Evolution of copper cabling: how new systems for Intelligent buildings and changing our infrastructure design

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This presentation is:

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Agenda

1. Update of 25G Ethernet
2. PoE and Installation Methods
3. Single Pair Ethernet
4. New Infrastructure for Intelligent buildings
5. The Bigger Picture

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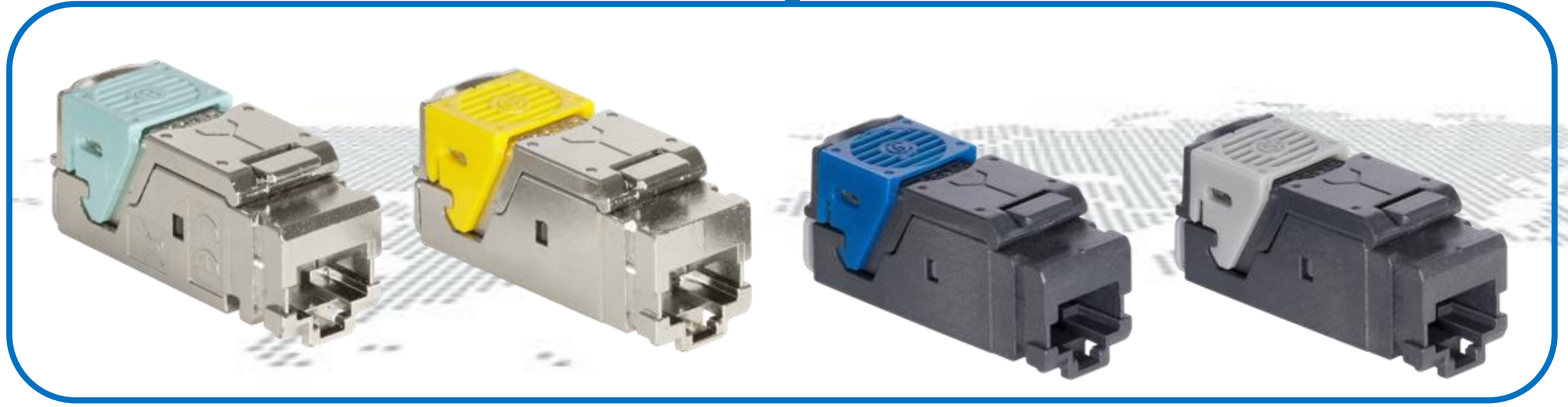
Cat.8, Class I and Class II

	Frequency	Distance	25 and 40 GBase-T	Cable	Connectors
TIA Cat.8	2 GHz	30m	Yes	F/UTP or S/FTP Cat.8	"RJ45" Cat.8
ISO Class I				Cat 8.1 = TIA Cat8	"RJ45" Cat.8.1 = TIA Cat.8
ISO Class II				S/FTP Cat.8.2	"Non-RJ45"



ISO / IEC TR 11801-9905

Guidelines for the use of installed cabling to support 25GBASE-T application

If you have existing cabling, can you use it for 25Gbase-T and how to verify compliance to the application.

Same as TIA TSB 95 for 1000Base-T on Cat.5

Same as TIA TSB 155-A and ISO/IEC TR 24750 for 10Base-T on Cat.6

- "Component requirements are not provided in this document and should not be inferred from the channel limits provided."
- "...design goals for 25GBASE-T ...frequency signal range up to 1250 MHz..."

manufacturers are not allowed to cite this document for product compliance

All channels must be re-qualified for 1250MHz.

Internal parameters
from 1 to 1250Mhz:
Field test.

Coupling attenuation
from 1 to 1250Mhz:
Field test or manufacturer test report

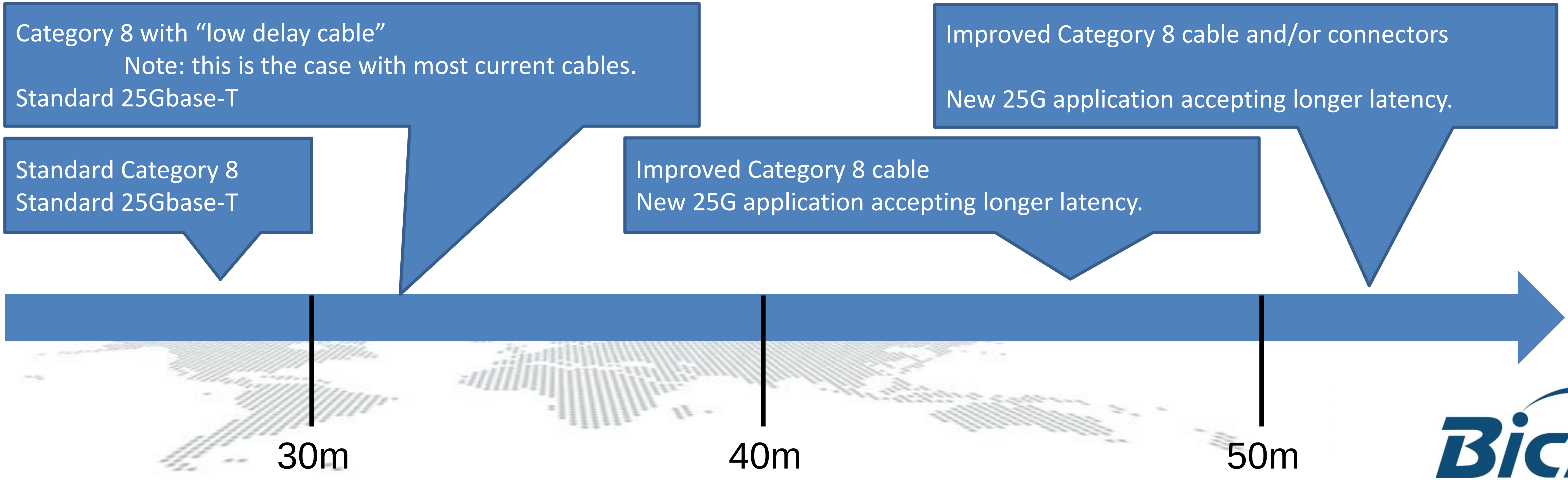
Alien crosstalk
from 1 to 1250Mhz:
Field test or manufacturer test report

ISO / IEC TR 11801-9909 DRAFT

Evaluation of balanced cabling in support of 25 Gb/s, with reach higher than 30m.

- Objective is to extend the reach of Category 8 (Classes I and II) from 30m to 50m…or more

Caution: IEEE is NOT interested in developing an new 25G application for longer latency



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1. Update of 25G Ethernet
2. PoE and Installation Methods
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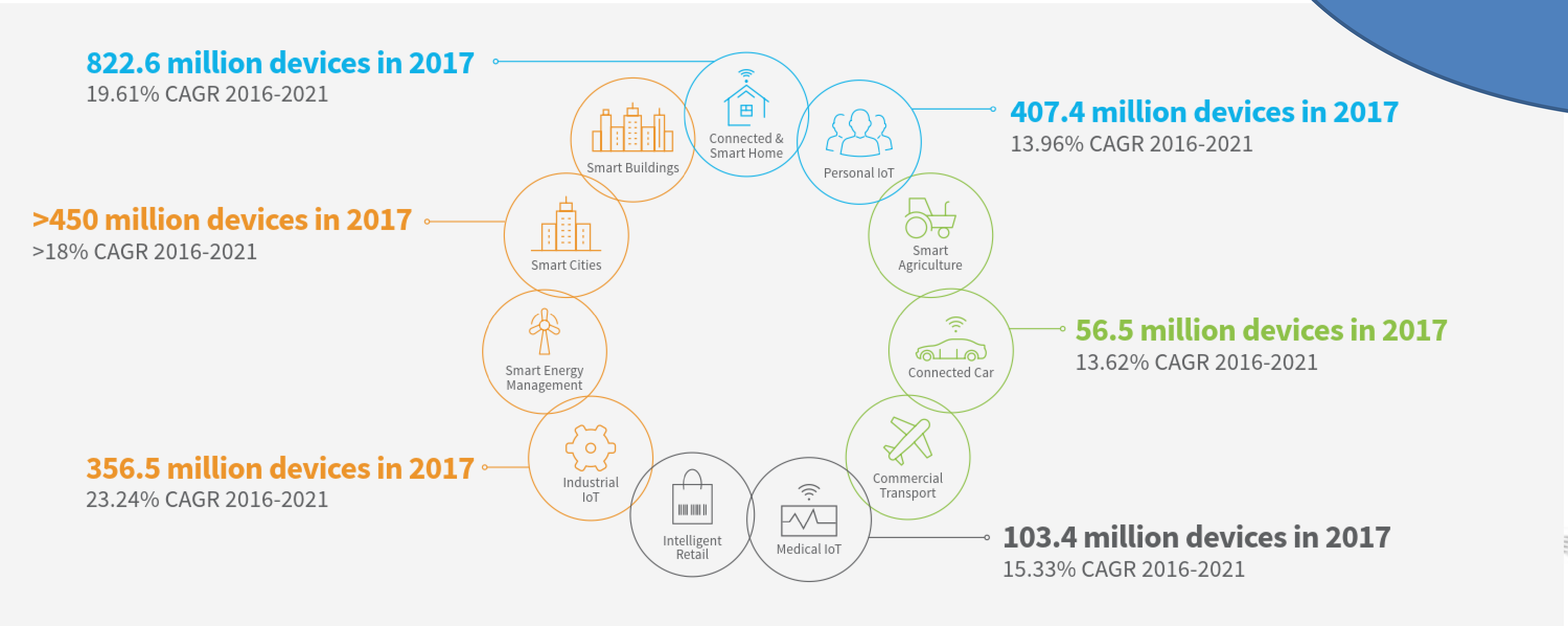
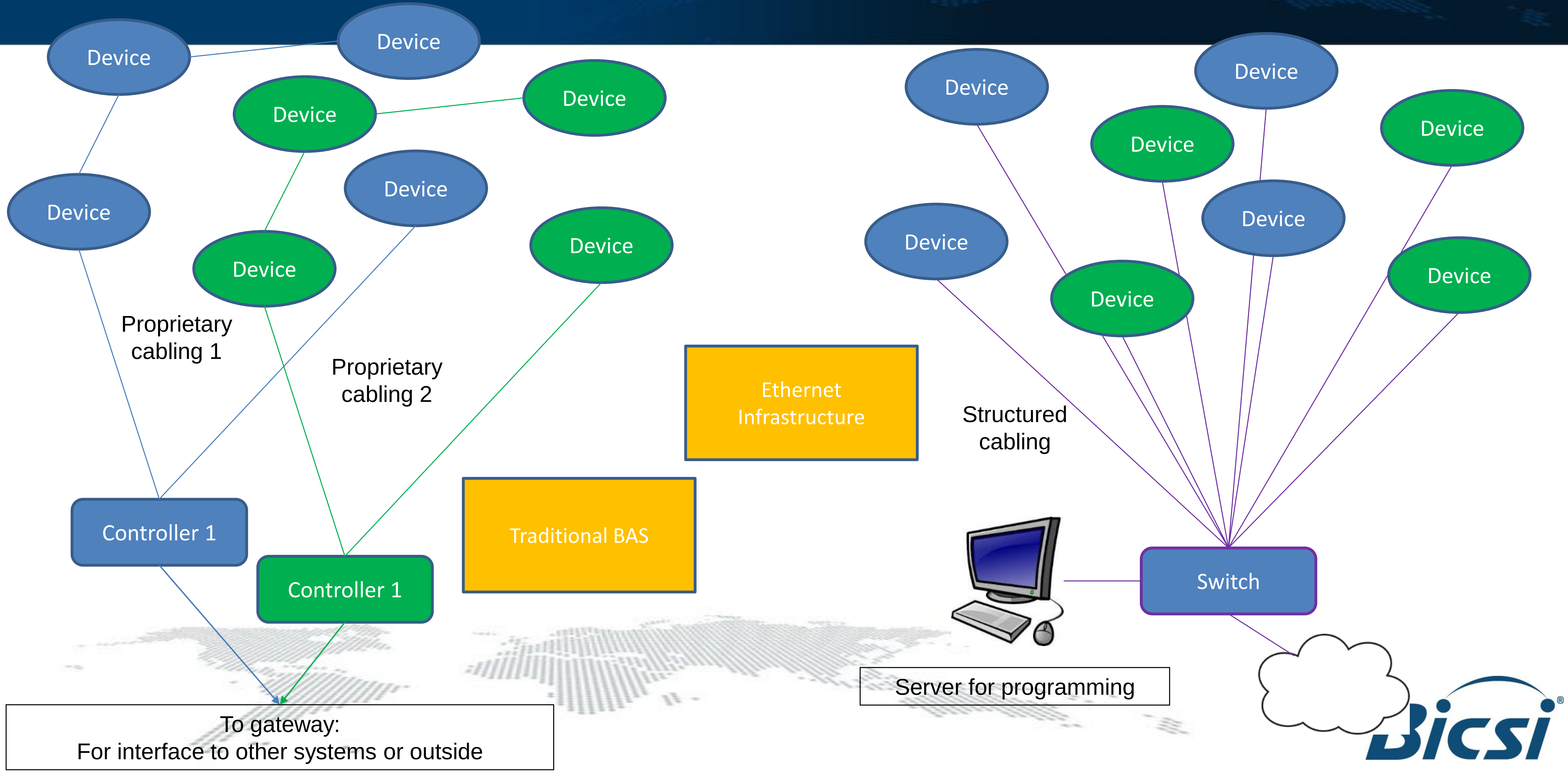
IoT

- From HIS Markit:

The number of connected IoT devices worldwide will jump 12% on average annually, from nearly 27 billion in 2017 to 125 billion in 2030.

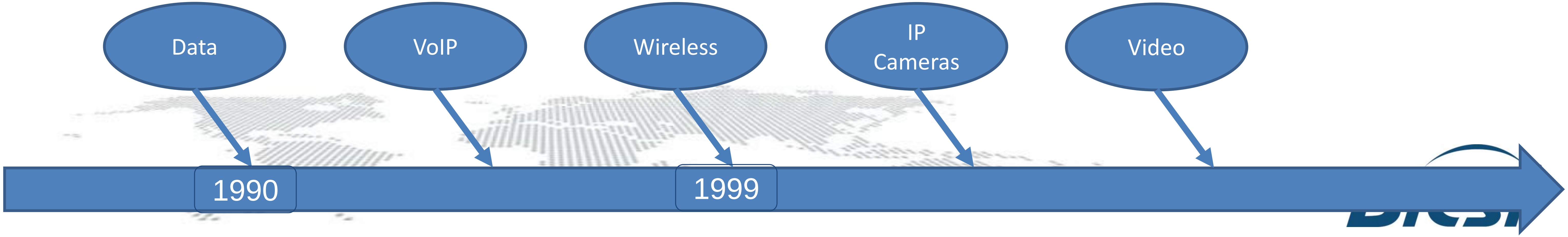


Why Ethernet?

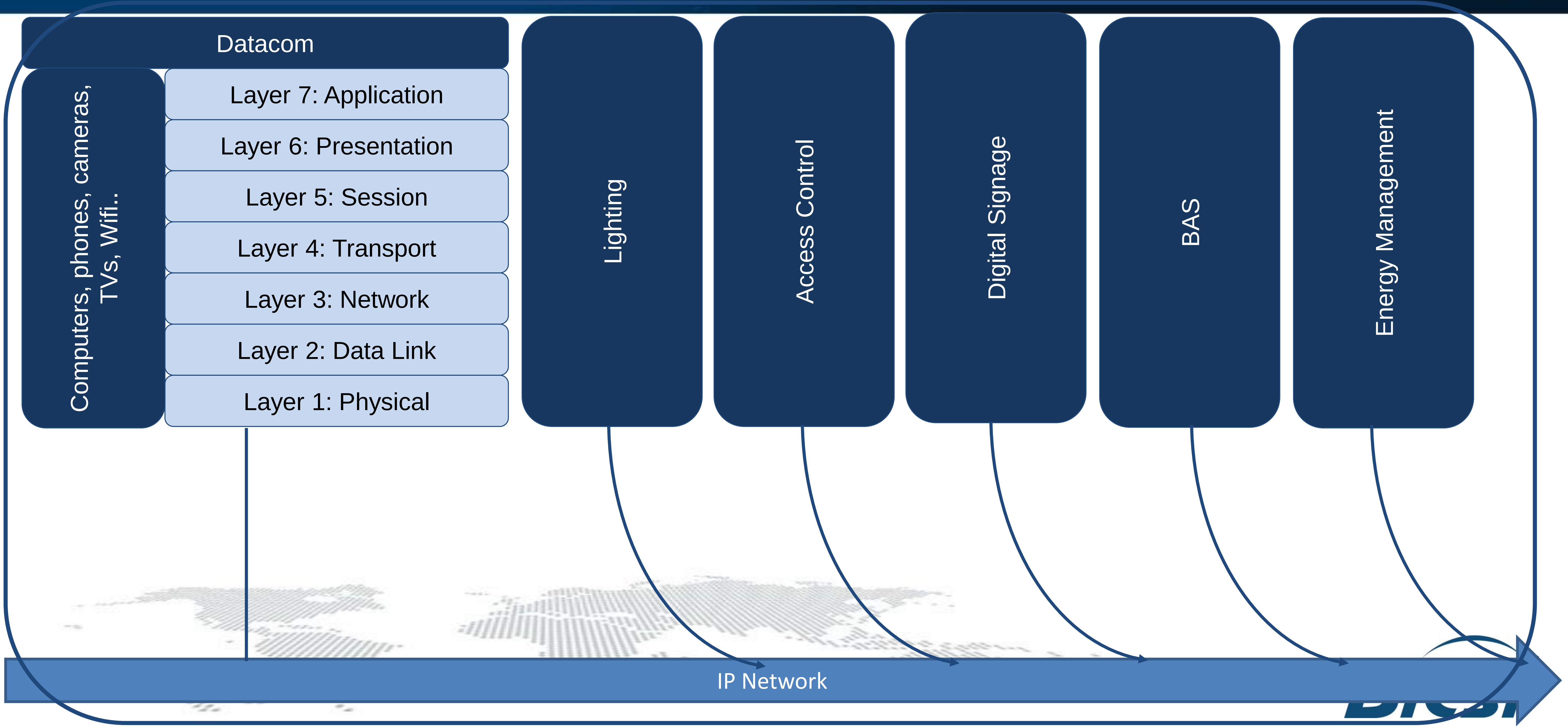


The OSI Model

Layer 7: Application
Layer 6: Presentation
Layer 5: Session
Layer 4: Transport
Layer 3: Network
Layer 2: Data Link
Layer 1: Physical

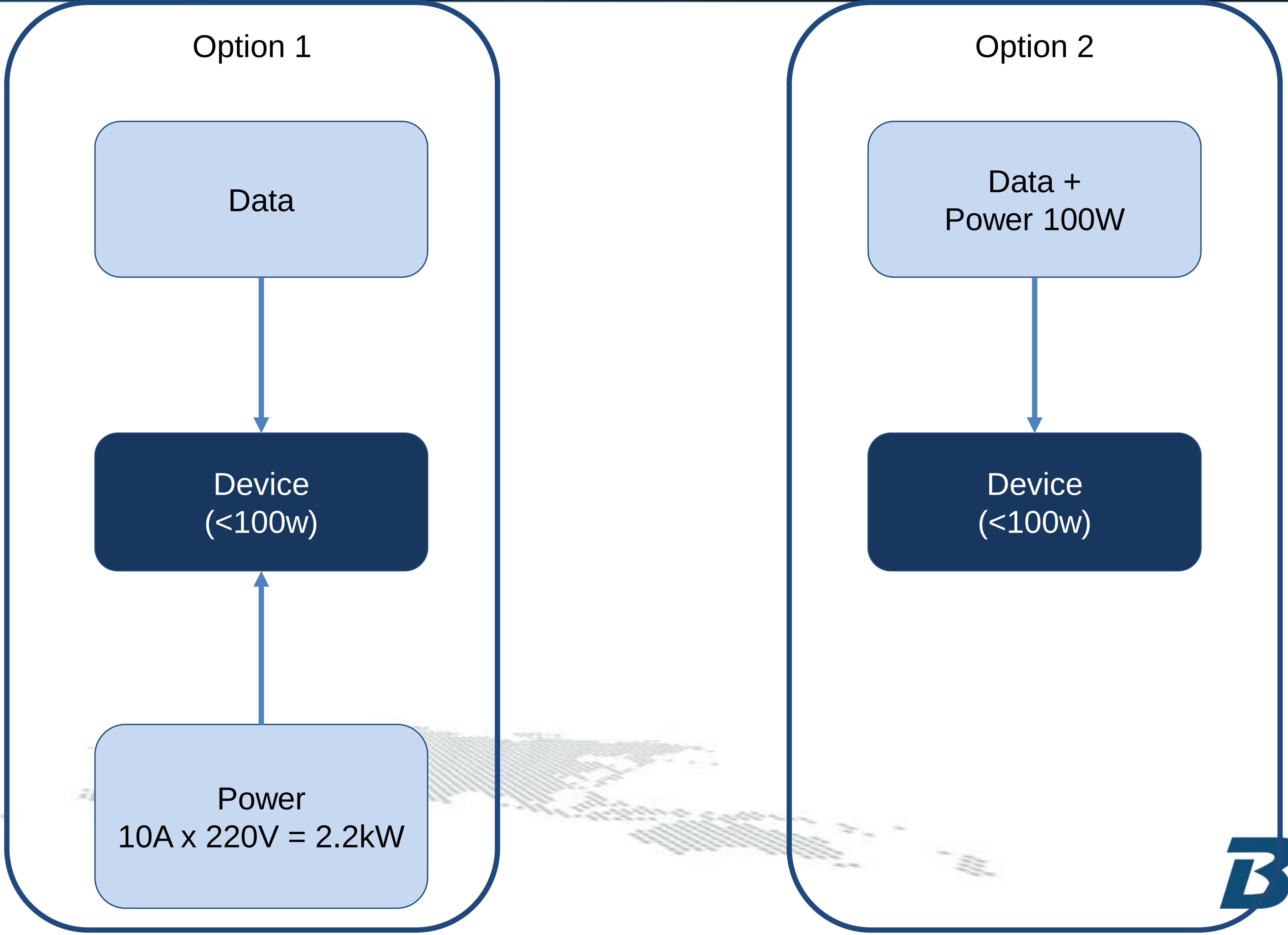


Breaking the Silos



Why PoE?

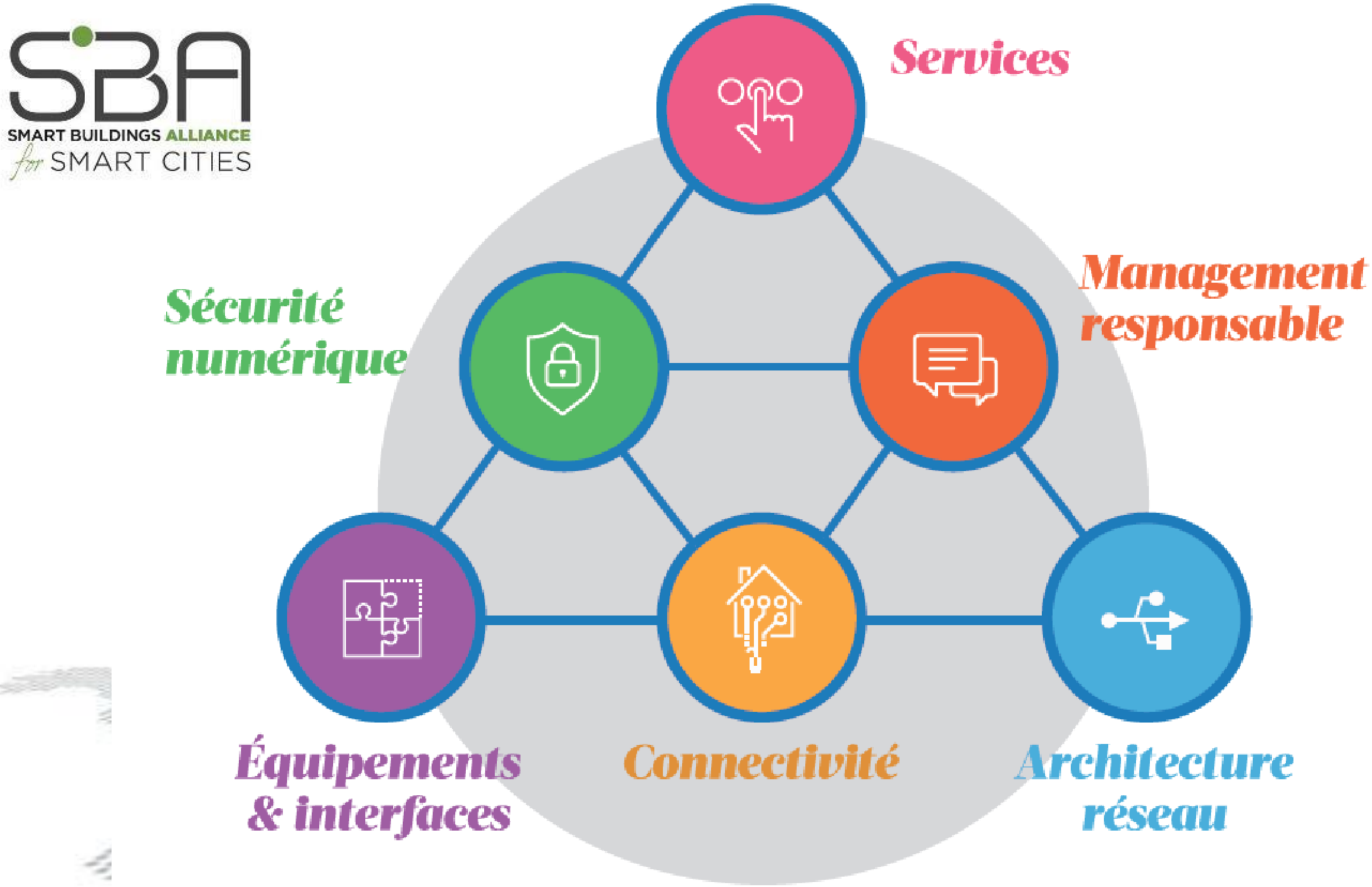
- Which is best?



Smart Buildings

Zigbee, BacNet, KNX, OCF, Thread have just agreed to promote a single IP Infrastructure.

- Certainty: Smart buildings will be based around an Ethernet infrastructure

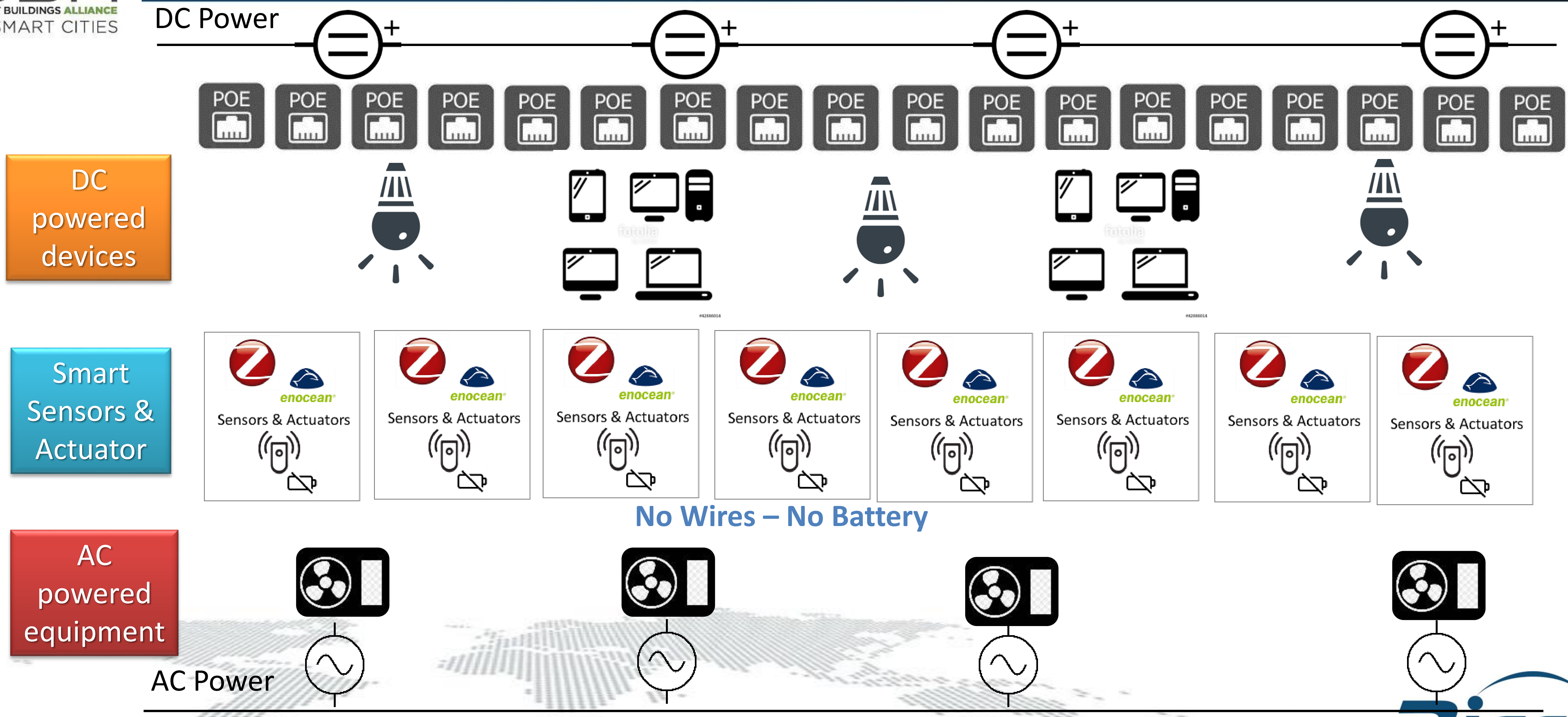


Services to building stakeholders

Governance

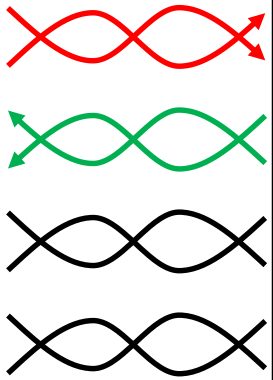
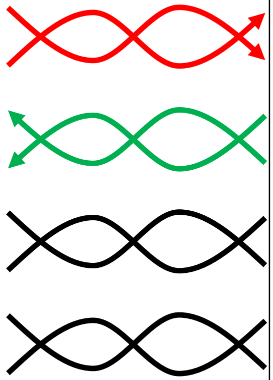
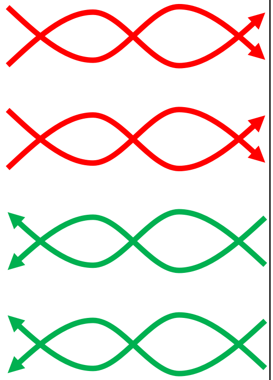
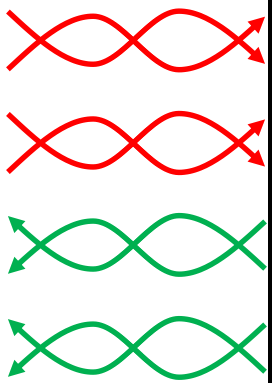
Technical Principles

Intelligent Building Infrastructure



PoE Powers

PoE Types

Name (Common name)	Type 1 (PoE)	Type 2 (PoE+)	Type 3 (PoE++)	Type 4 (PoE++)
IEEE Standard	802.3af (2003)	802.3at (2009)	802.3bt (2018)	802.3bt (2018)
Minimum Category Required	Category 3	Category 5e	Category 5e	Category 5e
Number of Pairs for Power	2	2	2 or 4	4
Maximum Current per Pair	350 mA	600mA	600mA	960mA
Guaranteed maximum power at PSE Output	15.4 W	30.0 W	60.0 W	90.0 W
Guaranteed maximum Power at PE Input	13 W	25.5 W	51.0 W	71.3 W
Diagram with maximum current per wire (mA)	175 175 175 175 	300 300 300 300 	300 300 300 300 300 300 300 300 	480 480 480 480 480 480 480 480 

PoE Classes

Class	1	2	3	4	5	6	7	8
Type	Type 1			Type 2	Type 3[1]		Type 4 [2]	
PSE maximum output average power (W)	4	7	15.4	30	45	60	75	90
PD Input Average Power (W)	3.8	6.5	13.0	25.5	40.0	51.0	62.0	71.3
PD Peak operating Power (W)	5.0	8.4	14.4	28.3	42.0	53.5	65.1	74.9

Notes:
(1) Type 3 can also support Classes 1 to 4.
(2) Only single signature PD shown

PoE Safety

IEC 60364

– limitation of voltage in the SELV or PELV system to the upper limit of voltage Band I, 50 V a.c. or 120 V d.c. (see IEC 60449), and

414.4.2 Protective separation of wiring systems of SELV and PELV circuits from the live parts of other circuits, which have at least basic insulation, may be achieved by one of the following arrangements:

– SELV and PELV circuit conductors shall be separated from conductors of circuits at voltages higher than Band I by an earthed metallic sheath or earthed metallic screen;

IEEE 802.3

PDs and PSEs shall provide isolation between all accessible external conductors, including frame ground (if any), and all MDI leads including those not used by the PD or PSE. Any equipment that can be connected to a PSE or PD through a non-MDI connector that is not isolated from the MDI leads needs to provide isolation between all accessible external conductors, including frame ground (if any), and the non-MDI connector. Accessible external conductors are specified in subclause 6.2.1 b) of IEC 60950-1 and subclause 5.4.10.1 b) of IEC 62368-1.

This electrical isolation shall withstand at least one of the following electrical strength tests:

a) 1500 V rms at 50 Hz to 60 Hz for 60 s, applied as specified in subclause 5.2.2 of IEC 60950-1 or subclause 5.4.9 of IEC 62368-1.
b) 2250 V dc for 60 s, applied as specified in subclause 5.2.2 of IEC 60950-1 or subclause 5.4.9 of IEC 62368-1.
c) An impulse test consisting of a 1500 V, 10/700 µs waveform, applied 10 times, with a 60 s interval between pulses. The shape of the impulses shall be 10/700 µs (10 µs virtual front time, 700 µs virtual time of half value), as defined in IEC 60950-1 Annex N or subclause 5.4.10 of IEC 62368-1.

There shall be no insulation breakdown, as defined in subclause 5.2.2 of IEC 60950-1 or subclause 5.4.9 of IEC 62368-1, during the test. The resistance after the test shall be at least 2 MΩ, measured at 500 V dc.

IEC 62368

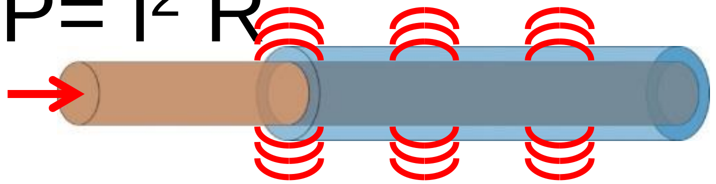
Table 4 – Electrical energy source limits for steady state ES1 and ES2

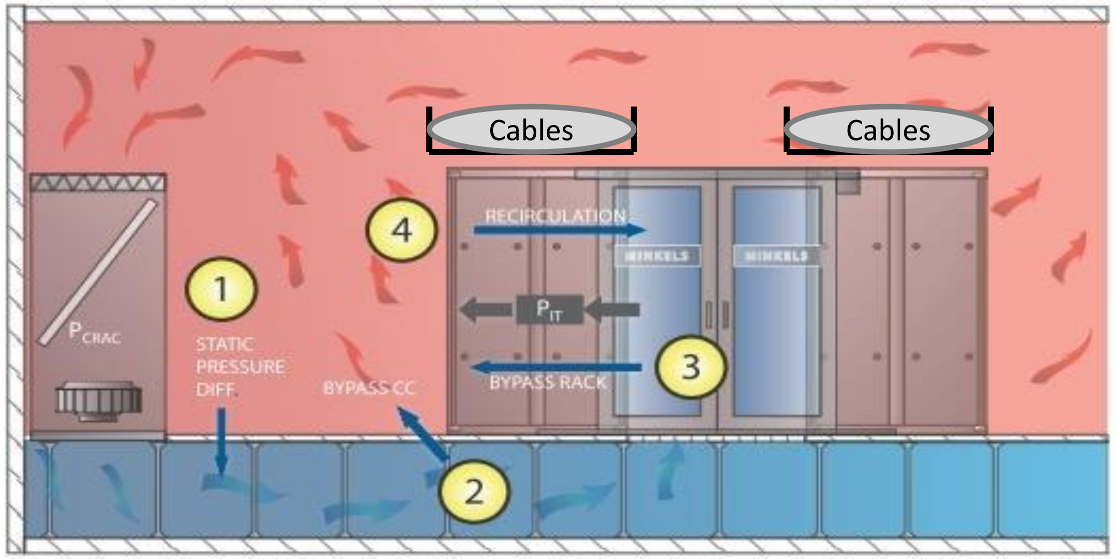
Energy source	ES1 limits		ES2 limits		ES3
	Voltage	Current [a, c, d]	Voltage	Current [b, c, e]	
DC [c]	60 V	2 mA	120 V	25 mA	
AC up to 1 kHz	30 V RMS 42,4 V peak		50 V RMS 70,7 V peak		
AC > 1 kHz up to 100 kHz	30 V RMS + 0,4 f 42,4 V peak. + 0,4 $\sqrt{2}\,f$	0,5 mA RMS 0,707 mA peak	50 V RMS + 0,9 f 70,7 V peak + 0,9 $\sqrt{2}\,f$	5 mA RMS 7,07 mA peak	
AC above 100 kHz	70 V RMS 99 V peak		140 V RMS 198 V peak		> ES2
Combined AC and DC	$\frac{U_{DC}(V)}{60}+\frac{U_{AC\ RMS}(V)}{U_{RMS\ limit}}\leq 1$ $\frac{U_{DC}(V)}{60}+\frac{U_{AC\ peak}(V)}{U_{peak\ limit}}\leq 1$	$\frac{I_{DC}(mA)}{2}+\frac{I_{AC\ RMS}(mA)}{0{,}5}\leq 1$ $\frac{I_{DC}(mA)}{2}+\frac{I_{AC\ peak}(mA)}{0{,}707}\leq 1$	See Figure 23	See Figure 22	

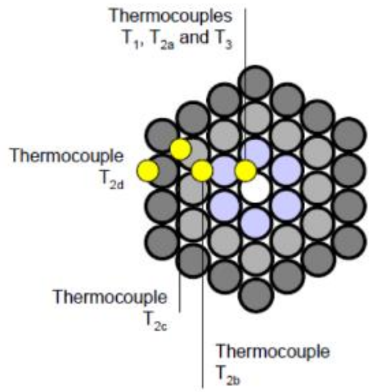
So what's so important about PoE in cabling?

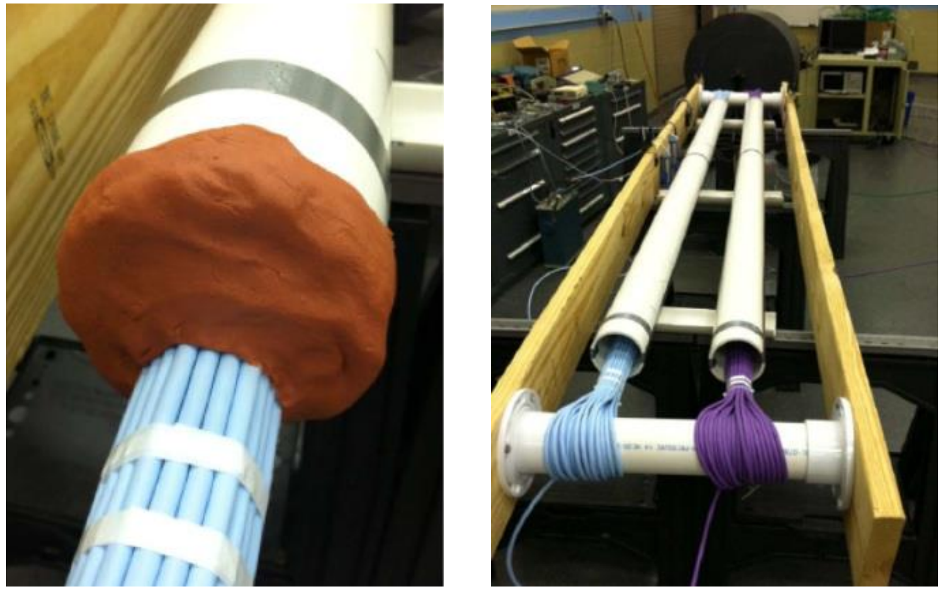
- Power through a cable, because of resistance, creates heat.
- Higher temperature = higher resistance = lower performance.

$P = i^2 R$









Draft IEC 61156-1-4

ISO/IEC 11801-1, chapter 9.3.2.3: operating temperatures of the cables: -20°C to +60°C.

PoE compliance for new cabling

- ISO /IEC 14673-2 (draft), information Technology - Implementation and operation of customer premises cabling – Part 2: Planning and installation.
  - For balanced cabling in accordance with ISO/IEC 11801-1
  - Remote Powering equipment to supply no more than 500mA per conductor.
  - Installation must be designated in one of the following categories:

Draft. But the content on PoE is identical to EN 50174-2 which is already ratified.

Category	$i_{c\text{-average}}$	i_c	Controls required during: Attachment of remote powering equipment	Controls required during: Planning of subsequent cabling installation
RP1	≤ 212 mA	≤ 500 mA	Yes	Yes
RP2	> 212 mA < 500 mA	≤ 500 mA	Yes	Yes
RP3	-	≤ 500 mA	No	Yes

Mandatory to control before connecting a PoE device. Unless RP3.
-> Someone takes responsibility for the compliance during operation.

REMOTE POWERING INSTALLATION CATEGORY RP1 NO UNAUTHORISED ATTACHMENT OF REMOTE POWERING EQUIPMENT	REMOTE POWERING INSTALLATION CATEGORY RP2 NO UNAUTHORISED ATTACHMENT OF REMOTE POWERING EQUIPMENT	REMOTE POWERING INSTALLATION CATEGORY RP3

Labeling required to identify the type

For installation of cabling in accordance with ISO/IEC 11801-2, ISO/IEC 11801-3, ISO/IEC 11801-4 and ISO/IEC 11801-6 the planning, installation and administration requirements of Category RP3 shall be applied.

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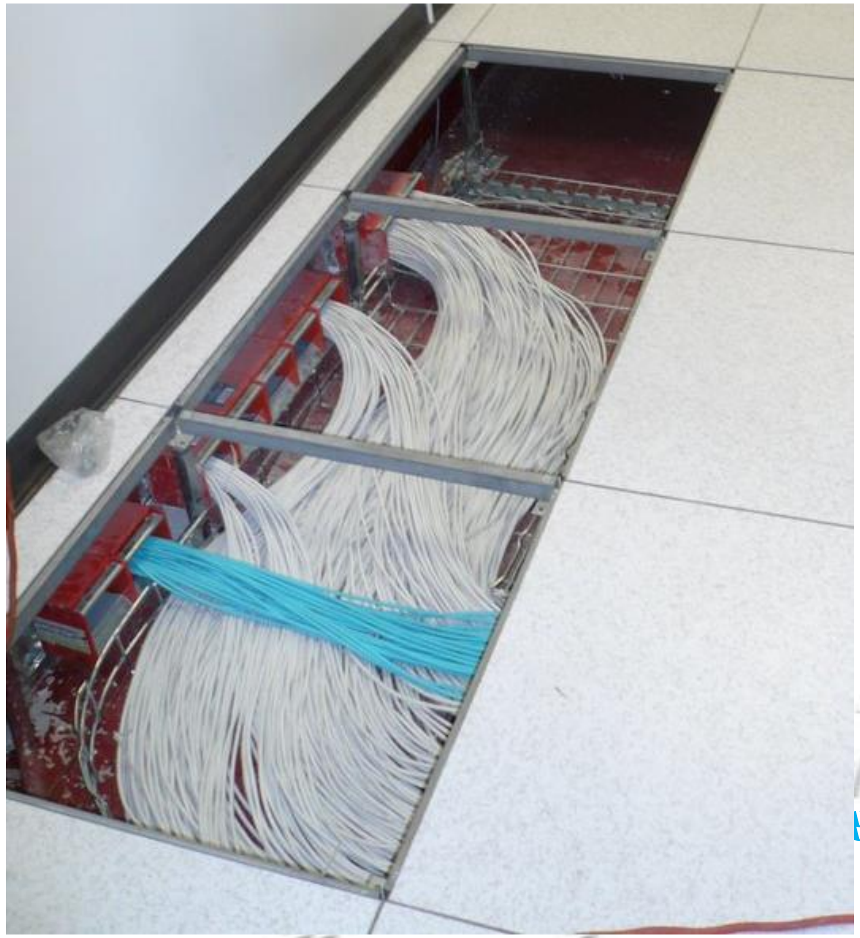
Calculate the heat increase

- Since you should comply to RP3, assume 500mA per conductor for 100% of the links (Type 4 100W everywhere).
- Irrelevant on PoE, the maximum number of cables in a bundle should be 24.
- However, bundles might join together in specific areas. For example through fire rated walls.



Calculate an average temperature

$$T_{\text{global}} = \frac{1}{L} \times \sum_{n=1}^{n} \left(T_{\text{ambient}-n} + \Delta T_n \right) \times L_n$$

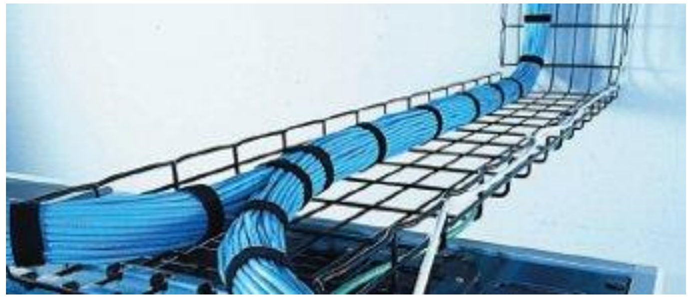
Suggestion: first only calculate worst case

Calculate the heat increase

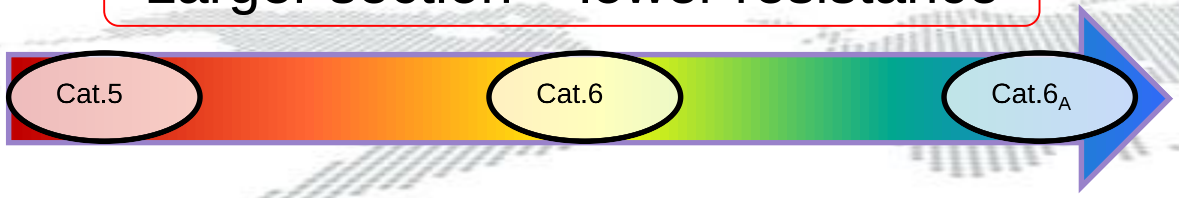
- Calculate the temperature increase with the formula.

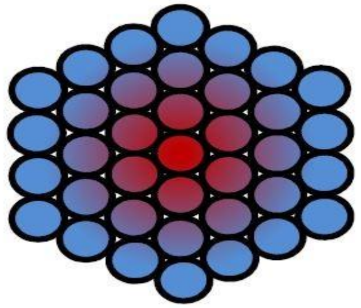
$$\Delta T\ °C = \left(0.8 \times N + \frac{K \times \sqrt{N}}{D}\right) \times R.$$

N = number of cables
K = temperature coefficient of the cable management
D = diameter of the cables
R = resistance of the cables



Larger section = lower resistance





ΔT Estimations

Table 19 - Temperature changes for various cable bundle sizes

	Installation condition E/F - Ventilated								
	No. of cables (N)	6	12	24	48	72	96	144	216
Cable R and D[a]	ΔT °C								
0,095 Ω/m 5,0 mm		3,0	5,0	7,0	11,0	15,0	18,0	24,0	32,5
0,07[illegible]									
0,06[illegible]									
[a] Wit[illegible]									

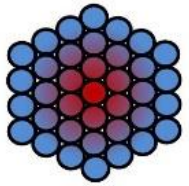
	Installation condition C - Unperforated tray								
	No. of cables (N)	6	12	24	48	72	96	144	216
Cable R and D[a]	ΔT °C								
0,095 Ω/m 5,0 mm		4,0	6,0	9,0	14,0	18,0	21,5	28,5	38,0
0,075 Ω[illegible]									
0,065 Ω[illegible]									
[a] Within[illegible]									

	Installation condition A - Insulation								
	No. of cables (N)	6	12	24	48	72	96	144	216
Cable R and D[a]	ΔT °C								
0,095 Ω/m 5,0 mm	$\approx \left(0,8\times N+\frac{0,27\times\sqrt{N}}{D}\right)\times R$	13,0	18,5	27,0	39,0	**	**	**	**
0,075 Ω/m 7,0 mm		7,5	10,5	15,5	23,0	29,0	34,0	**	**
0,065 Ω/m 7,7 mm		6,0	8,5	12,5	18,5	23,0	27,5	35,0	**

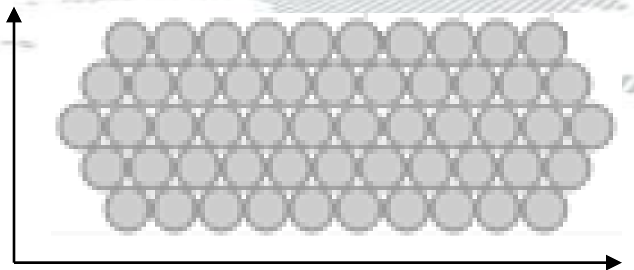
[a] Within the formula, D in metres e.g. for cable diameter 5 mm, D = 0,005

NOTE ** indicates a temperature in excess of 60 °C (assuming an ambient of 20 °C) which represent unacceptable localised heating

- You can estimate using the tables in the document.
- Or you could have a more precise using the annex I.
- Or most precise using the ISO/ IEC TS 29125
- Below is a simplification. (Caution: over – simplified. Add some extra margin)
- Adjust if the bundles are not round but rectangular



	Ventilated			Unperforated Tray			Trunking / Conduit			Insulation		
Typical Cat.	**24**	**72**	**216**	**24**	**72**	**216**	**24**	**72**	**216**	**24**	**72**	**216**
Cat.5	7.0	15.0	32.5	9.0	18.0	38.0	13.0	25.0	> 40	27.0	> 40	> 40
Cat.6	4.5	9.5	22.0	5.5	11.5	25.0	7.5	15.0	32.0	15.5	29.0	> 40
Cat.6A	4.0	8.0	18.5	4.5	9.5	21.0	6.0	12.5	26.0	12.5	23.0	> 40



Height to Width	1:1	1:2	1:3	1:4	1:5	1:6	1:7	1:8	1:9	1:10
ΔT multiplier	0.89	0.84	0.77	0.71	0.66	0.62	0.59	0.56	0.53	0.51

Verify the solution

- Estimate the temperature of the environment and add the two together.
- In any case T + ΔT should be maximum 60 °C for standard compliant cabling.
- Calculate your maximum lengths for permanent links adjusted with the temperature. Here is a simplified table.

T (°C)	Permanent Link (m)
20	90
25	88
30	85
35	83
40	80
45	78
50	75
55	73
60	70
Assuming 10m of cords with 50% extra attenuation	

Risks:
Performance not guaranteed
Faster ageing of the cables

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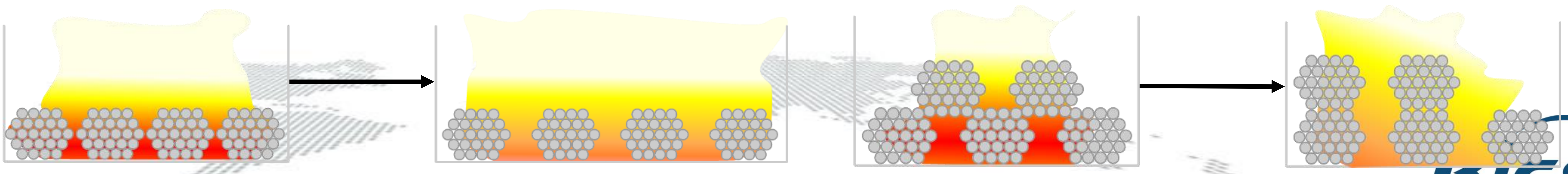
Mitigate

- At this point you might be trying to find solutions to reach a lower temperature.
- Calculate more precisely instead of using only absolute worst case.
- Then look into:
  - Bundle separation, geometry of bundles
  - Smaller bundles
  - Cables with lower resistance
  - Cables with larger diameter
  - Changes to the environment
  - Reduction of the ambient temperature
- If all fails, lower to RP2 and check again.
- In all cases, good practice is to arrange the bundles to improve airflow



New Installation rules

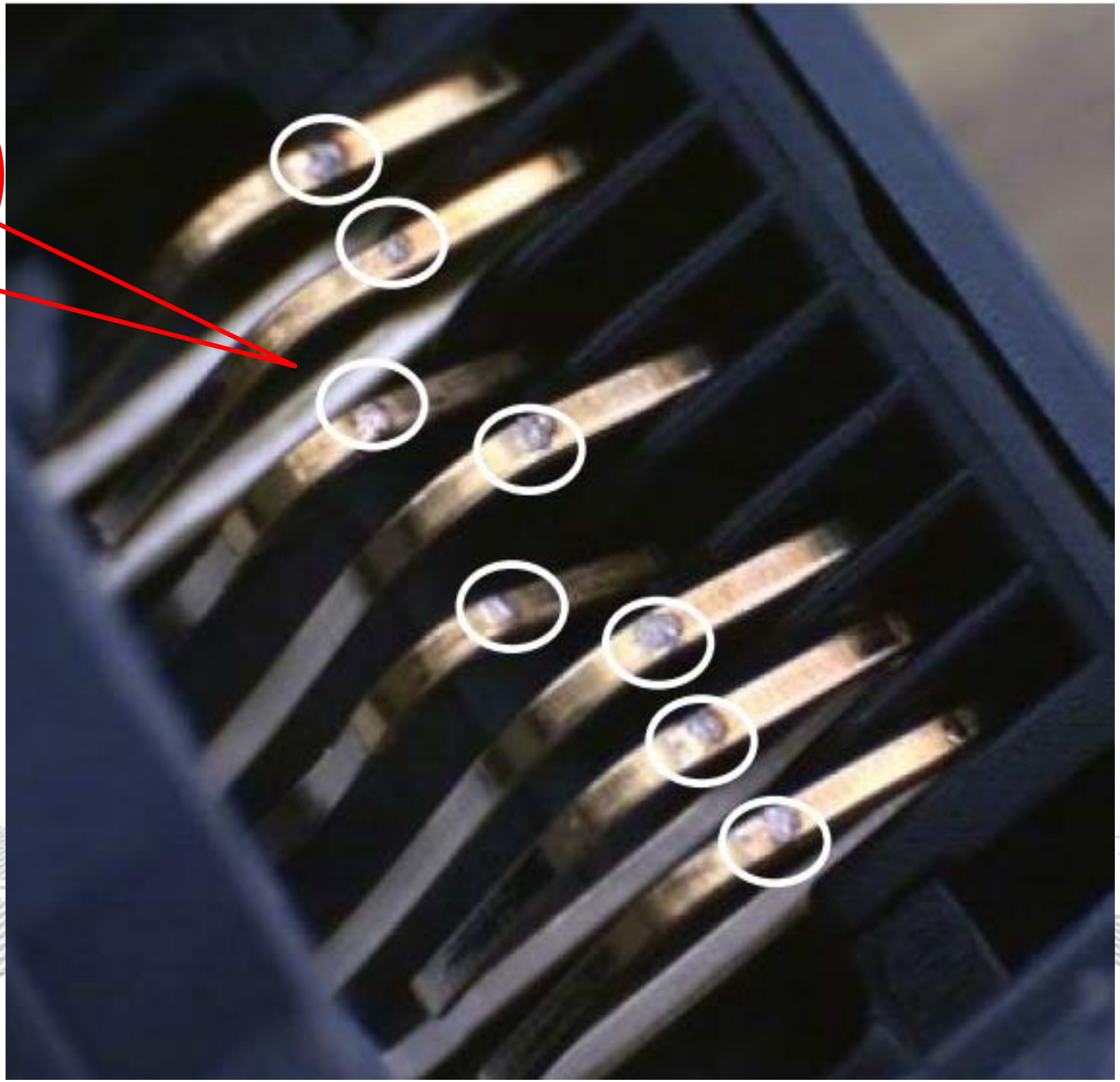
- PoE is no longer an option but a part of the system. Compliance must be ensured.
- The risk of non compliance is not safety but only lack of performance.
- To comply with ISO 11801, the installation must be compliant to ISO/EIC 14763, and must be of PoE type RP3.
- Forget the 90m Permanent link rule. The cable temperature is never 20 °C.

Hint: Aim for 80m maximum permanent link in the design to comply in the wide majority of cases.

A Word on Connectors:

PoE can destroy the connector during disconnection

Contacts burned



Standards to confirm the durability of the connectors under disconnection:

- IEC 60512-99-001 for up to IEEE 802.3 at 30W on 2 pairs.
- IEC 60512-99-001 for up to IEEE 802.3 bt 100W on 4 pairs

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Agenda

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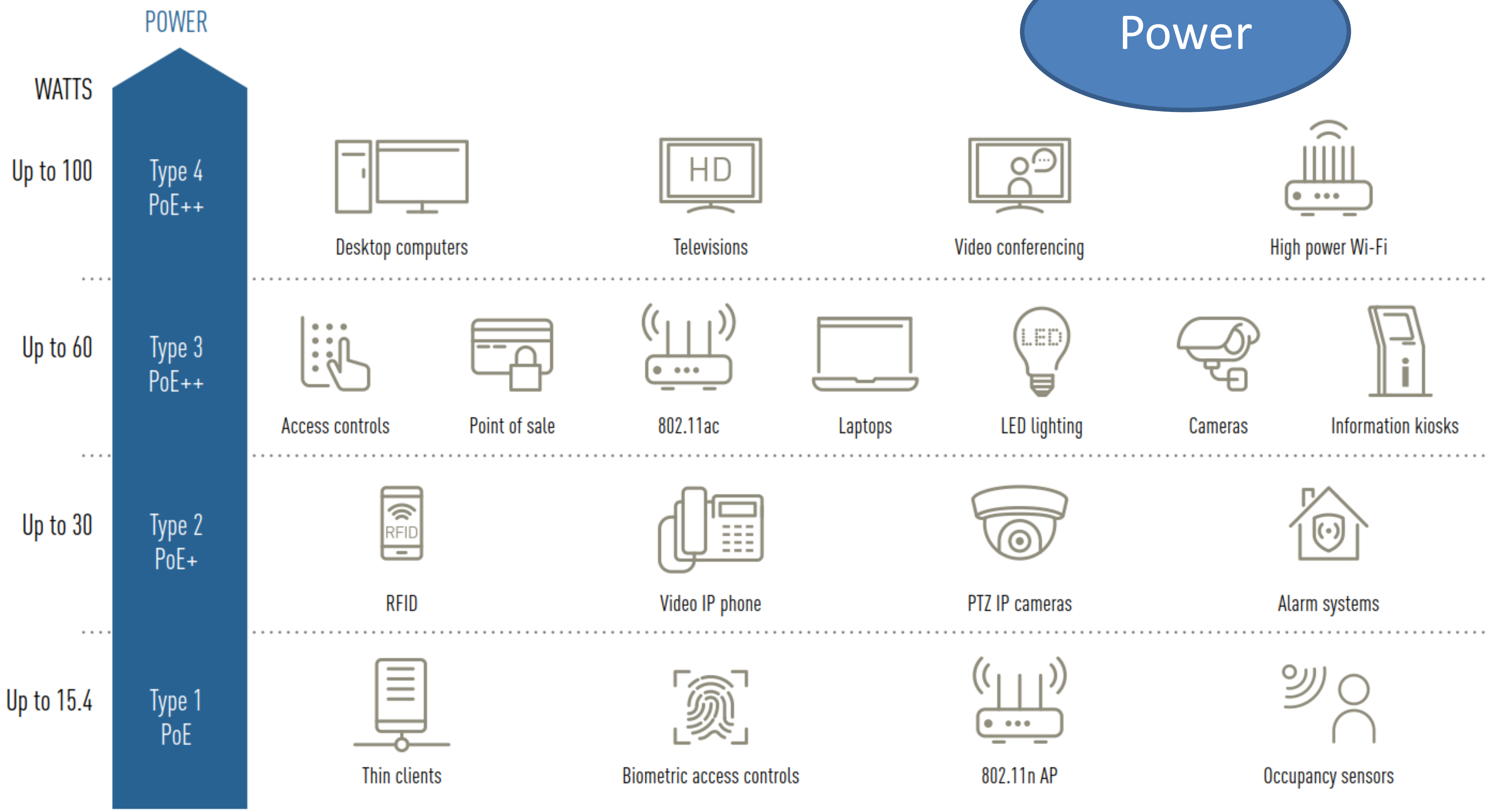
What we offer

- Our cabling systems can provide:

Power



Data

Cat.5e → 1Gbps

Cat.6A → 10Gbps

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Needs

Major Uses Cases ISO/IEC 11801-6 Distributed Services

Use Case	Application Data Rate (Mb/s)	In-Building Range of Reach (m)	Remote power (watts)	Remote Termination
IoT	< 10	15 - 100	< 5	NCP/device
BAS	< 10	15 - 100	15 - 30	NCP/device
WIFI (ac)	1000 – 10 G	< 15	15 - 50	NCP/AP
Lighting	< 10	15 - 100	10 - 50	NCP/device
Surveillance	100 - 1000	15 - 100	10 - 30	NCP/camera
VoIP phone	< 10	15 - 100	40	phones
Fire/smoke alarm	< 10	15 - 100	5 - 10	Console/speakers
Audio/speakers	< 10	15 - 100	5 - 10	speakers

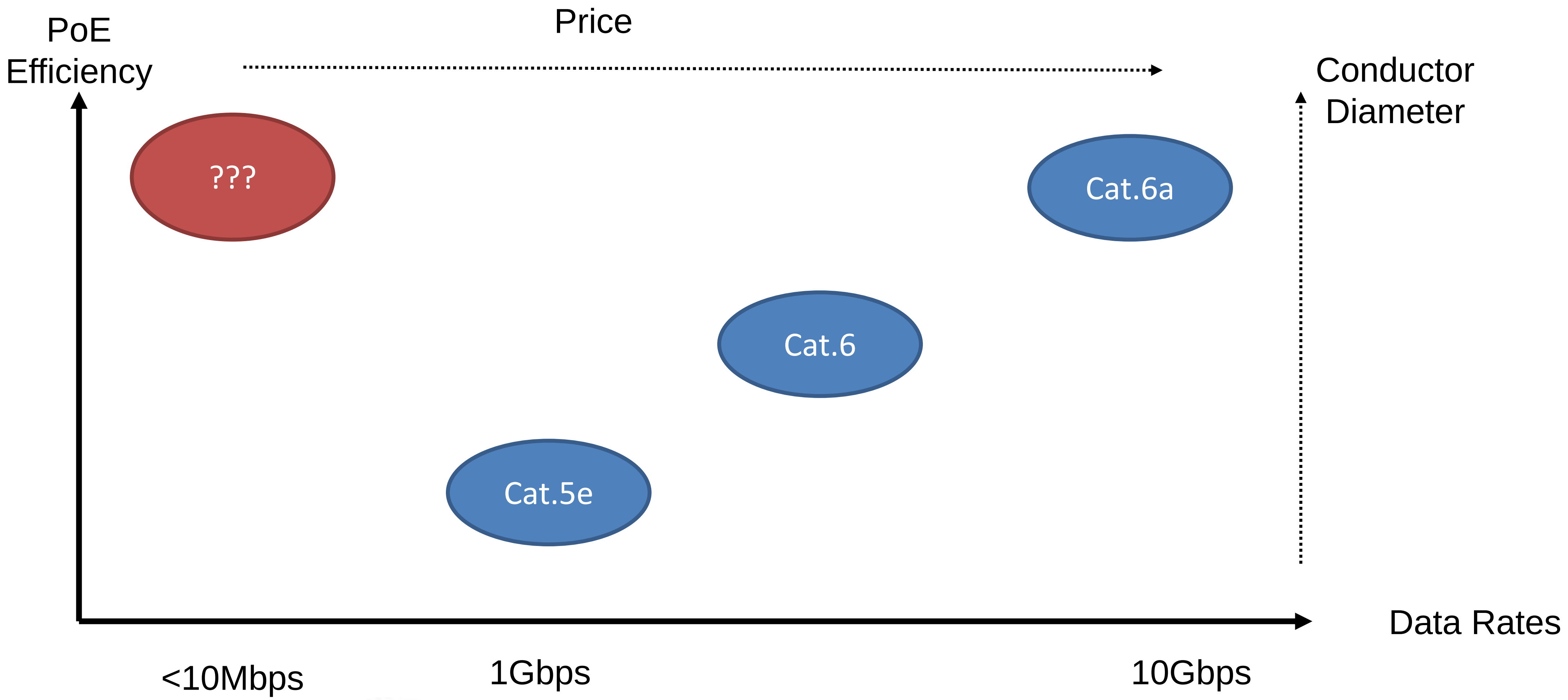
Building Controls Protocols

- BACnet: Physical Interface can be RS-485 (MS/TP), RS-232, LONTalk, Ethernet,
- LONTalk: Physical interface is twisted pair or Power Line
- MODBus: Physical Interface is RS-485 or RS-232
- Profibus/Fieldbus/ControlNet: Physical Interface is RS-485 or RS-232
- KNX (formerly EIB & BatiBus & EHS): Physical Interface is twisted pair, RF or Power Line
- DALI: Physical Interface for control signal is RS-485
- OPC (Open Platform Communications): can interface with LONTalk, BACnet or DALI

A new solution?

Our Current options

What we need



Single Pair Ethernet

- Objective: to offer a solution for IoT (and industrial) providing, compared to current 4-pair:
  - Lower data
  - Similar power
  - Allow longer distances
  - Lower cost
  - Compliance to standards
  - Possible bus topology

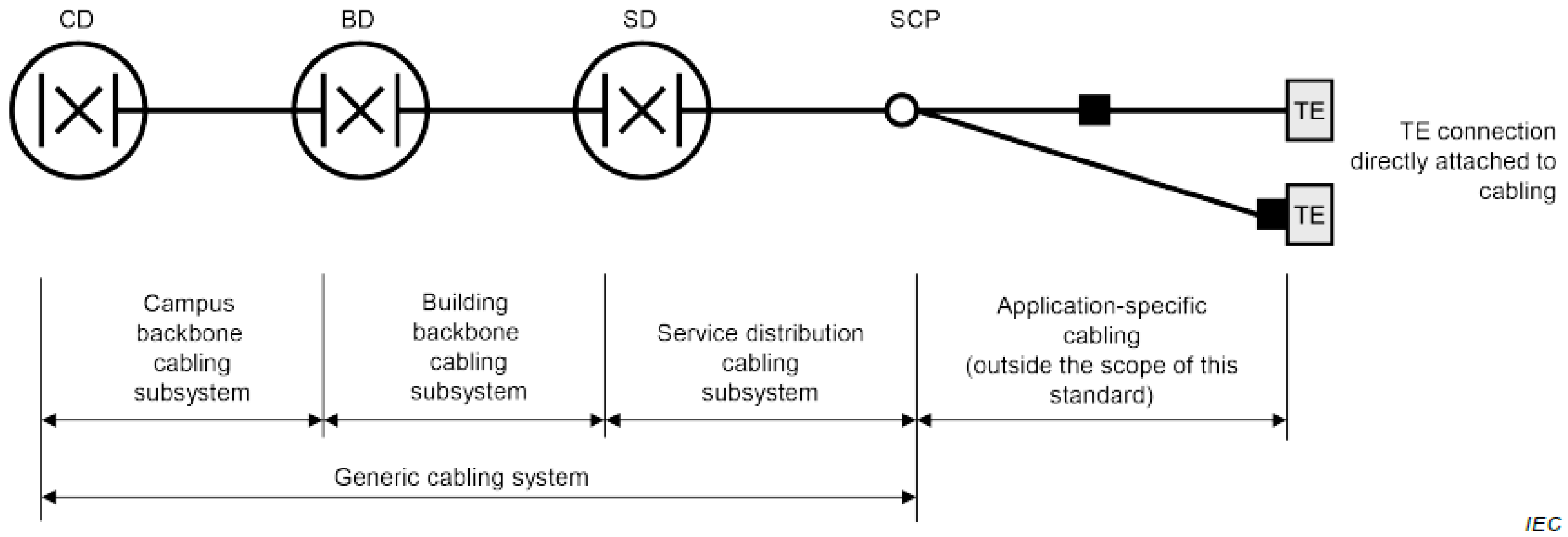
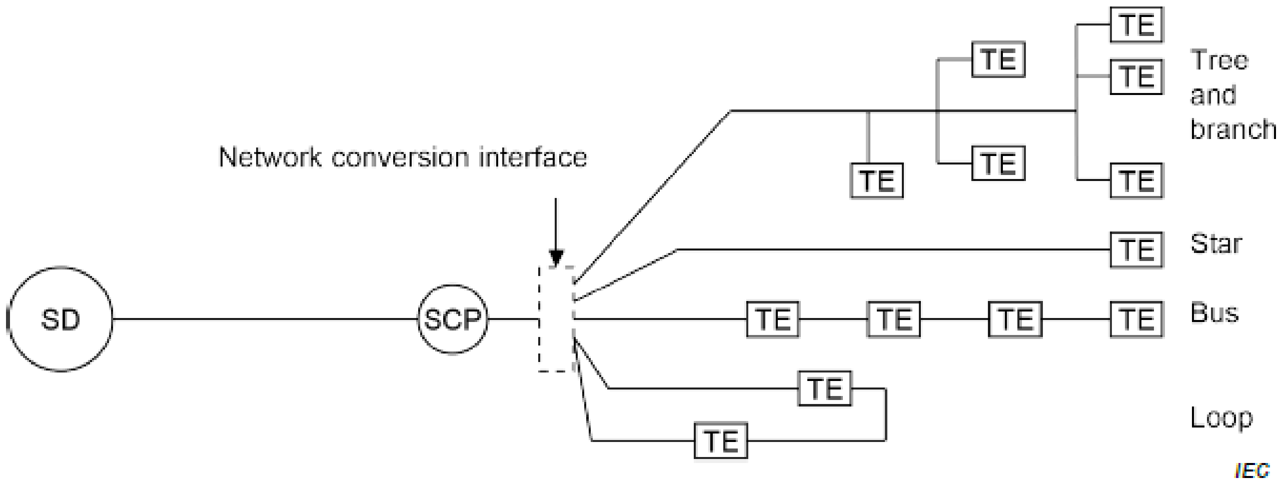


Figure 4 – Structure of Type B generic cabling

Extracts from ISO / IEC 11801-6



List of SPE Options

- IEEE Single Pair Ethernet

Standard	Content	Target	Distance	Specifics	Status
802.3bw	100mbps	Automotive	30m		Ratified
802.3bp (Type A)	1Gbps	Automotive	30m	4 connectors	Ratified
802.3bp (Type B)	1Gbps	Transport / industrial	40m		Ratified
802.3bu	PoDL	802.3 bw / bp	All	50V, 1.36Amp	Ratified
802.3cg (Short and Long)	10mbps + Power	Industrial / Commercial	S < 15m L < 1km	Up to 10 connectors	Draft Expected Sept 2019.
802.3ch Multi Gig	2.5G, 5G, 10G	Automotive	15m		Draft Expected 2020

Market

- IEEE 802.3cg

Source: IEEE

Broad Market Potential

Each proposed IEEE 802 LMSC standard shall have broad market potential. At a minimum, address the following areas:

a) Broad sets of applicability.

b) Multiple vendors and numerous users.

Broad Sets of Applications:

10 Mb/s single-pair Ethernet in the automotive market will enable replacement of multiple legacy protocols with Ethernet, taking advantage of lower cost and throughput requirements than 100 Mb/s automotive Ethernet, furthering consolidation of legacy in-car networks in a homogeneous architecture.

10 Mb/s single-pair Ethernet in the industrial market will enable replacement of multiple legacy protocols with Ethernet in a number of market segments in industrial automation, with greater applicability than 100BASE-T1 and lower system cost than 10BASE-T.

10 Mb/s single-pair Ethernet in the intra-system control market will enable replacement of multiple legacy protocols with Ethernet in a number of market segments including enterprise and data center networking and servers.

Multiple vendors and numerous users:

At the original Call for Interest, 79 individuals from 55 companies indicated they would support this project. These included companies from industrial automation, building automation, automotive, automotive OEMs, silicon, infrastructure, cabling, connector, and test equipment vendors.

At an additional Call for Interest held to add intra-system applications, 64 individuals from 43 companies indicated support. This included additional companies enterprise and data center networking and server vendors, and component suppliers to them.

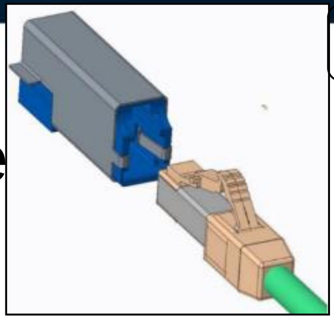
Substantial Market Potential:

Data presented at the original CFI indicate a substantial market potential, e.g., the prediction for 2019 is 165 million total ports/year.

Data presented at the additional CFI indicate an addition of > 450 million ports/year.

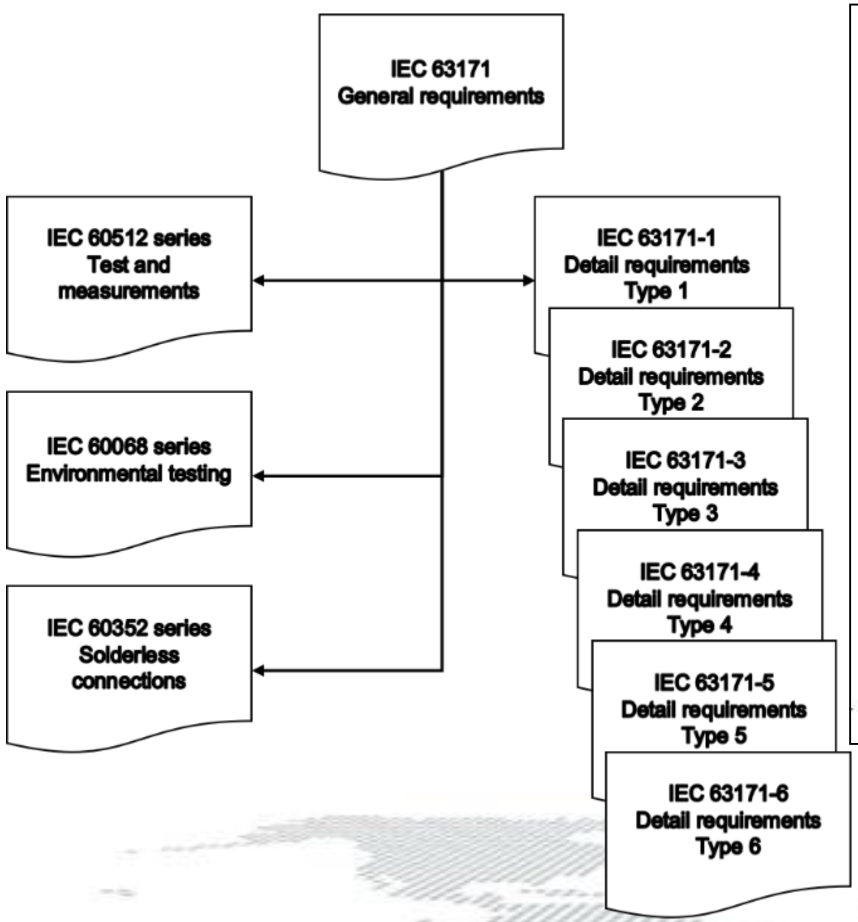
Cabling

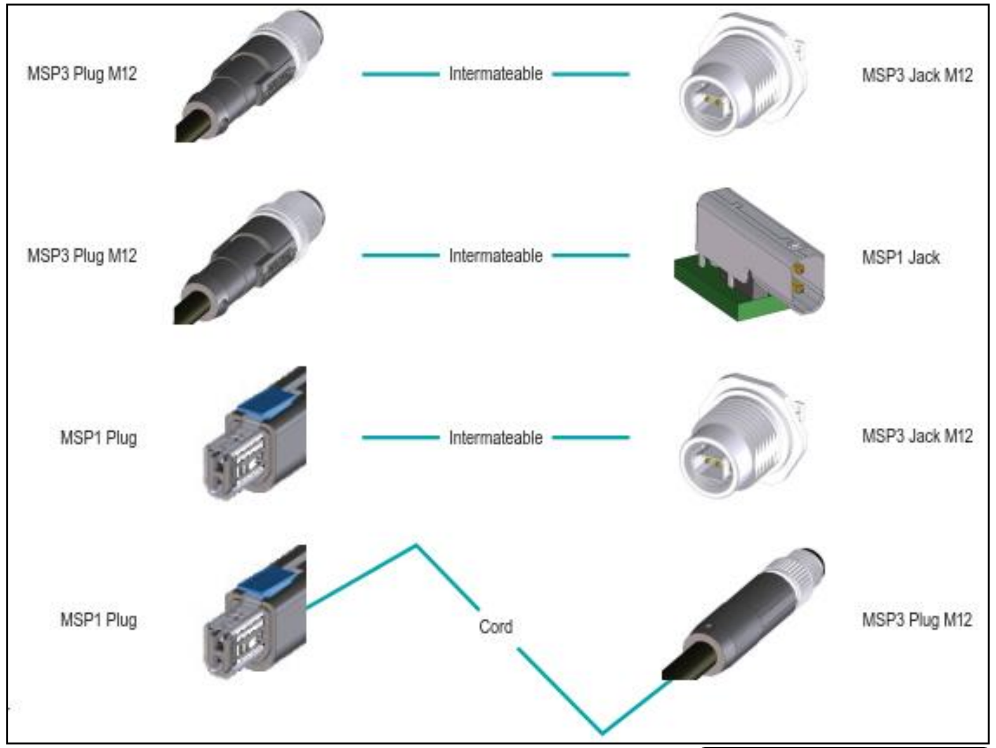
- IEC - Drafts 63171-x
  - Connectors for single pair use (not limited to Etherne
  - All 6 variant will be defined



63171-1

61076-3-25 -> 63171-6





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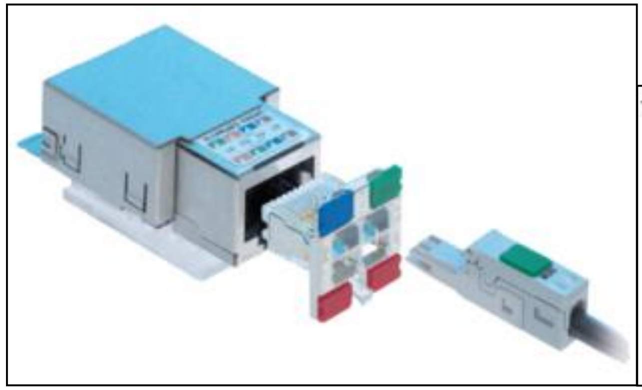
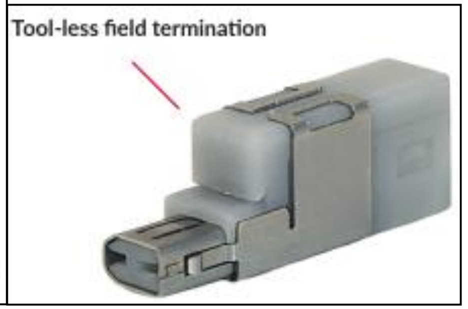
63171-2





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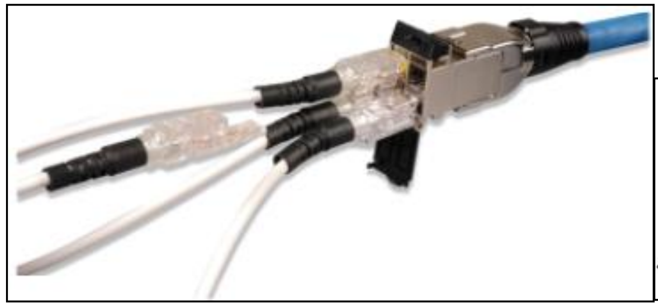
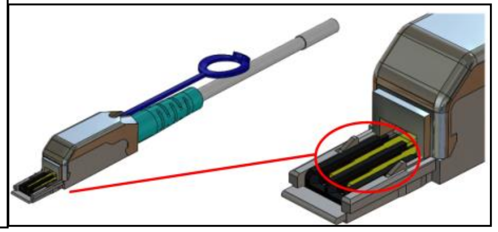
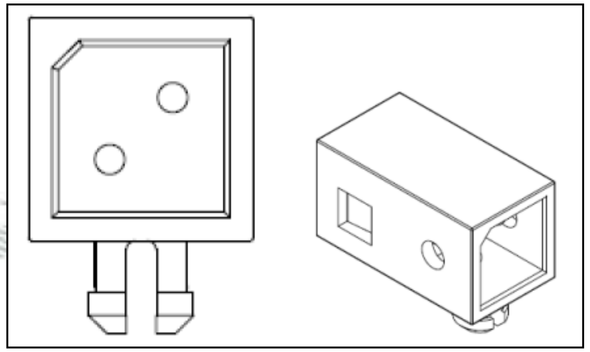




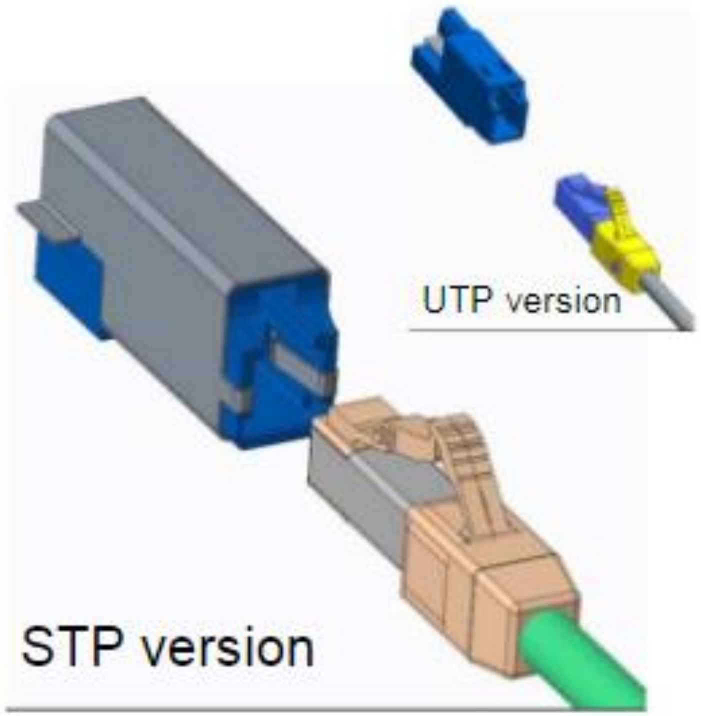


63171-4

Cabling

- ANSI / TIA 568-5 Draft
  - Components for single pair Ethernet
  - Systems (Channel and Permanent Link) for commercial buildings.

Variant 1 – LC style for $M_1I_1C_1E_1$ acc. IEC 63171-1



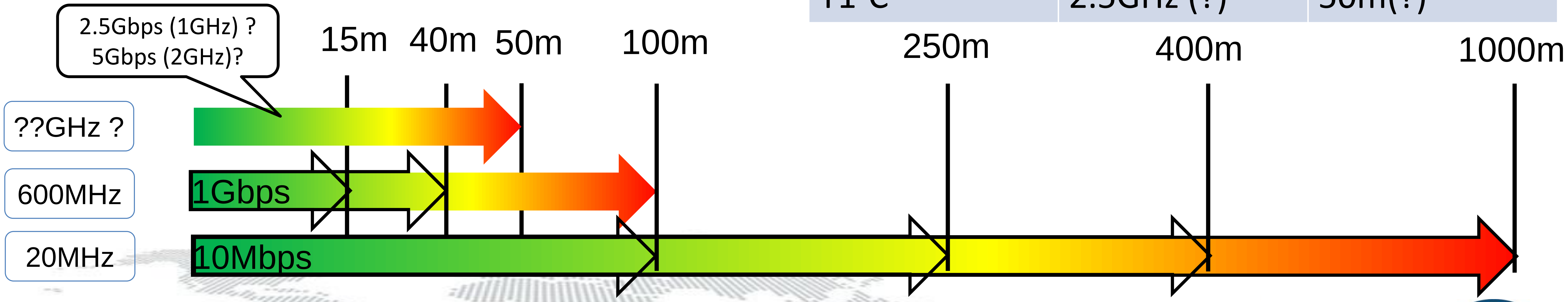
Variant 2 – Industrial style for $M_2I_2C_2E_2$ and $M_3I_3C_3E_3$ acc. IEC 61076-3-125

Cabling

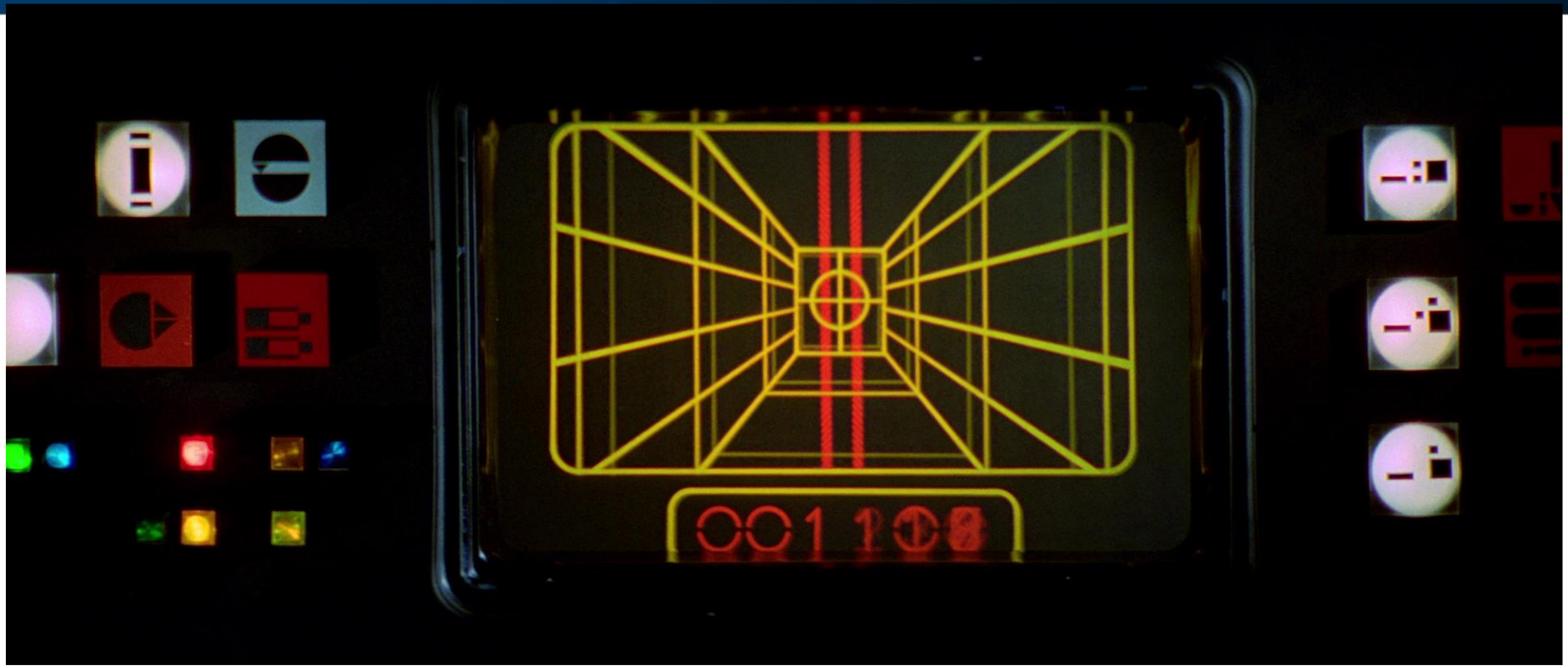
- ISO /IEC 11801–1 Amendment draft
  - Single pair channels
  - Cables will be 18AWG to 26AWG
  - Current to increase to 2Amp for 100W

Multiple cable AWGs

Channel	Frequency	Length(s)
T1-A	20MHz	100m, 250m, 400m, 1000m
T1-B	600MHz	100m
T1-C	2.5GHz (?)	50m(?)



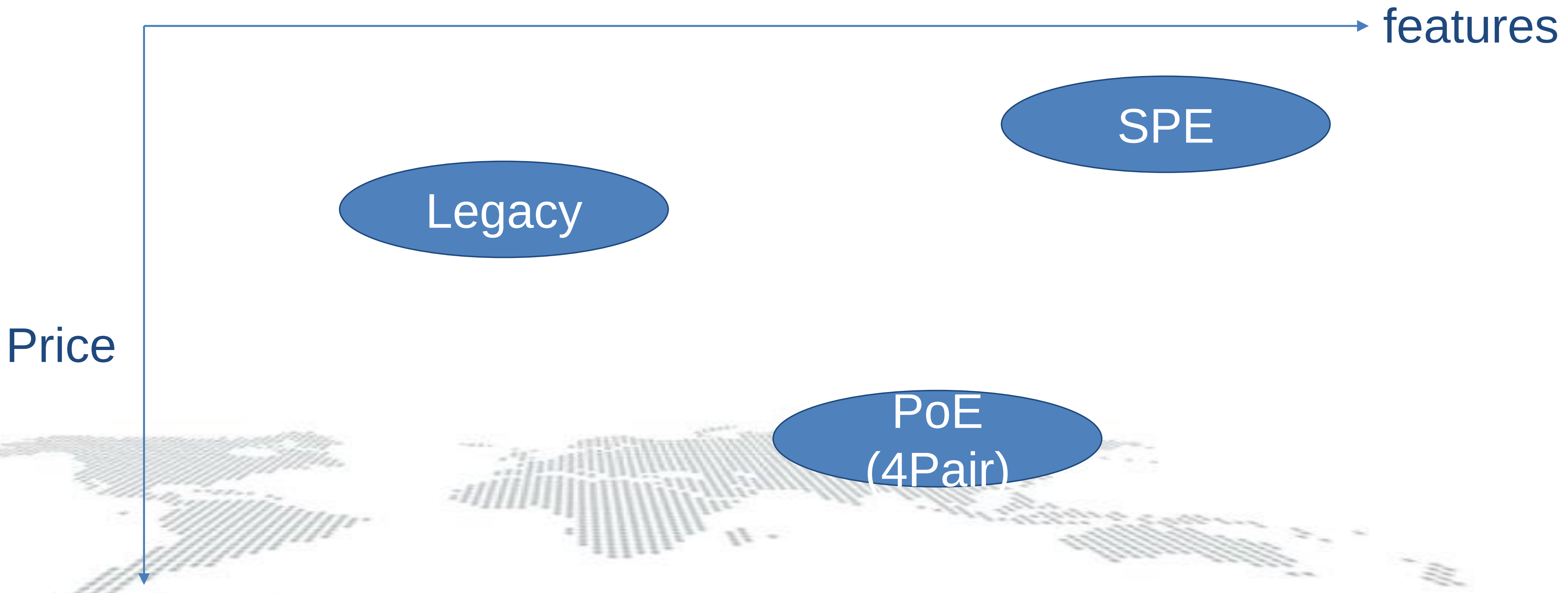
Stay on Target!



- Our objective is to provide an infrastructure for IoT:
  - 10Mbps (20MHz)
  - Distances from 15m to 1km
  - Power up to 100W
- Don’t get distracted by possibilities on higher frequencies and higher datarates.

Future of SPE

- Open architecture is the way forward.
- Buildings need a solid communications network, that Ethernet has already won
- (4-pair) PoE provides the best technological solution for power and data, but at a high price
- SPE, if it can reach the cost objectives, would tick all the boxes to provide the best solution



Agenda

1. Update of 25G Ethernet
2. PoE and Installation Methods
3. Single Pair Ethernet
4. New Infrastructure for Intelligent buildings
5. The Bigger Picture

Future Design

- So we now have the traditional cabling for TOs (Telecommunications Outlets)
- And we add the new IoT cabling for SOs (Service Outlets)
- How can we cable all this?

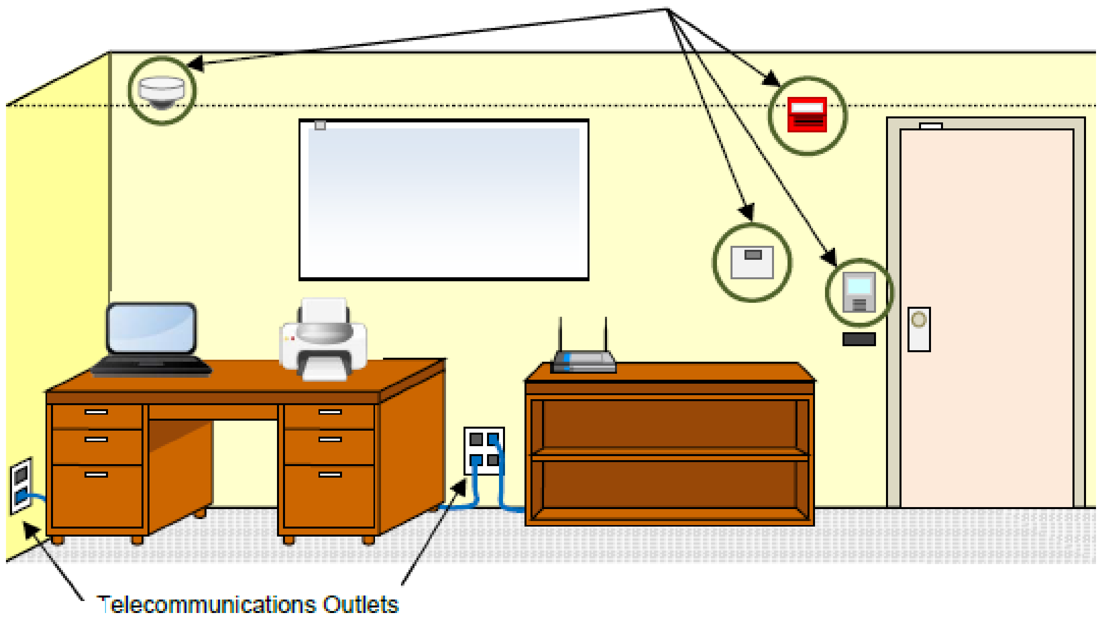


Figure 5-7
Types of Outlets Within a Building

Cabling for the intelligent building

BICSI 007: Information Communication Technology Design and Implementation Practices for Intelligent Buildings and Premises

5.6 Outlets and Connectors

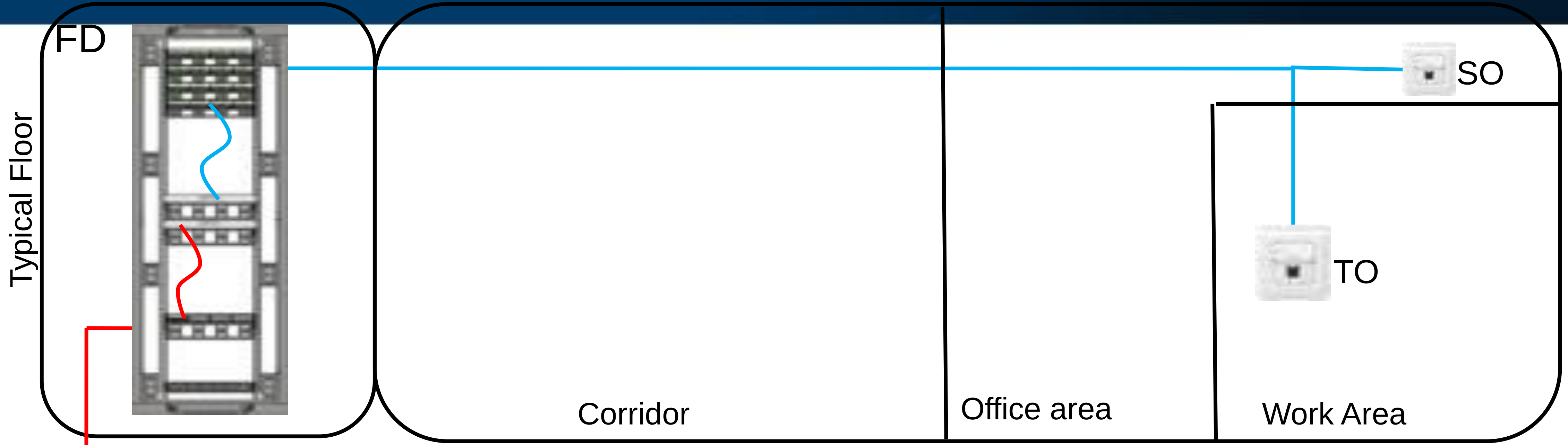
5.6.1 Overview

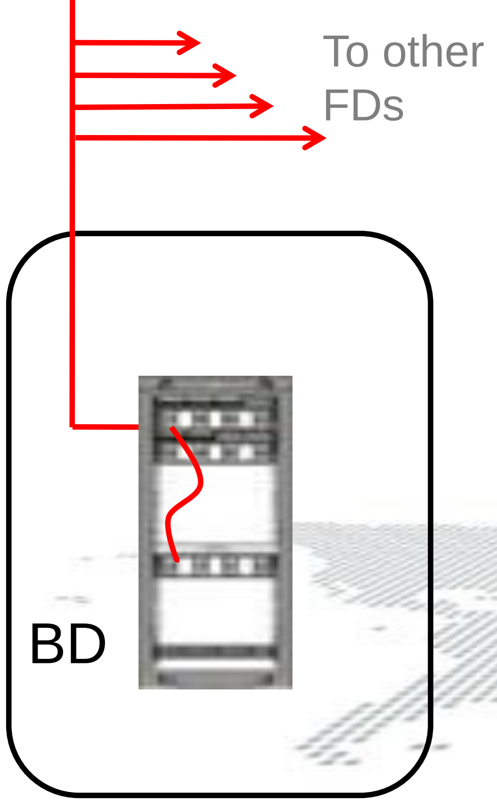
Outlets and their corresponding connectors provide the ability to easily connect equipment (e.g., computer, phone, security camera, wireless access point) to the ICT cabling system. A common example is a wall mounted connector within an outlet in which a cable or equipment cord for a telephone is inserted.

Outlets can be defined into the following two categories:

- Telecommunications outlet—used primarily in locations where the end device is administered by the user (e.g., computer, phone)
- Service outlet (SO)—connects a "non-telecommunications" device (e.g., door controller, security camera), and its location, media and topology is dependent on the application and location of the service.

Traditional hierarchal Star

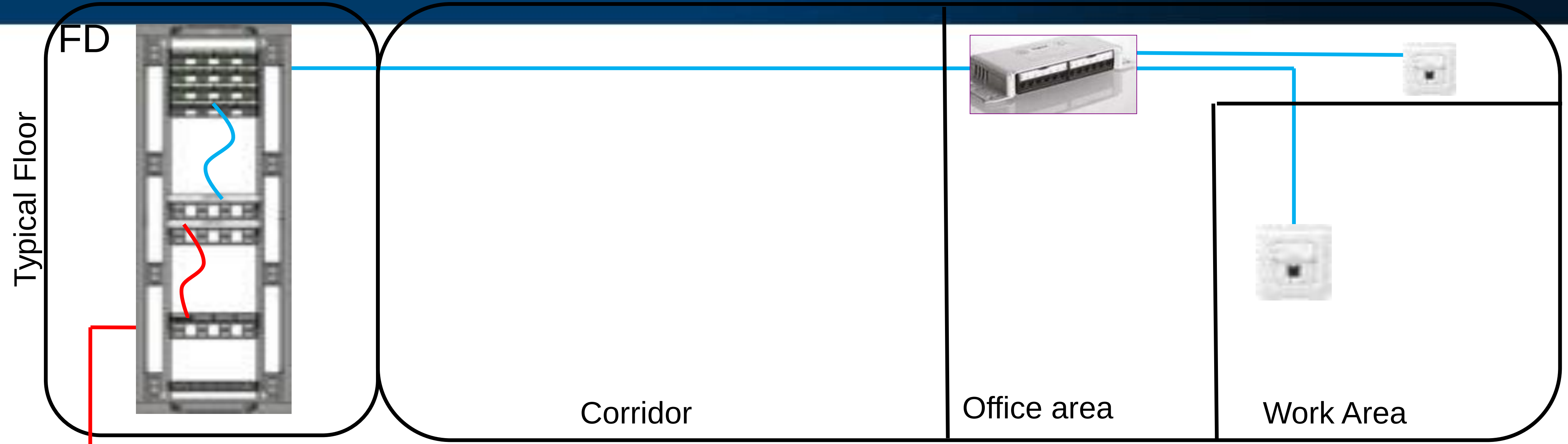


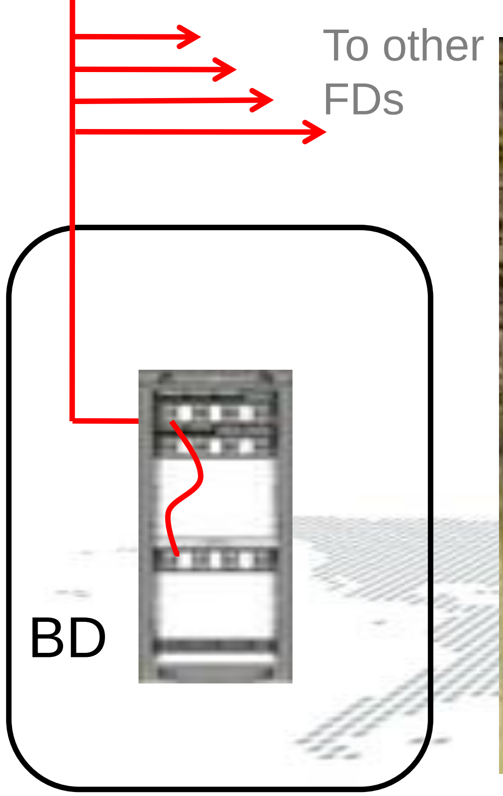


- Too much Cables,
- Too much patching
- Limited flexibility

- Note that TO is always 4pair but SO can be 4 pair, or 1 pair, or application specific.

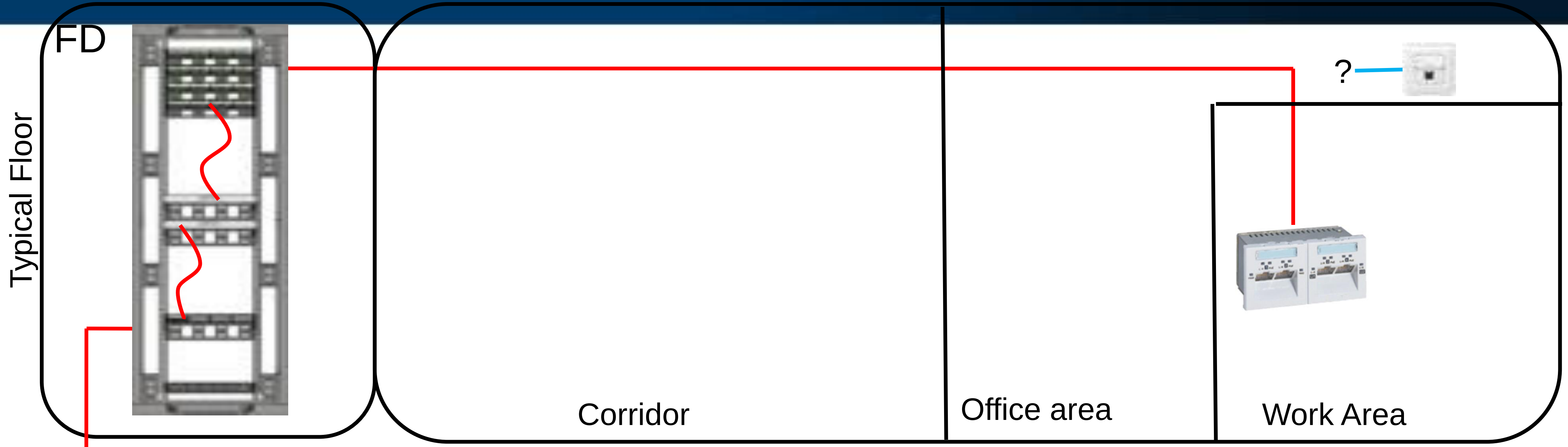
Consolidation Point

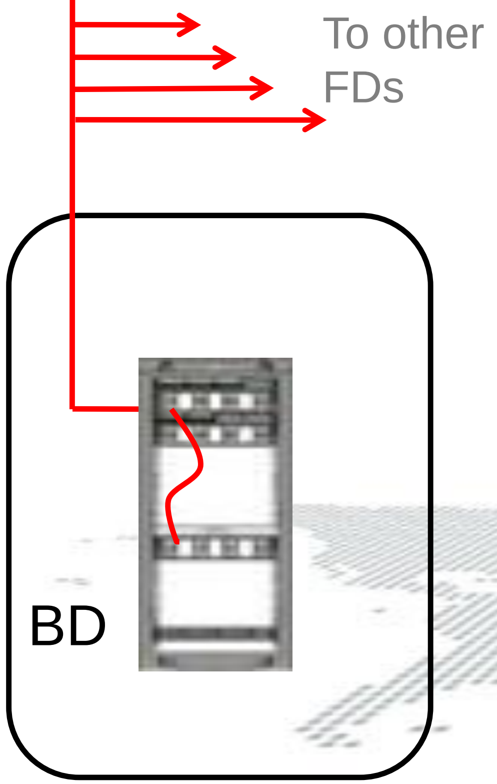




- Better flexibility, but…
- Still too much Cables,
- Still too much patching

Fiber to the Desk

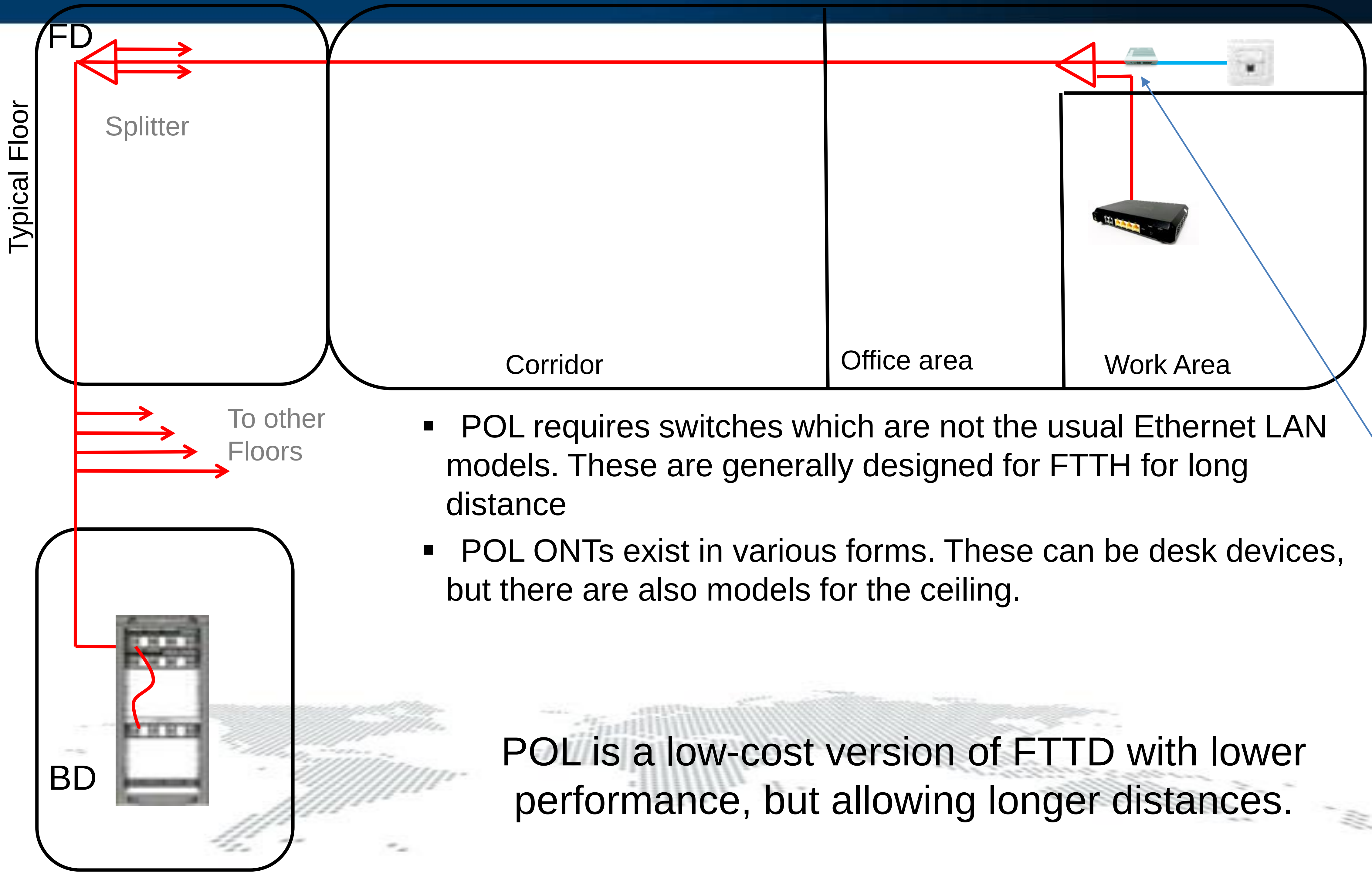




- Solves the cable issue
- Can’t connect the SOs,
  - Especially if using Single Pair Cabling.

- Notes: FD can be removed by splicing to fiber backbone (centralized fiber cabling)
- Solution usually with 4-port miniswitches because devices have RJ45 ports

POL



- Solves the cable issue
- Can connect the SOs only by adding ceiling ONTs
- Cannot connect Single pair cabling.

- POL requires switches which are not the usual Ethernet LAN models. These are generally designed for FTTH for long distance
- POL ONTs exist in various forms. These can be desk devices, but there are also models for the ceiling.

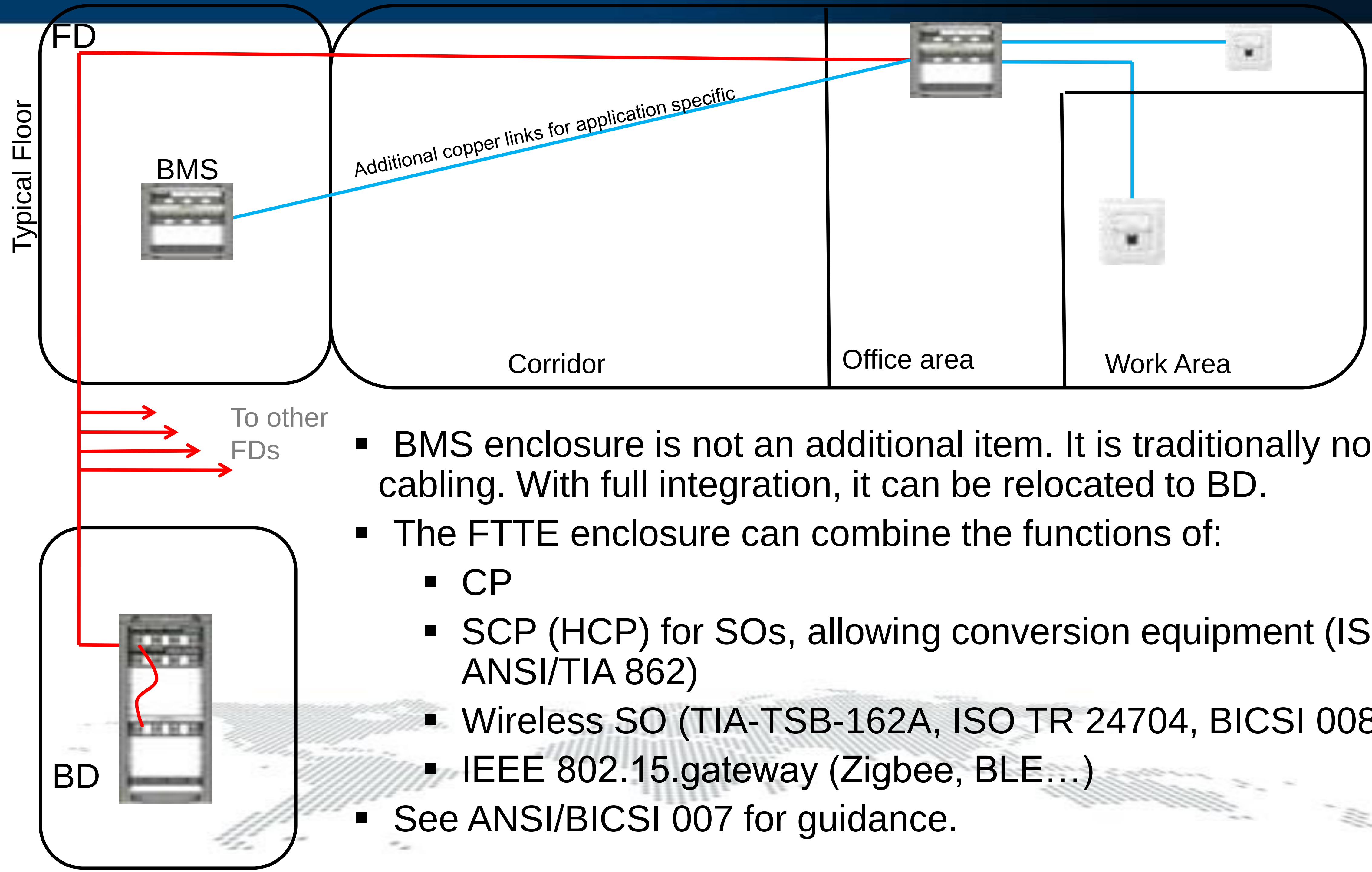
POL is a low-cost version of FTTD with lower performance, but allowing longer distances.

Alternative:

Are there alternative solutions with the right flexibility?

Anyone remember FTTE design?

FTTE



- Best flexibility
- Allowing all options.
- Needs redesign and improved coordination. (breaking the silos..)

- BMS enclosure is not an additional item. It is traditionally not part of structured cabling. With full integration, it can be relocated to BD.
- The FTTE enclosure can combine the functions of:
  - CP
  - SCP (HCP) for SOs, allowing conversion equipment (ISO/IEC 11801-6, ANSI/TIA 862)
  - Wireless SO (TIA-TSB-162A, ISO TR 24704, BICSI 008)
  - IEEE 802.15.gateway (Zigbee, BLE…)
- See ANSI/BICSI 007 for guidance.

Agenda

1. Update of 25G Ethernet
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The Bigger Picture

Our world is changing !

- **All buildings are based around a Ethernet communications infrastructure**
- **PoE, and its successor PoDL (SPE) are going to gradually gain momentum thanks to IoT in order to avoid proprietary cabling.**
- **Buildings must be flexible, to allow rapid reconfigurations. This requires the communications infrastructure to gradually become “plug-and-play”.**

The architecture of the communications cabling is changing to optimize the flexibility of the entire building.

Thank You

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