Evolution of Copper Cabling: How New Systems for Intelligent Buildings are Changing Our Infrastructure Design

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Agenda

1. End of the Road for Copper?
2. The Rise of Remote Powering
3. Single Pair Ethernet
4. Wireless for M2M
5. The Wide Angle

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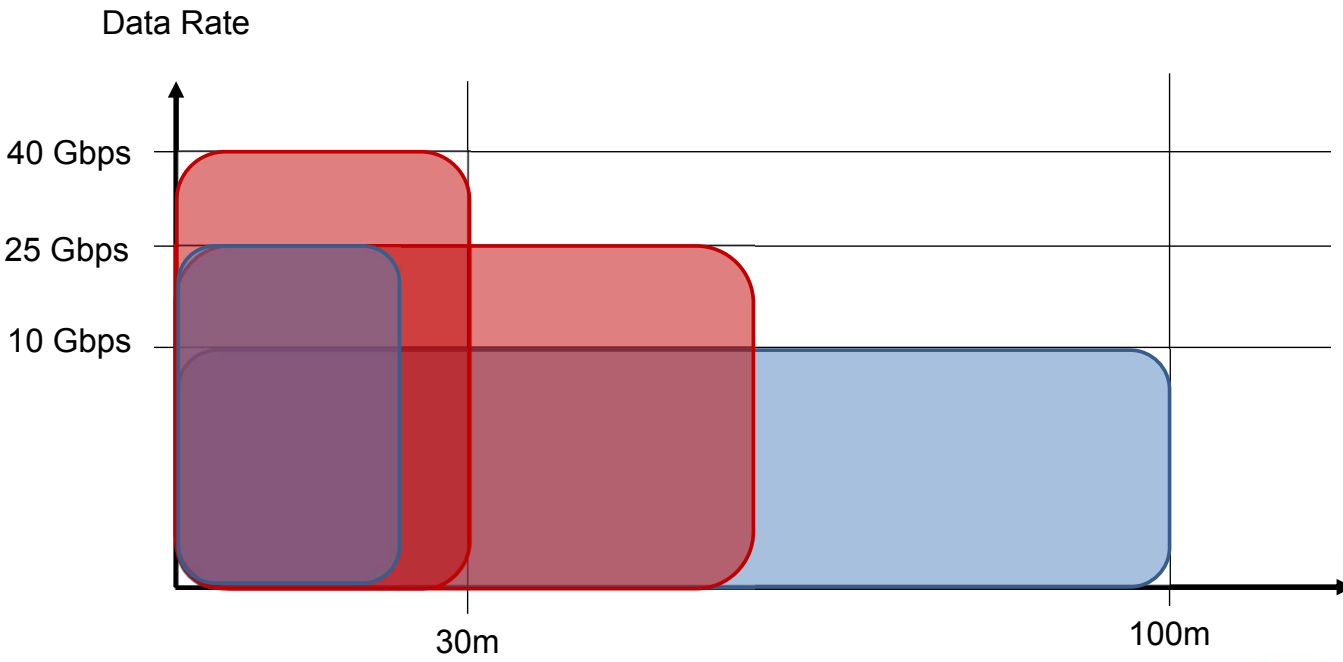
Cat.8, Class I and Class II

	Frequency	Distance	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”

What Comes After 40G on Cat.8 ?

Channel Class E_A ($Cat6_A$)

Channel Class I (Cat.8)



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

Same concept 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.

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

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

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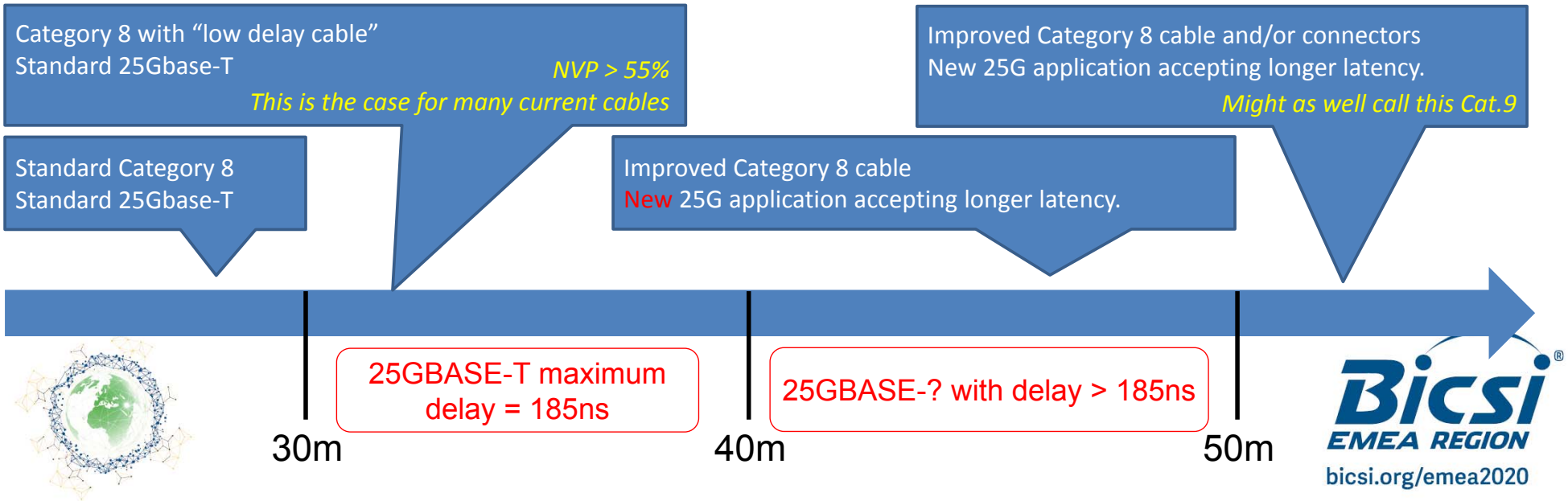
ISO / IEC TR 11801-9909

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 currently NOT interested in developing an new 25G application for longer latency



End of the Road

For now, there is no intent to develop higher performance copper

In fact, most development have been going the other direction:

- **2.5Gbase-T and 5Gbase-T after 10GBase-T**
- **25GBase-T after 40GBase-T**

But copper is not dead ! There are other applications coming…

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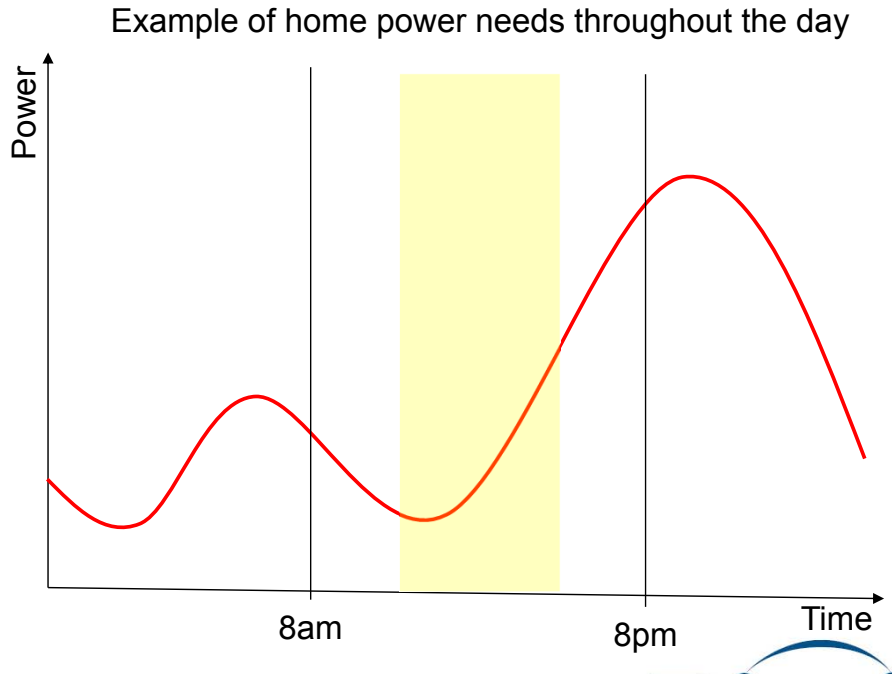
Why Do We Need DC ?

The choice to use A/C in the building distribution dates from more than 100 years ago.

But what are we connecting today ?

- **Most devices in the building are now DC while using a converter.**
- **Local renewable energy (I.e.. Solar) is DC**
- **The trend: increase of power use in the evening. This will require local storage…which is DC.**
- **Electric cars are DC…and can be used as local storage**

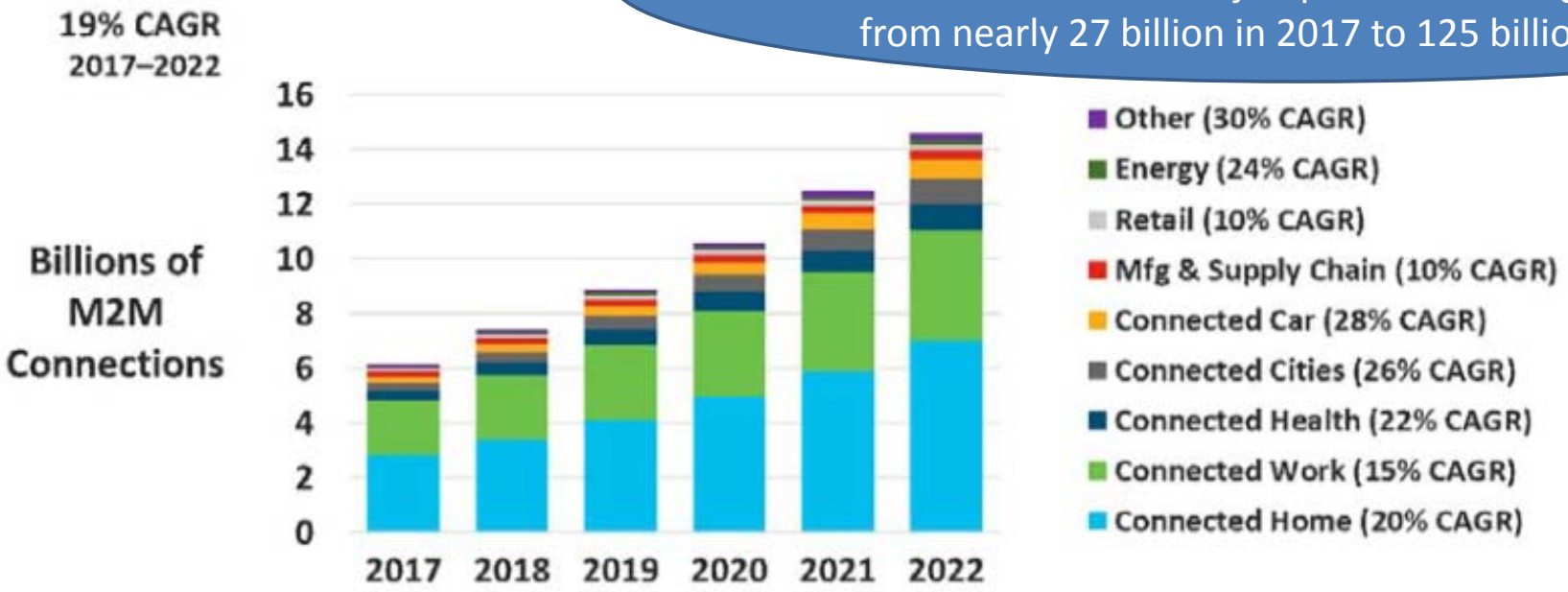


DC power is entering the buildings

We Need an M2M Infrastructure

- From IHS Markit:

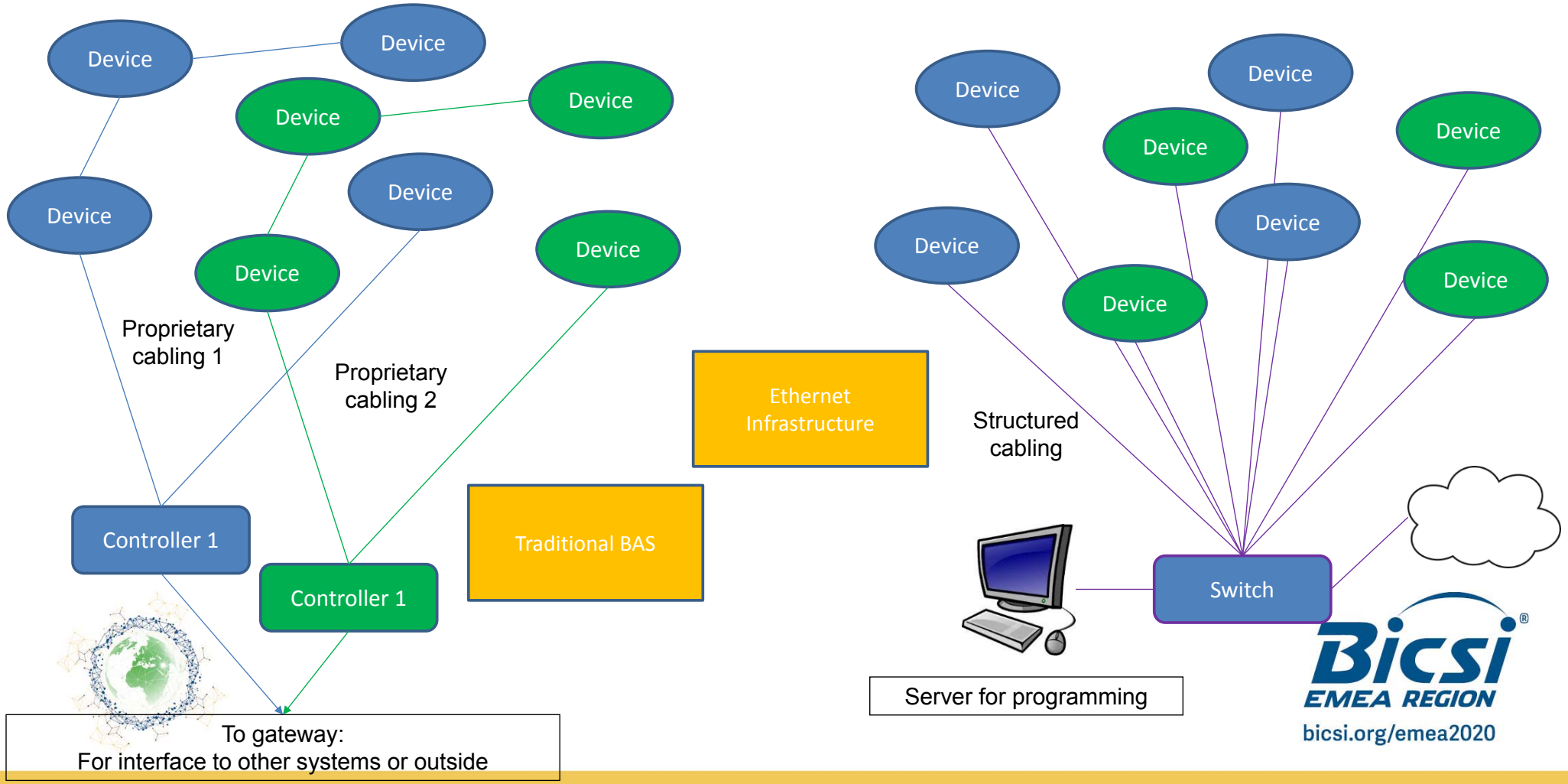
The number of connected IoT devices worldwide will jump 12% on average annually, from nearly 27 billion in 2017 to 125 billion in 2030.



Global IoT/M2M Connections / IoT growth.

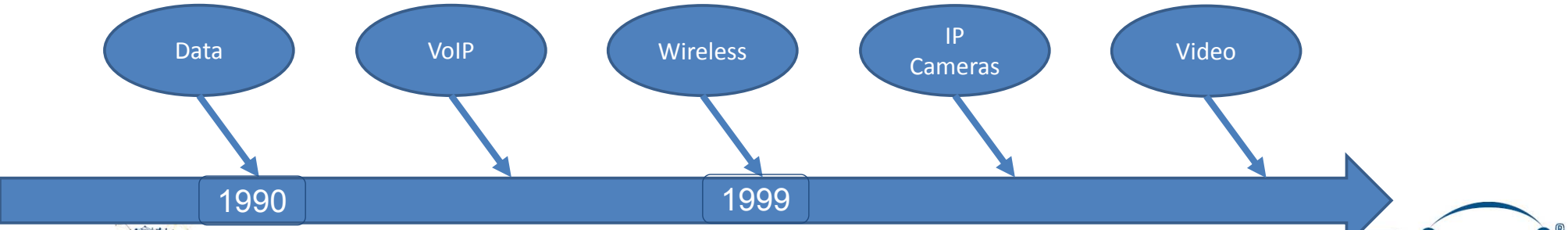
Source: IEEE 802.3™ Industry Connections Ethernet Bandwidth Assessment Part II, April 2020

Why Ethernet?



The OSI Model

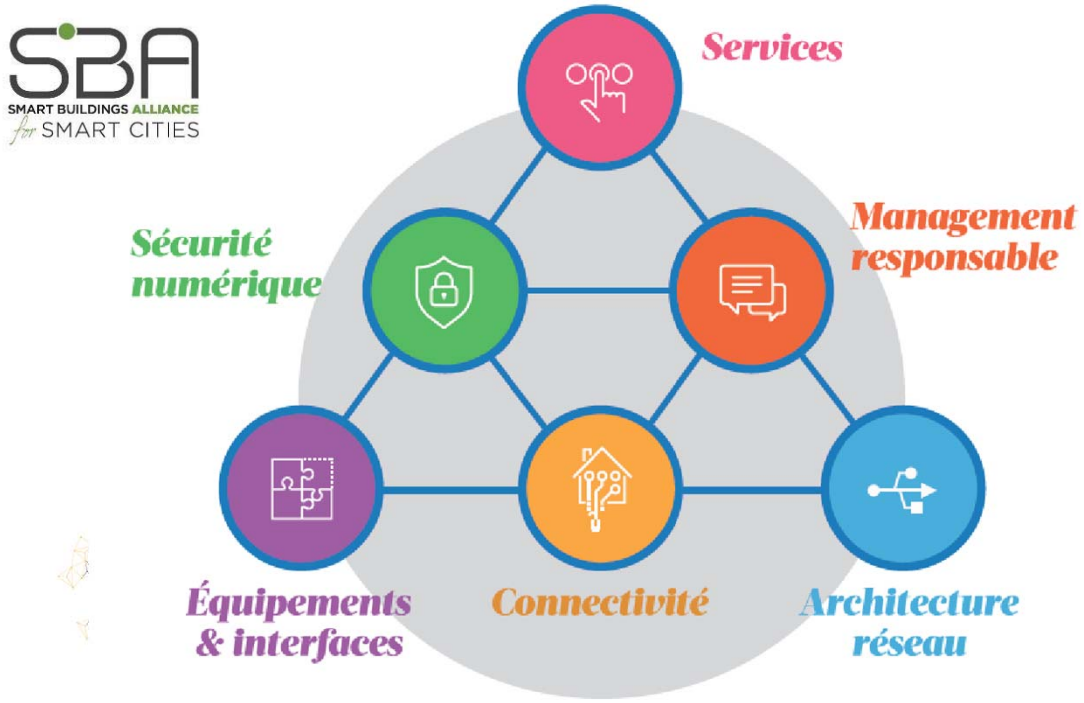
- Layer 7: Application
- Layer 6: Presentation
- Layer 5: Session
- Layer 4: Transport
- Layer 3: Network
- Layer 2: Data Link
- Layer 1: Physical



Smart Buildings

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

Smart buildings will be based around an Ethernet infrastructure



Services to building stakeholders

Governance

Technical Principles

Vision: To make commercial buildings more responsive to the needs of users by promoting a secure, multi-standard, IP-based harmonized IoT solution

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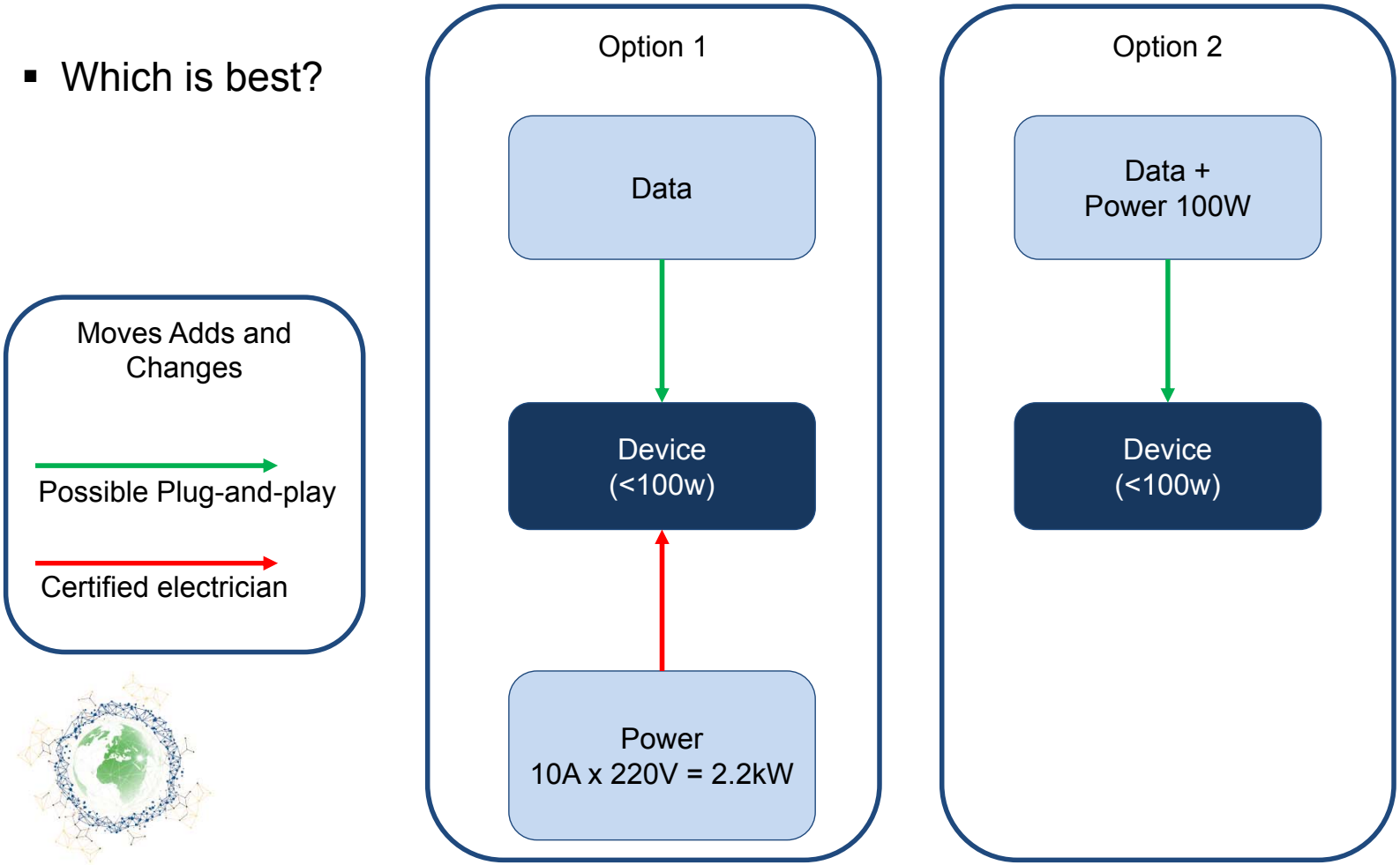
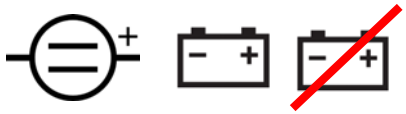
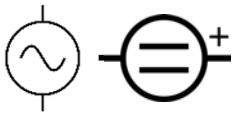
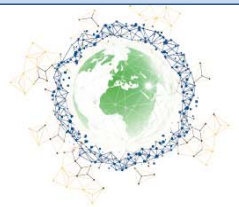
Why PoE?

- Which is best?



Cabling for the Power Infrastructure

	Devices connected to the cabling	Type of power
Plenum / Ceiling	Lighting , Fixed Machine-to-machine (IoT) *LEDs, motion detectors, controllers…*	
User Level	User interface *Light switches, touchscreens…*	
Floor Level	Fixed devices sourcing power *Kitchen appliances, Lamps, A/V..* Mobile devices sourcing power *Vacuum cleaners, phones / tablets…* Fixed devices sourcing data + Power *IT equipment…*	



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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

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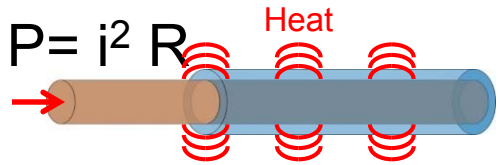
Basic PoE Rules



- Estimate the temperature increase of the cabling and add to the environment temperature. (1)
- In any case T + ΔT should be maximum 60 °C for ISO/IEC 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 at 20°C with 50% extra attenuation	

Risks:
Performance not guaranteed
Faster ageing of the cables

(1) See ISO/IEC 14763-2 ed.2, December 2019

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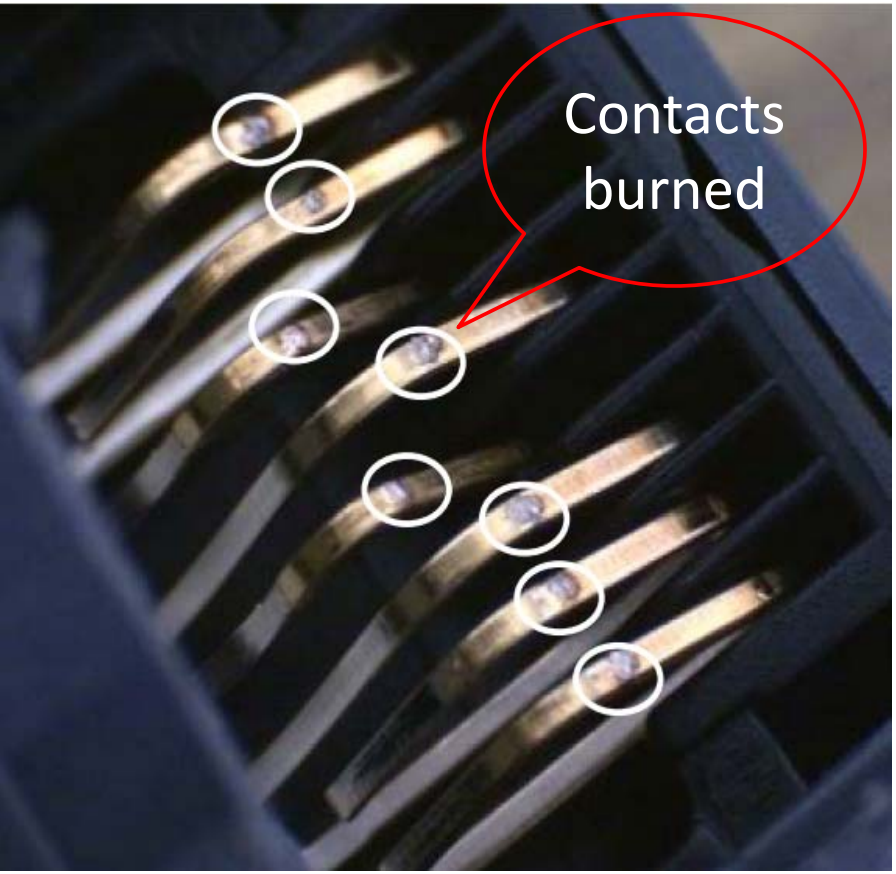
A Word on Connectors:

PoE can destroy the connector during disconnection



Standards to confirm the durability of the connectors under disconnection:

- IEC 60512-99-001: up to IEEE 802.3 at 30W on 2 pairs.
- IEC 60512-99-002: up to IEEE 802.3 bt 100W on 4 pairs (ratified 2019)

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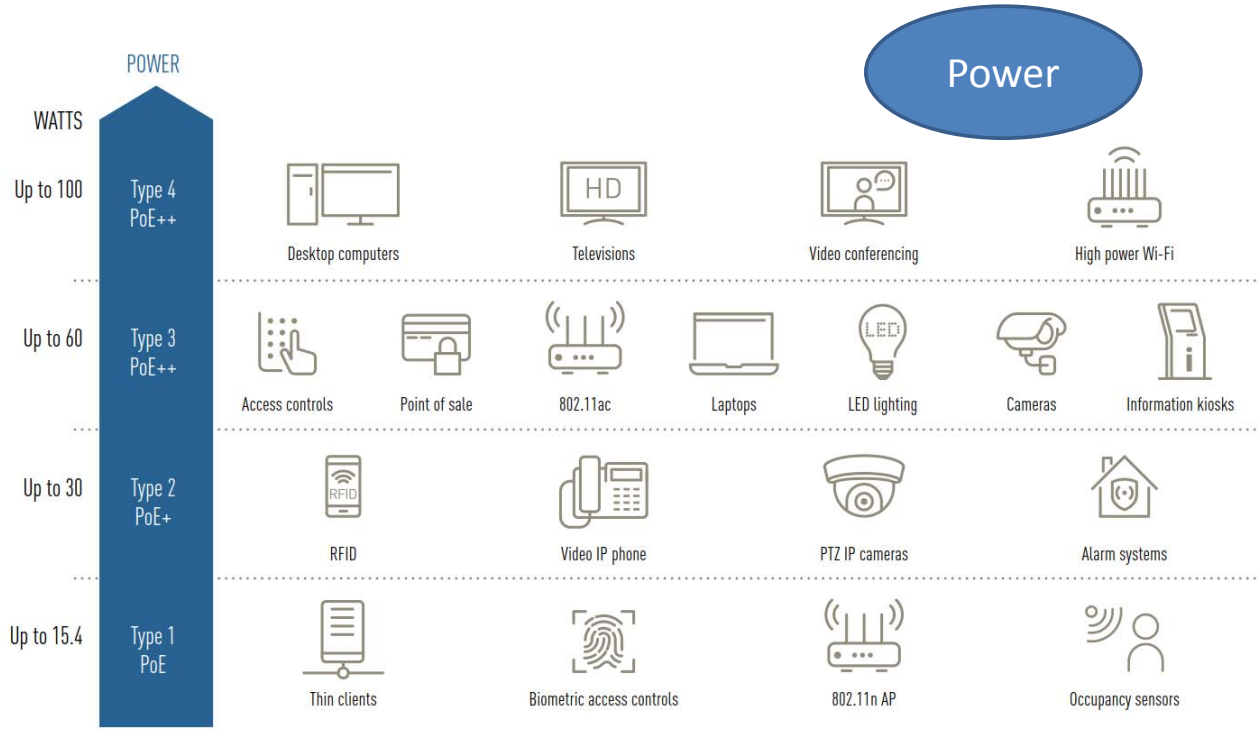
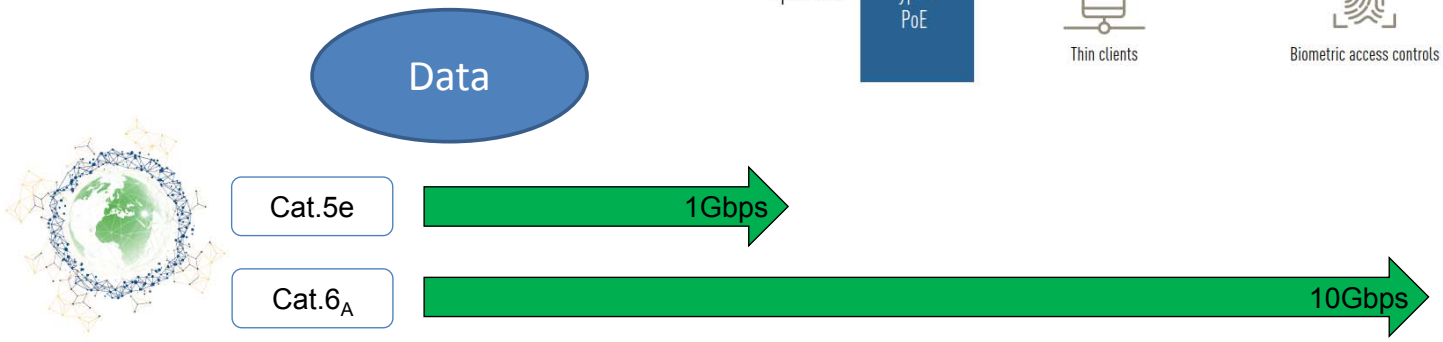
What We Offer

- Our cabling systems can provide:





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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

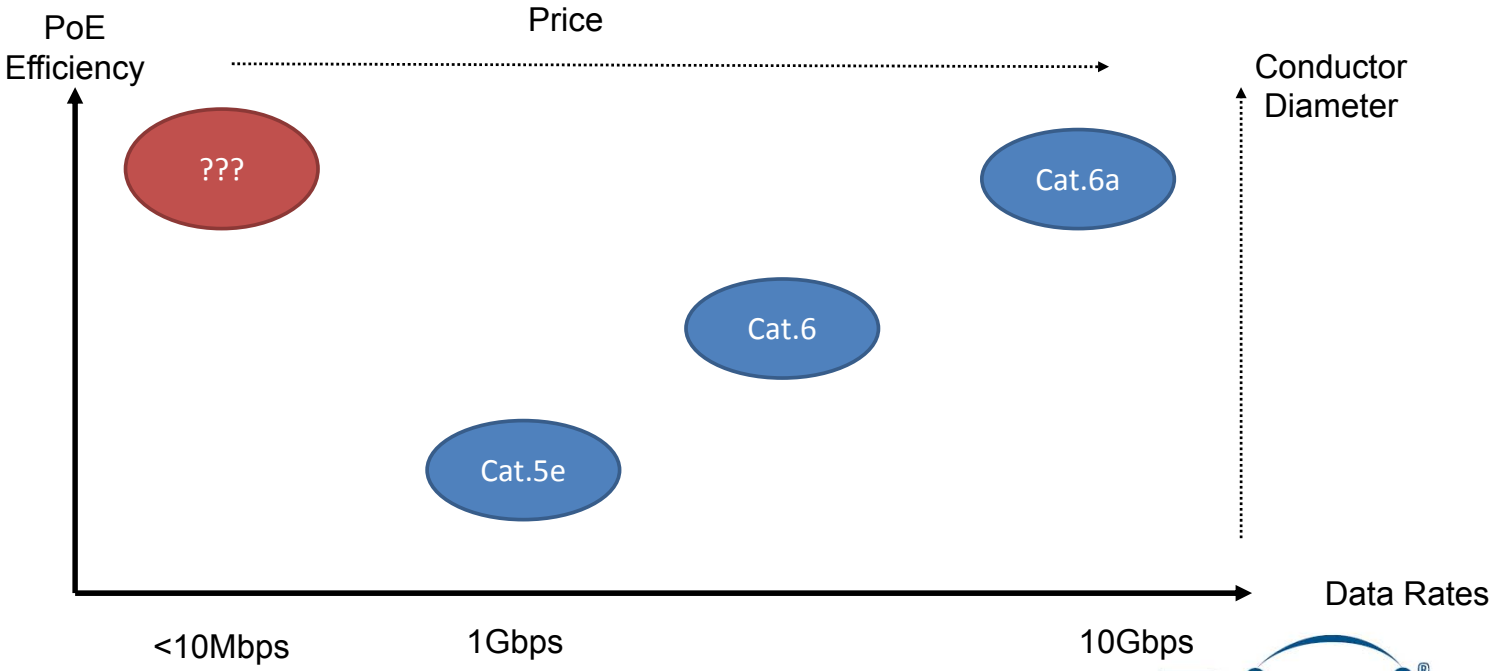
Building Controls Protocols

- 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



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Single Pair Ethernet

- 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.

Why?

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
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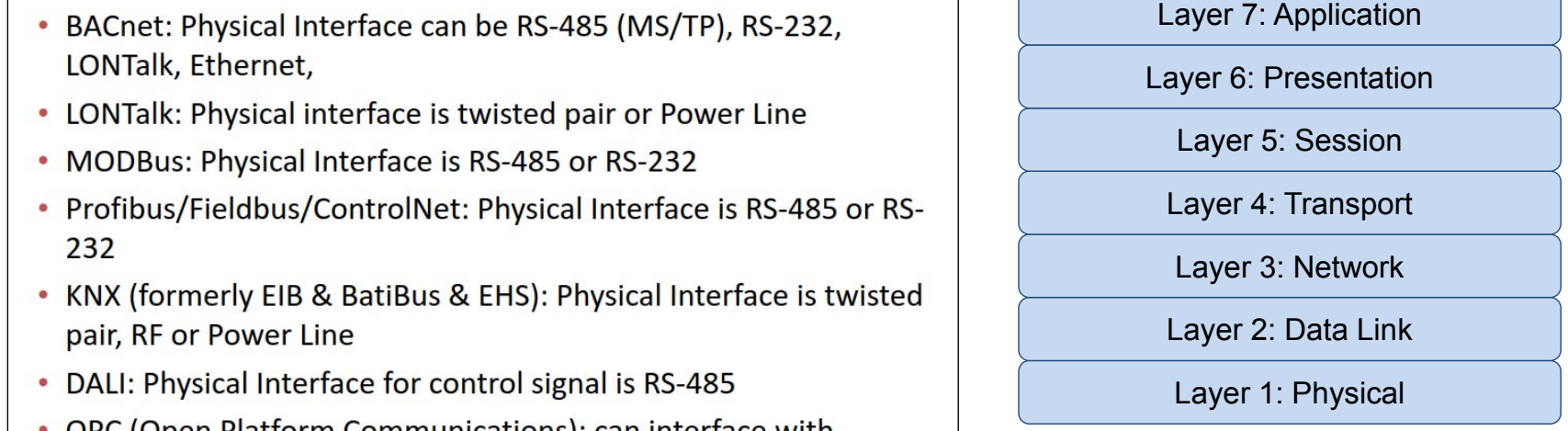


Single Pair Ethernet

- Objective: to offer a solution for M2M providing, compared to current 4-pair:
  - Lower data
  - Similar power
  - Allow longer distances
  - Lower cost
  - Compliance to standards
  - Possible bus topology

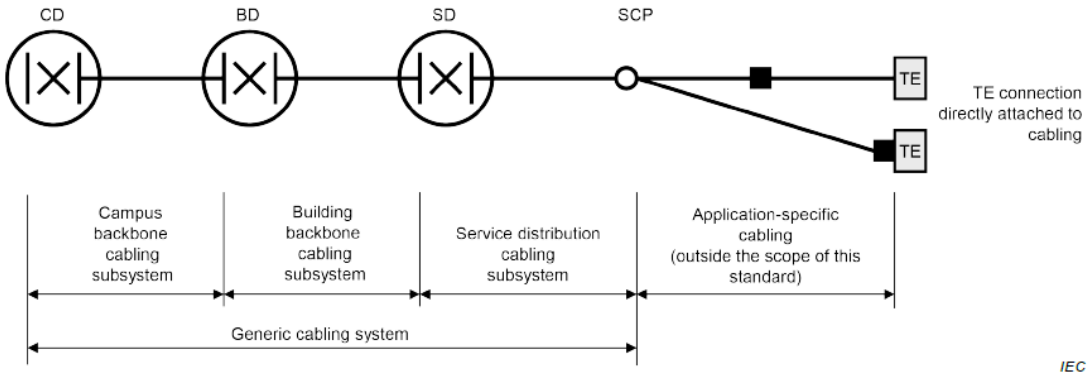
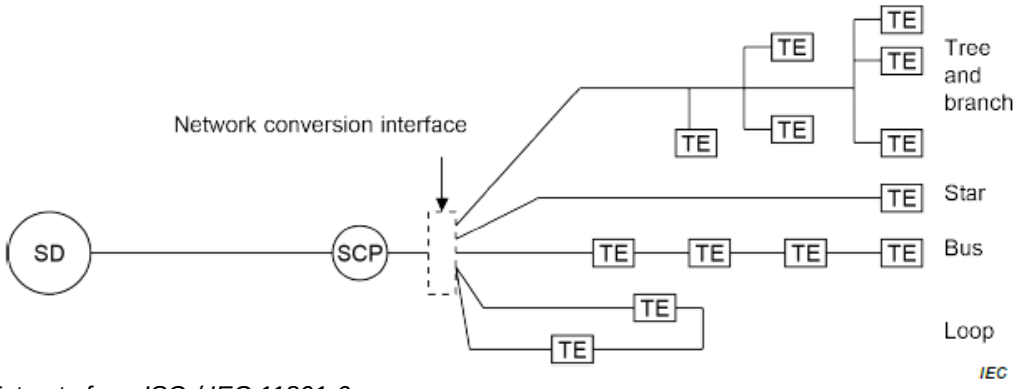


Figure 4 – Structure of Type B generic cabling



Extracts from ISO / IEC 11801-6

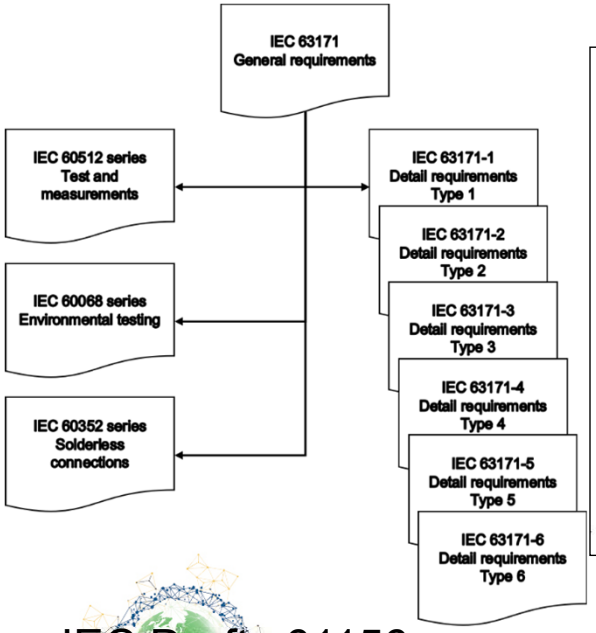
List of SPE Options

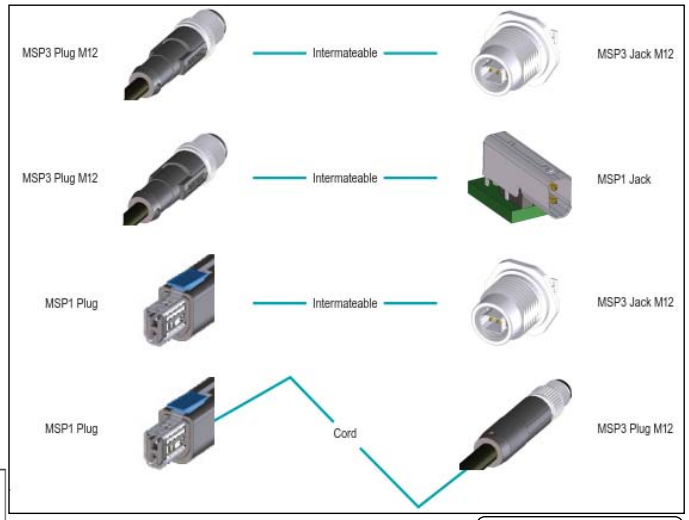
- IEEE Single Pair Ethernet

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	Ratified 2019
802.3ch Multi Gig	2.5G, 5G, 10G	Automotive	15m		Draft Expected 2020

IEC Standards

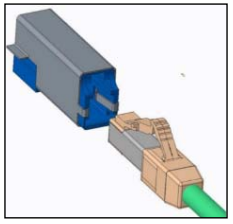
- IEC - Drafts 63171-x
  - Connectors for single pair use (not limited to Ethernet)
  - All 6 variant will be defined



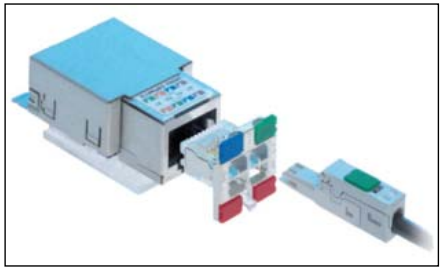


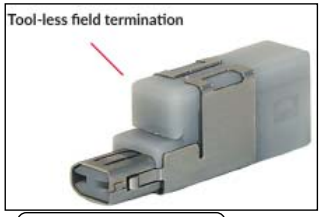
63171-5

63171-1



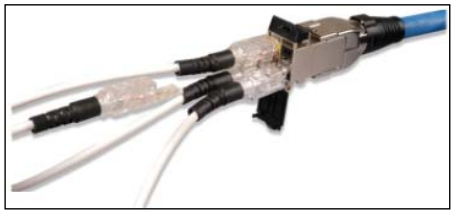
61076-3-25
-> 63171-6

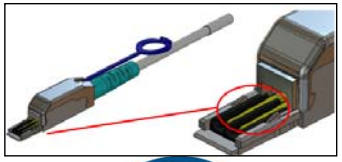




63171-2

63171-3





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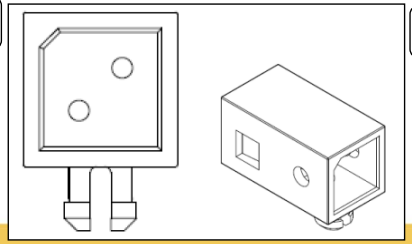


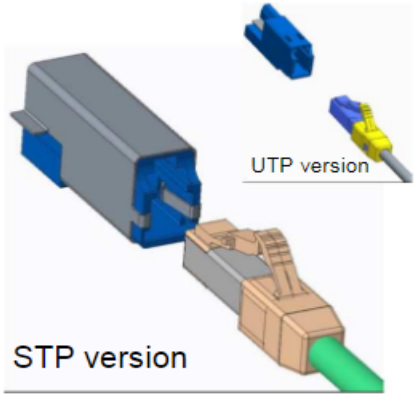
- IEC Drafts 61156-x
  - Cables for 20Mhz channels (x=13, 14)
  - Cables for 600 MHz channels (x=11, 12)

ISO/IEC 11801-1 Amd. Draft

Connectors:

- Two connectors are chosen

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

IP20

M8 IP65/67

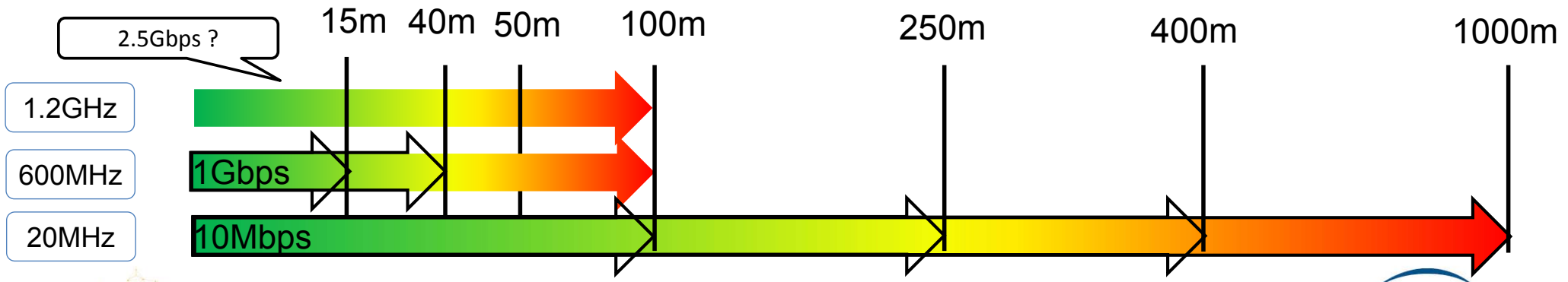
M12 IP65/67

ISO/IEC 11801-1 Amd. Draft

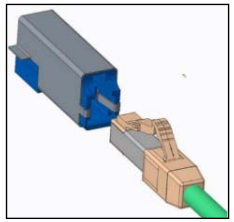
Single pair channels

- Cables are18AWG to 26AWG
- Channels based on connection between 4-pair and 1-pair are planned

Channel	Frequency	Length(s)
T1-A	20MHz	100m, 250m, 400m, 1000m
T1-B	600MHz	100m
T1-C	1.2GHz	100m?



ANSI/TIA 568-5 Draft



- Single Pair Balance Twisted Pair Telecommunication Cabling Standard
  - Components for single pair Ethernet (same 2 connectors as ISO/IEC 11801-1)
  - Systems (Channel and Permanent Link) for commercial buildings.
    - The 20MHz channel is divided into 2 options according to distance.
    - The 600MHz channel is moved to annex.

Category (TBD)	Wire Size	Channel reach	IEEE 802.3	Data Speeds
SP1 Version B	18 AWG	1000m	802.3cg	10Mbps
SP1 Version A	23 AWG	400m	802.3cg	10Mbps

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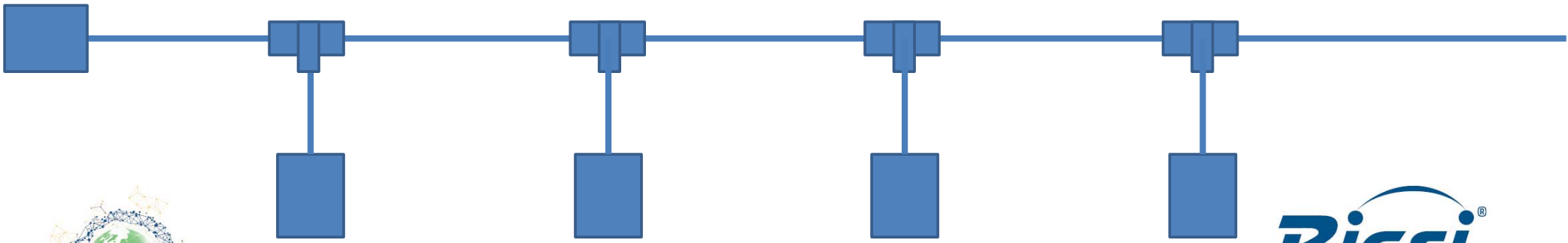
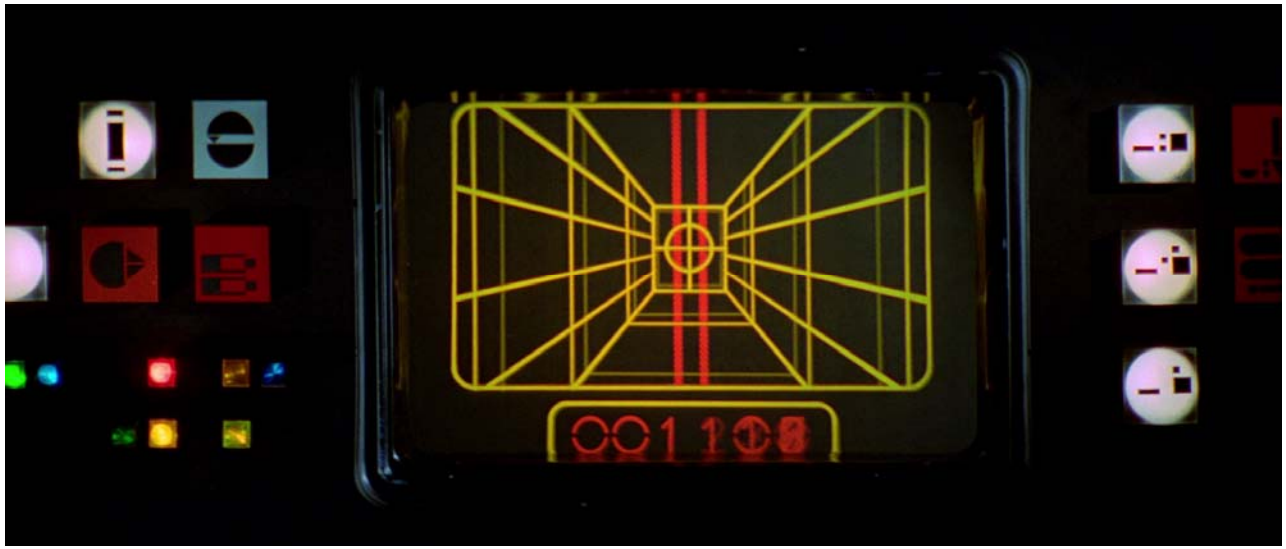
New Multidrop

- The study group of January 2020 just approved the objectives:
  - Mixing segment for 10Mbps supporting 16 nodes, for at least 50m
  - Select a single MDI Connector.
  - “Plug-and-play”
  - “Hot-plug”
  - Up to 5w per node



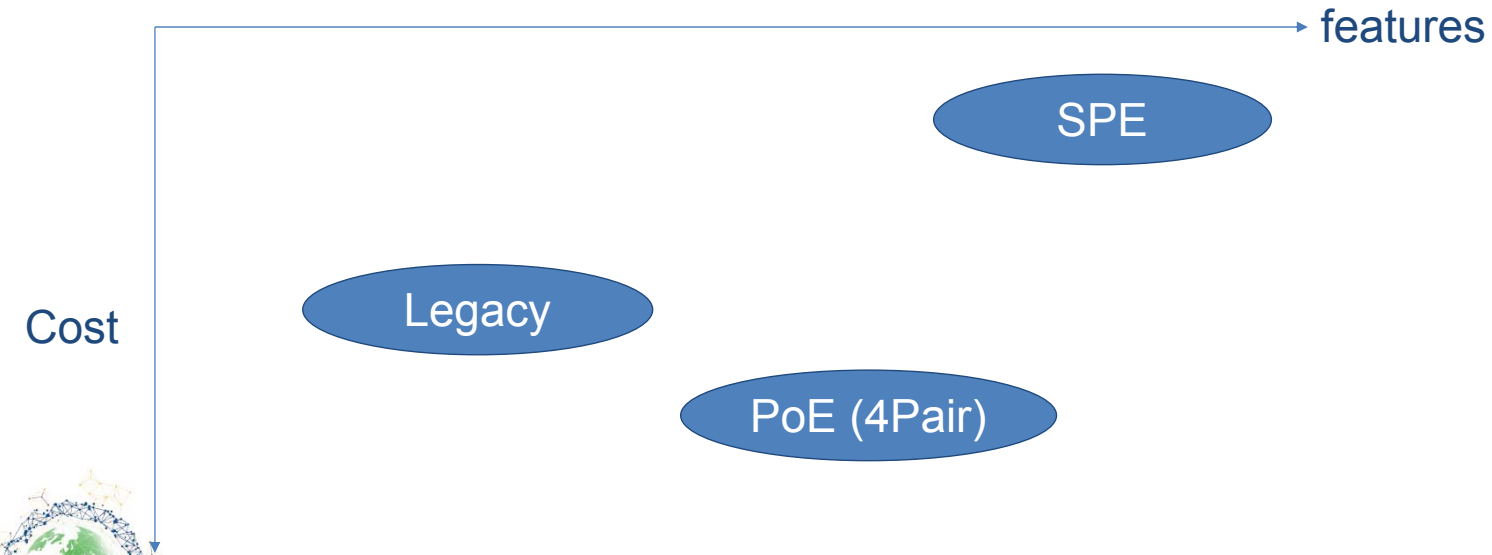
Stay on Target!

- Our objective is to provide an infrastructure for IoT:
  - 10Mbps (20MHz) — Remember M2M needs low data rate and low cost
  - Distances up to 1km — But mostly 50m to 400m.
  - Power up to 70W — But mostly 5W to 15W.
- Don’t get distracted by possibilities on higher frequencies and higher data rates.



Future of SPE

- Open architecture is the way forward: That's Ethernet.
- (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



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

Agenda

1. End of the Road for Copper?
2. The Rise of Remote Powering
3. Single Pair Ethernet
4. Wireless for M2M
5. The Wide Angle

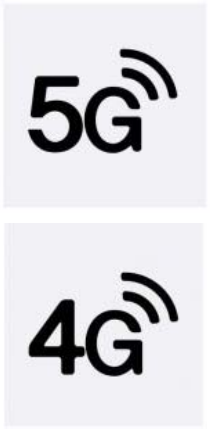
What About Wireless?

Too many choices !

Classification

M2M inside buildings

Mesh Wireless	Star Wireless	Cellular Network	LPWAN	
			Licensed	Unlicensed



Mesh topology	*Native Ethernet* *Market acceptance*	*Market Acceptance*	*Extra long distance* *Low cost for unlicensed.*
Multiple standards *Non-Ethernet Native*	*Power hungry* *Star topology*	*IoT would be on 5G, not yet deployed.* *Signal inside buildings* *Subscription Cost*	*Unadapted for high density in building* *Cost for licensed*

Key points for building IoT

The CHIP Project

Amazon, Apple, Google, Zigbee Alliance and board members form working group to develop open standard for smart home devices

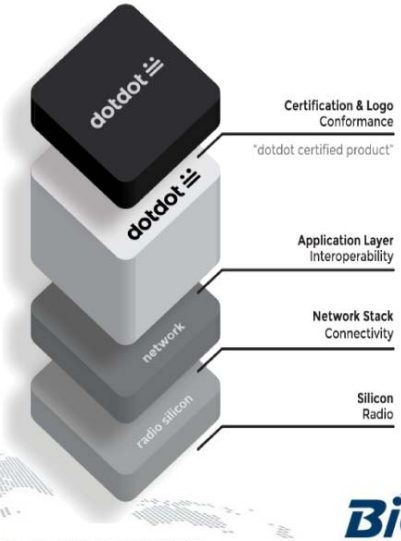
Amazon, Apple, Google, and the Zigbee Alliance today announced a new working group that plans to develop and promote the adoption of a new, royalty-free connectivity standard to increase compatibility among smart home products, with security as a fundamental design tenet. Zigbee Alliance board member companies such as IKEA, Legrand, NXP Semiconductors, Resideo, Samsung SmartThings, Schneider Electric, Signify (formerly Philips Lighting), Silicon Labs, Somfy, and Wulian are also onboard to join the working group and contribute to the project.

Announcement of December 2019

The Gateway of Tomorrow

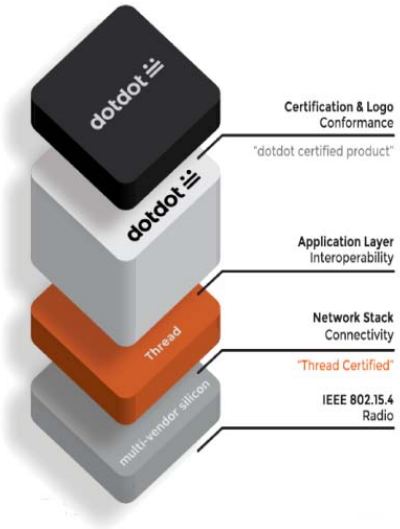
Dotdot is the first open, interoperable, certified application layer that can run over any network.

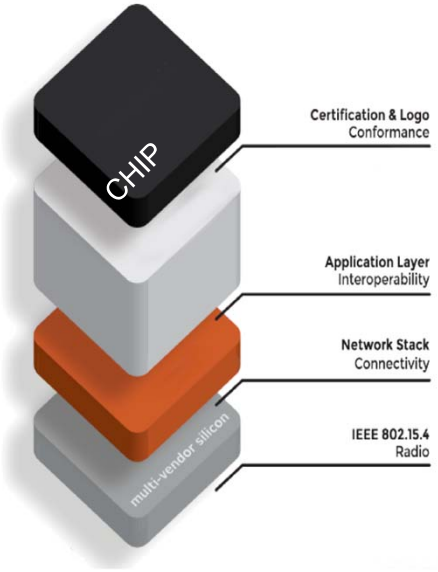
Based on our Zigbee Cluster Library, it comes to market with maturity and an ecosystem of suppliers, manufacturers, and experts.



Bicsi

BICSI Mainland Europe 2019 Roma, 30 October



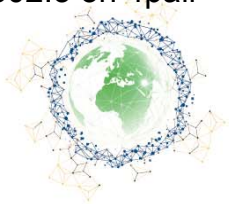


CSMA/CD
802.3 on 4pair

CSMA/CA
Any 802.11 b/g radio

802.3cg 10Base-T1 SPE,
or 4pair Ethernet

CHIP
Any 802.15.4 radio
Any 802.11 radio
Any IP stack



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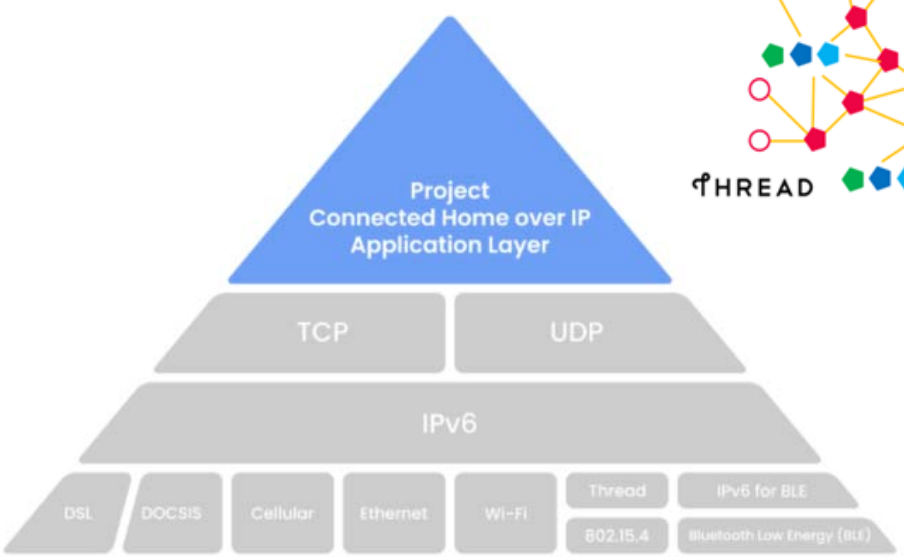
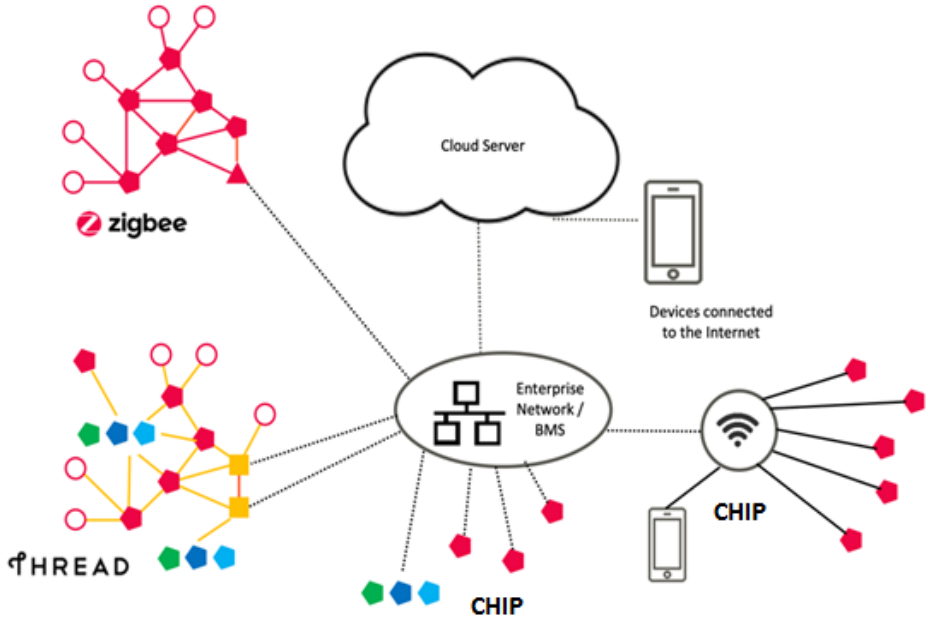
CHIP Will Be Support For M2M over Ethernet





Wired IP connection over Ethernet

Wireless IP connection over Wi-Fi

Low-power wireless connection over Zigbee PRO

Lower-power wireless IP connection over Thread

CHIP Device

CHIP Sleepy Device

Devices running BACnet, KNX, OCF

Zigbee Bridge

Thread Border Router

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Cabling for Mesh Wireless

Wireless did not kill cabling. Instead it needed more cabling in the ceiling.

Mesh Wireless will not replace cabling for M2M. It will require new cabling in the ceiling.

- **Distance: to ensure that there is always a connection available**
- **Reliability: to create guaranteed redundancy**
- **Separate networks: large networks will become unmanageable unless they are fragmented.**

ANSI/BICSI 007

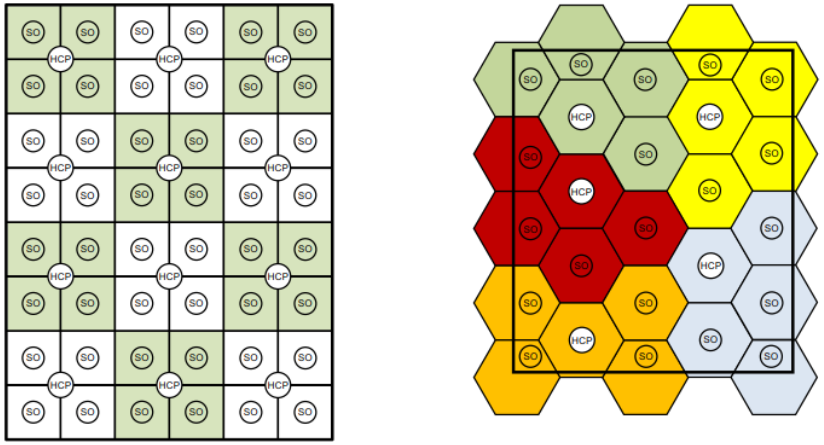

Figure 6-2
Example of Grid and Hexagonal Pattern Coverage Area Zones

We'll apply methods similar to ISO TR24704 or TIA TSB-162-A for cabling for wireless access points. Also see ANSI/BICSI 007 cabling for HCP/SCP.
Think of "zone cabling" if you haven't seen these standards.

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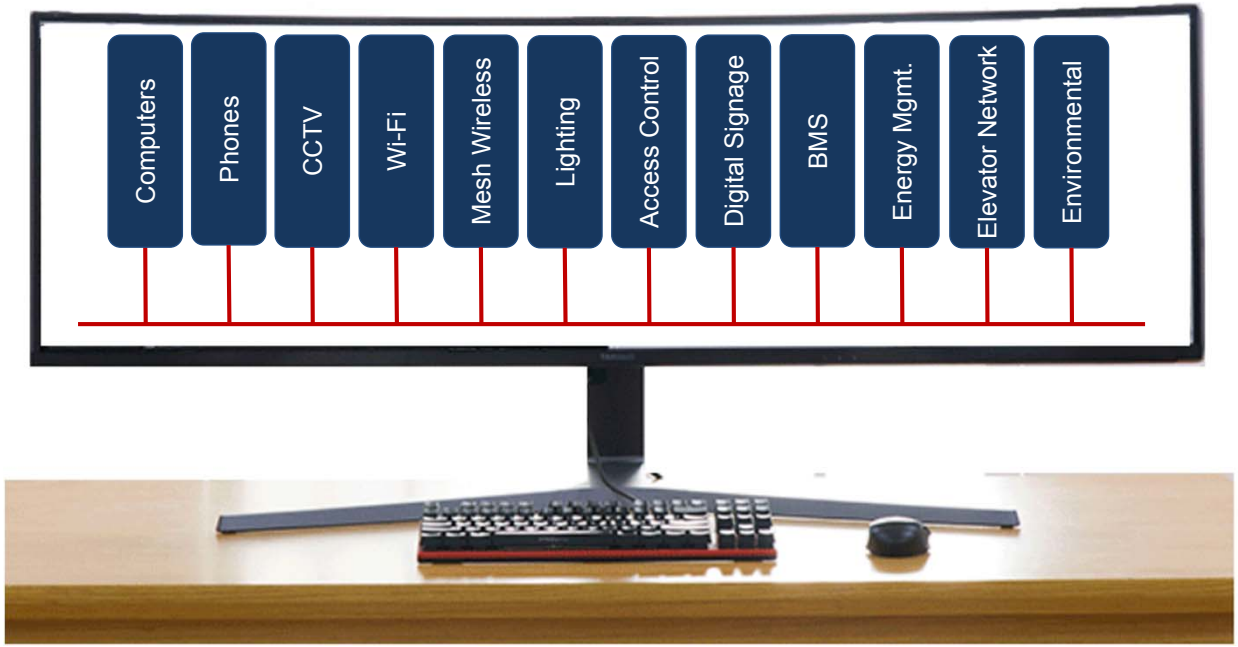
Get the Wide Angle View

Communications Infrastructure yesterday

Communications Infrastructure Tomorrow



The 4th Utility

The communications infrastructure is gradually becoming the core of every building, rather than being the annex in the past.

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Thank You

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