Campus Networking Best Practices

Session 3: Layer 0
Campus Network Structured Cabling

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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 six 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?

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Max Speed</th>
<th>Max Distance</th>
<th>Cost Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 5</td>
<td>100Mbs</td>
<td>100m</td>
<td>1x</td>
</tr>
<tr>
<td>Category 5e</td>
<td>1000Mbs</td>
<td>100m</td>
<td>1x</td>
</tr>
<tr>
<td>Category 6</td>
<td>1000Mbs</td>
<td>100m</td>
<td>1.3x</td>
</tr>
<tr>
<td>Category 6a</td>
<td>10,000Mbs</td>
<td>57m</td>
<td>1.3x</td>
</tr>
<tr>
<td>Category 6</td>
<td>10,000Mbs</td>
<td>100m</td>
<td>2x</td>
</tr>
</tbody>
</table>

- Strongly recommend category 5e cabling.
Unshielded Twisted Pair Cable

• Labeling is a key to reduce work later
Fiber Optic Cabling

• Two basic types of fiber
  – Multi Mode limited to 2km @ 100Mbs
  – Single Mode 70km @ virtually unlimited

• Multiple types of multi mode
  – 62.5 micron core
  – 50 micron core

• Multiple types of single mode
  – Optimized for 1310 and 1550 nm operation
  – Optimized for WDM operation
Physics of Fiber
What type of Fiber?

- **Multi mode Fiber**
  - 62.5 micron
    - 100baseFX for 2km, optical interface cost $250 USD
    - 1000baseSX for 275m, optical interface cost $250 USD
    - 1000baseLX for 500m, optical interface cost $750 USD
    - 10GbaseSR for 33m, optical interface cost $2000 USD
    - 10GbaseLRM for 220m, optical interface cost $1500 USD (not widely avail)
  - 50 micron laser optimized
    - 100baseFX for 2km, optical interface cost $250 USD
    - 1000baseSX for 550m, optical interface cost $250 USD
    - 1000baseLX for 500m, optical interface cost $750 USD
    - 10GbaseSR for 300m, optical interface cost $2000 USD
    - 10GbaseLRM for 220m, optical interface cost $1500 USD (not widely avail)

- **Single mode Fiber**
  - 100baseFX not supported
  - 1000baseSX not supported
  - 1000baseLX for 5km (most vendors support 10km), cost $750 USD
  - 1000baseLH (not a standard) 70 km with 1550nm lasers, cost $3000 USD
  - 10GbaseLR for 10km, optical interface cost $3000 USD
  - 10GbaseER for 30-40km, optical interface cost $8500 USD
Going Fast on Fiber

• Multi mode Fiber
  – 62.5 micron
    • 1Gbs to 500m
    • 10Gbs to 220m
  – 50 micron laser optimized
    • 1Gbs to 500m
    • 10Gbs to 300m

• Single mode Fiber
  – 1Gbs to 70km
  – 10Gbs to 70km
Fiber Optic Topology

• Need to install both Multi and Single Mode
  – Multi mode: either 62.5 or 50 micro is acceptable
  – Single mode: use fiber optimized for 1310/1550nm

• Run in star configuration from core network location to individual buildings

• Also run in star configuration inside of buildings from main phone 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 multimode plus 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.
Fiber Optic Topology

- Network Core Location
  - Building 3
  - Building 4
  - Building 5

- Building 1
  - Network Closet 1
  - Network Closet 2
  - Network Closet 3
Construction Hints

- Use outdoor cable between buildings
  - Armored (to protect against rodents)
  - Loose tube
- Use indoor cabling inside buildings
  - tight buffer
- Standardize on Connectors
  - Multi mode: ST or SC (epoxy or hot melt)
  - Single mode: SC or LC (fusion Splice factory UPC pigtail)
Fiber Optic Cable Construction

• Fiber has bend radius issues
More 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
Fiber Optic Cable Construction

• Leave slack loops
How About Going Even Faster?

- 100 Gigabits?
- Dispersion becomes your enemy
- Even single mode fiber has dispersion
  - Chromatic Dispersion (CD) Even slightly different colors of light travel different speeds
  - Polarization Mode Dispersion (PMD) Slight variations from true roundness causes differently polarized light to travel different distances.
The Solution Today is WDM

- Wave Division Multiplexing (WDM)
  - Provisioning multiple Gigabit or 10 Gigabit using different colors of light
  - Coarse (CWDM)
    - Fewer waves, low cost
    - 1310nm frequency spectrum
    - Not suitable for amplification – short haul (70km)
  - Dense (DWDM) more waves
    - More waves, higher cost
    - 1550nm frequency spectrum
    - Suitable for EDFA amplification – long haul (1000s of km)
WDM Simple Single Span
Optical Add Drop Multiplexor
Can Build Complex Networks

![Diagram of complex network with O ADMs and routers connected by fiber pairs.]

- OADM
- Fiber Pair
- Router

The diagram illustrates how OADM and router nodes are interconnected through fiber pairs to form a complex network.
Layer 0 Summary

• Install cabling in star configuration – don’t daisy chain
• Install cat5e or cat6a – cat6 is a waste of money if the runs are over 57m
• Install both single and multi mode fiber for runs over 300m
Thank You

Questions