

# Basics of Fiber Design and Deployment



## Why Fiber?

Tim Locker – CBM, Inc.

ICA IMPACT

November, 2018



# Agenda



- **Why Fiber?**
- Fiber Feeds Everything
- Nuts and Bolts - The Components
- Installation Techniques
- Network Architectures and Planning



# Why fiber? The time is now!



- 1** Fiber is future proof.
  - Technology and bandwidth adoption trends
  - Fiber vs. metal cables and wireless
- 2** Residents decide where to live based on quality of broadband. Fiber is best.
- 3** Fiber is simpler.
- 4** Fiber is less expensive.
- 5** Fiber is less intrusive and easier to install.



# Why Fiber?



Fiber is future proof.



# Bandwidth growth is accelerating

- In the past 15 years, we've seen...

- The Internet, iPods
- HDTVs, DVRs
- Smartphones, Tablet computers
- Streaming services
- Connected everything

- All require bandwidth

- We must expect more bandwidth growth in the future

## CISCO BANDWIDTH FORECAST

Figure 25. IP Traffic by Access Technology



Source: Cisco VNI Mobile, 2016



# The "Internet of Things" is changing our world



## Potential Connected Devices - Today



*E-mail Notification*



*Shades*



*Audio*



*Lighting*



*Irrigation*



*Cameras*



*Video*



*Leak Defect*



*Temperature*



*Home Appliances*



*Security*



*Kitchen Appliances*



# Bandwidth – then, now, and next

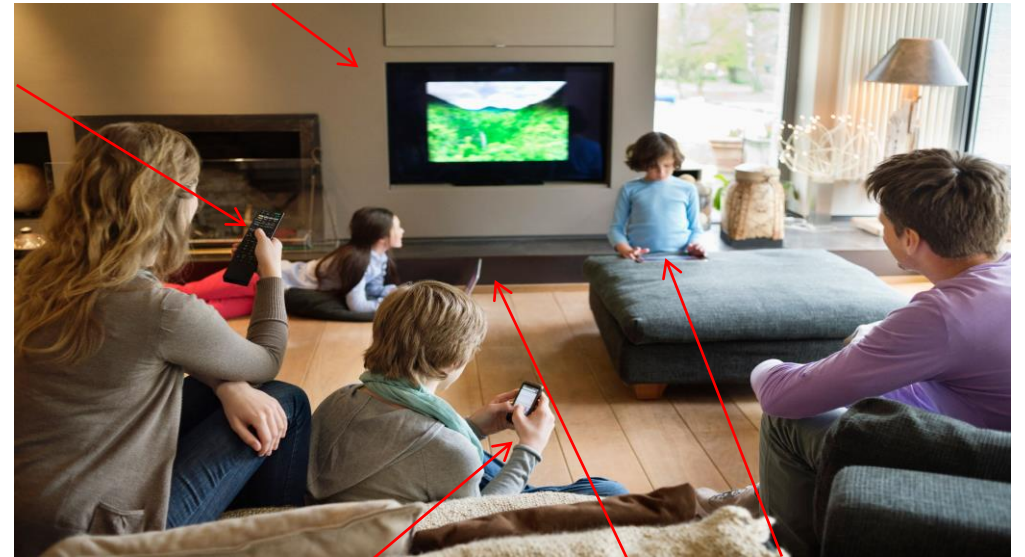


Then



1.5 Mbps  
≈ 0.6 kbps

Now



25 Mbps

2 Mbps

6 Mbps

9 Mbps

Next

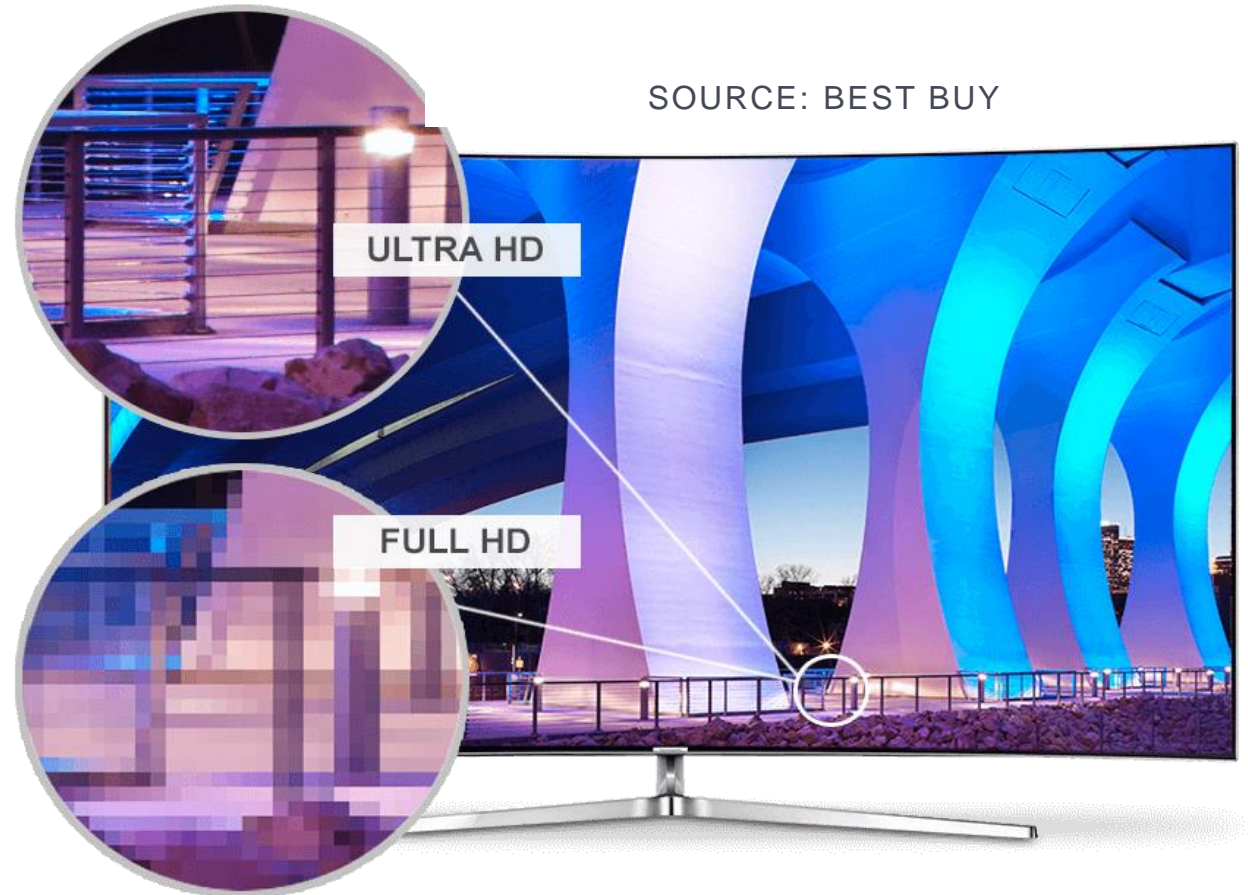


VR >  
500 MBPS



# 4k (ULTRA HD) TV

- Next generation TV format
- Content online and growing rapidly
- **For the first time ever, higher quality video is available via Internet streaming versus standard packages**
- Price continues to drop rapidly





## Internet Connection Speed Recommendations

Below are the Internet download speed recommendations per stream for playing movies and TV shows through Netflix.

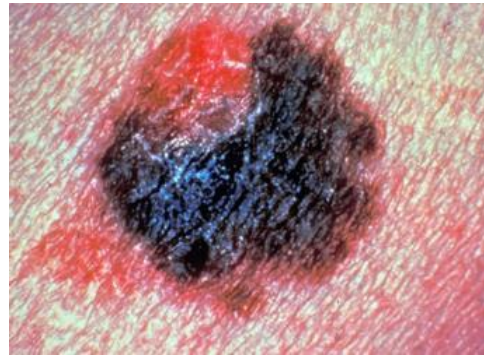
- 0.5 Megabits per second - Required broadband connection speed
- 1.5 Megabits per second - Recommended broadband connection speed
- 3.0 Megabits per second - Recommended for SD quality
- 5.0 Megabits per second - Recommended for HD quality
- 25 Megabits per second - Recommended for Ultra HD quality

25 Mbps/screen – How many screens used at once?

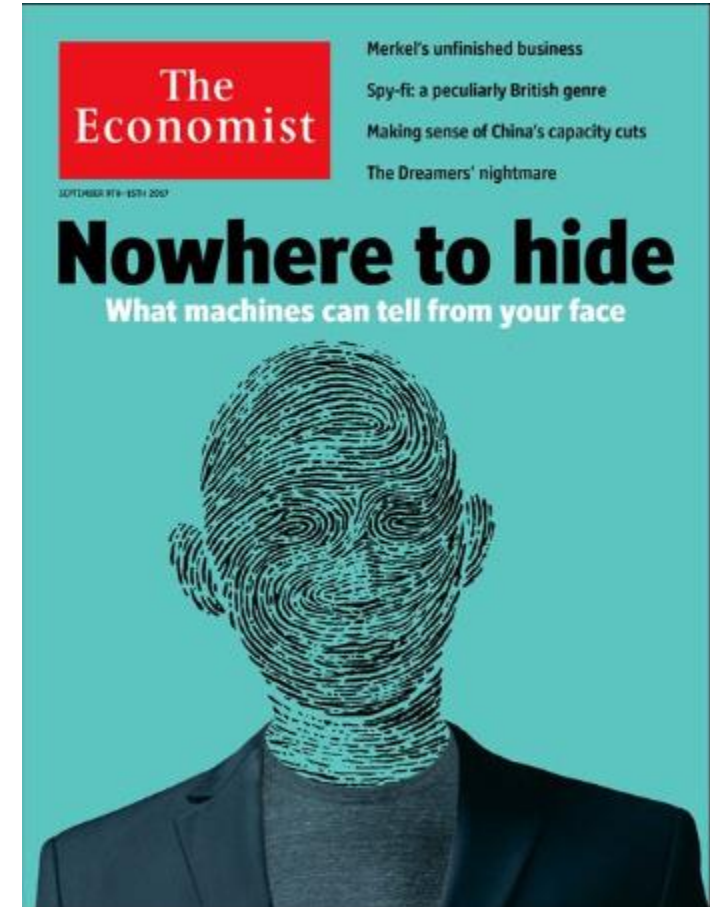


# Artificial intelligence

- Image analysis, voice analysis
- Natural language – digital assistants
  - Language translation
- Autonomous vehicles & robotics
- Enormous potential for early medical screenings using sensors and bandwidth



amazon echo



# Bandwidth – then, now, and next



# IOT

  
*E-mail Notification*

  
*Shades*

  
*Video*

  
*Home Appliances*

  
*Audio*

  
*Lighting*

  
*Leak Defect*

  
*Security*

  
*Irrigation*

  
*Cameras*



  
*Temperature*

  
*Kitchen Appliances*



# Why Fiber?

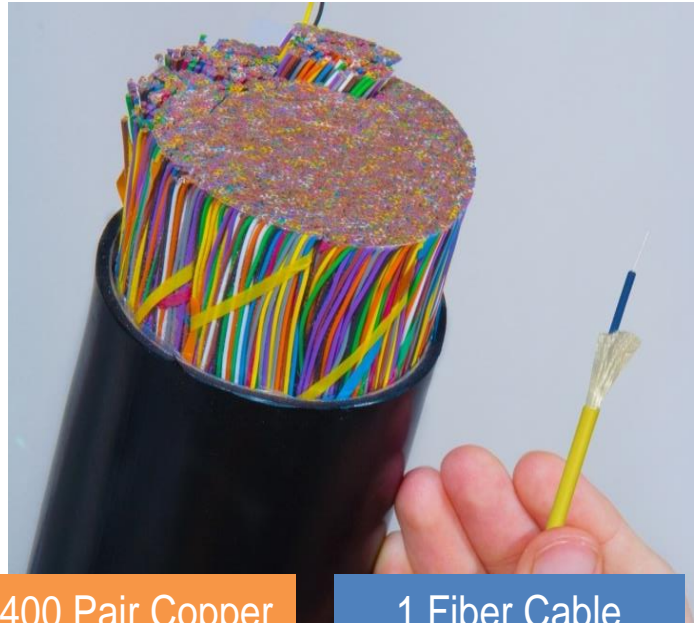


More

Less

Bandwidth  
Distance

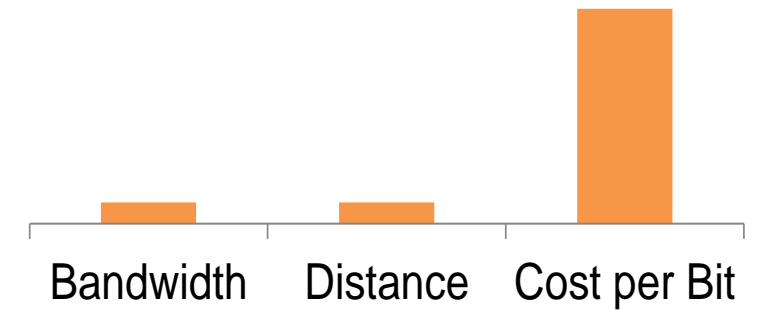
Cost/bit  
Size  
Weight  
Interference  
Conductivity (no power needed)



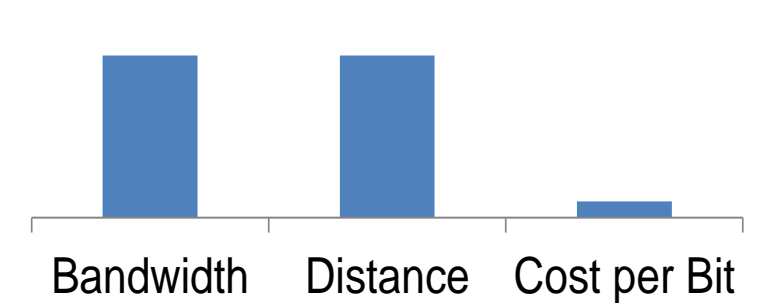
2,400 Pair Copper Cable  
100 Gbps to 1KM

1 Fiber Cable  
> 50 Tbps  
> 5,000 KM

### Copper



### Fiber



# Technology evolution



	Copper	Wireless - Cellular	Fiber
Mid-20 <sup>th</sup> century	Phone grade copper		
Early 1980s		1G -2G	Single-mode fiber introduced in early 1980s, still viable and compatible today, <b>100 Gbps+</b>
Early 1990s	Category 3		
1995	Cat 5		
1999	Cat 5E	2G-3G	
2002	Cat 6		
2009	Cat 6A	4G	
2016	Cat 8		

Single-mode fiber stands the test of time.



# Why Fiber?



## Fiber attracts 2

*Residents and businesses decide where to locate based on quality of broadband.*



# Bandwidth enables knowledge workers



“Economic Development is the Killer App for Local Fiber Developments”



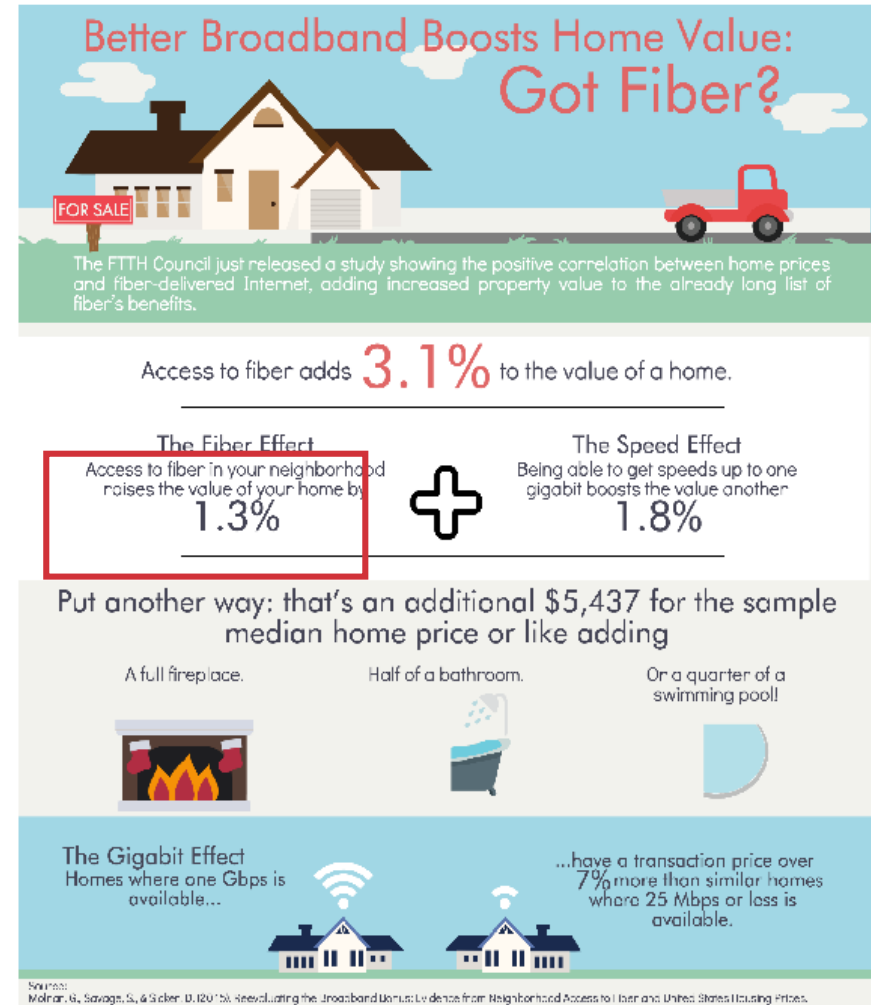
- Multiple studies linking fiber deployments to job growth
- Bandwidth enables...
  - Media development of all types
  - Language services
  - Technology development of all types
  - Telemedicine, education, etc.
  - “Aging at home”
- SOURCE: <http://www.bbpmag.com/Features/1116-Kill-App.php>



# FTTH increases home values

THE FIBER EFFECT  
Access to fiber in your neighborhood raises the value of your home by **1.3%**

SOURCE: FTTH COUNCIL INFOGRAPHIC





# Broadband - the amenity for MDU residents

- 2013/2015 US National Multifamily Housing Council survey
- High speed internet access is the most important amenity
- Renters will often pay more for a building with better broadband



## 2013 Apartment Resident Preferences Survey Executive Summary



### EXECUTIVE SUMMARY

#### RESIDENT PREFERENCES – APARTMENT FEATURES, COMMUNITY AMENITIES / ACTIVITIES

#### Resident Preferences:

Respondents were asked to indicate their interest level in a series of features, on a 1-5 scale where 1 = Not at all interested and 5 = Very interested. The list of items includes apartment features (e.g., granite countertops), community amenities (e.g., community-wide wireless internet) and community activities (e.g., ice cream social). The most highly rated features nationwide are: high speed internet access, patio / balcony, washer / dryer and garbage disposal. Below is a list of the top 20 areas (out of 47 total features) sorted by average score.

Figure 1

#	Category	Question	Average Score	% Interested / Very Interested (4s + 5s)
1	Apartment Features	Interest - High Speed Internet Access	4.64	93%
2	Apartment Features	Interest - Patio or Balcony	4.59	93%
3	Apartment Features	Interest - Washer / Dryer in Unit	4.55	88%
4	Apartment Features	Interest - Garbage Disposal	4.44	88%
5	Apartment Features	Interest - Microwave	4.40	85%
6	Apartment Features	Interest - Refrigerator With Water / Ice Dispenser	4.31	83%
7	Community Amenities	Interest - Fitness Center	4.31	84%
8	Apartment Features	Interest - Ceiling Fan	4.23	80%



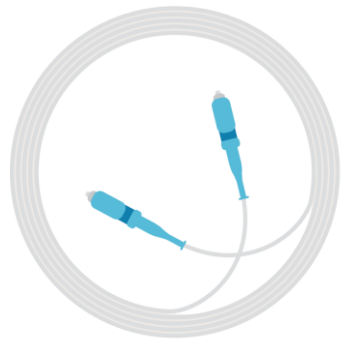
# Why Fiber?



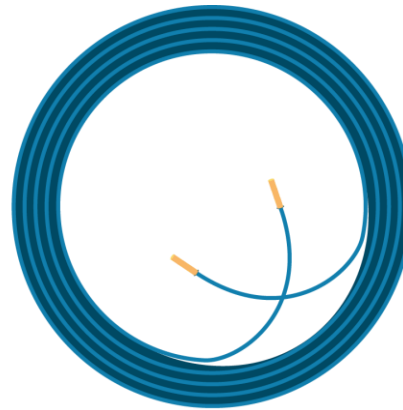
Fiber is simpler.



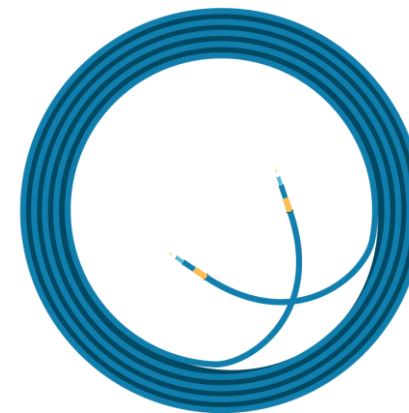
# Install one cable instead of two



*vs.*



*&*



**Fiber**  
TV & Voice & Data

**Coaxial**

**Copper**



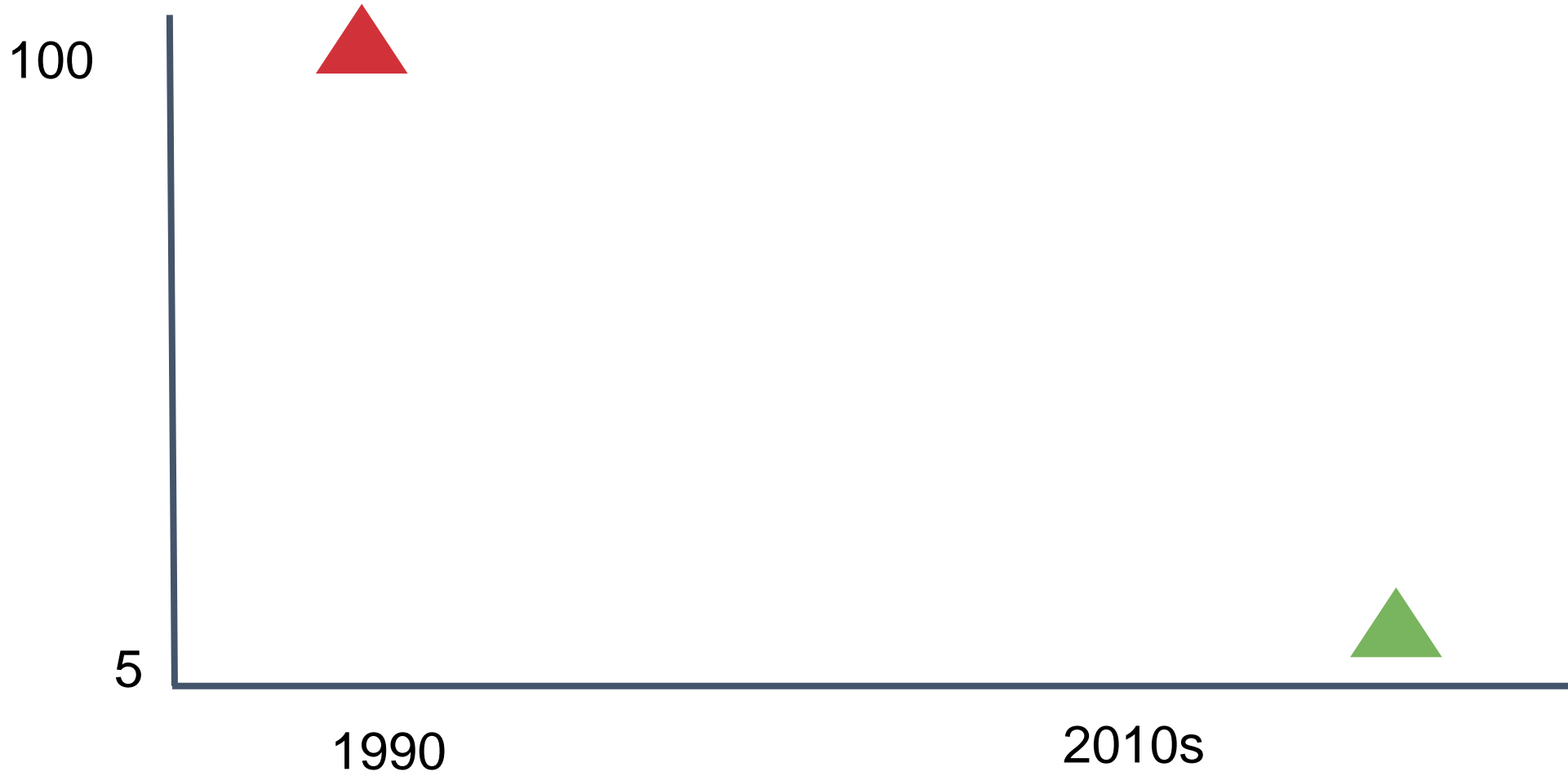
# Why Fiber?



Fiber is easier to install and less expensive.



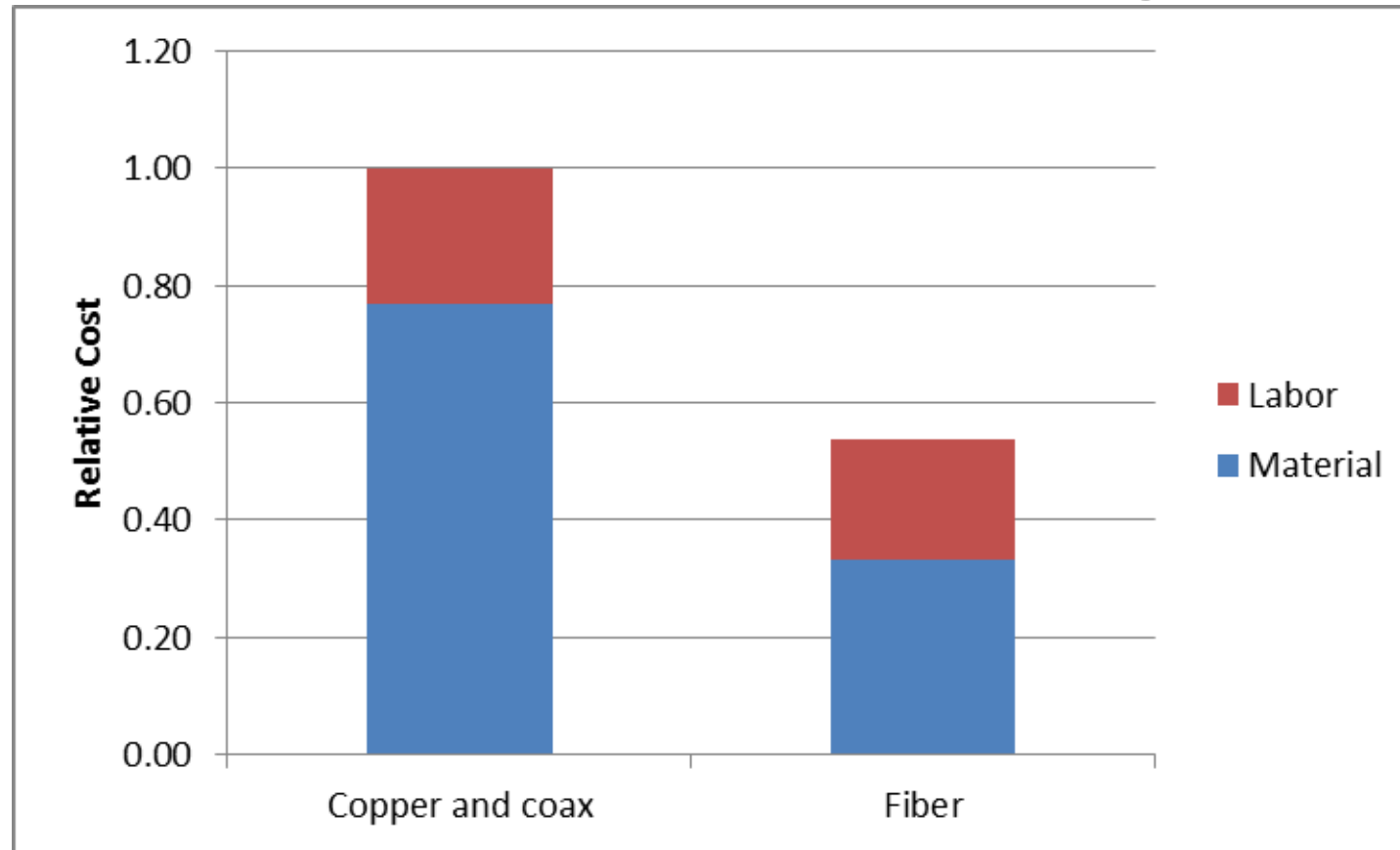
# Price of fiber



# Cost comparison



## Metal cables vs. fiber in a building

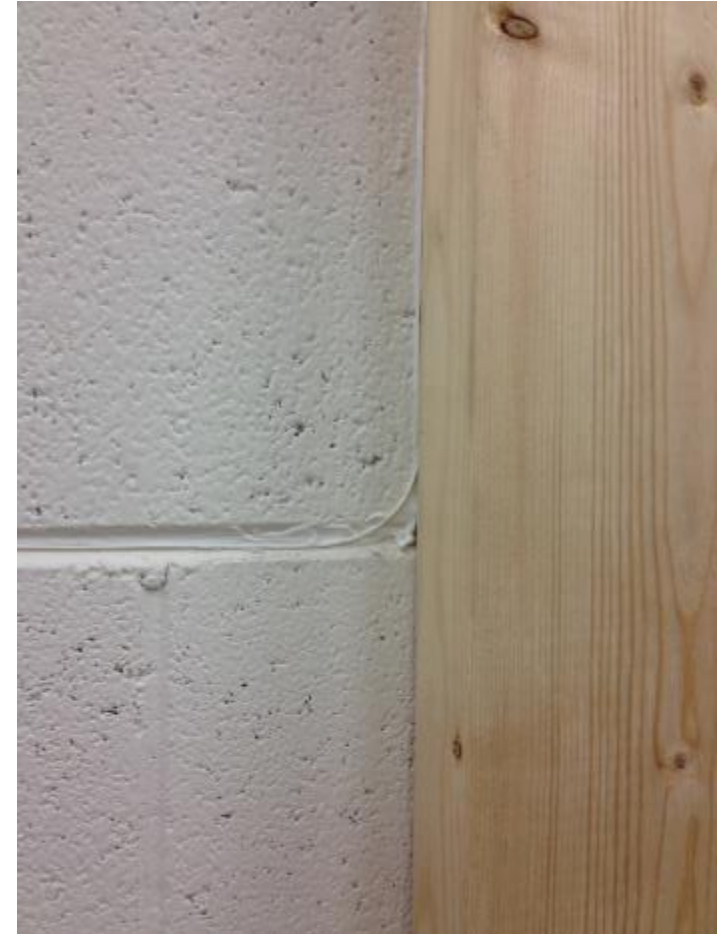




Fiber is less intrusive and easier to install.



# Fiber is less intrusive and easier to install





# Fiber is rugged and reliable



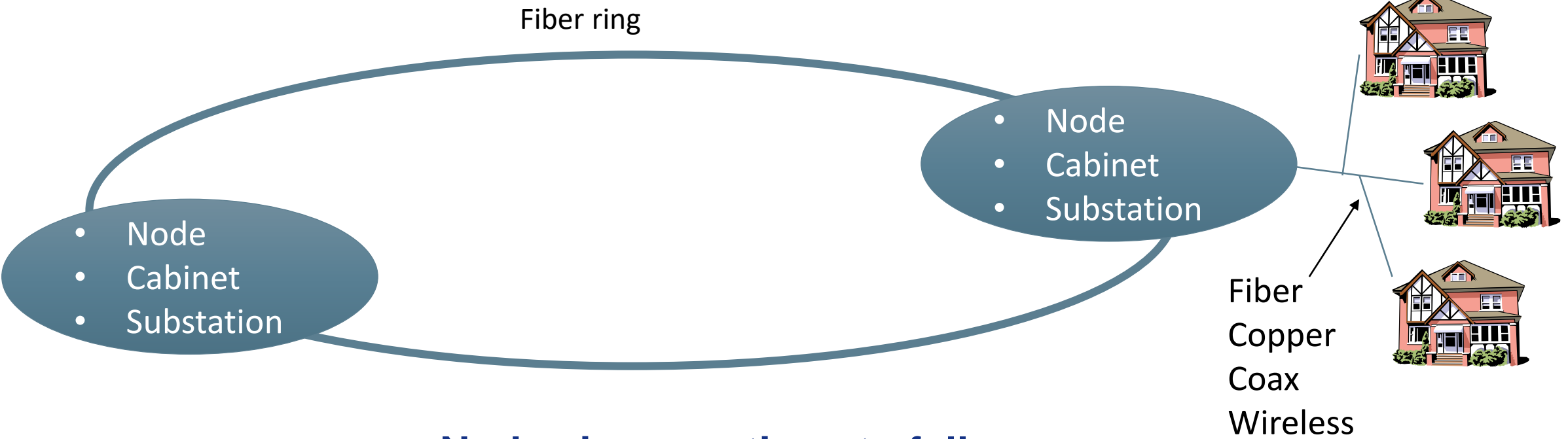
# Agenda



- Drivers for FTTH
- Why Fiber?
- **Fiber Feeds Everything**
- Nuts and Bolts - The Components
- Installation Techniques
- Network Architectures and Planning



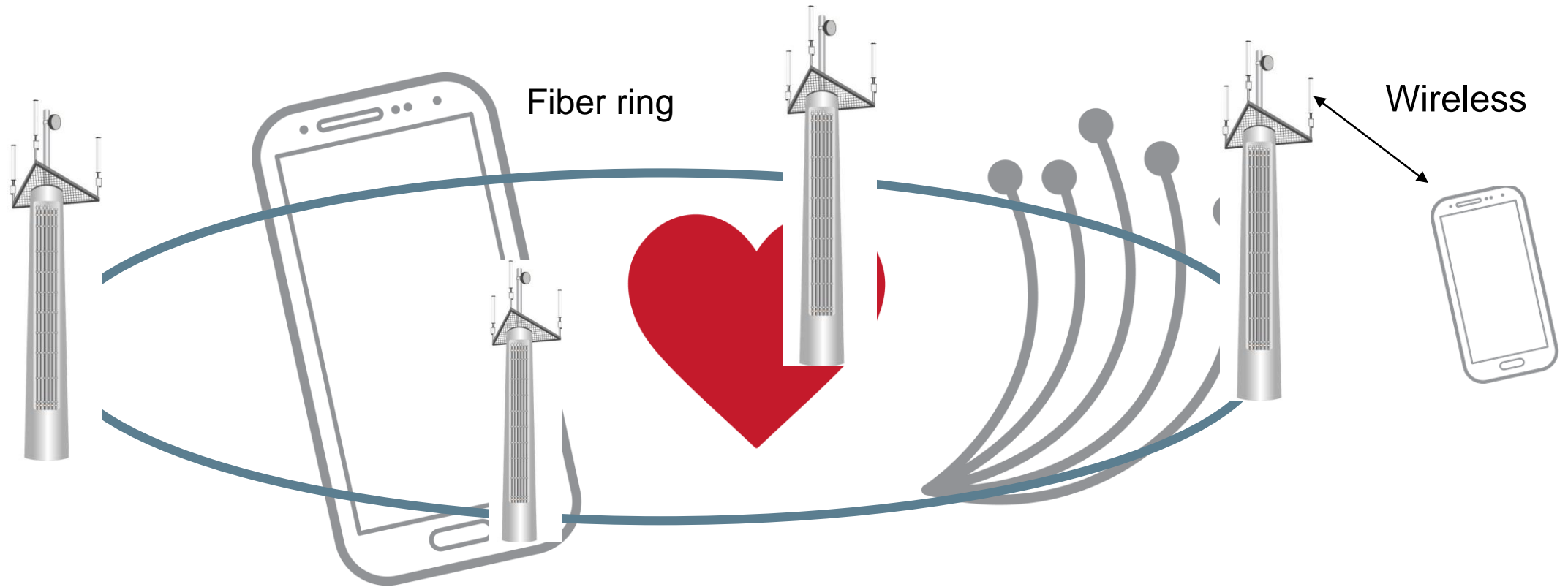
# Fiber - the core of most phone, cable, power networks



**Node sizes continue to fall**  
**FTTH = Node size = 1**



# Wireless loves fiber



*(and vice versa)*



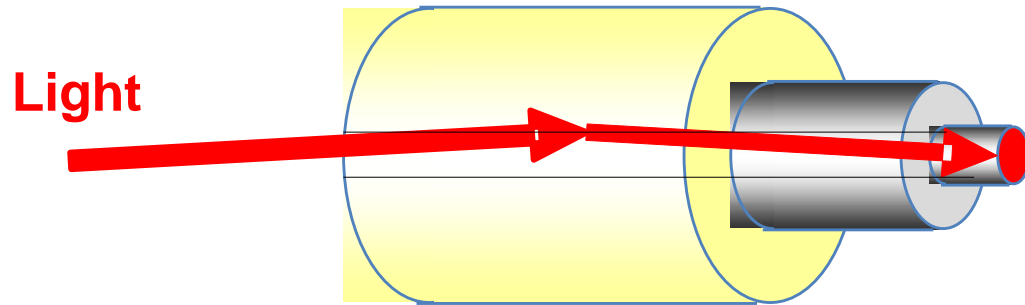
# Agenda



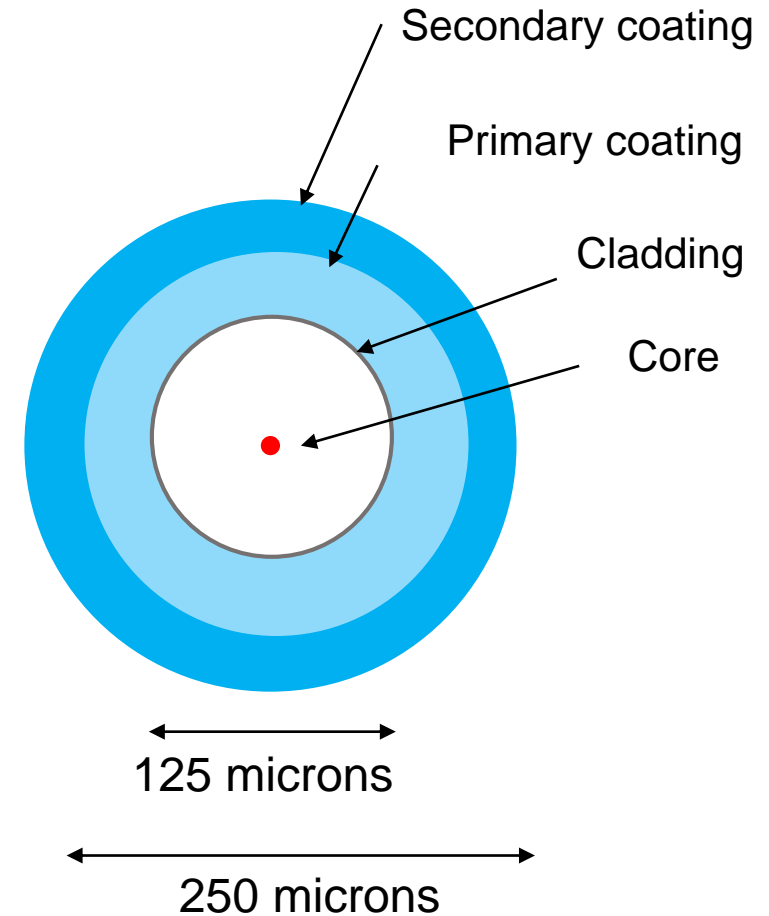
- Why Fiber?
- Fiber Feeds Everything
- **Nuts and Bolts - The Components**
- Installation Techniques
- Designing the OSP Network



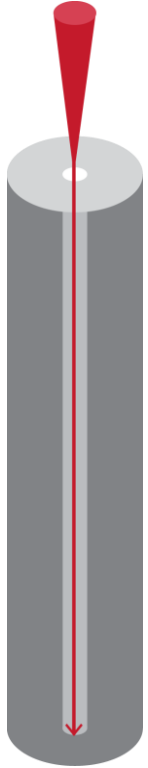
# Fiber Structure



- **Core** – Includes dopants
- **Cladding** - Outer layer of glass to contain light
  - Different index of refraction than core
- **Coating** - Cushions and protects fibers

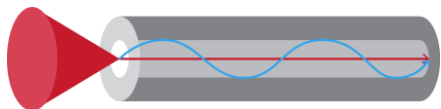


# Fiber types



## Single-mode Fiber

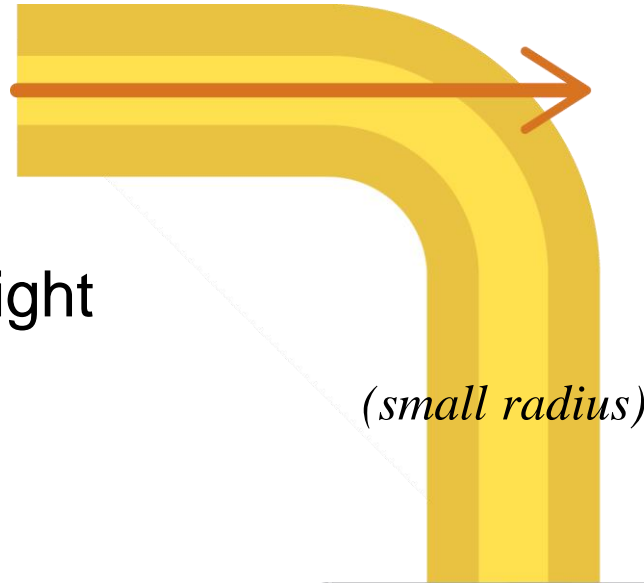
- Carries only one mode of light
- Used for FTTH



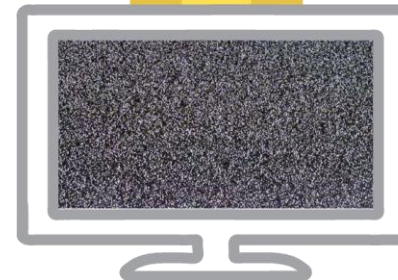
## Multimode Fiber

Carries multiple modes of light  
Not typically used in FTTH

Conventional Single-mode Fiber

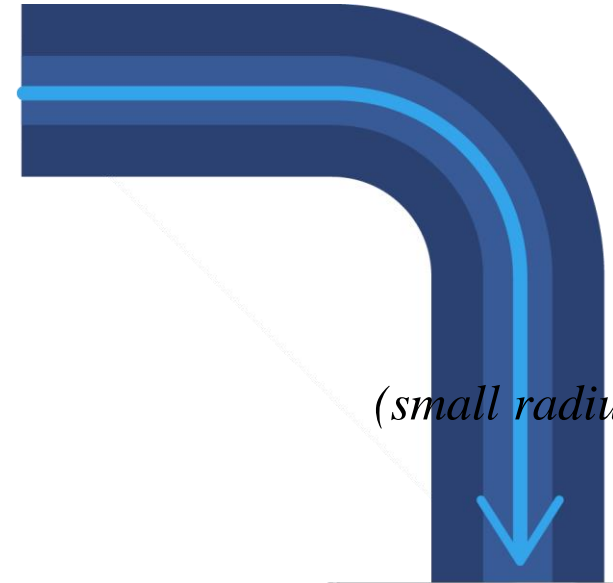


*(small radius)*

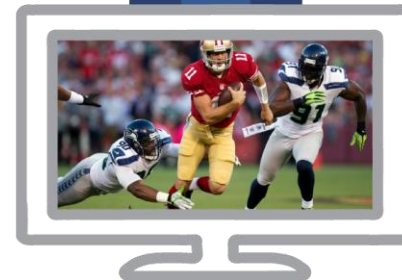


**SERVICE  
DISRUPTED**

Bend Insensitive Single-mode Fiber



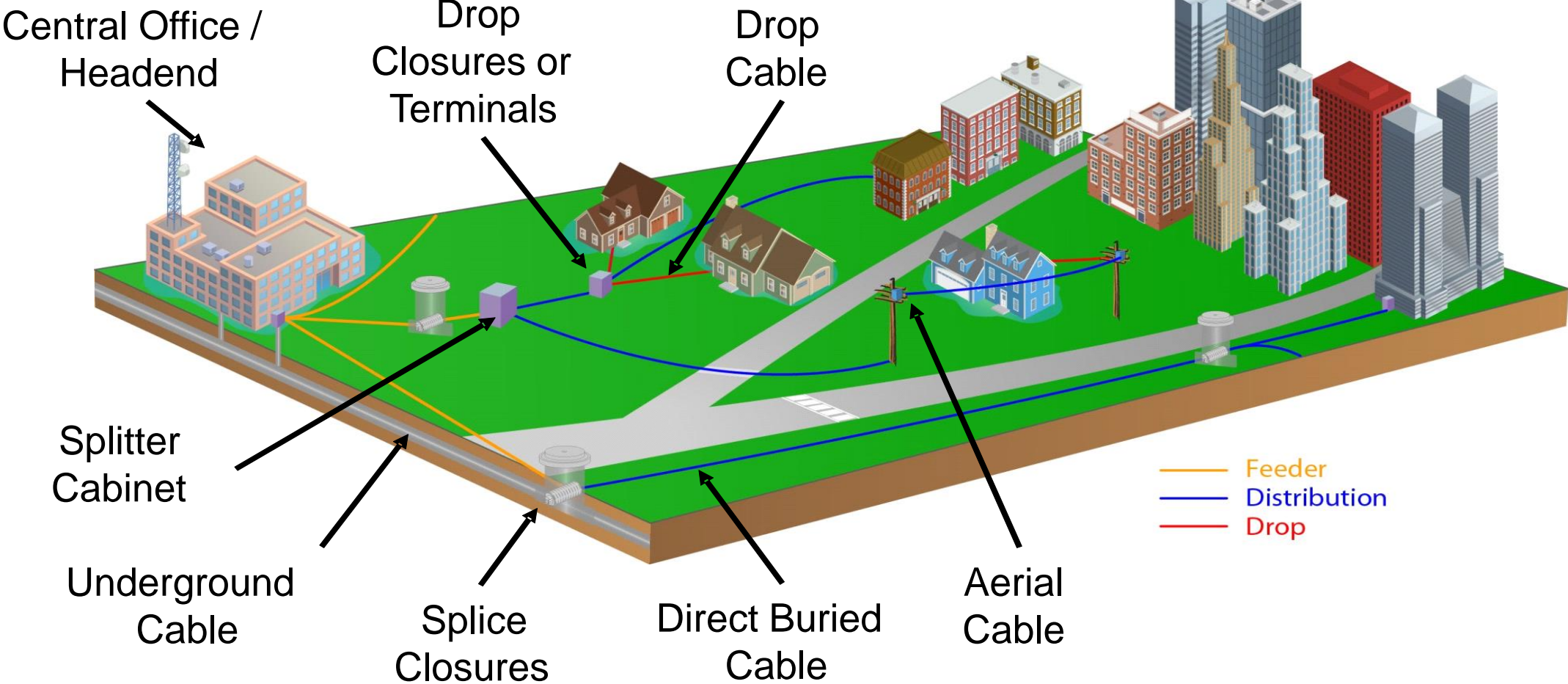
*(small radius)*



**SERVICE  
MAINTAINED**



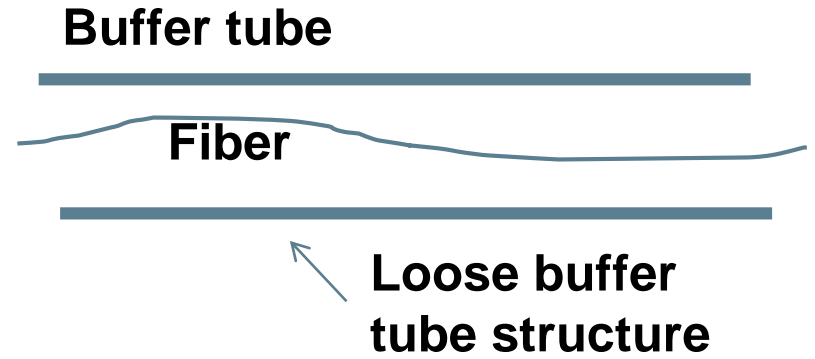
# FTTH Network Macro View



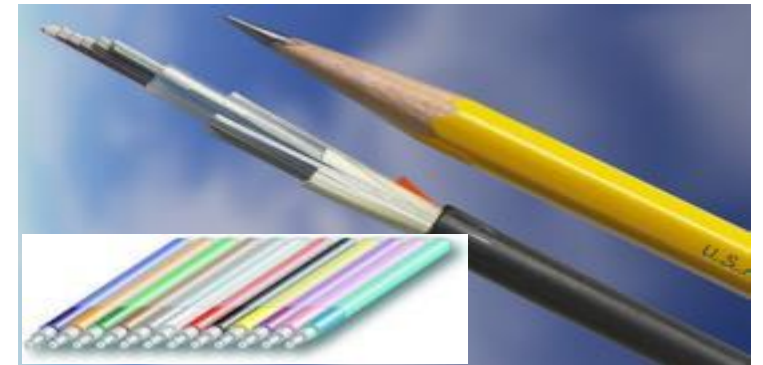


# Outside Plant Fiber Cable

- Most often “loose tube” cable structure
  - Fibers loose in buffer tubes
    - Handles stress/strain and temperature fluctuations and climatic extremes
  - Also available in ribbons
  - Fibers and buffers are color coded
- Underground applications
  - Direct buried or in duct
- Aerial applications
  - Lashed or self-supporting

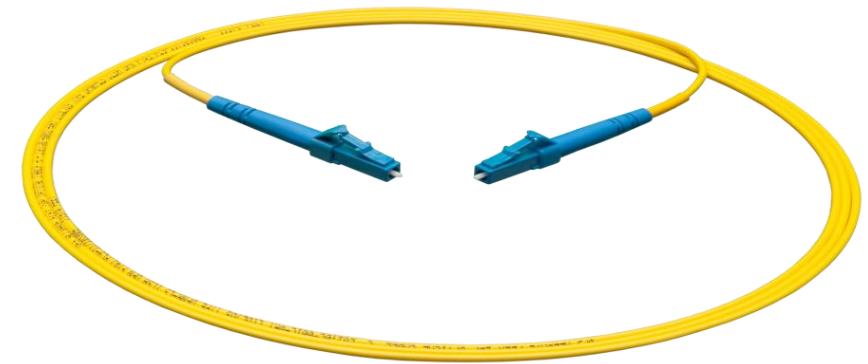
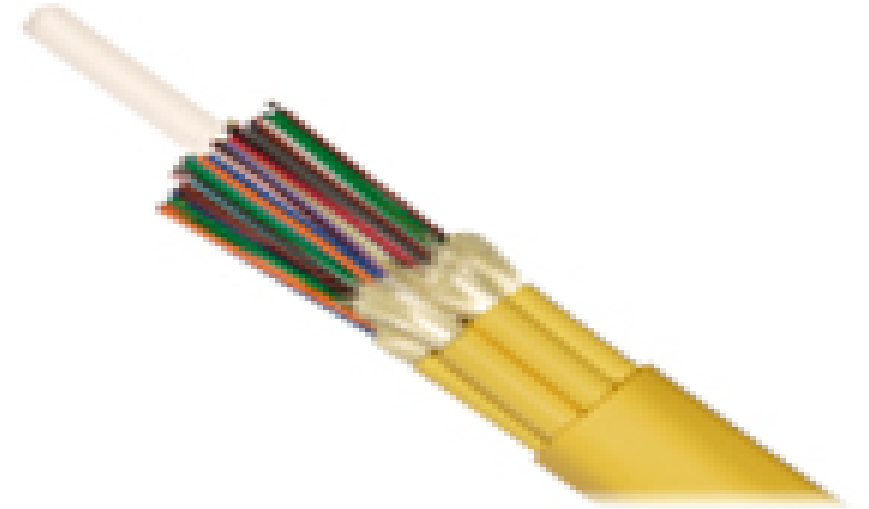


## Ribbon fiber and cable structure



# Inside Plant Fiber Cable

- Indoor cables can be different than outdoor cables
- Most often “tight buffer” cable structure
  - Provides additional protection for frequent handling and tight bends
  - Easier connectorization
- Multiple types of cable structures
- Riser, plenum, low smoke/zero halogen products
  - Designed to meet flame smoke ratings
- Some cables are indoor/outdoor hybrids



# Fiber Management Devices Closures, Terminals

- Fiber management devices are used in the central office or remote cabinets
- Closures are used in the field to connect cables and fibers
- Terminals are often used for the final drop to the home
- Multiple designs available for each component



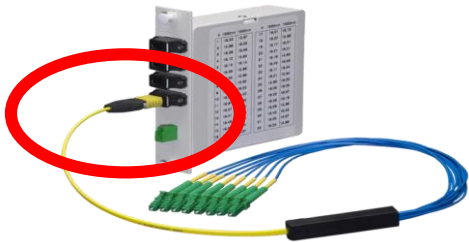
# Connectors and splitters



**SC Connector**



**LC Connector**



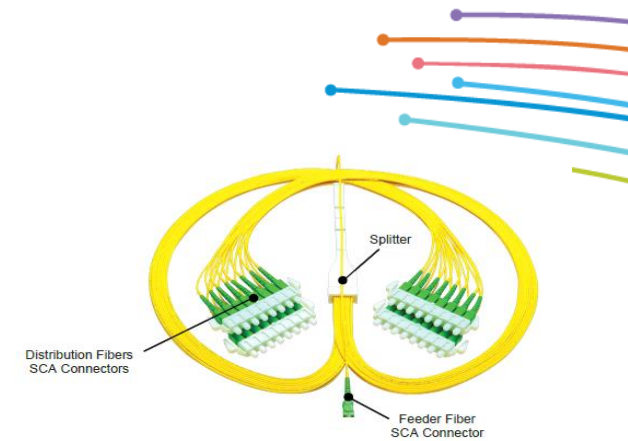
**MPO Connector  
(12 fiber ribbon  
connector)**

## Connectors

- “SC” and “LC” most common
- Color indicates polish (back reflection)
  - Blue = “Ultra” polish
  - Green = “Angle” polish

## Splitters

- Used with Passive Optical Network (PON) systems
- Used to split one fiber into multiple fibers
  - Decreases power
  - Splits bandwidth
- Split ratios are powers of 2
  - 1x2 to 1x64 (1x32 most common)



**Splitter**



**Splitter in splice tray**



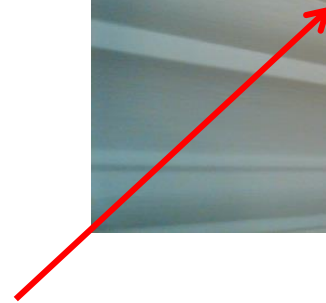
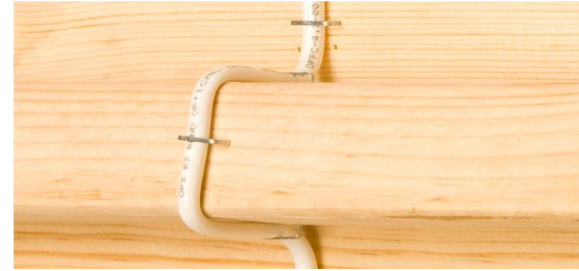
**Splitter Cabinet**



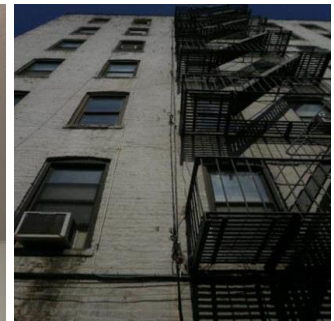
# MDU and in-home Deployments



- MDU and in-home installations are different than outside plant
- Most inside installations require tight bends and bend insensitive fibers
- Manufacturers have developed fibers and products for these applications



Fiber



# MDU and in-home Deployments



FIBER BROADBAND ASSOCIATION  
*Accelerating the Connected Future*

## Q: HOW DO I MAKE MY BUILDING FIBER-READY?

A: Guidelines from the **Fiber Broadband Association** to Facilitate Fiber Deployment in a Residential Building

**Fiber Broadband Association**

### FIBER TO THE MDU

FIBER BROADBAND ASSOCIATION

**50%** of new buildings built in 2016 include fiber to each living unit.

**100%** of new buildings should include fiber. Why?

**1** Fiber is future proof and able to meet rapidly increasing bandwidth needs.

Timeline of network technologies:

- MID 1900s: PHONE GRADE
- 1980s: CAT 3
- EARLY 1990s: CAT 5
- 1995: CAT 5E
- 1999: CAT 6
- 2002: CAT 6A
- 2009: CAT 6A
- 2016: CAT 8

\* Copper has required regular upgrading and is now reaching its limitations.

**FIBER** VIABLE AND COMPATIBLE since the early 1980s (100 Gbps+)

**2** Fiber is best: Quality of broadband increases residential property value.

**2.8%** Increase to Own

**8.0%** Increase to Rent

**MOST VALUED AMENITY**

www.fiberbroadband.org



# Agenda

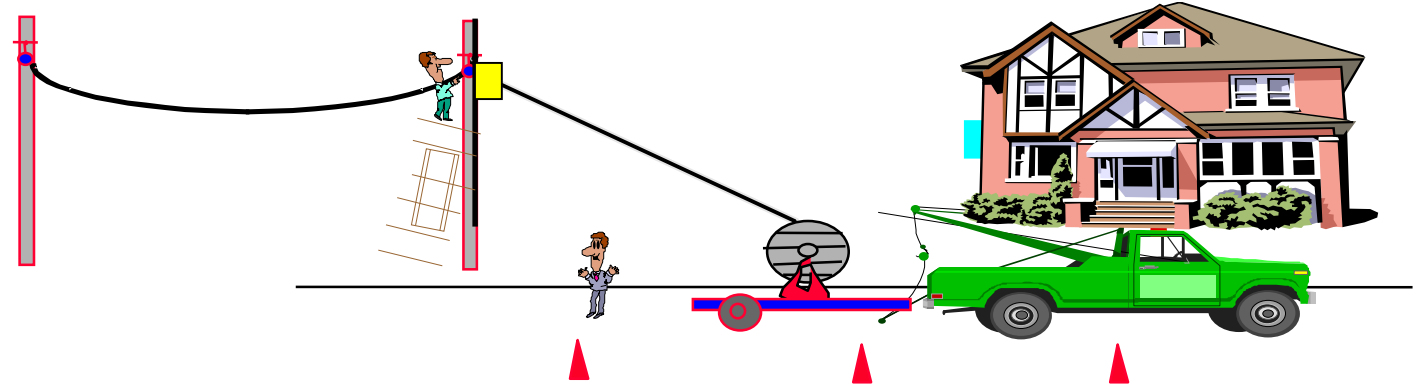
- Why Fiber?
- Fiber Feeds Everything
- Nuts and Bolts - The Components
- **Installation Techniques**
- Network Architectures and Planning



# OSP Cable Placement Options

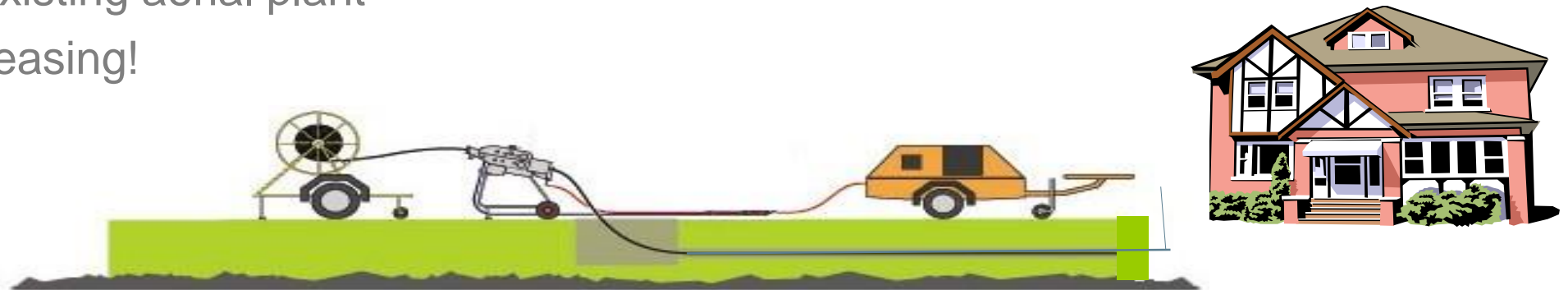
## Aerial

- Fast, minimal restoration time
- Typical choice for overbuilding existing aerial plant



## Below Grade

- Required if no existing aerial plant
- Aesthetically pleasing!





# Splicing

## Fusion

- Most common type of splice
- Fibers joined together and melted at approximately 1600 degrees C

## Mechanical

- Common overseas
- Less common in US FTTH installations

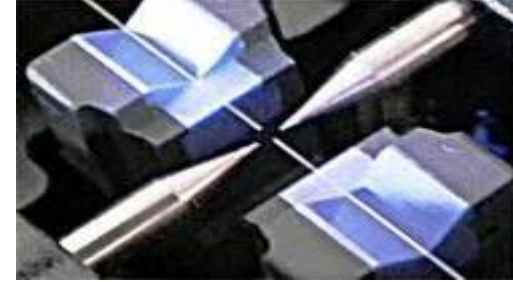


Illustration of electrodes used to form fusion splicing arc



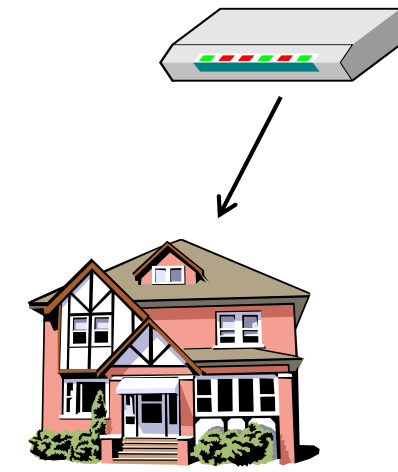
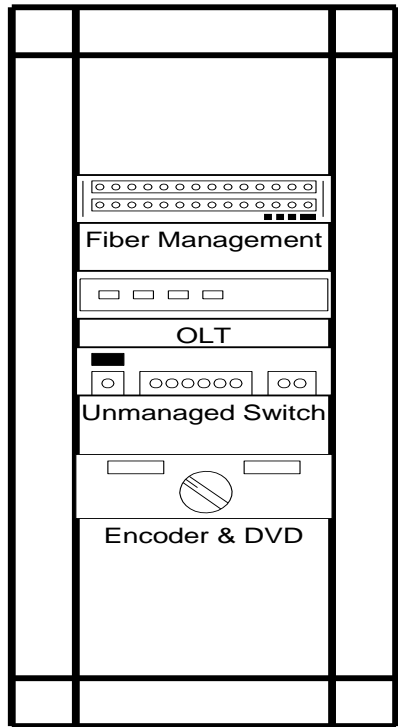
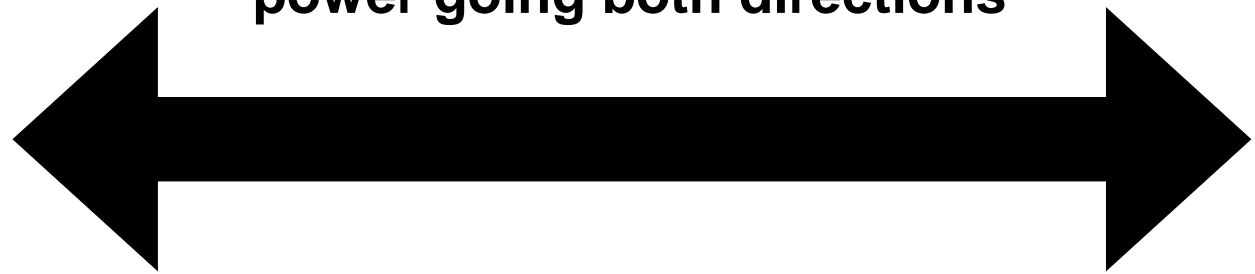
Splice sleeve to cover completed splice



# Optical Loss Budget



Designers must ensure adequate optical power going both directions



Component	Typical loss values @ 1550 nm
Fiber	0.2 dB/km
Splices	0.05 dB
Connectors	0.2 dB
Splitters (1x32)	17-18 dB



# Agenda



- Why Fiber?
- Fiber Feeds Everything
- Nuts and Bolts - The Components
- Installation Techniques
- **Network Architectures and Planning**

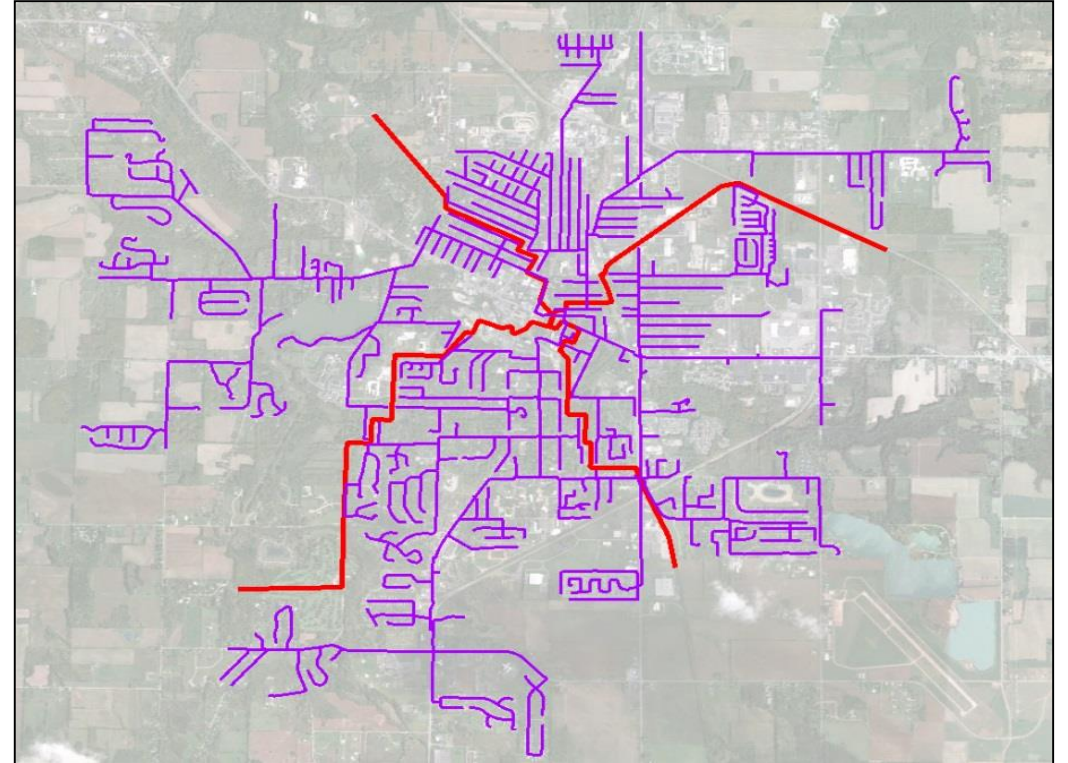


# FTTX Network Planning

## Establish Ultimate Network Plan

### Network Plan Objectives

- Reduce installed costs
- Increase speed of network build
- Increase return on investment
  - Target network segments based on ROI
- Streamline build cost estimation process



### Example Network Plan

Cable route design for 10k premise network



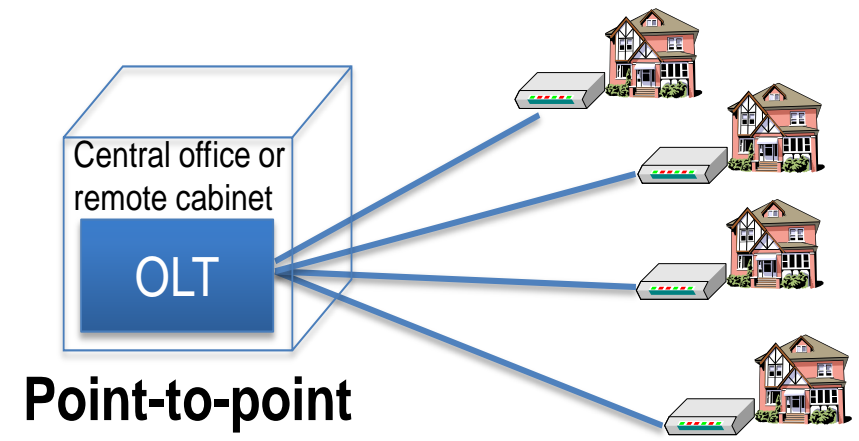
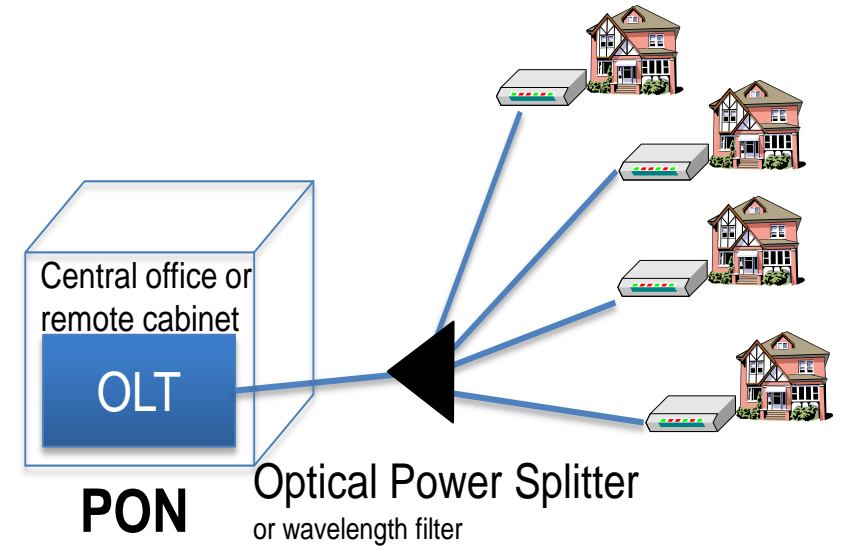
# Typical FTTH Architectures

## PON (Passive Optical Network)

- Uses a signal divider, such as an optical power splitter
- One fiber at the central office feeds many fibers in the field
- G-PON (Gigabit PON) and GE-PON (Gigabit Ethernet-PON) are the most common architectures

## Point-to-Point (“Active Ethernet”)

- One fiber in the head end = one fiber in the field



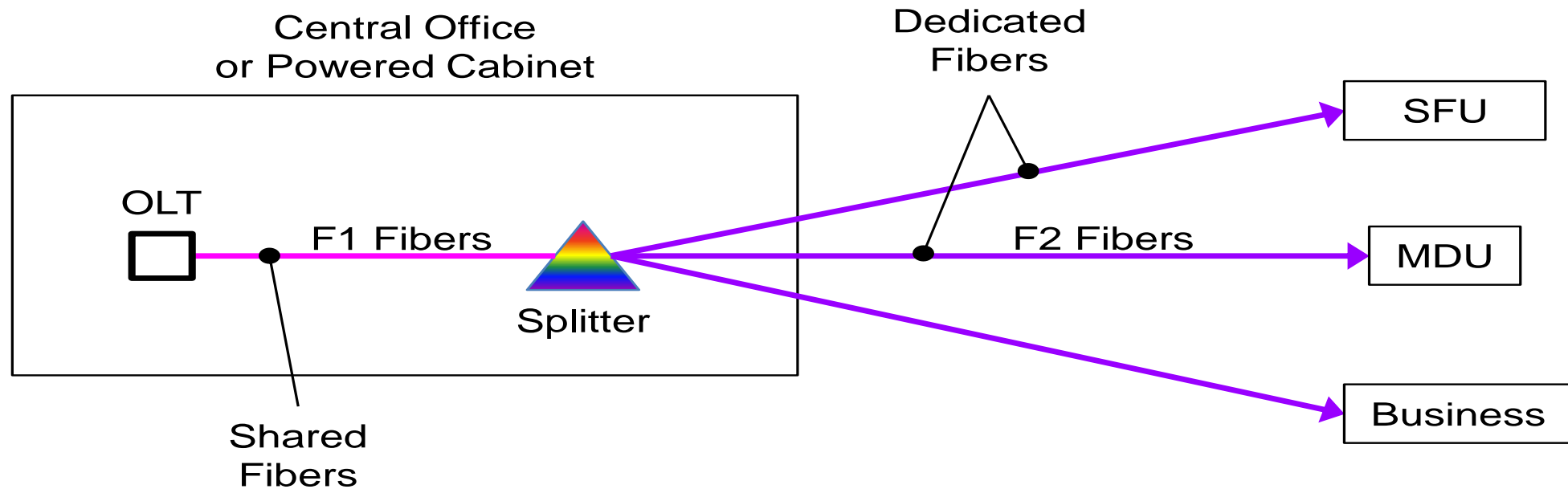
# FTTX Architectures



	GPON		GE-PON		Point to Point (Active Ethernet)
	GPON	XGS-PON	GE-PON	10G-EPON	
Downstream Bandwidth	2.4 Gbps total	10 Gbps total	1.2 Gbps total	10 Gbps total	100 -1000 Mbps per sub
Upstream Bandwidth	1.2 Gbps total	10 Gbps total	1.2 Gbps total	10 Gbps total	100 -1000 Mbps per sub
Typical distance	20 km	20 km	20 km	20 km	20 km
Wavelengths (nm), Downstream Upstream	1490 1310	1577 1270	1550 1310	1577 1270	1550 1310



## PON - Central Office Splitting

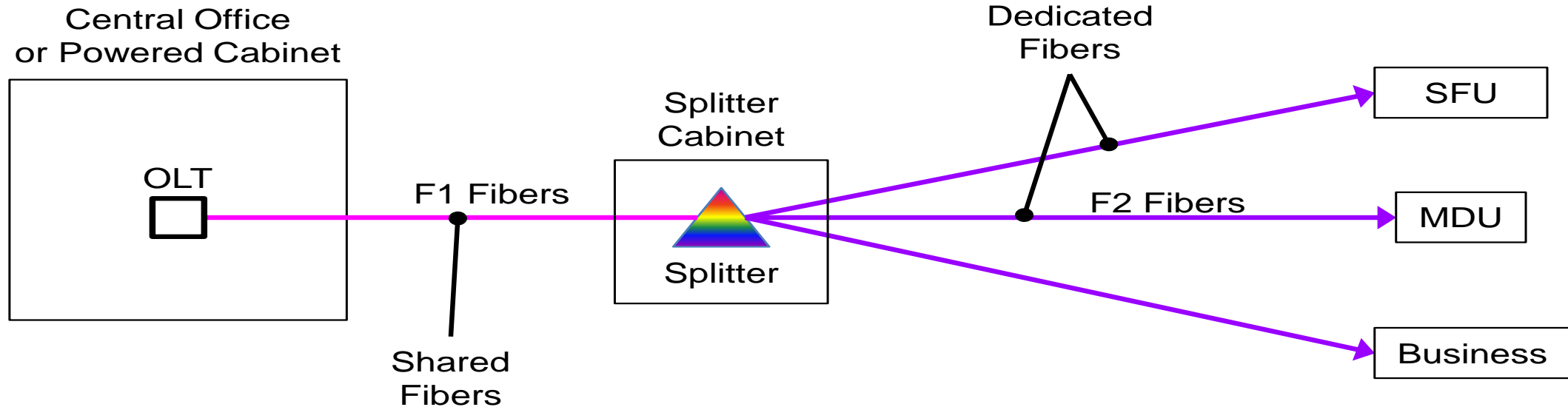


- Requires largest cables and most splicing
- Maximizes OLT port utilization
- Utilized in dense urban deployments



# FTTX Architectures

## PON - Cabinet Splitting



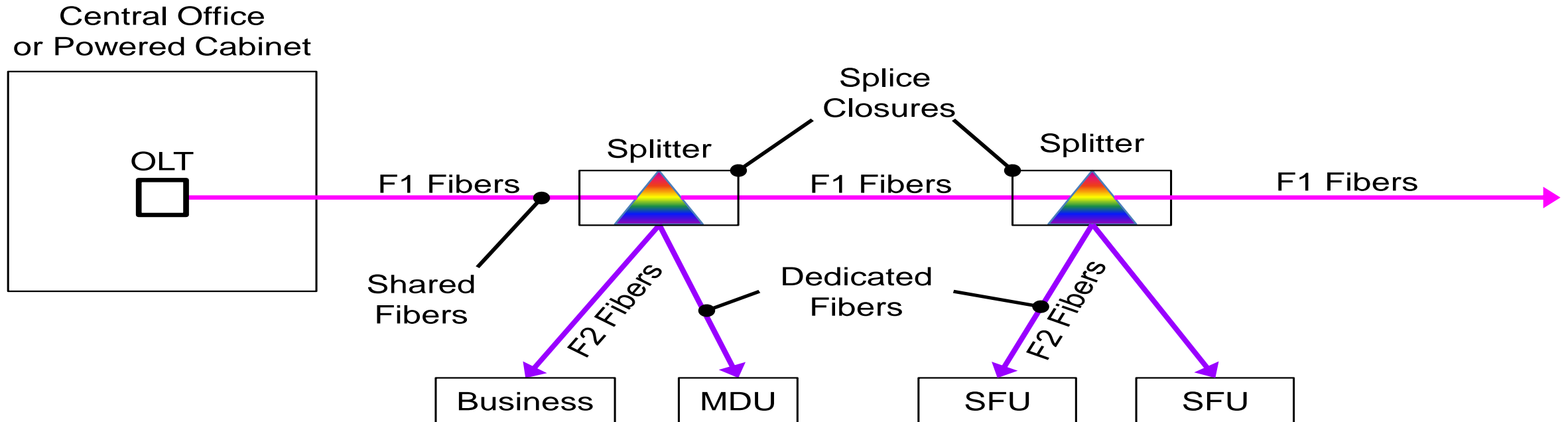
- **Closely resembles copper networks**
  - Cross connect cabinets
- **Most common method of deployment in U.S.**





# FTTX Architectures

## PON - Distributed Splitting

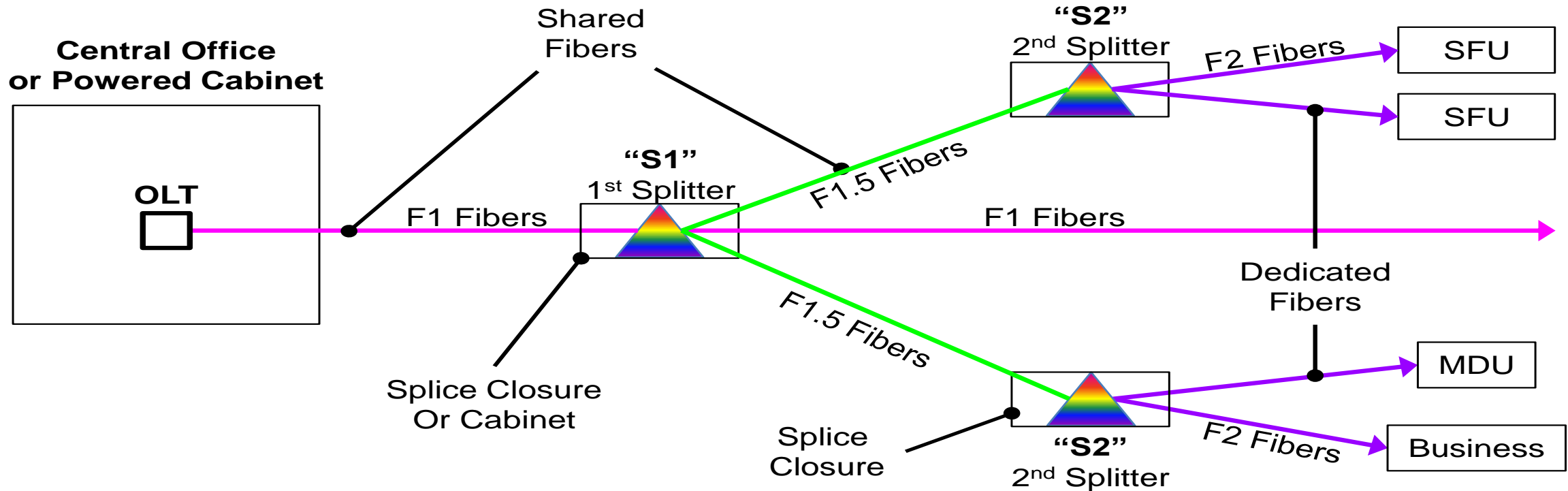


- **Greatly reduces cable sizes and splicing**
- **Requires more OLT ports than CO or cabinet splitting**
  - Typical break-even take rate is 20-25%



# FTTX Architectures

## PON - Cascaded Splitting



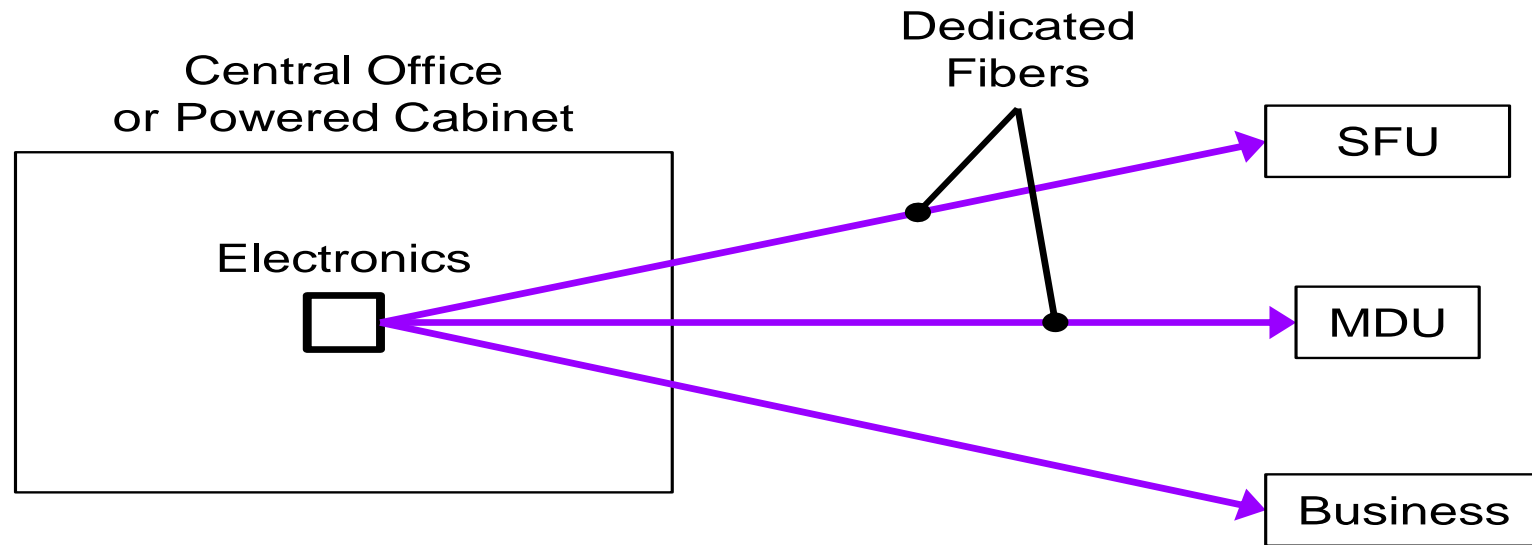
- **Minimizes cable sizes and splicing**
- **Ideal for rural deployments**



# FTTX Architectures



## Active Ethernet (Active E) or Point-to-point (P2P)



- Requires largest cables and most splicing
- Highest cost of electronics per customer
- Maximum bandwidth per customer



# FTTX Architectures



## Distributed / Cascaded Splitting vs CO / Cabinet Splitting

<b>Advantages</b>	<ol style="list-style-type: none"><li>1. Significantly reduces cable sizes</li><li>2. Significantly reduces splicing requirements</li><li>3. Eliminates need for splitter cabinets<ul style="list-style-type: none"><li>• Associated permitting</li></ul></li></ol>
<b>Disadvantages</b>	<ol style="list-style-type: none"><li>1. 100% splitter installation<ul style="list-style-type: none"><li>• Initial as opposed to incremental</li></ul></li><li>2. 100% OLT port installation<ul style="list-style-type: none"><li>• Initial as opposed to incremental</li></ul></li></ol>

### Typical break-even take rate is 20-25%

- Greater than 25% - distributed / cascaded more economical
- Less than 20% - CO / cabinet more economical



# Summary



- New technologies require bandwidth, which requires fiber
- Fiber is the best method for providing low cost, high bandwidth services
  - Fiber is future proof
  - Fiber drives economic development and attracts residents
  - Fiber is simpler
  - Fiber is less expensive and easy to install
- Fiber architectures include multiple types of PON and point-to-point
- Multiple ways of deploying FTTH
  - OSP design decisions have significant impacts on network build costs



Tim Locker  
CBM, Inc.  
515-231-7904  
[timl@cbmrep.com](mailto:timl@cbmrep.com)



**ofs**

*A Furukawa Company*

