Campus Network Design Workshop

Structured Cabling

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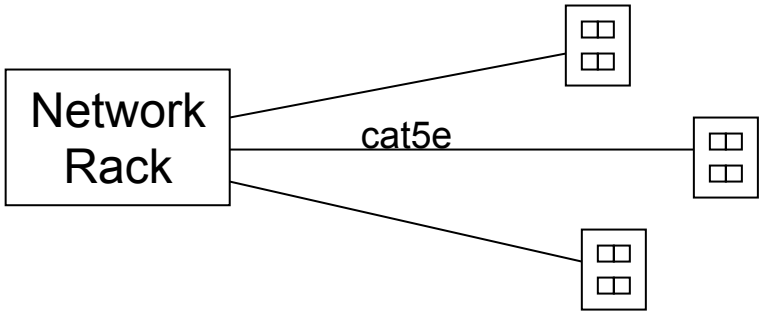
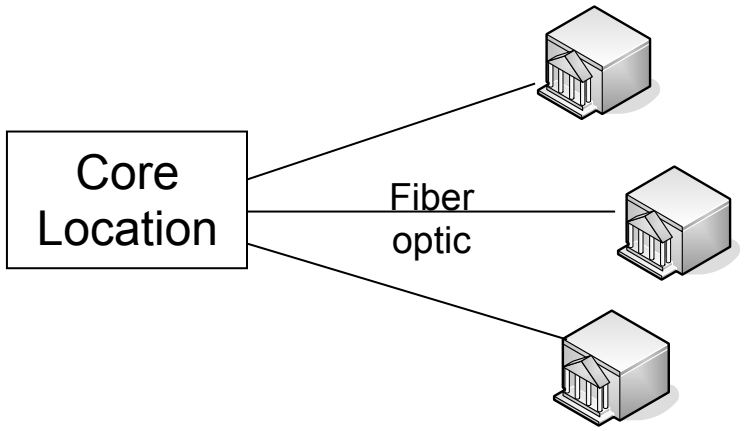
Structured Cabling Systems

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





Unshielded Twisted Pair Cable

- Run in star configuration from network rack location to individual outlets in offices or labs.
- Run at least 2 cables to every outlet – I recommend 4 if you can afford it.
- Run 4 to 6 cables between network racks if the distance is less than 90 meters
- Question: what type of cable to run? Cat5, cat5e, Cat6, Cat6A

What type of UTP

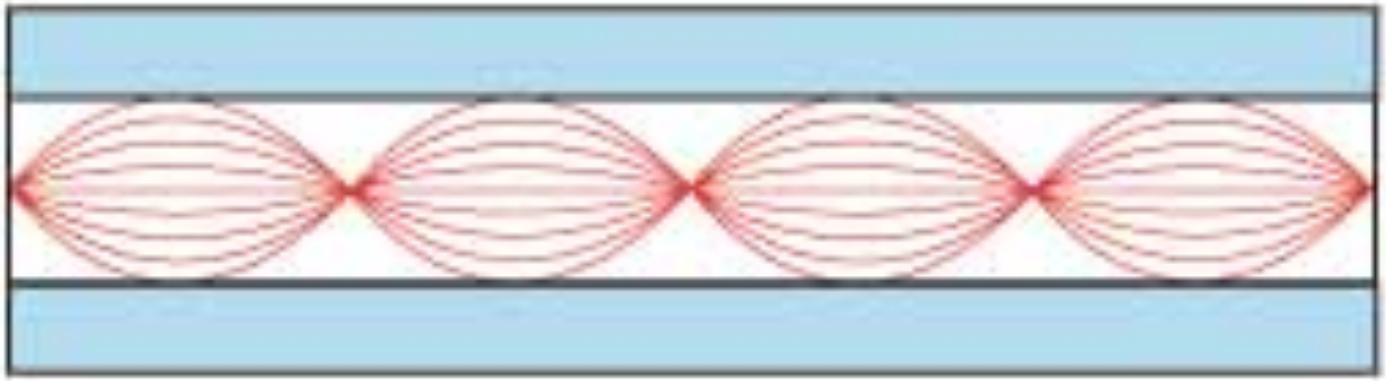
- What speed does each type support?

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	4x

* Prices in USA with USA contractors

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:
  - OS1 and OS2 (OSI/IEC 11801 types)
  - ITU G.652 (A, B, C, D)
  - 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
- You want G.652.D or OS2 single mode

Optical Interface Standards

Standard	Speed	Fiber Type
100baseFX	100Mbs	MM
1000baseSX	1Gbs	MM
1000baseLX/LH	1Gbs	MM or SM
10GbaseSR	10Gbs	MM
10GbaseLRM	10Gbs	MM
10GbaseLR	10Gbs	SM
10GbaseER	10Gbs	SM

Optical Interfaces: Cost & Distance

Standard	Cost*	OM1	OM2	OM3	OM4	G.652.D
100baseFX	$55	2km	2km	2km	2km	No
1000baseSX	$30	275m	550m	1km	1.1km	No
1000baseLX/LH	$50	500m	500m	500m	500m	10km
10GbaseSR	$210	33m	82m	300m	550m	No
10GbaseLRM	$320	220m	220m	300m	400m	No
10GbaseLR	$320	No	No	No	No	10km
10GbaseER	$600	No	No	No	No	40km

*pricing for Cisco compatible SFP/SFP+ optics from http://approvedoptics.com in May 2016

Fiber Price Comparison

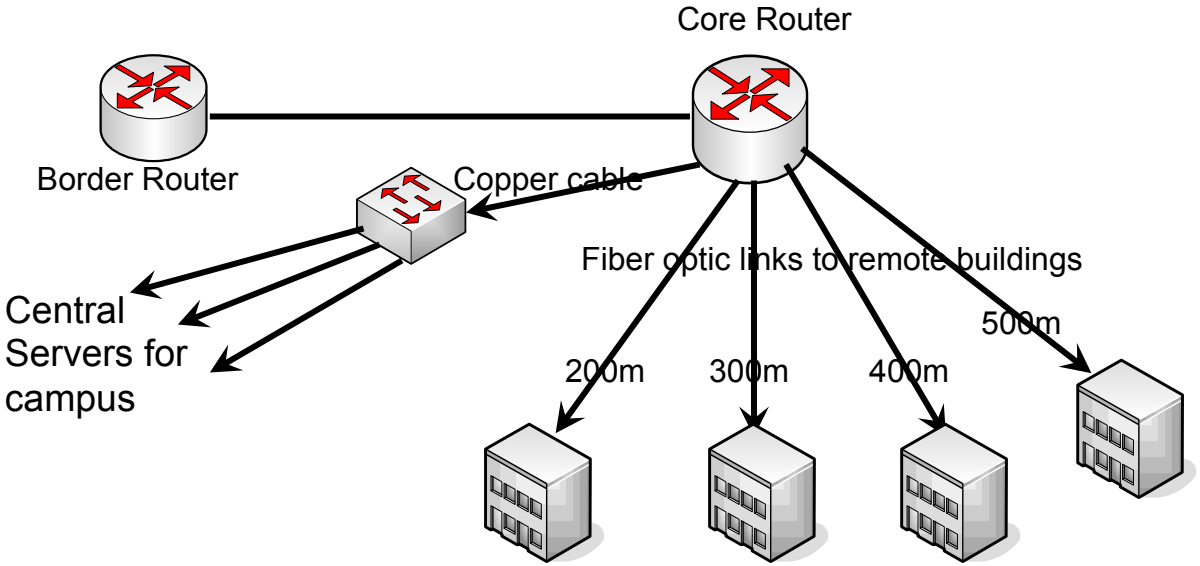
- Single mode fiber cabling is cheaper
- Multi mode optical interfaces are cheaper
- What makes sense for your campus?

Fiber Type	Cost per km*
OM1 (62.5 legacy)	$4,170
OM2 (50 legacy)	$3,319
OM3 (50 laser optimized)	$7,838
OM4 (new std)	$8,640
G.652.D (single mode)	$964

*Pricing in US dollars based on 12-fiber outdoor cable, Corning 012TU4-T41xxD20, quote obtained in May of 2016

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	Total Cost
OM1	1.4*4170 = $5838	2x1000baseSX@30 6x1000baseLX@50 = $360	$5,868
OM2	1.4*3319 = $4647	8x1000baseSX@30 = $240	$4,887
OM3	1.4*7838 = $10973	8x1000baseSX@30 = $240	$11,213
OM4	1.4*8640 = $12096	8x1000baseSX@30 = $240	$12,336
G.652.D	1.4*964 = $1350	8x1000baseLX@50 = $400	$1,750

Pricing Example – 10Gig Links

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

Fiber Type	Fiber Cost	Optics	Total Cost
OM1	1.4*4170 = $5838	Can't do 10G farther than 220m	No
OM2	1.4*3319 = $4647	Can't do 10G farther than 220m	No
OM3	1.4*7838 = $10973	Can't do 10G farther than 300m	No
OM4	1.4*8640 = $12096	8x10GbaseSR@210 = $1680	$12,264
G.652.D	1.4*964 = $1350	8x10GbaseLR@320 = $2560	$3,910

Fiber Pricing Exercise

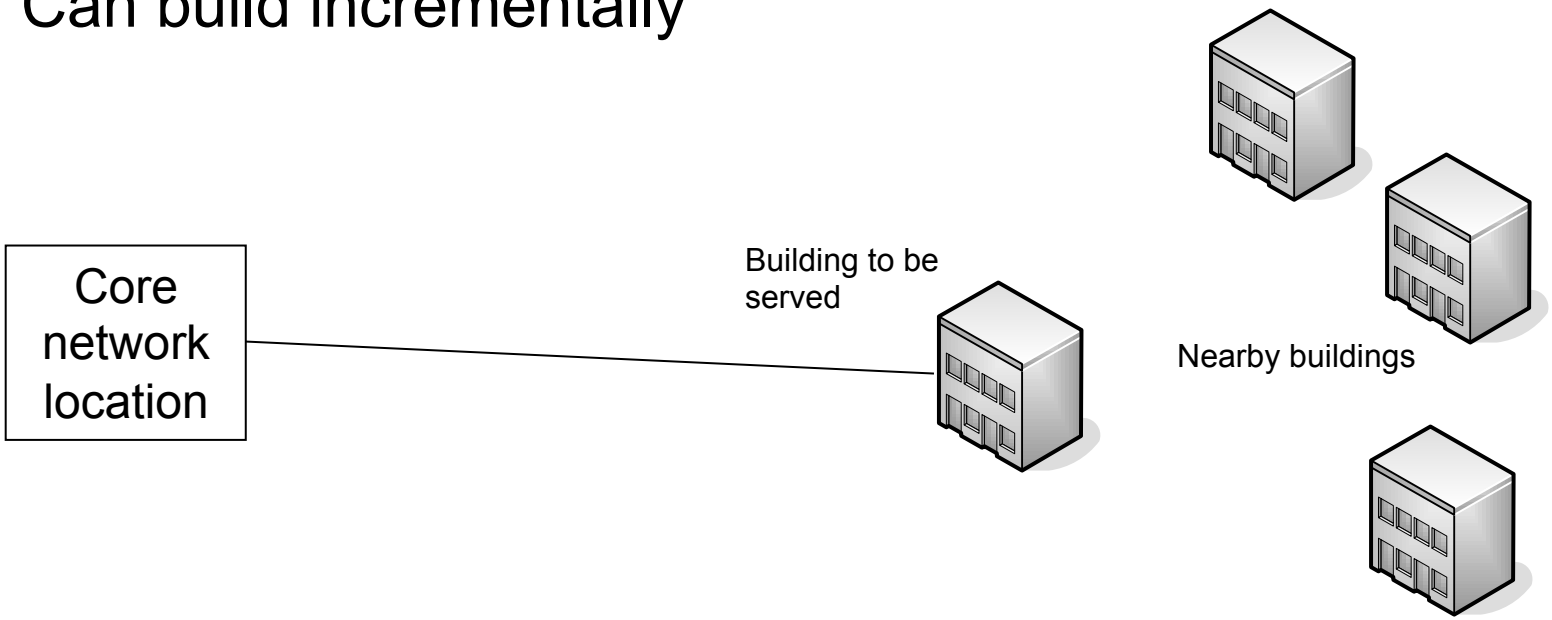
- See workshop wiki for exercise
- Don’t mix fiber types: try to build network with all OM1 fiber, then all OM2 fiber, then all OM3 fiber
- Round to nearest dollar
- Do for both 1G backbone network and 10G backbone network
- Which type of fiber would be best?

Fiber Optic Recommendations

- Don’t install any Multi mode
- Only install Single mode
- Run in star configuration from core network location to individual buildings
- Run in star configuration inside of buildings from main network rack to other network racks
- 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
  - Between Buildings: 6 single mode from core to each building (consider 12 fibers if you can afford it)
  - Inside of buildings: 6 single mode between network racks
  - Can build incrementally



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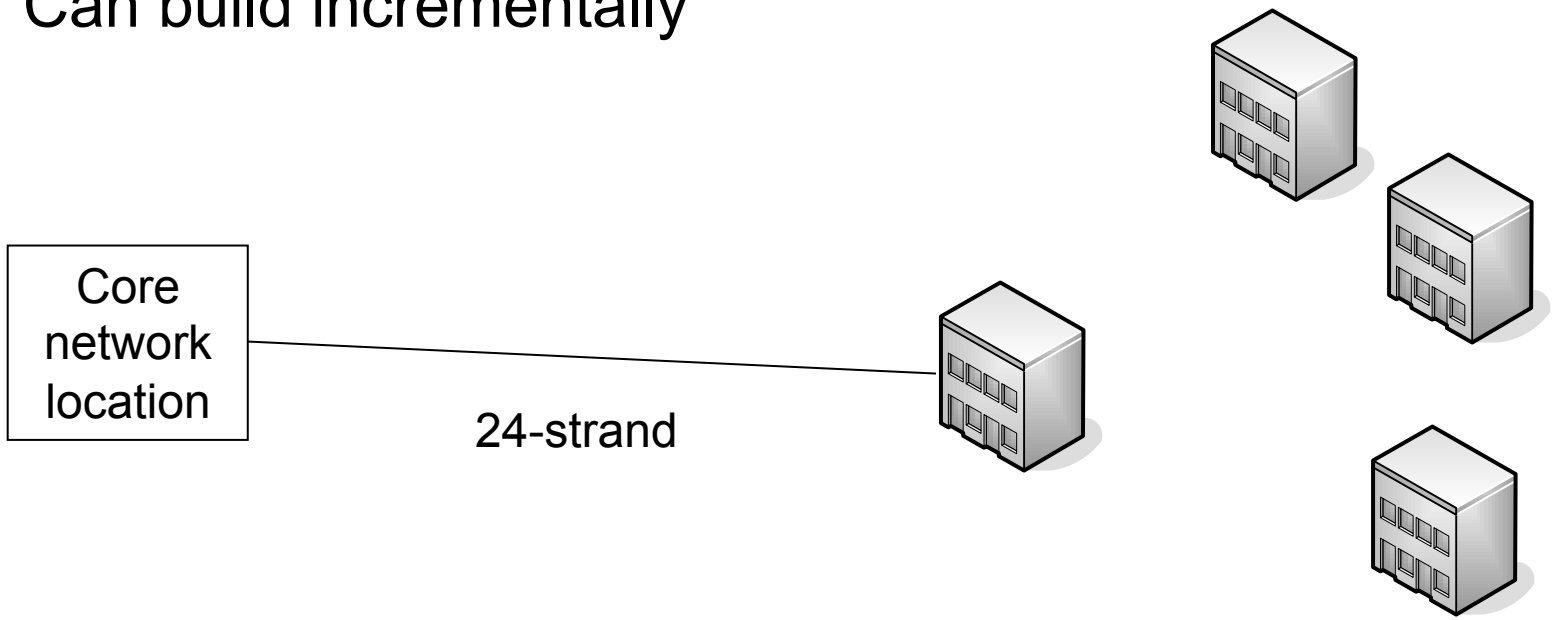

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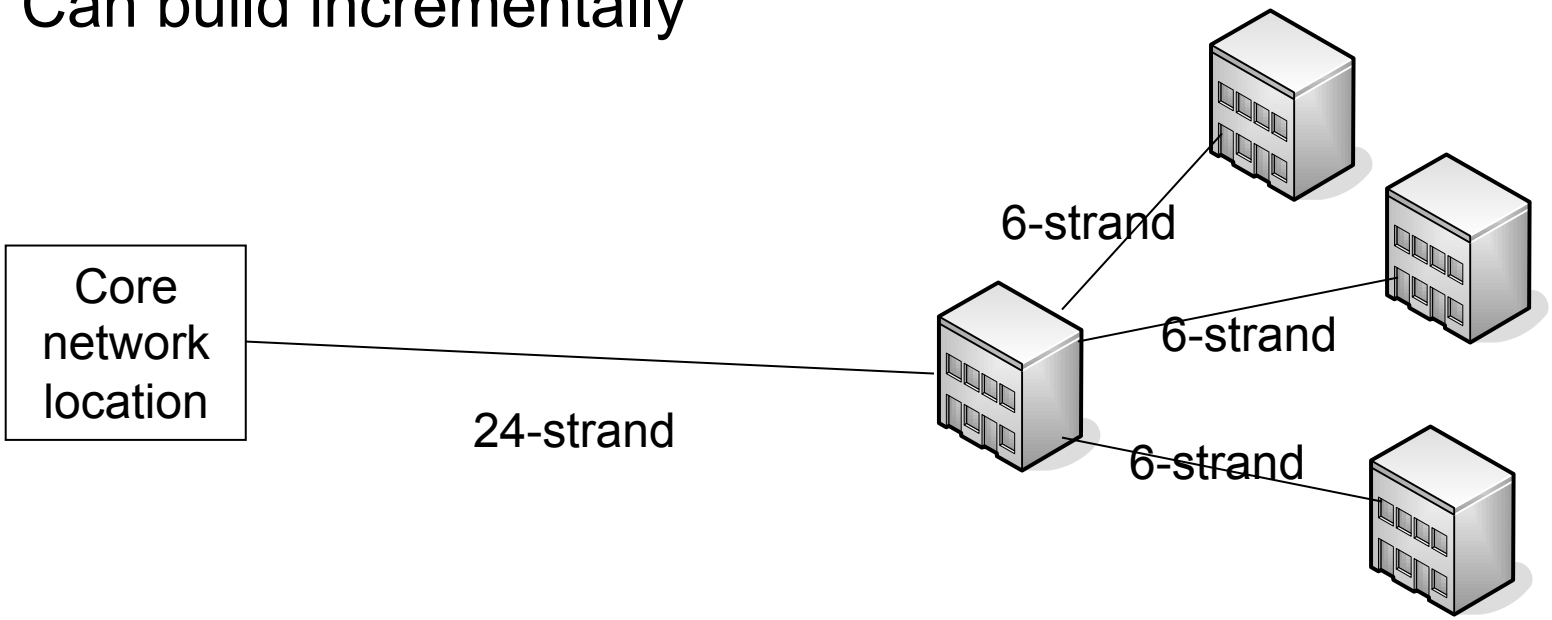
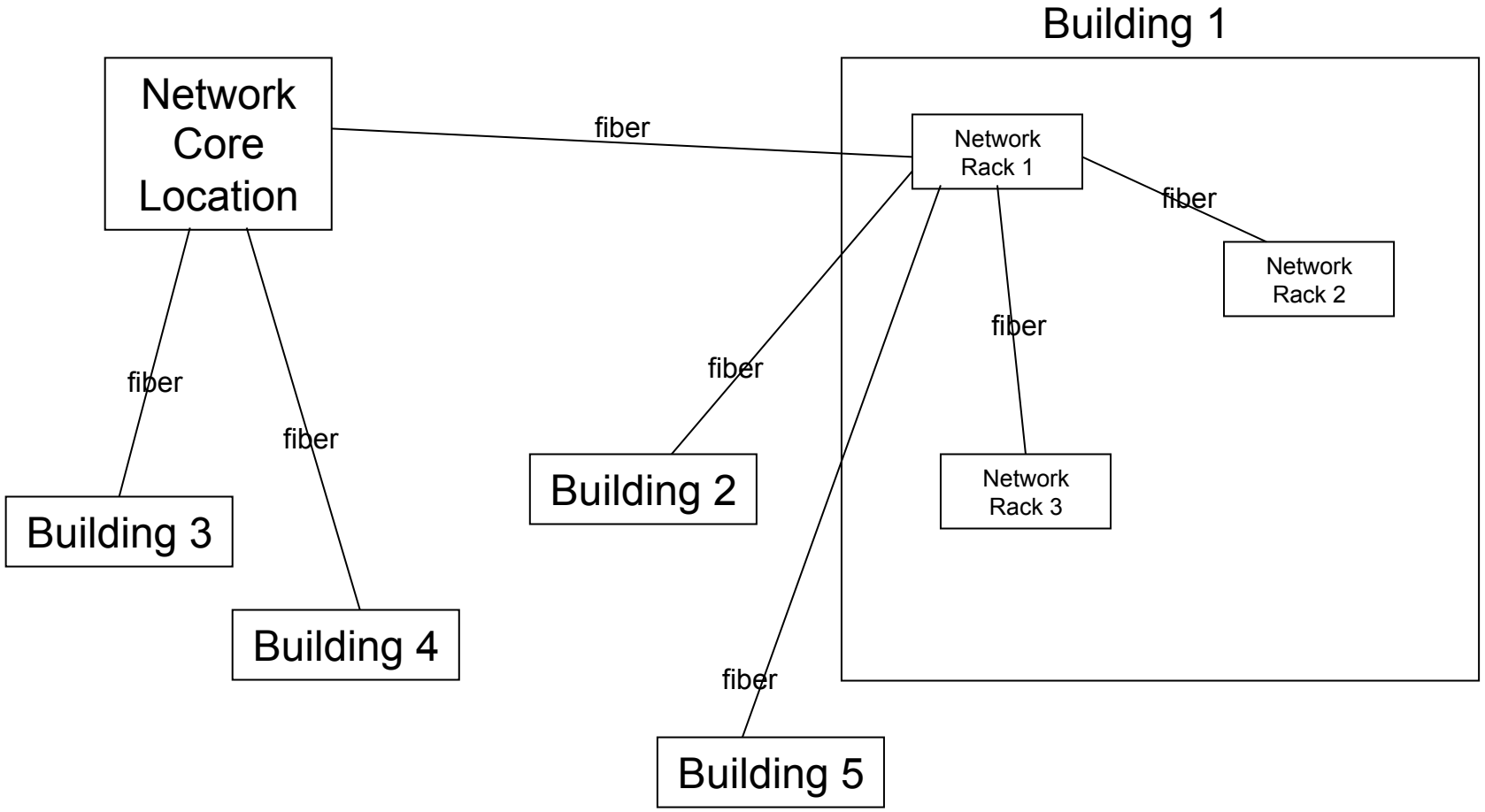
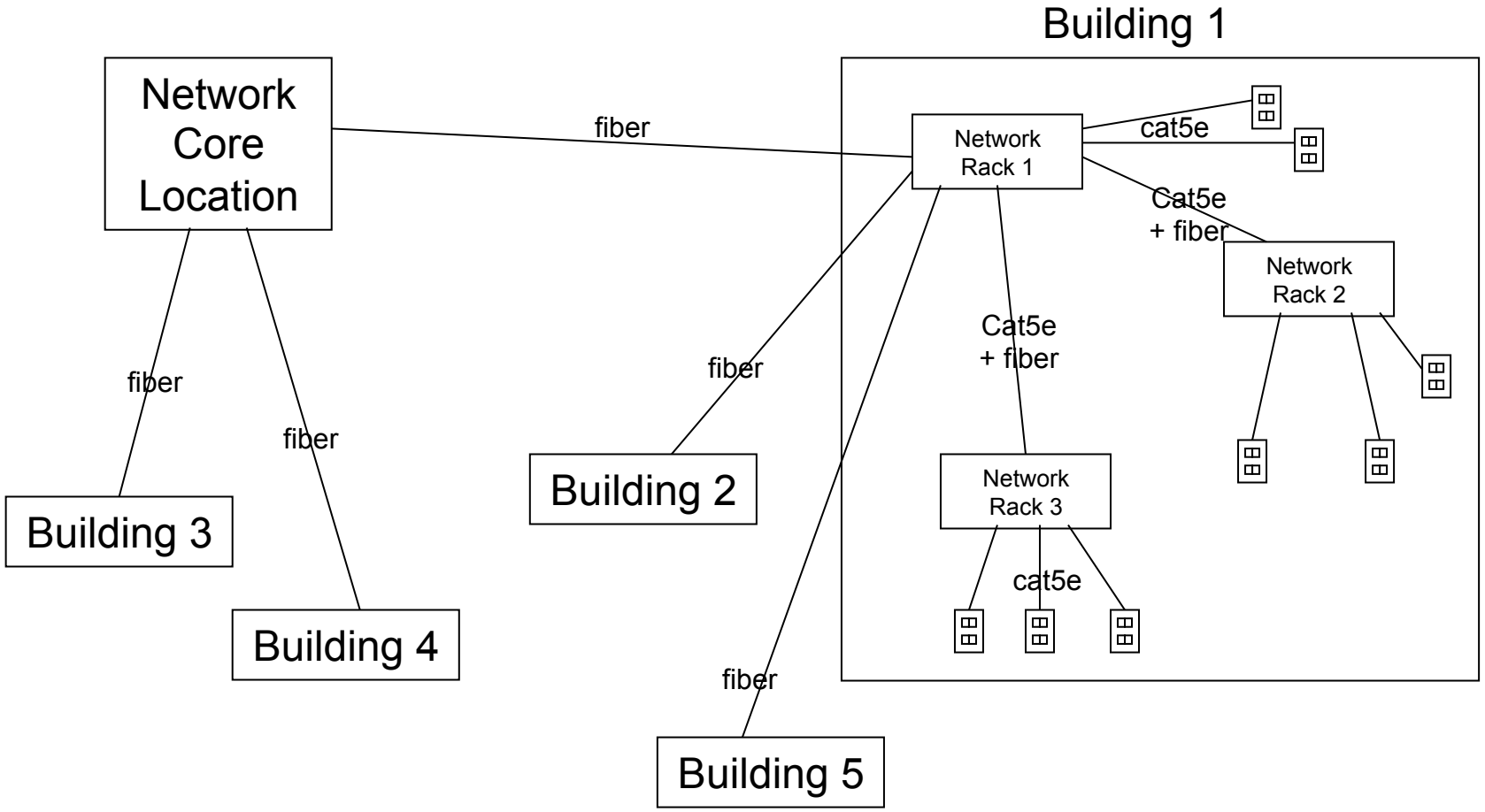


Fiber Optic Topology



Putting it all Together



Questions?

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Slide Diagram for Lab Exercise