SPMD Usecase Library

Usecases

Name	Contact	Affiliation
Prof. Lighting controls	Lennart Yseboodt	Signify
Industrial Sensor Networks	Christopher Pohl	Beckhoff Automation
Industrial In-Cabinet Use Case	Bill Martin	Rockwell Automation
Elevators	Ari Kattainen	Kone
Building HVAC	David Hoglund	Johnson Controls
Commercial HVAC	Andrew Rodgers	ACE IoT Solutions
Industrial Networked Sensors	Bill Martin	Rockwell Automation
Transportation – Train / Tram Inside	Cornelia Eitel	Hirschmann Automation
Train/Tram- Door	Cornelia Eitel	Hirschmann Automation
Industrial Sensor Network	Cornelia Eitel	Hirschmann Automation
Buildings Use Cases	Bruce Nordman	LBNL
Node Based Lighting Solution	Chad Jones	Cisco
Retrofitting buildings with building automation	Gideon Intrater	Adesto Technologies
Lighting control	Scott Wade	WadeLux/DiiA
IEC/IEEE 60802 - UC10 - 10 Mbit/s end-stations (Ethernet sensors)	Jordon Woods	ADI

Item	Description
Supported nodes on one mixing segment	Indicate the numbers of nodes on a single mixing segment. The minimum reflects the number of nodes needed for the usecase to make sense. The desired value represents a natural fit for the application. Both numbers could be the same.
Minimum supported cable length	Is the length you need between the two furthest nodes on the mixing segment.
Acceptable cable gauges	What cable gauges can be accepted for the application (consider cost, size, bend radius, …)
Required power for a node	How much power is needed in the node to run the application. This is the power level as measured at the connector of the device. Note that there may be a rectifier or other elements that cause some loss (2% to 5% typical).
60V voltage OK ?	Is it acceptable for the input voltage to be up to 60V ? If not, what is the reason ?
Required initial power allocation	Because this is a bus powered system, a node needs to be permitted to draw some amount of power after being plugged in. This power is used to communicate with the PSE about the power requirements. The system should be able to operate it's PHY with this power. How much power do you foresee to need for this. This is different from the "Required power for a node" which is about the complete power need of the device.
Interoperability level for the application	Choose between "plug&play" or "engineered" system. Plug & play means that a compliant device works when connected to a network of other compliant devices. There is no need for configuration or to verify if devices will be compatible or not. Engineered system means that you will use the standard within your own products or that the end user can determine which devices will work in the system.
Pass through or T connection	See slide 4-6 of http://grouper.ieee.org/groups/802/3/SPMD/public/sep19/spmd_cjones_01_0919.pdf If the application cannot be equipped with two connectors, select T connection. If it must be possible to live connect a new node without disconnecting other nodes, also select T connection.
Hotpluggability	Should it be supported to connect new devices while the bus is powered and guaranteed that this does not cause devices to be interrupted (eg. Reboot, lose long stretches of data). If not required, select no.
Possible market size	Potential market expressed in number of nodes. Do not express this in currency of any kind due to IEEE SA rules.
PTP/1588, TSN	Requirement for IEEE 1588/802.1AS Precision Time Protocol (PTP) and Time Sensitive Networking (TSN)

Library

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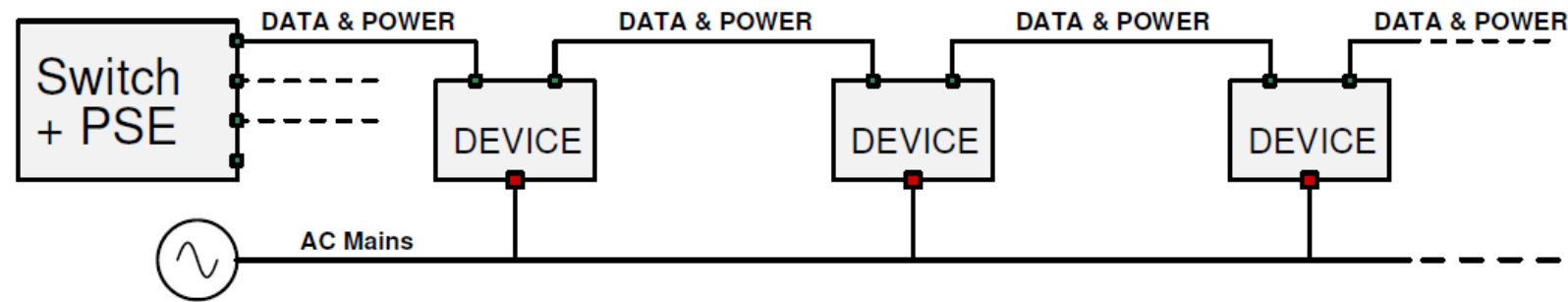
Devices (luminaires, sensors, …) are connected in passive linear topology. DALI carries a limited amount of power, and offers bus based data at very low data rate.

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)

Usecase: Prof. Lighting controls

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	8	16	
Minimum supported cable length	30	50	
Acceptable cable gauges	#28 to #23		
Required power for a node	5	More=better	
Required initial power allocation	1W	1.5W	1W per current understanding of power requirements of 10BASE-T1
60V voltage OK ?	Yes		
Interoperability level for the application	Plug&play		
Pass through or T connection	Passthrough		Passthrough is preferred due to installer familiarity
Hotpluggability	Required		
Possible market (in #nodes/year)			
PTP/1588, TSN			

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

Usecase: Industrial Sensor Networks

- Lower end multidrop bus **including power**

- Easy to wire in the field

- Small footprint

- Significantly reduce wiring cost

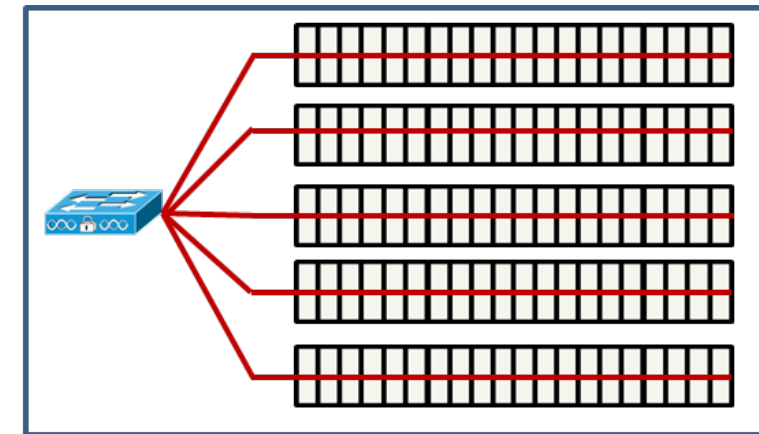- Allow for more sensors in the field (condition monitoring, predictive maintenance, IIOT, ...)

Switch & PSE
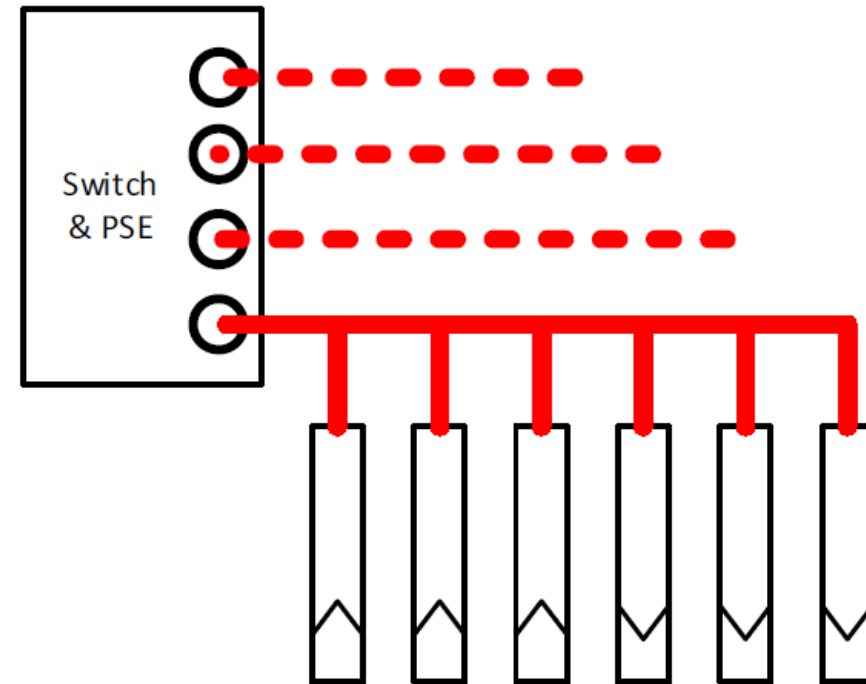
Usecase: Industrial Sensor Networks

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	8	32	
Minimum supported cable length	50	75	
Acceptable cable gauges	#24 to #18		
Required power for a node	2W		Tolerating current peaks from (e.g.) solenoid switching is more important than greater overall power
Required initial power allocation	~0.15W + PHY	~0.25W + PHY	
60V voltage OK ?	Yes **		24V tolerated in engineered solutions + what kind of tolerance is generally attached to 60V?
Interoperability level for the application	engineered		
Pass through or T connection	T		
Hotpluggability	Required		
Possible market (in #nodes/year)	3 million +		
PTP/1588, TSN			

Presentation: http://www.ieee802.org/3/SPMD/public/sep19/spmd_pohl_01_0919.pdf

Usecase: Motor Control Cabinet

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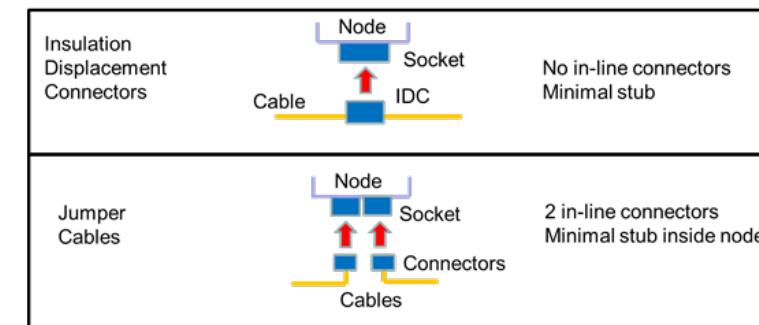
- A typical cabinet might contain 5 rows of 20 devices
- Low port count switch serves the segments.
- Replace 100 wires with 5 multidrop modular connections
- Reduces material costs, cabinet size, assembly time, etc.

Example connectivity options

- 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%
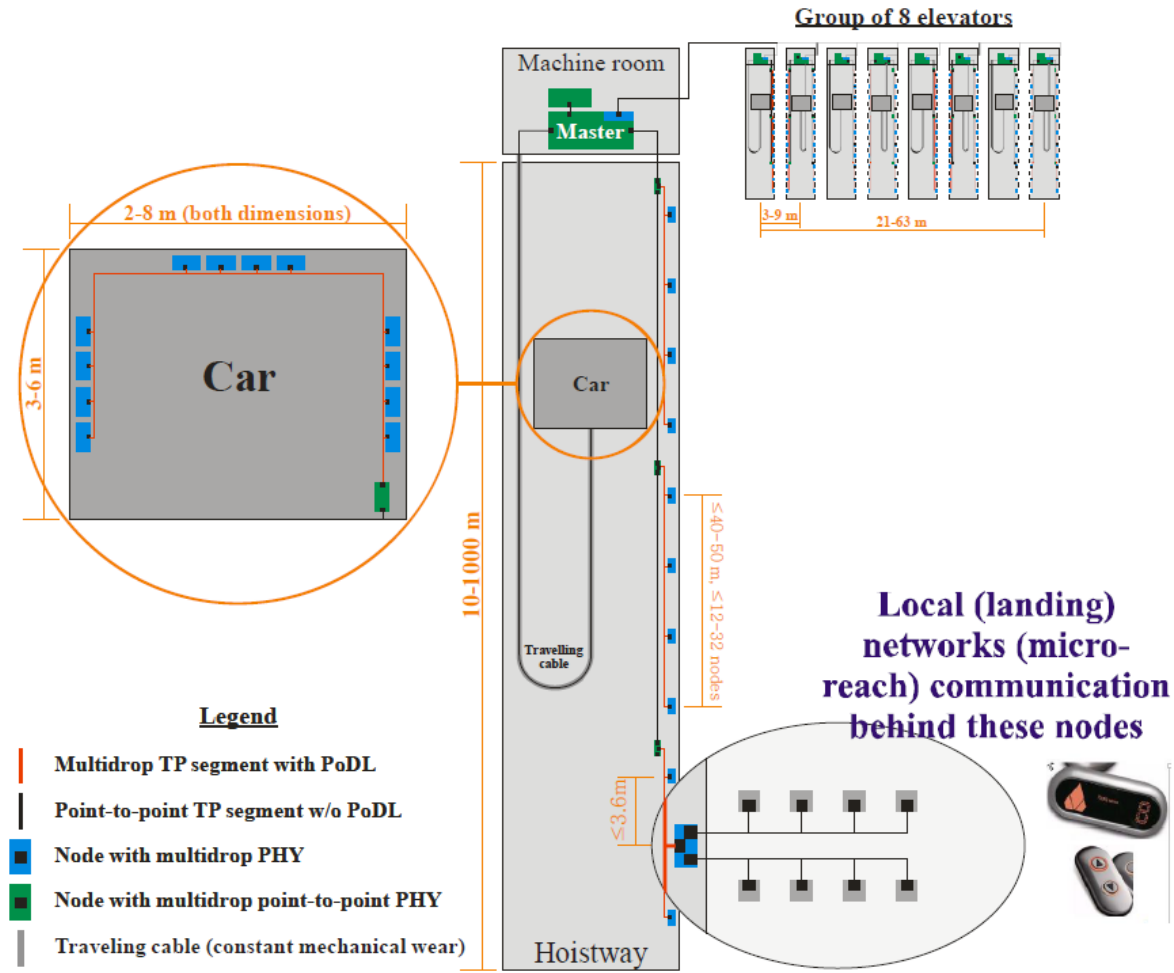 - L2 Managed Switches CAGR 2018-2024:   13.9%

Presentation: http://www.ieee802.org/3/SPMD/public/sep19/martin_SPMD_01_0919.pdf

Usecase: Motor Control Cabinet

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	40	64	
Minimum supported cable length	25	75	
Acceptable cable gauges	#24 -#20		
Required power for a node	0.5W	1W	
Required initial power allocation	0.5W		
60V voltage OK ?	No		
Interoperability level for the application	Engineered		
Pass through or T connection	T connection		
Hotpluggability	Required		
Possible market (in #nodes/year)			
PTP/1588, TSN			

Presentation: http://www.ieee802.org/3/SPMD/public/sep19/martin_SPMD_01_0919.pdf

Usecase: Elevators

Group of 8 elevators

Machine room

Master

Car

2-8 m (both dimensions)

3-6 m

Car

10-1000 m

Travelling cable

3-9 m

21-63 m

≤40-50 m, ≤12-32 nodes

≤3.6m

Hoistway

Local (landing) networks (micro-reach) communication behind these nodes

Legend

| Multidrop TP segment with PoDL
| Point-to-point TP segment w/o PoDL
■ Node with multidrop PHY
■ Node with multidrop point-to-point PHY
| Traveling cable (constant mechanical wear)

Usecase: Elevators

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	16	24	Current RS485 product max config. is 1+16 nodes, 5 m cable between nodes and 100W power at 24VDC and 4A.
Minimum supported cable length	50	75	4m cable x 12 floors
Acceptable cable gauges	24 to 16		Equals to 0,25 to 1,5 mm2
Required power for a node	5W	More=better	Separate wires for power are acceptable
Required initial power allocation	1W	1,5W	
60V voltage OK ?	Yes, desired value 24VDC		Currently 24VDC is standard in Elevator applications.
Interoperability level for the application	Engineered		
Pass through or T connection	Pass through		
Hotpluggability	No		Node physical order in the chain needs to be known. Current solution is seprate output to input wire between nodes.
Possible market (in #nodes/year)	30 000 000 nodes		Total world wide elevators market is 1 000 000 per year having average 30 mixing segment nodes. Currently dominated with RS485, CAN and proprietary serial.
PTP/1588, TSN			

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

Usecase: Building HVAC

- The room controller communicates with the sensors and actuators.
- The air flow controller includes an ac motor.
- The other components are physical IO.

SPE topology
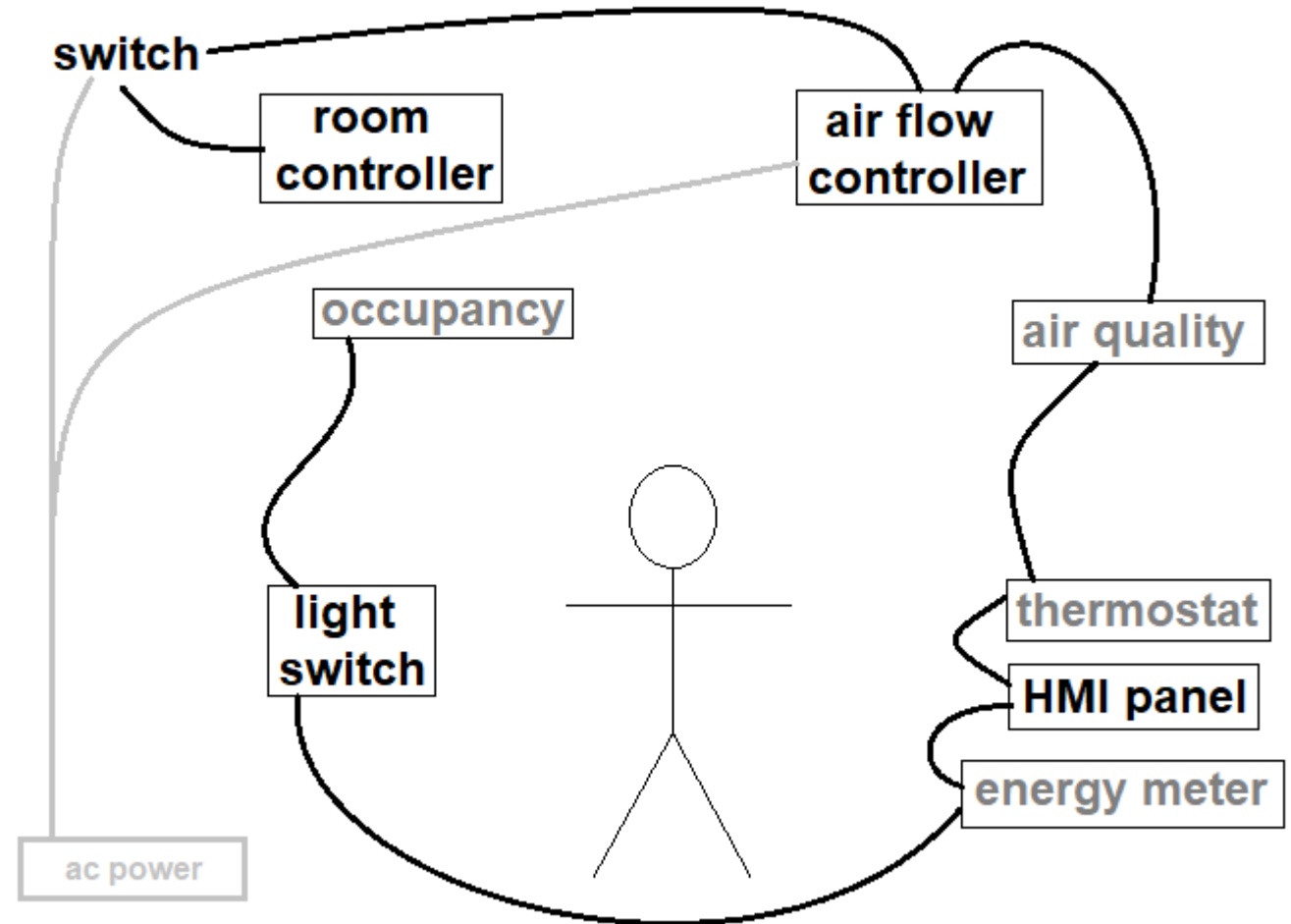
Usecase: Building HVAC

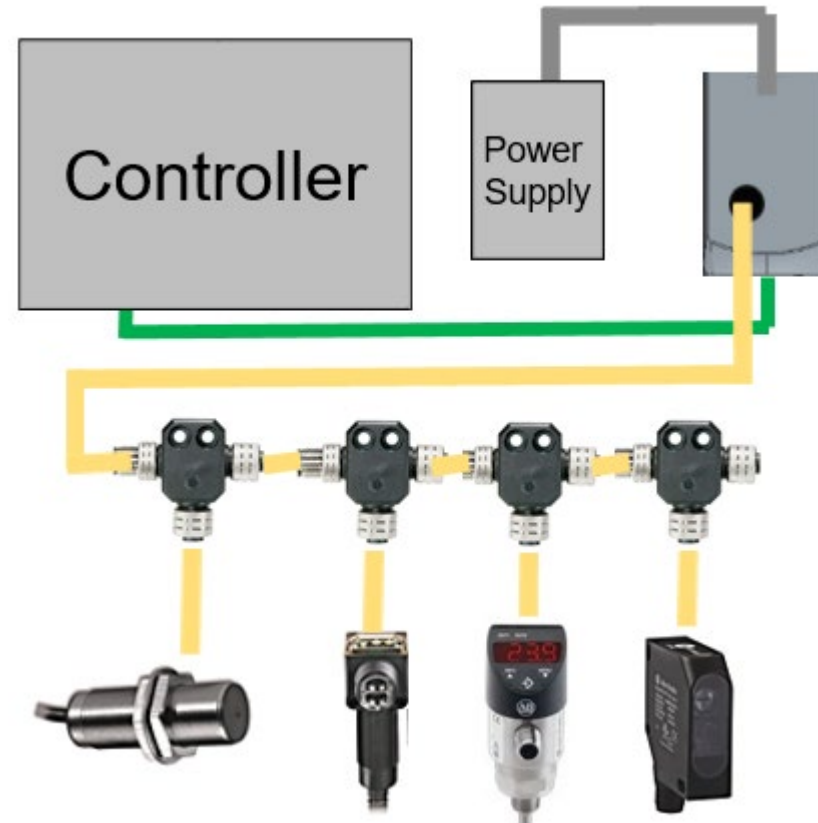| Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	8	16	
Minimum supported cable length	30 m	60 m	Circumference of a room
Acceptable cable gauges	22, 24, 26		Typical. We could also use thicker wire.
Required power for a node	2 W	5 W max	
Required initial power allocation	0.5 W	1 W	
60V voltage OK ?	yes		
Interoperability level for the application	Plug&play		
Pass through or T connection	Pass through		The stubs for T would not be long enough. Everything is 0.5 t o1.5 m above the floor. The ceiling height is 2.5 to 4 meters.
Hotpluggability	yes		Can tolerate a 30 sec dropout
PTP/1588, TSN			

Usecase: Commercial HVAC

Simple use case figure

Usecase: Commercial HVAC

Item>	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	8	32	Replacing MSTP usually seen in VAV and Room thermostat deployments in commercial office buildings
Minimum supported cable length	10m		
Acceptable cable gauges	20-24		Currently deployed with 24ga comms and 20ga 24VAC power cable
Required power for a node	5W	10W	These devices make rather infrequent adjustments to their outputs, which means the vast majority of the time they may use as little as 1W, but would need to turn a motor occasionally. Coordinating the mixing segment to allow one device to draw additional power for a set amount of time would be acceptable.
Required initial power allocation	1W		
60V voltage OK ?	Not Sure		
Interoperability level for the application	Plug and Play		
Pass through or T connection	T		
Hotpluggability	Yes		
Possible market (in #nodes/year)	>100,000		
PTP/1588, TSN			

Usecase: Networked Sensors

Usecase: Industrial Networked Sensors

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	8	32	
Minimum supported cable length	10 Meters	100 Meters	
Acceptable cable gauges	#24 to #18		
Required power for a node	0.5 Watts	2.0 Watts	
Required initial power allocation	0.5 Watts	2.0 Watts	
60V voltage OK ?	No		Existing sensor product line is 24V DC
Interoperability level for the application	Engineered		
Pass through or T connection	T connection		
Hotpluggability	Required		
Possible market (in #nodes/year)	1 Million +		
PTP/1588, TSN	TSN		

Use Case: Transportation – Train / Tram Inside
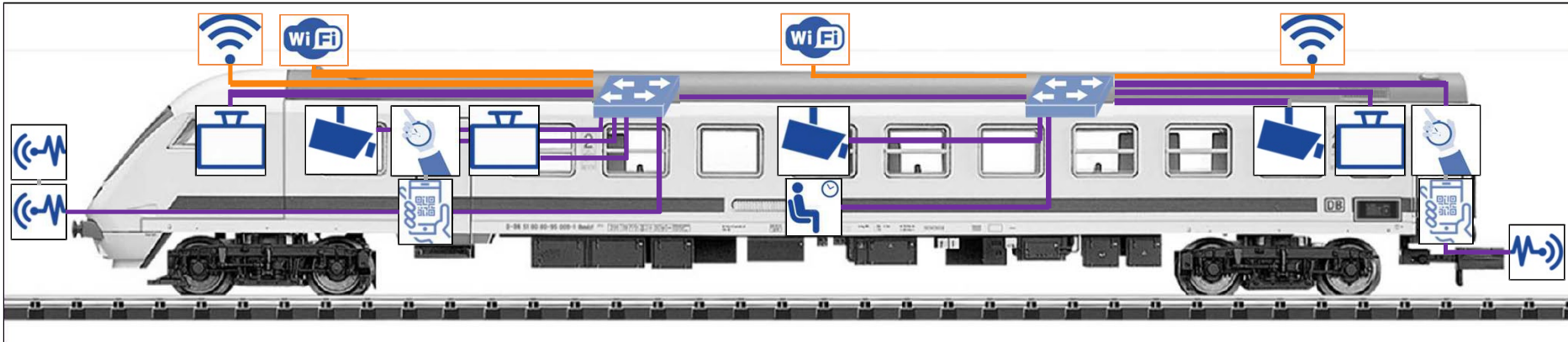
Display (inside/outside)		WLAN Router / Router		
Sensors		Ticket Automat		
IP Camera (inside/outside) / Door Surveillance		Seating Reservation		
Cellular Router		Passenger Counter IP Speaker / SOS Terminal		

— Single Pair Ethernet   — 4-pair Ethernet

Usecase: Train/Tram/Bus

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment		6	Passanger Counter, Stop Signal, Ticket automat, Door opener, SOS Terminal
Minimum supported cable length		25	
Acceptable cable gauges	AWG24/22		
Required power for a node	1W-30W	40-50W	In Summary without IP Speaker (no PoDL)
Required initial power allocation		2W	
60V voltage OK ?	24V		
Interoperability level for the application	Engineered		
Pass through or T connection	T-Connection		
Hotpluggability	No		
Possible market (in #nodes/year)	260 000 multidrop lines /year		IHS for 2020 with annual growth of 9%
TSN/PTP	Yes		Pre-emption

Usecase: Industrial Sensor Network
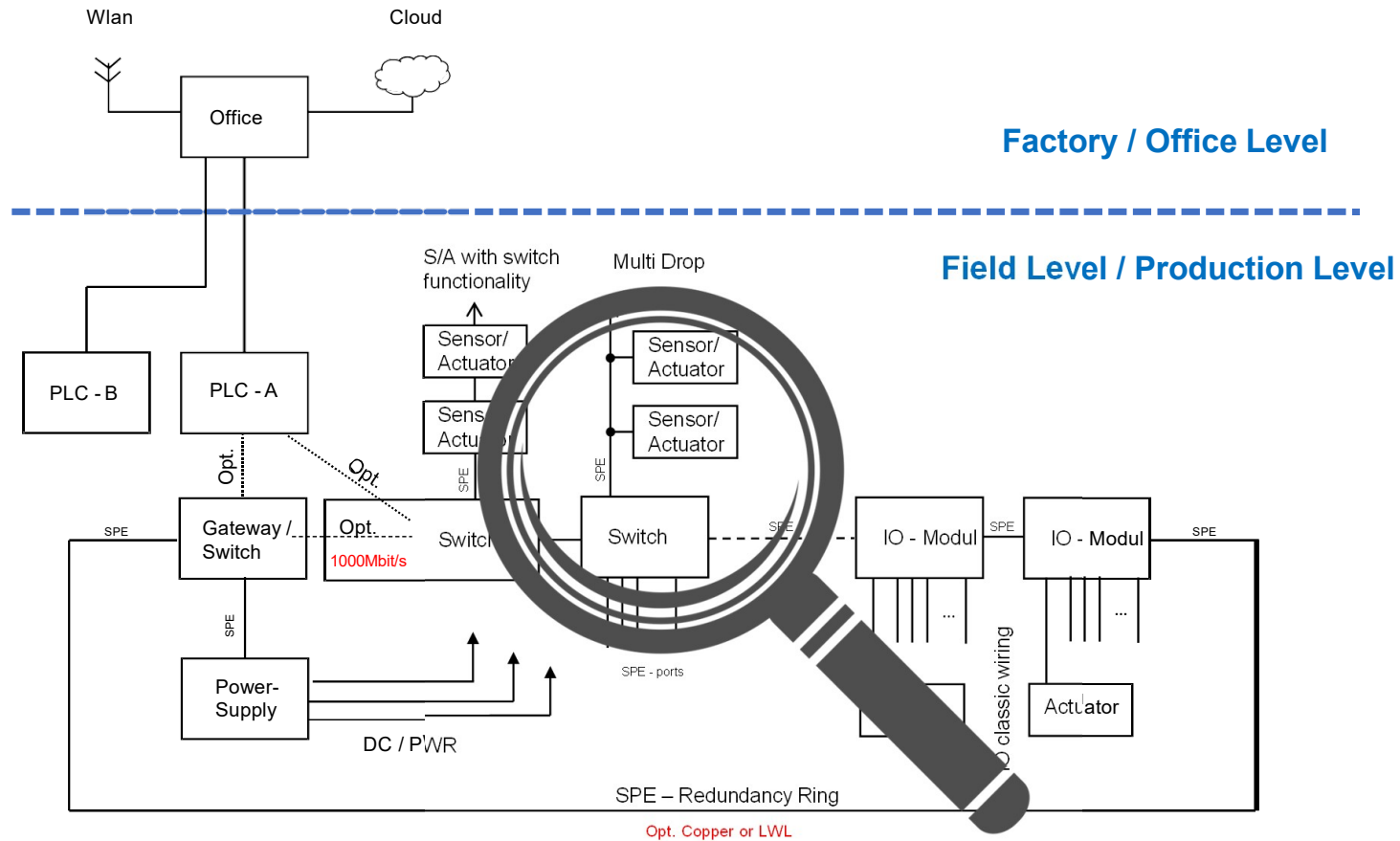
Usecase: Industrial Sensor Network

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	10	Up to 20	
Minimum supported cable length		50/75m	
Acceptable cable gauges	AWG24/22		
Required power for a node	1,5W	10W	
Required initial power allocation	0,5W	2W	
60V voltage OK ?	24V		
Interoperability level for the application	Engineered		
Pass through or T connection	T-Connection		
Hotpluggability	required		
Possible market (in #nodes/year)	1 Mio. multidrop lines/year		
TSN/PTP	Yes both required		

Presentation: http://www.ieee802.org/3/SPMD/public/jan20/Eitel_01_SPMD_0120.pdf

Usecase: Buildings Use Cases

Buildings (commercial and residential; industrial non-process) could host many, diverse, applications of MultiDrop SPE. Almost all would use new wiring. Three cases with slides. Others are: sensors (smoke, CO, CO_2, occupancy, …), ventilation fans, cameras, audio, HVAC (dampers, baffles). A single SPE cable might have diverse devices on it.

Availability of reliable power often a necessary or appealing feature.

Notes: Cable length values just a guess. Most other values loose.
Generally assume that if a device is removed, can join cables with a simple connector. Always want hot pluggability and plug-and-play configuration. A few devices will only use power; most will communicate.

Usecase: Lighting

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	5	10	
Minimum supported cable length	20 m	30 m	
Acceptable cable gauges			likely new wiring, so wire loss is main consideration.
Required power for a node	5	20	
Required initial power allocation	0.5	1	Only what needed to communicate.
60V voltage OK ?	Yes		
Interoperability level for the application	PnP		
Pass through or T connection	either, assuming can join cables with a connector		
Hotpluggability	Yes		
Possible market (in #nodes/year)	millions		

Notes: Mostly light sources of a variety of power levels. Could also include lighting controls (e.g. wall units) to power controls and facilitate communication with light sources. Some lights may be reliable emergency lights. Could be only controls (for SPE lights). Could include miscellaneous other ceiling devices, e.g. cameras, sensors, and HVAC controls.

Usecase: USB wall outlets

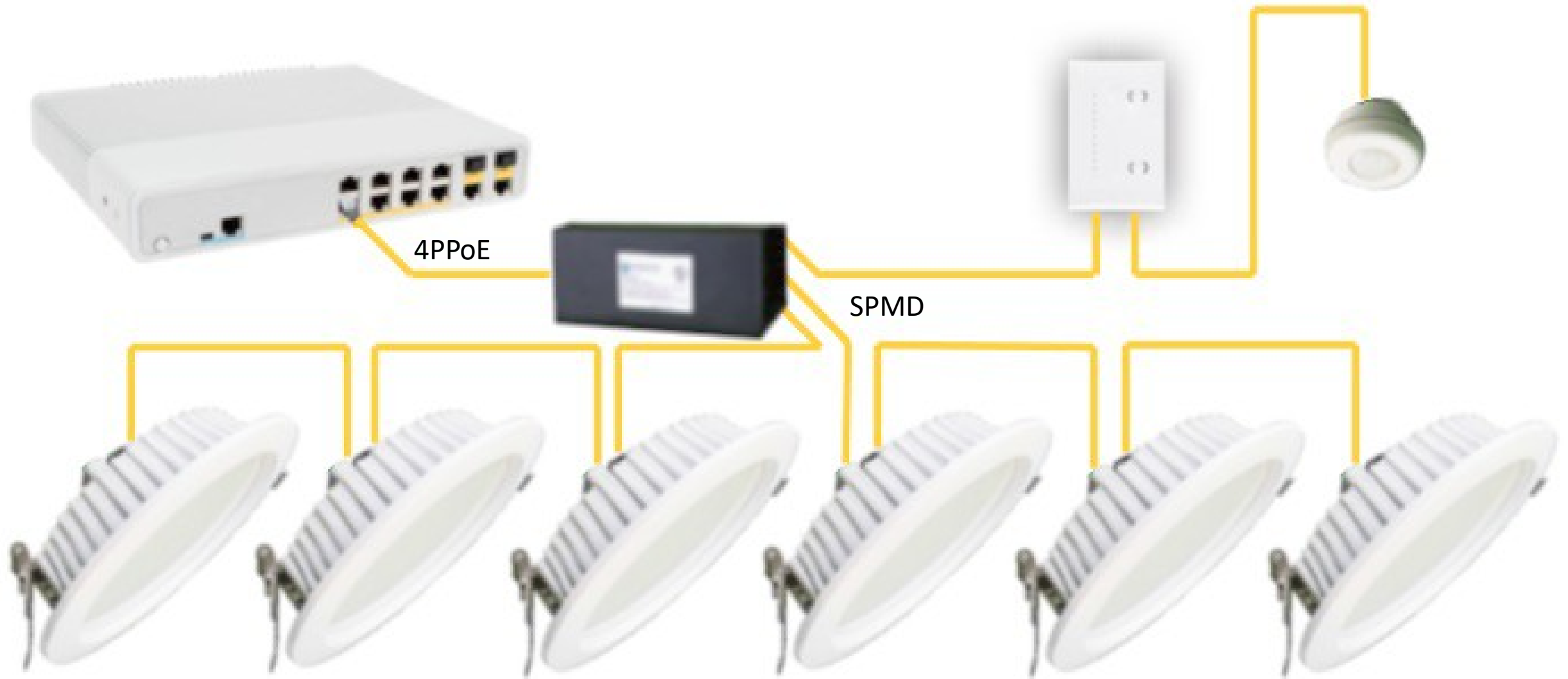| Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	4	10	
Minimum supported cable length	20	30	
Acceptable cable gauges			likely new wiring, so wire loss is main consideration.
Required power for a node	5	10	Min. available. Assume can negotiate higher levels.
Required initial power allocation	0.2	0.5	
60V voltage OK ?	Yes		
Interoperability level for the application	PnP		
Pass through or T connection	likely new wiring, so wire loss is main consideration.		
Hotpluggability	Yes		
Possible market (in #nodes/year)	millions		

Notes: 5 W minimum per port; some boxes may have multiple ports. Assume can negotiate any level up to near 100W if available.

Usecase: Outdoor loads

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	4	20	
Minimum supported cable length	20	40	
Acceptable cable gauges			likely new wiring, so wire loss is main consideration.
Required power for a node	5	10	
Required initial power allocation	0.5	1	Min. available. Assume can negotiate higher levels.
60V voltage OK ?	Yes		
Interoperability level for the application	PnP		
Pass through or T connection	likely new wiring, so wire loss is main consideration.		
Hotpluggability	Yes		
Possible market (in #nodes/year)	millions		

Notes: Loads could include anything outdoor including lighting, lighting control, cameras, audio, USB outlets, small pumps (fountains), sensors (occupancy, temperature, light). Safety, small wire size, and ease of installation a key benefit.

Node Based Lighting Solution

4PPoE

SPMD

Usecase: Node Based Lighting

Item	Min Value	Desired value
Supported nodes on one mixing segment	8	14
Minimum supported cable length	25ft	35ft
Acceptable cable gauges	14AWG, 16AWG	
Required power for a node	5W	0.5W - 30W
60V voltage OK ?	Yes	
Required initial power allocation	No opinion, what ever the industry can offer	
Interoperability level for the application	Plug and play, but also engineered options	
Pass through or T connection	Pass through	
Hotpluggability	yes	
Possible market (in #nodes/year)	This is lighting. It's huge. But no definitive number I can state.	

Use case: Lighting
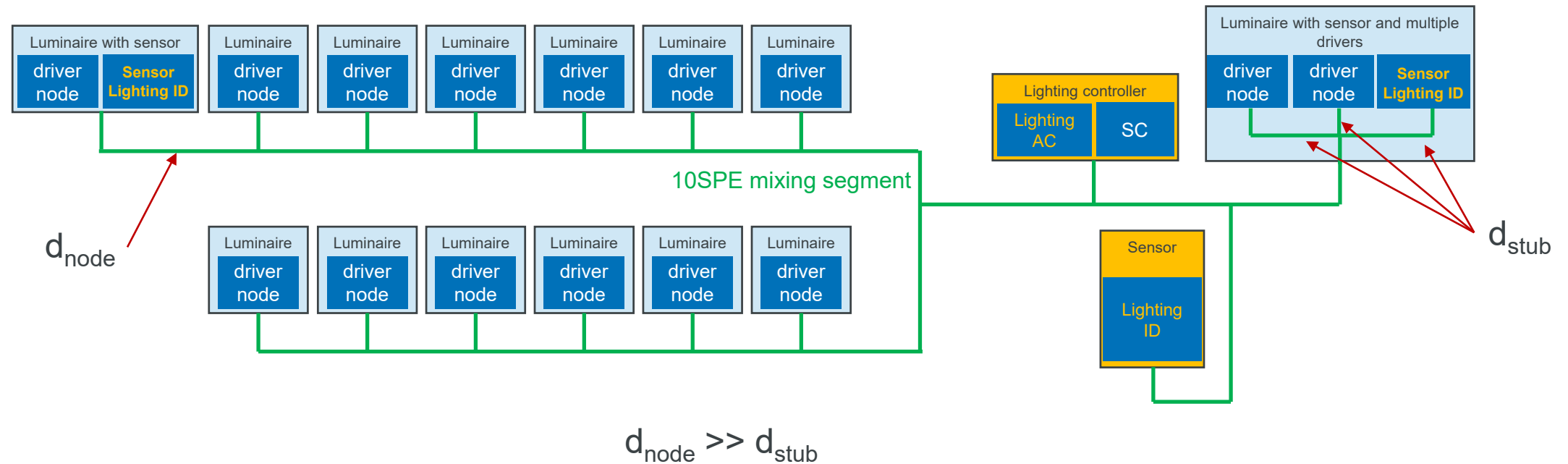
Lighting commissioning: The location or proximity of devices helps make it easier to assign them to groups that operate together. Each room or area may have lighting devices in 1 or more groups. Without knowledge of the topology, each luminaire/device must be identified (flashed) in turn.

Lighting AC = Lighting application controller (at least one per lighting system)
Lighting ID = Input device: provides information to the system, such as sensor data, button presses, etc.
**SC** = Segment coordinator. Often in the same product as the lighting application controller

Presentation: http://www.ieee802.org/3/SPMD/public/jan20/Wade_01_SPMD_0120.pdf

Usecase: Lighting control

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	Case 1: 128 Case 2: 6 Case 3: 10	512 50 30	MIN: Luminaires in a grid layout, so 3x3 luminaires plus 1 sensor.
Minimum supported cable length	30m	300m	MIN: 10 nodes, 2-3m between Desired: Same as DALI, making it suitable for larger offices.
Acceptable cable gauges	Sufficient to carry the power over the required distance.		
Required power for a node	Case 1: 0.3W (+ PHY) Case 2: 5W Case 3: 25W		Most nodes require 0.1W or less. Some outdoor wireless transceivers can may require up to 2W average, 5W peak. Office luminaires typically require 20-30W.
Required initial power allocation	0.1W + PHY		
60V voltage OK ?	Yes		Lighting control (0-10V and DALI) already require insulation rated above this.
Interoperability level for the application	Plug & play		Lighting must give basic operation "out-of-box" without configuration. This means "broadcast" on/off from sensors/buttons to the luminaires.
Pass through or T connection	-		Needs to be a low-cost solution for control gear (drivers)
Hotpluggability	Y		
Possible market (in #nodes/year)	250M		Based on expected regulatory push towards connected lighting for energy saving. Sales: EU: 100M pieces in 2030 + rest of world 1,5* EU Based on EU report (http://ecodesign-lightingsystems.eu/documents) Assumption that cost is equal or lower to DALI system.

Presentation: http://www.ieee802.org/3/SPMD/public/jan20/Wade_01_SPMD_0120.pdf

Retrofitting buildings with buildingautomation

- We won't define a 10Mb/s standard with >1Km range
- An alternative is shorter segments with nodes serving as Two Port MAC Relays (TPMRs)
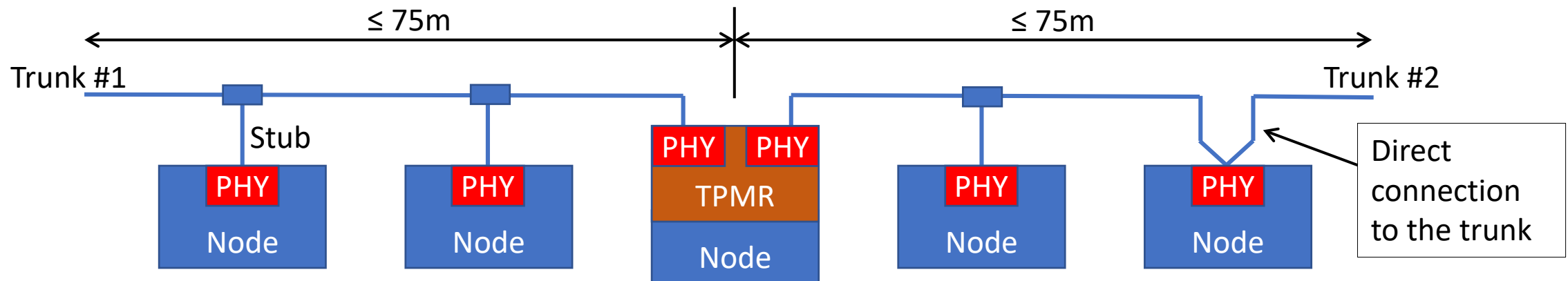
- The cost of nodes with a relay function will be higher
- Existing wire stubs may still pose an issue

Use case: Retrofitting buildings with building automation

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment	Up to 32	Up to 64	
Minimum supported cable length	75m	>> 75m	
Acceptable cable gauges	16 through 24AWG	16 through 24AWG	
Required power for a node	?	?	
60V voltage OK?	?	?	
Required initial power allocation	?	?	
Interoperability level for the application	engineered	plug & play	
Pass through or T connection	T-connection (1m)	T-connection (>>1m)	
Hotpluggability	?	?	
Possible market size	> 10s of million devices annually		

Presentation: http://www.ieee802.org/3/SPMD/public/jan1520/Retrofitting_buildings_with_building_automation.pdf

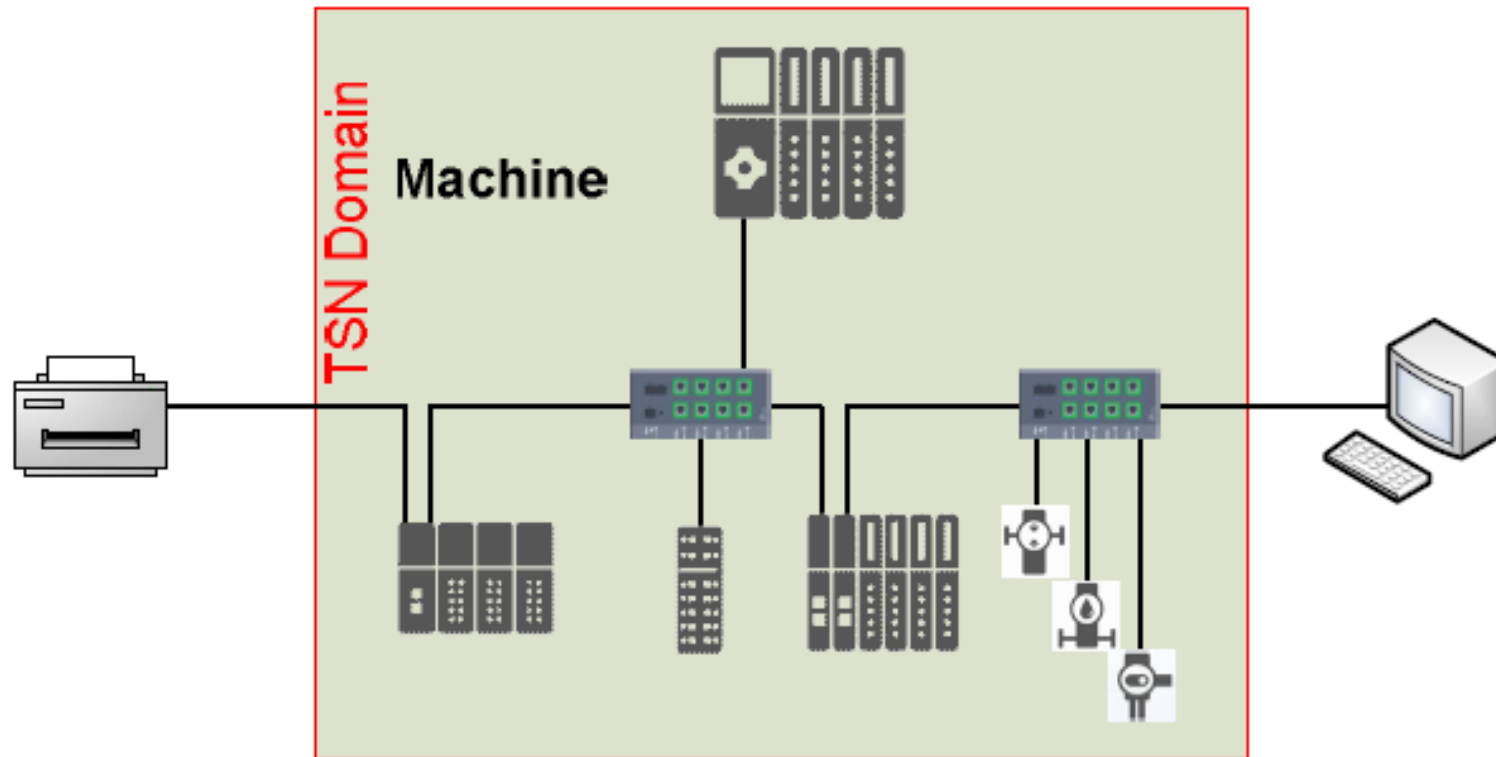# Usecase: IEC/IEEE 60802 - UC10 - 10 Mbit/s end-station

Figure 36 – Ethernet sensors

Usecase: IEC/IEEE 60802 - UC10 - 10 Mbit/s end-station

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment			
Minimum supported cable length			
Acceptable cable gauges			
Required power for a node			
Required initial power allocation		TBD	
60V voltage OK ?			
Interoperability level for the application			
Pass through or T connection			
Hotpluggability			
Possible market (in #nodes/year)			
PTP/1588, TSN			

Supplemental Material

Industrial Sensor Networks: 60V

- Industrial 24V is defined with a tolerance (-15%/+20%)
- This is required for any non-theoretical use case because of
  - SELV is 60V DC and below!
  - All components (e.g. power supplies!) come with a tolerance
  - Varying resistances, e.g. due to cabling
  - Alien noise + communication over power line
  - …
- Therefore, it looks like 48V (-15%/+20%) to me, allowing for SELV designs
- Also: wide input voltage range supply components up to 60V are readily available

Industrial Sensor Networks: Stub Lengths

- In Indianapolis, up to 10m were discussed
- This is not possible in any pratically feasible bus with more than a few 100 kBaud because
  - Impedances at the taps don't match
  - Results in reflections
  - Results in loss of signal strength
  - Can only be handled by a lot of electrical trickery and strict rules… not feasible

- → Stubs must be very few cm

Template

Usecase: <TITLE>

Simple use case figure

Usecase: <TITLE>

Item	Min Value	Desired value	Extra information
Supported nodes on one mixing segment			
Minimum supported cable length			
Acceptable cable gauges			
Required power for a node			
Required initial power allocation			
60V voltage OK ?			
Interoperability level for the application			
Pass through or T connection			
Hotpluggability			
Possible market (in #nodes/year)			
PTP/1588, TSN			

Presentation: <URL>

Item	Description
Supported nodes on one mixing segment	Indicate the numbers of nodes on a single mixing segment. The minimum reflects the number of nodes needed for the usecase to make sense. The desired value represents a natural fit for the application. Both numbers could be the same.
Minimum supported cable length	Is the length you need between the two furthest nodes on the mixing segment.
Acceptable cable gauges	What cable gauges can be accepted for the application (consider cost, size, bend radius, …)
Required power for a node	How much power is needed in the node to run the application. This is the power level as measured at the connector of the device. Note that there may be a rectifier or other elements that cause some loss (2% to 5% typical).
60V voltage OK ?	Is it acceptable for the input voltage to be up to 60V ? If not, what is the reason ?
Required initial power allocation	Because this is a bus powered system, a node needs to be permitted to draw some amount of power after being plugged in. This power is used to communicate with the PSE about the power requirements. The system should be able to operate it's PHY with this power. How much power do you foresee to need for this. This is different from the "Required power for a node" which is about the complete power need of the device.
Interoperability level for the application	Choose between "plug&play" or "engineered" system. Plug & play means that a compliant device works when connected to a network of other compliant devices. There is no need for configuration or to verify if devices will be compatible or not. Engineered system means that you will use the standard within your own products or that the end user can determine which devices will work in the system.
Pass through or T connection	See slide 4-6 of http://grouper.ieee.org/groups/802/3/SPMD/public/sep19/spmd_cjones_01_0919.pdf If the application cannot be equipped with two connectors, select T connection. If it must be possible to live connect a new node without disconnecting other nodes, also select T connection.
Hotpluggability	Should it be supported to connect new devices while the bus is powered and guaranteed that this does not cause devices to be interrupted (eg. Reboot, lose long stretches of data). If not required, select no.
Possible market size	Potential market expressed in number of nodes. Do not express this in currency of any kind due to IEEE SA rules.
PTP/1588, TSN	Requirement for IEEE 1588/802.1AS Precision Time Protocol (PTP) and Time Sensitive Networking (TSN)

Thank You