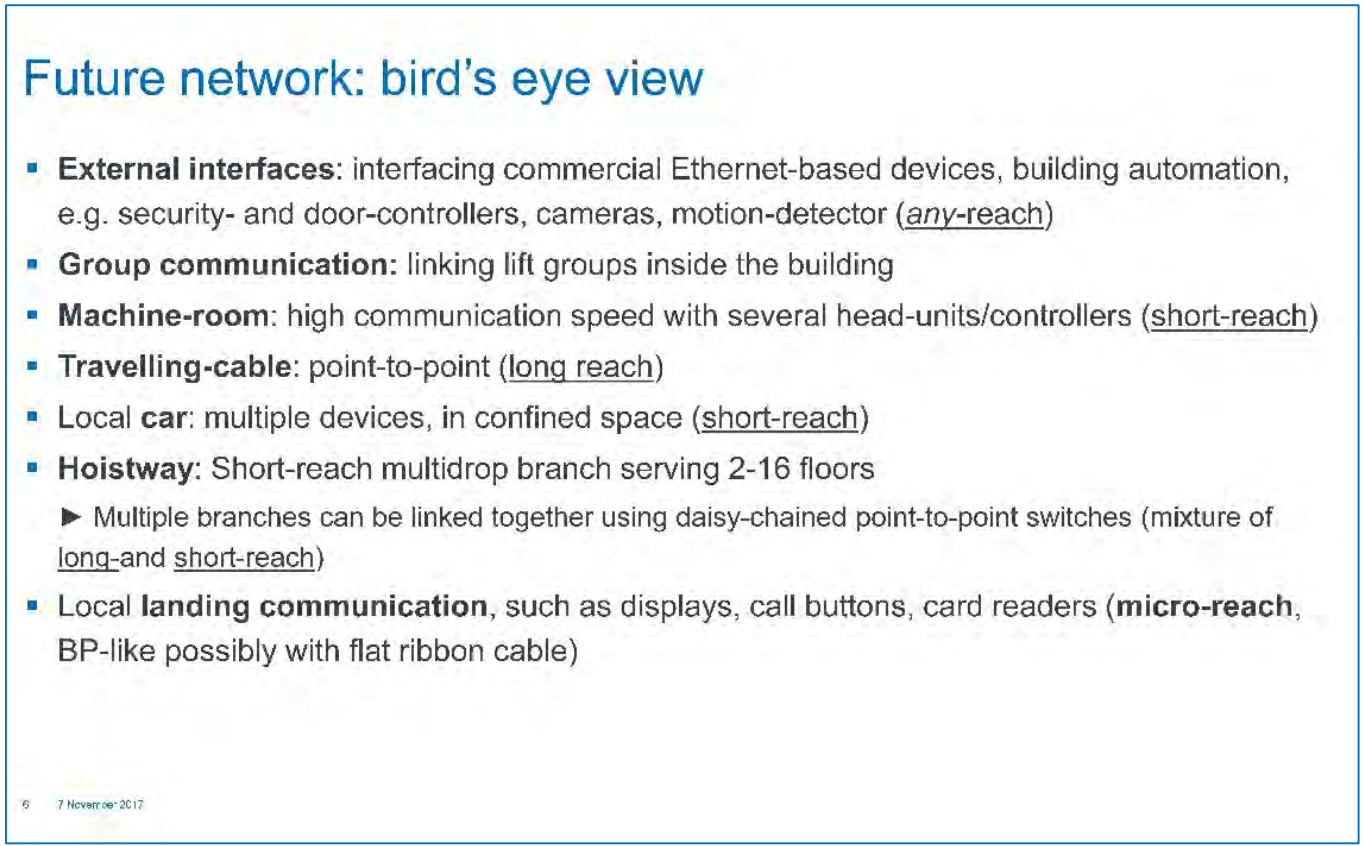
From http://www.ieee802.org/3/10SPE/public/Nov2016/yseboodt_10spe_01_1116.pdf

Elevators



From http://www.ieee802.org/3/cg/public/Nov2017/kattainen_huszak_3cg_01b_1117.pdf

Elevators



From http://www.ieee802.org/3/cg/public/Nov2017/kattainen_huszak_3cg_01b_1117.pdf

Elevators

Future network: "all over Ethernet" network end-to-end

Type	Reach	Nodes	Topology	PoNetwork	Notes
Micro-reach[1]	≤10m	≤8 nodes	Multidrop	Yes	New use-case, similar to BP[1]
Short-reach	**≤40m**	**≤24 nodes**	Multidrop	Yes	**Would a straw-poll be possible to probe interest and support?**
Long-reach	≤1000m	2 nodes	Point-to-point	No	

- Multidrop (half-duplex) 10SPE to **replace legacy networks** (RS485, CAN, I2C etc.), extension of reach and number of nodes shall be considered, as follows:
  - Reach: "minimum 40m" instead of "minimum 15m"
  - Nodes: "up to 24 nodes" instead of "up to 6-8 nodes"

  + PoNetwork as an option

- [1] Not a new PHY, just a new use-case, so in real life micro- ad short-reach would run on the same PHY

7 7 November 2017

From http://www.ieee802.org/3/10SPE/public/Nov2016/yseboodt_10spe_01_1116.pdf

Elevators

Power-budget (short- and micro-reach)

- Some (original) expectations were beyond possibilities
- Adjusted expectations show that core features of up to 24 nodes / MD segment could be covered by 32W (at 24VDC) at the PD side → **is this reasonable or shall we go deeper in adjustment of requirements?**
- Further decrease of consumption can be achieved by:
  - Decoupling core features (communication and control) from mechanisms where consumption can not be brought beyond a certain point (involving physical motion, sound, lightning)
    - All functional and safety control elements has PoNetwork
    - Exposed and power-demanding parts (LCD displays, actuators, relays, LED arrays) have local PSU
  - Introduction of new technologies (with less power consumptions)

From http://www.ieee802.org/3/cg/public/Nov2017/kattainen_huszak_3cg_01b_1117.pdf

Market Data

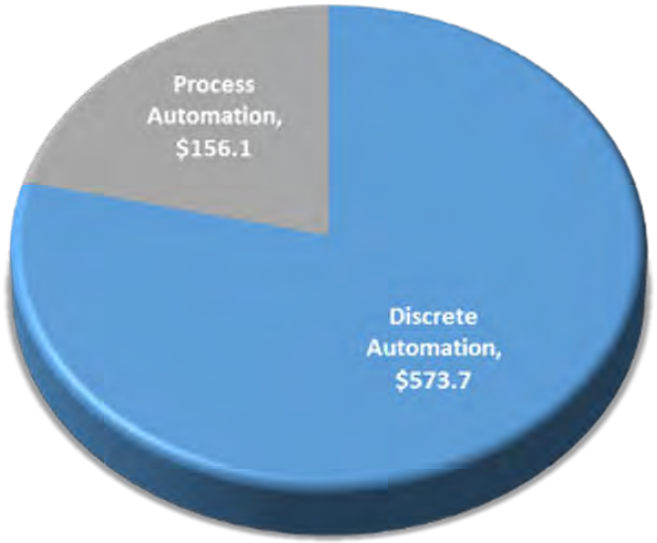
In-Cabinet

From www.ieee802.org/3/cg/public/Mar2017/brandt_cg_01_0317.pdf

“Simple Industrial I/O Devices

- PAM for Industrial Internet of Things in 2019 is projected to be $48.6B with a 15.6% CAGR
- Simple industrial I/O devices have a projected PAM of $729.8M with a 22.3% CAGR in 2019

IIoT I/O PAM (2019): $729.8M



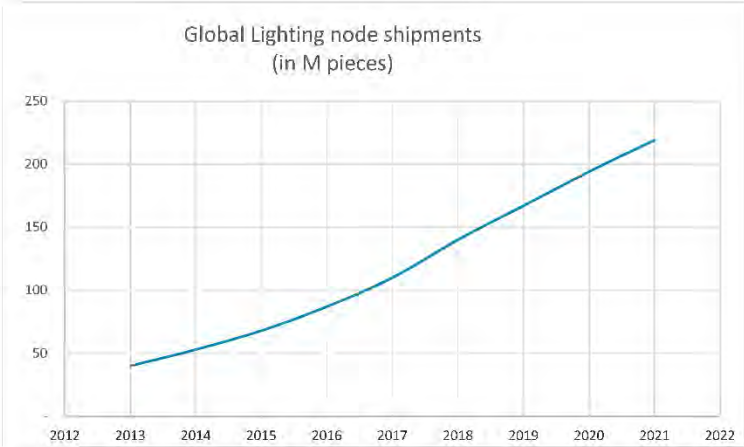
Data Source: ARC “Total Available Market for the Industrial Internet of Things” 2015

PAM for this study is the “Projected Available Market”. PAM = TAM x adoption rate
“Simple Industrial I/O Devices” includes pilot lights, push buttons, selector switches , contactors, etc.

Lighting

Connected Lighting market

- Market studies show constant growth in Building Automation Systems
- The market for connected Lighting nodes grows as projected by Navigant Research



Source:
NAVIGANT RESEARCH
Smart Buildings Networking and Communications, 2014

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From http://www.ieee802.org/3/10SPE/public/Sept2016_Interim/wendt_10SPE_01_0916.pdf

Elevators

Introduction (elevators, global)

- Current network solutions: legacy, slow-speed networking
  - Volume: mainly RS485-, CAN- and simple proprietary solution-based products
- On the worldwide market:
  - Currently: ≈850.000 new installations / year: each having avg. 20 serial port interfaces
  - 2020: ≈1.000.000 new installations / year, meaning 20 million nodes / year
- Requirements of near-future systems (functional safety, voice and video streaming, Power over Network/PoNetwork) can not be met using these networks
- Product's life (market-dependent):
  - Life-cycle is 15-30 years
- We can estimate that half of the 20 million nodes per year market could be Ethernet-based in ten years' time

From http://www.ieee802.org/3/10SPE/public/Nov2016/yseboodt_10spe_01_1116.pdf

Info, Ideas, Questions, etc.

Possible Power Allocation

- All devices implementing multidrop must tolerate power
  - This is already covered in 147.9.3 MDI line powering voltage tolerance
- Device connection sequence
  - Multidrop PD is connected
  - PD draws limited power during power negotiation (0.5w??)
  - PD uses LLDP (802.3 2018 79.3.2 Power Via MDI TLV) to negotiate with PSE:
    - If granted: PSE allocates power and PD moves to power up phase (implies inrush)
    - If denied (insufficient power at PSE): PD goes to some low power standby mode
  - If the request was denied and power later becomes available:
    - PSE uses “Wake-on-LAN” to get PD out of standby state.
    - PD restarts LLDP negotiation

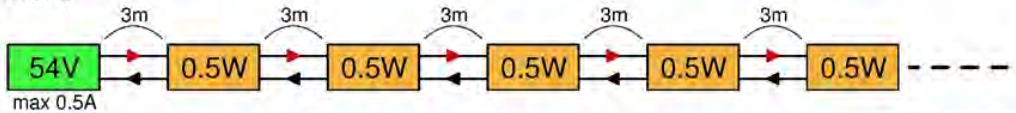
Lighting

Benchmarking

Common assumptions to all simulations:

- V_{PSE} = 54V, maximum current 0.5A
- Between each node: 3 meter of AWG24 copper cable, single twisted pair at 20°C
- Each device consumes 500mW
- Lowest allowable PD voltage is 35V (stability)
- 220 µH inductors (L_1 – L_4)
- The relative cost compares the BOM cost of inductors L_1 – L_4 only!

The simulation keeps attaching a node in daisy chain with the last until either the last PD voltage is less than 35V, or the PSE current exceeds 0.5A.



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From http://www.ieee802.org/3/10SPE/public/Nov2016/yseboodt_10spe_01_1116.pdf

Lighting

Benchmarking results

Name	DCR	Rel. cost	Nodes	Efficiency
Multidrop	5.40 Ω	1.00	48	88.7 %
Full Duplex (inductor 1)	0.75 Ω	6.90	28	70.7 %
Full Duplex (inductor 2)	0.40 Ω	14.7	36	71.7 %
Full Duplex (inductor 3)	0.19 Ω	33.9	43	77.6 %
Full Duplex (inductor 4)	0.15 Ω	62.0	44	80.0 %

Calculations show there is a severe cost and performance penalty for the full duplex linear powering method. The most cost effective full duplex solution is still more than 6x as expensive (inductor wise) compared to multidrop, and can support 28 versus 48 nodes at much lower efficiency. If lower DCR inductors are used (eg. inductor 3), performance is somewhat comparable, but the inductor cost is 33x higher than multidrop.

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From http://www.ieee802.org/3/10SPE/public/Nov2016/yseboodt_10spe_01_1116.pdf

Things to consider

- High level requirements, e.g., reach, number of devices, max PSE power.
  - Current reach/device count is 25m and 8 devices
  - Need to look at coupling inductance for power
  - Need to look PLCA performance
- Power details
  - Power allowed to complete LLDP negotiation
  - Power allowed for low power standby
  - Inrush current
  - Connector (MDI) power characteristics
  - Live insertion for all devices or detection for first device (NEC implication)
- Best practice guidance for cable design/installation (expected to vary per company and/or per vertical).

Next Steps

How to help?

I'm planning for a CFI in Vienna in July

I will be running weekly calls to review the draft CFI deck. I plan to schedule these at 8:00am – 9:00am PT Wednesdays

802.3cg and 802.3ch/B10GAUTO adhocs alternate using the Wednesday 7-9PT slot. I expect 802.3cg will not meet or will not require the full slot, and the overlap with 802.3ch/B10GAUTO will be manageable.

I'm looking for:

- Interested parties to participate in the process
- Additional use cases
- Additional market data
- Additional technical analysis

Please contact me (petejone@cisco.com) if you are interested in helping.

Thank You!