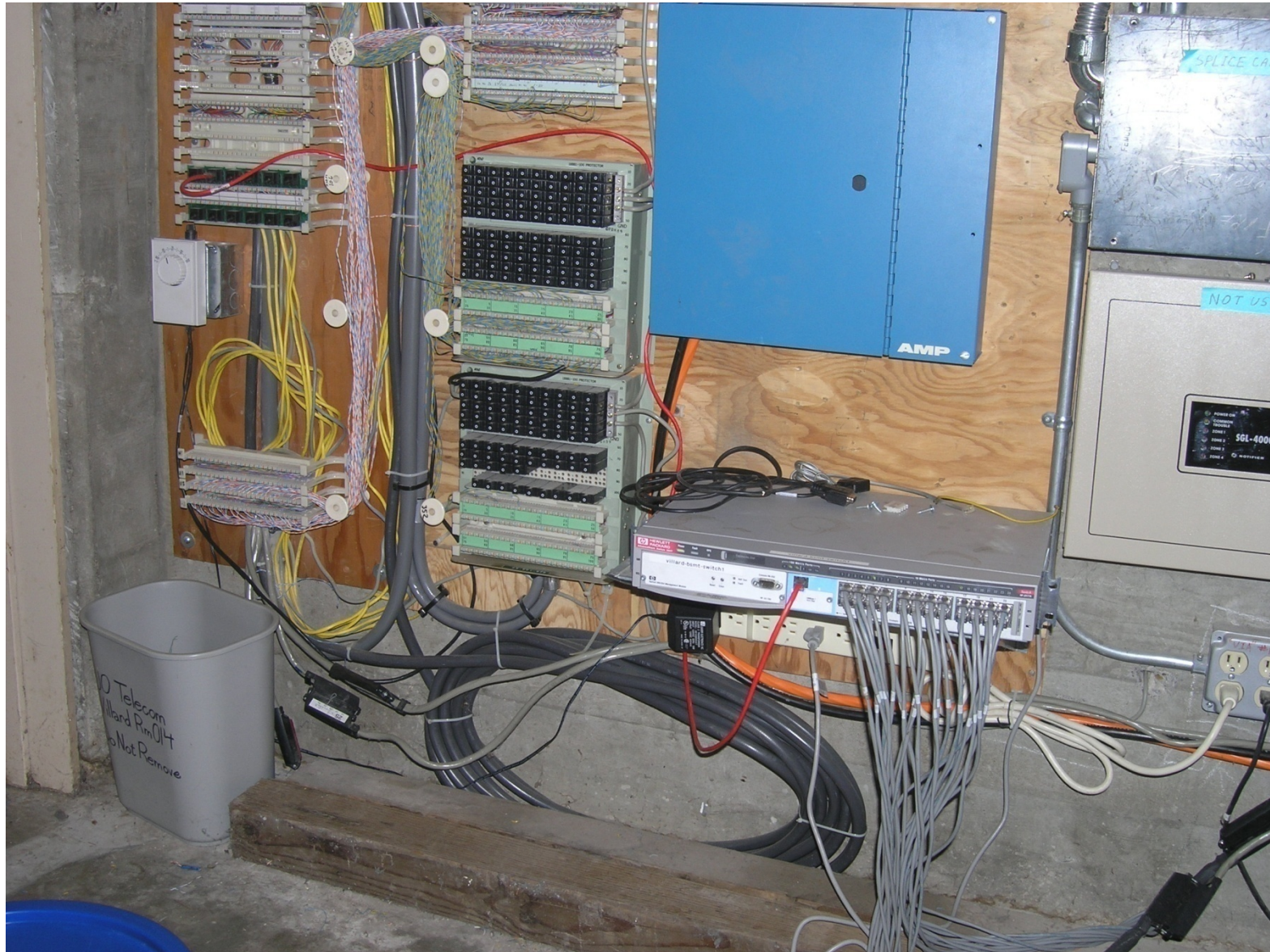


Campus Network Best Practices: Structured Cabling

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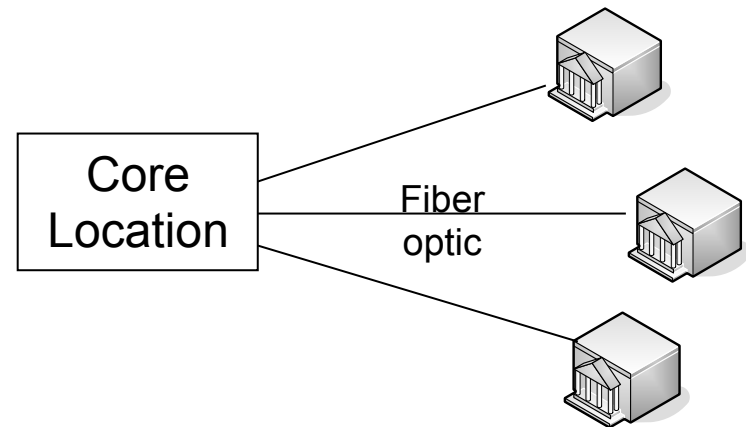
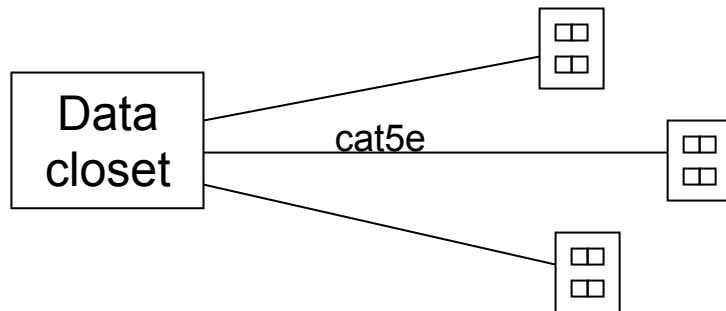
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We all have some ugly wiring



Structured Cabling Systems

- Only two types of cabling:
 - Unshielded twisted pair copper – provides service to individual computers and between network closets
 - Fiber optic cabling – provides service to buildings and between network closets
- Everything is run in a star configuration



Unshielded Twisted Pair Cable

- Run in star configuration from Network Closet location to individual outlets in offices or labs.
- Run at least two cables to every outlet – I recommend four if you can afford it.
- Run at least 12 cables between network closets if the distance is less than 90 meters
- Question: what type of cable to run? Cat5, cat5e, Cat6, ???

What type of UTP

- What speed does each type support?

Cable Type	Max Speed	Max Distance	Cost Factor
Category 5	100Mbps	100m	1x
Category 5e	1000Mbps	100m	1x
Category 6	1000Mbps	100m	1.5x
Category 6	10,000Mbps	57m	1.5x
Category 6a	10,000Mbps	100m	3x

- Strongly recommend category 5e cabling.

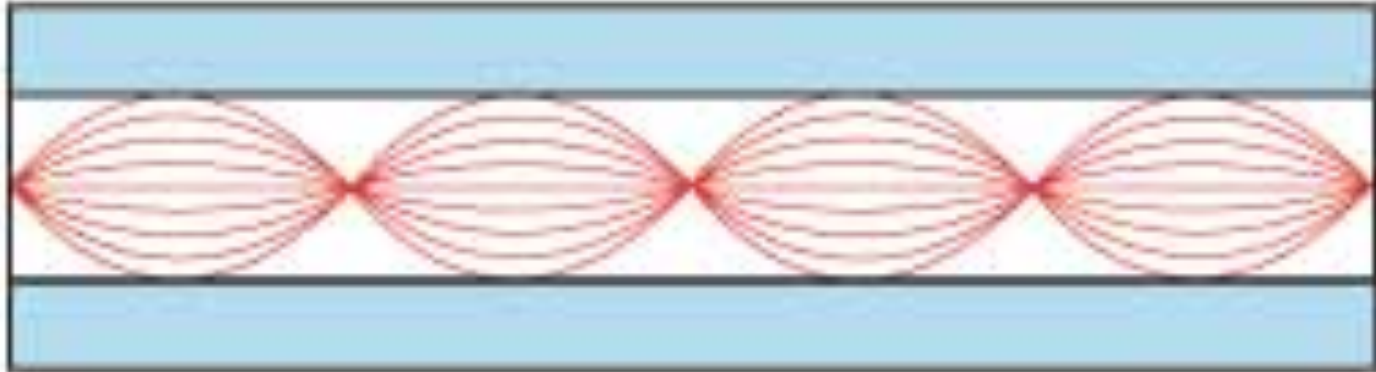
Unshielded Twisted Pair Cable

- Always terminate in Jack Panel
- Labeling is a key to reduce work later



Fiber Optic Cabling

- Two basic types of fiber
 - Multi Mode



- Single Mode



Multi Mode Fiber

- Two basic types:
 - 62.5 micron core. Legacy, older style
 - 50 micron core. Newer
- A number of standards to be aware
 - G.651 – 50 micron
 - OSI/IEC 11801 OM1 – 62.5
 - OSI/IEC 11801 OM2 – 50 micron
 - OSI/IEC 11801 OM3 – 50 micron laser optimized
 - OSI/IEC 11801 OM4 – 50 micron higher bw

Single Mode Fiber

- All have core between 8 and 10 micron
- Standard types:
 - ITU G.652 (A, B, C, D) – This is what you want
 - ITU G.653 – 1310/1550 with EDFA amps
 - ITU G.654 – 1550 only
 - ITU G.655 – 1550/1625 for long haul DWDM
 - ITU G.656 – 1460/1625 for long haul DWDM
- Key point: there are different types. Pay attention to what you buy (G.652.D)

Types of Optical Interfaces

Standard	Speed	Fiber Type	Cost
100baseFX	100Mbps	MM	\$250
1000baseSX	1Gbs	MM	\$500
1000baseLX/LH	1Gbs	MM or SM	\$1000
10GbaseSR	10Gbs	MM	\$1500
10GbaseLRM	10Gbs	MM	\$1300
10GbaseLR	10Gbs	SM	\$4000
10GbaseER	10Gbs	SM	\$10000

Distance Supported by Optics

- Here is what is guaranteed on the various types of fiber:

Standard	OM1	OM2	OM3	OM4	G.652.D
100baseFX	2km	2km	2km	2km	No
1000baseSX	275m	550m	1km	1.1km	No
1000baseLX/LH	500m	500m	?	?	10km
10GbaseSR	33m	82m	300m	550m	No
10GbaseLRM	220m	220m	220m	?	No
10GbaseLR	No	No	No	No	10km
10GbaseER	No	No	No	No	40km

Unfortunately, Not Simple

- Various types of fiber make this confusing
- Different equipment vendors claim different numbers
- From Cisco web site:

“On average, customers will experience much longer transmission reaches than reported in the IEEE specifications, given better than worst-case optics and better than worst-case multimode fiber characteristics. “

Fiber Price Comparison

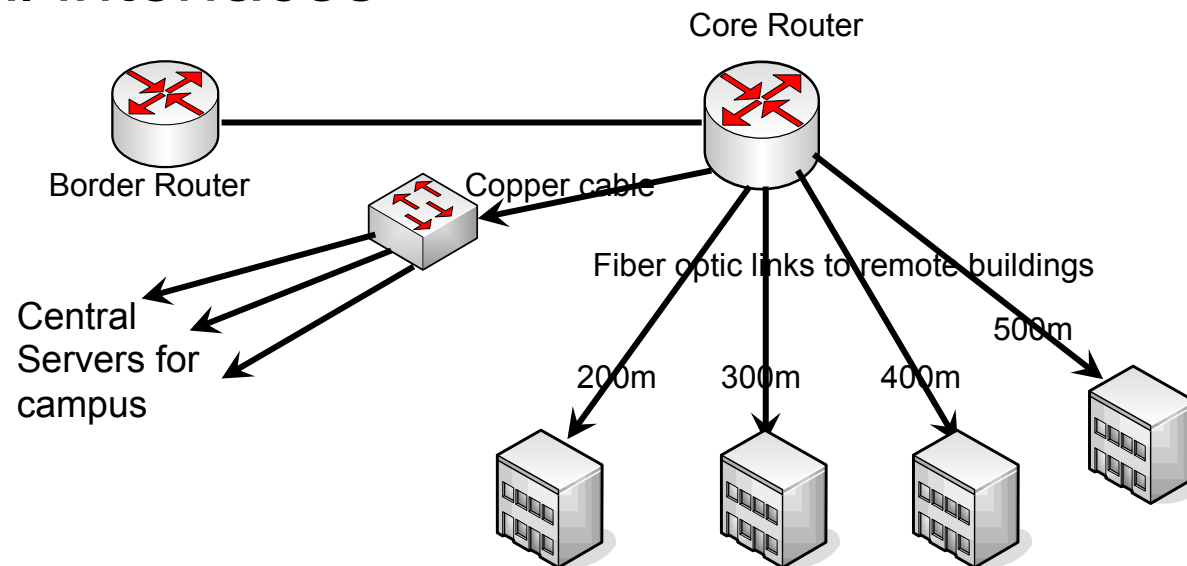
- Single mode fiber cabling is cheaper
- Multi mode optical interfaces are cheaper
- What makes sense for your campus?

Fiber Type	Cost per km	Cost 1Gbs	Cost 10Gbs
OM1 (62.5 legacy)	\$4,884	\$500/1000	\$1300/\$1500
OM2 (50 legacy)	\$4,054	\$500/1000	\$1300/\$1500
OM3 (50 laser optimized)	\$10,151	\$500/1000	\$1300/\$1500
OM4 (new std)	\$19,959	\$500/1000	\$1300/\$1500
G.652.D (single mode)	\$1,185	\$1000	\$4000

Pricing based on 12-fiber outdoor cable, Corning 012TU4-T41xxD20

Simple Fiber Pricing Example

- Consider the simple network below
 - Total fiber length 1400m
 - 8 optical interfaces



Pricing Example – 1Gig Links

- Use cheapest optical interface possible, but note that cheap interface is distance limited based on fiber type

Fiber Type	Fiber Cost	Optics	Optics Cost	Total Cost
OM1	\$6,837	2x1000baseSX 6x1000baseLX	\$7,000	\$13,837
OM2	\$5,675	8x1000baseSX	\$4,000	\$9,675
OM3	\$14,211	8x1000baseSX	\$4,000	\$18,211
OM4	\$27,942	8x1000baseSX	\$4,000	\$31,942
G.652.D	\$1,659	8x1000baseLX	\$8,000	\$9,659

Pricing Example – 10Gig Links

- Note that some fiber types won't support 10Gig over the required distances

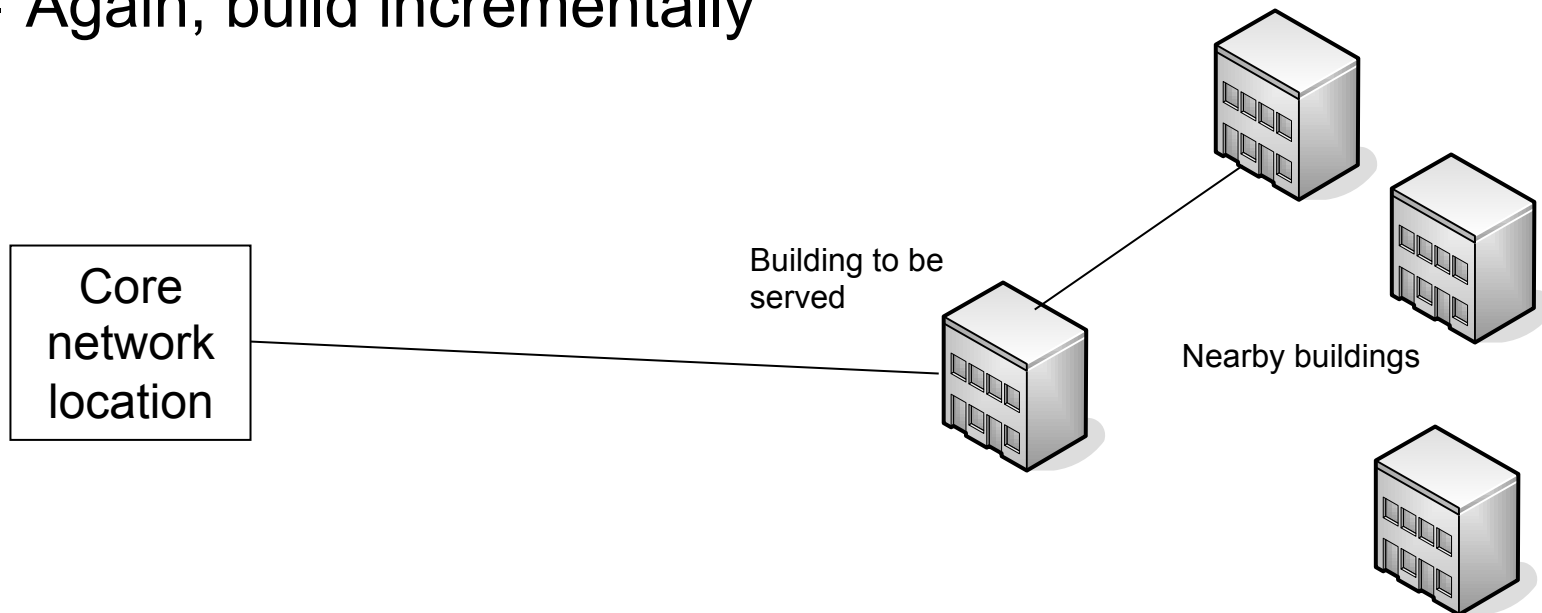
Fiber Type	Fiber Cost	Optics	Optics Cost	Total Cost
OM1	\$6,837	Not supported		No
OM2	\$5,675	Not supported		No
OM3	\$14,211	Not supported		No
OM4	\$27,942	8x10GbaseSR	\$10,400	\$38,342
G.652.D	\$1,659	8x10GbaseLR	\$32,000	\$33,659

Fiber Optic Recommendations

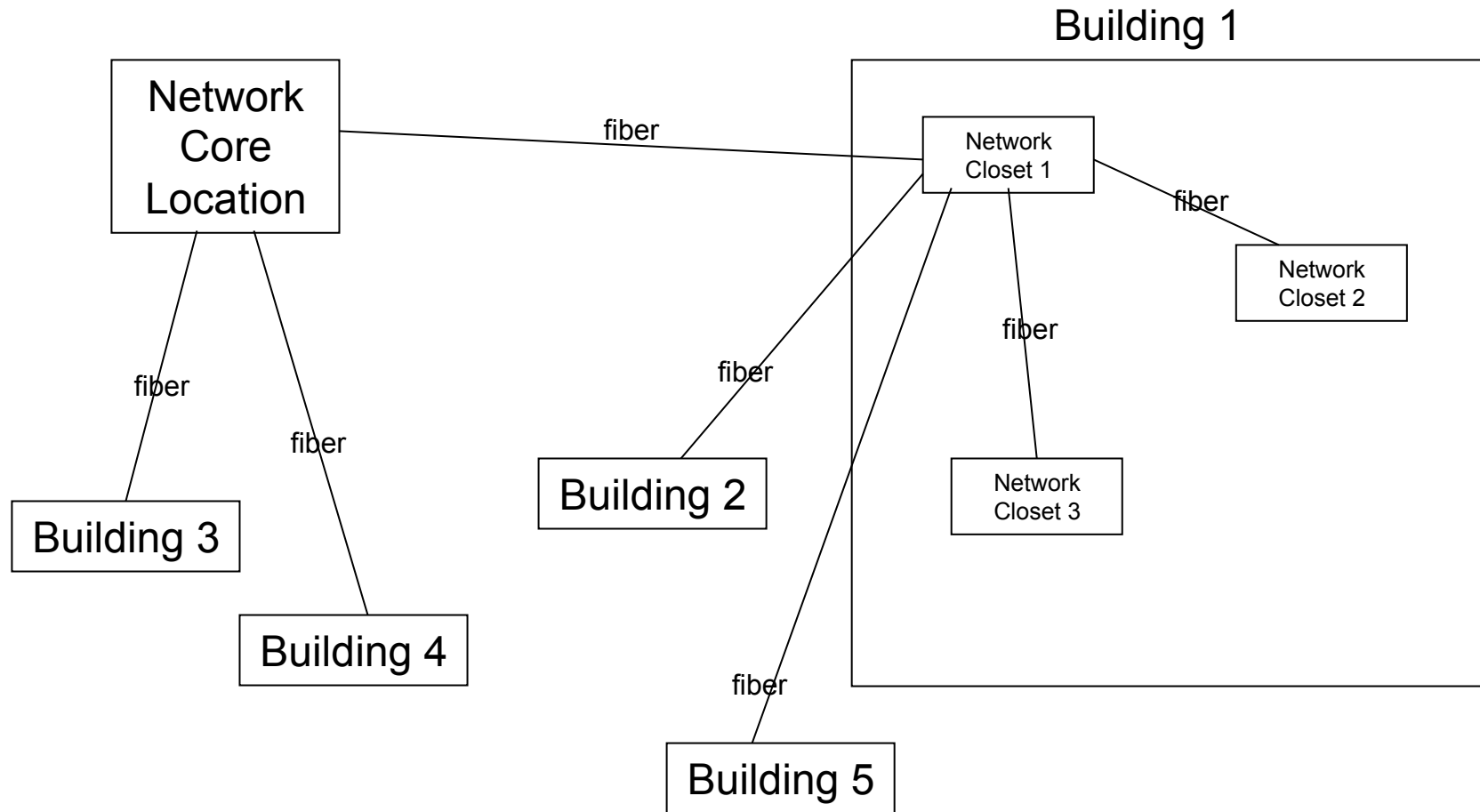
- Only install Multi Mode OM2 if distances are short, don't do OM1, OM3 or OM4 anywhere
- Install Single mode everywhere
- Run in star configuration from core network location to individual buildings
- Run in star configuration inside of buildings from main network closet to other closets
- To reduce costs, can run large fiber cable from core to some remote location, then smaller cables from there to surrounding buildings

Star Configuration

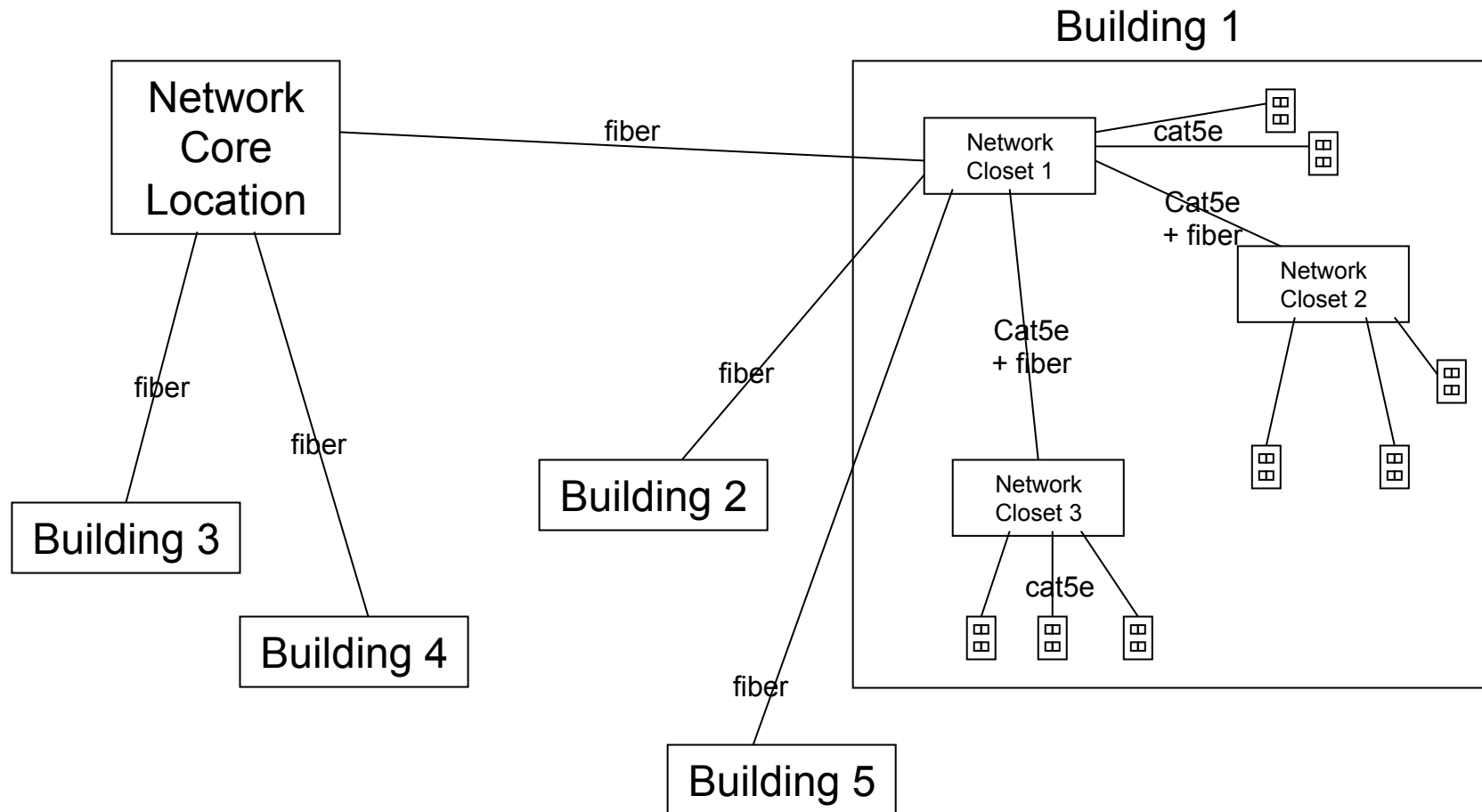
- Plan for future -- Install enough fiber
 - Minimum 6 single mode from core to each building
 - Minimum: 6 multimode plus 6 single mode from building entrance network closet to every other network closet in the building.
 - Again, build incrementally



Fiber Optic Topology



Putting it all Together



Outside Plant Construction

- Use outdoor cable between building
 - Armored Loose tube (to protect against rodents)
 - Un-armored loose tube in conduit if rodents not an issue
 - Indoor/Outdoor tight buffer if possible
- Use indoor cabling inside buildings
 - tight buffer
- Standardize Connectors
 - Multi mode: ST or SC (epoxy or hot melt)
 - Single mode: SC or LC (fusion Splice factory UPC pigtail - Can hand polish for short runs <2 km)

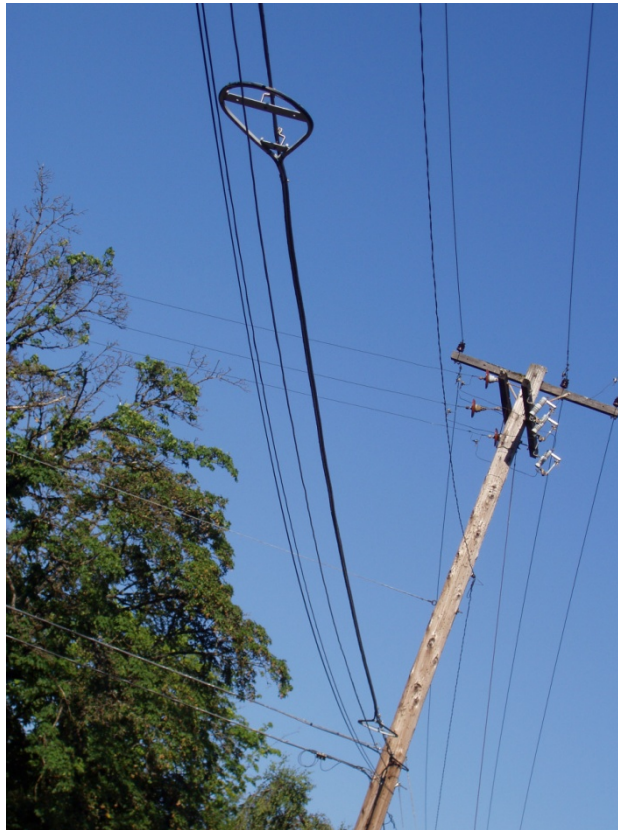
Fiber Optic Cable Construction

- Fiber has bend radius issues
- Keep bends $\geq 10\times$ cable diameter



Fiber Optic Cable Construction

- Leave slack loops, usually 10m per location



Small Vault Slack Loop



Closet Slack Loops



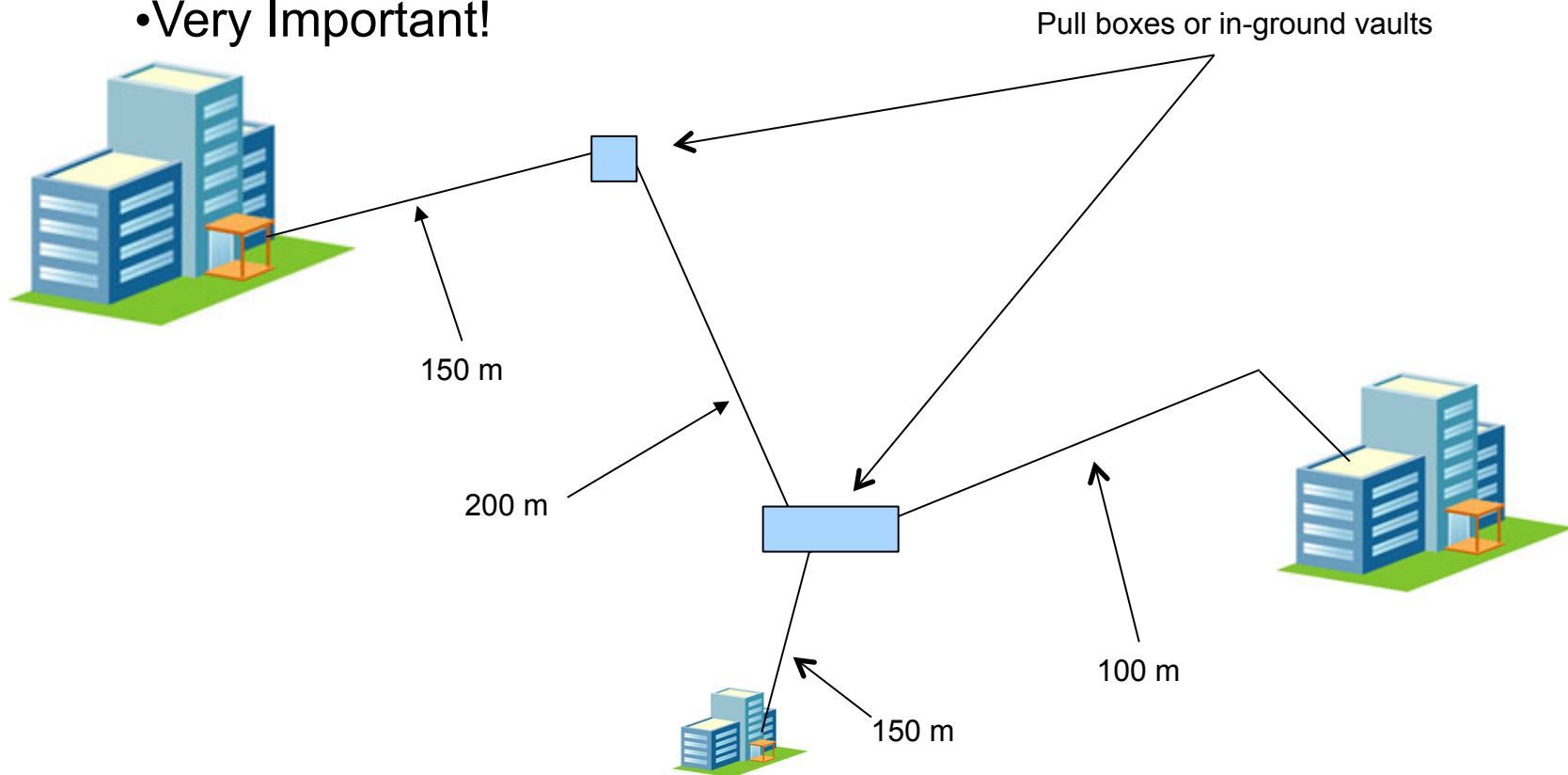
Conduit Construction

- Sizing Conduit Pathway
 - Bigger is better, allows installation of more than one cable package per conduit
 - Install additional runs of pathway (100% more than you need today)
 - Plan for the future, think of strand count
 - Install a pull-rope with the fiber
- Label conduits if possible
- Identifying Fiber
 - Label at each end, strand count, type and destination
 - Label slack loops, Where from? Where to?

Conduit Construction Hints

- For cable installed in underground conduit:
 - No more than 200m between pull points
 - Reduce distance by 50m for every 90 degrees of bend
 - Do not exceed 270 degrees
 - Survey the site and do the arithmetic

•Very Important!



Instructions to Contractors

- Please refer to NSRC web site for this workshop to retrieve document that gives complete instructions to contractors for
 - Category 5e cabling
 - Fiber optic cabling
 - Installation of underground conduit and vaults
- Download and edit this document to meet your needs.

Questions?

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