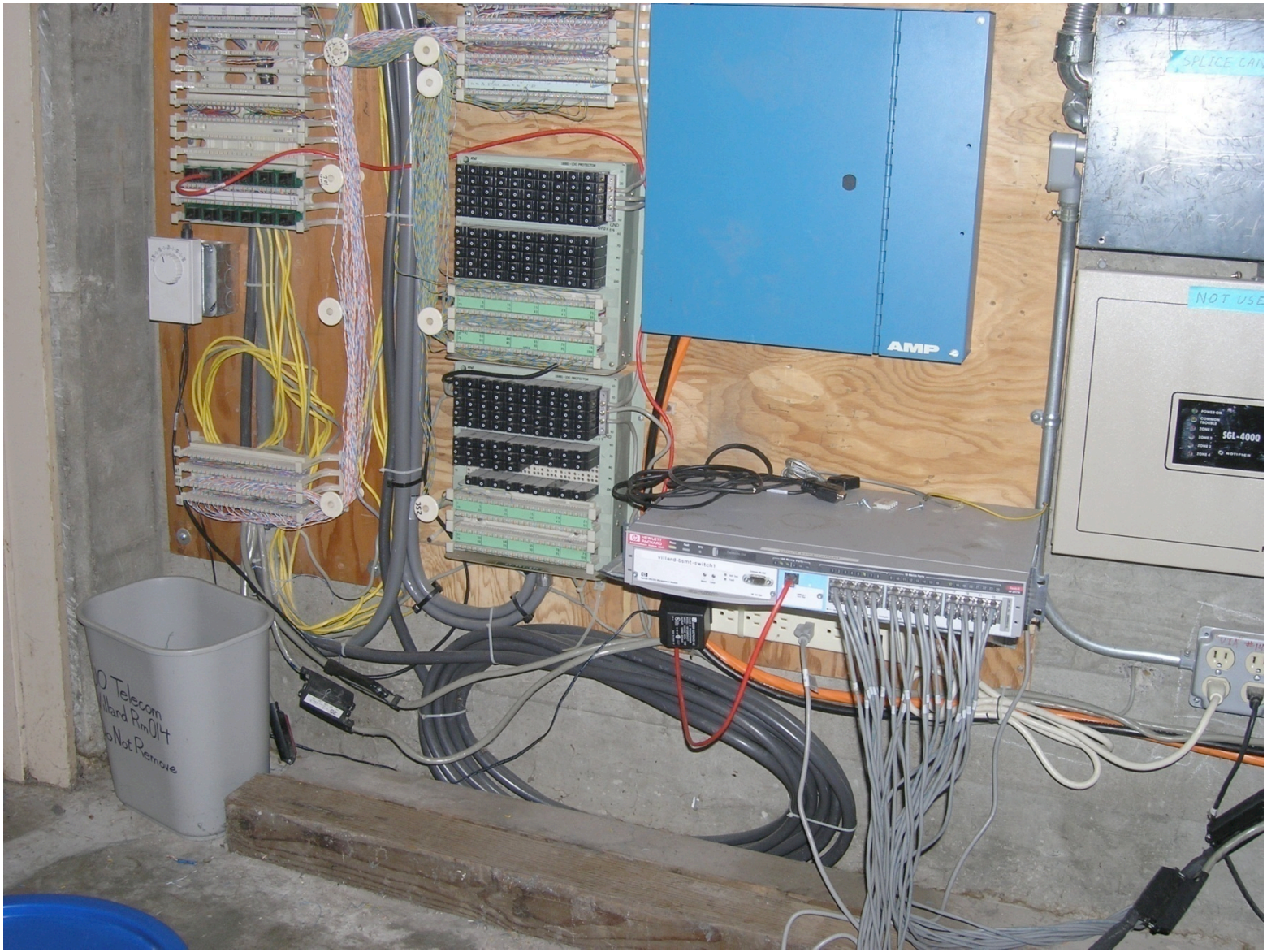
Campus Network Best Practices: Structured Cabling

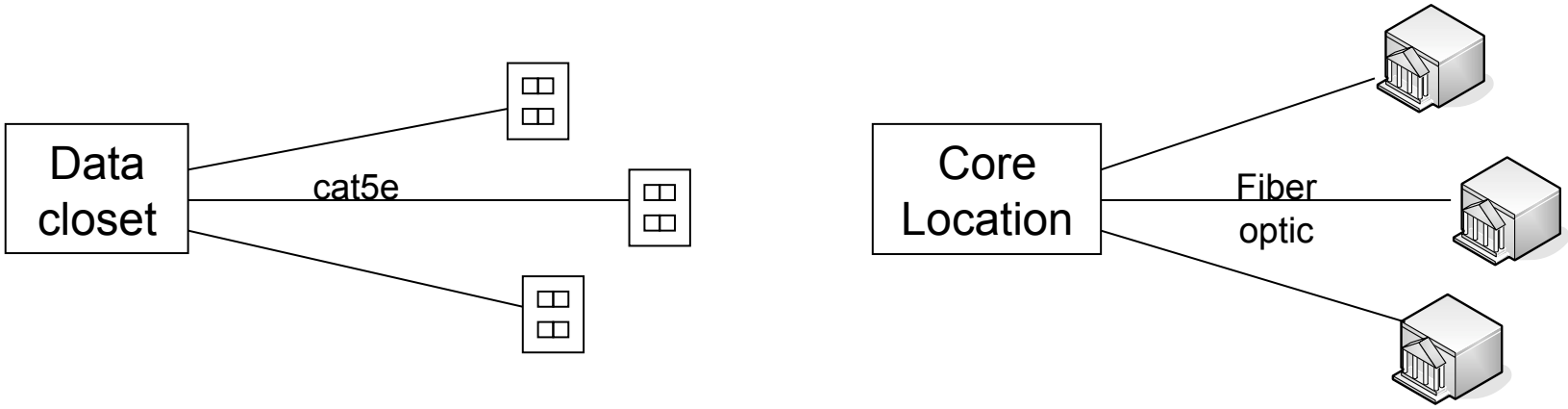
Dale Smith
Network Startup Resource Center
dsmith@nsrc.org

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

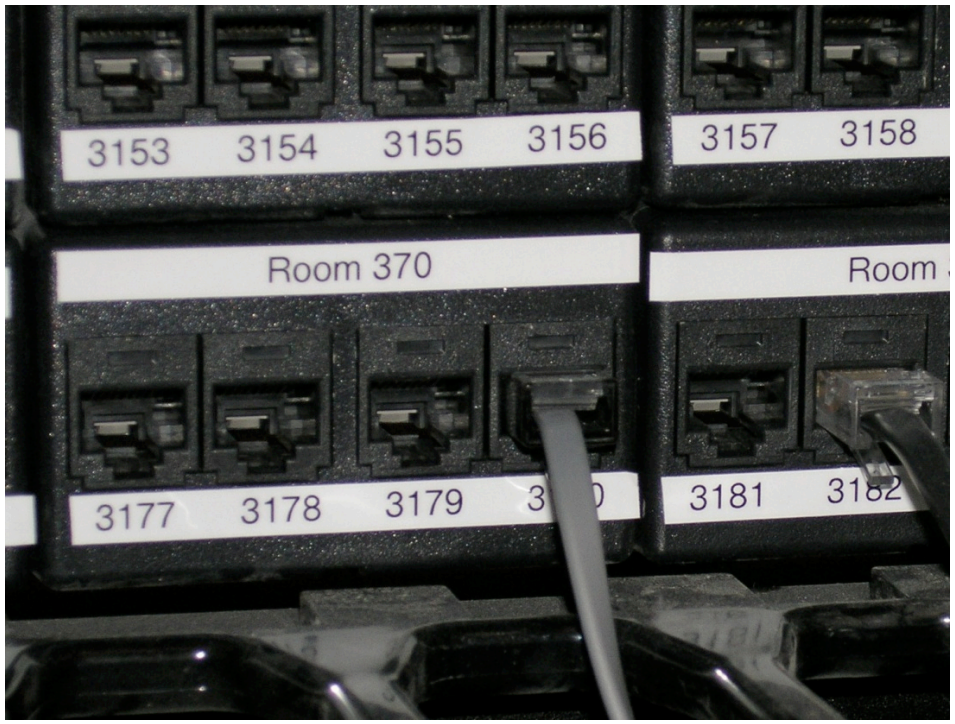
- What speed does each type support?

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

- Strongly recommend category 5e cabling.

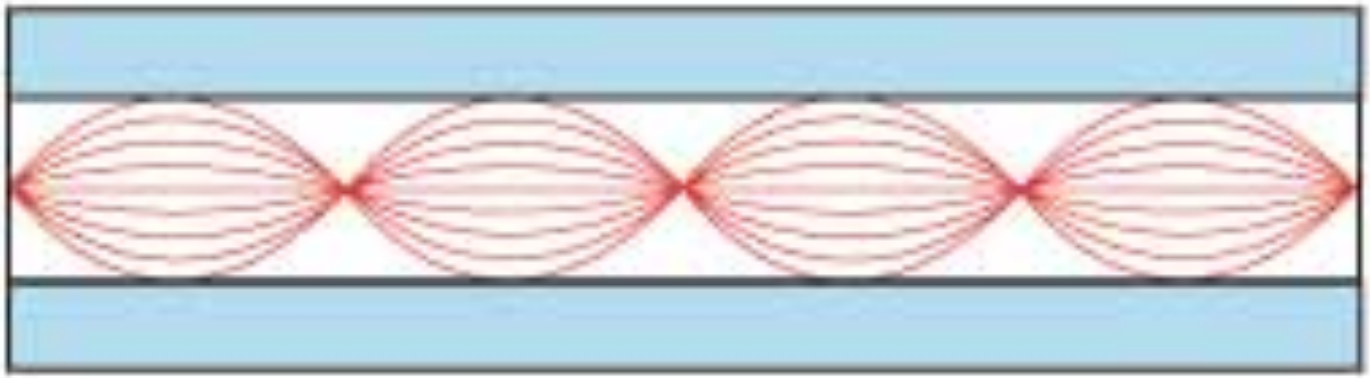
Unshielded Twisted Pair Cable

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

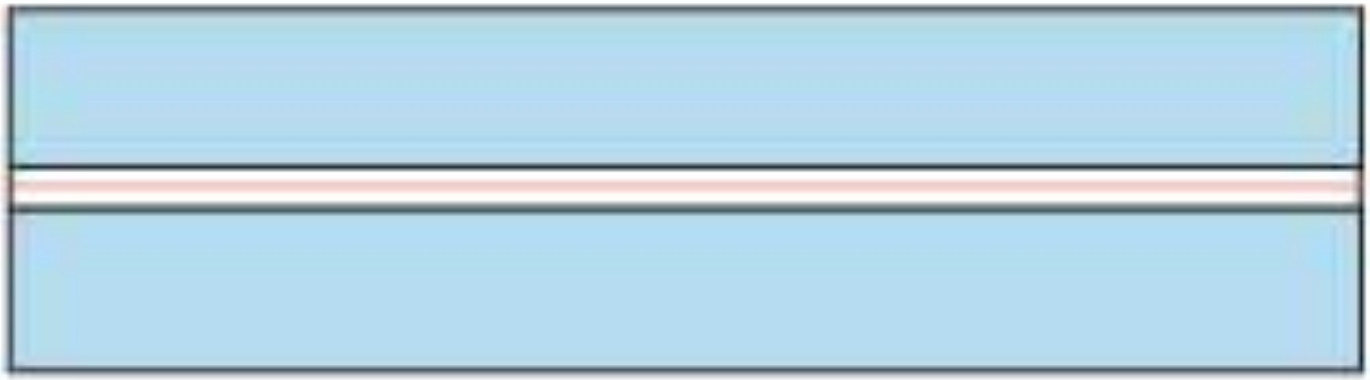


Fiber Optic Cabling

- 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	100Mbs	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

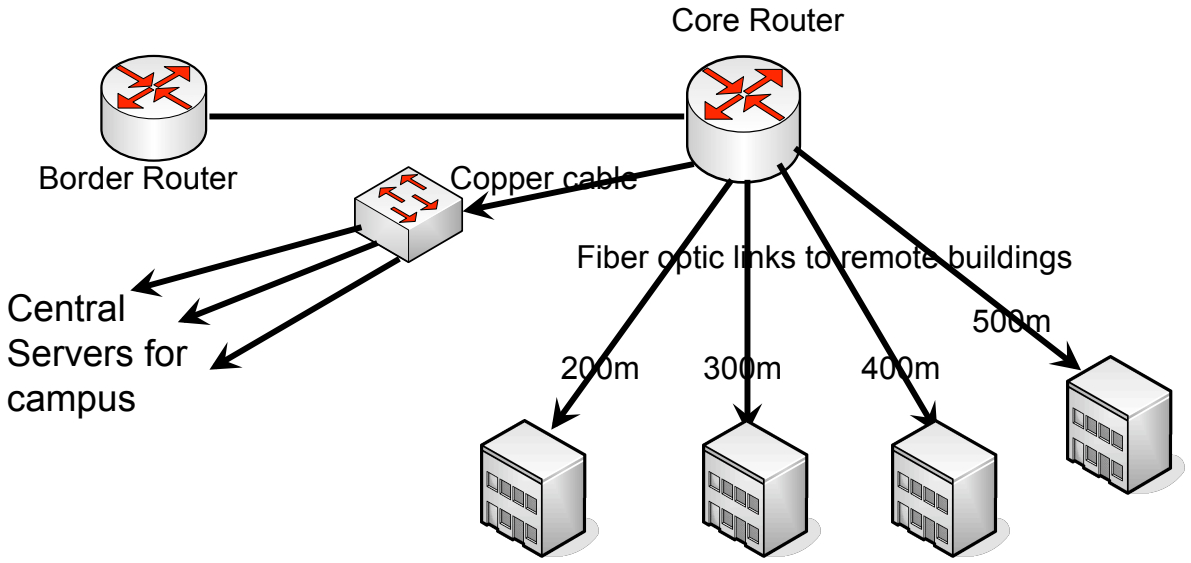
- Single mode fiber cabling is cheaper
- Multi mode optical interfaces are cheaper
- What makes sense for your campus?

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

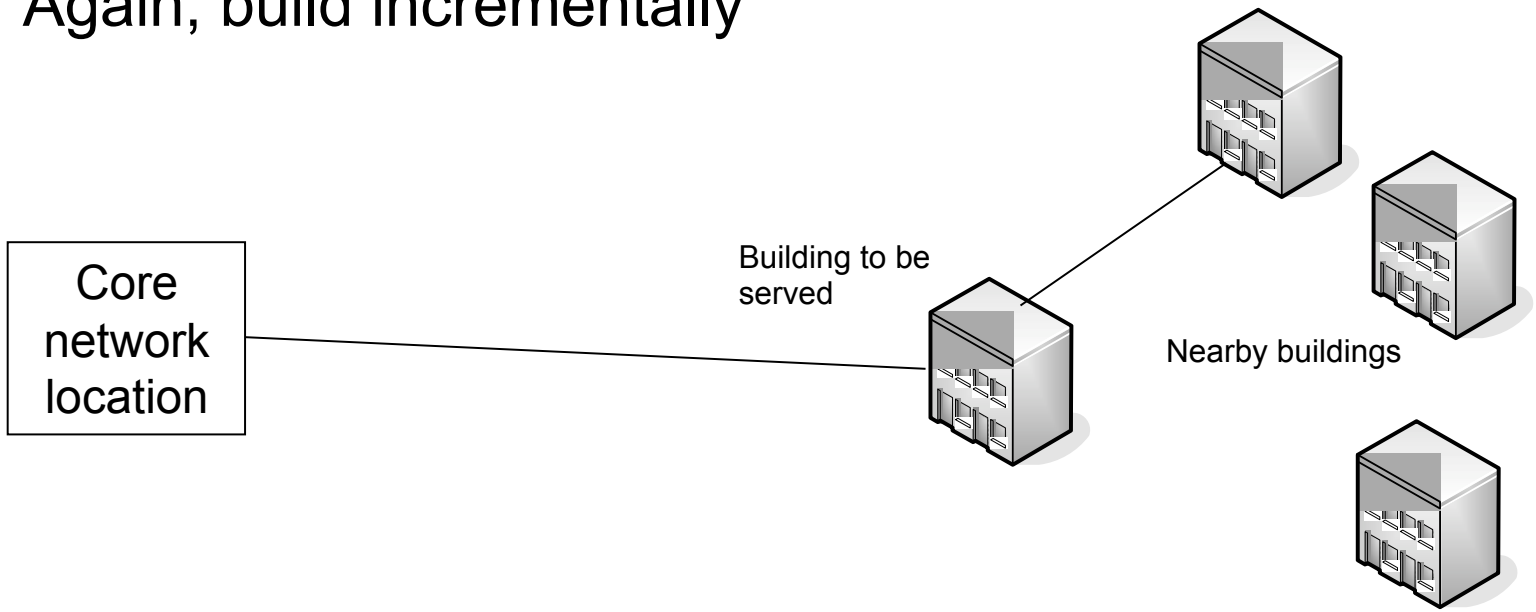
Fiber Type	Fiber Cost	Optics	Optics Cost	Total Cost
OM1	$6,837	Not supported		No
OM2	$5,675	Not supported		No
OM3	$14,211	Not supported		No
OM4	$27,942	8x10GbaseSR	$10,400	$38,342
G.652.D	$1,659	8x10GbaseLR	$32,000	$33,659

Fiber Optic Recommendations

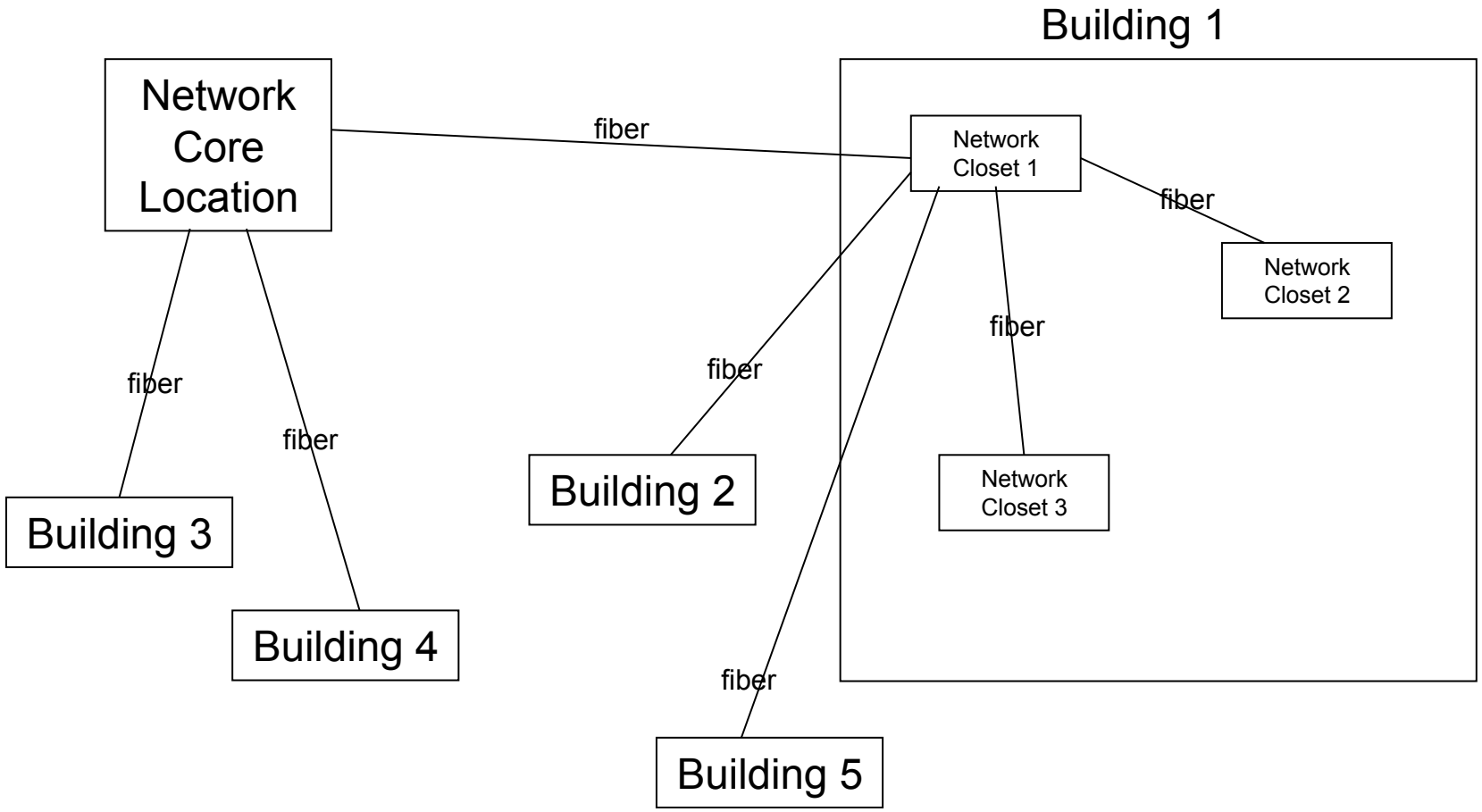
- Only install Multi Mode OM2 if distances are short, don’t do OM1, OM3 or OM4 anywhere
- Install Single mode everywhere
- Run in star configuration from core network location to individual buildings
- Run in star configuration inside of buildings from main network closet to other closets
- To reduce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

Star Configuration

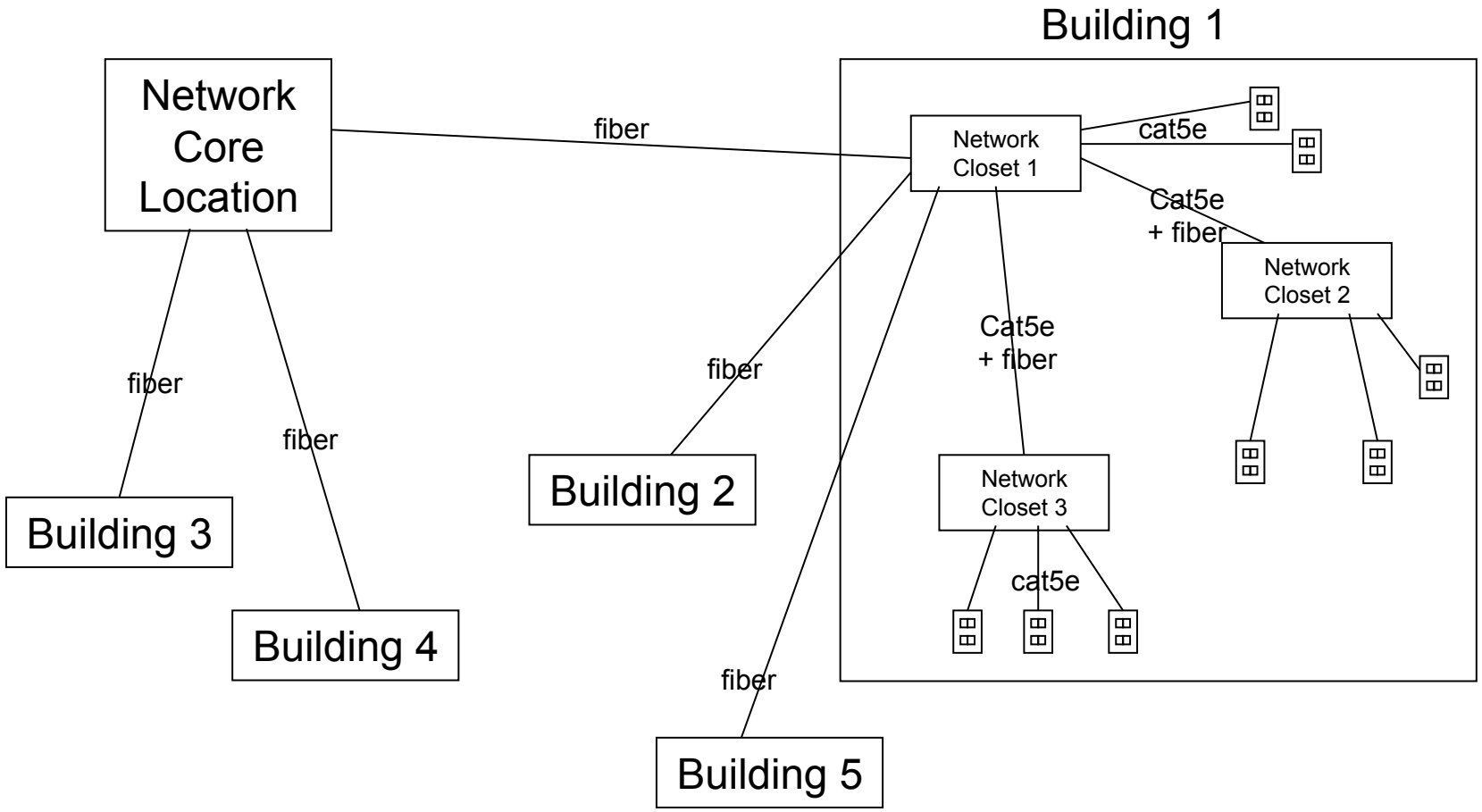
- Plan for future -- Install enough fiber
  - Minimum 6 single mode from core to each building
  - Minimum: 6 multimode plus 6 single mode from building entrance network closet to every other network closet in the building.
  - Again, build incrementally



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 $\geq$ 10x cable diameter

Fiber Optic Cable Construction

- Leave slack loops, usually 10m per location

Small Vault Slack Loop

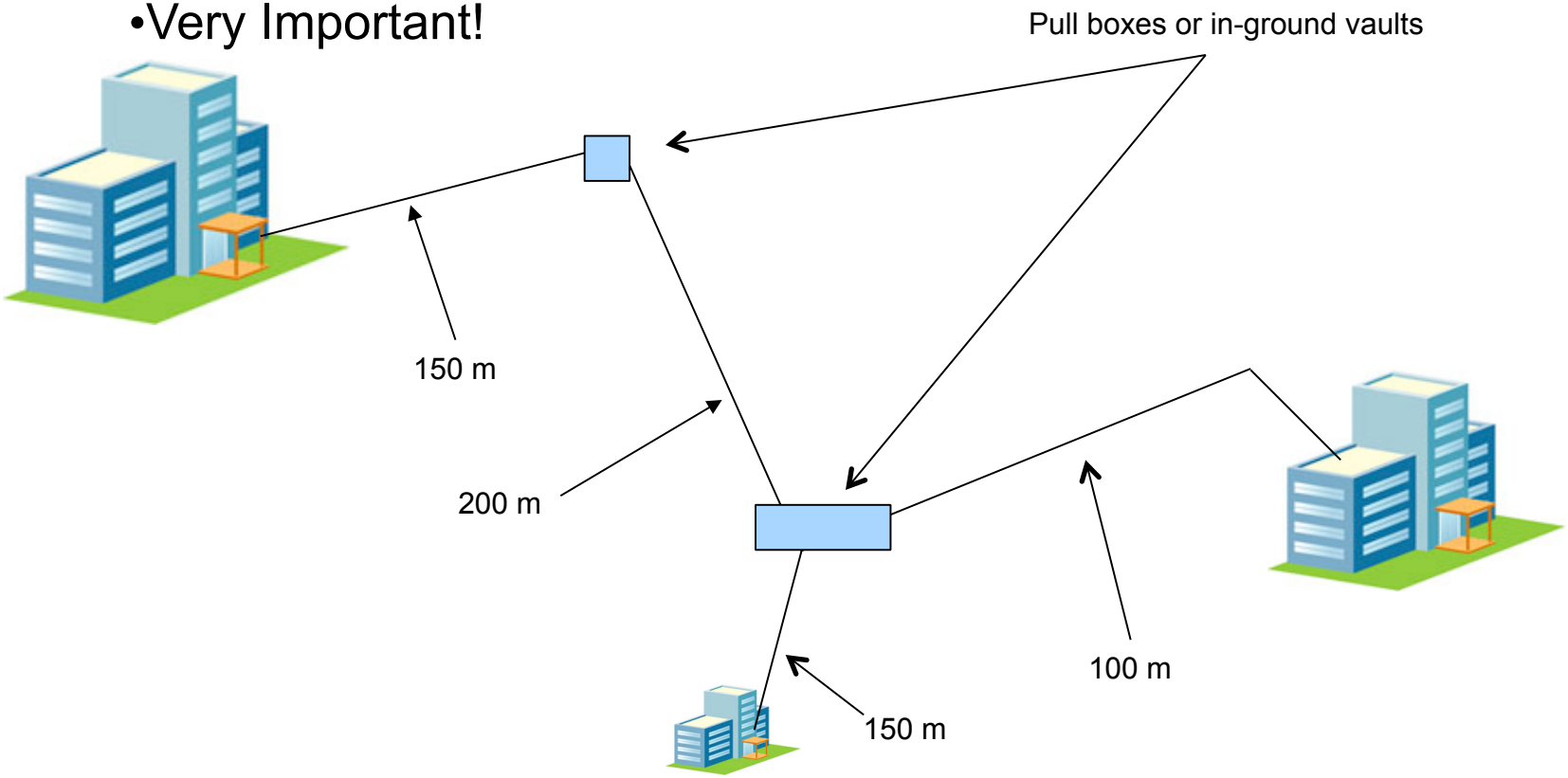
Closet Slack Loops

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?