Industry Standards in ICT-Enabled Projects
Reading and Applying the "Fine Print"

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Introduction to Standards

IEEE for Ethernet

IEEE 802:
LAN / Man Standards

802.5: Token Ring (disbanded)

802.1: Higher LAN Protocols

802.15: WPAN (bluetooth, Zigbee,...)

IEEE 802: LAN / MAN standards

802.3 Ethernet (CSMA / CD)	**802.11 Wireless (CSMA / CA)**
802.3j (1990) 10base-T, 10base-F	**802.11a (1999)** 54Mbps @ 5GHz
802.3u (1995(100base-TX, 100base-T4, 100base-FX	**802.11b (1999** 11Mbps @ 2.4GHz
802.3z (1998) 1000base-X (Fiber optic)	**802.11g (2003** 54Mbps @ 2.4GHz
802.3ab (1999) 1000base-T	**802.11n (2012)** 150Mbps @ 2.4 and 5GHz, 600M w/MIMO 4
802.3ae (2003) 10G on fiber	**802.11ac (2012)** 867Mbps @ 5GHz , 6.77G w/ MIMO 8
802.3af (2003) Power over Ethernet, 15w	**802.11ad (2013)** 6.75Gbps @ 2.4, 5, and 60GHz
802.3an (2006) 10Gbase-T	**802.11ax (2019?)** improvement of 802.11ac for high density
802.3at "PoE+" 30W	
802.3ba (2010) 40G and 100G on fiber	
802.3bq (2016) 25Gbase-t and 40Gbase-T	
802.3bz (2016) 2.5Gbase-t and 5Gbase-T	
802.3bt (2018 ?) "PoE++" 100W	
802.3bs (2018 ?) 200G and 400G on fiber	

ISO, International

Edition 3 in 2018

ISO Information Technology Generic Cabling Systems

Components	Performance, Design	Implementation	Validation
	ISO/IEC 11801-1 General requirements	**ISO/IEC 14763-2** Planning and Installation Implementation	**ISO/IEC 61935-1** Testing of balanced twisted Pair Cabling
	ISO/IEC 11801-2 Offices and commercial buildings		**ISO/IEC 14763-3** Testing of Fiber Optic Cabling
	ISO/IEC 11801-3 Industrial premises		
	ISO/IEC 11801-4 Homes		
	ISO/IEC 11801-5 Data centers		
	ISO/IEC 11801-6 Distributed building services		

International Electrotechnical Commission

CENELEC, European

CENELEC
EUROPEAN COMMITTEE FOR ELECTROTECHNICAL STANDARDIZATION

CENELEC Information Technology Generic Cabling Systems

Components	Performance, Design	Implementation	Validation
	CENELEC EN50173-1 General Requirements	**CENELEC EN50174-1** Specification and quality assurance	**CENELEC EN50346** Testing of installed cabling
	CENELEC EN50173-2 Office premises	**CENELEC EN50174-2** Installation planning and practices	
	CENELEC EN50173-3 Industrial premises	**CENELEC EN50174-3** Planning and Installation	
	CENELEC EN50173-4 Homes		
	CENELEC EN50173-5 Data centers		
	CENELEC EN50173-6 Distributed Building Services		

IEC International Electrotechnical Commission

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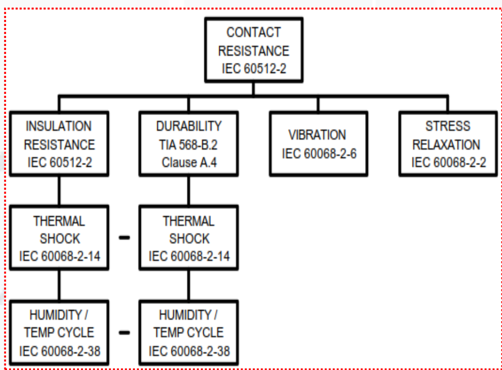
TIA, North American

ANSI/TIA: Telecommunications Cabling for Customer Premises

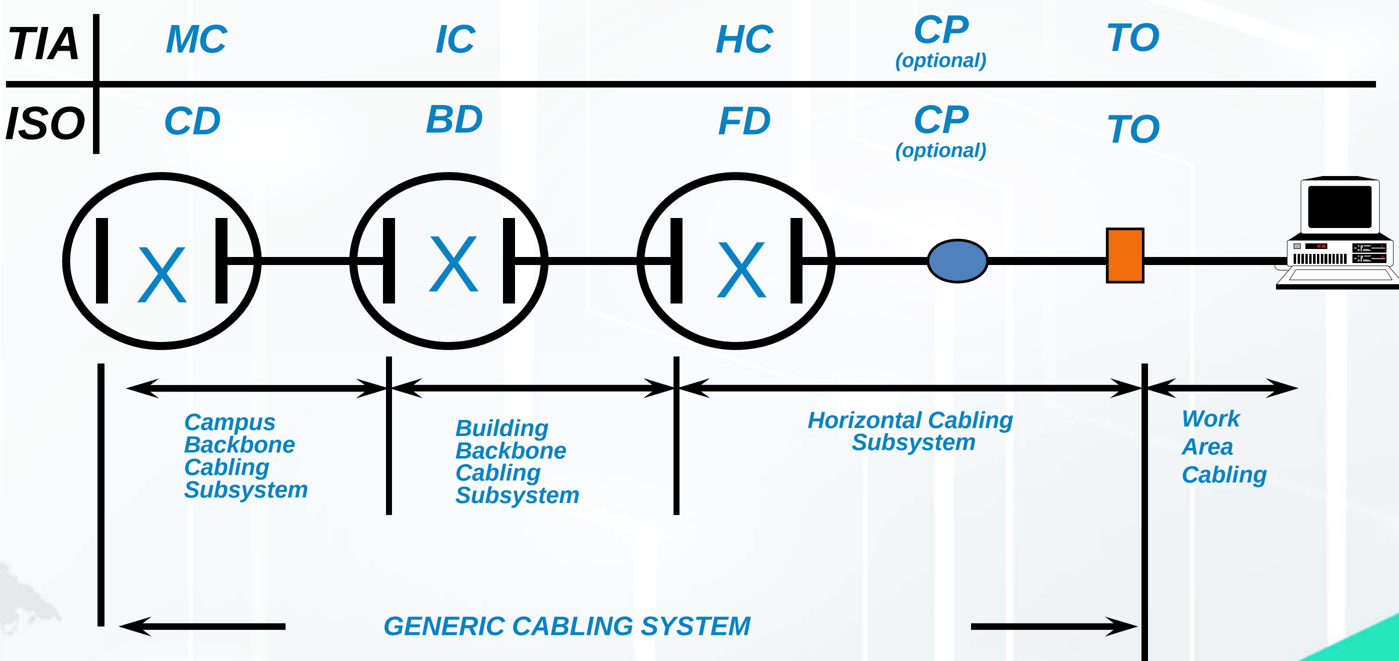
Components, Performance	Design	Implementation	Validation
TIA - 568-C.2 Balanced twisted-pair cabling	**TIA - 568.0-D** Generic cabling	**TIA - 569-D** Telecommunications pathways and spaces	**TIA - 526-7-A** Single-mode fibre testing
TIA - 568.3-D Optical fibre cabling	**TIA - 568.1-D** Commercial building	**TIA - 607-C** Bonding and grounding telecommunications	**TIA - 536- 14-C** Multi-mode fibre testing
TIA - 568.4-D Broadband coaxial cabling and components	**TIA - 758-B** Customer-owned outside plant	**TIA - 606-C** Administration	**TIA - TSB-155-A** Support of 10Gbase-T on eixiting Cat.6
	TIA - 942-B Data centers	**TIA - 862-B** Intelligent building systems	**TIA - TSB-5021** Guidelines for 2.5G and 5G on Cat5e and Cat6
	TIA - 1005-A Industrial premises	**TIA - 5017** Physical network security	
	TIA - 1179-A Healthcare facilities		
	TIA - 570-C Residential		
	TIA - 4966 Educational facilities		
	TIA - 162-A Cabling for wireless access points		
	TIA - 5018		



Differences and limits

The Star Topology

Let's start simple with the terminology for design in commercial environment



The TO

But what's an outlet?

…is this 1 or 2 outlets?

The TO

- ANSI/TIA 568.1-D

telecommunications outlet: An assembly of components consisting of one or more connectors mounted on a faceplate, housing or supporting bracket.

1 outlet with 2 connectors

- ISO 11801

telecommunications outlet
fixed connecting device where the horizontal cable terminates

2 outlets in one assembly

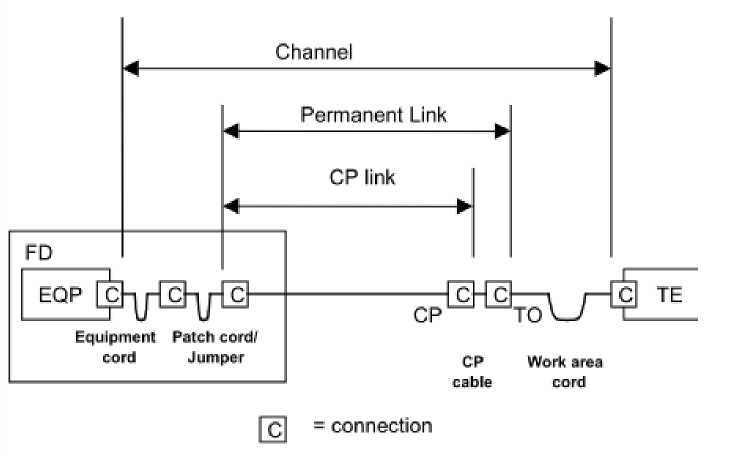
- ANSI/TIA 568.0-D

outlet/connector (telecommunications): An equipment outlet used in commercial and residential cabling.

Not really defined in the generic standard.

Maximum Distances

How about some distances for horizontal cabling..

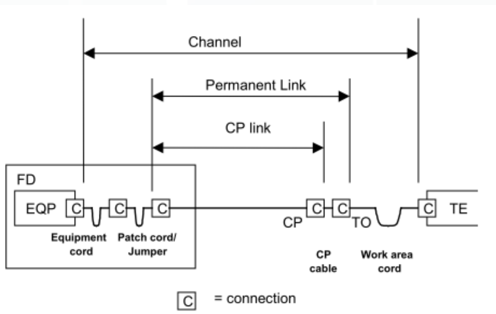


ISO 11801 , figure 10

- Maximum PL length:
  - 90m
- Maximum CHA length:
  - 100m
- Maximum WA cord length:
  - 5m
- Equipment cord and patch cord combined
  - 5m

Minimum Distances

What about the minimum distances?



ISO 11801 , figure 10

Note: Except for the 15m CP rule, the other minimum values are not actual requirements, but only “modeling configurations”.

TIA 568-1.D:

For balanced twisted-pair cabling, in order to reduce the effect of multiple connections in close proximity on NEXT loss and return loss, the CP should be located at least 15 m (49 ft) from the TR or TE.

The 3dB rule:
If the measured Insertion Loss is less than 3dB, then the Return Loss measurement is ignored .

The 4dB rule: *(Only for ISO.)*
If the measured Insertion Loss is less than 4dB, then the NEXT measurement is ignored .

TIA 568-C.2: Figure J.1: Channel modeling configurations used for worst case analysis

ID	Description	Channel configuration 1	2	3	4	5
A	Work area cord	5 m	2 m	1 m	1 m	1 m
TO	Telecommunications outlet / connector	P	P	P	P	P
B	Consolidation point cabling	5 m	5 m	5 m	NP	NP
CP	Consolidation point connector	P	P	P	NP	NP
C	Horizontal cabling	85 m	15 m	15 m	15 m	10 m
C1	Horizontal cross-connect or interconnect	P	P	P	P	P
D	Patch cord or jumper cable	2 m	1 m	1 m	1 m	1 m
C2	Horizontal cross-connect or interconnect	P	P	P	P	NP
E	Telecommunications room equipment cord	3 m	2 m	2 m	2 m	NP

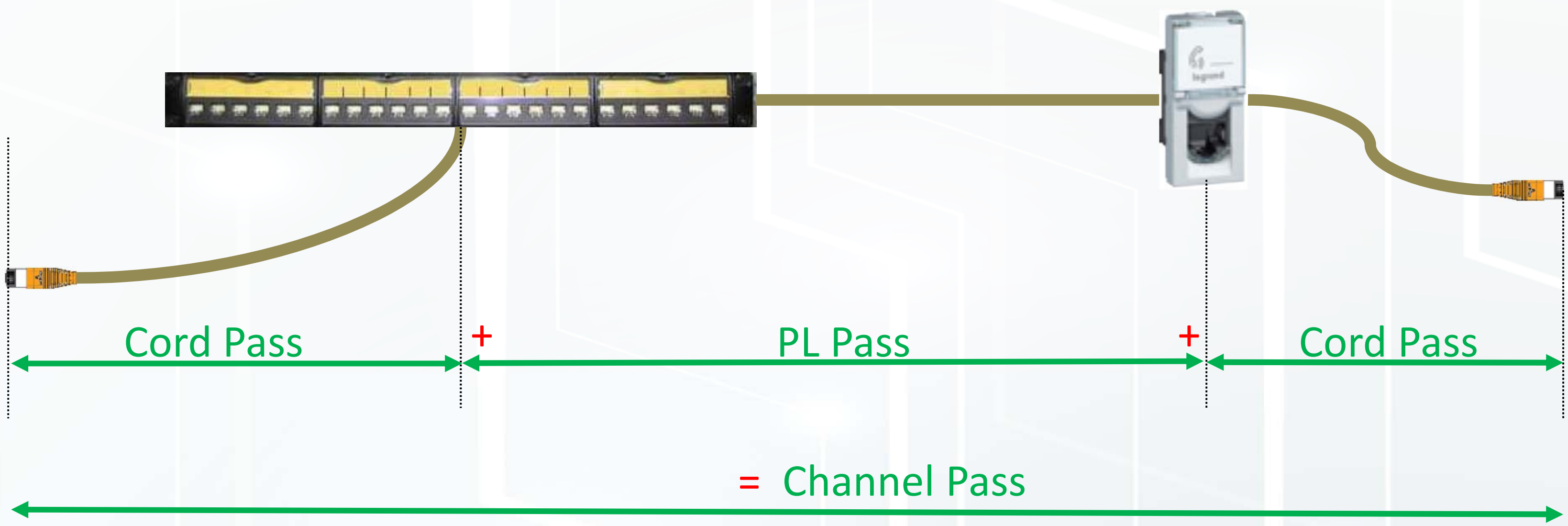
NP = Not present in this channel model
P = Present in this channel model

Segment	Minimum m	Maximum m
FD-CP		85
CP-TO		-
FD-TO (no CP)		90
Work area cord [a]		5
Patch cord		-
Equipment cord [b]		5
All cords		10

ISO 11801, table 32: Length assumptions used in the mathematical modeling of balanced horizontal cabling

Rules of Testing

The rule is: if the permanent link passes, and you add compliant patch cords, then the channel will always pass.



Testing the Limits

Let’s test to see

Permanent Link ISO and TIA	Result
NEXT margin	0.5dB
Return Loss margin	-2.1dB
Result	✓

Ignored
Because IL < 3dB

The 3dB rule:
If the measured Insertion Loss is less than 3dB, then the Return Loss measurement is ignored .

Test the cords	
Cord 1	✓
Cord 2	✓

Test (ISO and TIA)	Result
2-Connector Channel	X
3-Connector Permanent Link	X
3-Connector Channel	X

Note: application 10Gbase-T passing

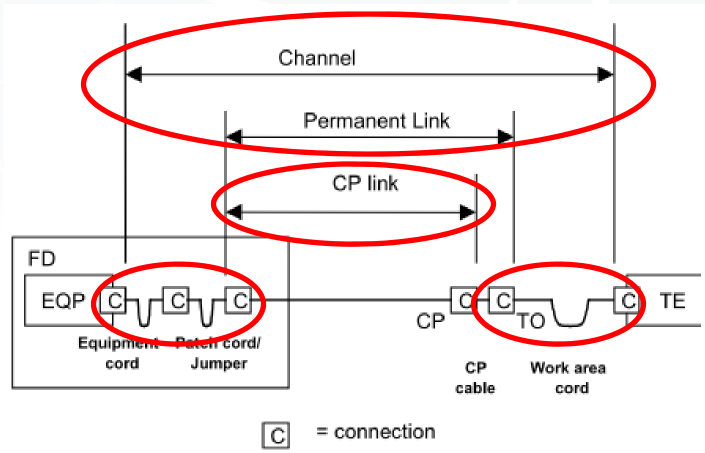
Interpretation

Let's summarize this minimum length stuff…

- Compliance to standards guarantees the performance and inter-operability. Alternative designs can function, but are not guarantee by the standard.
- If your CP is closer than 15m to the patch panel, your test will probably pass because of the 3dB rule...

  … but this doesn't mean that the complete permanent link with CP or channel will pass.
- Don't do it. *- Unless specific single manufacturer warranty*
- Cords shorter than 1m are not standard compliant in the "inter- operable" sense.

  -But they can be covered by the single manufacturer warranty



Measuring the Length

Back to this 90m permanent link rule

The test of a permanent link of 95m would pass or fail?

1. Which standard are we using?
   - TIA : the 90m limit applies. The link would fail.
   - ISO: the length is informative only. The link would pass irrelevant on length.

2. How does the instrument know the length?
   - Length = NVP x C x Propagation Delay
     - C = speed of light in a vacuum
     - Propagation delay is measured (time)
     - NVP is written on the cable = % of speed of light
   - NVP is a user input…anyone can make mistakes…
   - NVP is not precise. 10% uncertainty is "normal".

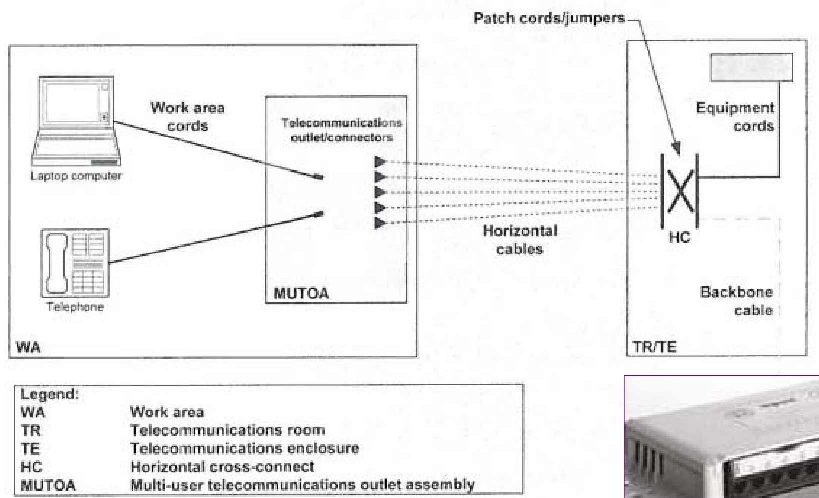
American test limits for equipment are in ANSI/TIA-1152. Although the limit is 90m, it takes into account the 10% uncertainty and will allow up to 99m.

The shortest pair is used as reference.

Validity of the 90m rule

And is the 90m PL rule always valid?

Condition 1: Not if we use a MUTOA



TIA-568-C.1, figure 6

Length of horizontal cable H m (ft)	24 AWG cords: Maximum length of work area cord W m (ft)	24 AWG cords: Maximum combined length of work area cord, patch cords, and equipment cord C m (ft)	26 AWG cords: Maximum length of work area cord W m (ft)	26 AWG cords: Maximum combined length of work area cord, patch cords, and equipment cord C m (ft)
90 (295)	5 (16)	10 (33)	4 (13)	8 (26)
85 (279)	9 (30)	14 (46)	7 (23)	11 (35)
80 (262)	13 (44)	18 (59)	11 (35)	15 (49)
75 (246)	17 (57)	22 (72)	14 (46)	18 (59)
70 (230)	22 (72)	27 (89)	17 (56)	21 (70)

TIA-568-C.1, Table 1

Model	Figure	Implementation Equation: Class D channels using Category 5 components	Implementation Equation: Class E channels using Category 6 components	Implementation Equation: Class F channels using Category 7 components
Interconnect - TO	12a	*H* = 109 – *FX*	*H* = 107 – 3 [a] – *FX*	*H* = 107 – 2 [a] – *FX*
Cross-connect - TO	12b	*H* = 107 – *FX*	*H* = 106 – 3 [a] – *FX*	*H* = 106 – 3 [a] – *FX*
Interconnect - CP -TO	12c	*H* = 107 – *FX* – *CY*	*H* = 106 - 3 [a] – *FX* – *CY*	*H* = 106 – 3 [a] – *FX* – *CY*
Cross-connect - CP - TO	12d	*H* = 105 – *FX* – *CY*	*H* = 105 - 3 [a] – *FX* – *CY*	*H* = 105 – 3 [a] – *FX* – *CY*

H the maximum length of the fixed horizontal cable (m)

F combined length of patch cords/jumpers, equipment and work area cords (m)

C the length of the CP cable (m)

X the ratio of cord cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m) – see Clause 9

Y the ratio of CP cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m) – see Clause 9

ISO 11801, Table 33

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Validity of the 90m rule

And what's the maximum length of the W.A. cord in this case?

- ISO:

where a multi-user TO assembly is used, the length of the work area cord should not exceed 20 m

- TIA:

Length of horizontal cable H m (ft)	24 AWG cords: Maximum length of work area cord W m (ft)	24 AWG cords: Maximum combined length of work area cord, patch cords, and equipment cord C m (ft)	26 AWG cords: Maximum length of work area cord W m (ft)	26 AWG cords: Maximum combined length of work area cord, patch cords, and equipment cord C m (ft)
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TIA-568-C.1, Table 1

NEW: TIA-568.0-D:

$$L_{cords} \le \frac{102 - L_{link}}{1 + D} \text{ m}$$

No limit in TIA 568.0-D and TIA 568.1-D

Validity of the 90m rule

Is the 90m PL rule always valid? (part 2)

Condition 2: All values in the standards assume an ambient temperature of 20°C (68°F)

		Implementation Equation		
Model	**Figure**	**Class D channels using Category 5 components**	**Class E channels using Category 6 components**	**Class F channels using Category 7 components**
Interconnect - TO	12a	*H* = 109 – *FX*	*H* = 107 – 3 [a] – *FX*	*H* = 107 – 2 [a] – *FX*
Cross-connect - TO	12b	*H* = 107 – *FX*	*H* = 106 – 3 [a] – *FX*	*H* = 106 – 3 [a] – *FX*
Interconnect - CP -TO	12c	*H* = 107 – *FX* – *CY*	*H* = 106 - 3 [a] – *FX* – *CY*	*H* = 106 – 3 [a] – *FX* – *CY*
Cross-connect - CP - TO	12d	*H* = 105 – *FX* – *CY*	*H* = 105 - 3 [a] – *FX* – *CY*	*H* = 105 – 3 [a] – *FX* – *CY*

H the maximum length of the fixed horizontal cable (m)

F combined length of patch cords/jumpers, equipment and work area cords (m)

C the length of the CP cable (m)

X the ratio of cord cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m) – see Clause 9

Y the ratio of CP cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m) – see Clause 9

NOTE For operating temperatures above 20 °C, H should be reduced by 0,2 % per °C for screened cables; 0,4 % per °C (20 °C to 40 °C) and 0,6 % per °C (>40 °C to 60 °C) for unscreened cables.

[a] This length reduction is to provide an allocated margin to accommodate insertion loss deviation.

ISO 11801, Table 33

PoE and the Connectors

PoE in the Connector

But something was missed…

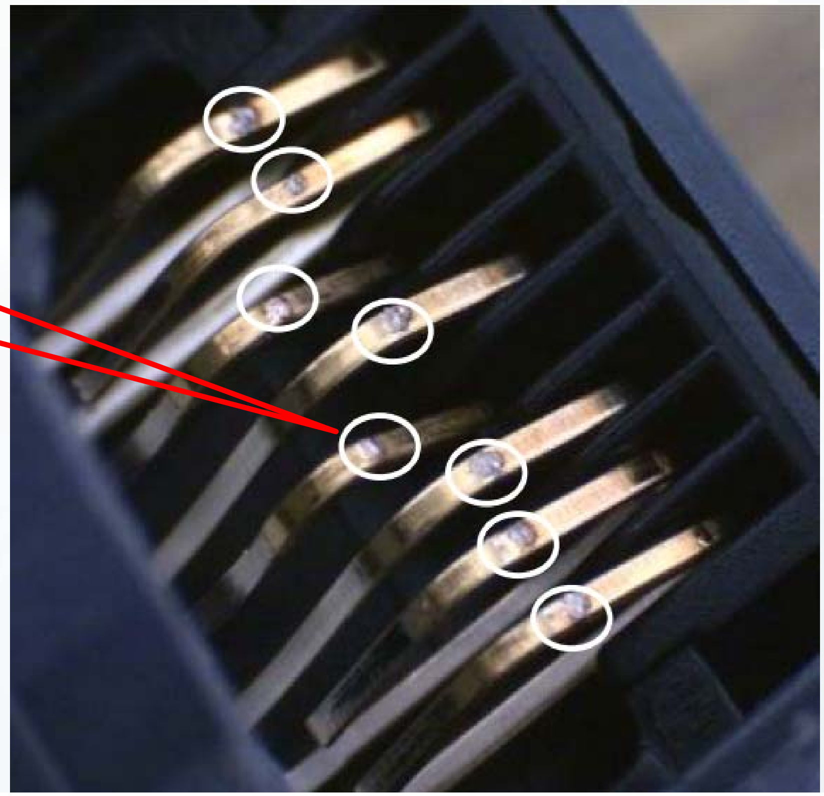
- The future PoE will be around 500mA per conductor.
- We've seen the possible issues with heat in the cable.
- What about the connector?
  - Unplugging a connector under power creates an electrical arc

PoE in the Connector

The RJ45 is not designed for this !!!

PoE can destroy the connector !

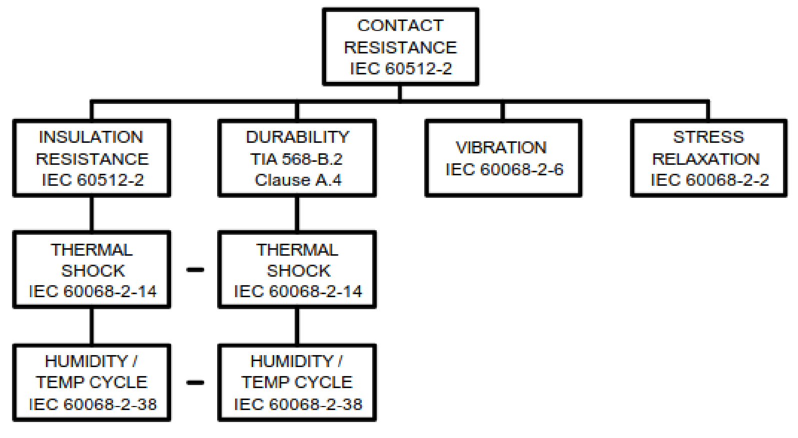
Contacts burned



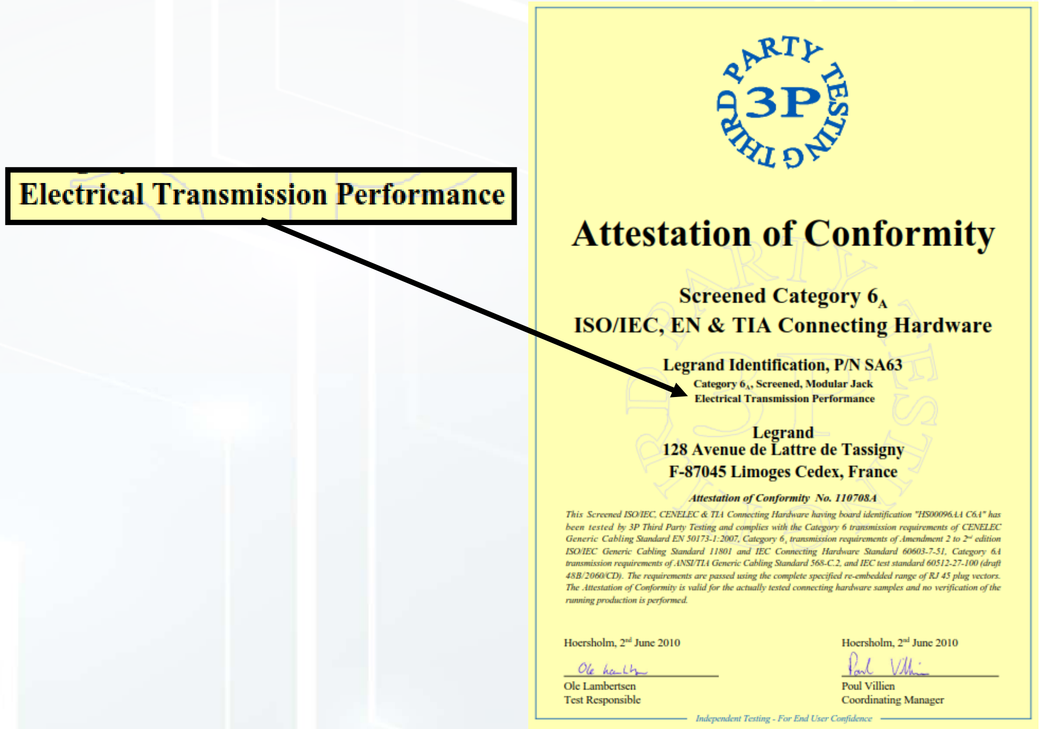
PoE in the Connector

Performance vs. Reliability

All performance tests and 3rd party certificates so far have never taken into account the possibility of 100W through the connector.



ANSI/TIA 568-B.2, Figure A.1



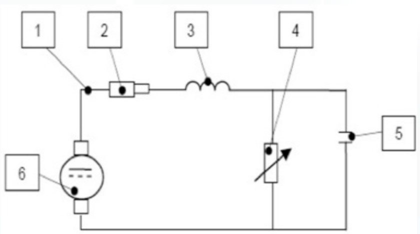
PoE in the Connector

New standard

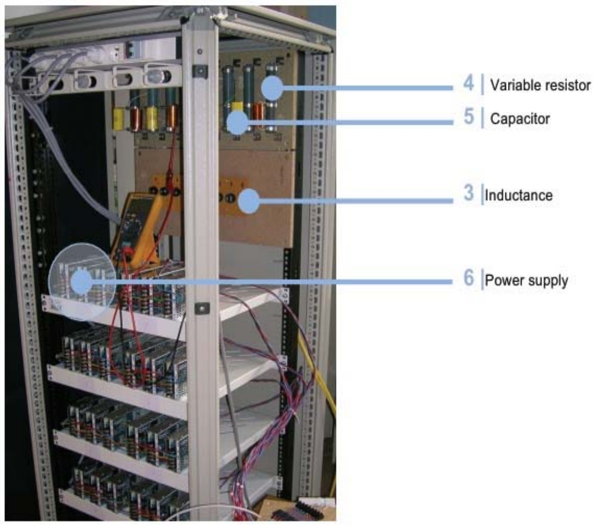
In 2012, a new standard was created for this measurement:

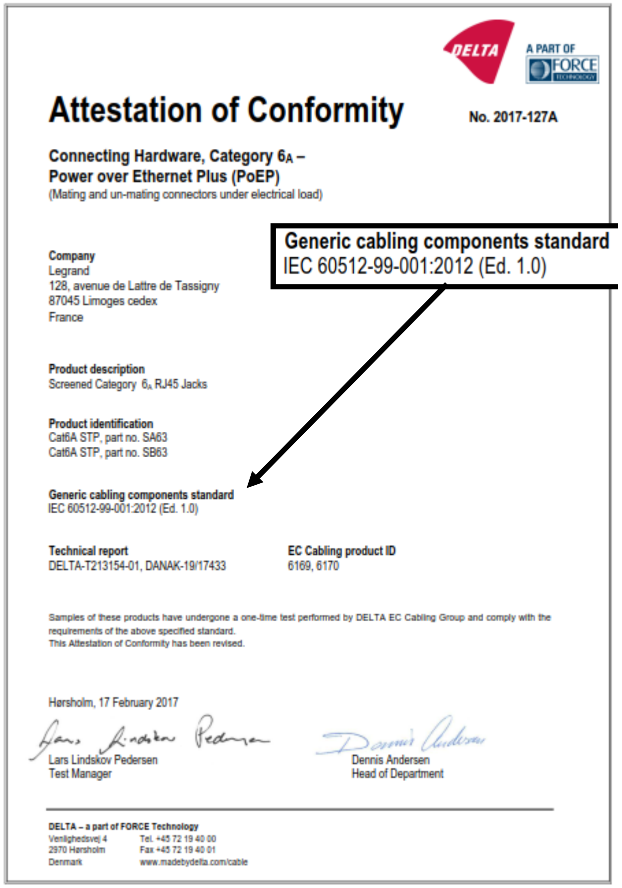
IEC 60512-99-001

Connectors for electronic equipment – Tests and measurements – Part 99-001: Test schedule for engaging and separating connectors under electrical load – Test 99a: Connectors used in twisted pair communication cabling with remote power



1. Cables in accordance with 4.1
2. Connector under test
3. Inductor 100 µH
4. Variable resistor
5. Capacitor 5 µF
6. Power source





Attestation of Conformity No. 2017-127A

Connecting Hardware, Category 6_A – Power over Ethernet Plus (PoEP)
(Mating and un-mating connectors under electrical load)

Company
Legrand
128, avenue de Lattre de Tassigny
87045 Limoges cedex
France

Product description
Screened Category 6_A RJ45 Jacks

Product identification
Cat6A STP, part no. SA63
Cat6A STP, part no. SB63

Generic cabling components standard
IEC 60512-99-001:2012 (Ed. 1.0)

Technical report
DELTA-T213154-01, DANAK-19/17433

EC Cabling product ID
6169, 6170

Samples of these products have undergone a one-time test performed by DELTA EC Cabling Group and comply with the requirements of the above specified standard.
This Attestation of Conformity has been revised.

Hørsholm, 17 February 2017

Lars Lindskov Pedersen
Test Manager

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Head of Department

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www.madebydelta.com/cable

PoE in the Connector

The limits of IEC 60512-99-001

- It ensures only minimal compliance to 802.3at: “PoE+” 30w. But the future “PoE++” is 100W.
- Only 100 disconnections. Very far from the industry standard guarantee of 750 cycles for performance.

Table A.3 – Modular plugs and jacks operations matrix

Connecting hardware type	Insertion and withdrawal, and conductor re-termination, operations	Minimum number of operations
Modular plug	Insertion / withdrawal with modular jack	750
	Cable re-termination	0
Modular jack	Insertion / withdrawal with modular plug	750
	Cable re-termination	20 [1)]
[1)] Unless not intended for re-termination, in which case this value equals 0.		

ANSI / TIA 568-C.2

6.6.1 Mechanical operation

Conditions: IEC 60512, Test 9a

Speed: 10 mm/s maximum

Rest: 1 s minimum (mated and unmated)

PL 1: 750 operations

PL 2: 2 500 operations

IEC 60512

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PoE in the Connector

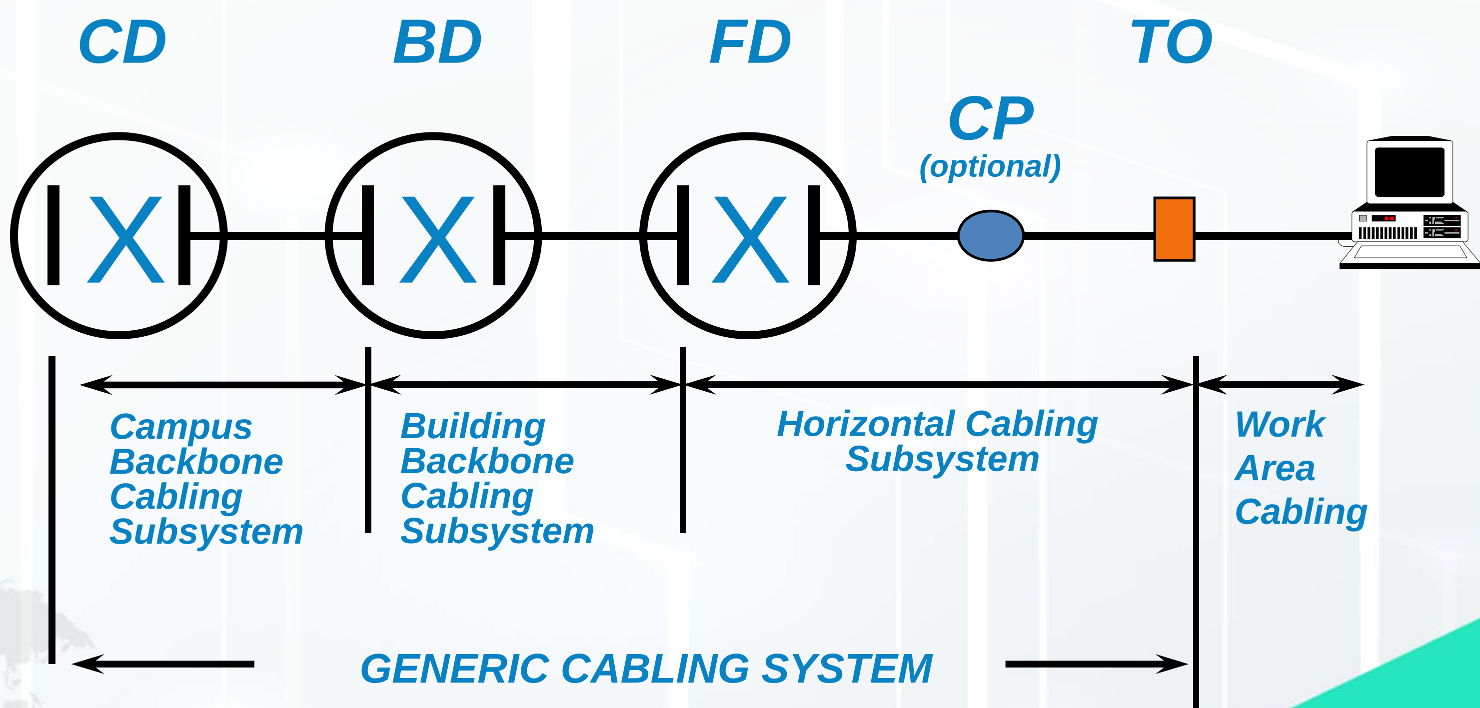
New IEC 60512-99-002

- IEEE 802.3bt PoE Types 3 and 4 will be ratified soon
- To guarantee compliance, the test IEC 60512-99-002 for up to 100W will also be ratified in the very near future.
- Some manufacturers can offer better reliability than the standard.

Evolution of the Design

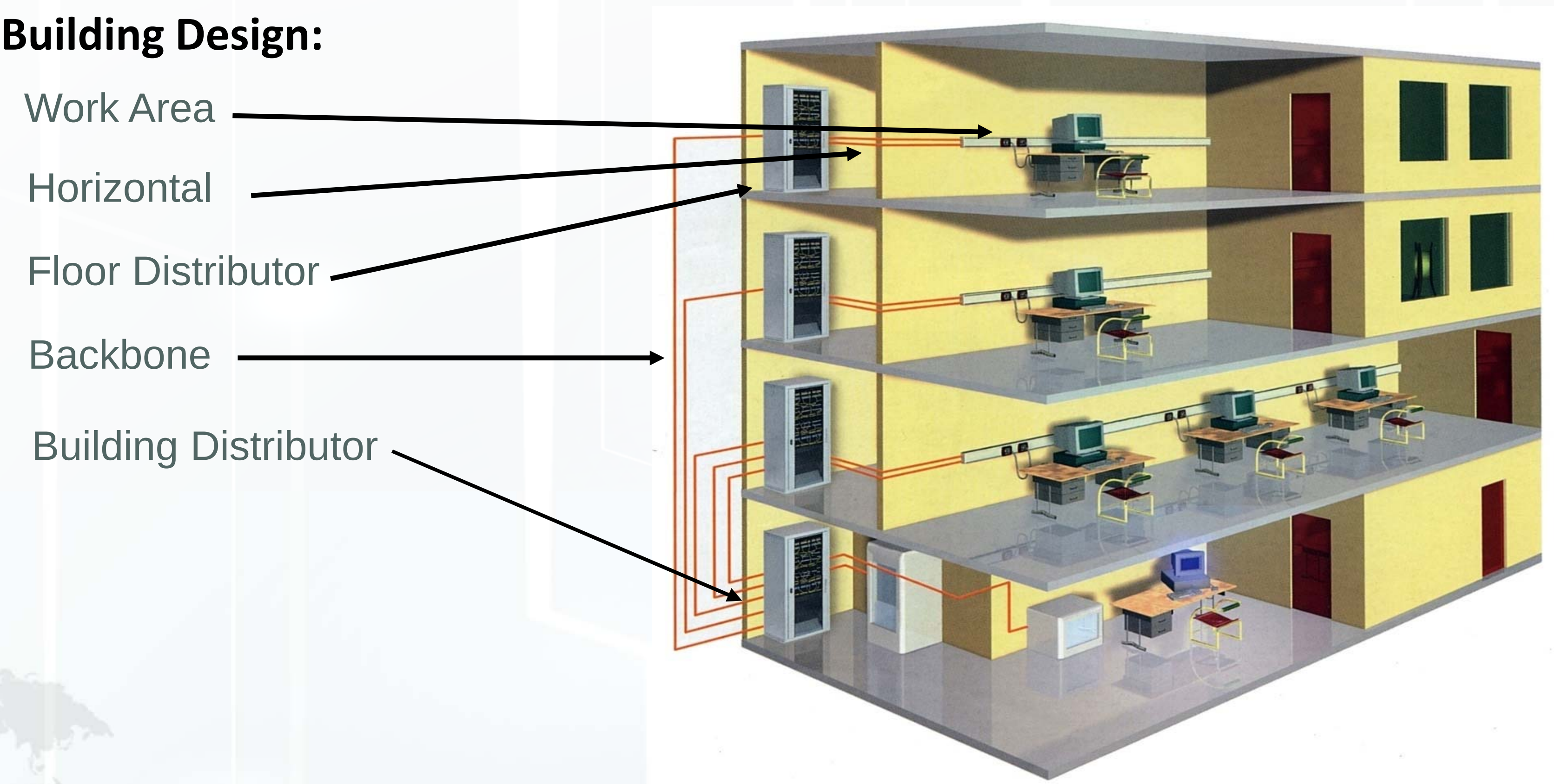
Traditional Star Topology

Generic cabling system:



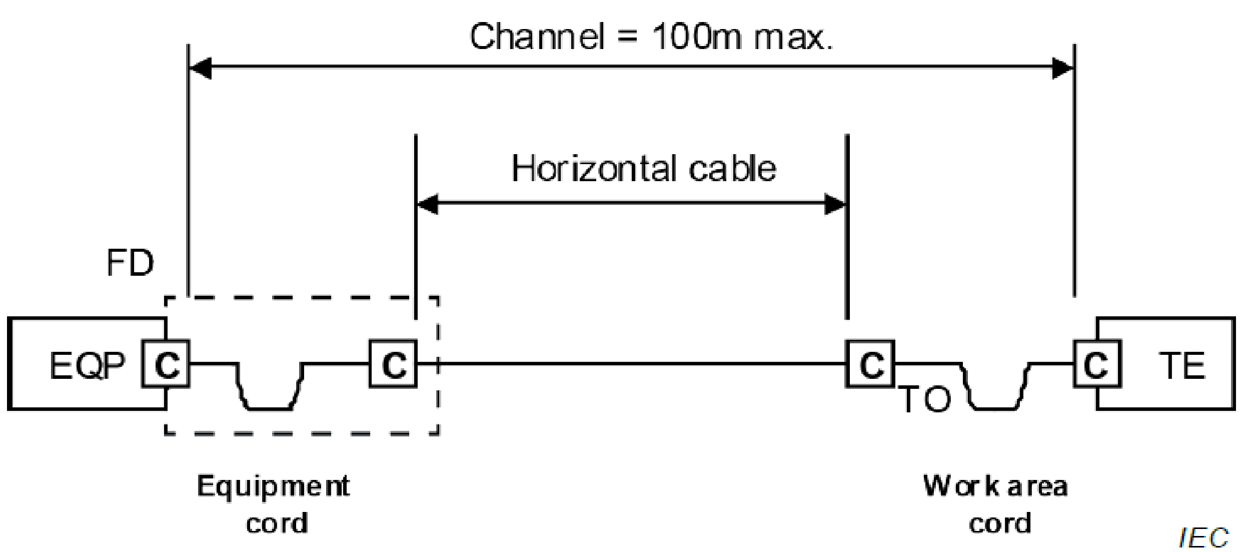
Traditional Star Topology

Typical Building Design:



Traditional Star Topology

Typical Horizontal Cabling:



a) Interconnect - TO model

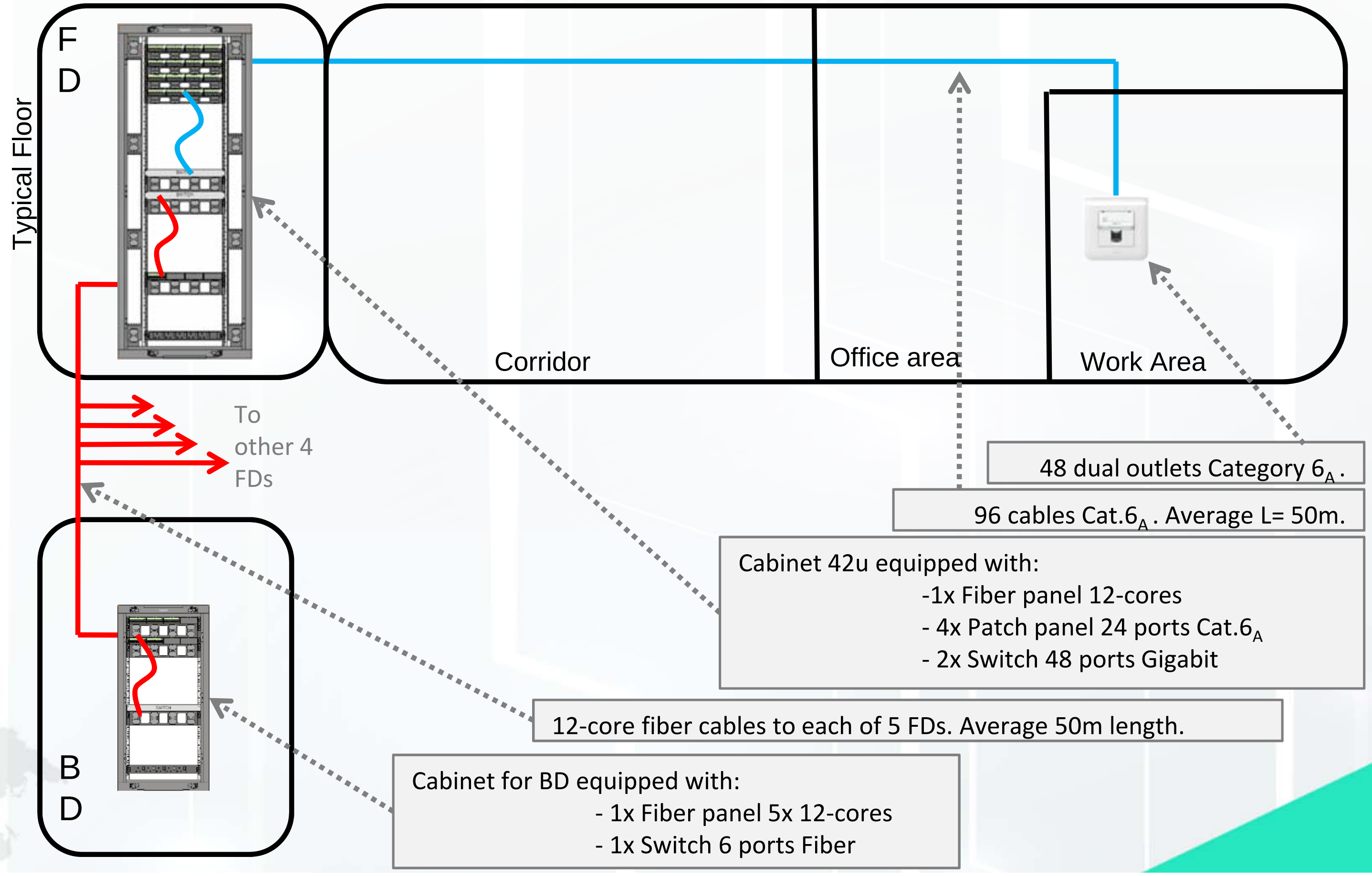
ISO/IEC 11801-2 2017, horizontal cabling models

Example:

5-floor building:

- **48 work areas per floor,**
- **Each work area is composed of 2 ports: 1 data and 1 IP phone**
- **Horizontal cabling is Category 6A**
- **Backbone cabling is OM3**
- **Switches can provide 1G Ethernet to the user, with 10G backbone**

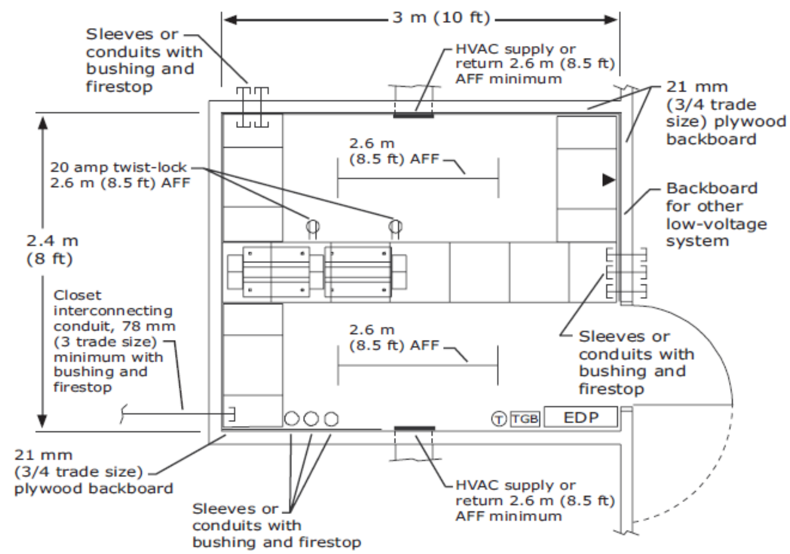
Traditional hierarchal Star:



Limits:

The Telecom room, as designed:

Figure 6.1
Typical telecommunications room layout

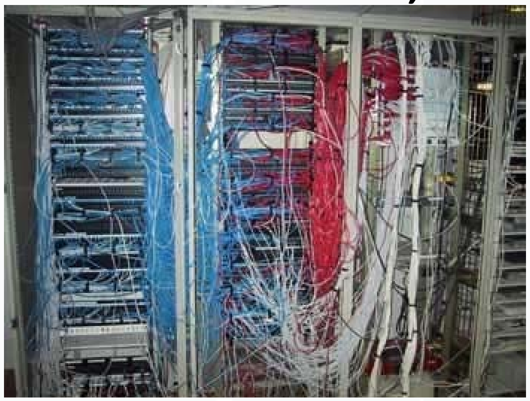


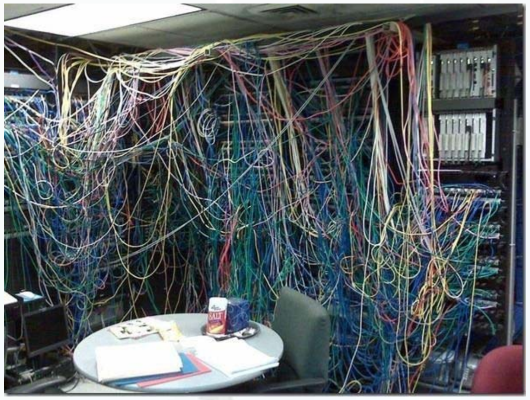
▼ = Telecommunications outlet/connector
Ⓣ = Thermostat
AFF = Above finished floor
EDP = Electrical distribution panel
HVAC = Heating, ventilating, and air conditioning
TGB = Telecommunications grounding busbar

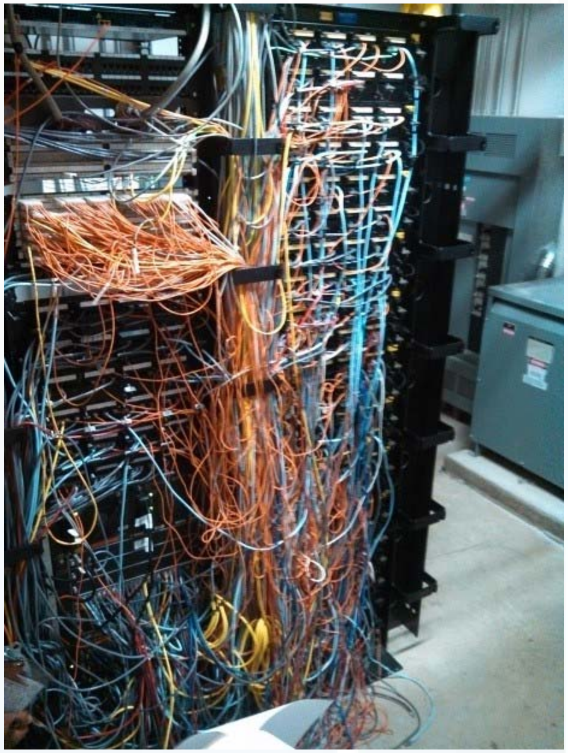
BICSI TDMM,

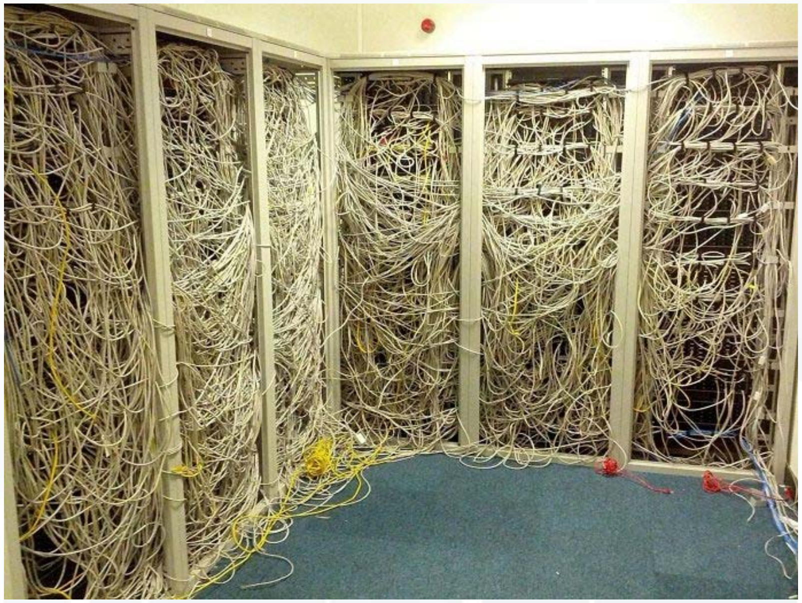
Limits:

The Telecom room, as delivered:









Issues:

- Manageability
- Future expansion

Pictures from Cabling Installation and Maintenance magazine,

Limits:

The pathways, as designed:

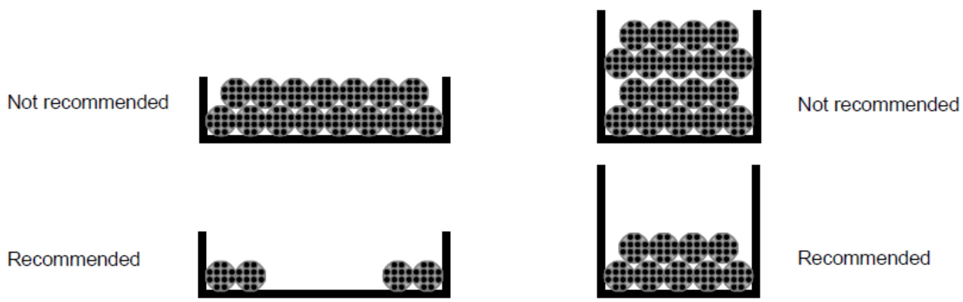
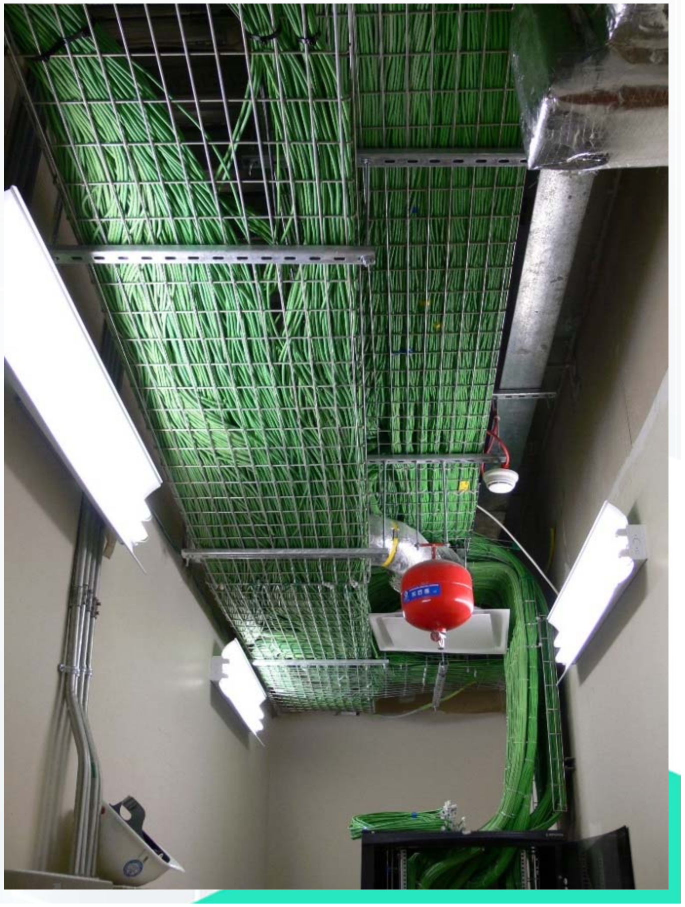


Figure 2 – Cable arrangement in a metallic section

EN50174-2, cable management systems

Limits:

The pathways, as delivered:

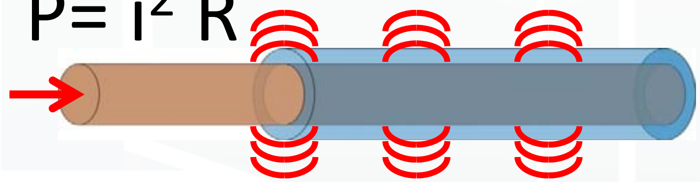


Issues:

- Future expansion
- Weight
- Fire !!!

Limits:

$$P = i^2 R$$



Power over Ethernet:

Sending power through any cable creates heat:

Table 6-2 PoE and HDBaseT Power Specifications

Transmission Method	*Power at Source (W)*	*Maximum Current per Conductor (A)*	*Notes*
PoE Type 1	15.40	0.175	IEEE 802.3af, uses two pairs to transmit power
PoE + Type 2	30	0.3	IEEE 802.3at, uses two pairs to transmit power
PoE ++ Type 3	60	0.3	IEEE 802.3bt, uses all pairs to transmit power
PoE ++ Type 4	100	0.5	IEEE 802.3bt, uses all pairs to transmit power
HDBaseT	100	0.5	HDBaseT 1.0 and HDBaseT 2.0 have the same power specifications. Also known as POH (power over HDBaseT)

Tables from TIA TSB-184-A, similar to ISO TR 29125 ed.2 and to CENELEC TR50174-99-1

Number of Cables in a bundle	Temperature Rise 1A per pair (°C) - In air -			
	26 AWG	Category 5e	Category 6	Category 6A
1	1.9	1.1	0.8	0.7
7	5.7	3.5	2.6	2.3
19	10.5	6.7	5.1	4.4
37	16.2	10.7	8.2	7.0
61	22.7	15.5	12.0	10.1
91	30.1	21.0	16.4	13.8
127	38.4	27.3	21.4	17.9
169	47.6	34.3	27.1	22.6

Number of Cables in a bundle	Temperature Rise 1A per pair (°C) - In conduit -			
	26 AWG	Category 5e	Category 6	Category 6A
1	3.1	1.7	1.3	1.1
7	9.1	5.2	4.0	3.3
19	16.5	9.7	7.4	6.1
37	25.1	15.2	11.6	9.5
61	34.9	21.6	16.6	13.4
91	45.9	29.0	22.2	17.9
127	58.1	37.4	28.6	23.0
169	71.5	46.6	35.7	28.6

- Cables are rated up to 60°C, so assuming 30°C ambient, some configurations are impossible.
- Higher category cables have lower temperature increase.
- Smaller bundles are preferable.

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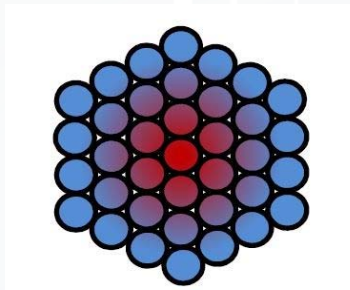
Limits:

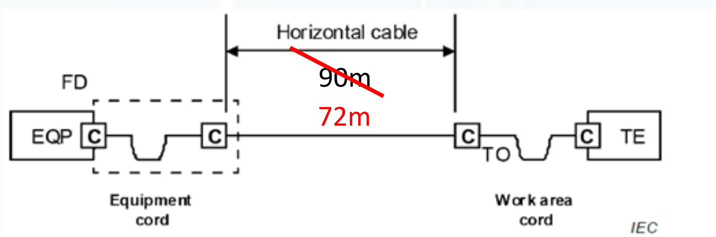
Power over Ethernet:

Issues:

- Longer cables = more resistance
  - Higher loss
  - More heat
- Bigger bundles = less ventilation
  - More heat
  - Risk of damage to the cables over 60 °C
- More heat = shorter distance !
  - Example with Cat5e UTP at 60°C
  - Maximum Permanent Link can reduce to 72m !

$$P = i^2 R$$





Model	Figure	Implementation Equation: Class D channels using Category 5 components	Implementation Equation: Class E channels using Category 6 components	Implementation Equation: Class F channels using Category 7 components
Interconnect - TO	12a	*H* = 109 – *FX*	*H* = 107 – 3 [a] – *FX*	*H* = 107 – 2 [a] – *FX*
Cross-connect - TO	12b	*H* = 107 – *FX*	*H* = 106 – 3 [a] – *FX*	*H* = 106 – 3 [a] – *FX*
Interconnect - CP -TO	12c	*H* = 107 – *FX* – *CY*	*H* = 106 - 3 [a] – *FX* – *CY*	*H* = 106 – 3 [a] – *FX* – *CY*
Cross-connect - CP - TO	12d	*H* = 105 – *FX* – *CY*	*H* = 105 - 3 [a] – *FX* – *CY*	*H* = 105 – 3 [a] – *FX* – *CY*

H the maximum length of the fixed horizontal cable (m)

F combined length of patch cords/jumpers, equipment and work area cords (m)

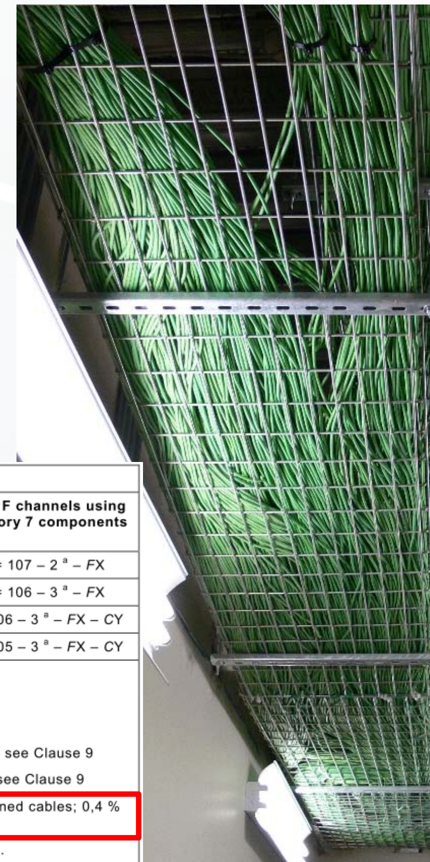
C the length of the CP cable (m)

X the ratio of cord cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m) – see Clause 9

Y the ratio of CP cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m) – see Clause 9

NOTE For operating temperatures above 20 °C, H should be reduced by 0,2 % per °C for screened cables; 0,4 % per °C (20 °C to 40 °C) and 0,6 % per °C (>40 °C to 60 °C) for unscreened cables.

[a] This length reduction is to provide an allocated margin to accommodate insertion loss deviation.

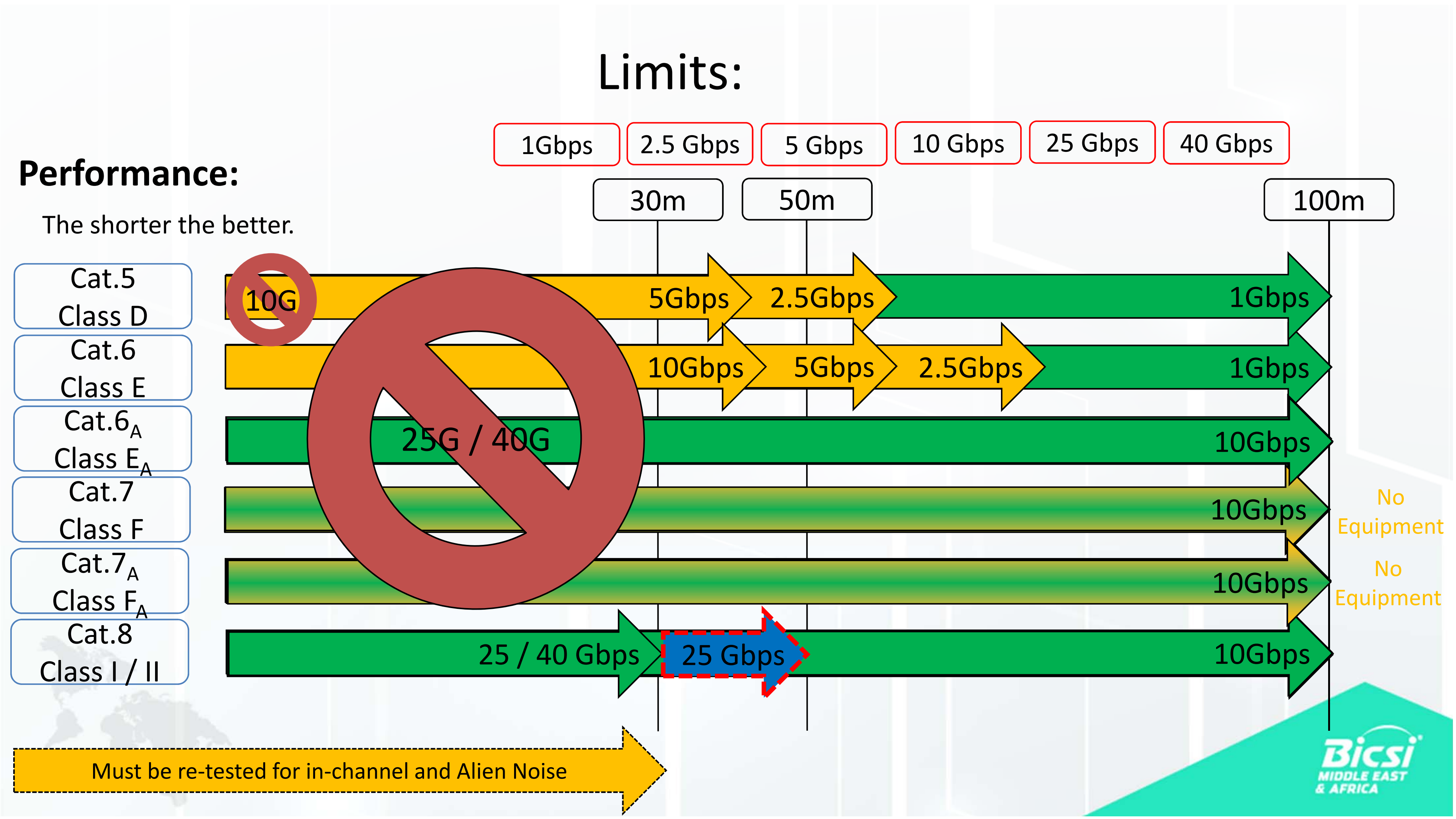


Limits:

Cable Moves, Add and Changes:

Issues:

- Any change in the future requires substantial work:
  - Dust
  - Ceiling
  - Noise
  - And fire barriers !



Limits:
Performance:
The shorter the better.
1Gbps
2.5 Gbps
5 Gbps
10 Gbps
25 Gbps
40 Gbps
30m
50m
100m
Cat.5 Class D
10G
5Gbps
2.5Gbps
1Gbps
Cat.6 Class E
10Gbps
5Gbps
2.5Gbps
1Gbps
Cat.6A Class EA
25G / 40G
10Gbps
Cat.7 Class F
10Gbps
No Equipment
Cat.7A Class FA
10Gbps
No Equipment
Cat.8 Class I / II
25 / 40 Gbps
25 Gbps
10Gbps
Must be re-tested for in-channel and Alien Noise
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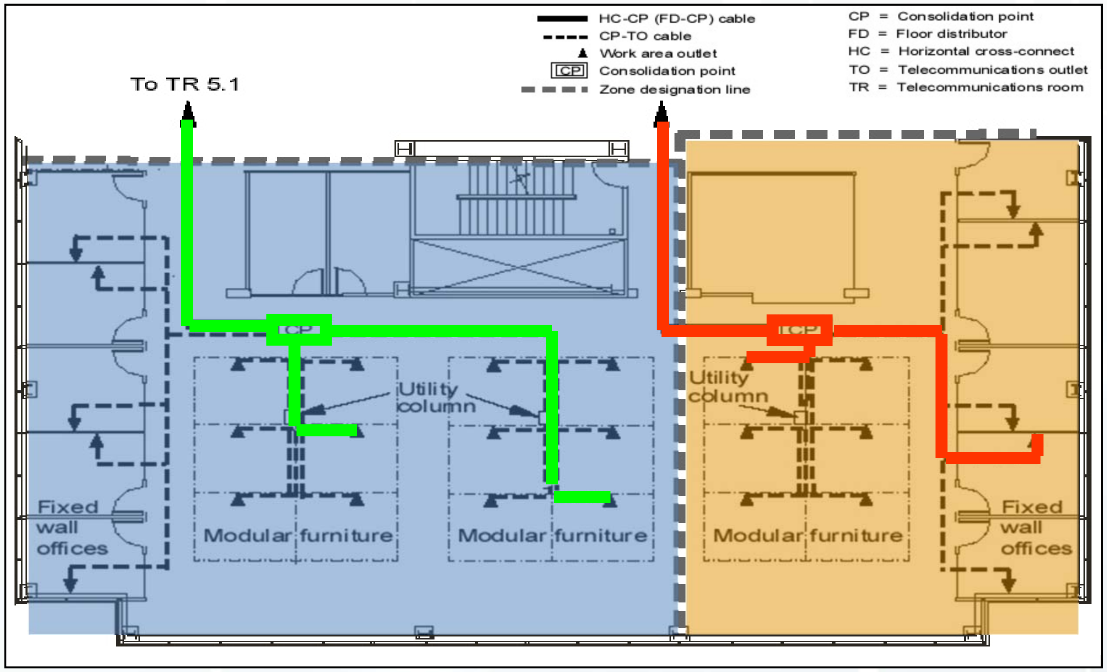
Alternatives:

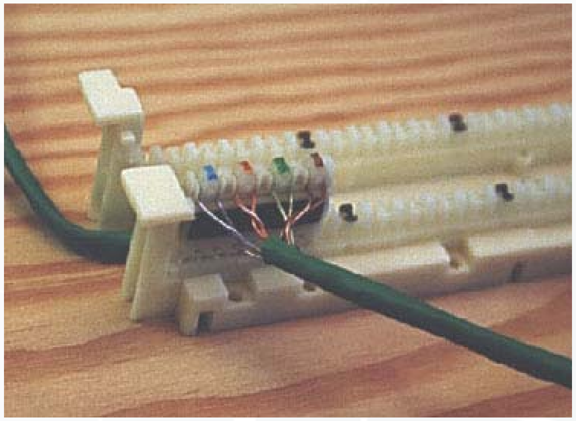
Are there alternative solutions?

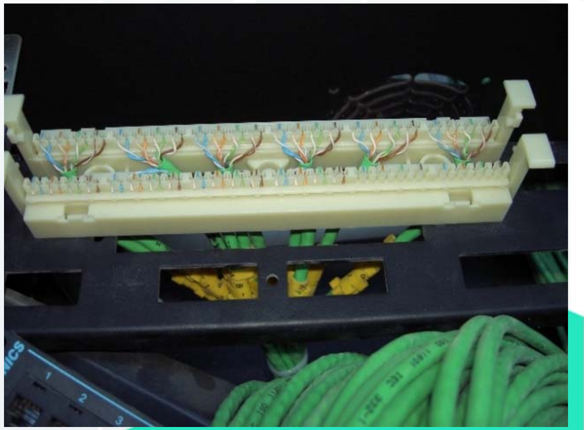
Alternatives

Consolidation Point:

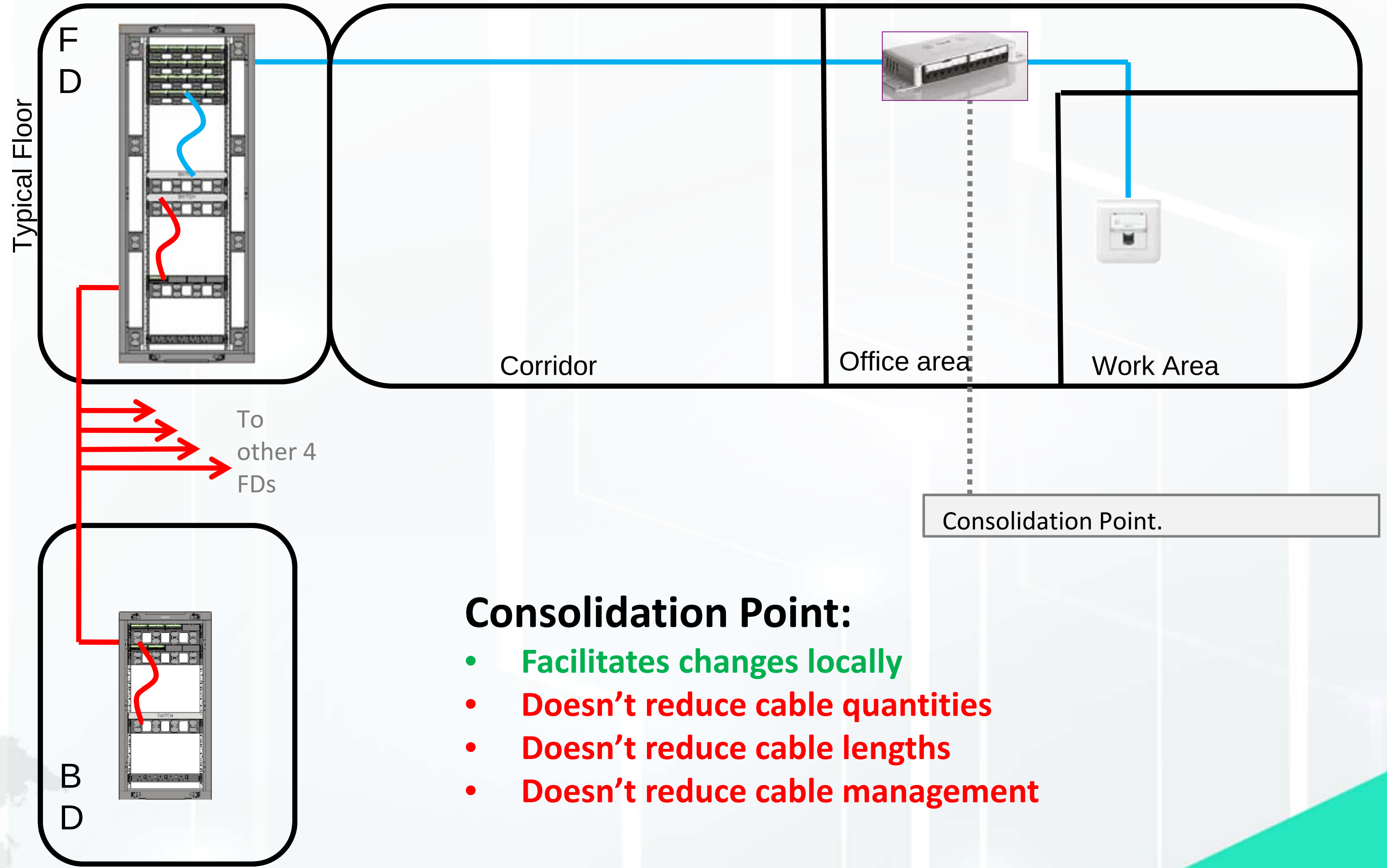
- **Facilitates changes locally**
- **Doesn't reduce cable quantities and lengths**







Alternatives

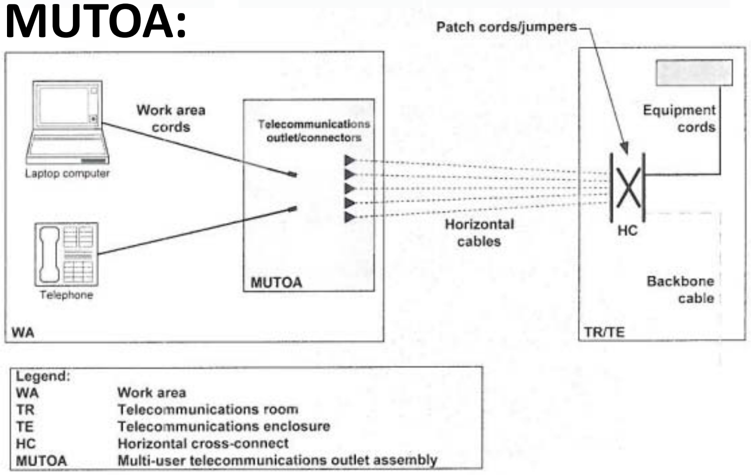


Consolidation Point:

- Facilitates changes locally
- Doesn't reduce cable quantities
- Doesn't reduce cable lengths
- Doesn't reduce cable management

Alternatives

MUTOA:



TIA-568-C.1, figure 6

TIA-568.0-D: $L_{cords} \leq \frac{102 - L_{link}}{1 + D}$ m

Model	Figure	Implementation Equation		
		Class D channels using Category 5 components	Class E channels using Category 6 components	Class F channels using Category 7 components
Interconnect - TO	12a	$H = 109 - FX$	$H = 107 - 3^{a} - FX$	$H = 107 - 2^{a} - FX$
Cross-connect - TO	12b	$H = 107 - FX$	$H = 106 - 3^{a} - FX$	$H = 106 - 3^{a} - FX$
Interconnect - CP -TO	12c	$H = 107 - FX - CY$	$H = 106 - 3^{a} - FX - CY$	$H = 106 - 3^{a} - FX - CY$
Cross-connect - CP - TO	12d	$H = 105 - FX - CY$	$H = 105 - 3^{a} - FX - CY$	$H = 105 - 3^{a} - FX - CY$

H the maximum length of the fixed horizontal cable (m)

F combined length of patch cords/jumpers, equipment and work area cords (m)

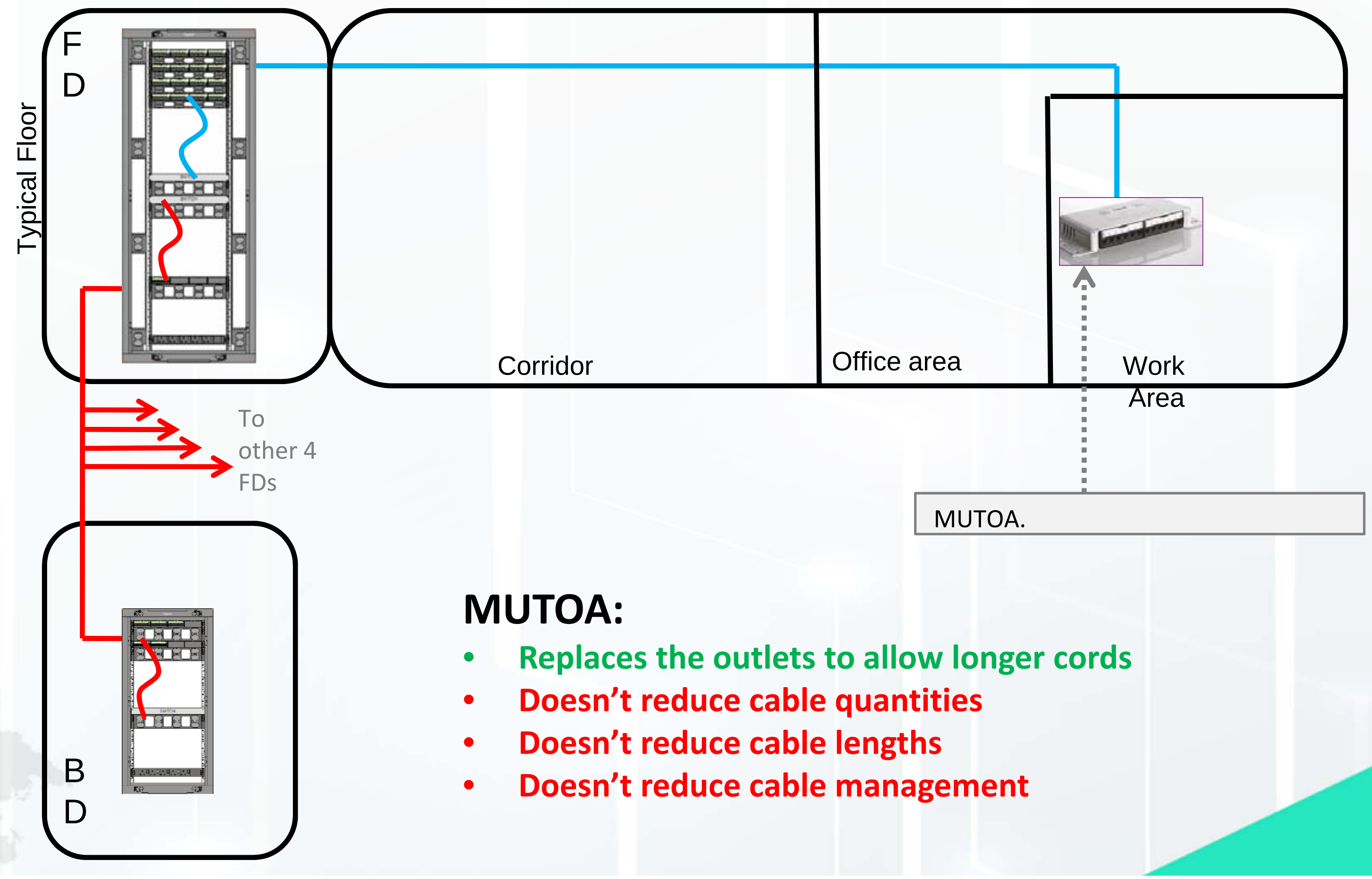
C the length of the CP cable (m)

X the ratio of cord cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m) – see Clause 9

Y the ratio of CP cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m) – see Clause 9

ISO 11801, Table 33

Alternatives



MUTOA:

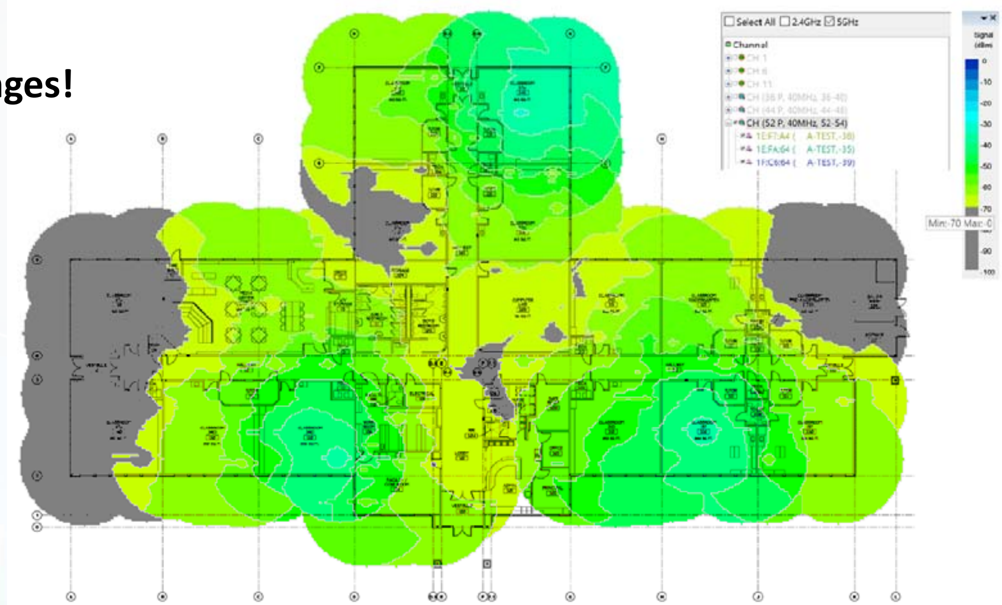
- Replaces the outlets to allow longer cords
- Doesn't reduce cable quantities
- Doesn't reduce cable lengths
- Doesn't reduce cable management

Alternatives

Cabling for wireless access points:

- **The traditional method is a site survey.**
- **To then define position of access points.**
- **And then install cabling.**
- **This allows almost no possibility for future changes!**
    - **Office converted to meeting room**
    - **New metallic furniture**
    - **…**

BICSI 008: Wireless LAN design



gray areas indicate signal strength is below desired levels

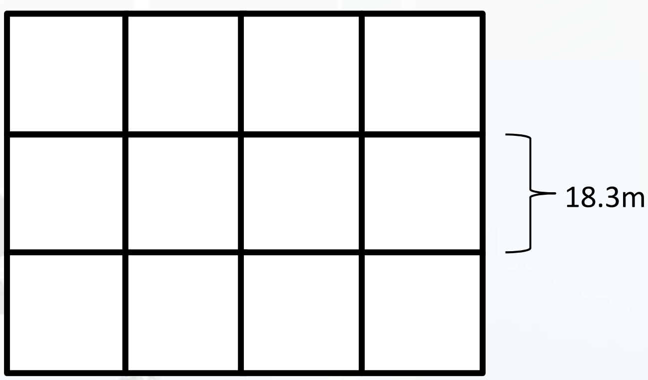
Figure 6-3

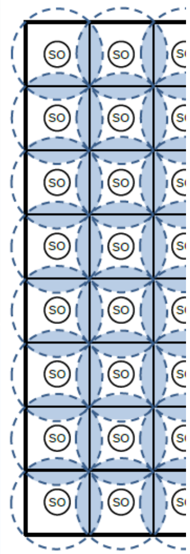
Alternatives

Cabling for wireless access points:

- **Cabling standards created for cabling independent of position of the access points.**
- **SO = Service Outlet**
  - **2 ports minimum**
  - **Cat6a minimum**

TIA-TSB-162-A





Example of Square

ISO / IEC TR 24704

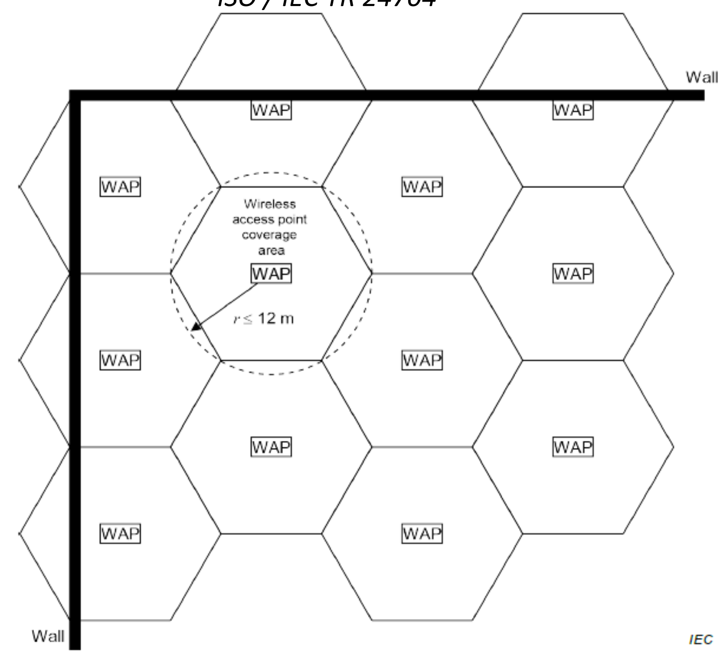
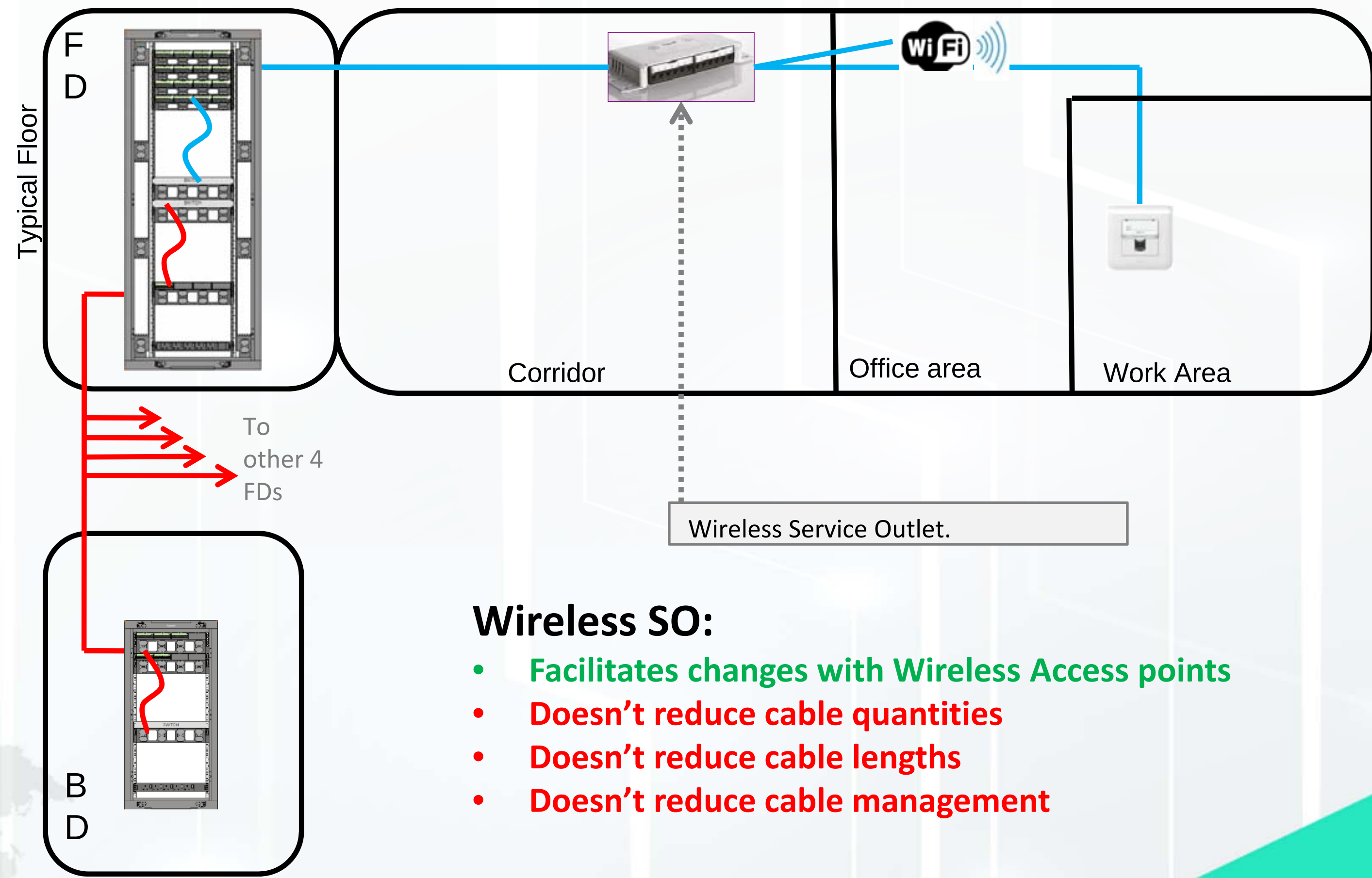


Figure A.1 – Wireless application coverage area grid

Alternatives



Wireless SO:

- Facilitates changes with Wireless Access points
- Doesn't reduce cable quantities
- Doesn't reduce cable lengths
- Doesn't reduce cable management

Alternatives

Cabling for the intelligent building:

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

5.1 Overview

Intelligent building systems may either share the collective set of cabling system components, cabling pathways, and related telecommunications spaces with a traditional voice/data ICT network or use separate dedicated networks operating in parallel. Regardless of the way these systems are deployed, telecommunications cabling infrastructure standards and telecommunications cabling installation best practices should be followed.

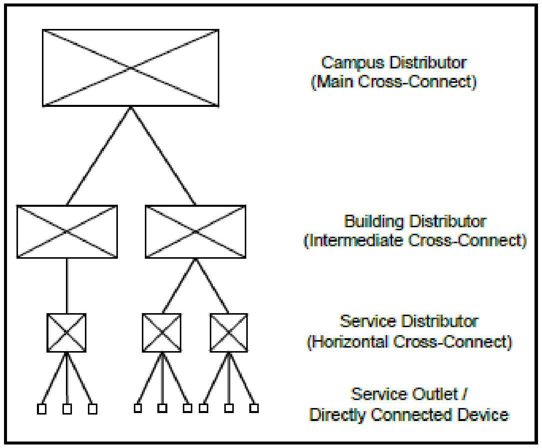


Figure 5-1
Hierarchical Star Topology

Alternatives

Cabling for the intelligent building

BICSI 007:

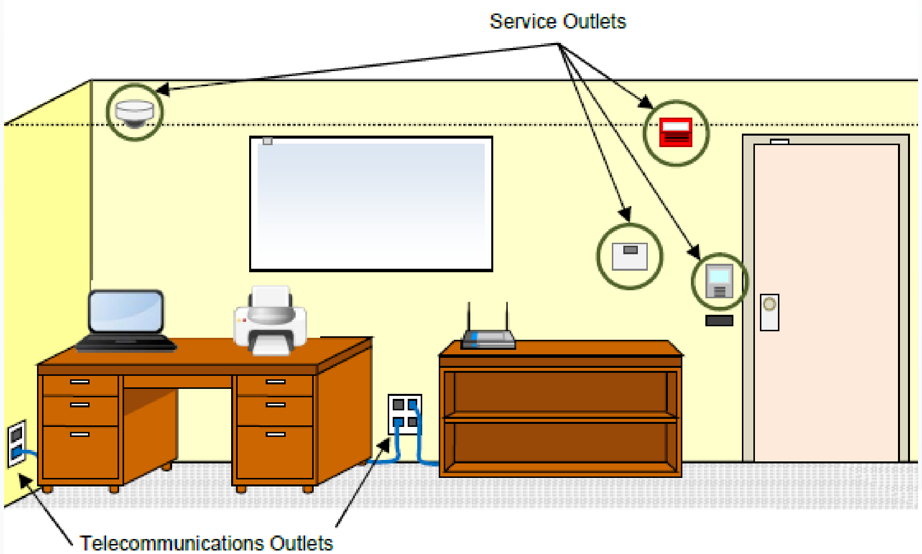


Figure 5-7
Types of Outlets Within a Building

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.

Alternatives

Cabling for the intelligent building

BICSI 007:

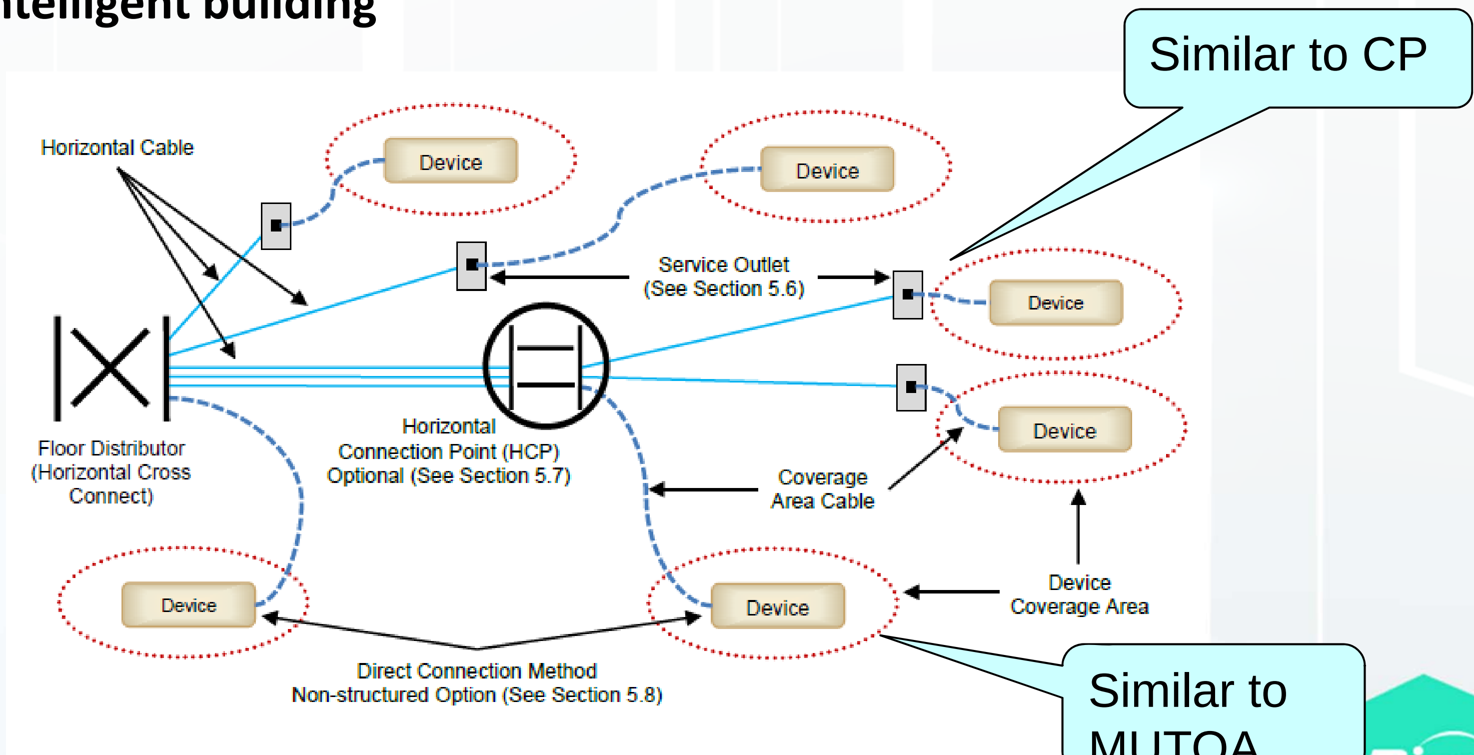


Figure 5-6
Building System Horizontal Cabling Elements within a Star Topology

Alternatives

Cabling for the intelligent building

BICSI 007:

5.7 Horizontal Connection Point (HCP)

NOTE: A service concentration point (SCP), as defined in ISO/IEC ISO11801-6, is analogous to a horizontal connection point. The requirements and recommendations of this section are applicable, except where otherwise noted.

5.7.1 Introduction

An HCP is a connection point within the horizontal cabling between the TR and the corresponding building service outlet or device, and is analogous to the consolidation point used within communication and data networks. HCPs often are the most efficient solution in areas where there is a high density of building system connections.

Figure 5-6 shows an example of an HCP implemented within horizontal cabling. HCPs are commonly used within zone cabling design, as the use of an HCP reduces the length of cable that may need to be pulled or changed as devices are added, moved, or removed. For most building systems, an HCP may be configured as an interconnect (i.e., one patch panel or connecting block) or a cross-connect (i.e., two patch panels or connecting blocks).

Figure 5-8 shows and example of an interconnect HCP mounted inside a ceiling enclosure.

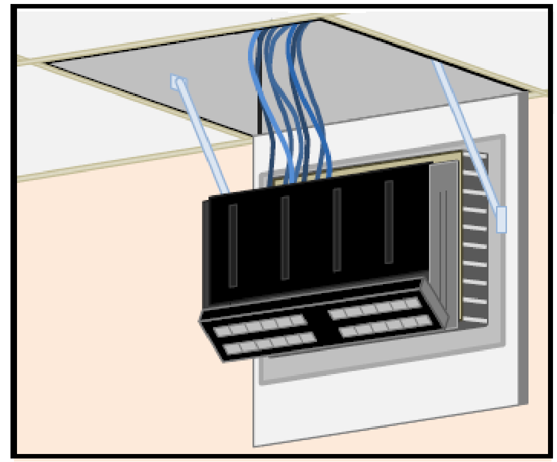


Figure 5-8
Example of an HCP Mounted in a Ceiling Enclosure

Alternatives

Cabling for the intelligent building

BICSI 007:

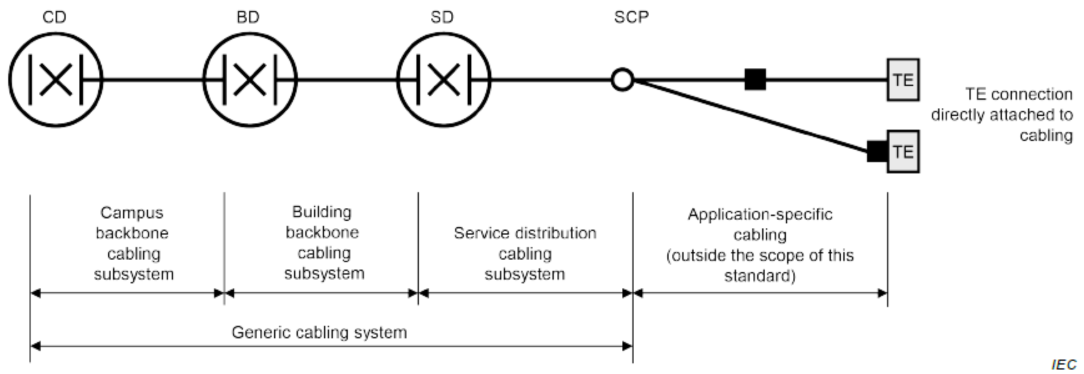


Figure 4 – Structure of Type B generic cabling

Extracts from ISO / IEC 11801-6

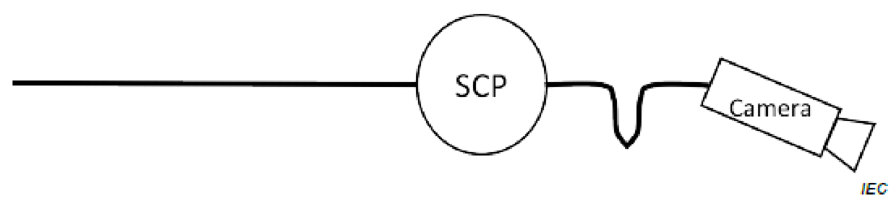
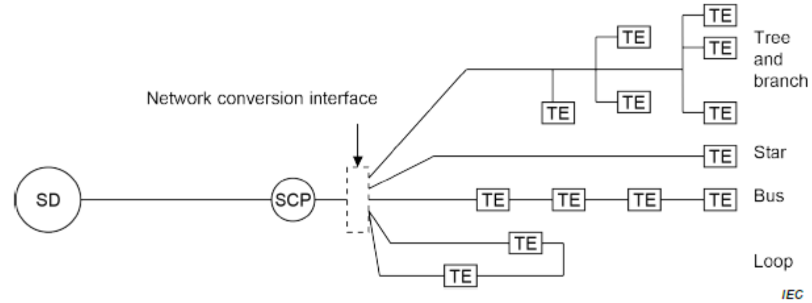


Figure 7 – Cabling without the use of an SO



Alternatives

Cabling for the intelligent building

BICSI 007:

How do we design Service Outlets (SO) without prior knowledge of the equipment?

6.1.2 Service Outlet Coverage Areas

Like the building system device that may be connected to it, a service outlet can also be said to have a coverage area. The use of a uniform service outlet coverage shape, typically square or hexagonal, can approximate the typical circular coverage patterns of the device it supports, while ensuring that a given area is covered without gaps. See Figure 6-1 for examples of both coverage area shapes.

As different building systems often have devices in close proximity, the service outlet in the middle of a coverage area may represent one, two, or more service outlets. The use of an SO coverage area also allows the design process to move forward while the expected placement of the devices is determined.

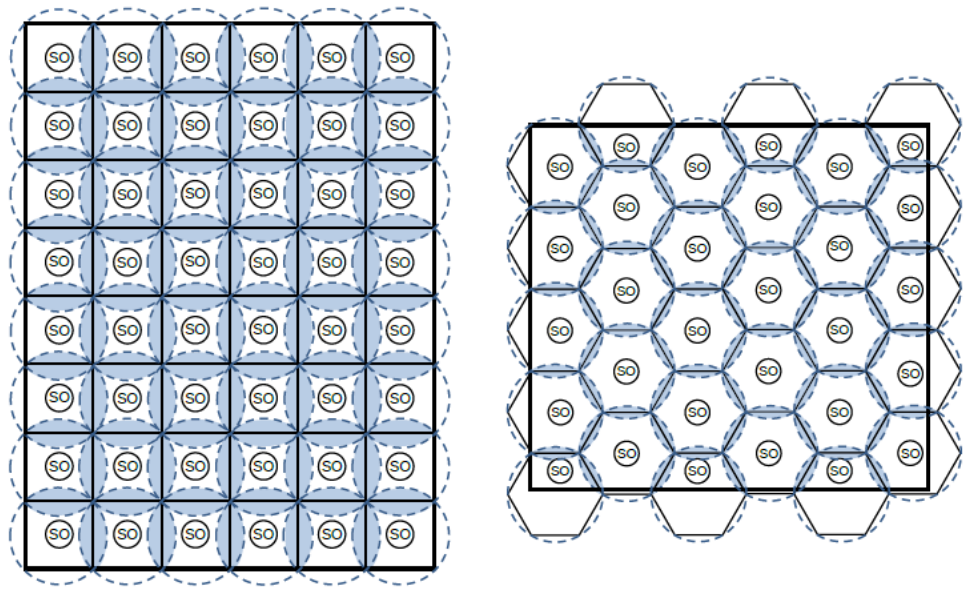


Figure 6-1
Example of Grid and Hexagonal SO Coverage Area Patterns with Circular Device Coverage Areas Shown

Alternatives

Cabling for the intelligent building

BICSI 007:

So where to position the HCPs (SCPs)?

6.1.3 Service Outlet Coverage Area Zones

For SO coverage areas within 17 m (50 ft) of a TR, a connection point is not required, as cabling may be routed directly from the TR. For SO coverage areas further than 17 m (50 ft), the use of a HCP is recommended to consolidate cabling from the TR to near the SO coverage area. When HCPs are used, a HCP can typically serve 4-5 SO coverage areas, which creates a zone. Figure 6-2 illustrates both a grid and hexagonal pattern divided into zones with HCPs and service outlets shown.

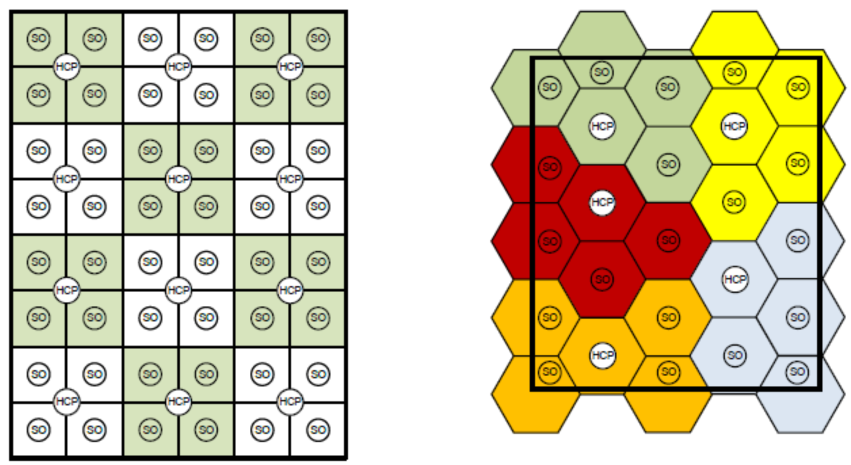


Figure 6-2
Example of Grid and Hexagonal Pattern Coverage Area Zones

The total number of SO coverage areas that can be served by a connection point is dependent on the number of devices that will be served. For example, in areas with a limited number of devices or for connection points dedicated to one type of device (e.g., WAPs), a connection point may be able to serve up to seven or eight coverage areas.

Alternatives

Cabling for the intelligent building

BICSI 007:

- **The HCP (SCP) can be used as a MUTOA, Wireless SO, building services SO**
- **What else?**

Table 6-2 PoE and HDBaseT Power Specifications

Transmission Method	*Power at Source (W)*	*Maximum Current per Conductor (A)*	*Notes*
PoE Type 1	15.40	0.175	IEEE 802.3af, uses two pairs to transmit power
PoE + Type 2	30	0.3	IEEE 802.3at, uses two pairs to transmit power
PoE ++ Type 3	60	0.3	IEEE 802.3bt, uses all pairs to transmit power
PoE ++ Type 4	100	0.5	IEEE 802.3bt, uses all pairs to transmit power
HDBaseT	100	0.5	HDBaseT 1.0 and HDBaseT 2.0 have the same power specifications. Also known as POH (power over HDBaseT)

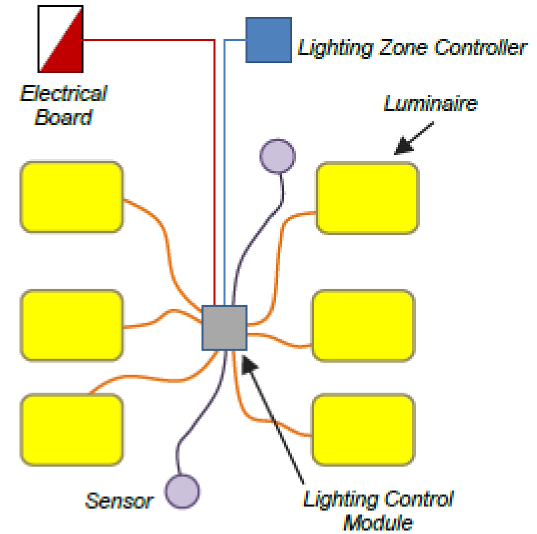


Figure 8-1
Modular LCM Lighting Control Topology

Alternatives

Cabling for the intelligent building

BICSI 007:

- **Structured Cabling for lighting.**

8.2.2.4 Extra Low Voltage Lighting Control

8.2.2.4.1 Overview

LED lights consume much less energy than other types of lamps so it becomes possible to connect them using extra low voltage DC current from a central controller using PoE or other methods. The advantages of this topology (see Figure 8-3) include installation cost savings relating to cabling because the category cables are used for power and control, and in many locations are not subject to regulations applicable to mains power voltages (e.g., 120, 230, or 277 V_{AC}). Disadvantages include that all light fixtures must be fitted with a controller compatible with the proprietary network protocol and sensors must also be compatible.

Cabling may be brought back to the same floor distributor as other intelligent building systems, data and telephony and separated at the patch field. Cable terminations at the light fixtures are unlikely to be changed for other uses, so these may terminate with a modular plug (e.g., RJ-45) for connection directly to the LED controller.

Interfaces with other systems together with user control and monitoring is normally by an IP network connection to the matrix controller. Lighting controls ease the interfacing with other systems, as each light fixture becomes a network port and are able to provide switching, dimming and other advanced features such as color changes of the LED's.

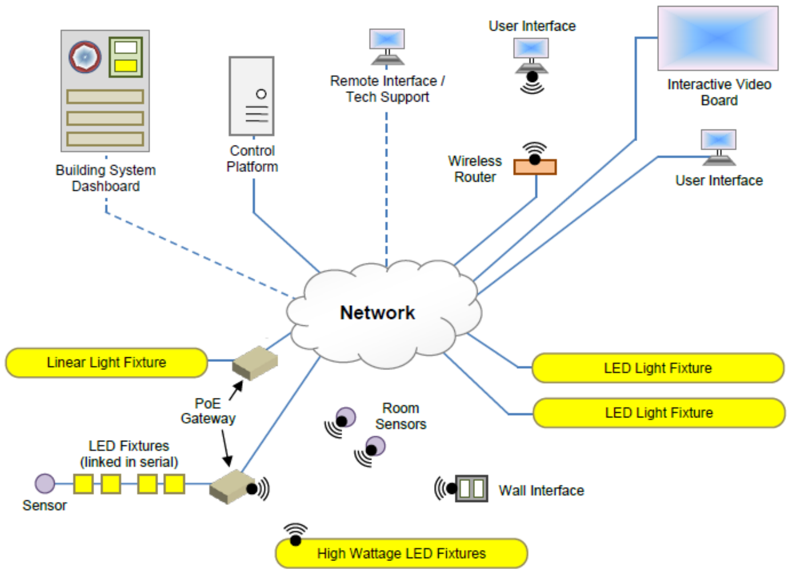


Figure 8-3
DC Lighting Power Supply and Control Topology

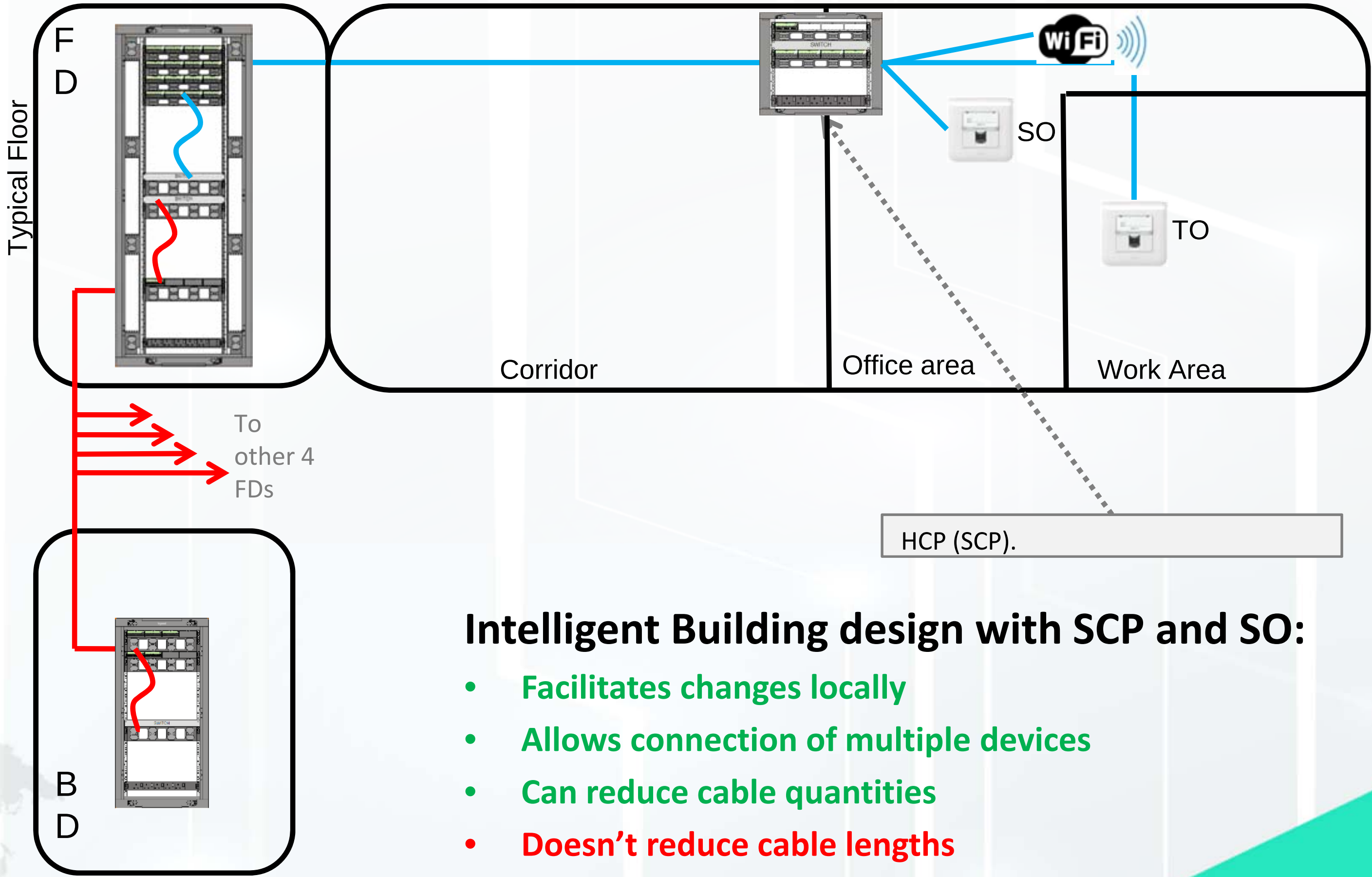
Alternatives

Cabling for the intelligent building

BICSI 007:

- **The Intelligent Building cabling is about ensuring that all systems can be integrated.**
- **The concept is to allow the maximum flexibility for any changes or additions.**

Alternatives



Intelligent Building design with SCP and SO:

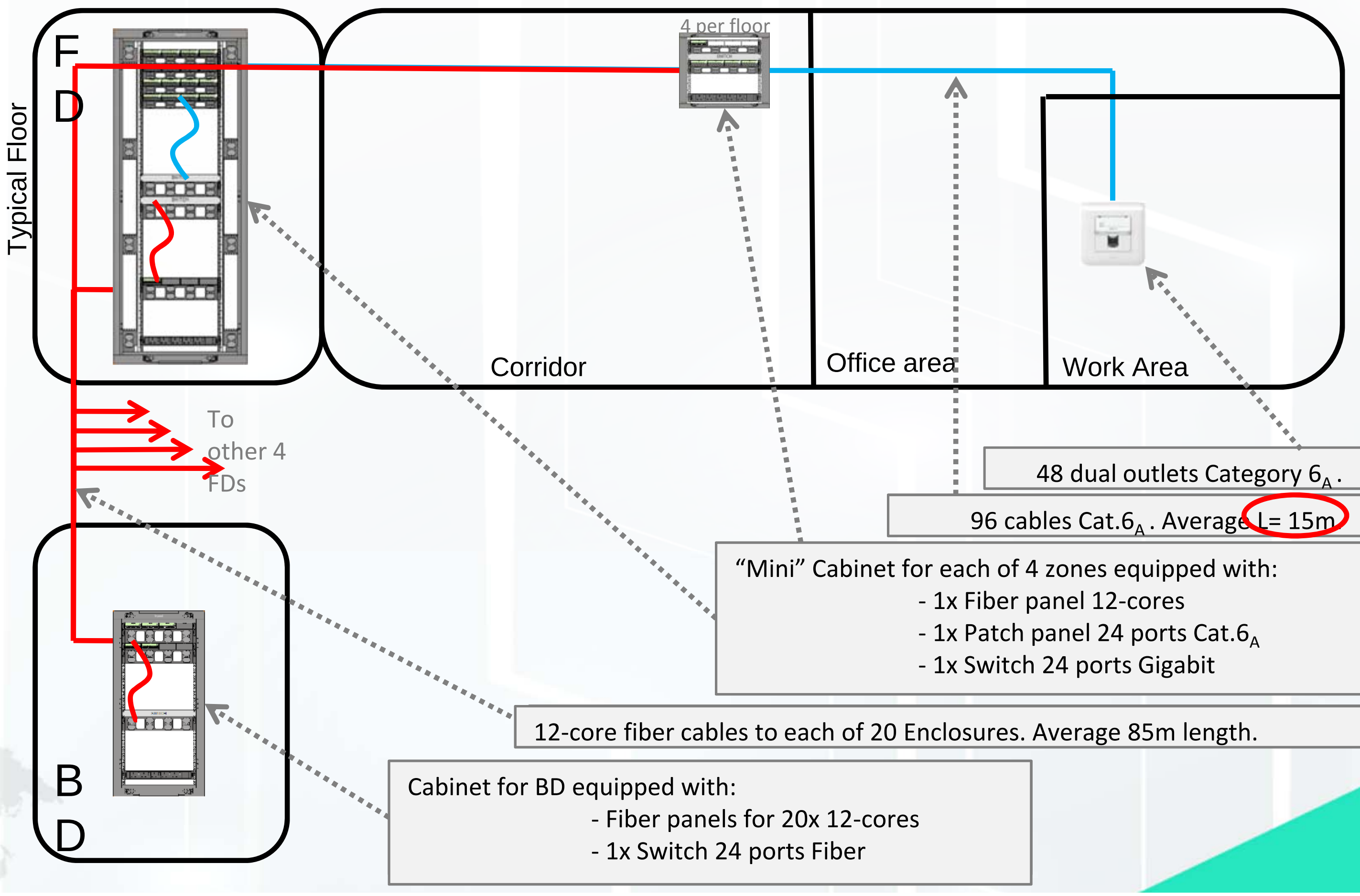
- Facilitates changes locally
- Allows connection of multiple devices
- Can reduce cable quantities
- Doesn't reduce cable lengths

Alternatives

Fiber to the Zone

- Continue the fiber backbone cabling through the telecom room and closer to the user.
- Place a local enclosure.

Alternatives



Alternatives

Base Elements:

	Traditional	FTT-Zone
Users per floor	96	96
Average Copper cable length	50	15
Average fiber backbone cable length	50	85
Average fiber horizontal cable length	0	0

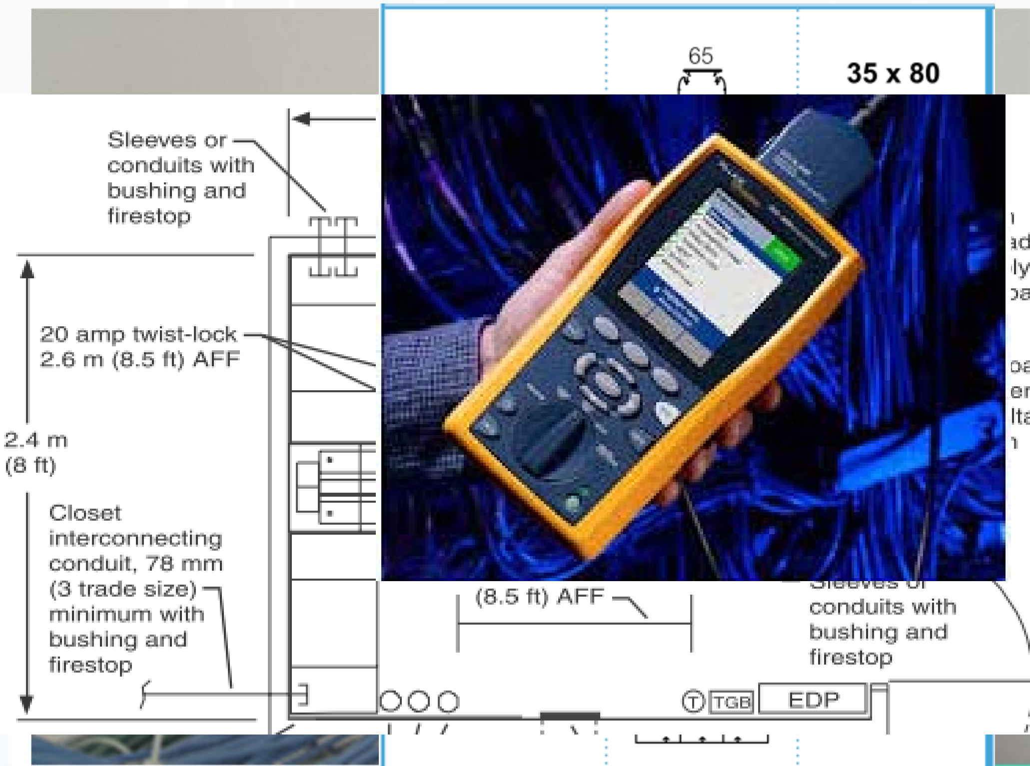
Totals for 5 floors:

	Traditional	FTT-Zone
Number of user ports	*480*	*480*
Meters of copper cables	24,000	7,200
Number of fiber backbone cables	*5*	*20*
Number of fiber horizontal cables	*0*	*0*
Meters of fiber cables	250	1,700

Alternatives

Fiber to the Zone: other savings.

- Cables Trays
- Cable Trunking
- Drilling through walls
- Telecom room size
- Labor associated with all
- Far simpler MACs

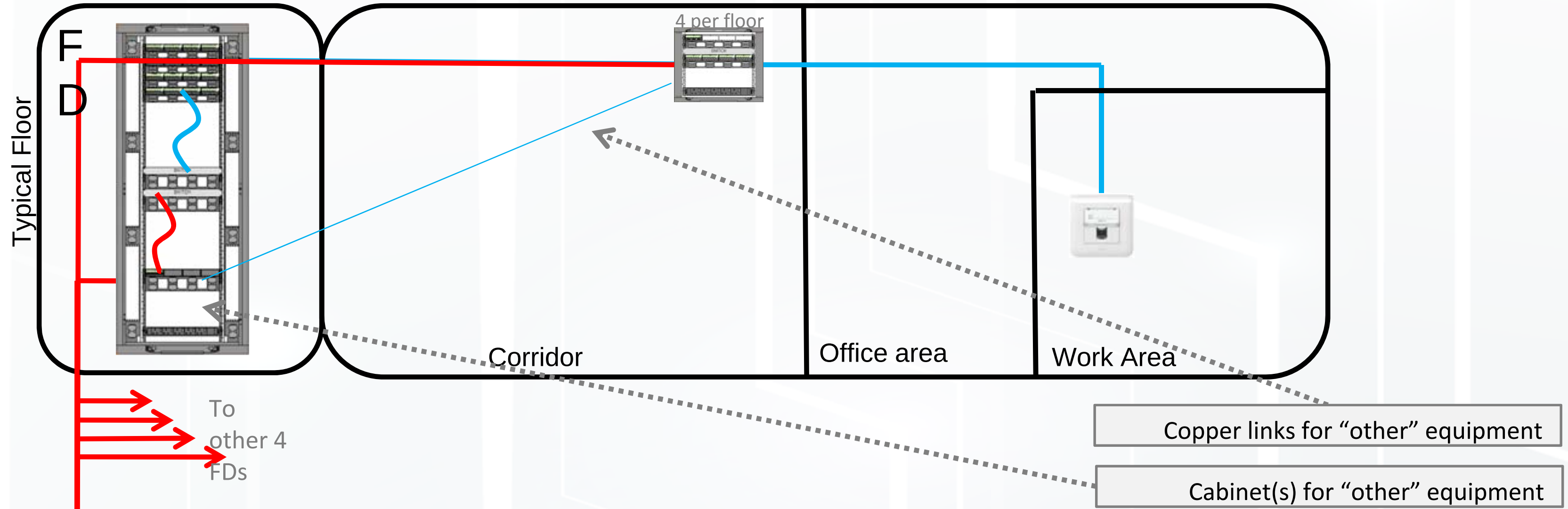


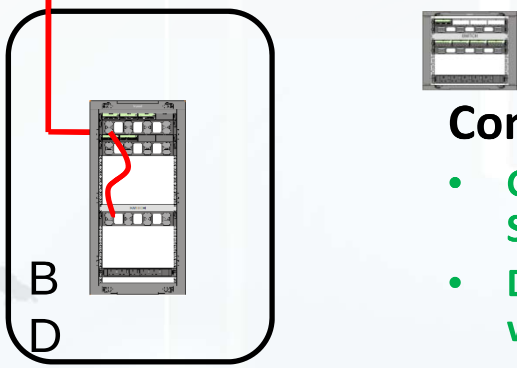
Alternatives

Fiber to the Zone

- Many advantages that we were looking for
- But missing copper links for proprietary systems
- So let’s combine the FTTE with the Intelligent building SCP + SO design

Alternatives





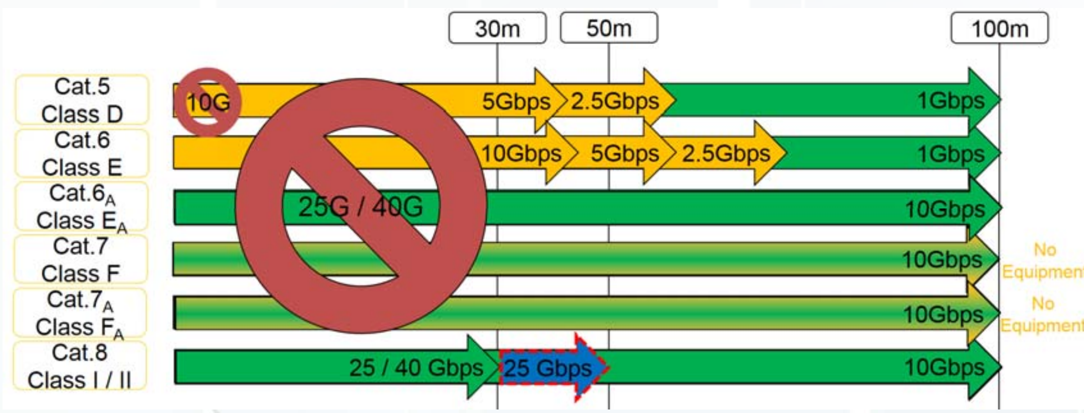
Combined FTTZ design with SCP and SO:

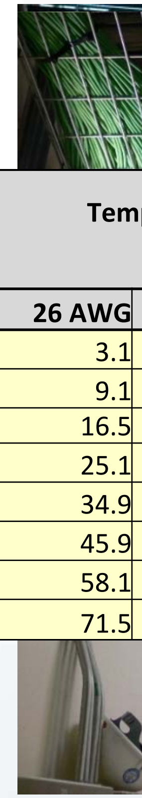
- Gains the savings of FTTZ, while adding the flexibility of SCP and SO cabling in the intelligent building design
- Does not add cabling compared to FTTZ. (Cables shown would have existed in proprietary systems)

Alternatives

Combined FTTZ with HSP and SO

- Reduces the cabling in telecom rooms
- Reduces cables in cable trays
- Improves efficiency in PoE
- Reduces heat and risk of damage to cables
- Facilitates MACs (Moves, Adds and Changes)
- Improves performance





Number of Cables in a bundle	Temp
	26 AWG
1	3.1
7	9.1
19	16.5
37	25.1
61	34.9
91	45.9
127	58.1
169	71.5

Conclusion

- ISO, IEC, TIA Standards are only minimum requirements. Compliance is required to guarantee performance.
- BICSI standards cover the implementations and best practices. They should be used to ensure optimal design.
- Technologies evolve, so do standards, to design and installation methods must evolve accordingly.

THANK YOU

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