Campus Network Best Practices: 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 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, ???
## 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>1.5x</td>
</tr>
<tr>
<td>Category 6</td>
<td>10,000Mbs</td>
<td>57m</td>
<td>1.5x</td>
</tr>
<tr>
<td>Category 6a</td>
<td>10,000Mbs</td>
<td>100m</td>
<td>3x</td>
</tr>
</tbody>
</table>

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

• Always terminate in Jack Panel
• Labeling is a key to reduce work later
• Pull more than one cable
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
# Types of Optical Interfaces

<table>
<thead>
<tr>
<th>Standard</th>
<th>Speed</th>
<th>Fiber Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>100baseFX</td>
<td>100Mbs</td>
<td>MM</td>
</tr>
<tr>
<td>1000baseSX</td>
<td>1Gbs</td>
<td>MM</td>
</tr>
<tr>
<td>1000baseLX/LH</td>
<td>1Gbs</td>
<td>MM or SM</td>
</tr>
<tr>
<td>10GbaseSR</td>
<td>10Gbs</td>
<td>MM</td>
</tr>
<tr>
<td>10GbaseLRM</td>
<td>10Gbs</td>
<td>MM</td>
</tr>
<tr>
<td>10GbaseLR</td>
<td>10Gbs</td>
<td>SM</td>
</tr>
<tr>
<td>10GbaseER</td>
<td>10Gbs</td>
<td>SM</td>
</tr>
</tbody>
</table>
# Optical Interfaces: Cost & Distance

<table>
<thead>
<tr>
<th>Standard</th>
<th>Cost</th>
<th>OM1</th>
<th>OM2</th>
<th>OM3</th>
<th>OM4</th>
<th>G.652.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>100baseFX</td>
<td>$250</td>
<td>2km</td>
<td>2km</td>
<td>2km</td>
<td>2km</td>
<td>No</td>
</tr>
<tr>
<td>1000baseSX</td>
<td>$500</td>
<td>275m</td>
<td>550m</td>
<td>1km</td>
<td>1.1km</td>
<td>No</td>
</tr>
<tr>
<td>1000baseLX/LH</td>
<td>$1000</td>
<td>500m</td>
<td>500m</td>
<td>?</td>
<td>?</td>
<td>10km</td>
</tr>
<tr>
<td>10GbaseSR</td>
<td>$1500</td>
<td>33m</td>
<td>82m</td>
<td>300m</td>
<td>550m</td>
<td>No</td>
</tr>
<tr>
<td>10GbaseLRM</td>
<td>$1300</td>
<td>220m</td>
<td>220m</td>
<td>220m</td>
<td>?</td>
<td>No</td>
</tr>
<tr>
<td>10GbaseLR</td>
<td>$4000</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>10km</td>
</tr>
<tr>
<td>10GbaseER</td>
<td>$10000</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>40km</td>
</tr>
</tbody>
</table>
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?

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

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

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Fiber Cost</th>
<th>Optics</th>
<th>Optics Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM1</td>
<td>$6,837</td>
<td>2x1000baseSX, 6x1000baseLX</td>
<td>$7,000</td>
<td>$13,837</td>
</tr>
<tr>
<td>OM2</td>
<td>$5,675</td>
<td>8x1000baseSX</td>
<td>$4,000</td>
<td>$9,675</td>
</tr>
<tr>
<td>OM3</td>
<td>$14,211</td>
<td>8x1000baseSX</td>
<td>$4,000</td>
<td>$18,211</td>
</tr>
<tr>
<td>OM4</td>
<td>$27,942</td>
<td>8x1000baseSX</td>
<td>$4,000</td>
<td>$31,942</td>
</tr>
<tr>
<td>G.652.D</td>
<td>$1,659</td>
<td>8x1000baseLX</td>
<td>$8,000</td>
<td>$9,659</td>
</tr>
</tbody>
</table>
# Pricing Example – 10Gig Links

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

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

Note that some fiber types won’t support 10Gig over the required distances.
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
  – Between Buildings: 6 single mode from core to each building (multi mode OK if distances are short)
  – Inside of buildings: 6 single mode and 6 multi mode between network racks
  – Can build incrementally
Star Configuration

• Plan for future -- Install enough fiber
  – Between Buildings: 6 single mode from core to each building (multi mode OK if distances are short)
  – Inside of buildings: 6 single mode and 6 multi mode between network racks
  – Can build incrementally
Fiber Optic Topology

Building 1

Network Rack 1

Network Rack 2

Building 2

Network Rack 3

Building 5

Building 3

Building 4

Building 5

Network Core Location

fiber

fiber

fiber

fiber

fiber
Putting it all Together

Network Core Location

Building 3

Building 2

Building 1

Network Rack 1

Cat5e + fiber

Cat5e

Network Rack n2

Building 2

Building 4

Building 5

Network Rack 3

cat5e

fiber

fiber

fiber

cat5e

fiber
Questions?

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