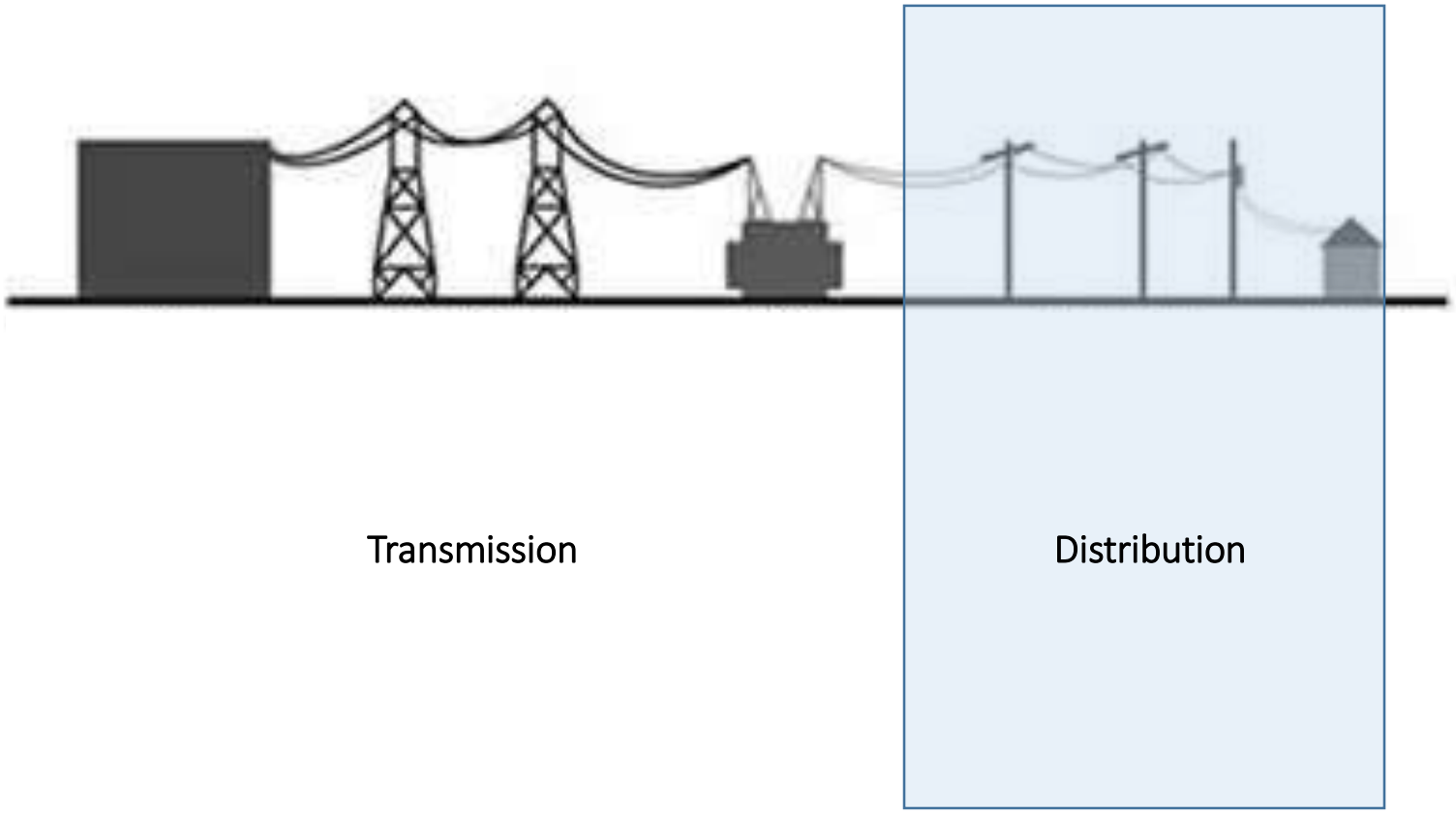
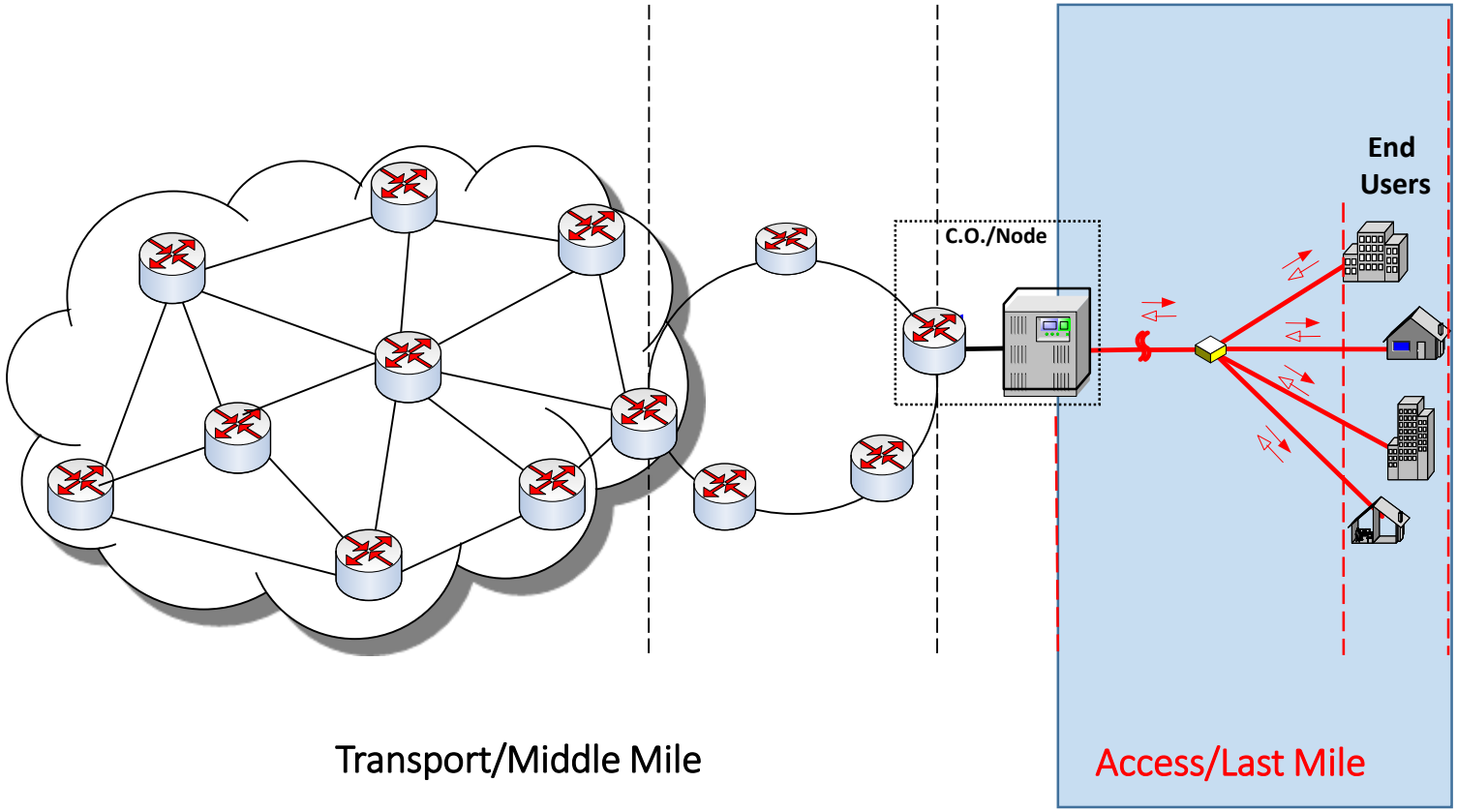
Distribution Architectures and Standards

Robert Schafer
September 30, 2015

Electrical Architecture

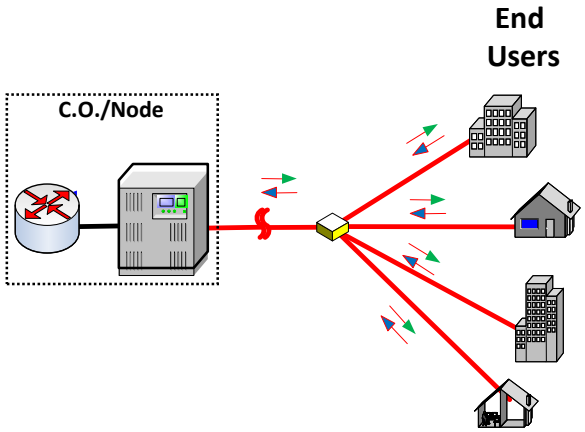


Communications Network Architecture



Passive Optical Network (PON)

- Uses a Point to Multipoint (PMP) topology
- From “Central Office”/Node’s Optical Line Terminal (OLT), a single fiber goes out to a passive splitter where signal is divided onto multiple fibers
- Transmit and receive directions on different wavelengths
  - Example: Upstream 1310nm and Downstream 1490nm
- Powered Optical Network Terminal (ONT) (aka., Optical Network Unit) at each endpoint
- Splitter ratios vary by technology and network design



PON Splitters

- PON splitters are 1X32 or some smaller number of splits in binary sequence (2, 4,8, 16)

- Splitters add considerable loss to an FTTH link, limiting the link distance. Following are typical losses for various split ratios:

Splitter Ratio	Typical Loss (dB)
1:2	4
1:4	7
1:8	11
1:16	15
1:32	19


YINGDA TECHNOLOGY LIMITED
ISO 9001
CE
RoHS

How do PONs work?

- Transmitting downstream
  - The OLT broadcasts all traffic to every ONT
  - Each ONT only reads packet content addressed to it
  - Encryption is used to prevent eavesdropping
- Transmitting upstream
  - OLT controls all ONT transmissions/arbitration protocol
  - Popular methods are:
    - TDM timeslot arrangement
    - Pre-scheduled packet allocation
    - Bandwidth allocation

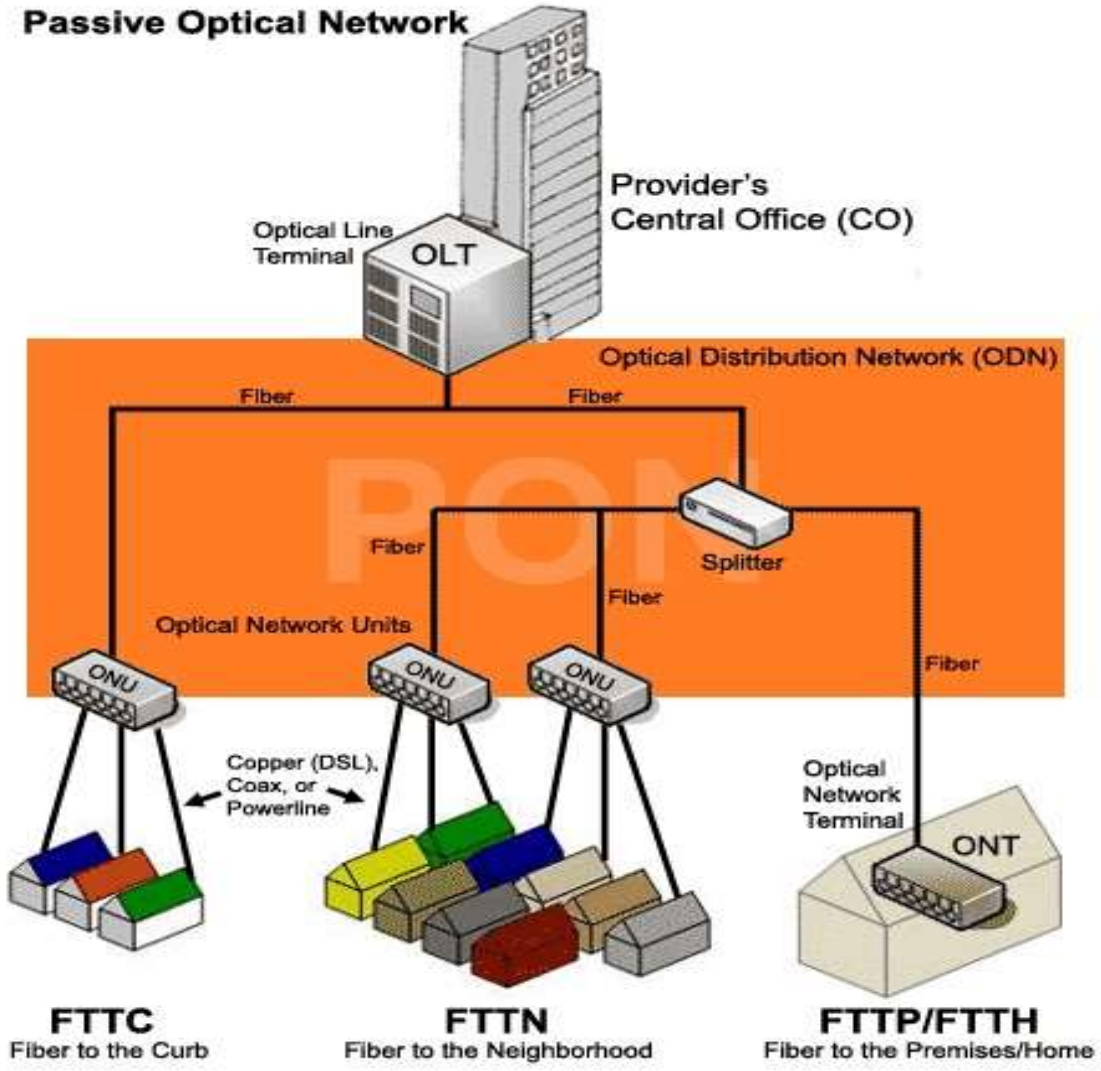
How do PONs work?

- "Ranging" difficulties
  - OLT must coordinate all ONT upstream transmission into proper timeslots
  - Physical delay from each ONT measured and figured into "offset"
    along with timeslot assignment to avoid collisions
  - Misbehaving ONT can impact entire upstream transmission
  - Aging optical components may cause drift requiring OLT monitoring
- Operating speeds, frame formats, optical interface specifications, etc. depend on the type of PON

PON Types (aka, FTTx)

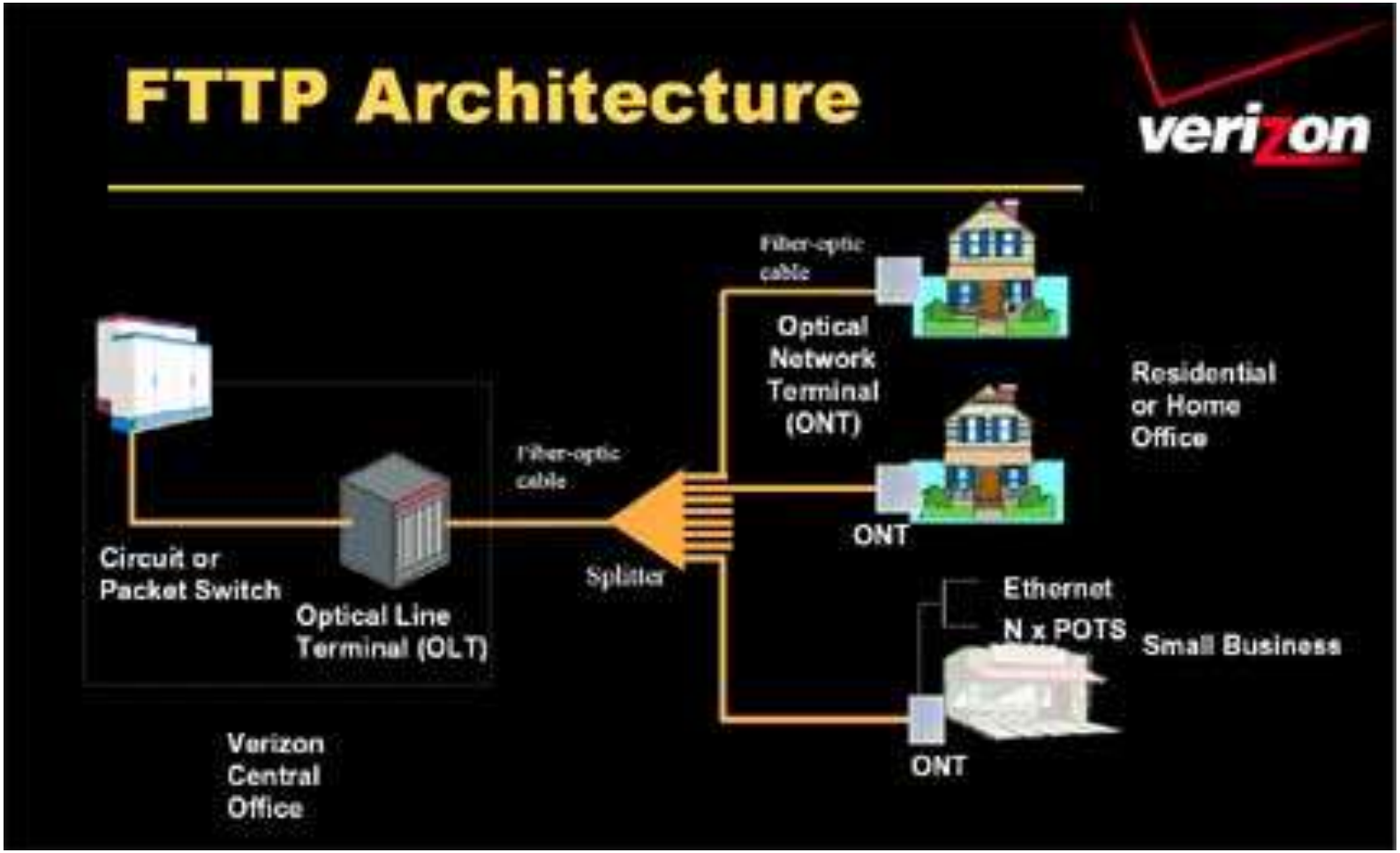
- FTTx is general term used to describe the penetration of optical fiber into the last mile network
- Possible to use P2P links to reach end users **or** a PON based PMP topology. Most current FTTx deployments use PON
- The ‘x’ in FTTx stands for different things based on how close the fiber terminates to end user

PON Types (aka, FTTx)




ZHONE
WPS
RESET
USB
POTS1
POTS2
GE1
GE2
GE3
GE4
UPS
PWR
ON/OFF

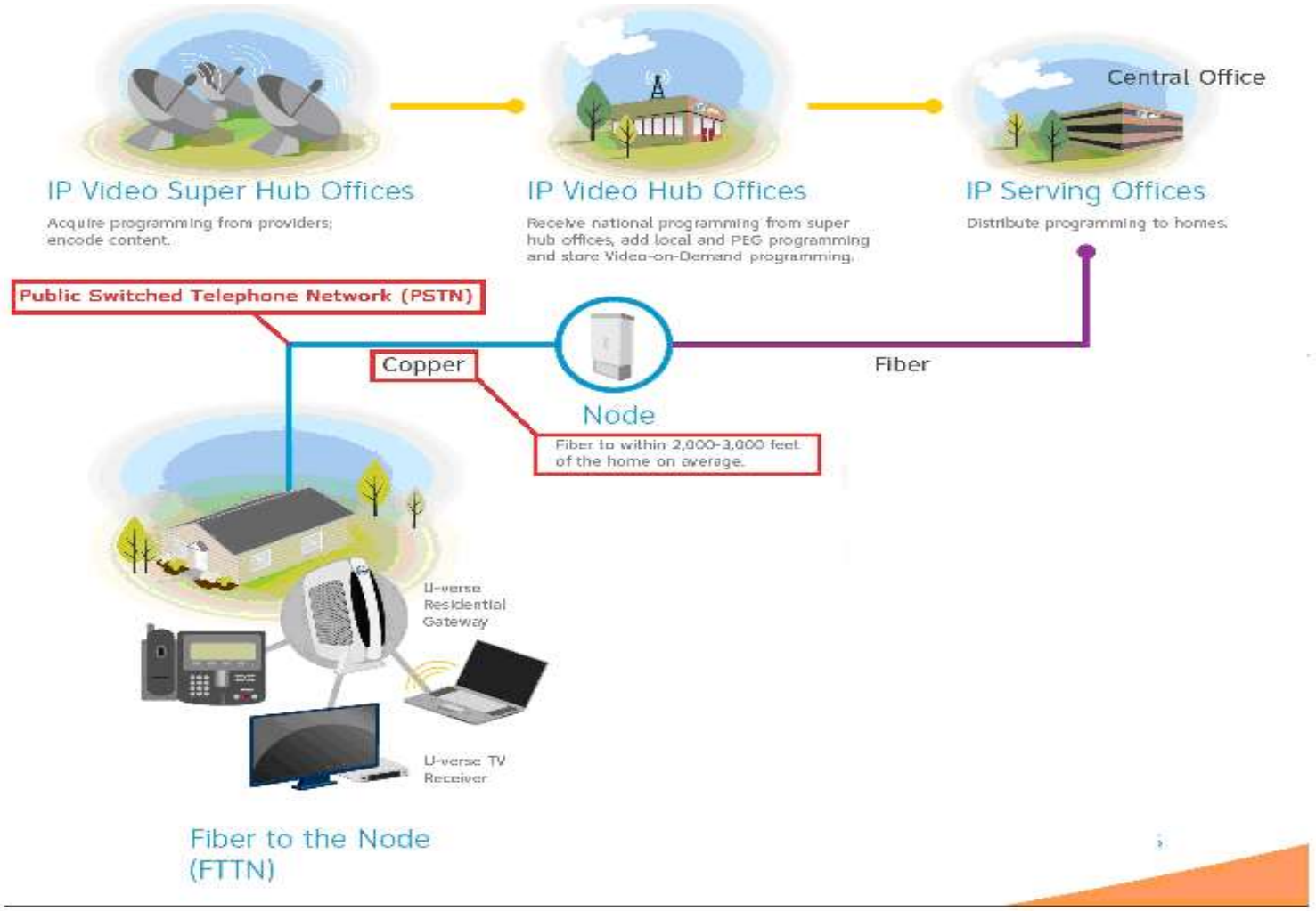
Verizon Fios©

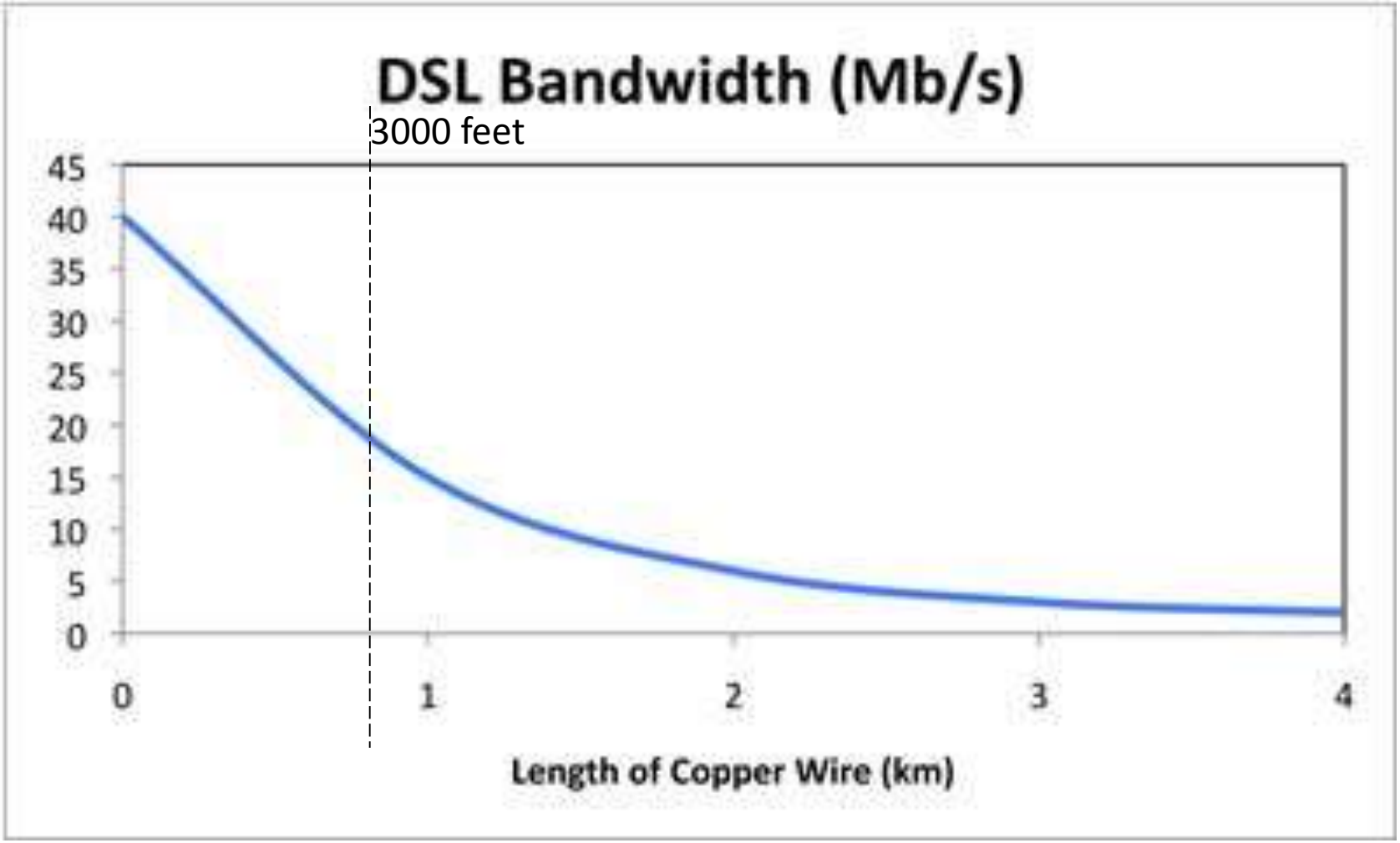



Vancouver
Victoria
MONTANA
NORTH DAKOTA
MINNESOTA
Minneapolis
SOUTH DAKOTA
WISCONSIN
MICHIGAN
Quebec City
Ottawa
Montreal
MAINE
VERMONT
Toronto
Milwaukee
Detroit
Chicago
IDAHO
WYOMING
IOWA
NEBRASKA
Salt Lake City
Denver
United States
NEVADA
UTAH
COLORADO
KANSAS
ILLINOIS
OHIO
MISSOURI
WEST VIRGINIA
KENTUCKY
Sacramento
San Francisco
San Jose
CALIFORNIA
Las Vegas
Nashville
TENNESSEE
OKLAHOMA
Albuquerque
ARKANSAS
NORTH CAROLINA
Charlotte
ARIZONA
Phoenix
NEW MEXICO
MISSISSIPPI
Atlanta
SOUTH CAROLINA
ALABAMA
GEORGIA
Tucson
El Paso
BAJA CALIFORNIA
SONORA
Austin
San Antonio
LOUISIANA
New Orleans
Jacksonville
CHIHUAHUA
COAHUILA
Monterrey
Miami
Gulf of Mexico
BAJA CALIFORNIA SUR
SINALOA
DURANGO


verizon
verizon
verizon

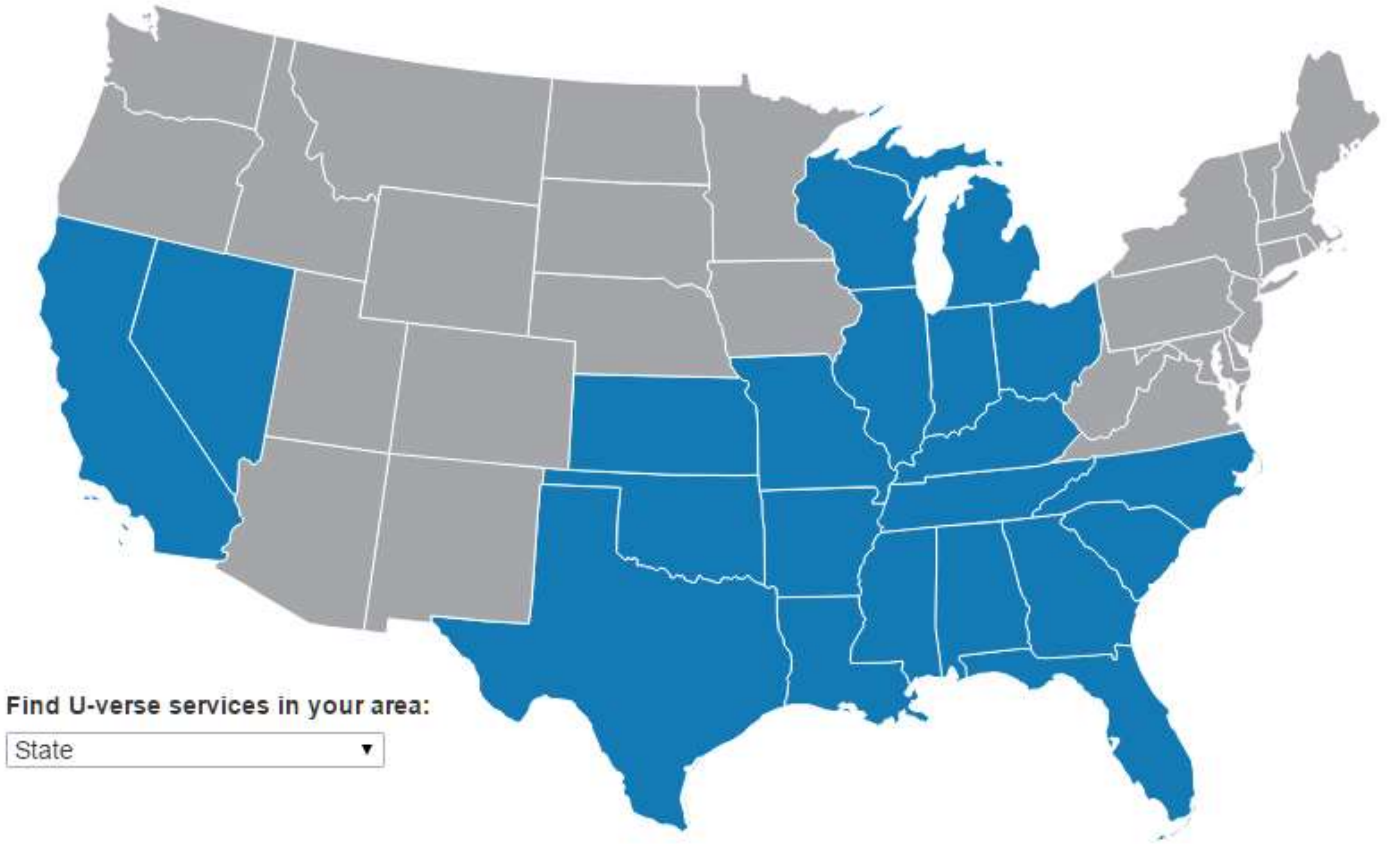
AT&T U-Verse©


IP Video Super Hub Offices
Acquire programming from providers; encode content.
IP Video Hub Offices
Receive national programming from super hub offices, add local and PEG programming and store Video-on-Demand programming.
Central Office
IP Serving Offices
Distribute programming to homes.
Public Switched Telephone Network (PSTN)
Copper
Fiber
Node
Fiber to within 2,000-3,000 feet of the home on average.
U-verse Residential Gateway
U-verse TV Receiver
Fiber to the Node (FTTN)


DSL Bandwidth (Mb/s)
3000 feet
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
Length of Copper Wire (km)

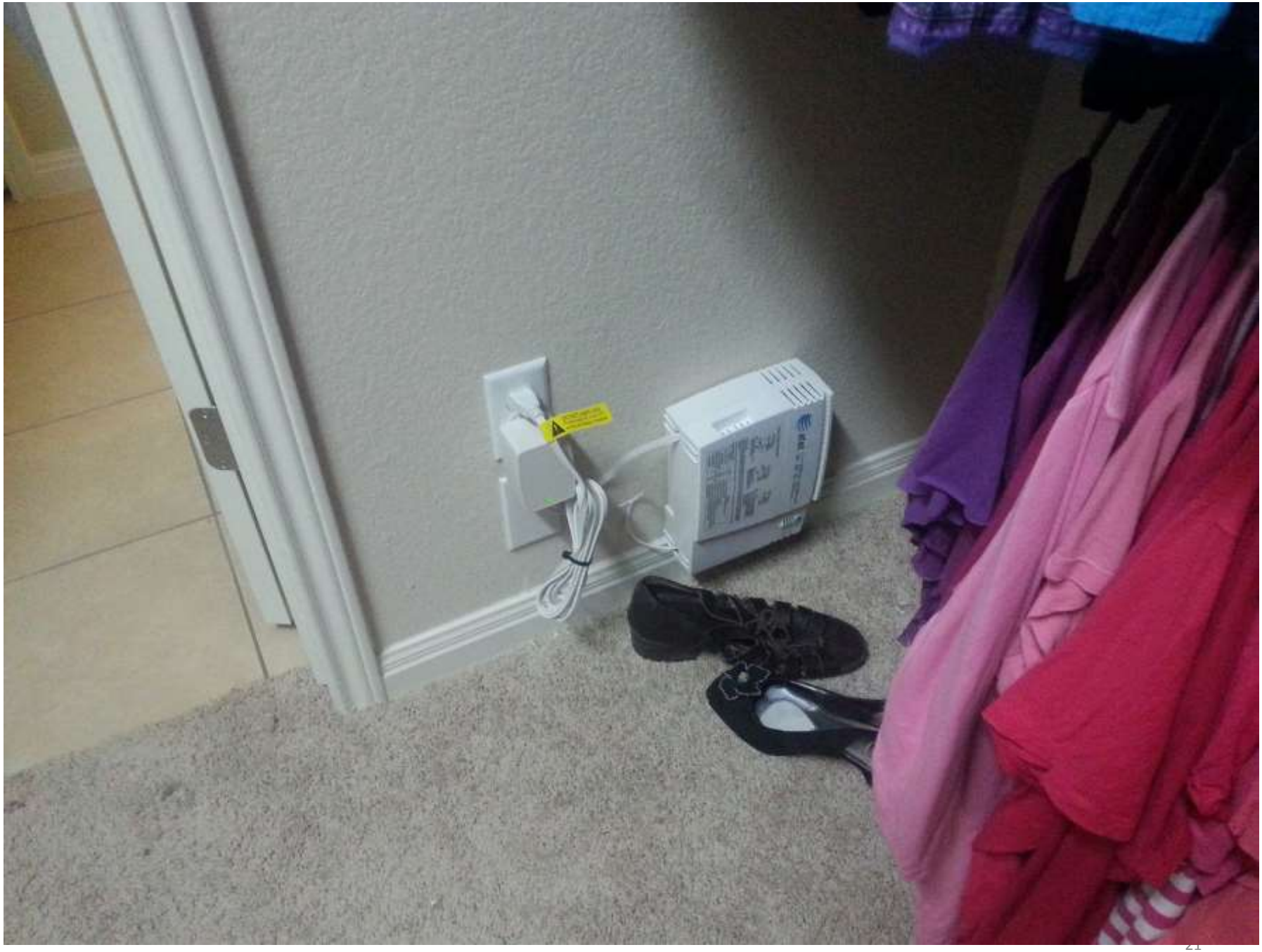
Find out which AT&T U-verse® services are available in your area.

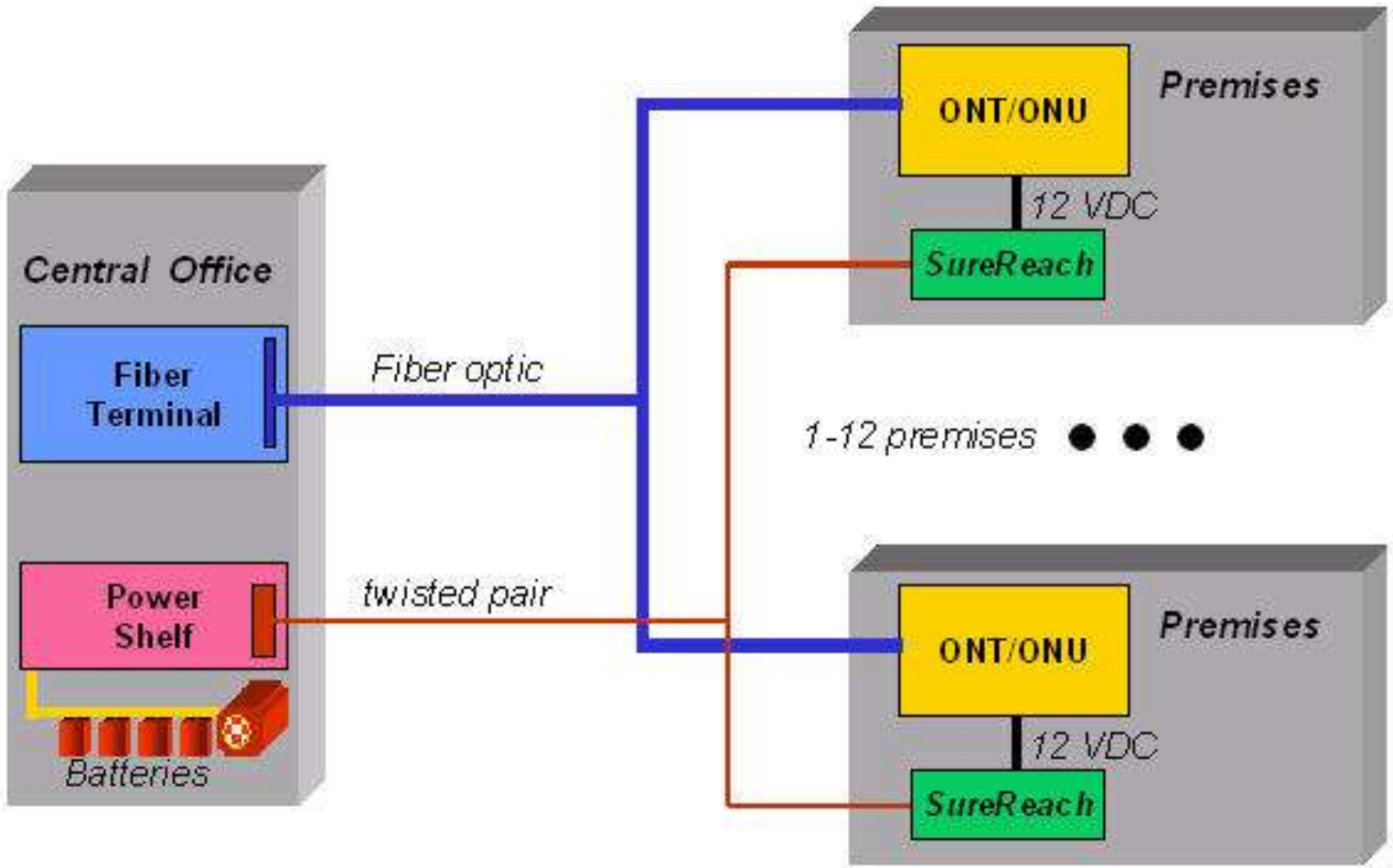
Check availability by selecting a state (blue) on the map or from the drop down below.



Find U-verse services in your area:

State ▾




Central Office
Fiber Terminal
Power Shelf
Batteries
Fiber optic
twisted pair
ONT/ONU
12 VDC
SureReach
Premises
1-12 premises
ONT/ONU
12 VDC
SureReach
Premises

Passive Optical Network Evolution

G-PON (Gigabit-capable PON)

XG-PON (10 Gigabit capable PON)

NG-PON2 (40 Gigabit capable PON)

[aka, TWDM-PON]

G-PON (Gigabit-capable PON)

• UPLINK	1.244 Gbps
• DOWNLINK	2.488 Gbps
• MAX SPLIT RATIO	128:1
• YEAR STANDARDIZED	2004
• OPTICAL	One SM fiber Down 1490 nm Up 1310 nm

G-PON (Gigabit-capable PON)

- System defined in the Recommendation ITU-T G.984 series
  - ITU-T G.984.1: System requirements
  - ITU-T G.984.2: PMD specifications
  - ITU-T G.984.3: TC specifications
  - ITU-T G.984.4: OMCI - Subsumed by ITU-T G.988
    - Now used for all ITU PONs and P2P systems
  - ITU-T G.984.5: WDM matters for the future
  - ITU-T G.984.6: Reach extension
  - ITU-T G.984.7: Long reach
- Widely Deployed
- Standards considered stable and mature
- Minor optional enhancements continue

XG-PON (10 Gigabit capable PON)

• UPLINK	2.488 Gbps
• DOWNLINK	10 Gbps
• MAX SPLIT RATIO	256:1
• YEAR STANDARDIZED	2012
• OPTICAL	One SM fiber
	Down 1260-1280 nm
	Up 1575-1580 nm

XG-PON (10 Gigabit capable PON)

- System defined in the Recommendation ITU-T G.987 series
  - ITU-T G.987: Definitions, abbreviations and acronyms
  - ITU-T G.987.1: General requirements
  - ITU-T G.987.2: Physical media dependent (PMD) layer specification
  - ITU-T G.987.3: Transmission convergence (TC) layer specification
  - ITU-T G.987.4: Reach extension
- ITU-T G.988 = Management and control interface

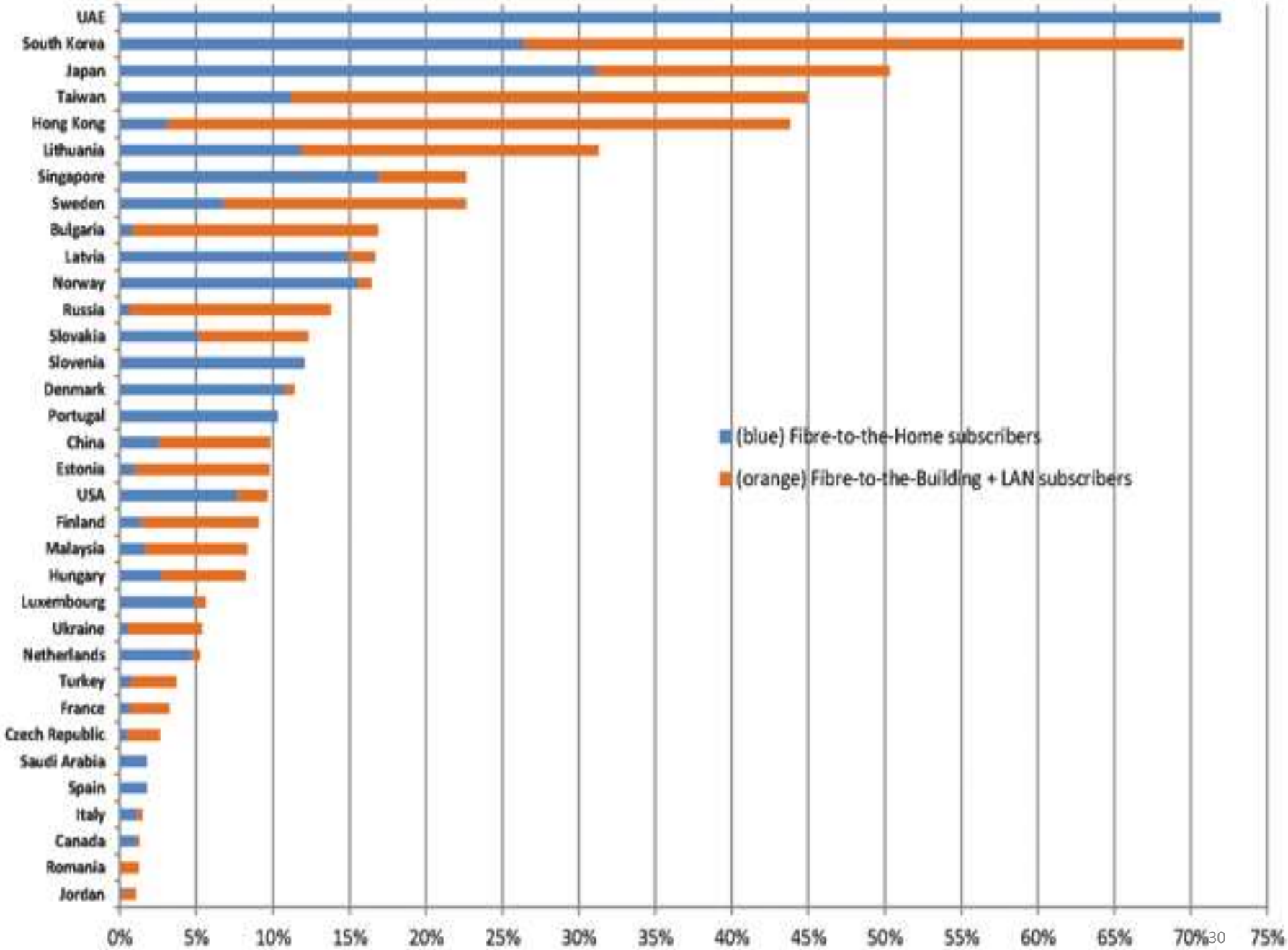
NG-PON2 (40 Gigabit capable PON)

[aka, TWDM-PON]

• UPLINK	40 Gbps
• DOWNLINK	40 Gbps
• MAX SPLIT RATIO	64:1
• YEAR STANDARDIZED	2014/2015
• OPTICAL	One SM fiber
	Down 4ㅅx 10g
	Up 4ㅅx 10g

XG-PON2 (40 Gigabit capable PON)
[aka, TWDM-PON]

- System defined in the Recommendation ITU-T G.989 series
  - ITU-T G.989 : Definitions and conventions
  - ITU-T G.989.1: General requirements
  - ITU-T G.989.2: Physical media dependent (PMD) layer specification
  - ITU-T G.989.3: Transmission convergence (TC) layer specification
    - Based on G.987.3, with wavelength control and 10G upstream added
  - ITU-T G.multi = Wavelength control layer
    - Meant as a general framework for TWDM-systems, of which G.989 is one
  - ITU-T G.984.5 = Wavelength coexistence
- ITU-T G.988 = Management and control interface
  - Standard in force, can be easily reused for TWDM


UAE
South Korea
Japan
Taiwan
Hong Kong
Lithuania
Singapore
Sweden
Bulgaria
Latvia
Norway
Russia
Slovakia
Slovenia
Denmark
Portugal
China
Estonia
USA
Finland
Malaysia
Hungary
Luxembourg
Ukraine
Netherlands
Turkey
France
Czech Republic
Saudi Arabia
Spain
Italy
Canada
Romania
Jordan
(blue) Fibre-to-the-Home subscribers
(orange) Fibre-to-the-Building + LAN subscribers
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%

Deployment

- Issues to consider
  - Vendor choices?
  - Migration path to higher speeds?
  - Connectorized cabling vs fusion splicing?
  - In-house vs. contracted labor?