
Network Topologies and Distances

Chris Di Minico
MC Communications
cdiminico@ieee.org

Presentation objectives

- **Considerations for 802.3ba fiber link distance objectives**

HSSG Objectives

- Support full-duplex operation only
- Preserve the 802.3 / Ethernet frame format utilizing the 802.3 MAC
- Preserve minimum and maximum FrameSize of current 802.3 standard
- Support a BER better than or equal to 10^{-12} at the MAC/PLS service interface
- Provide appropriate support for OTN

- Support a MAC data rate of 40 Gb/s
- Provide Physical Layer specifications which support 40 Gb/s operation over:
 - at least 100 m on OM3 MMF
 - at least 10 m over a copper cable assembly
 - at least 1m over a backplane

- Support a MAC data rate of 100 Gb/s
- Provide Physical Layer specifications which support 100 Gb/s operation over:
 - at least 40 km on SMF
 - at least 10 km on SMF
 - at least 100 m on OM3 MMF
 - at least 10m over a copper cable assembly

Background: Network Types

- **Enterprise Networks**
- **Carrier Networks - Service Providers**

Enterprise Network

- **An intra-company network – both local and wide area in scope**
- **Integrating all the systems within an organization**
- **Enabling users in a company to access any data or computing resource i.e., plug-and-play connectivity.**
- **All systems can potentially communicate with all other systems while maintaining:**
 - **security**
 - **performance,**
 - **and reliability**
- **Providing interoperability among autonomous and heterogeneous systems**
 - **TCP/IP, Ethernet**

Carrier Networks - Service Providers

- **Carrier networks are typically hierarchical networks that consist of a wide variety of technologies and can span large geographical areas over which services are provided.**
- **An Ethernet service could span:**
 - **native Ethernet, Ethernet over SONET,**
 - **Ethernet over Multiprotocol Label Switching (MPLS),**
 - **etc..**
- ***E and T carriers (E1, E3....)***

Customer Application Environments

Network Topologies

**Enterprise Networks,
Carrier Networks – Service Provider**

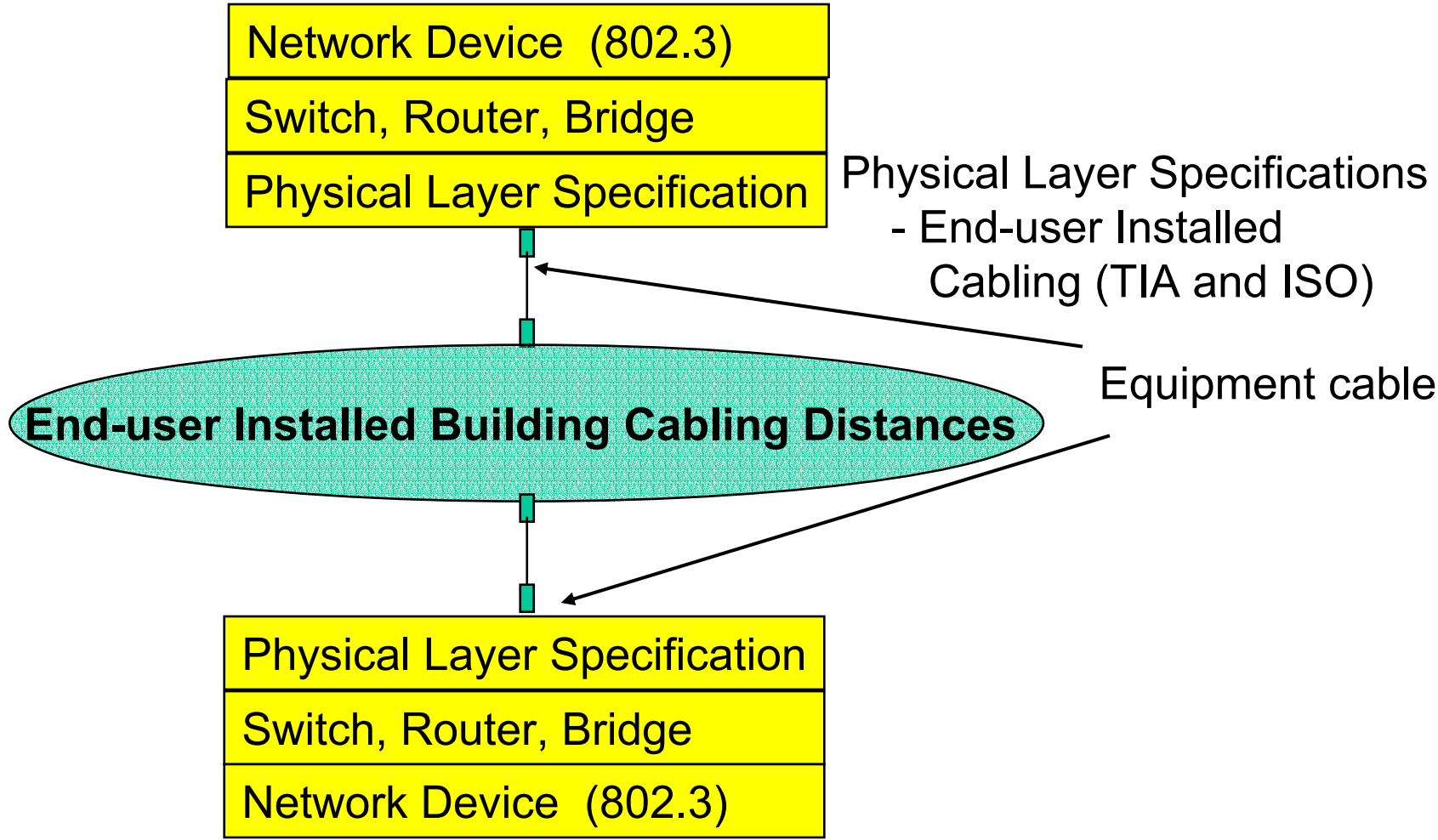
Technologies

**Ethernet , SONET, Fiber Channel,
InfiniBand, SAS, SATA, PCI Express**

Environments

**Outside Plant (FTTX),
–Central Office
Commercial and Industrial Buildings
–Data Centers, Computer rooms
–Equipment Room and Work Area**

Networking Equipment LAN - Plug-and-Play



Physical Layer: 1000BASE-X

Application Standard: Gigabit Ethernet -1999

1000BASE-CX	
CableType	Minimum Range (meters)
twinax	15

1000BASE-LX		
Fiber Type	Modal Bandwidth (Mhz*km)	Minimum Range (meters)
62.5/125 μm MM	500	2-550
50/125 μm MM	400-500	2-550
10 μm SM		2-5000

1000BASE-SX		
Fiber Type	Modal Bandwidth (Mhz*km)	Minimum Range (meters)
62.5/125 μm MM	160	2-220
62.5/125 μm MM	200	2-275
50/125 μm MM	400	2-500
50/125 μm MM	500	2-550

Computer Room and Equipment Room

TIA/EIA-Structured Cabling Standards - 1995

Media Type	Interbuilding	Intrabuilding
62.5 μm Optical fiber	2000 m (6560 ft) maximum	500 m (1640 ft) maximum
Singlemode Optical fiber	3000 m (9840 ft) maximum	500 m (1640 ft) maximum

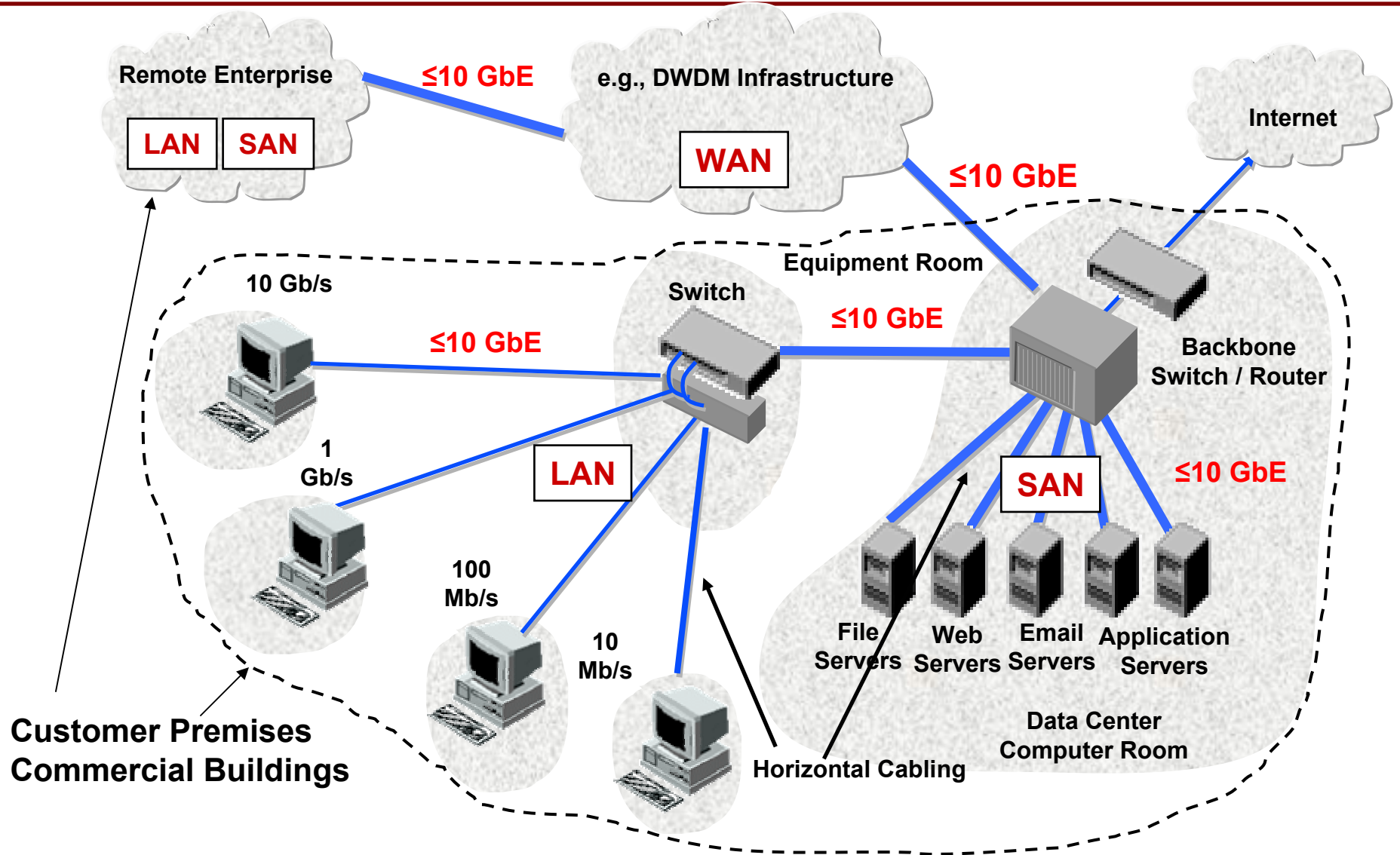
10 GbE – Fiber Port Types

10 GbE Port Type	wavelength (nm)	Cable Type	ISO/IEC 11801:2002 Fiber Type	Core Size (micron)	Modal Bandwidth-min OFL (MHz/km)	Cabling Distance
10GBASE-S	850	MMF	*	62.5	160/500	26 m
			OM1	62.5	200/500	33 m
			--	50.0	400/400	66 m
			OM2	50.0	500/500	82 m
			OM3	50.0	1500/500	300 m
10GBASE-L	1310	SMF	G.652 fiber		--	10 km
10GBASE-E	1550	SMF	G.652 fiber		--	30 km 40** km
10GBASE-LX4	4 Lanes 1269.0 – 1282.4 1293.5 – 1306.9 1318.0 – 1331.4 1342.5 – 1355.9	MMF	*	62.5	160/500	300 m
			OM1	50.0	200/500	300 m
			--	50.0	400/400	240 m
			OM2	50.0	500/500	300 m
10GBASE-LRM	1300	MMF	*	62.5	160/500	220 m
			OM1	62.5	200/500	220 m
			--	50.0	400/400	100 m
			OM2	50.0	500/500	220 m
			OM3	50.0	1500/500	220 m

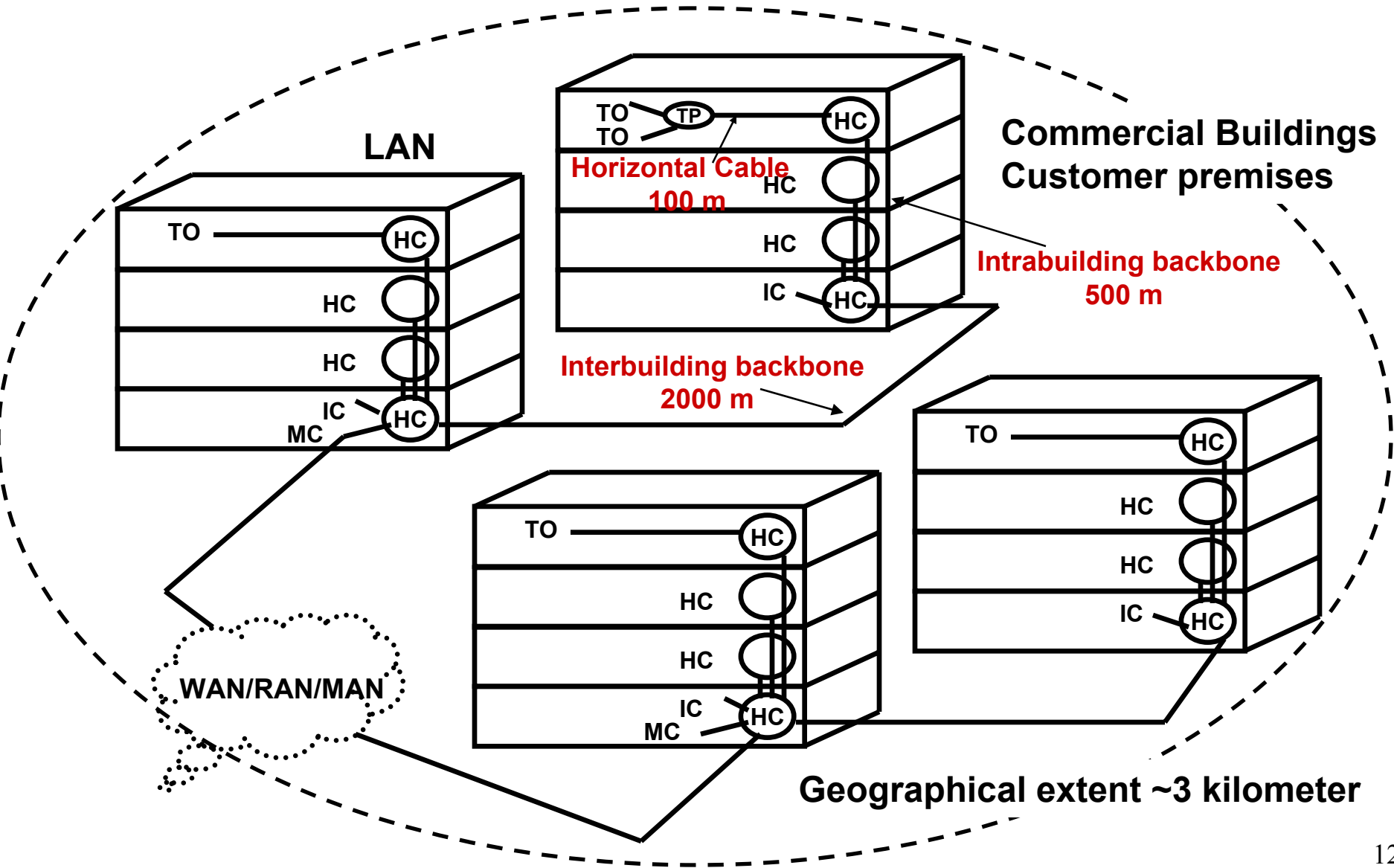
*FDDI grade

**Greater than 30 km distance mandates an "engineered link", requiring "field-testing" for verification of conformance to the 11 dB channel insertion loss specification. Insertion loss measurements of installed fiber cables are made in accordance with ANSI/TIA/EIA-526-14A/method B and, ANSI/TIA/EIA-526-7/method A-1

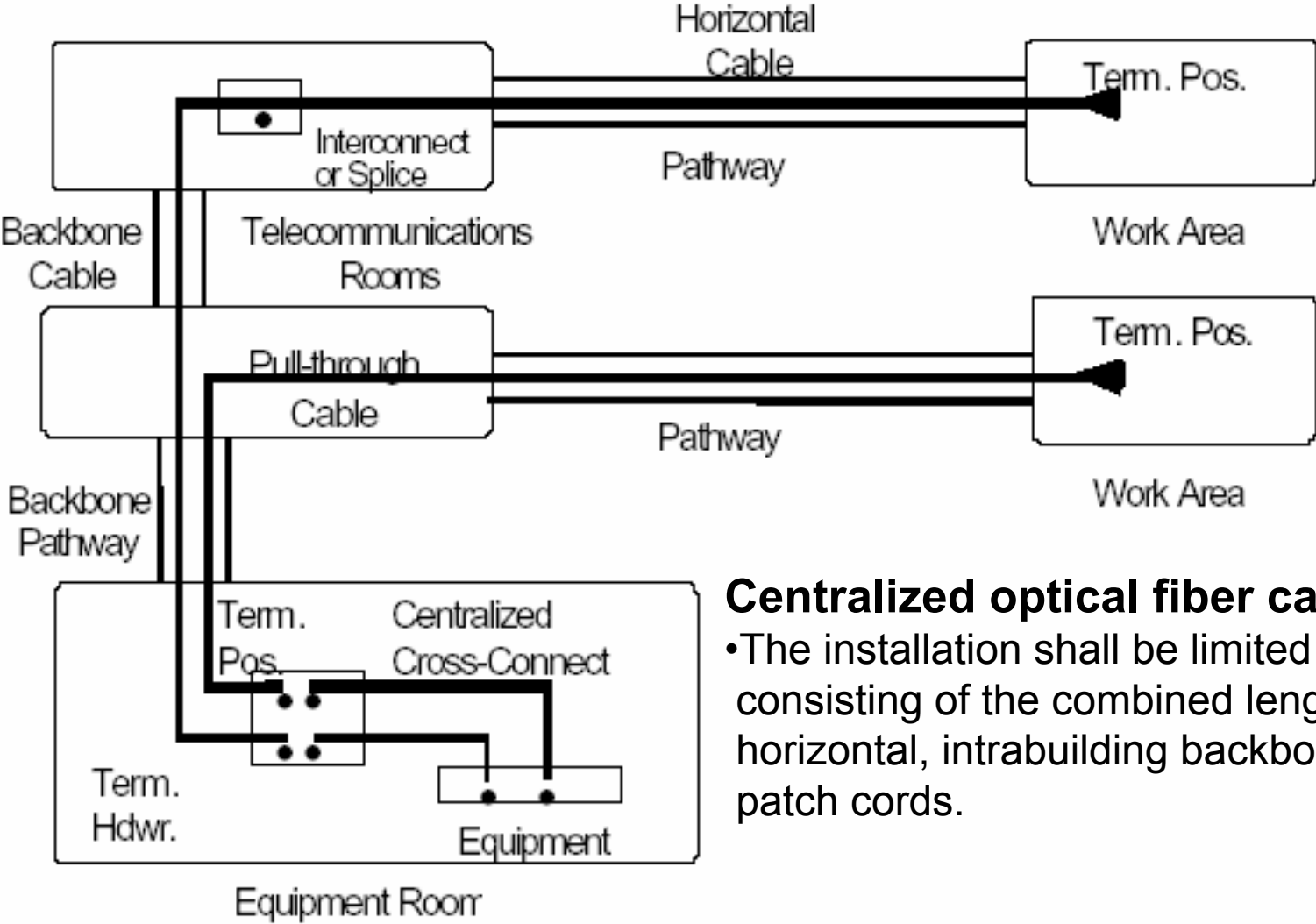
Ethernet Enterprise Network - LAN/WAN/SAN



Generic telecommunication cabling- TIA-568 and ISO/IEC-11801

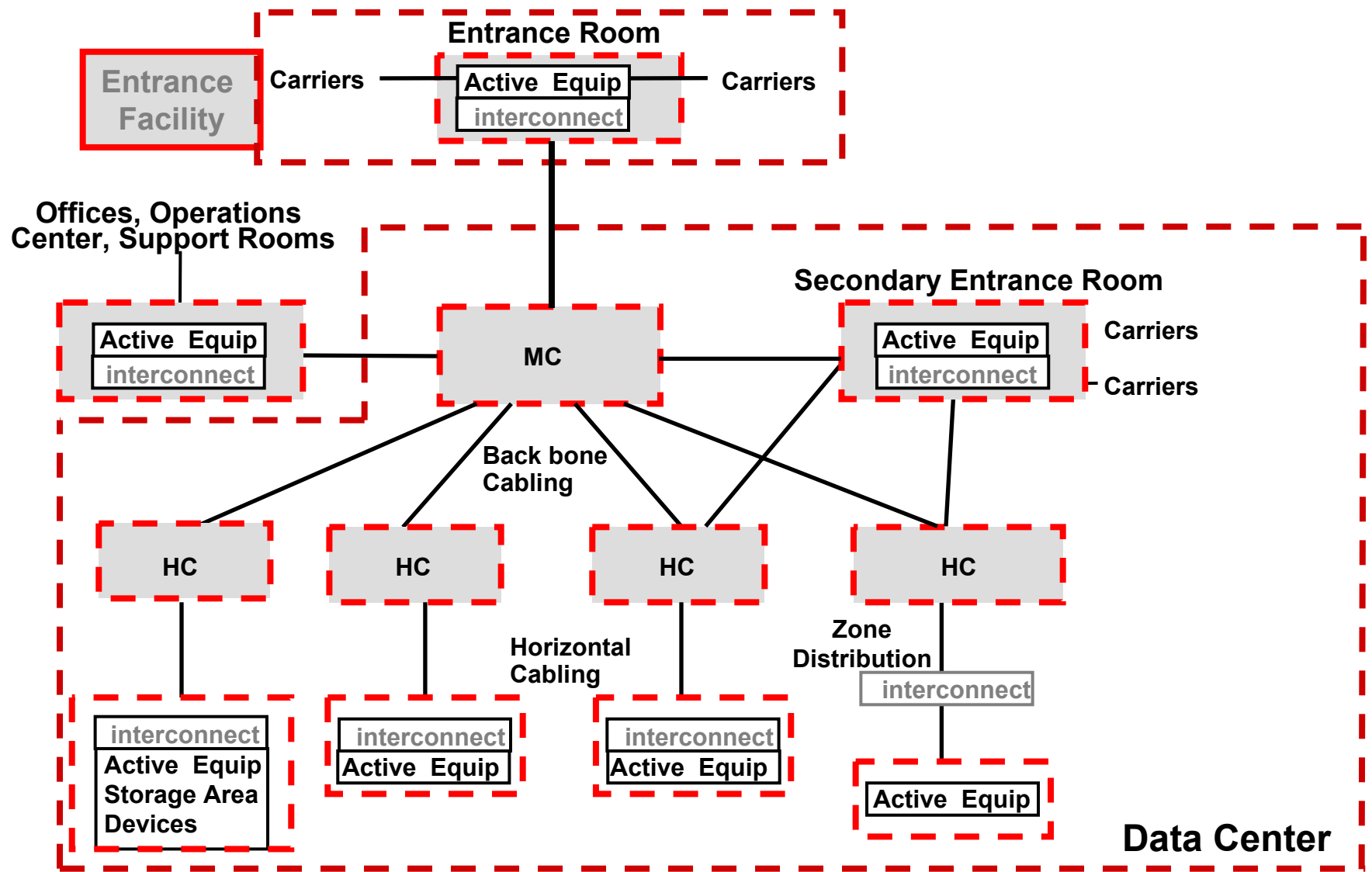


Generic telecommunication cabling- TIA-568 and ISO/IEC-11801

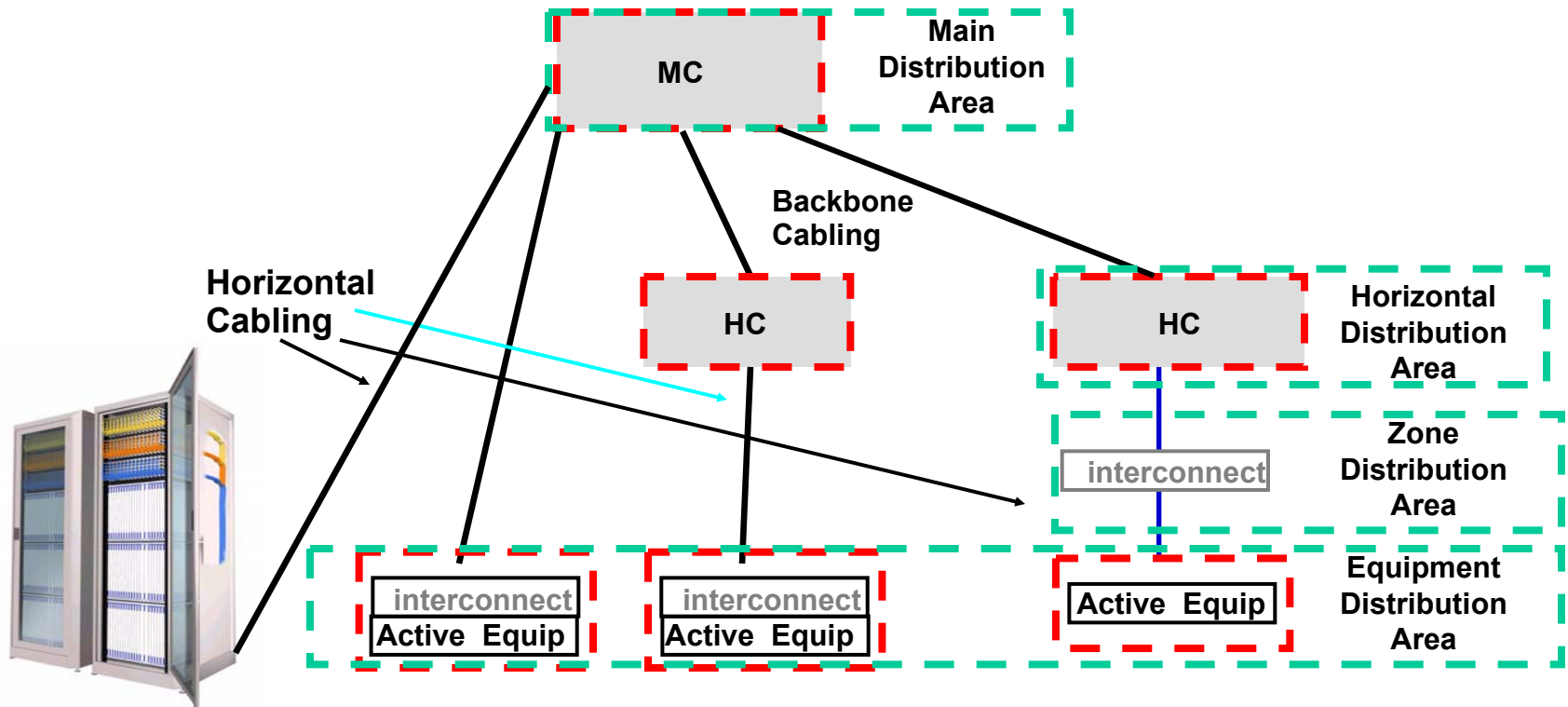


Centralized optical fiber cabling
•The installation shall be limited to 300 m consisting of the combined length of the horizontal, intrabuilding backbone, and patch cords.

Telecommunications Infrastructure Standard for Data Centers - ANSI/TIA-942



Data center cabling - ANSI/TIA-942



Horizontal cabling is the cabling from the horizontal cross-connect (in the main distribution area or horizontal distribution area) to the outlet in the equipment distribution area or zone distribution area.

Horizontal and backbone cabling - ANSI/TIA-942

- Recognized Cables:
 - a) 100-ohm twisted-pair cable (ANSI/TIA/EIA-568-B.2), category 6 recommended (ANSI/TIA/EIA-568-B.2-1)
 - b) multimode optical fiber cable, either 62.5/125 micron or 50/125 micron (ANSI/TIA/EIA-568-B.3), 50/125 micron 850 nm laser optimized multimode fiber is recommended (ANSI/TIA-568-3-1)
 - c) singlemode optical fiber cable (ANSI/TIA/EIA-568-B.3)
 - d) 75-ohm (734 and 735 type) coaxial cable (Telcordia Technologies GR-139-CORE)

Horizontal cabling distances - ANSI/TIA-942

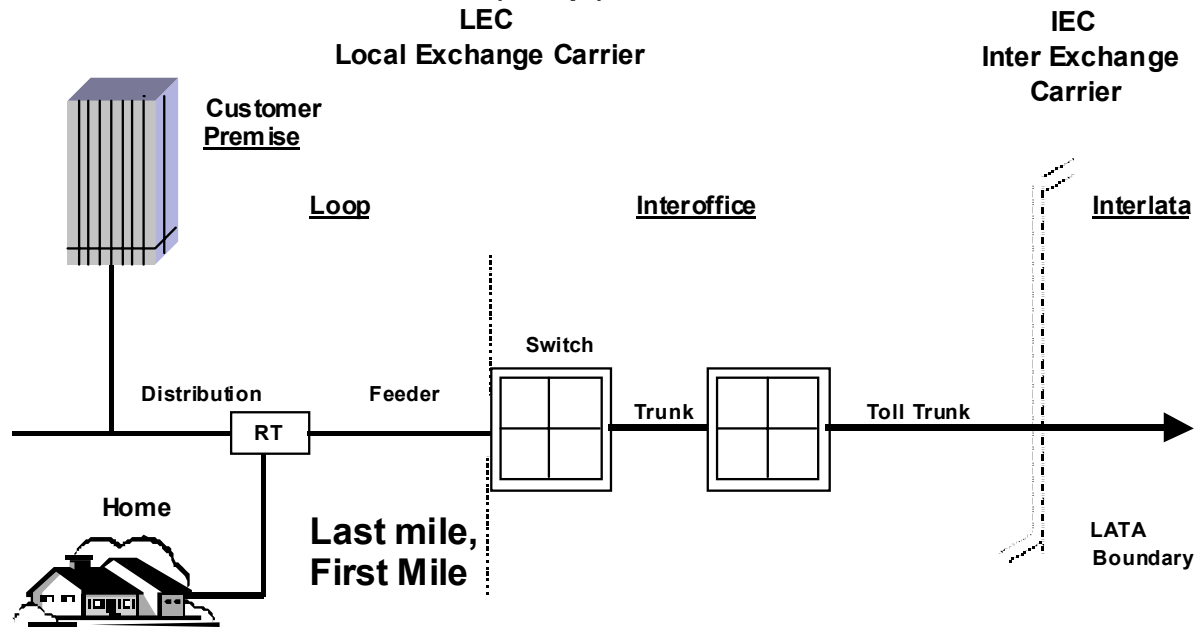
- The maximum horizontal distance is 90 m independent of media type.
- The maximum channel distance including equipment cords is 100 m.

Backbone cabling - ANSI/TIA-942

- Includes cabling from MDA to ER, HDA
- Optional cabling between HDAs allowed
- Maximum backbone cable lengths depend on applications to be supported
- Centralized optical fiber cabling supported with interconnect, splice, or pull-through at the HAD (distance shall not exceed 300 m)
- Star topology with no intermediate cross-connects
- Various topologies permit redundancy and flexibility to support various data center sizes

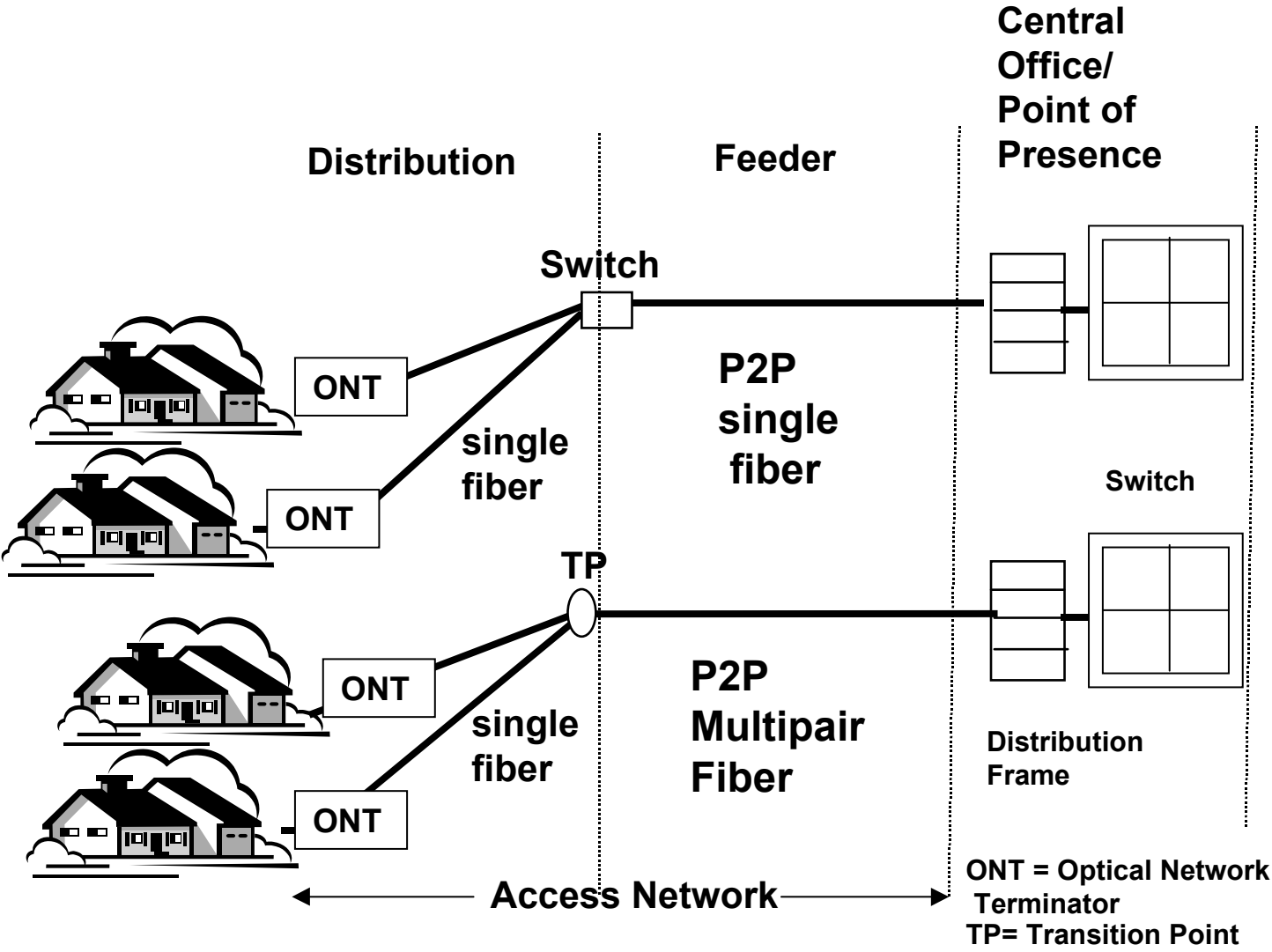
Network boundaries and distances

- Post divestiture telephone network boundaries with reference to the “last mile”. The local exchange carrier (LEC) serviced the local access and transport area (LATA) which included the “last mile” (loop) and the interoffice trunks.

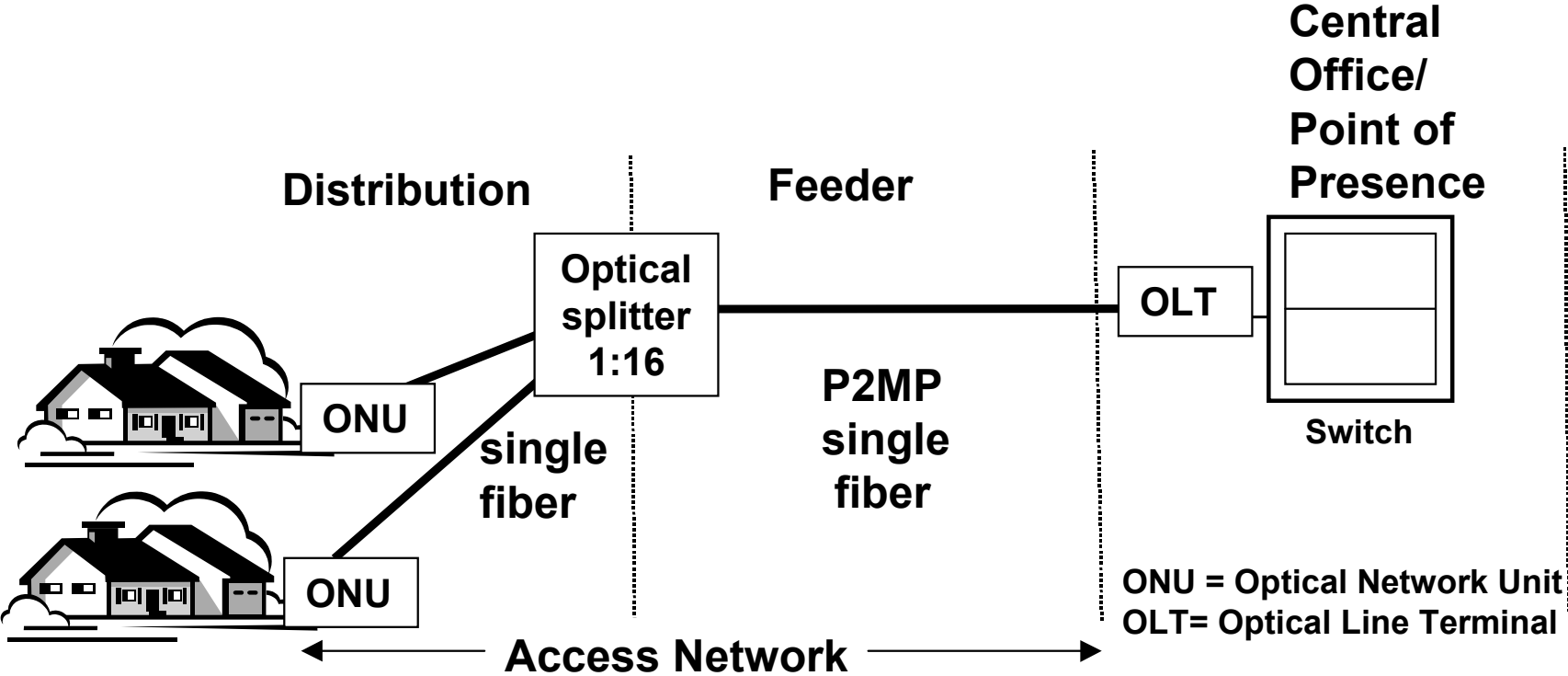


- Multimode and single mode in the interoffice segment with distances ranging up to approximately 5 miles (~8 km).
- The network segment distances interconnecting the local area transport areas (interlata) range from 100 miles to 4200 miles on single mode fiber.

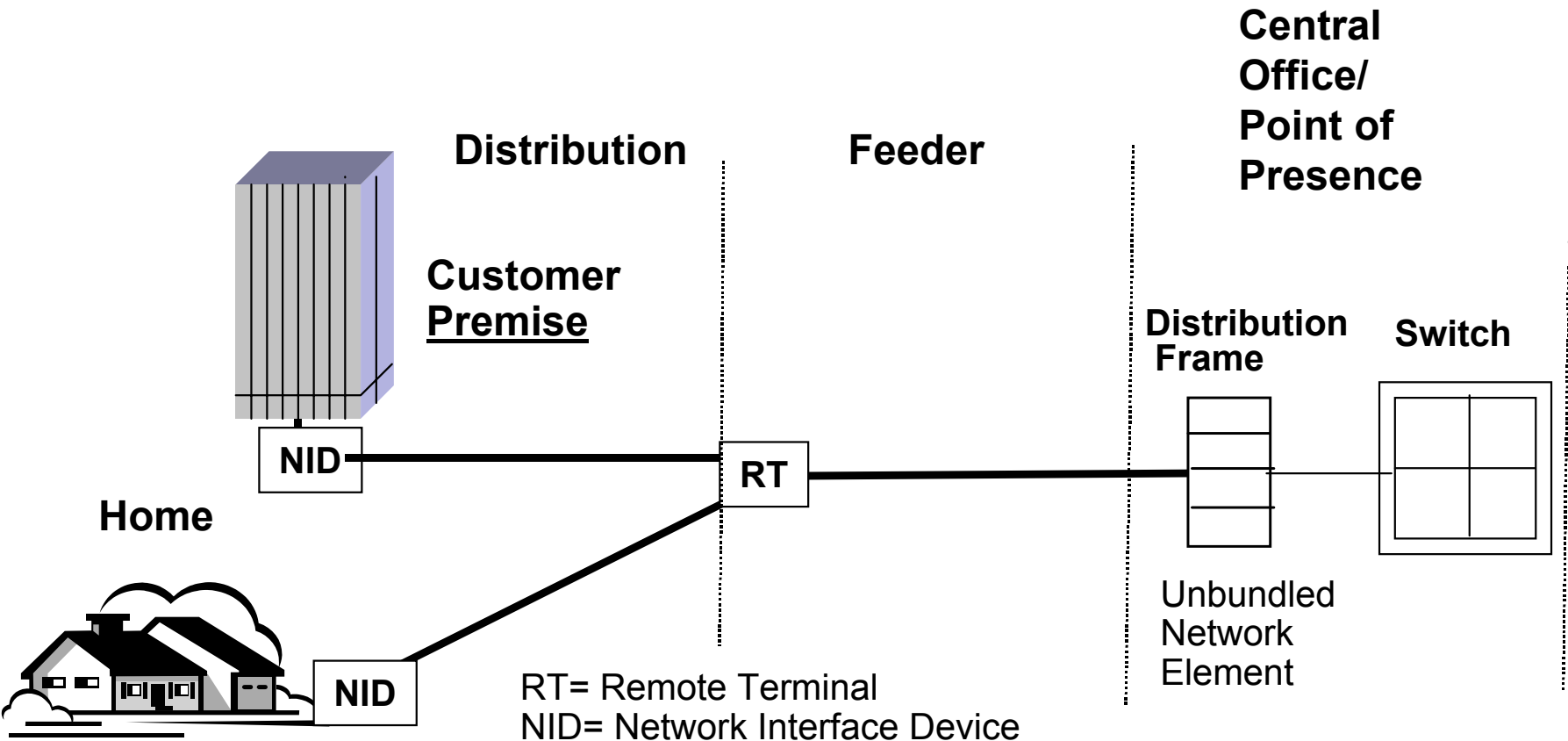
Point-to-point Optical Fiber



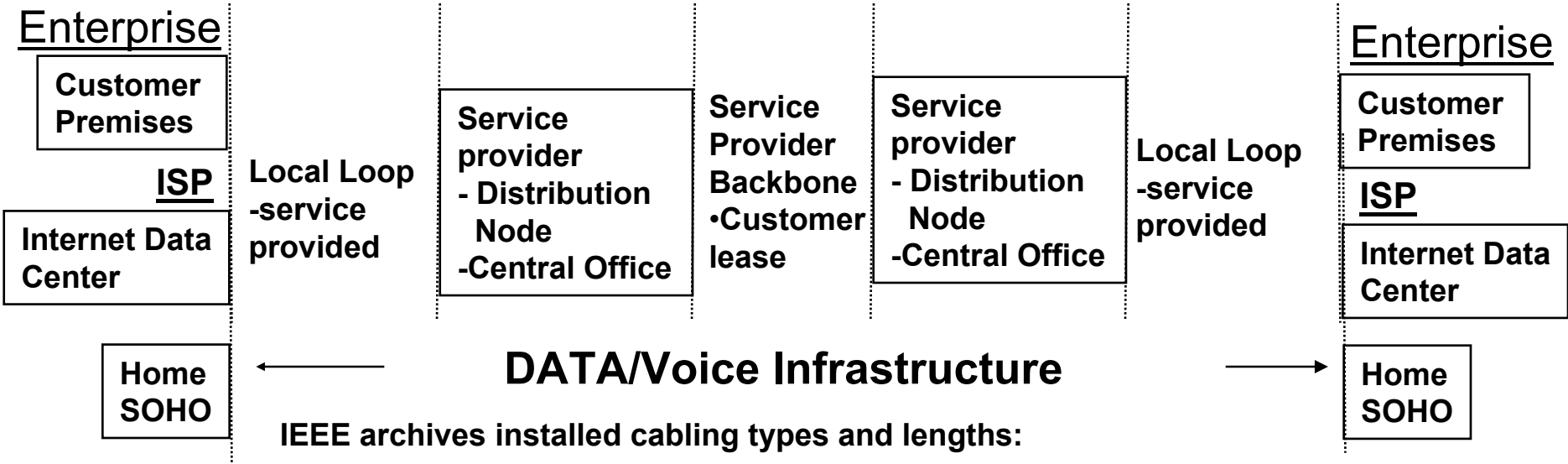
Point- to- multipoint optical topology



Point-to-point copper



Telecommunication Infrastructure



IEEE archives installed cabling types and lengths:

Generic cabling – customer premises

•Ahmad Nouri

-<http://www.ieee802.org/3/z/public/presentations/july1996/ANfibsurl.txt>

•Chris DiMinico

-<http://www.ieee802.org/3/z/public/presentations/nov1996/CDfibsurl.txt>

-<http://www.ieee802.org/3/z/public/presentations/nov1996/CDsyvres.pdf>

Alan Flatman

-http://www.ieee802.org/3/10G_study/public/july99/flatman_1_0799.pdf

Local loop

•Aitkem Haile-Mariam

-http://www.ieee802.org/3/10G_study/public/july99/haile-mariam.pdf

AMP tyco INTERNATIONAL LTD. Company

Key Customer/ Large Metro CLEC "Stats"

- "Typical" ring per CLEC network:
 - "bimodal" 20 km or 40 km
- "Typical" number of CO per network: 1
- "Typical" building distance from CO:
 - 10 km or 20 km
- Prototype implementations of GBE noted at these distances
- We should, therefore, set 2 distance objectives of 10 km and 20 km

15

Aitkem Haile-Mariam

http://www.ieee802.org/3/10G_study/public/july99/haile-mariam.pdf

AMP tyco INTERNATIONAL LTD. Company

ILEC / RBOC "Stats"

- Thankfully, data is clearer for metro based ILEC / RBOC networks
- Architecture studies were conducted by AT&T (and Bell Core) in 1964, 1974, and 1983³
- Last study showed the following link lengths for the (star) networks:
 - Distance CO-to-Drop (ft)
 - Min.: 186 ft
 - Mean: 10,780 ft
 - Max: 114,000 ft
 - "Drop-In-Distribution"
 - 1,888 ft

³ Source: Telephony Magazine Loop Survey 10/5/97 (and Bell Core)

16

Aitkem Haile-Mariam

http://www.ieee802.org/3/10G_study/public/july99/haile-mariam.pdf



ILEC / RBOC "Stats"

- We should therefore set an additional objective of 3 or 4 km's for single mode fiber

Mean Length (ft)	10,780
Drop (ft)	1,888
Total (ft)	12,668
Total (km)	3.85

³ Source: Telephony Magazine Loop Survey 10/5/97 (and Bell Core)

18

Aitkem Haile-Mariam

http://www.ieee802.org/3/10G_study/public/july99/haile-mariam.pdf