

# Structured Cabling

## Campus Network Design & Operations Workshop



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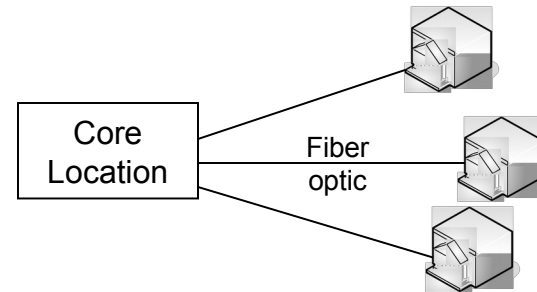
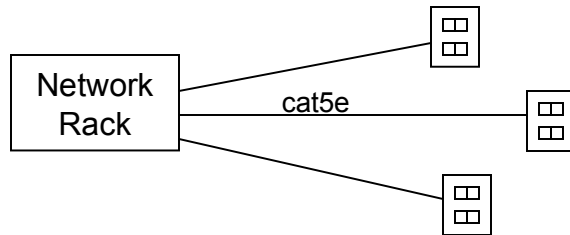
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Last updated 10<sup>th</sup> December 2018



# 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 – we 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	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	4x

\* Prices in USA with USA contractors

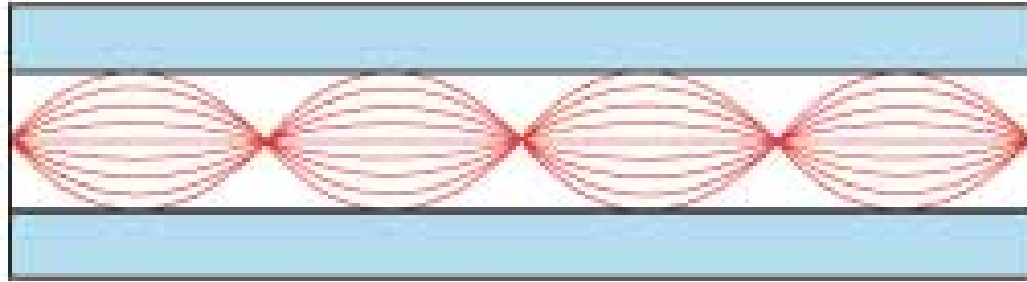


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# Fibre Optic Cabling

- 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 bandwidth
  - OSI/IEC 11801 OM5 – 50 micron wideband optimized (for SWDM)



# 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 OS2 single mode, which is the same as G.652.D



# Optical Interfaces: Cost & Distance

Standard	Speed	Cost*	# of Fibers	OM1	OM2	OM3	OM4/OM5	OS2
1000baseSX	1Gbps	\$6	2	275m	550m	1km	1.1km	No
1000baseLX	1Gbps	\$7	2	500m	500m	500m	500m	10km
10GbaseSR	10Gbps	\$16	2	33m	82m	300m	550m	No
10GbaseLRM	10Gbps	\$34	2	220m	220m	300m	400m	No
10GbaseLR	10Gbps	\$34	2	No	No	No	No	10km
10GbaseER	10Gbps	\$149	2	No	No	No	No	40km
40GbaseSR4	40Gbps	\$49	8**	No	No	100m	150m	No
40GbaseLR4	40Gbps	\$340	2	No	No	No	No	10km
100GbaseSR4	100Gbps	\$199	8**	No	No	70m	100m	No
100GbaseLR4	100Gbps	\$1499	2	No	No	No	No	10km

\* pricing for Cisco compatible SFP/SFP+ optics from <http://fs.com> in May 2018.

\*\* Connector used is a 12-fiber MPO connector but the standard only uses 8 of the strands.

Note: there are a number of additional 40Gbps and 100Gbps options. SR4 and LR4 are most common.



# Optical Interfaces

- We refer to optical interfaces as the module that is placed in a switch or router to attach to fiber optic cable
- Most common types are SFP, SFP+ and QSFP



# A Closer Look at SFP/SFP+ and QSFP



# Fiber Optic Cable Price Comparison

- Below is a table outlining the pricing for a 12-fiber outdoor cable, non-armored cable.
- Manufacturer is Corning, part number 012TU4-T47xxD20, which is more expensive than many suppliers.
- Pricing obtained May, 2018

Fiber Type	Cost per km*
OM1 (62.5 legacy)	\$4,921
OM2 (50 legacy)	\$3,465
OM3 (50 laser optimized)	\$8,147
OM4 (40 laser optimized)	\$8,977
OS2 (single mode)	\$1,010



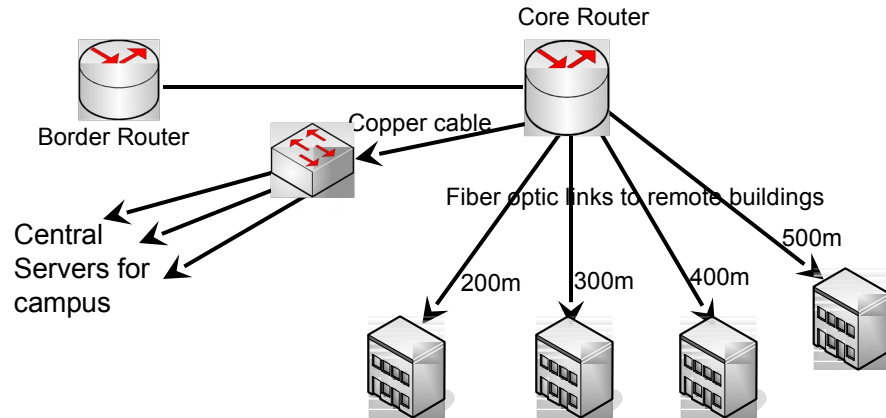
# Think About the Cost of a Fiber Cable **System**

- Multi mode optical interfaces are less expensive than single mode optical interfaces
  - Cost factor is significant as you look at higher speeds
- Single mode fiber cable is less expensive than multi mode fiber cable
- Don't listen to your fiber installation contractor
- Don't listen to your equipment provider
- They don't know about the cost of the whole system
- What is the cost of the whole system?
  - Estimate how much the fiber cable costs
  - Estimate how much the optical interfaces will cost



# Simple Fiber Pricing Example

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



# Pricing Example – 1Gbps Links

- Use cheapest optical interface possible, but note that the cheaper 1000BaseSX interface is distance limited based on fiber type

Fiber Type	Fiber Cost	Optics	Total Cost
OM1	$1.4 * 4921 = \$6889$	2x1000baseSX@6 6x1000baseLX@7 = \$54	\$6,943
OM2	$1.4 * 3465 = \$4851$	8x1000baseSX@6 = \$48	\$4,899
OM3	$1.4 * 8147 = \$11406$	8x1000baseSX@6 = \$48	\$11,454
OM4	$1.4 * 8977 = \$12568$	8x1000baseSX@6 = \$48	\$12,616
OS2	$1.4 * 1010 = \$1414$	8x1000baseLX@7 = \$56	\$1,470



# Pricing Example – 10Gbps Links

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

Fiber Type	Fiber Cost	Optics	Total Cost
OM1	$1.4 * 4921 = \$6889$	Can't do 10Gbps further than 220m	N/A
OM2	$1.4 * 3465 = \$4851$	Can't do 10Gbps further than 220m	N/A
OM3	$1.4 * 8147 = \$11406$	Can't do 10Gbps further than 220m	N/A
OM4	$1.4 * 8977 = \$12568$	8x10GbaseSR@16 = \$128	\$12,696
OS2	$1.4 * 1010 = \$1414$	8x10GbaseLR@34 = \$272	\$1,686



# Pricing Example – 100Gbps Links

- Note that some fiber types won't support 100Gbps over the required distances

Fiber Type	Fiber Cost	Optics	Total Cost
OM1	$1.4 \times 4921 = \$6889$	Can't do 100Gbps at all	N/A
OM2	$1.4 \times 3465 = \$4851$	Can't do 100Gbps at all	N/A
OM3	$1.4 \times 8147 = \$11406$	Can't do 100Gbps further than 70m	N/A
OM4	$1.4 \times 8977 = \$12568$	Can't do 100Gbps further than 100m	N/A
OS2	$1.4 \times 1010 = \$1414$	$8 \times 100\text{GbaseLR4}@1499 = \$11,992$	\$13,406



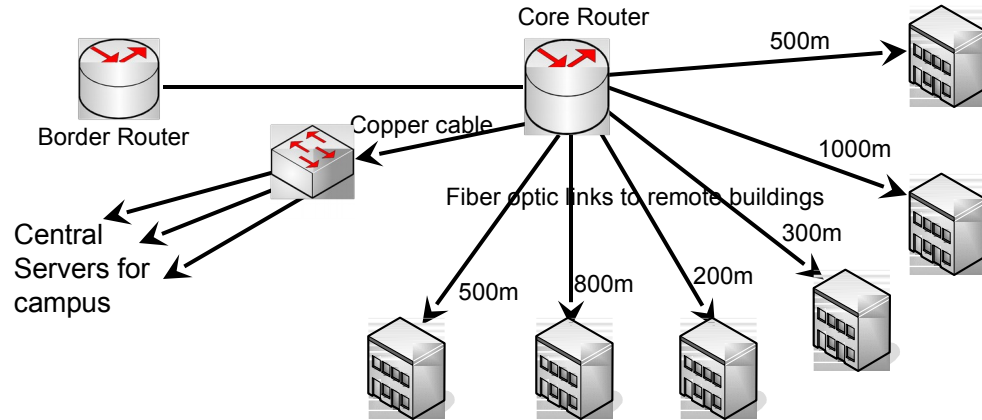


# Fiber Pricing Exercise

- 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 1Gbps backbone network and 10Gbps backbone network
  - Don't worry about 100Gbps networks, we see that it won't work on any kind of multi mode
- Which type of fiber would be best?



# Slide Diagram for Lab Exercise



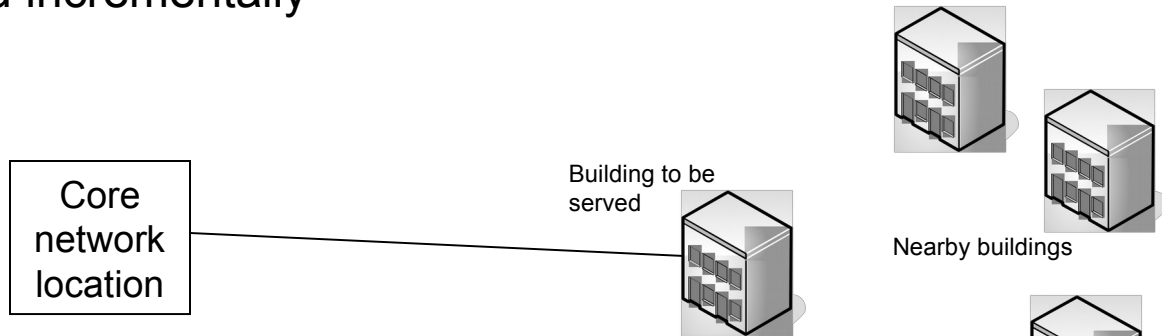
# Fiber Optic Recommendations

- 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



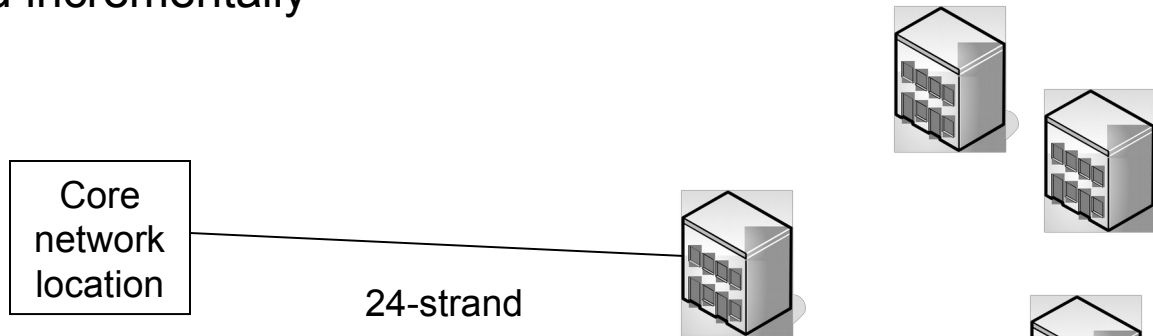
# Star Configuration

- 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



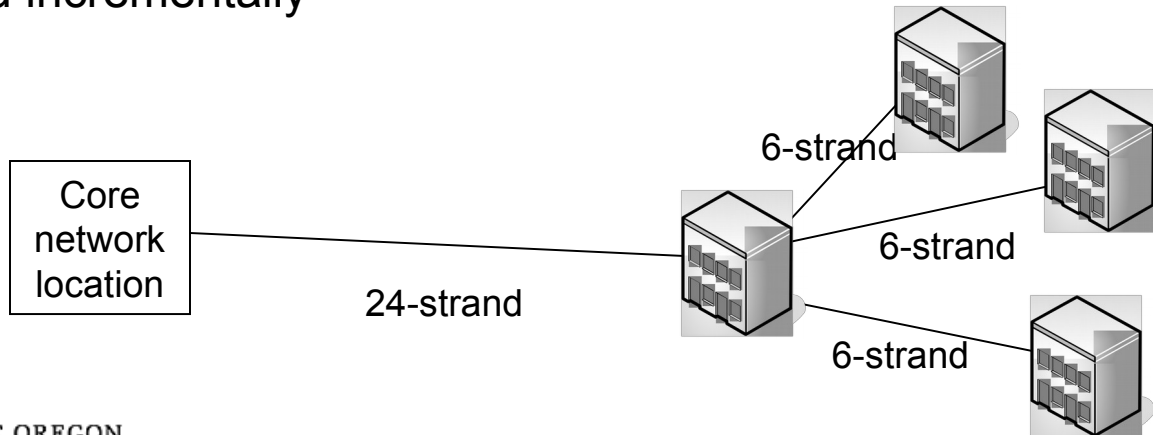
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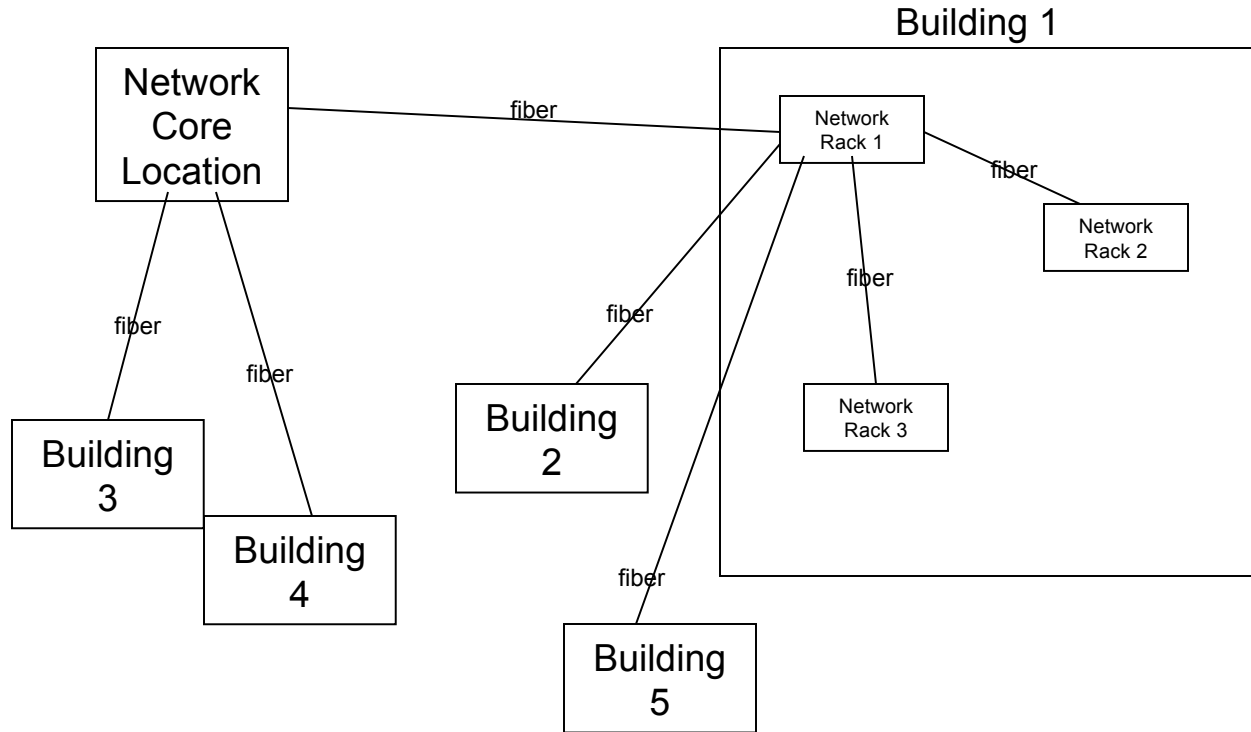


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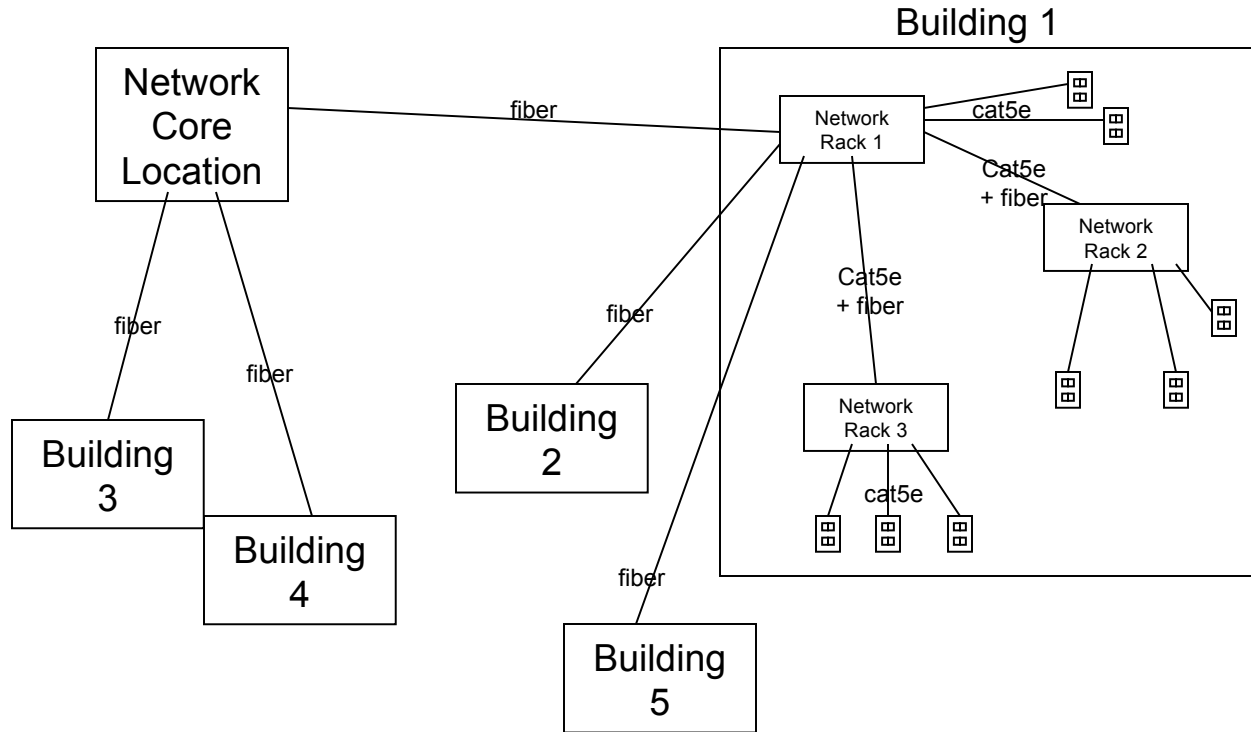
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# Fiber Optic Topology



# Putting it all Together





# Questions?

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