Total Access 5000

Gigabit Passive Optical Network

GPON Overview

What is a PON?

Passive – no electronics in OSP

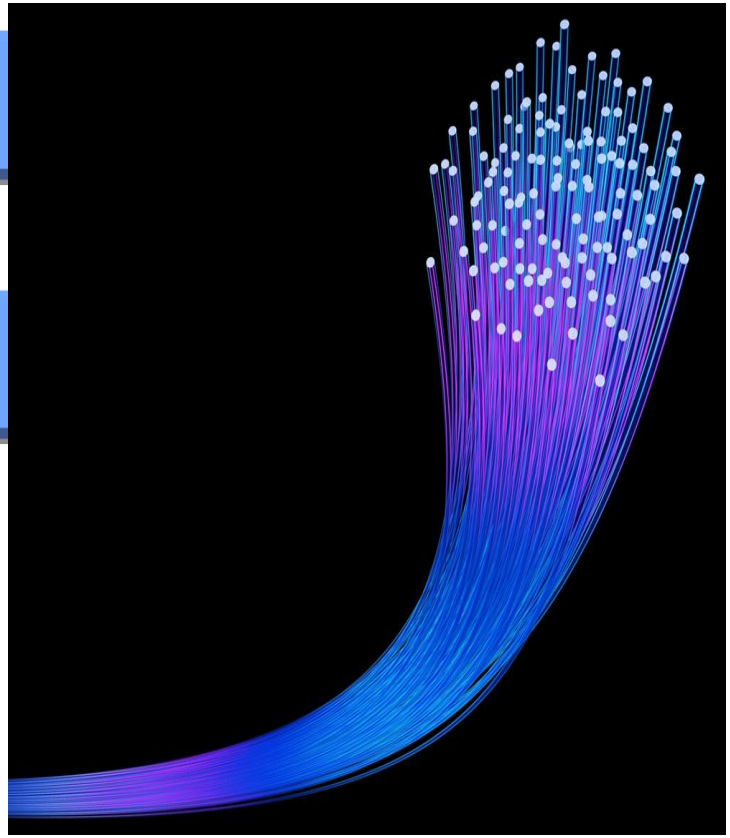
- Less maintenance, higher reliability
- Splitters to allow sharing of network – unpowered, unmanaged

Optical – all fiber

- Extremely high bandwidth

Network

- Point to multipoint
- Access network technology
- Carries voice, video, and lots of data



General GPON Characteristics

Single fiber* or dual fiber shared access network

Targeted to residential applications

Specified to carry Ethernet, TDM, and ATM

Efficient and secure

High bandwidth

*ADTRAN supports single fiber

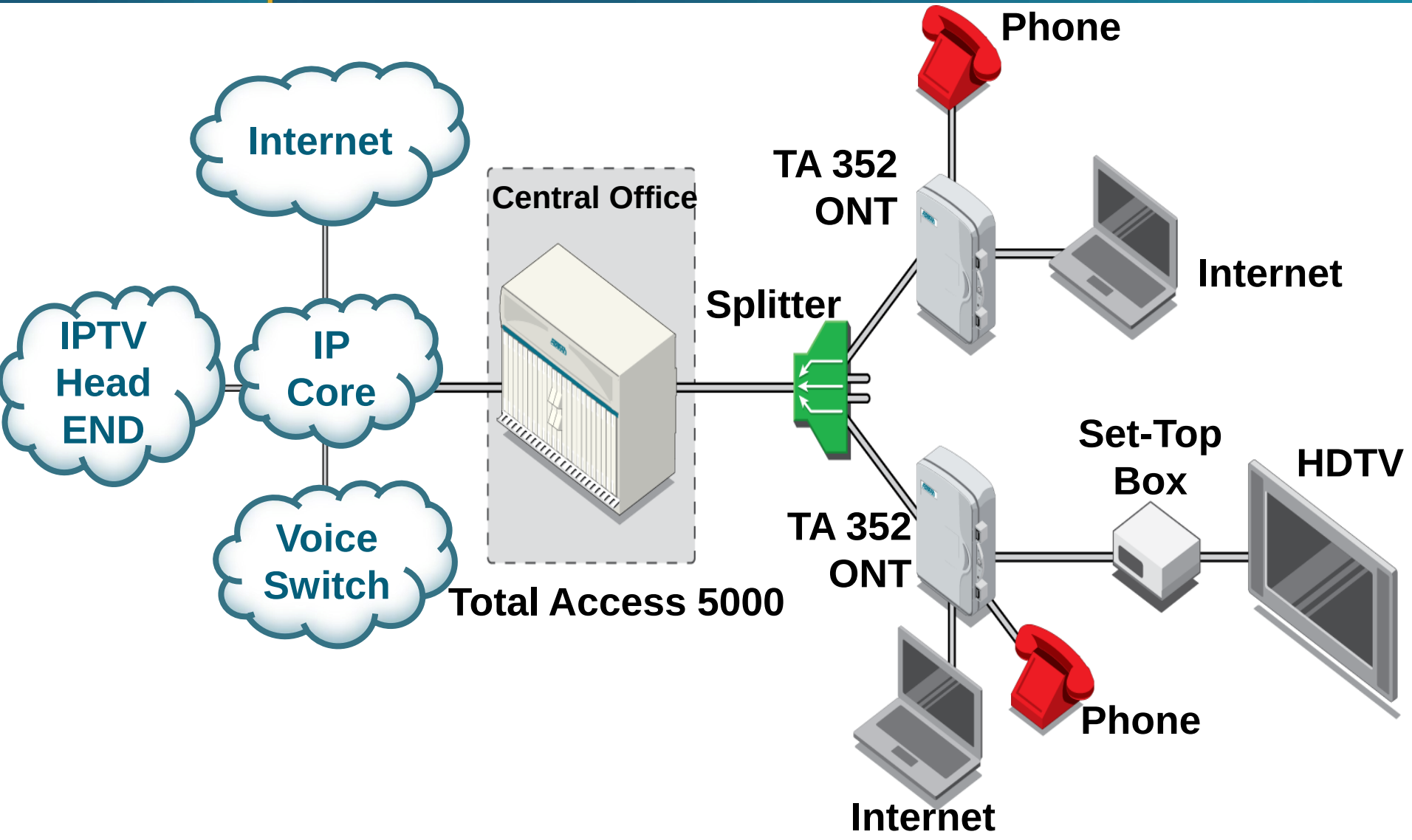
GPON Concept and Standards

- Concept developed by FSAN and standardized in ITU to provide flexible and cost-effective optical access
- FSAN (Full Service Access Network) A Consortium to promote broadband fiber access networks
- Goal of GPON
  - Address limitations of BPON and EPON
  - Provide high bandwidth and universal transport
- ITU G.984 Standards
  - G.984.1 – General Characteristics
  - G.984.2 – Physical Layer
  - G.984.3 – Transmission Convergence
  - G.984.4 – OMCI management

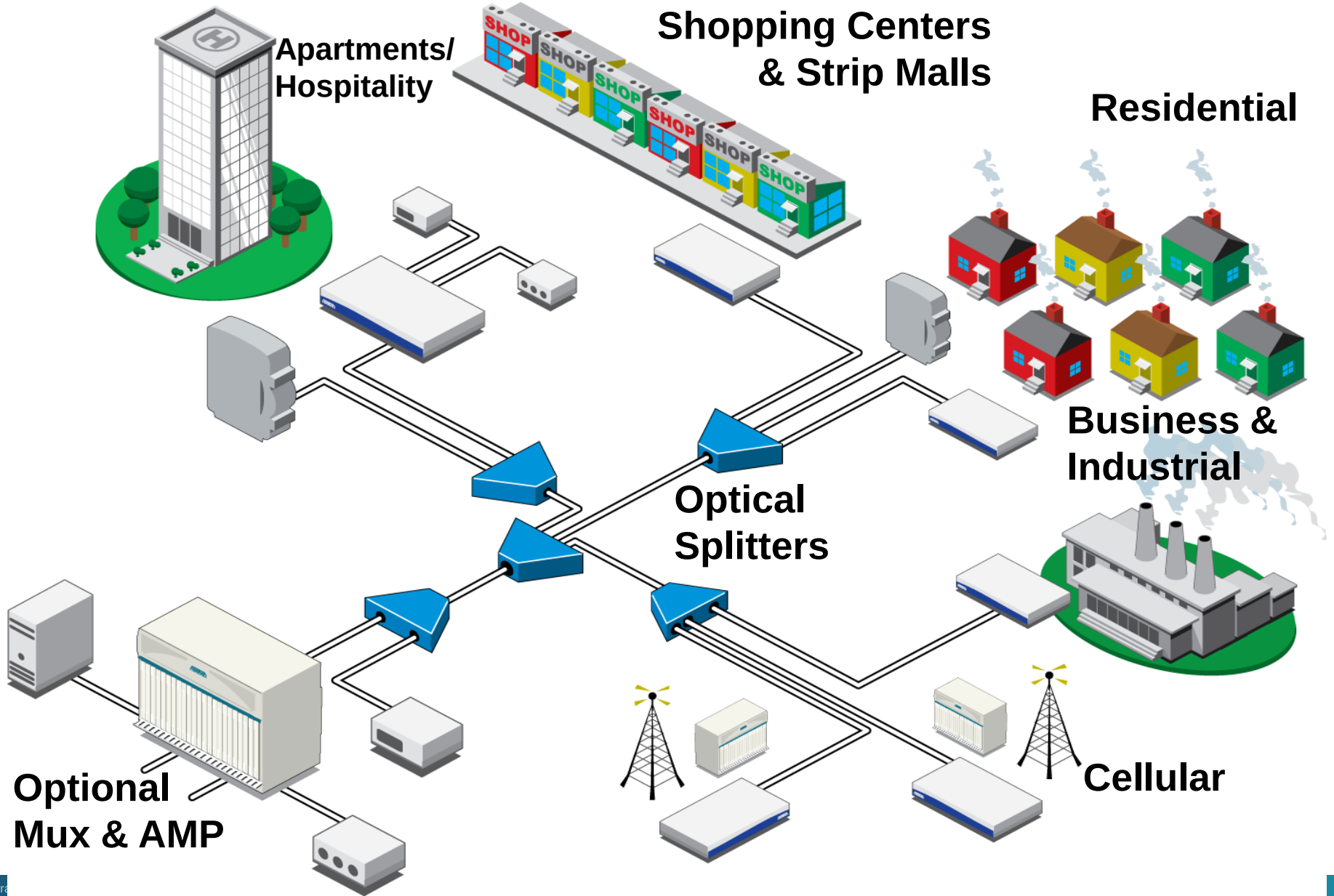
PON Evolution

	BPON	EPON	GPON
Standard	ITU G.983	IEEE 802.3ah	ITU G.984
Rate	622/155 Mbps	1.25/1.25 Gbps	2.5/1.2 Gbps
Transports	ATM	Ethernet	Ethernet,ATM,TDM
Video	RF	RF, IPTV	RF, IPTV
Voice	ATM	VoIP	VoIP, ATM, TDM
Nominal Reach	20 km	10 km	20 km

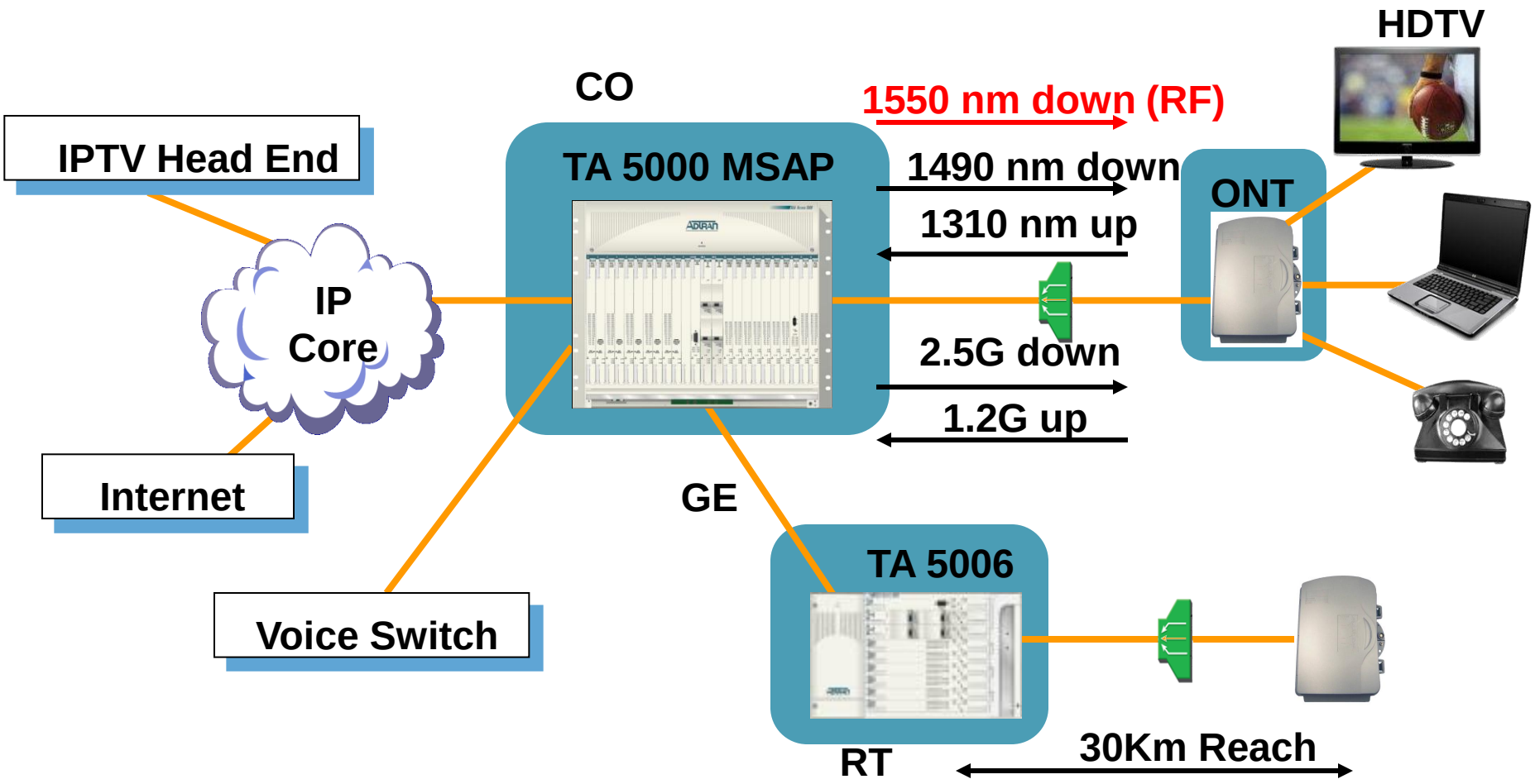
GPON Reference Architecture



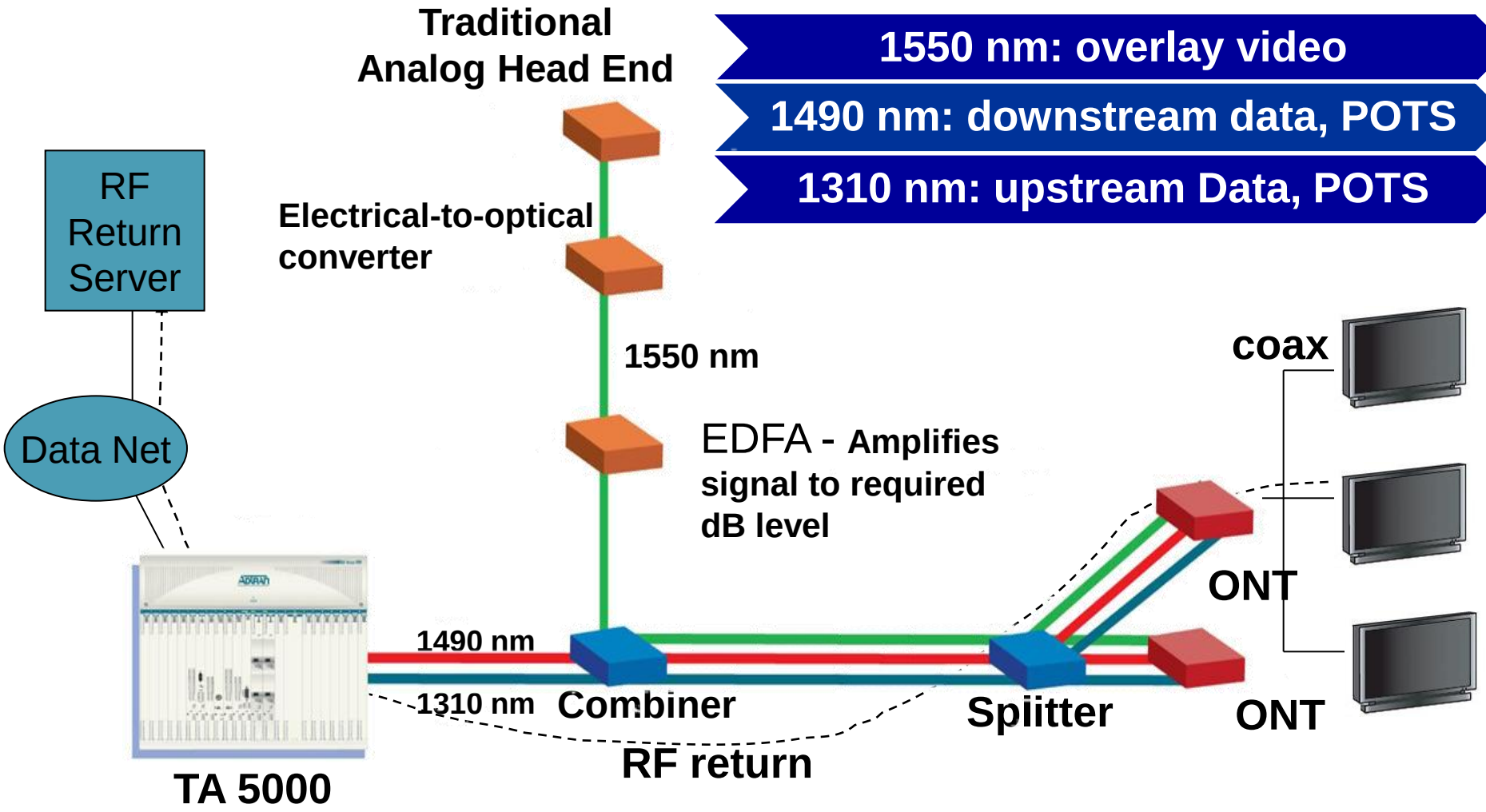
GPON Applications



GPON Network Specifications



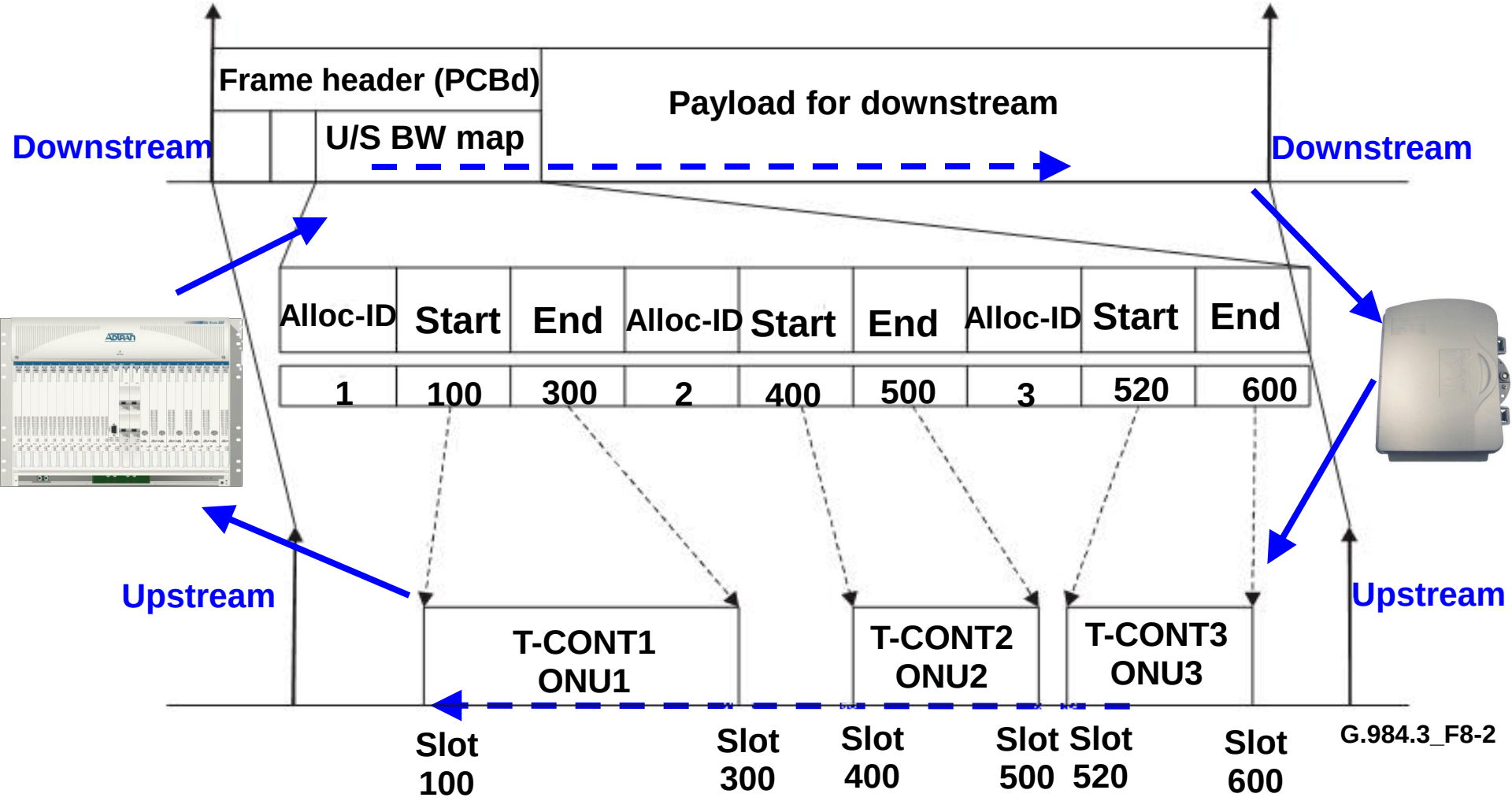
RF Overlay Architecture



GPON Protocol

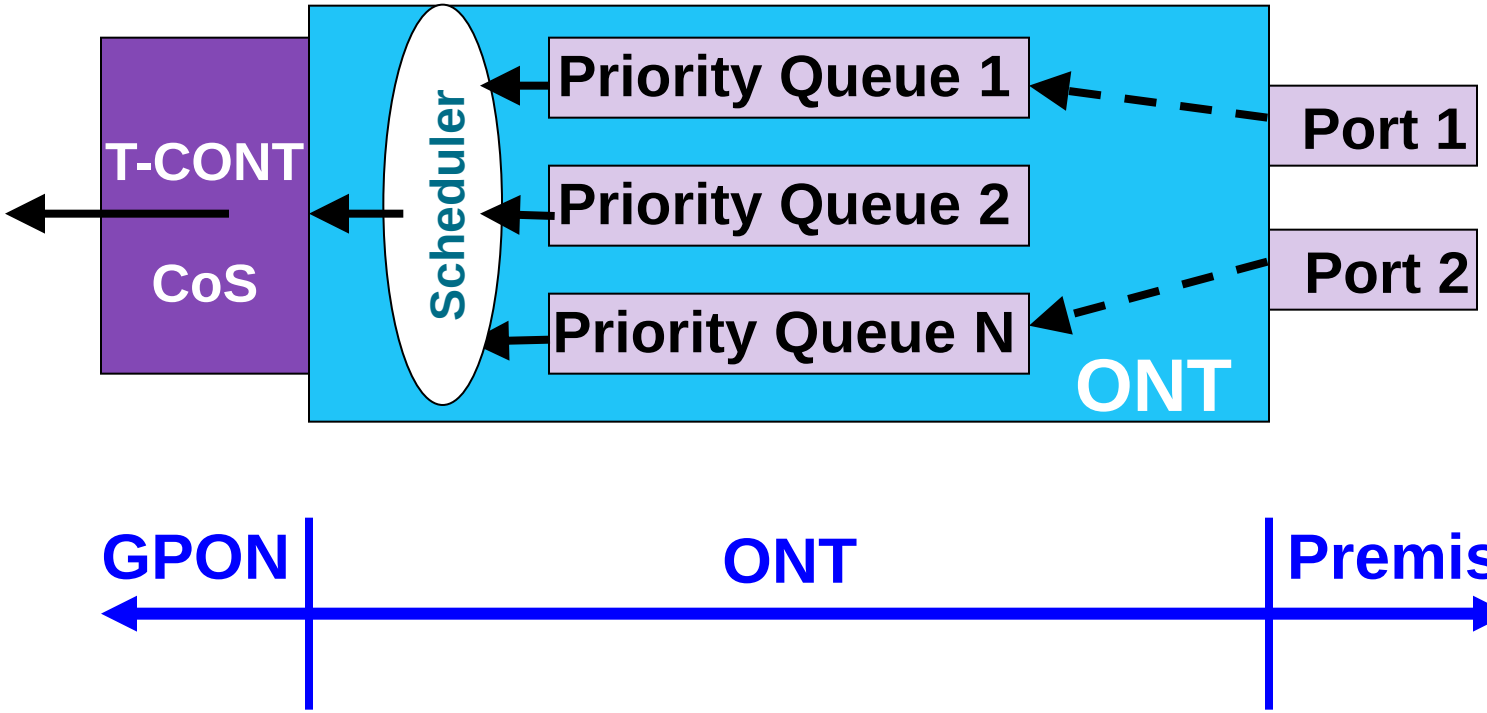
- Downstream
  - All frames arrive at all ONTs/ONUs
  - ONT/ONU filters frames accepting only those destined for it (based on ONT-specific frame headers)
- Upstream
  - Traffic carried in one or more Traffic Containers (or T-CONTs) from each ONT/ONU
  - Each T-CONT can carry a different traffic type
- ONT: ITU term, ONU: IEEE term

Media Control



Upstream Flow Management

Upstream Data Flows
Prioritized and Scheduled by ONT



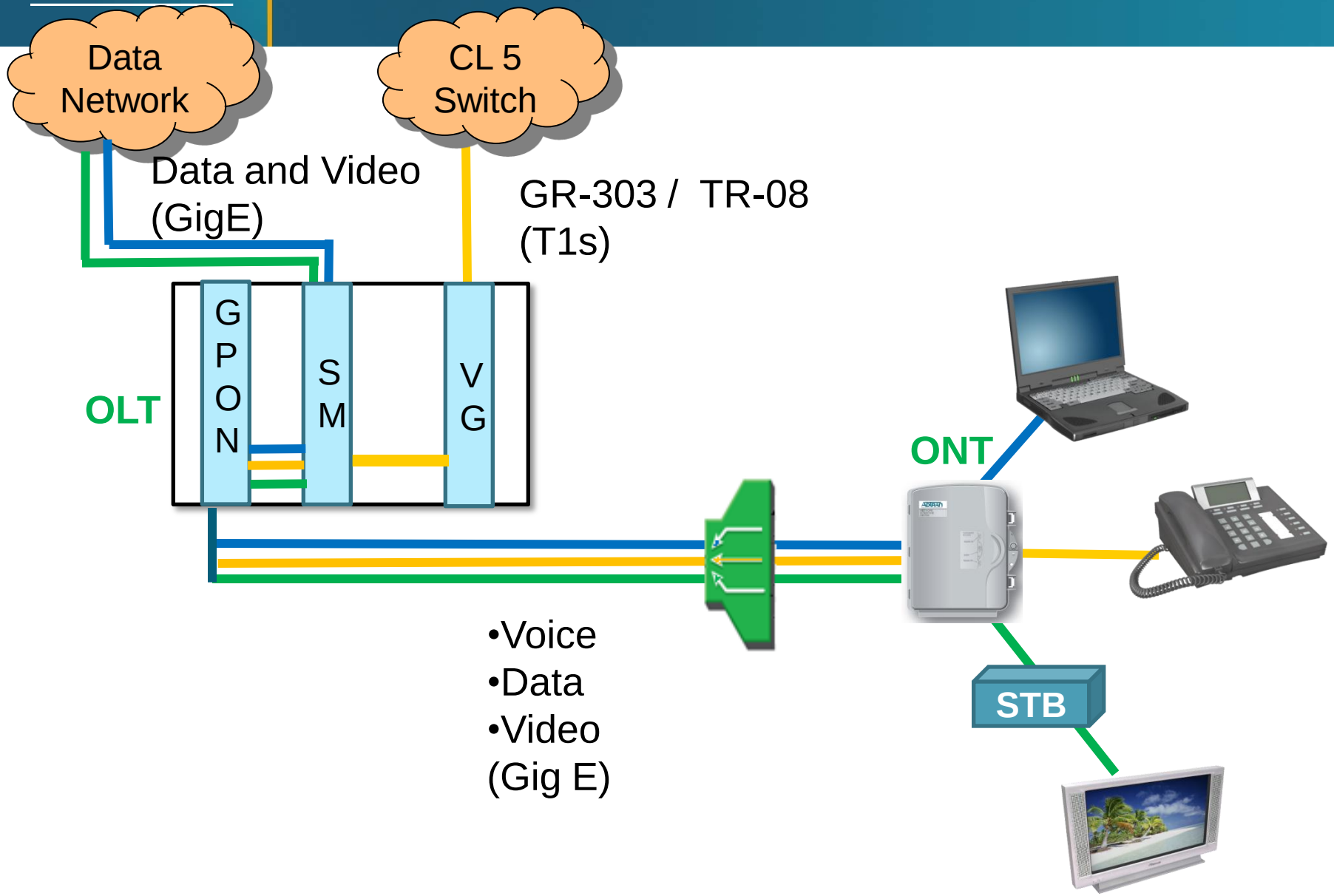
ONT Management and Control Interface

- Runs across a connection between the OLT and the ONT
- Establishes and release connections across the ONT
- Manages the UNIs at the ONT
- Request configuration information and performance statistics
- Informs the system of events such as link failures

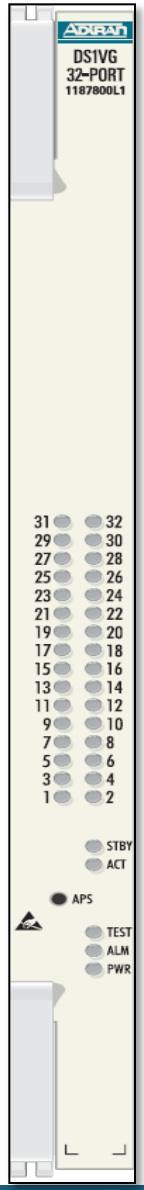
Total Access 5000 GPON

Typical Application

GPON Modules



DS1VG 32-Port LM



Serves as a VoIP to TDM gateway, allowing interface to traditional Class 5 TDM switches

Supports GR-303 and TR-08 Mode 1 signaling

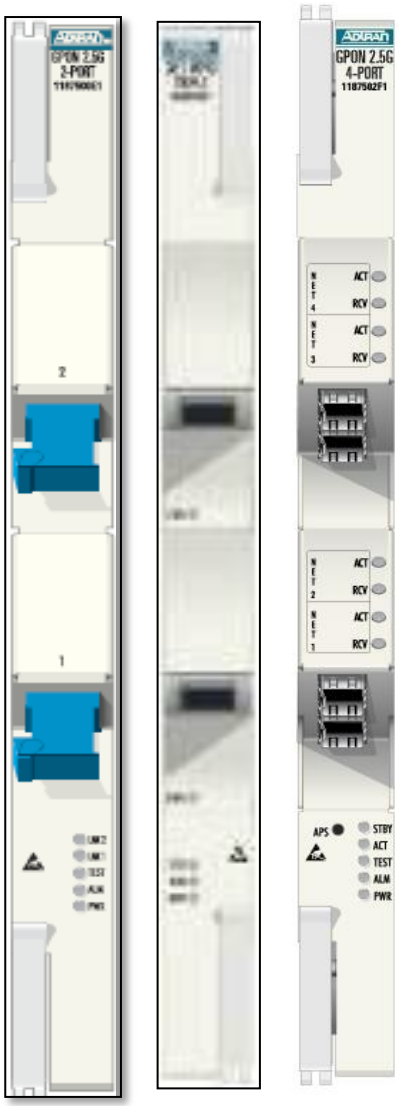
Provides 32 DS1 interfaces

Always at NODE 1 when using node expansion

GR-303 Scalability

- 2,048 CRVs per IG
- 3 Interface Groups per Voice gateway
- Up to 9 IGs per COT

OLT - GPON 2.5G 2-Port Access Module



- Two G.984 compliant GPON interfaces
- 2.488 Gbps downstream rate
  1.244 Gbps upstream rate
- Enet GEM encapsulation for all services, including video, voice, and data.
- Supports up to 32 ONTs
- Acts as a proxy for ONT provisioning and maintenance

ONT

Features

- G.984 compliant GPON interface
- POTS uses in-band signaling tones and currents to determine call status
- System clocks derived from GPON network clock of 2.488 GHz
- Remote alarm support

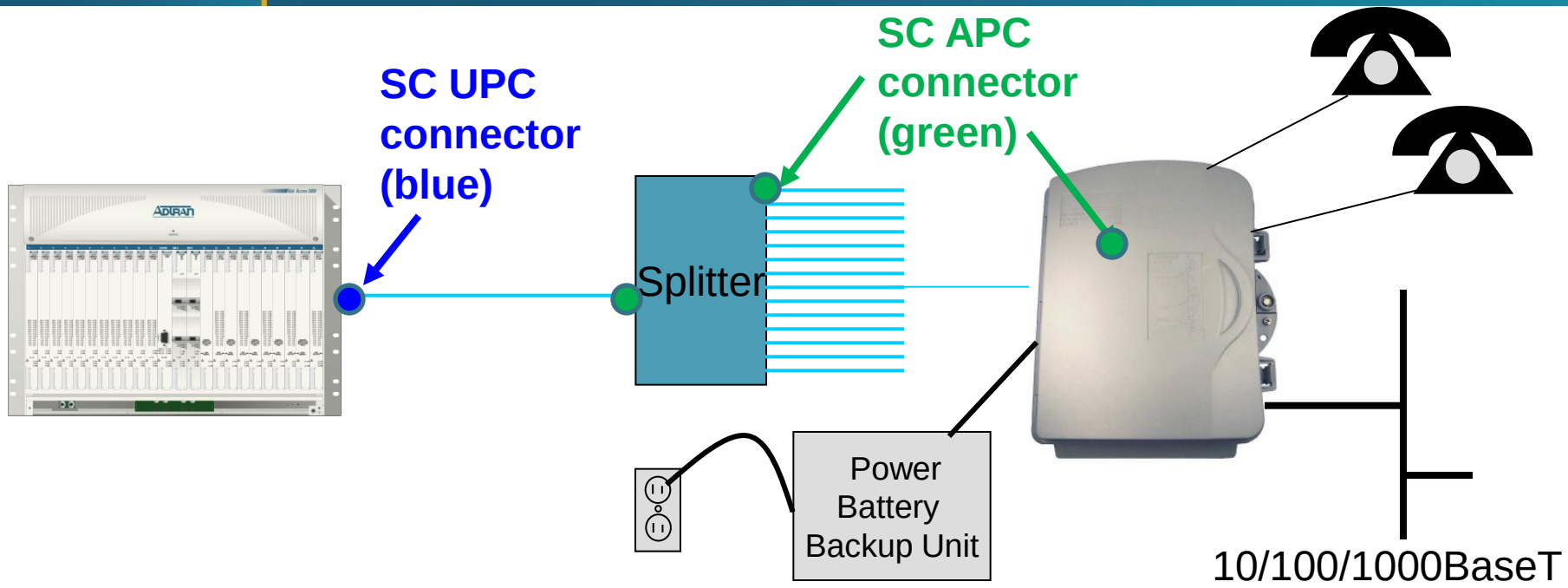
Physical Features

- Weatherproof and access controlled construction
- Entry ports for fiber, power, ground, Ethernet and telephone
- Two 10/100/1000Base-T Ethernet interfaces
- Two POTS interfaces
- 12 VDC power supply

FTTP ONT Portfolio – 2010 and beyond

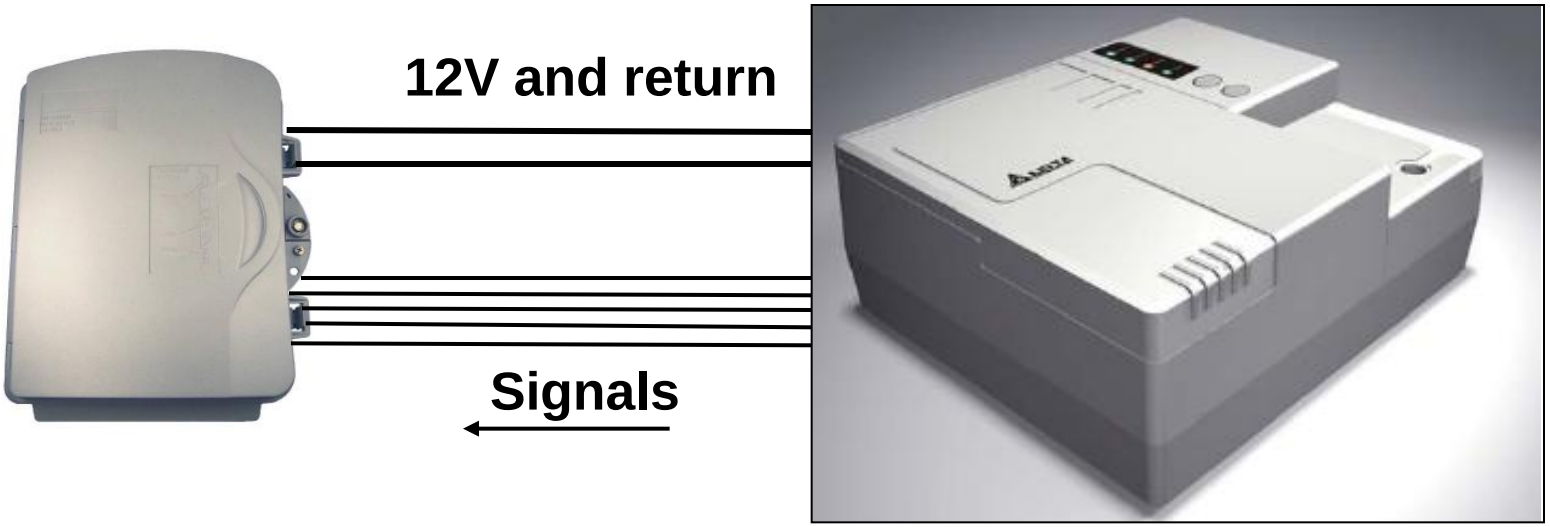
ONT Model	Status	FTTP Type	Application	Telephony	Gigabit Ethernet	T1	HPNA	RF Video
TA 324	**GA**	GPON	SFU / Indoor	2	4	-	-	-
TA 334	**GA**	GPON	SFU / Indoor	2	4	-	-	1
TA 324E	**GA**	AE	SFU / Indoor	2	4	-	-	-
TA 351	**GA**	GPON	SFU	2	1	-	-	-
TA 352	**GA**	GPON	SFU	2	2	-	-	-
TA 352H	**Q4 2010**	GPON	SFU	2	2	-	1	-
TA 354E	**GA**	AE	SFU/SBU	2	4	-	-	-
TA 354u	**Q2 2010**	GPON & AE	SFU	2	4	-	-	-
TA 354M	***Investigating***	GPON & AE	SFU	2	4	-	1 -MoCA	-
TA 361	**GA**	GPON	SFU	2	1	-	-	1
TA 362	**GA**	GPON	SFU	2	2	-	-	1
TA 362H	**Q4 2010**	GPON	SFU	2	2	-	1	1
TA 362S	**GA**	GPON	SFU	2	2	-	-	1 (w/SWRD pwr)
TA 362R	**GA**	GPON/RFoG	SFU	2	2	-	-	1 (w/RF return)
TA 371	***Investigating***	GPON	SBU	4	4	2	-	-
TA 371 - RF	***Investigating***	GPON	SBU	4	4	2	-	1
TA 371E	***Investigating***	AE	SBU	4	4	2	-	-
TA 372	**GA**	GPON	SBU	8	2	4	-	-
TA 372E	**GA**	AE	SBU	8	2	4	-	-
TA 372 - RF	***Q4 2010***	GPON	SBU	8	2	4	-	1
TA 384	***Investigating***	GPON/AE	MDU/MTU	12	12	-	-	Hi-Power: Optional
TA 388	***Investigating***	GPON/AE	MDU/MTU	24	24	-	-	Hi-Power: Optional
TA 380	**GA**		MDU/MTU	Up to 8	Up to 8	-	Up to 4	Up to 4

ONT – Total Access 352



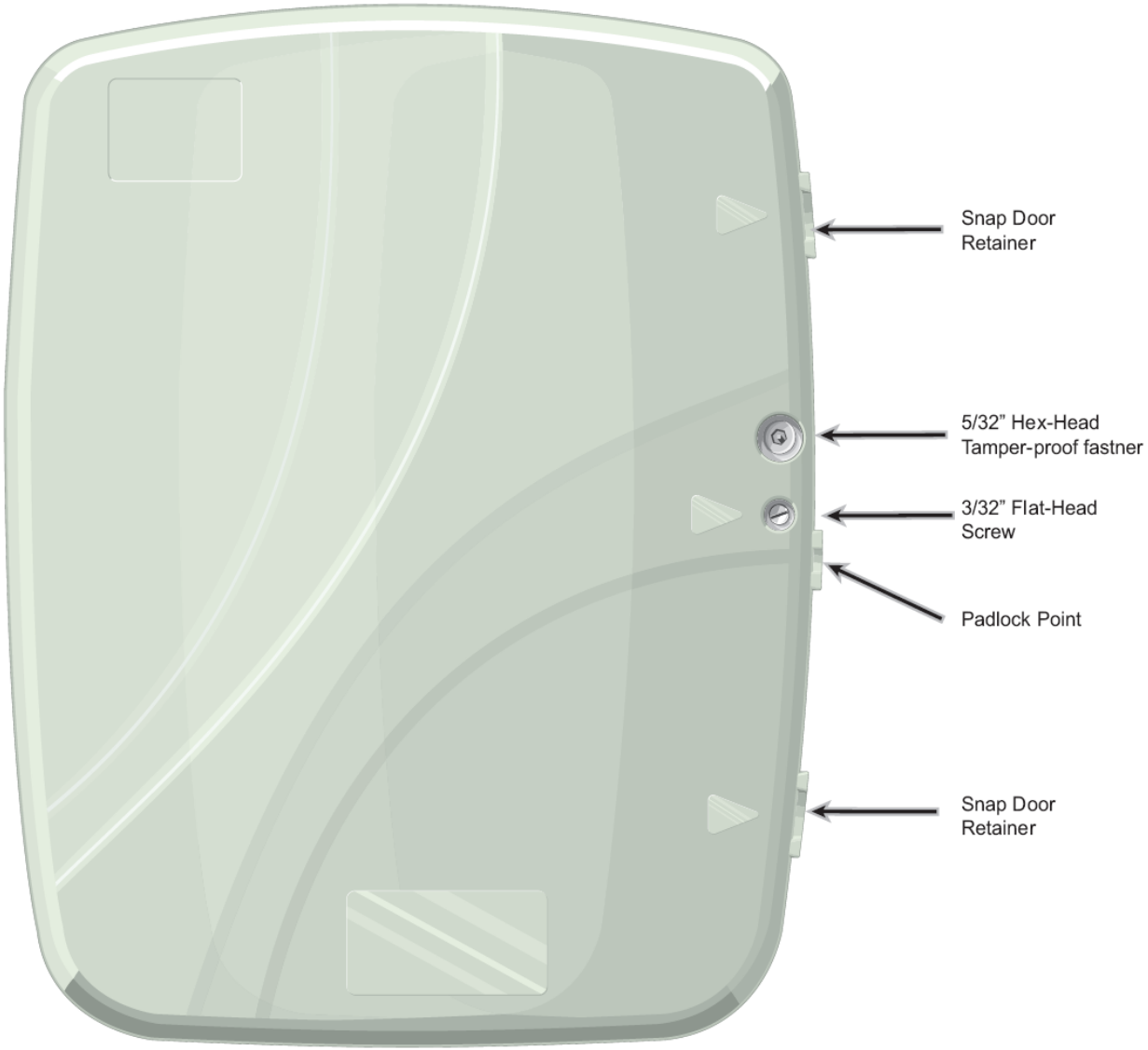
- SC APC connector (green) for network connection on ONT.
- Always use matching jumper.
- SC UPC (blue) jumper can damage interface and will at least introduce extra loss.

Battery Backup Unit/Power Supply

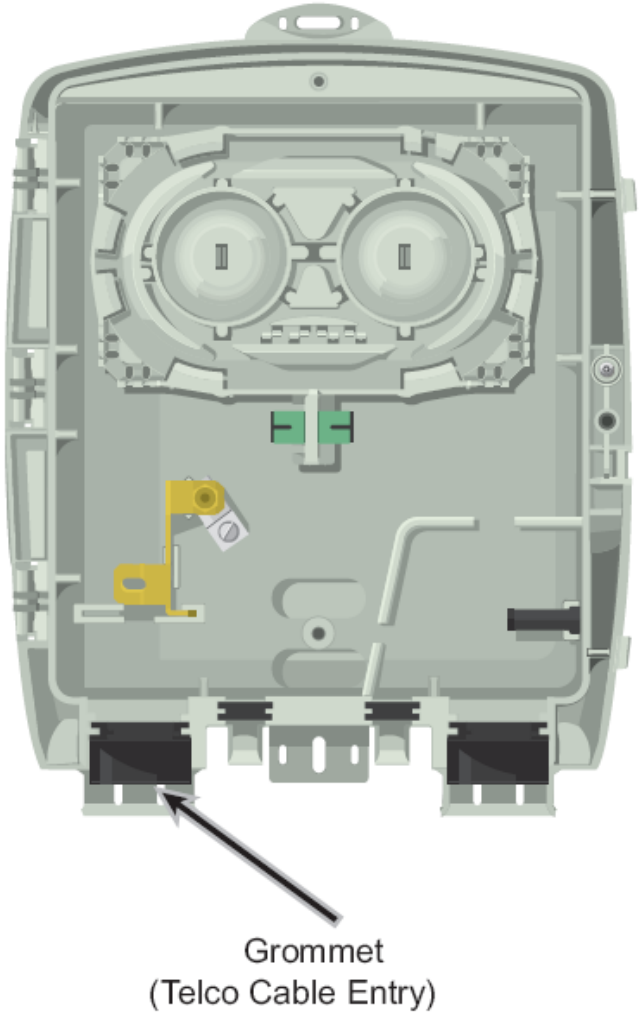


- 7 conductors: 2 for power and 5 for signals
- Signals: Low battery, battery missing, replace battery, on battery, and a signal return wire
- Approx. 50 feet between with 18 AWG power conductors

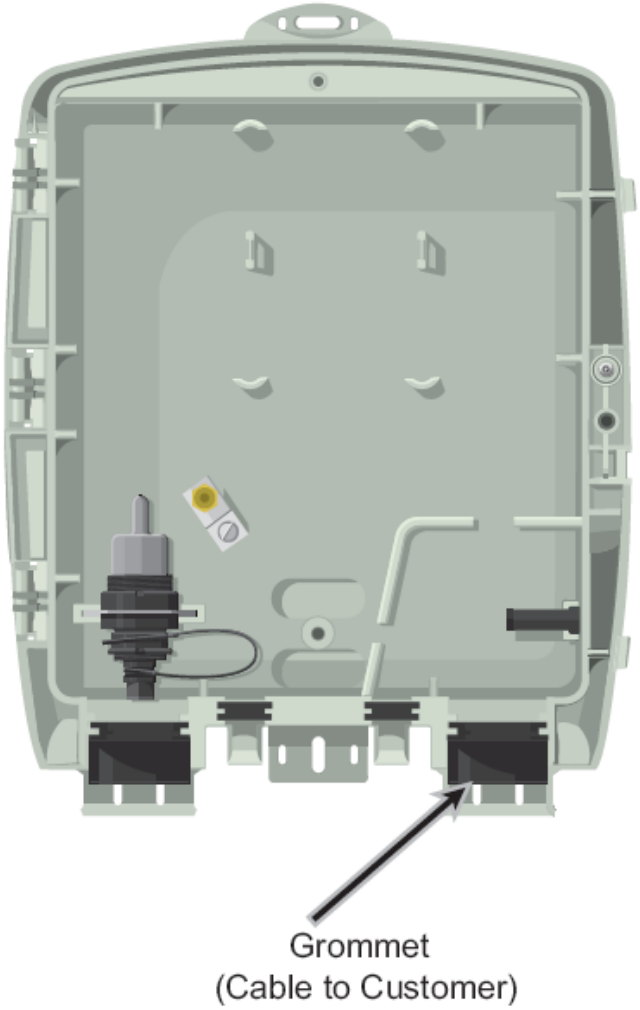
Front cover



Splice & OptiTap Housings



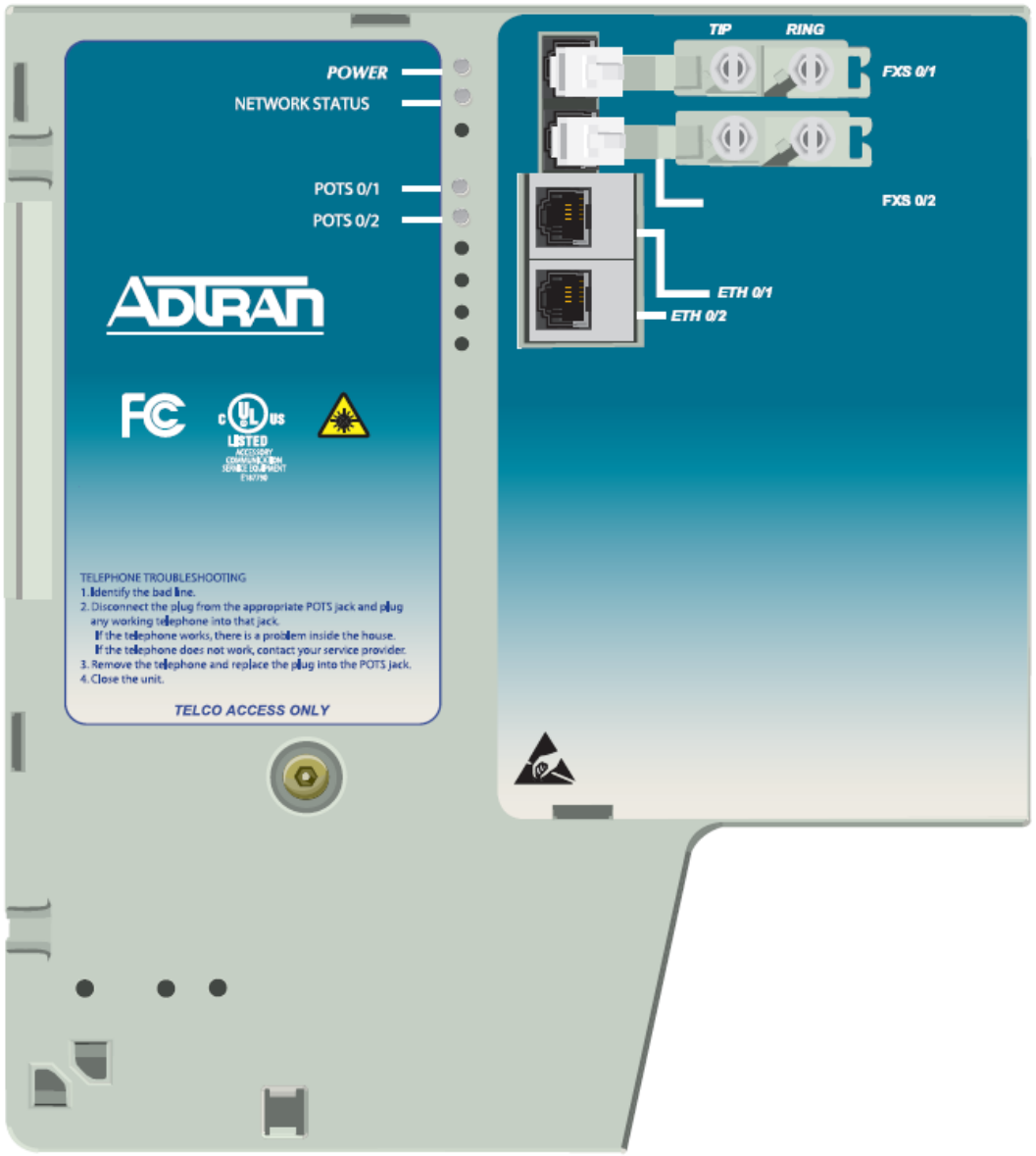
Splice Housing



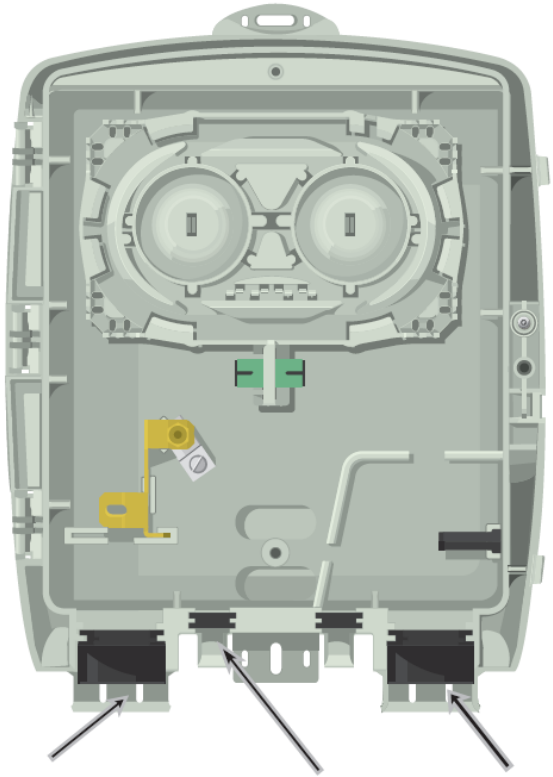
OptiTap Housing

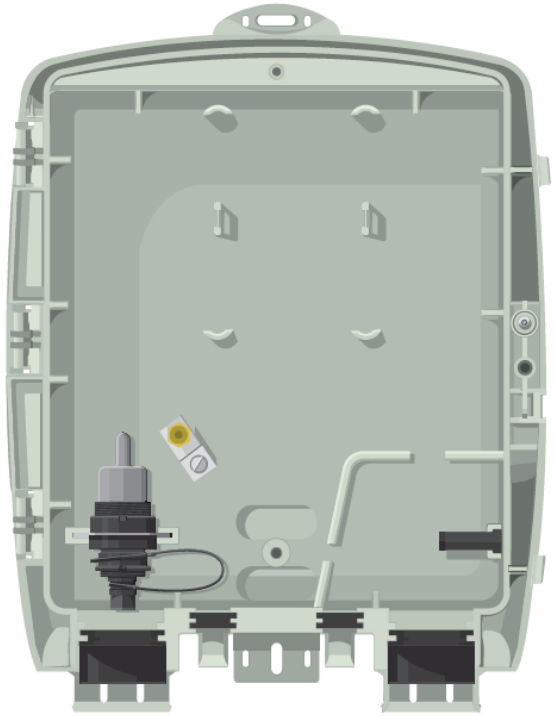
Electronics

Hinge Points

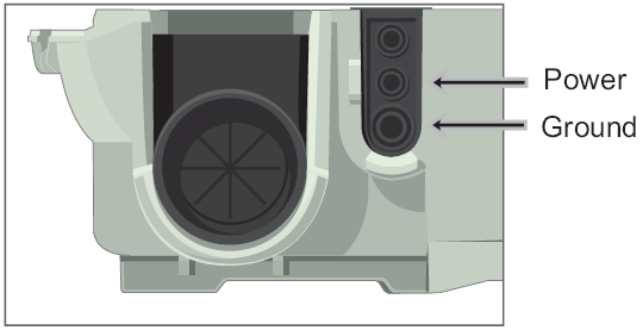


Wire Routes



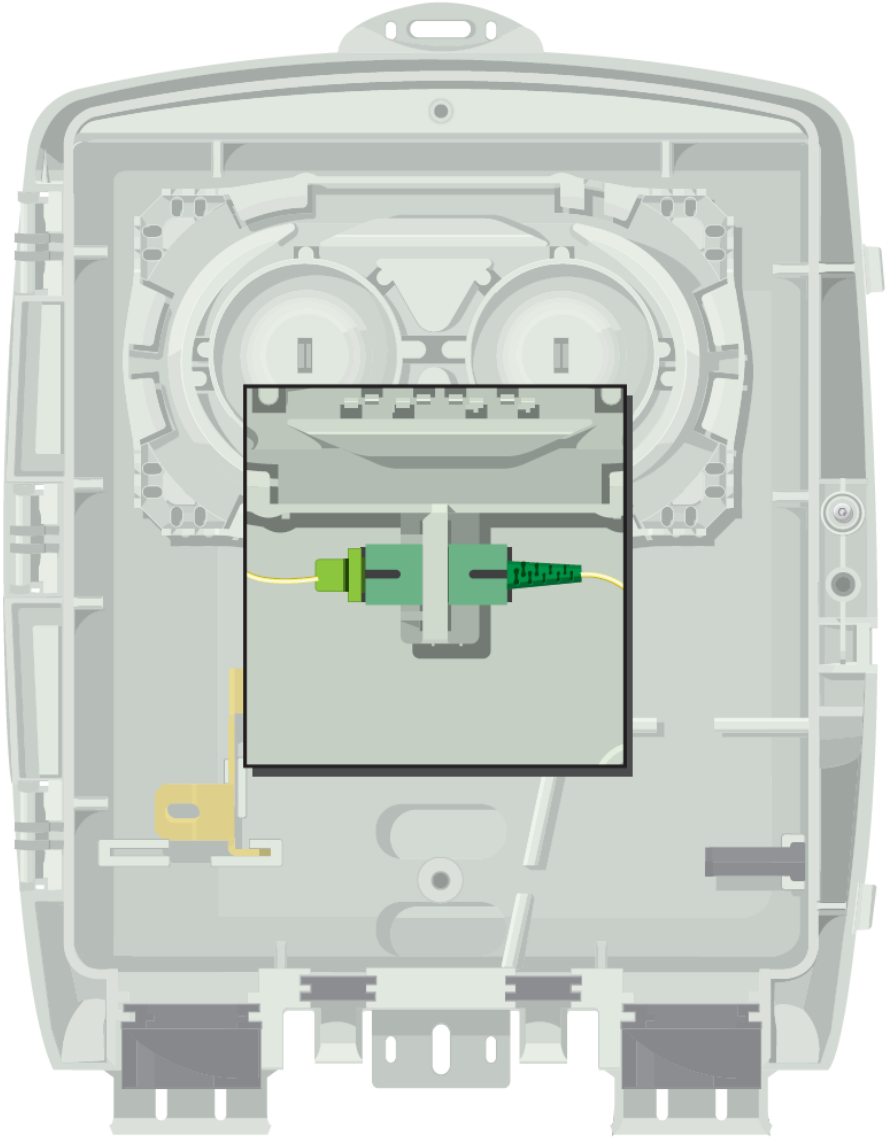


Note: Fiber, Ground/Power and Video/Pots Drops are the same for each housing.

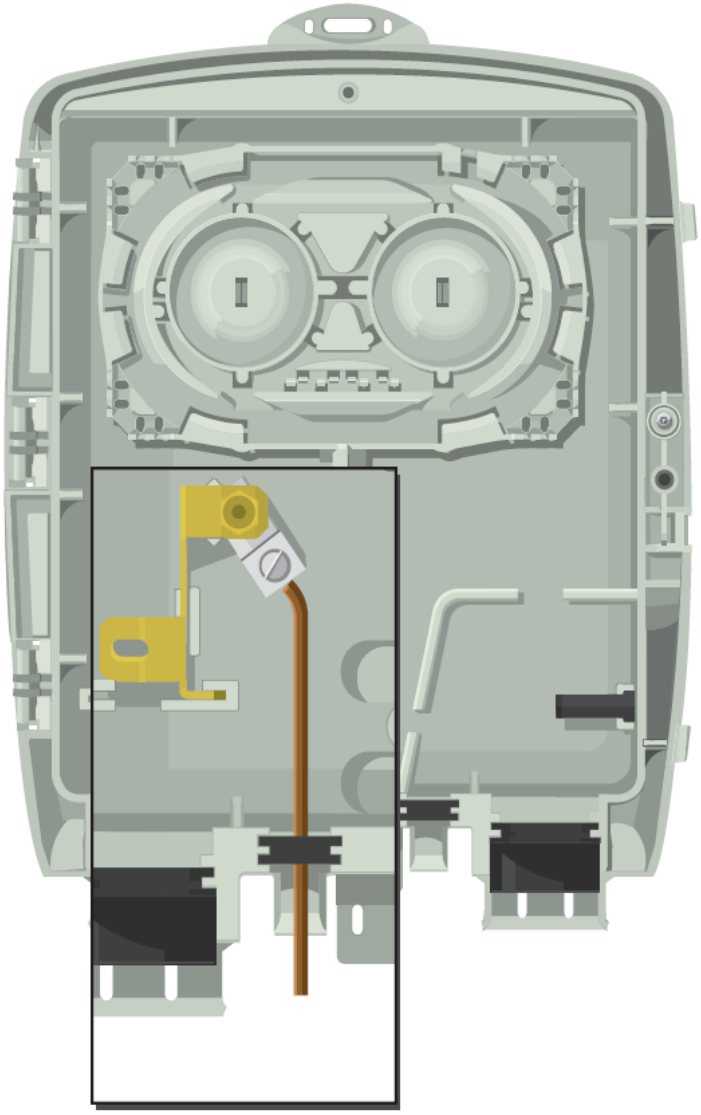


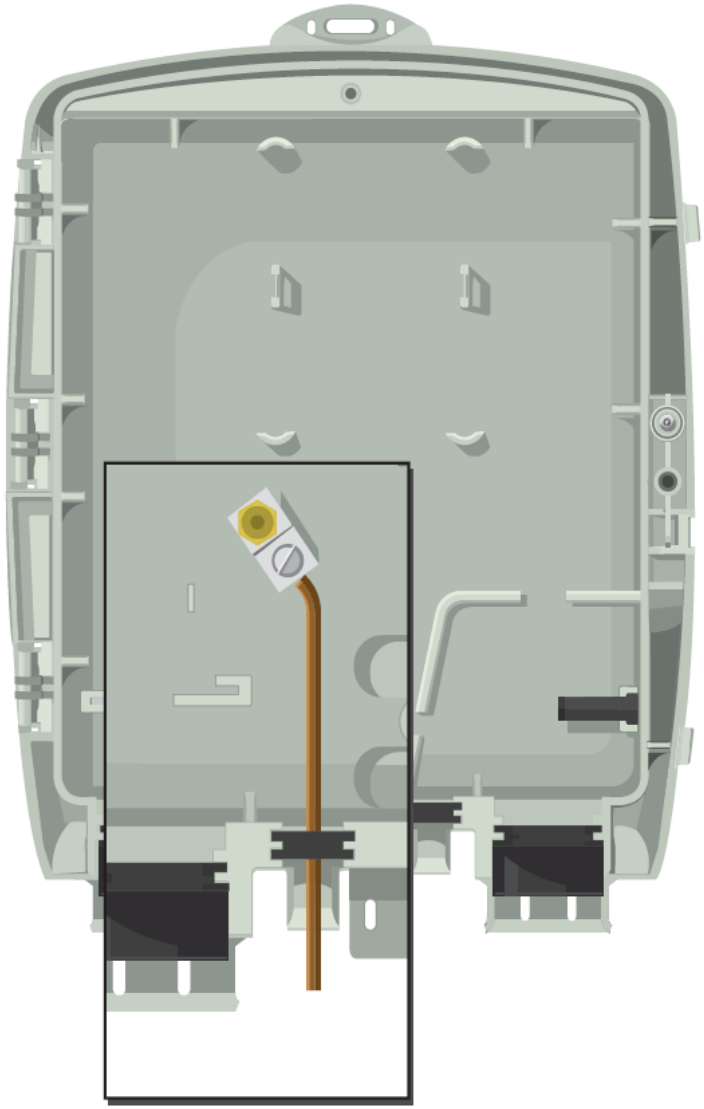
Ground and Power Drop Callout

Bulk Head Connection

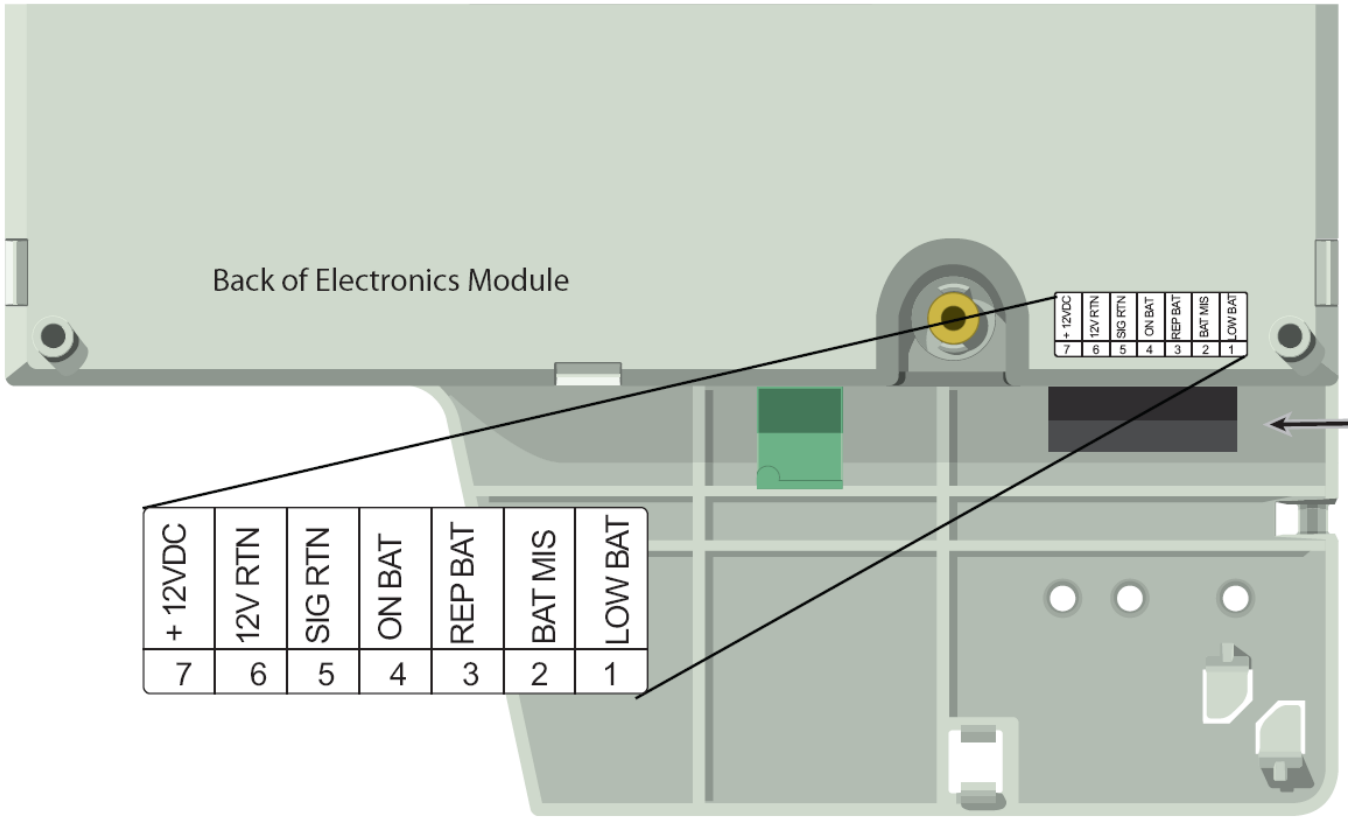


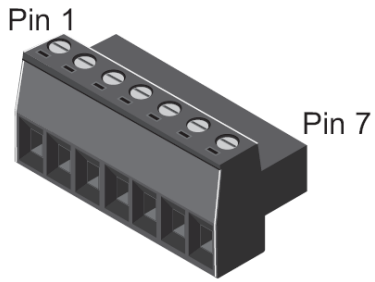
Ground Connection





Power Connection

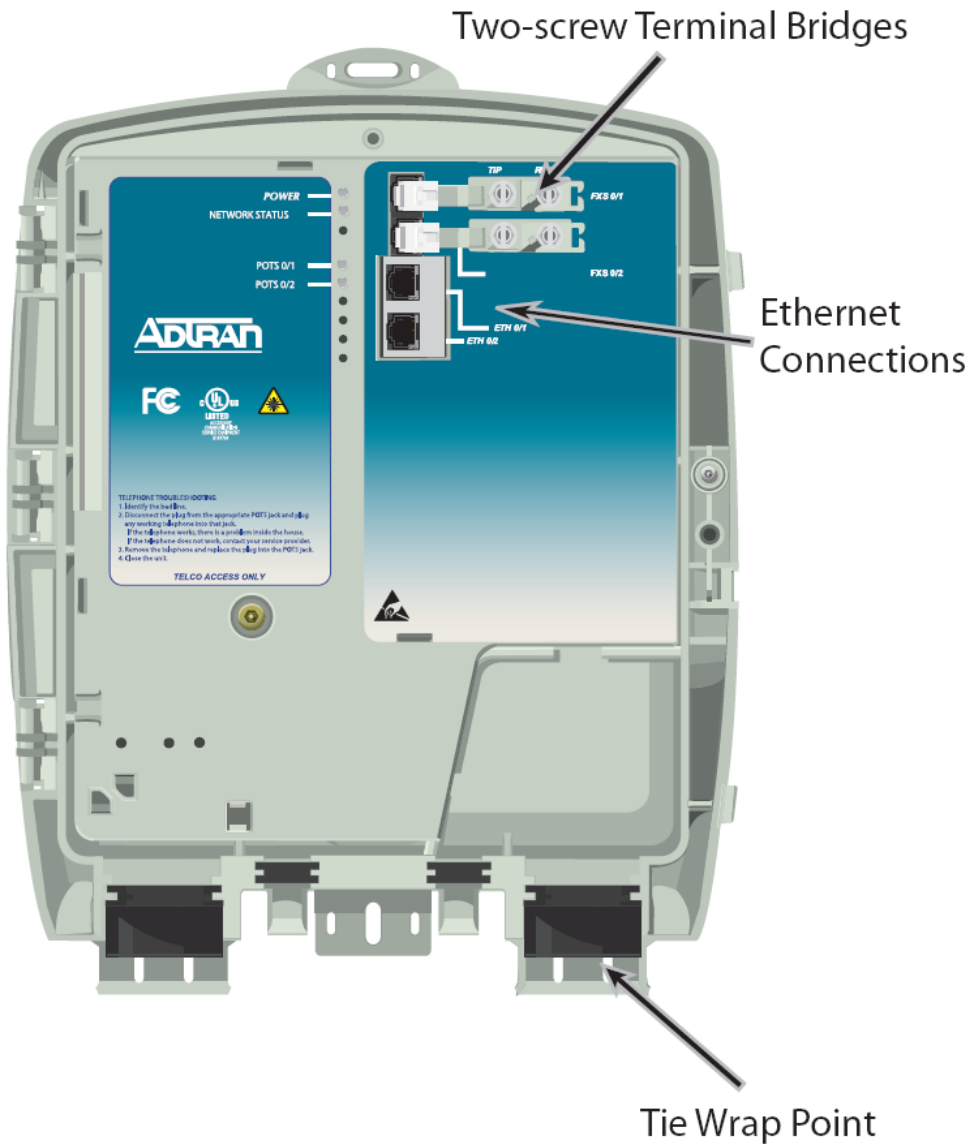




Power/Alarm Connector

Pin	Description
1	Low Battery
2	Battery Missing
3	Replace Battery
4	On Battery
5	Signal Return
6	12V Return
7	+12VDC

POTS & Ethernet Locations



Pin Number	Color Code
1	White/Orange
2	Orange
3	White/Green
4	Blue
5	White/Blue
6	Green
7	White/Brown
8	Brown

Warranty & Technical Support

- WARRANTY
  - ADTRAN will replace or repair this product within the warranty period if it does not meet its published specifications or fails while in service
  - Warranty information can be found at www.adtran.com/warranty

- ADTRAN Technical Support
  - Pre-Sales Applications/Post-Sales Technical Assistance
    - 800-726-8663
  - Standard hours: Monday - Friday, 7 a.m. - 7 p.m. CST
  - Emergency hours: 7 days/week, 24 hours/day

Beyond GPON

Richard Goodson
Senior Staff Scientist
ADTRAN

Technologies Beyond GPON

- GPON should give sufficient peak bandwidth to individual users beyond 2020.
- However, the standards bodies continue doing what standards bodies do – creating more standards
- Two primary categories:
  - 10 Gbps PON (XGPON)
  - 40 Gbps PON (NGPON2)

GPON has legs past 2020?

- Average (US) busy hour traffic load is about 150 kbps per household in 2010
  - Combines data from Cisco VNI, Pew Internet life project, US census, other sources
  - Extrapolating data to 2020, avg. traffic load should be 1 – 5 Mbps
- FCC Nat'l Broadband Plan calls for 100 Mbps downstream per user in 2020
  - Our analysis shows that GPON (2.5 Gbps) can easily provide 100 Mbps / user 95% of the time with average load at 5 Mbps / user
    - With 32-way split
    - Peak rates over 1 Gbps are possible

10 Gbps PON

- Two options: XGPON1 and 10GEPON
- Applications: MDU, PON-fed DSLAMs
- XGPON1
  - Completed by ITU and FSAN 2010
  - Telco oriented
  - 10 Gbps Down / 2.5 Gbps Up
  - ADTRAN G.987.2 (PHY layer XGPON1) editor
  - Industry availability – 2012 time frame
- 10GEPON
  - Completed by IEEE
  - Two flavors: 10/1 and 10/10
    - 10/10 upstream components not readily available

Comparing GPON and XGPON1

	GPON	XGPON1
Rate (dn/up)	2.5 / 1.25 Gbps	10 / 2.5 Gbps
Typ. Reach / # splits	20km / 32 splits	20km / 32 splits
Wavelength(dn/up)	1490 / 1310 nm	1578 / 1270 nm*
RF Overlay Coexist	Yes	Yes
ONU Management	OMCI	OMCI
Loss Budgets	28-32 dB	29-35 dB

*Note that XGPON1 and GPON wavelengths allow both to co-exist on the same PON as migration plan

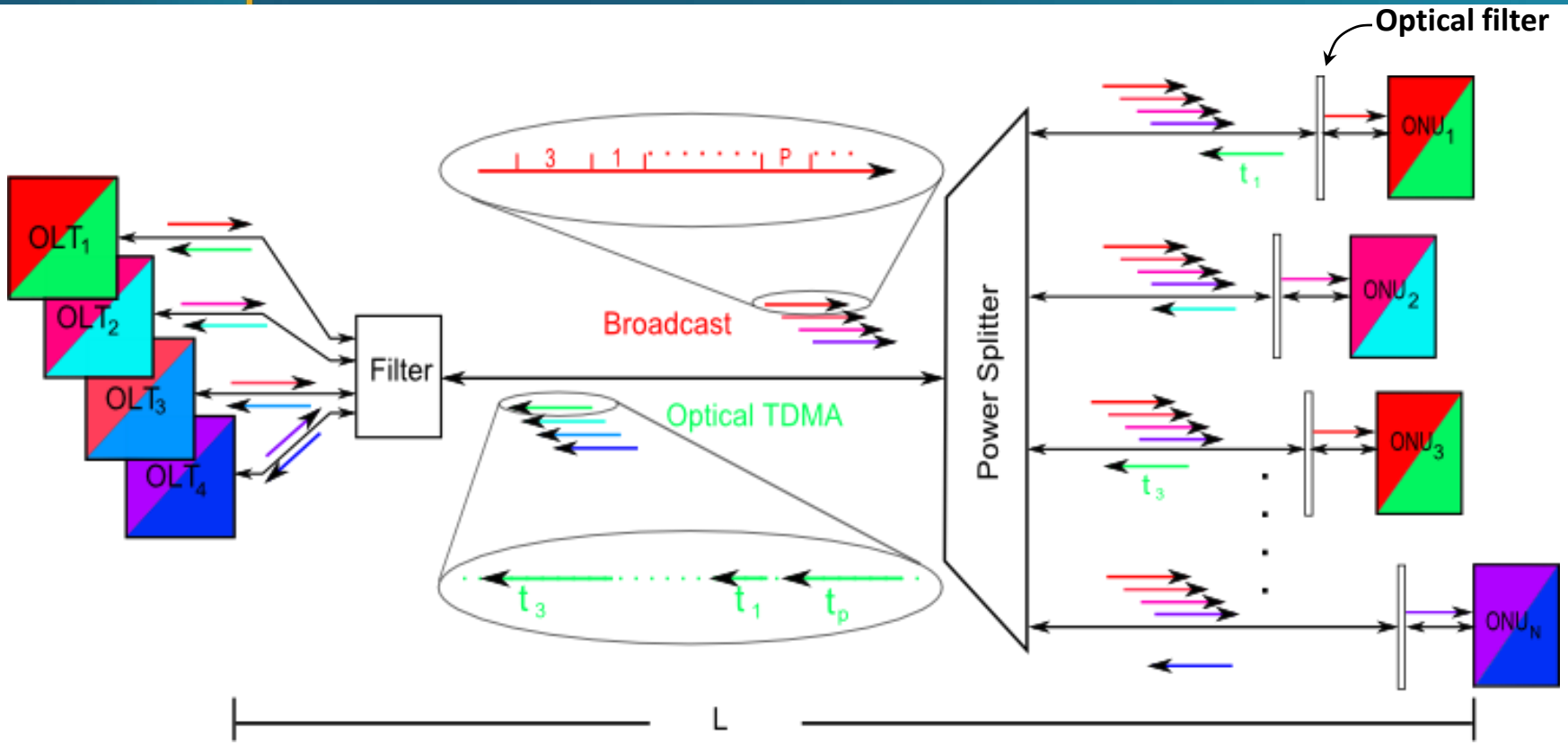
40 Gbps PON

- Currently under study by FSAN – NGPON2
- Several major categories under consideration
  - Stacked PON
  - WDM PON
  - OFDM PON
  - Coherent PON

Stacked PON

- Use WDM to “stack” four XGPON1 systems on four different wavelengths over same PON
- Allow factor of four increase in average data rate per user versus non-stacked XGPON1
  - Peak rate “limited” to 10 Gbps
- Various flavors
- Interim technology (at best)

Stacked PON

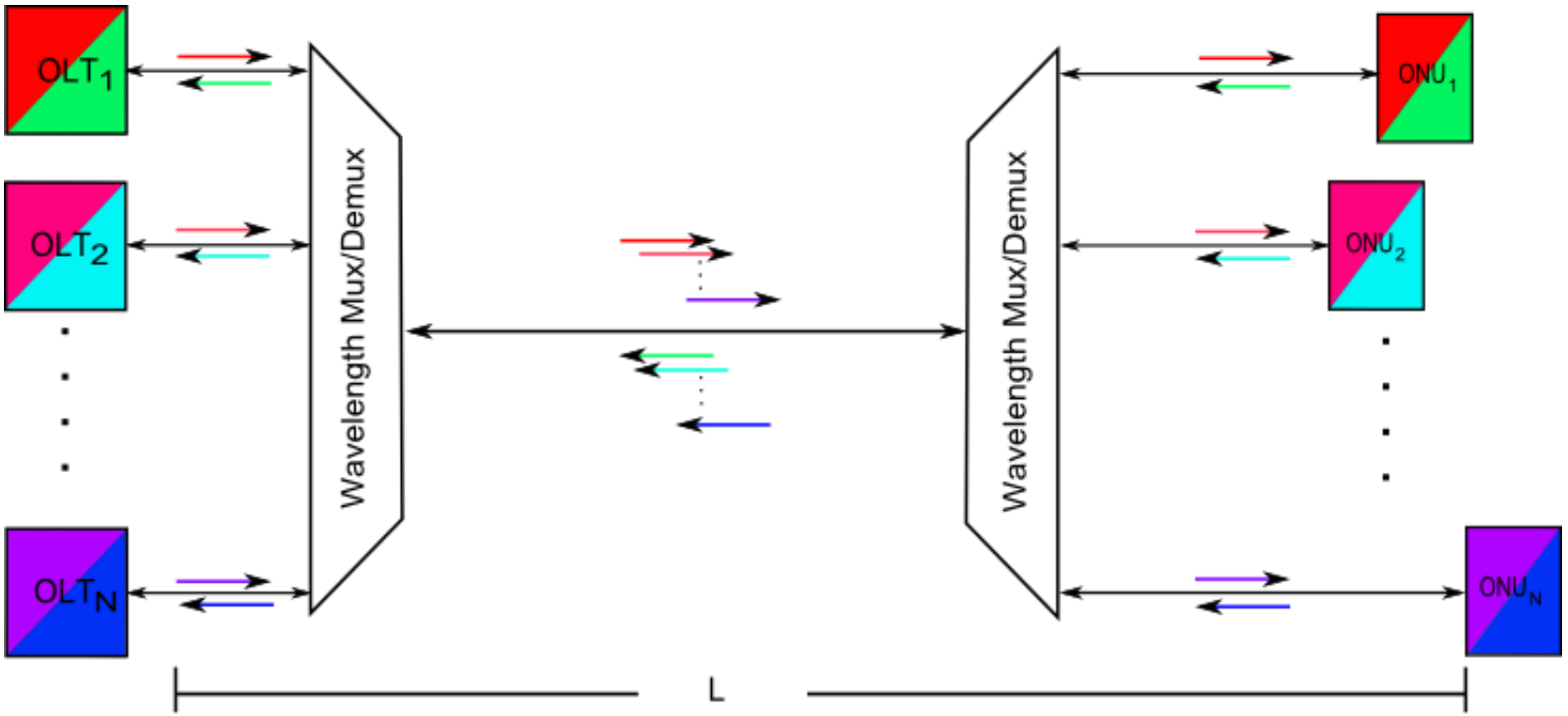


- You can trade off splits (N) for distance (L) within the bounds of the optical link budget.
- Likely limits for L and N are (dependent on optics and wavelengths used)
  - L = 20 km
  - N = 32
- P is the number of ONUs on a given stacked- PON. P≤N

WDM PON

- Each user gets their own wavelength
- Essentially point-to-point connections per wavelength
- E.g. 1 Gbps / user at 32-way split (what are the mux/demux called?????)
- Typically use either tunable lasers or injection locked lasers
- “PHY agnostic”
- Hybrid WDM/TDM approaches possible

WDM-PON

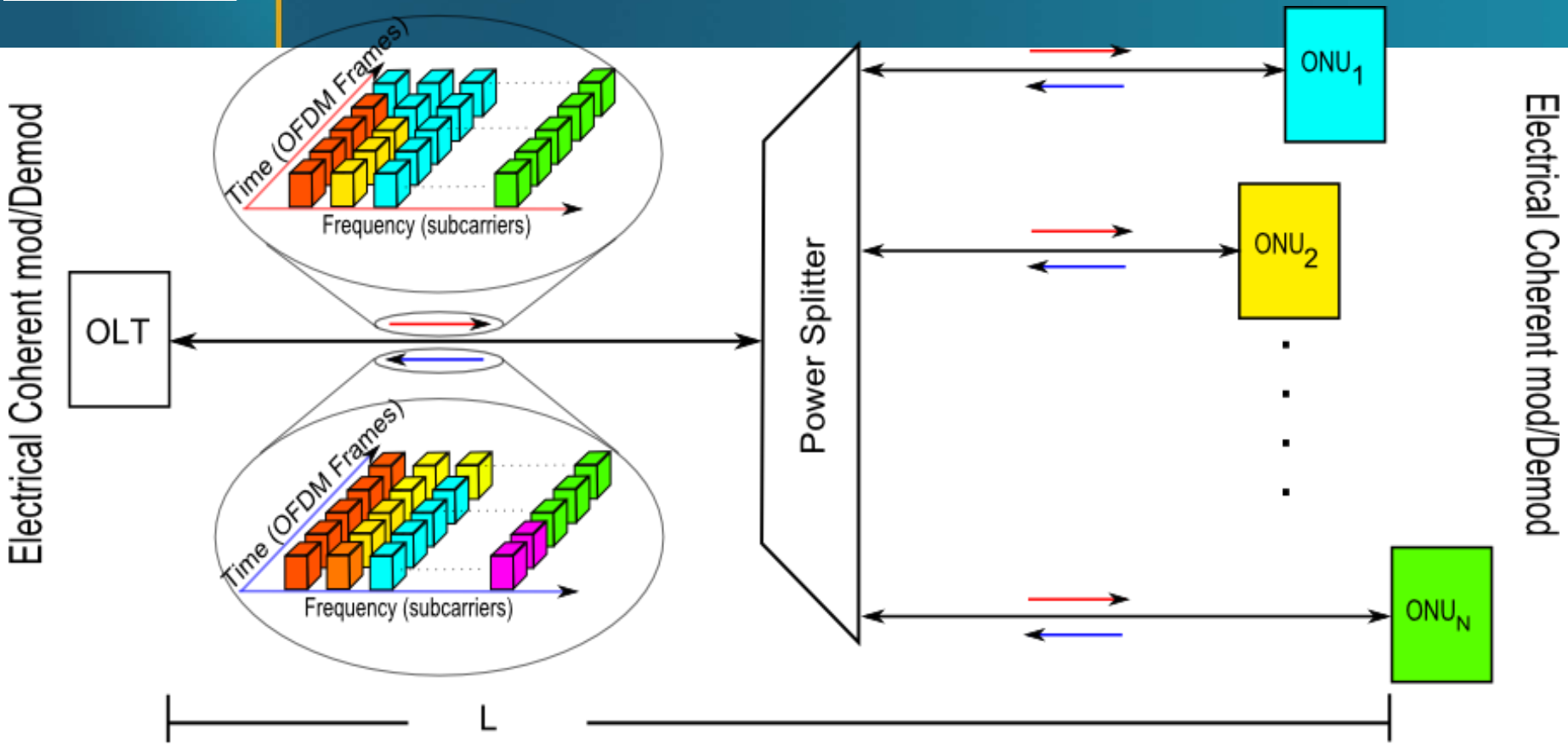


- L and N are flexible and somewhat independent
- N is set by the wavelength spacing of the Mux/Demux
  - Typically N < 40 (100 GHz channels)
- L is dependent on the optical technology used to implement the WDM-PON (see Supplemental slides)
  - Typically L = 20 km

OFDM PON

- “DMT over PON”
  - Same basic technology as ADSL/VDSL
- Allows user assignment by wavelength, frequency and/or time
- Uses DSP technology in the electrical domain

OFDMA-PON

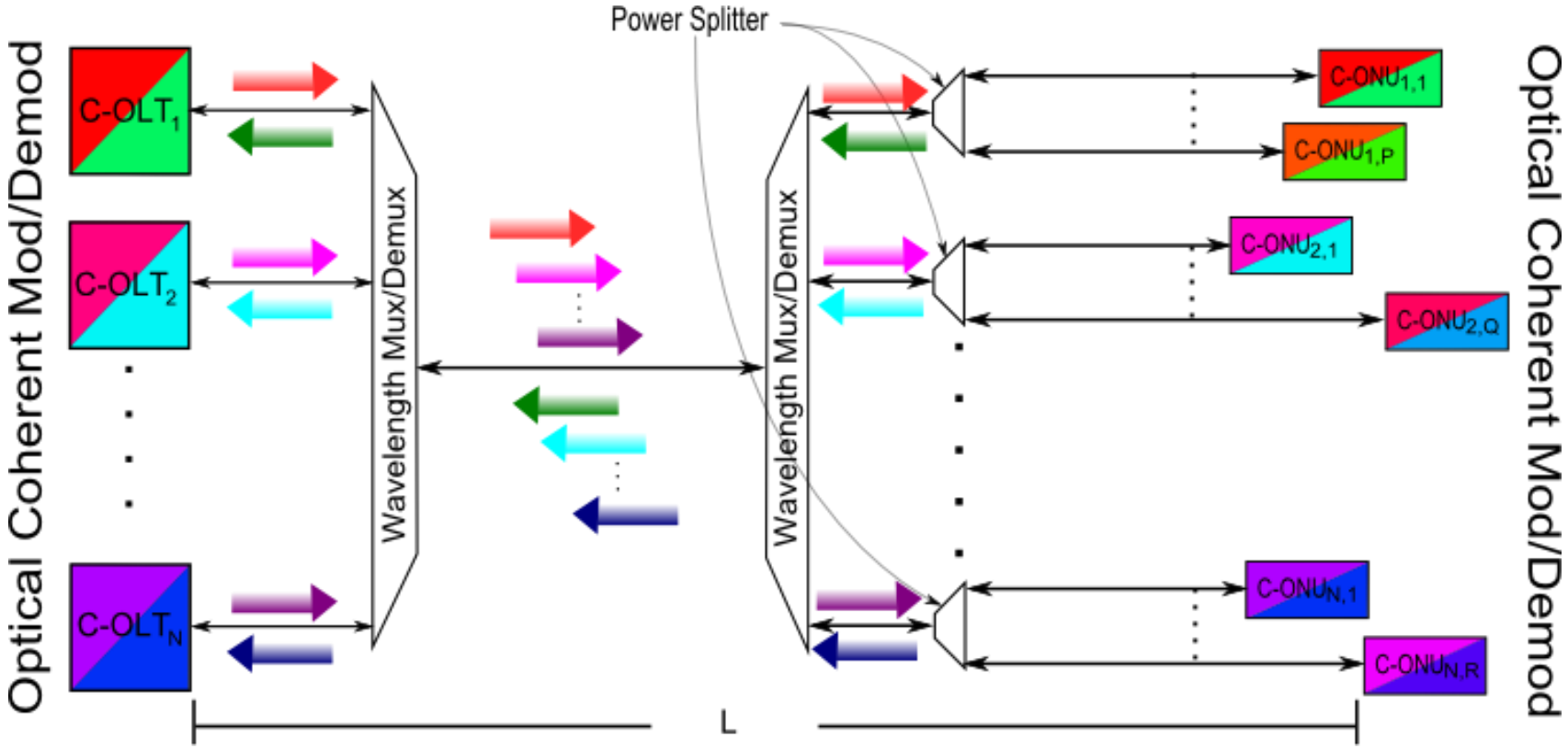


- Different colors represent data to/from different end-users
  - Different users are assigned different subcarriers. Assignments can change dynamically over time. (TDM) .
- OFDMA over a PON with a power splitter is shown.
  - Note that for both upstream and downstream transmission, different ONUs are assigned different (orthogonal) subcarriers and coherent demodulation is used to recover the data. Therefore, though data from different ONUs may arrive at the OLT simultaneously, the upstream data not is corrupted or lost.
  - Carrier Frequencies must be locked to each other (with a constant delta) across all ONUs on the PON for upstream OFDMA (a frequency equalizer will correct phase offsets at the OLT Receiver)
  - OFDMA removes the need for burst-mode reception at the OLT receiver.
- OFDM can also be used over a PON with a Wavelength Mux/Demux (WDM) or over a hybrid PON containing both power splitters and WDMs
  - In these cases the Optical Link budget limits for OFDM are similar to the corresponding link budgets for TDM and or WDM-PON.

Coherent PON

- Uses coherent optical detection to substantially improve performance
- Can either substantially improve reach (up to 100km) or capacity (1000’s of channels per PON)
- Expensive

Coherent PON



- C-OLT is an OLT that employs a Coherent Optical Mod/Demod instead of OOK/ Direct Detect scheme
- C-ONT is an OLT that employs a Coherent Optical Mod/Demod instead of OOK/ Direct Detect scheme
- Note the combination of Wavelength and Power splitters which implies the a WDM-TDM hybrid PON.
- References [8], [9], and [11] claim that L ≤ 100 km or total customers / PON ≤ 1024
  - Possible because of the Rx gain provided by the local oscillator (laser) in coherent detection.
  - Possible because of the precise channel discrimination provided by the local oscillator in coherent detection.
- Cost is the issue…

Conclusions

- 10Gbps PON
  - Industry availability ~2012
  - Primarily MDU and PON-fed DSLAM applications
- 40 Gbps PON
  - Still in the research stage
  - No clear winning technology at this stage