Optical Fiber Networks: Industry Trends, Application Influences and New Options for Networks

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Preview

- Deciding between OM1, OM2, OM3 and OM4 fiber
- Options for the new 40G/100G applications
- Deciding between single-mode and multimode fiber
- Network Architecture Comparison
  - Traditional Hierarchal Star
  - Centralized
  - Telecommunications Enclosures
  - PON

Standards

- History
  - TIA-568-A
    - Horizontal (100m), Intrabuilding (500m), Interbuilding (1500m, or 2000m minus Intrabuilding)
  - TIA-568-B
    - 500m became 300m
    - Gigabit Ethernet Support

10Gb/s Ethernet Distances

10GBASE-SR (850nm Serial)

Fiber Type	Minimum OFL Bandwidth (@850nm)	Minimum Range
62.5/125µm	160 MHz•km	2-26m
	200 MHz•km	2-33m
50/125µm	400 MHz•km	2-66m
	500 MHz•km	2-82m
850nm Laser Optimized 50/125µm	2000 MHz•km Effective Modal Bandwidth	2-300m

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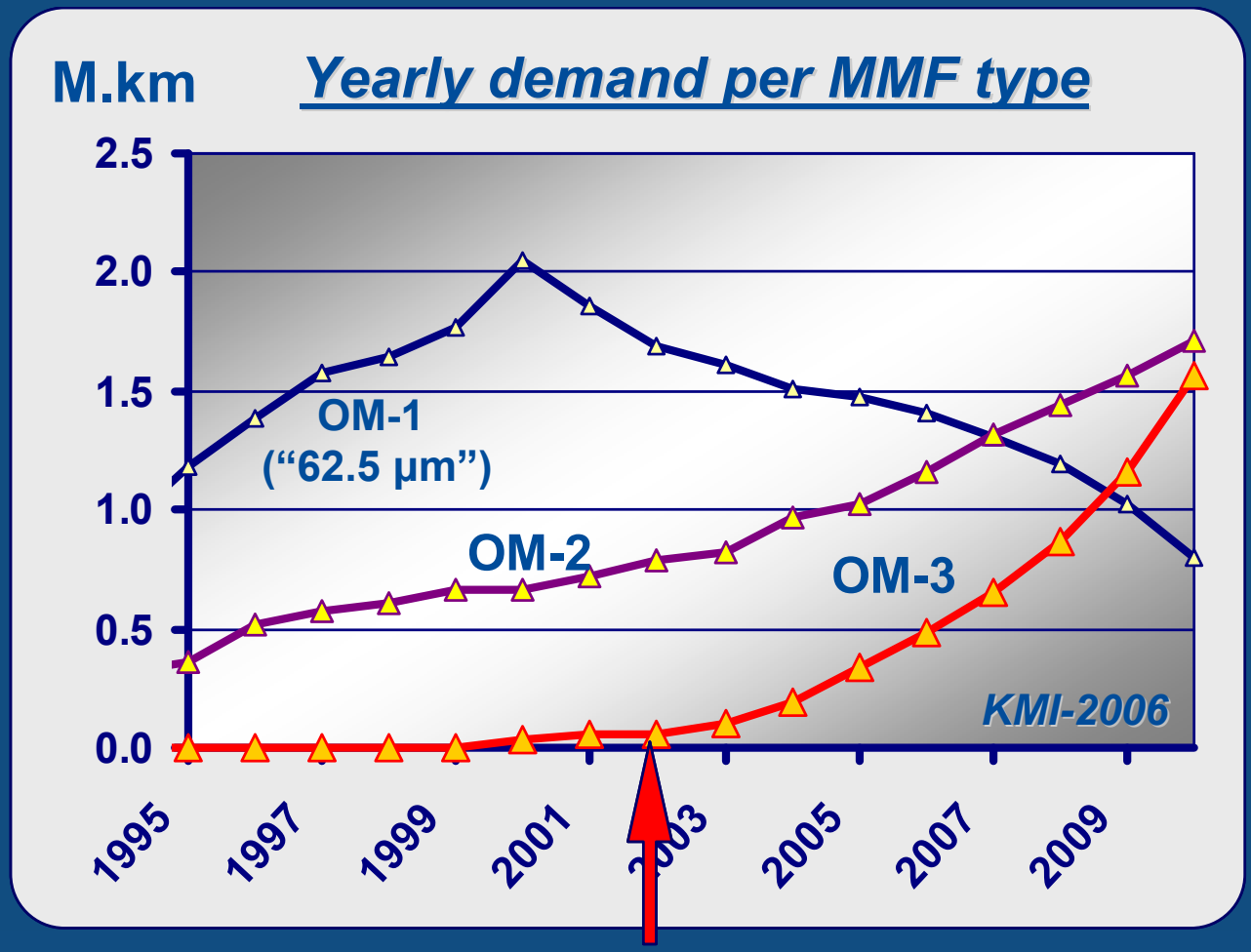
What about 62.5/125µm?

- Alive and well in legacy installations
- Proposals to remove it from standards
  - Still a recognized medium

What about 62.5/125µm?



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What about 62.5/125µm?

- Still a very capable medium
  - 10G to 300m
    - 10GBASE-LX4
  - 10G to 220m
    - 10GBASE-LRM

10Gb/s Ethernet Distances

10GBASE-LX4 (1310nm WDM)

Fiber Type	Minimum OFL Bandwidth (@850nm)	Minimum Range
62.5/125µm	160 MHz•km	2-300m
	200 MHz•km	2-300m
50/125µm	400 MHz•km	2-240m
	500 MHz•km	2-300m
850nm Laser Optimized 50/125µm	2000 MHz•km Effective Modal Bandwidth	2-300m
Single-mode	N/A	2-10,000m

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10Gb/s Ethernet Distances

10GBASE-LRM (1310nm Serial on MMF)

Fiber Type	Minimum OFL Bandwidth (@850nm)	Minimum Range
62.5/125µm	160 MHz•km	0.5-220m
	200 MHz•km	0.5-220m
50/125µm	400 MHz•km	0.5-100m
	500 MHz•km	2-220m
850nm Laser Optimized 50/125µm	2000 MHz•km Effective Modal Bandwidth	2-220m

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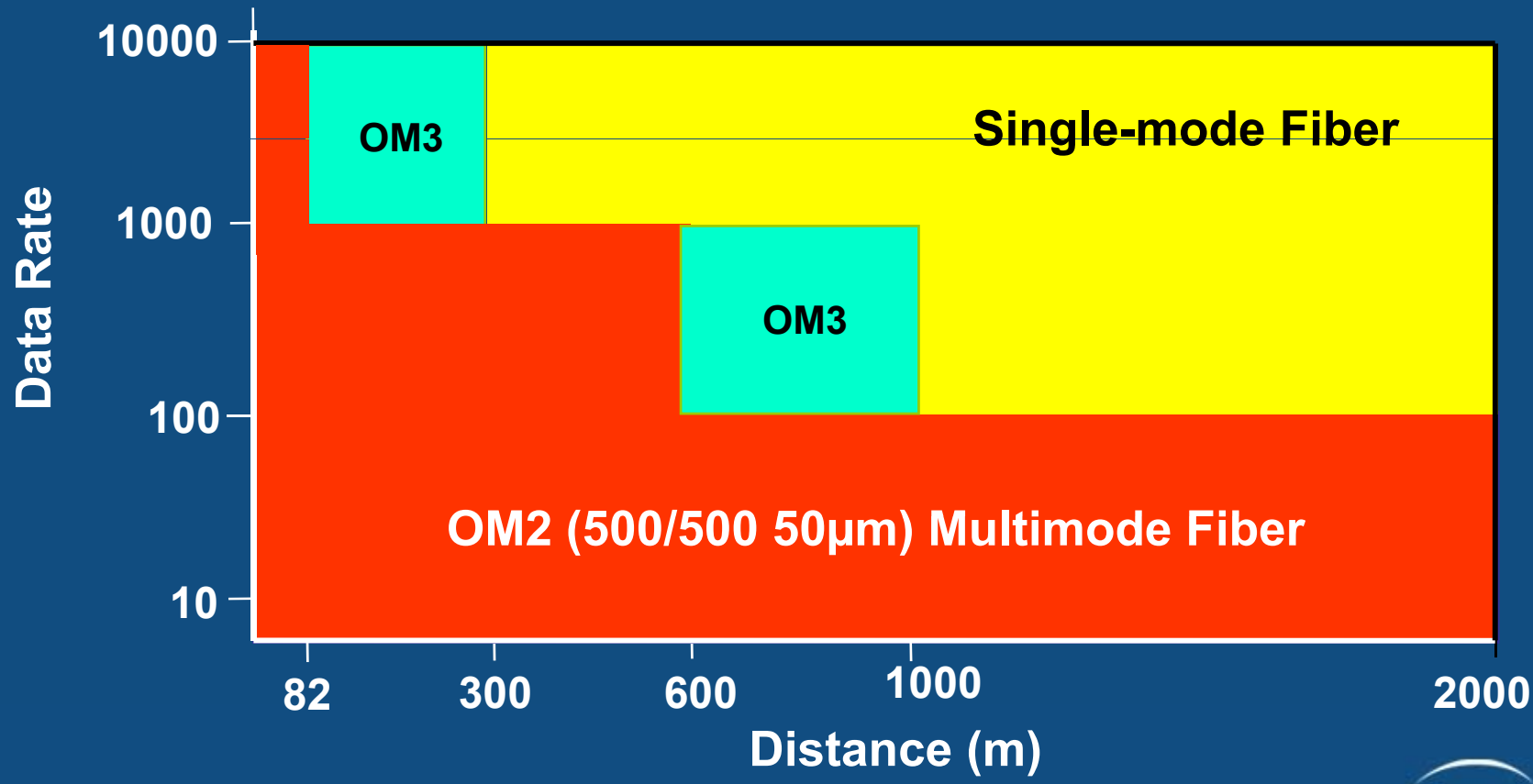
Fiber Choices With OM3



Selection based on lowest cost electronics

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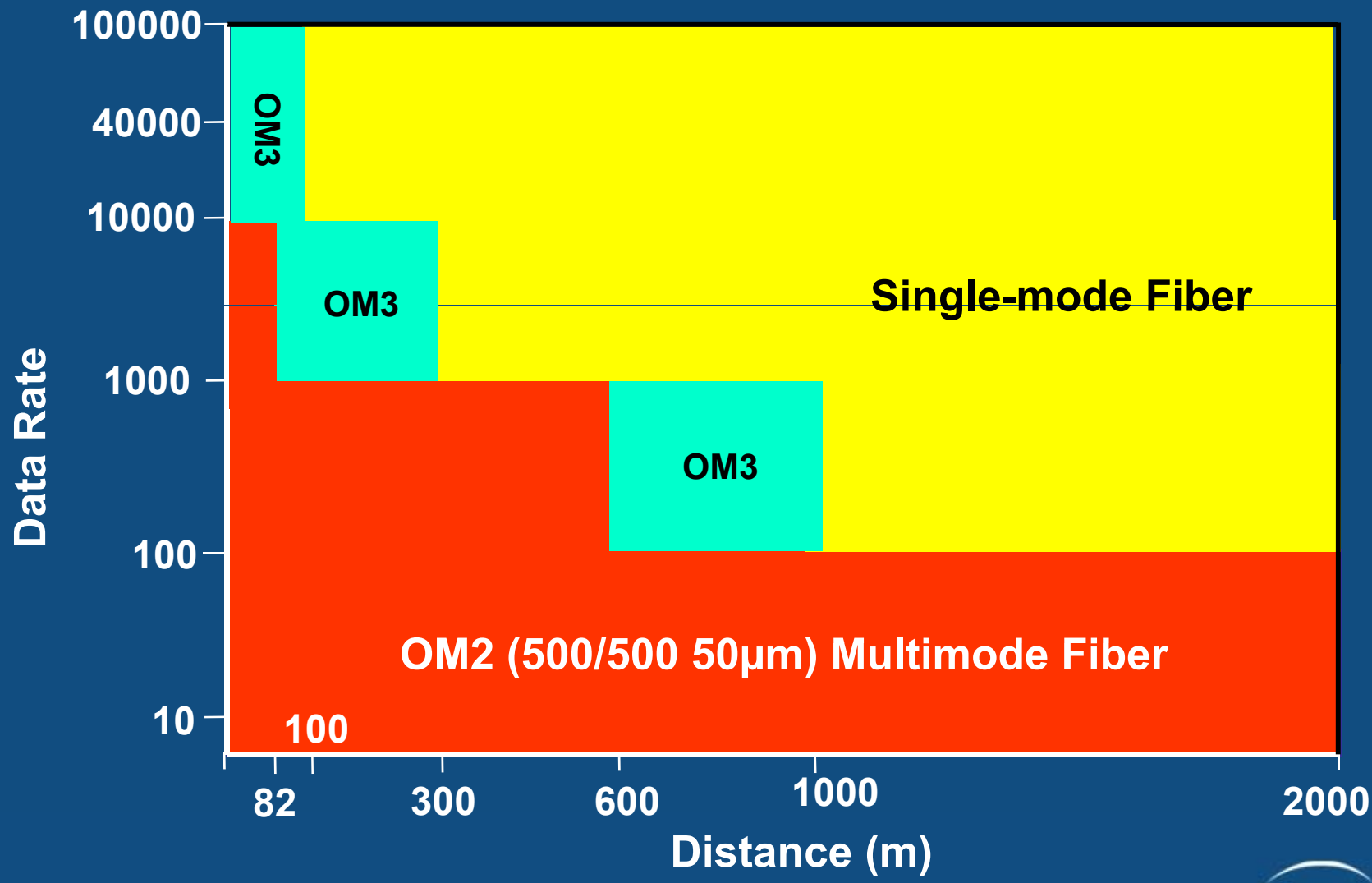
IEEE 802.3ba – 40G/100G

- Provide Physical Layer specifications which support 40 Gb/s over:
  - at least 100m on OM3 MMF
- Provide Physical Layer specifications which support 100 Gb/s over:
  - at least 100m on OM3 MMF

Fiber Choices With OM3



Selection based on lowest cost electronics

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40G/100G Questions

- Why 100m not 300m?
  - at least 100m on OM3 MMF
- How can you get the same distance on the same fiber at 2.5x the data rate?
  - 40G and 100G

100m vs. 300m

- The IEEE Cost Objective
  - 10x the data rate at 3x the cost

- How do you get four 10G channels at 1.2x the cost of one 10G channel?
- How do you get ten 10G channels at 3x the cost of one 10G channel?

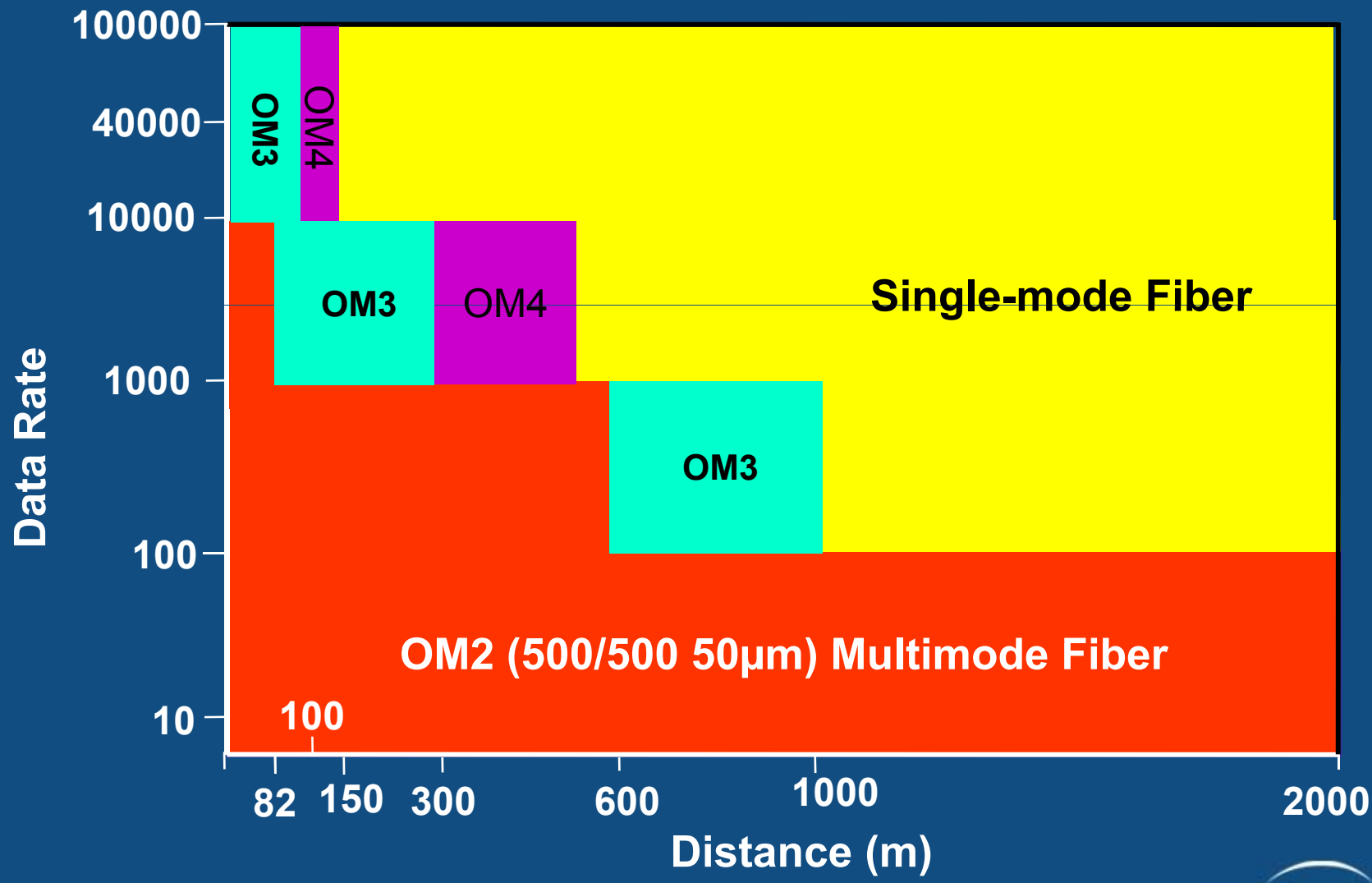
100m vs. 300m

- Serial VCSELS
  - Technology tops out at ~20-25G
- Wave Division Multiplexing
  - 10λ separation difficult in 850nm window
  - No cost savings on the electronics

100m vs. 300m

- Parallel
  - Requires more fibers
  - Requires cost reduction on 10G
    - Relaxed transceiver specifications
- Better Fiber
  - OM4 fiber

Fiber Choices With OM4



Selection based on lowest cost electronics

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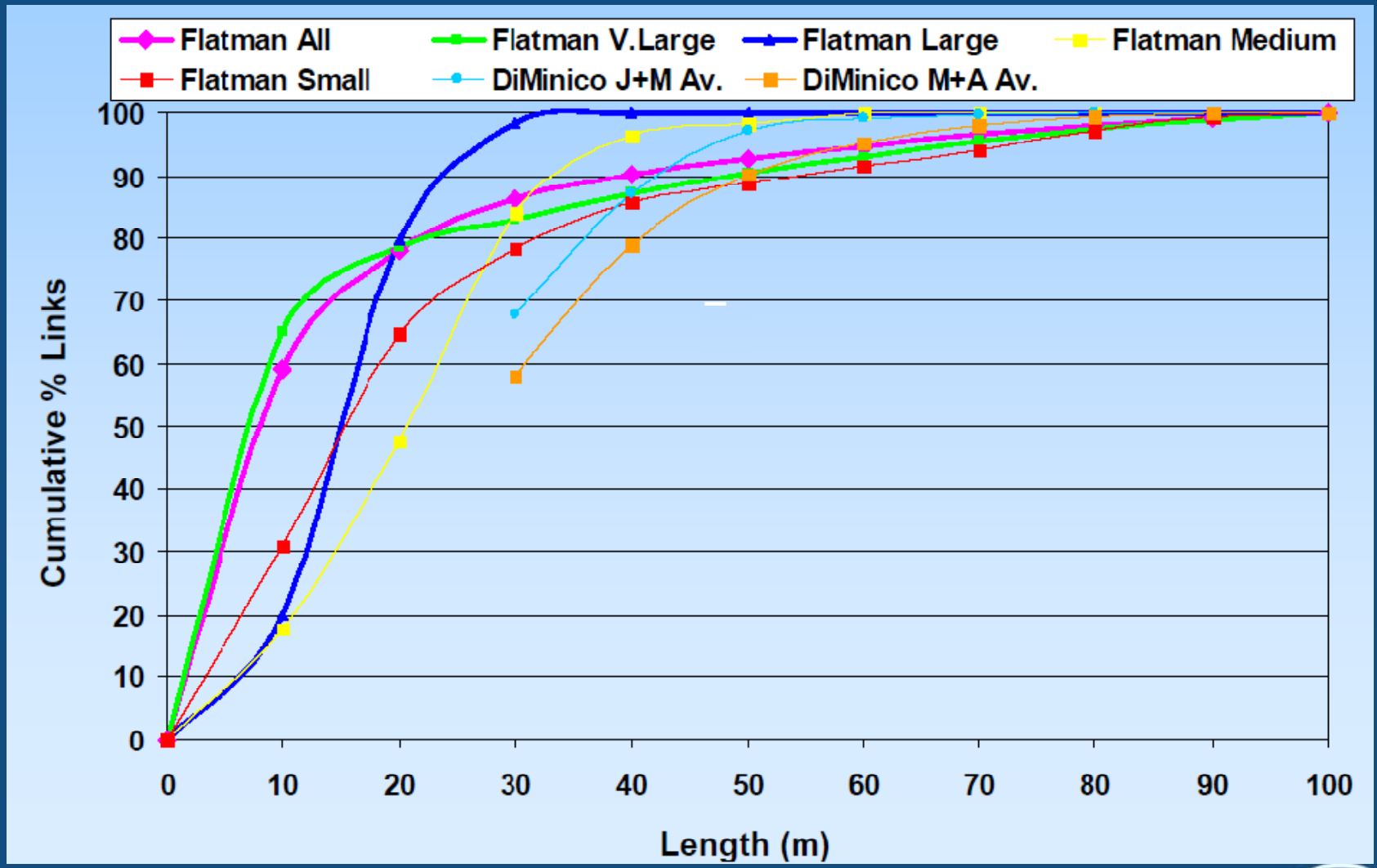
100m vs. 300m



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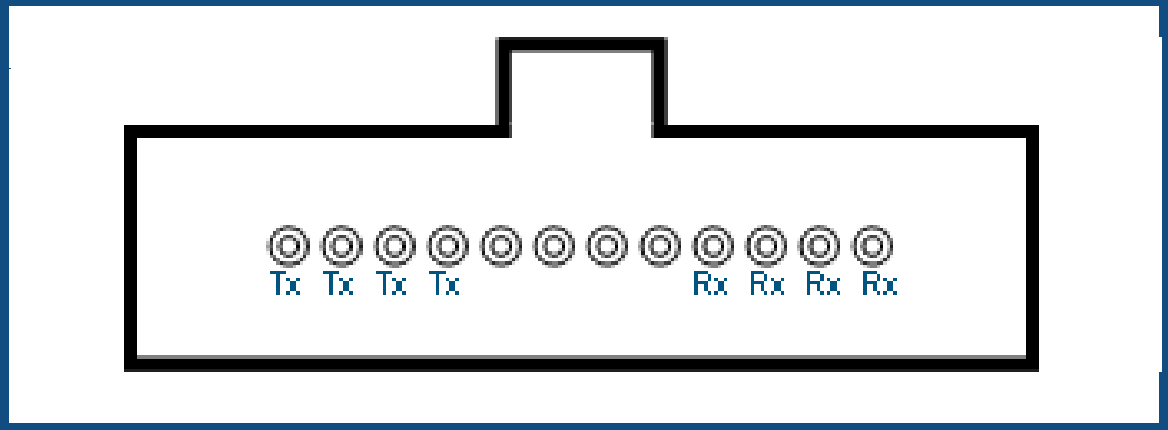
IEEE 802.3ba

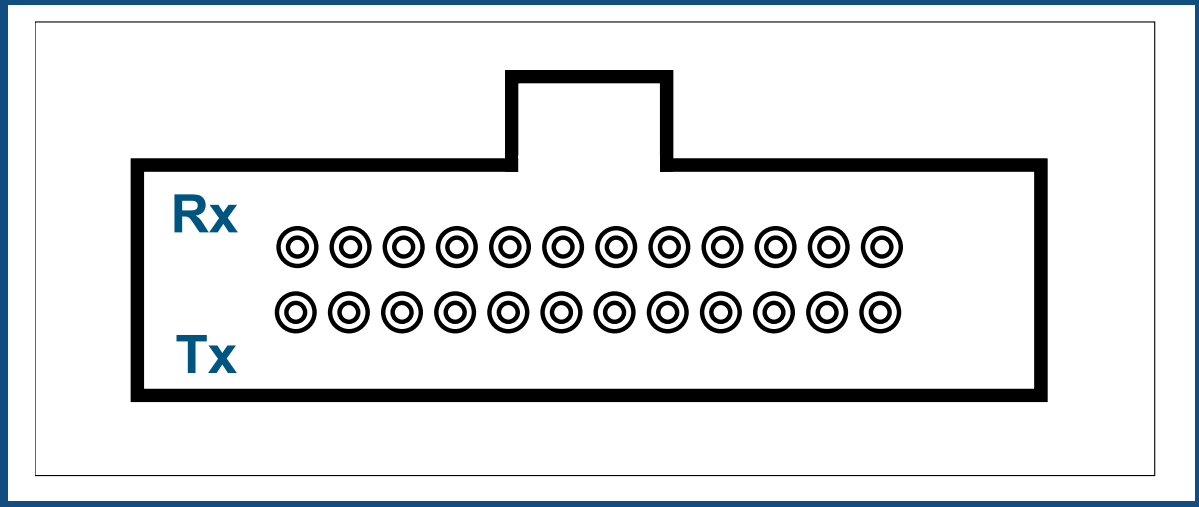
- Multimode solutions will be parallel
  - 4 TX and 4 RX for 40G



NOTE: all views are looking into transceiver

IEEE 802.3ba

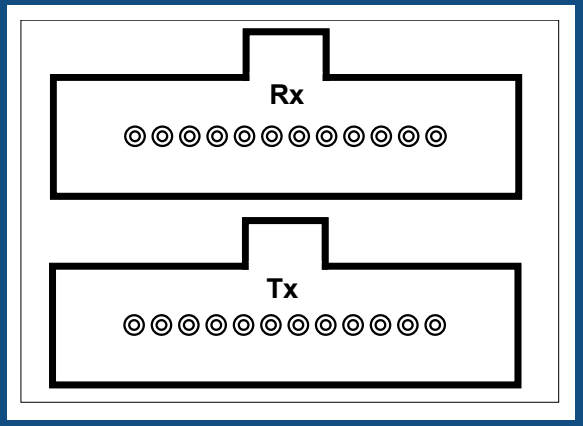
- Multimode solutions will be parallel
  - 10 TX and 10 RX for 100G
    - Center 10 fibers, both rows (preferred)

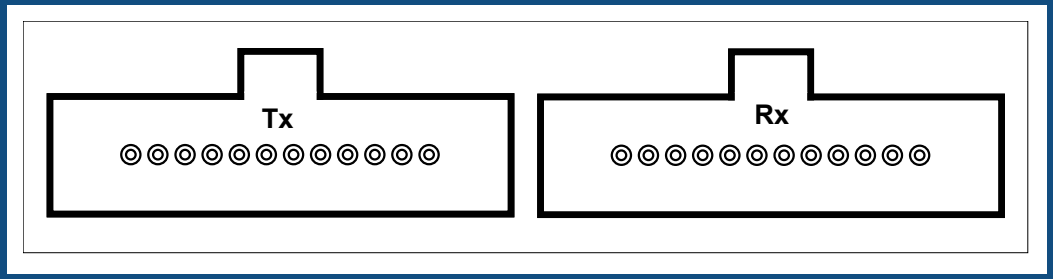


NOTE: all views are looking into transceiver

IEEE 802.3ba

- Multimode solutions will be parallel
  - 10 TX and 10 RX for 100G
    - Center 10 fibers, two MPO (allowed)





NOTE: all views are looking into transceiver

IEEE 802.3ba

- No lane assignments (1-4 or 1-10)
  - Protocol will self-detect
  - Reduces importance of polarity for these applications
- Skew budget very generous
  - Not likely to be a concern unless building with duplex links with a length differential more than 15 meters

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Standards & Polarity

- Component Polarity (Illustrated)
  - ANSI/TIA 568-C.3
- System Polarity (Illustrated)
  - ANSI/TIA 568-C.0

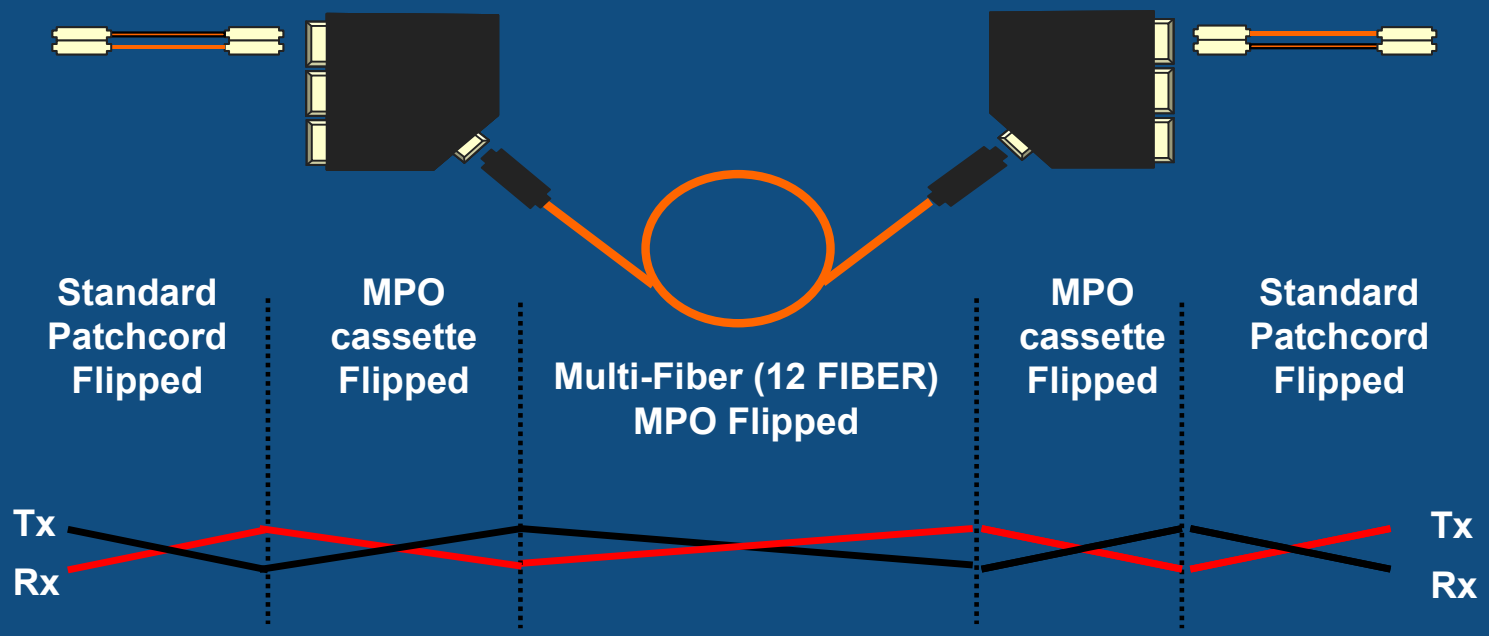
Standards & Polarity

- Component Polarity – Array Patch Cords
  - Type A: 1-to-1…12-to-12
  - Type B: 1-to-12…12-to-1
  - Type C: 1-to-2; 2-to-1…11-to-12
- Component Polarity – Adapters
  - Type A: Key Up to Key Down
  - Type B: Key Up to Key Up
- Component Polarity – Duplex Patch Cords
  - A-to-B
  - A-to-A

Standards & Polarity

- System Polarity
  - Method A
    - Type A array patch cord and adapter
    - One A-to-A; one A-to-B duplex patch cords
  - Method B
    - Type B array patch cord and adapter
    - Two A-to-B duplex patch cords
  - Method C
    - Type C array patch cord and Type A adapter
    - Two A-to-B duplex patch cords

MPO Link Connectivity - Flip



Always use in one link:
- 2 flipped cassettes
- 1 flipped MPO trunk cable

3 Part Numbers:
- 1 patch cord type
- 1 cassette type
- 1 trunk type

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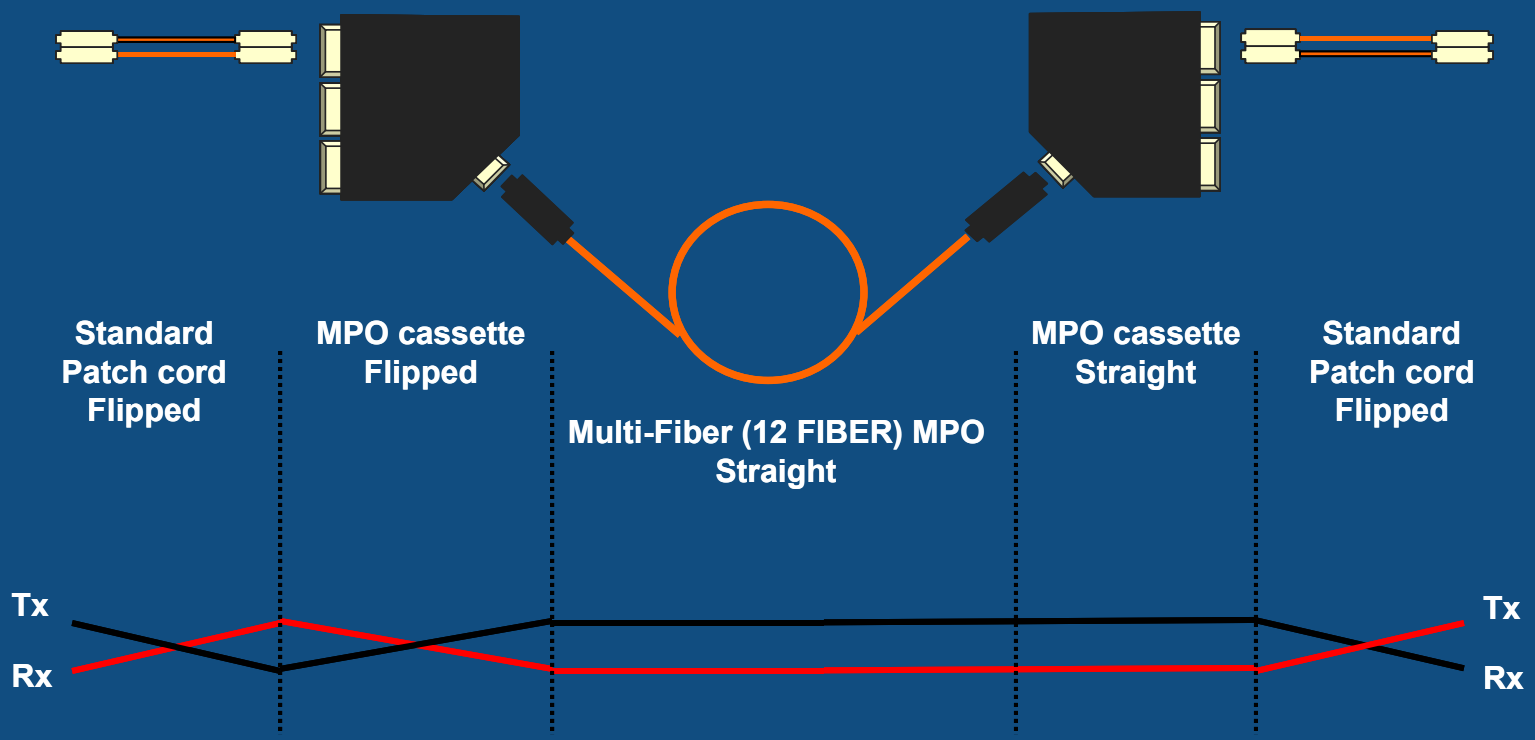
MPO Link Connectivity - Straight



Always use in one link:
- 1 flipped cassette
- 1 straight cassette
- 1 straight MPO trunk cable

4 Part Numbers:
- 1 patch cord type
- 2 cassette types
- 1 trunk type

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Options

- Existing Duplex Network
  - Can couple multiple links into a 40G or 100G channel
    - Skew Budget Limitations
    - Attenuation Limitations
- Existing MPO Network
  - Can use installed links with MPO Patch cords and/or MPO transitions
    - Attenuation Limitations
    - Length Limitations

Why not just jump to Single-mode?

10Gb/s Ethernet Distances

10GBASE-LR (1310nm Serial)

Fiber Type	Minimum Range
Single-mode	10km

10GBASE-ER (1550nm Serial)

Fiber Type	Minimum Range
Single-mode	40km

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IEEE 802.3ba – 40G/100G

- Provide Physical Layer specifications which support 40 Gb/s over:
  - at least 10km on SMF
- Provide Physical Layer specifications which support 100 Gb/s over:
  - at least 40km on SMF
  - at least 10km on SMF (note: CWDM)

Why not just jump to Single-mode?

- MM solution still expected to have higher port density
  - QXFP vs. CXFP
    - at least 2x density
- MM solution still expected to cost less
  - SM Link ~3-4x cost of MM Link
    - electronics and cabling
- MM solution still expected to consume less power
  - 3-4W for MM port
  - 20W for SM port
  - 3-to-1 at the meter

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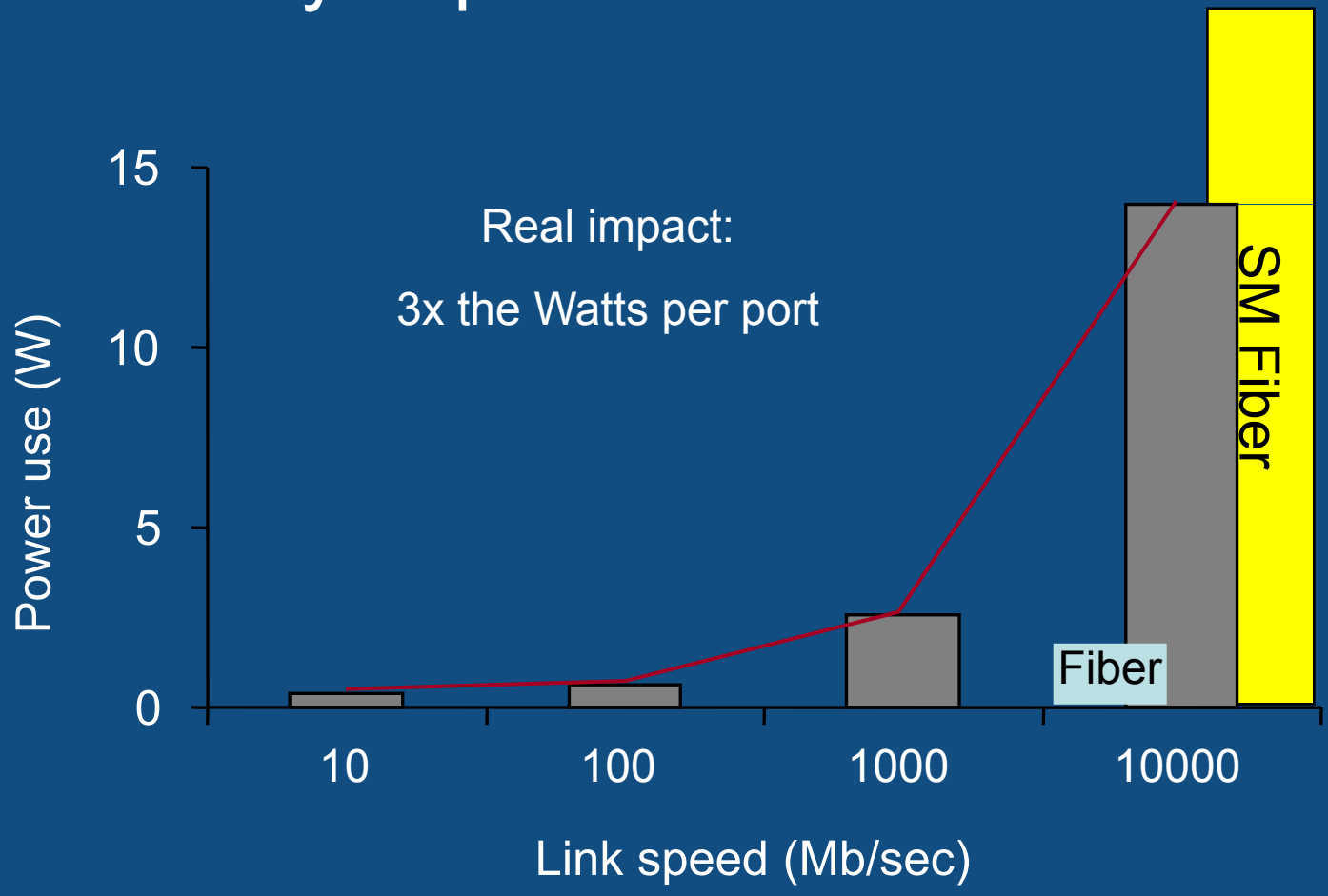
Application Cabling Power

- Summary of power measurements



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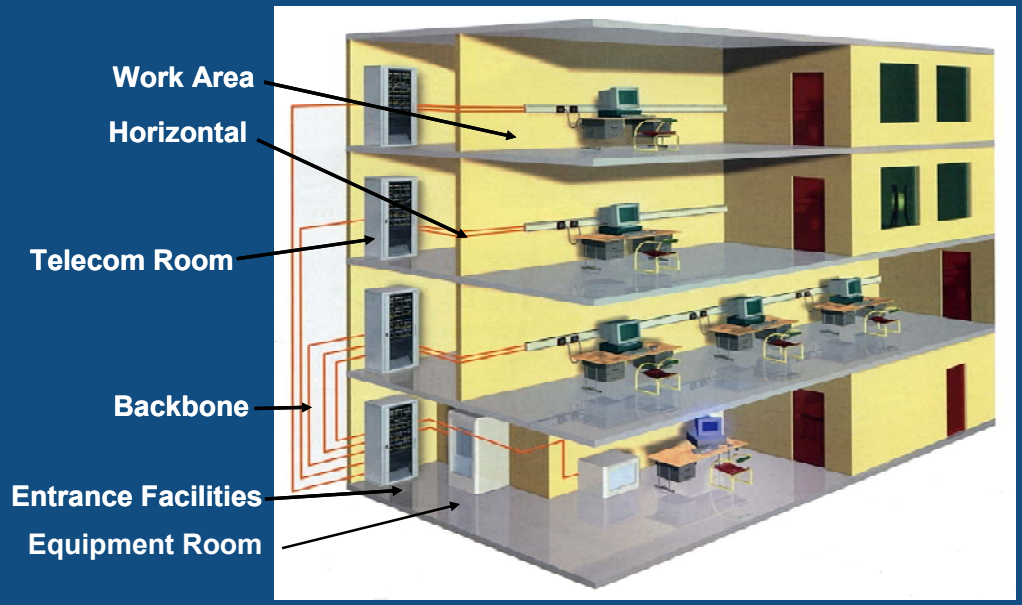
Structured Cabling System Architectures Evolve

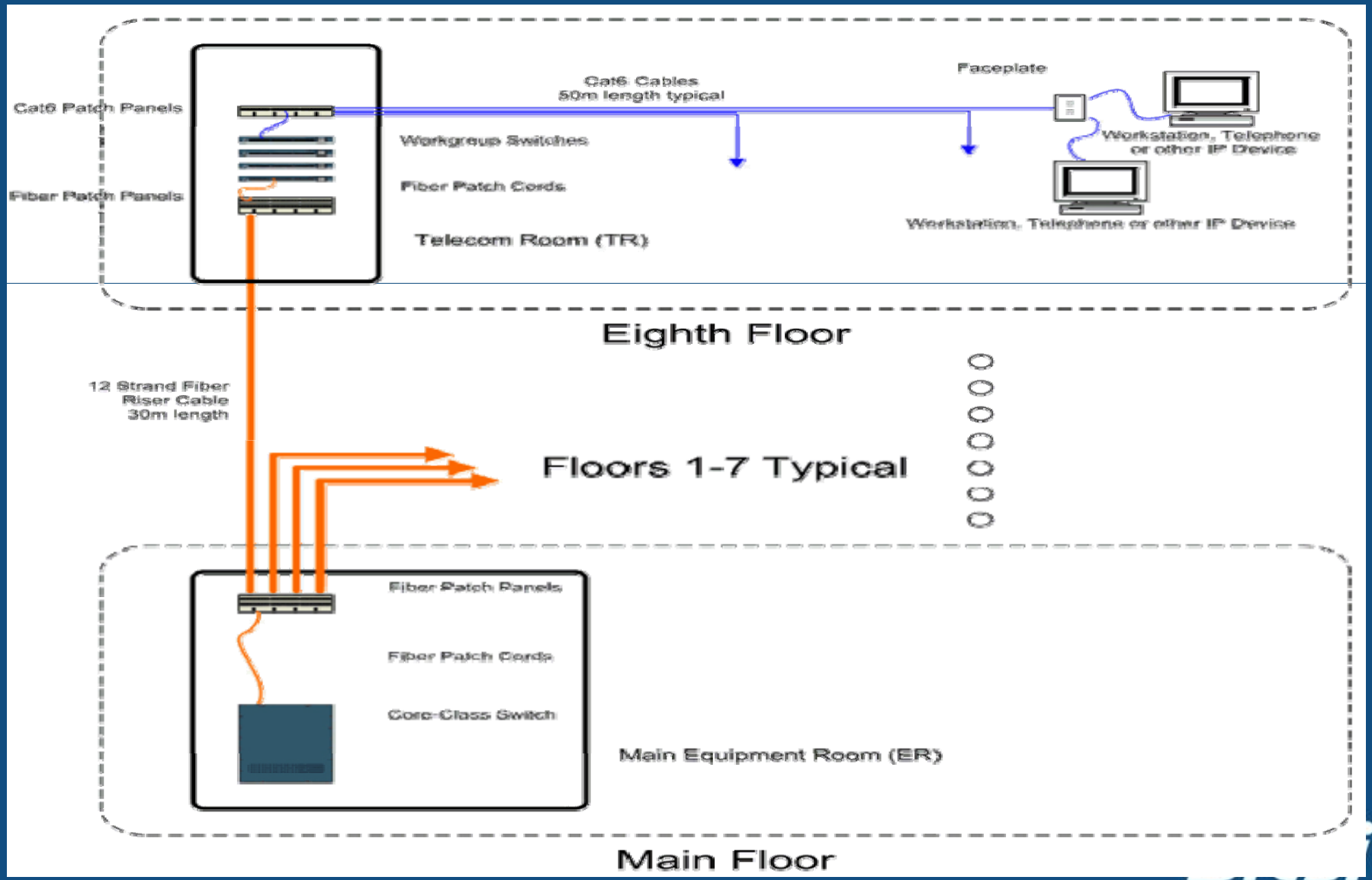
- 1991
  - TIA 568 standard ratified with Hierarchical Star Architecture
    - Optimized for copper performance characteristics & limitations
    - 100 meter horizontal cabling subsystem limit

Enterprise Networks

- Traditional Hierarchal Star
  - Main cross-connect in equipment room (ER)
  - Fiber backbones to remote Telecom-munications Rooms (TRs)
  - Floor space for the passive Horizontal Cross-Connect in the TR
  - Balanced twisted-pair in horizontal



Traditional Hierarchical Star Topology



Hierarchical Star Pros/Cons

- Pros:
  - Large number of users serviced by a single TR
  - Local patching and administration
  - POE capability via switch or midspan
  - Easy dedicated and back-up power to TR
  - Supports other topologies (i.e. bus, star, ring etc.)
  - Easier to secure equipment in a TR

Hierarchical Star Pros/Cons

- Cons:
  - Useful life – Comparatively short
  - Scalability - Adding TRs is time consuming & costly
  - Floor space – High cost
  - Outages in TRs affect more users
  - 24/7 Heating & Cooling Requirements
  - Potential for inefficient use of switch ports

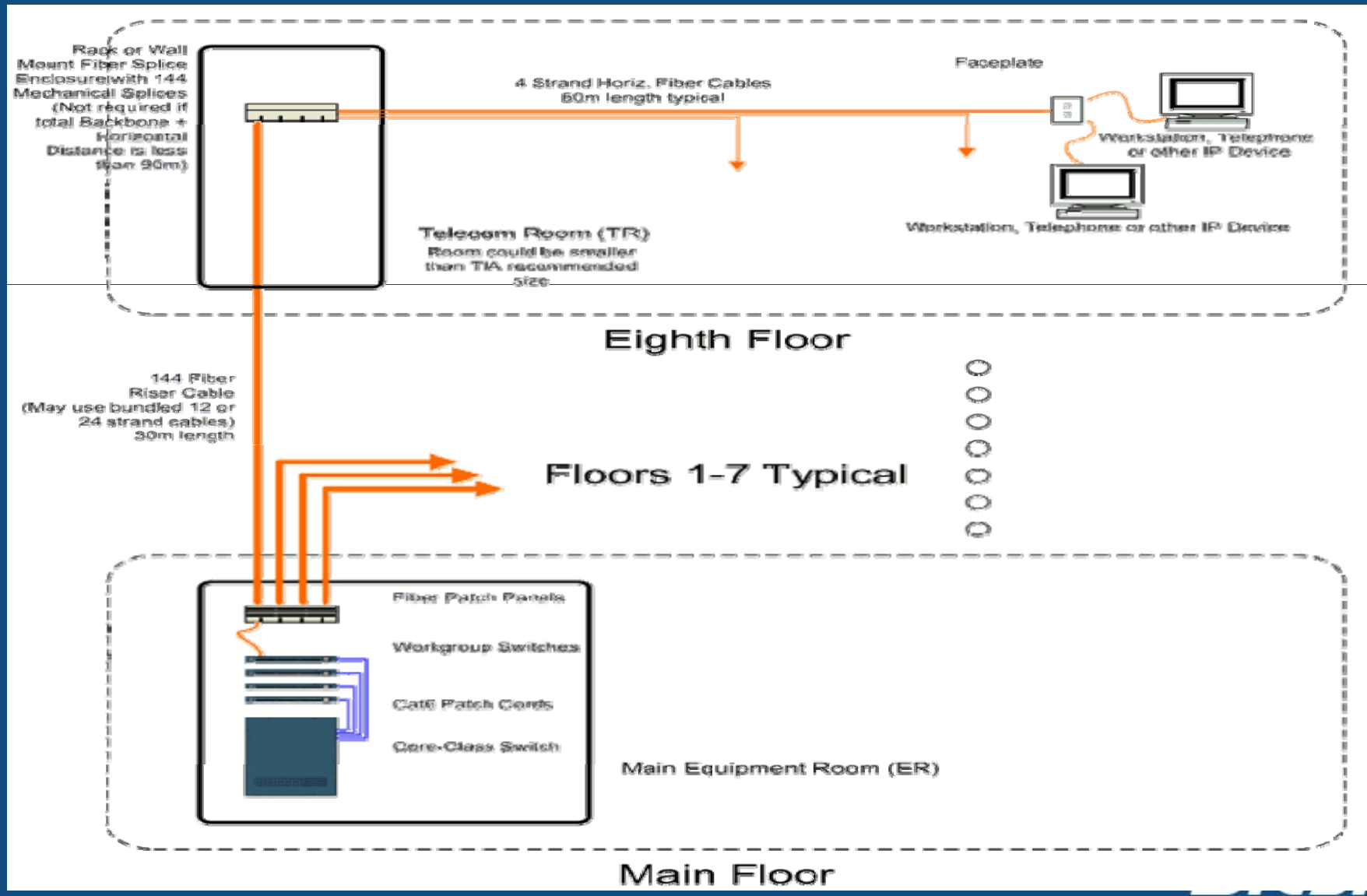
Structured Cabling System Architectures Evolve

- 1995
  - TSB-72 “Centralized Fiber Optic Guidelines”
- 2001
  - TIA 568-B.1 supports centralized cabling

Enterprise Networks

- Centralized Cabling
  - Main Cross-Connect in Equipment Room
  - Horizontal cables from ER end at work area
  - For fiber: TR only functions as passive optical interconnect/patch

Centralized Cabling



Centralized Fiber Cabling

- Pull-through from the ER to the WA
  - 90 meters or less
- Pass through a TR with interconnect or splice
  - Over 90m (fiber)
- All the electronics are within the ER
- Typically, 2-4 fiber cables are home-run to WA

Centralized Pros/Cons

- Pros:
  - Security - no switch gear outside of ER
  - Longer horizontal potential (>100m)
  - Minimal number of TRs required
  - Most efficient use of switch ports
  - Centralized power and back-up

Centralized Fiber Pros/Cons

- Cons:
  - Cost may be comparatively high (esp. FTTD)
    - Media converters vs. NICs
  - Scale - Infrastructure changes more difficult
  - Familiarity & Acceptance
  - Migrate to a converged network
  - Cable congestion in ER
  - POE not supported (fiber)

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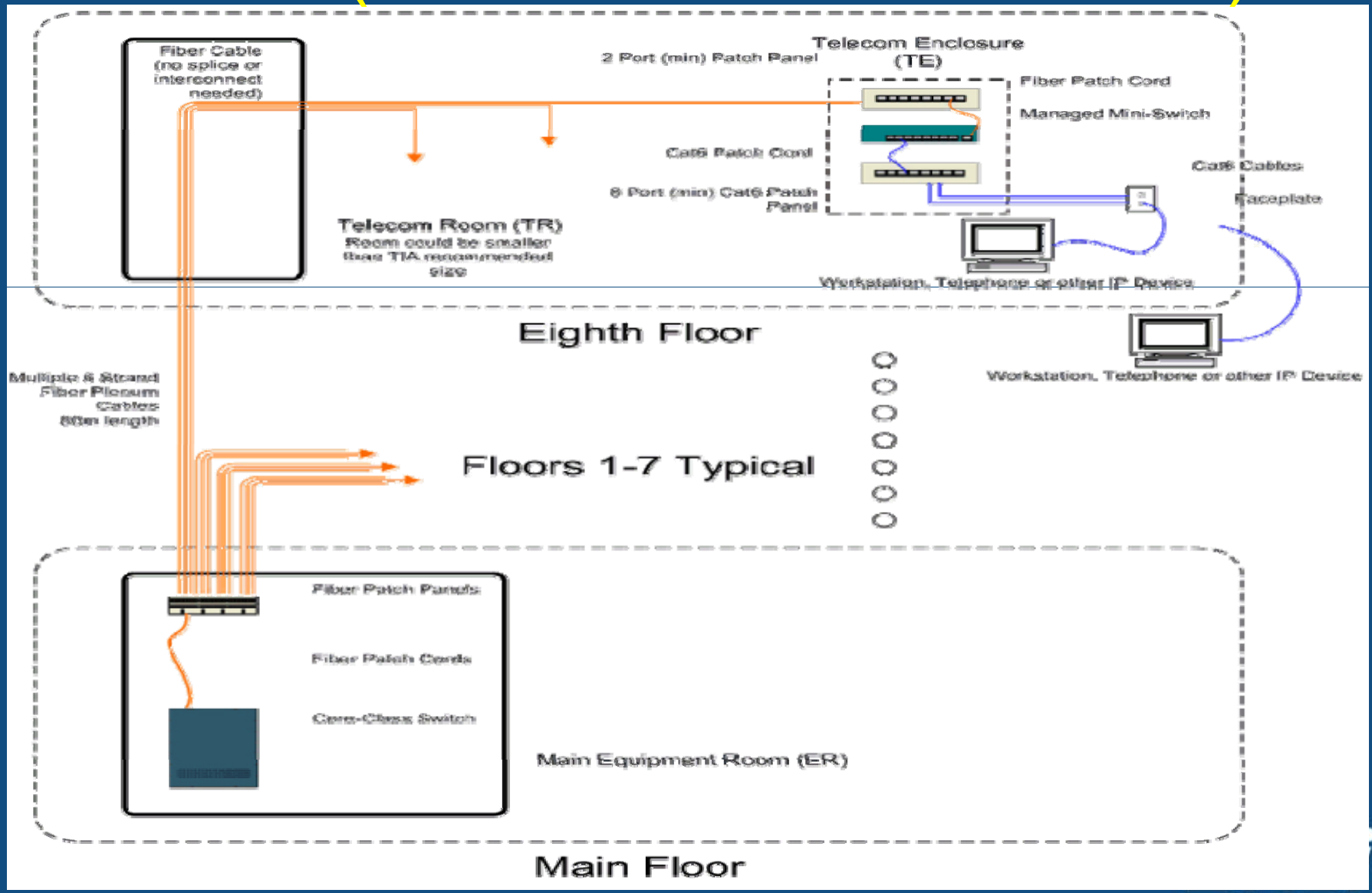
Structured Cabling System Architectures Evolve

- 2005: TIA 569-B & 568-B.1-5 supports “Telecom Enclosure” (TE)

Enterprise Networks

- Fiber To The Enclosure (FTTE)
  - Main cross-connect in ER
  - Fiber backbone through TR to remote TEs
  - Copper to WA

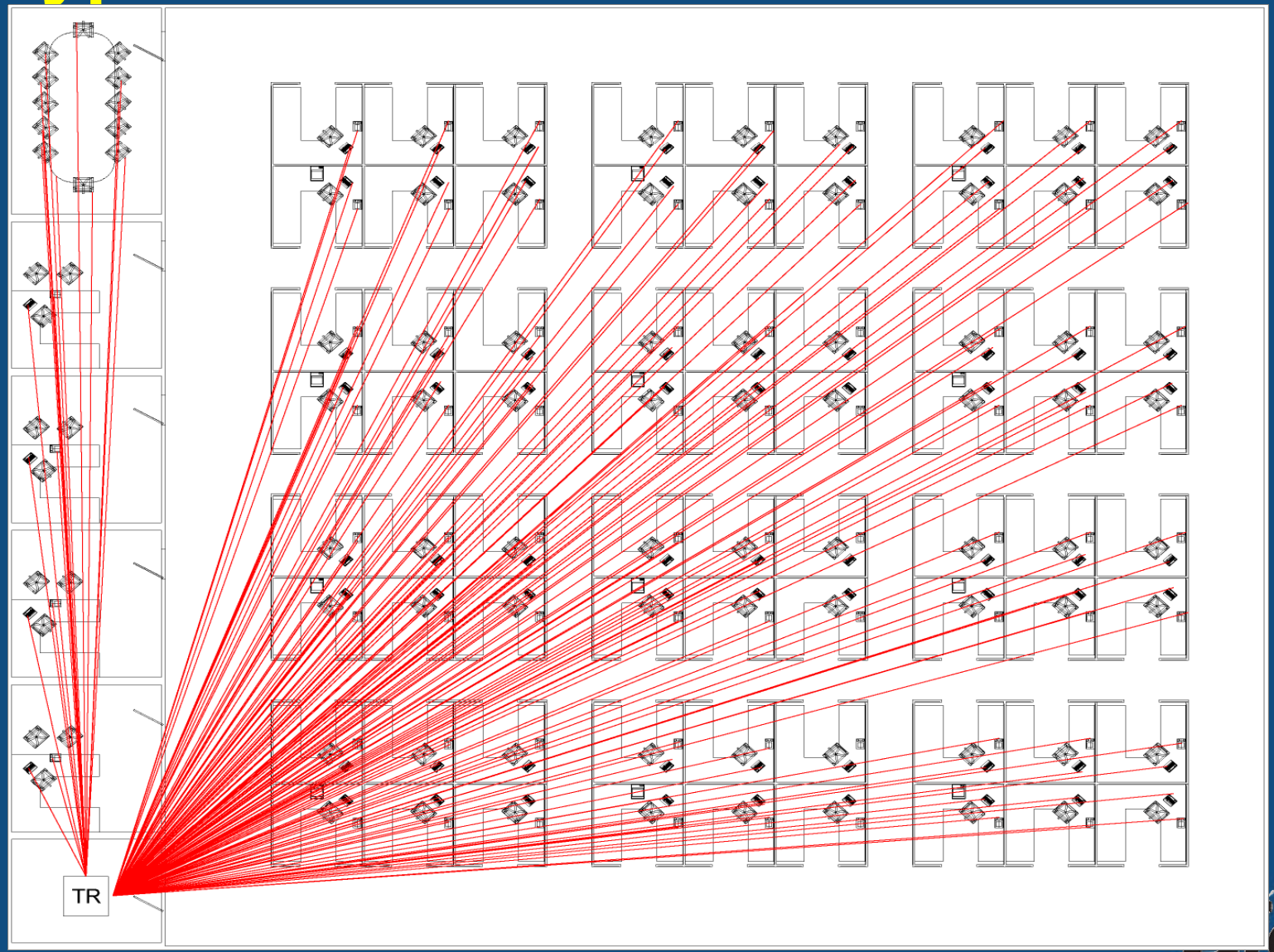
FTTE (Fiber To The Enclosure)



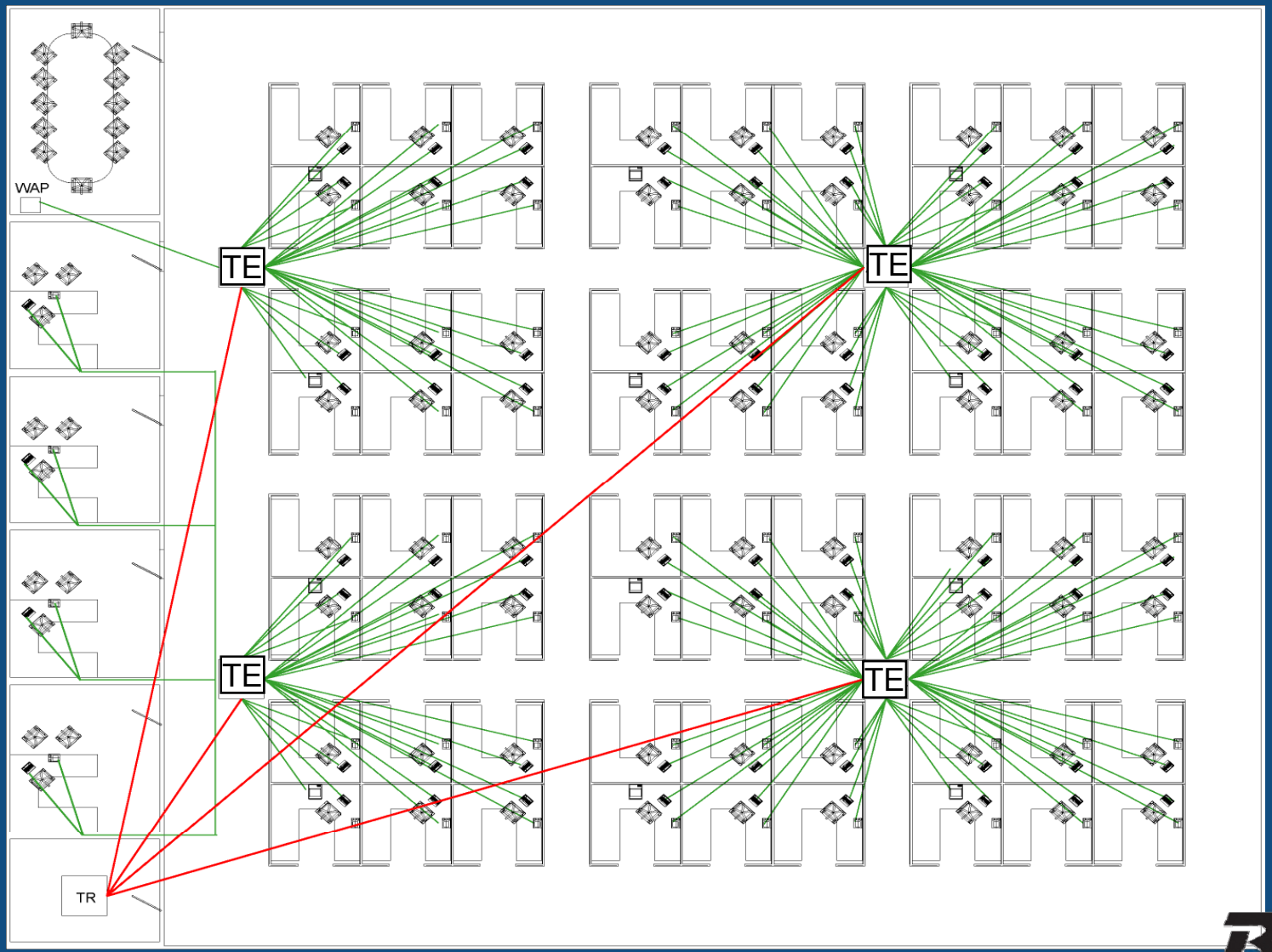
FTTE

- Allowed up to 300 meters to the TE
- Horizontal cross-connect in TE, not TR
- Still need a TR

Typical Hierarchical Star with UTP



Typical FTTE with Fiber and UTP



FTTE Pros/Cons

- Pros:
  - Quick deployment
  - Lowest cost
  - Easy integration of new technology (BAS, POE, wireless, etc.)
  - Scalable with minimal cost & disruption
  - Easy MACs
  - Reduce number of users affected by downtime
  - Extends backbone distance >100m
  - Fiber closer to the desk

FTTE Pros/Cons

- Cons:
  - Security of dispersed electronics
  - Heat dissipation near work areas
  - Noise levels near work areas
  - Limitations on users served per enclosure
  - Dedicated and backup power coverage
  - Management of dispersed electronics
  - Placement concerns (ceiling)

TIA FOLS Cost Model Summary

- FTTE can be the most cost effective
  - Especially if there are many TRs
  - Most savings come from construction and sustaining multiple TRs
- FTTD in certain situations (<34 ports per TR) has lower installed cost than H. Star
- Hierarchal Star remains more cost effective than FTTD in most scenarios
  - Mostly due to the cost of 100Base-FX switches

New Proposals

- Passive Optical Network (PON)
  - Fiber to the Home
- Passive Optical LAN (POL)
  - All simplex, single-mode fiber cabling
  - Point-to-multipoint
  - Splitters instead of patch panels

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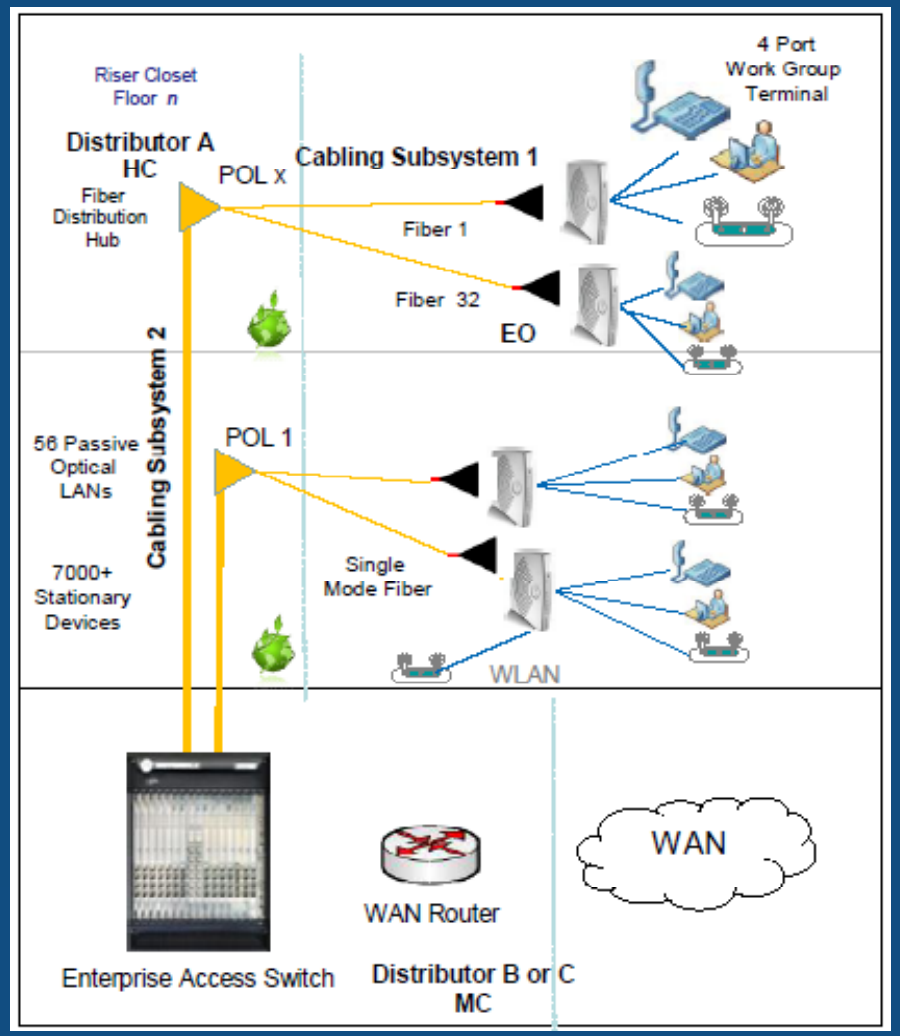
POL



- Central Switch
- Remote Optical Network Devices in WA

POL Pros/Cons

- Pros
  - Standards-based applications (IEEE and ITU)
  - Capability for supporting faster data rate PON applications
  - Single-mode optical fiber is a very high bandwidth media, with a low total cost of ownership, long service life and a lower per-meter cost less than multimode fiber
  - Single-mode fiber has greatest distance capability
  - One single single-mode fiber is used for upstream and downstream
  - Passive optical splitters costs less than patch panels and telecommunications spaces (rooms, square footage)
  - A single, central switch
  - Very similar to the FTTH networks

POL Pros/Cons

- Cons
  - Shared bandwidth
  - Broadcast technology - security concerns
  - Single-mode connectivity more expensive
  - Simplex point-to-multipoint cabling infrastructure is not TIA compliant
  - No projects to develop a 10G or higher PON
  - The single central switch is comparatively expensive
  - Network terminal devices need local power supply & backup
  - The Power Over Ethernet and Power Over Ethernet Plus applications not supported by the POL

Other Topics

- Types of Single-mode Fiber
- Bend-insensitive Fiber

Types of Single-mode Fiber

- Standard Single-mode
  - Dispersion Unshifted Single-mode Fiber
  - Commonly deployed in LAN backbones
- Low Water Peak Single-mode
  - Dispersion Unshifted Single-mode Fiber
  - Lower attenuation in 1383nm window
- Non-zero Dispersion-shifted Single-mode
  - Optimized for operation in 1550nm window

Bend Insensitive Fiber

- Multimode and Single-mode
- Attenuation is less sensitive to tight bends and bending stress
- Able to withstand “poor” installation
  - Still pass the attenuation limits
- May “hide” minimum bend radius violations

Summary

Summary

- Options for the 40G/100G applications
  - Duplex Single-mode
    - Cost and density
  - Parallel (MPO) Multimode
    - OM3 or OM4 – pick based on distance
  - Polarity
    - Tx to Rx
- Is 62.5/125µm dead?
  - No, but not a 40G/100G media

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Summary

- Telecommunications Enclosures
  - Supplements TRs
  - Not recommended, but allowed
  - Can be cost-effective
- PONs and POLs
  - Simplex, single-mode, passive infrastructure
  - Not currently cabling standards compliant

Summary

- No option is perfect for every environment so consider all factors and choose based on individual requirements
- FOLS Cost Model is a good resource for evaluating options
  - www.fols.org for cost model and questions