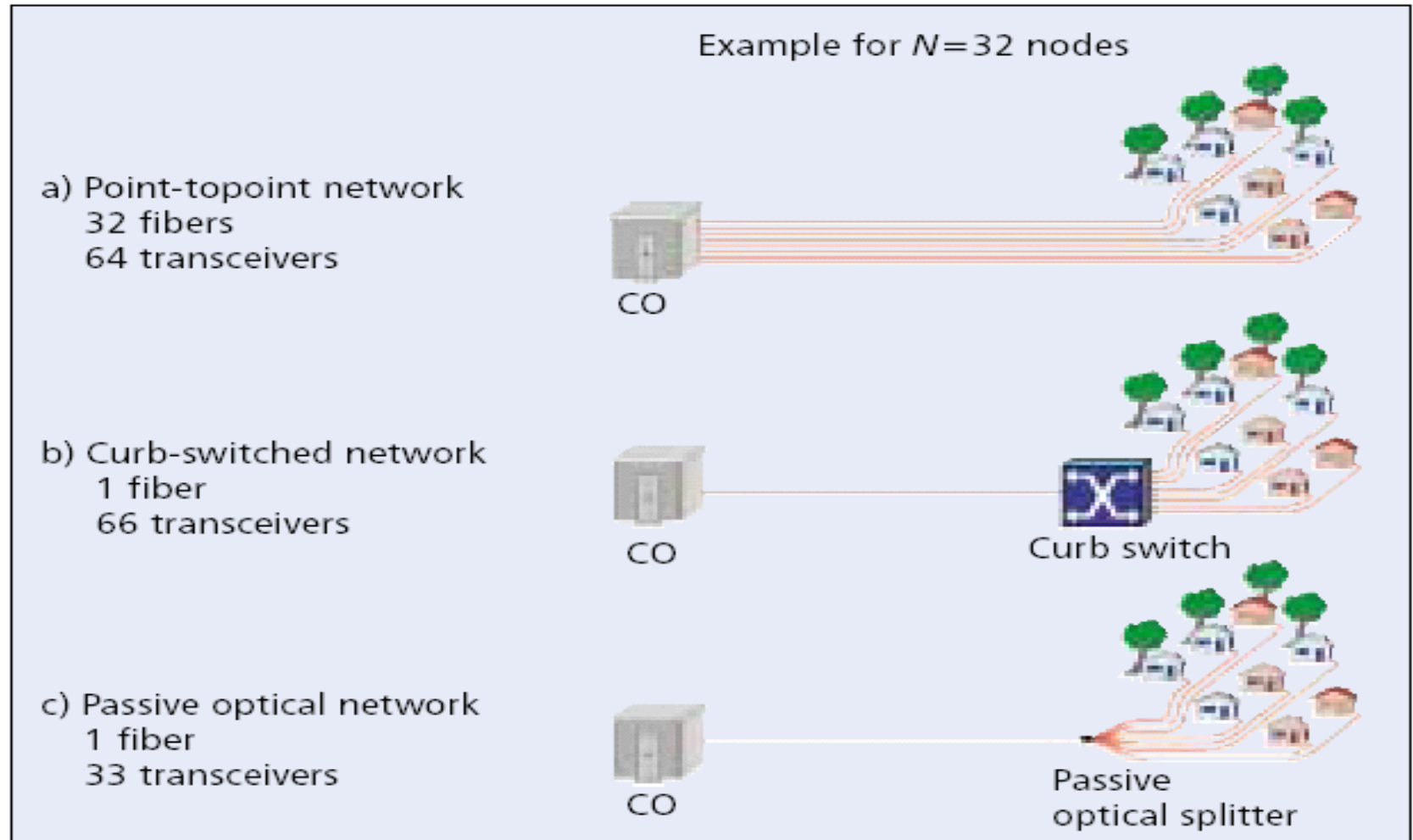


Fundamentals of Passive Optical Network – Components & its Variants

FTTH deployment scenarios



Passive Optical Network

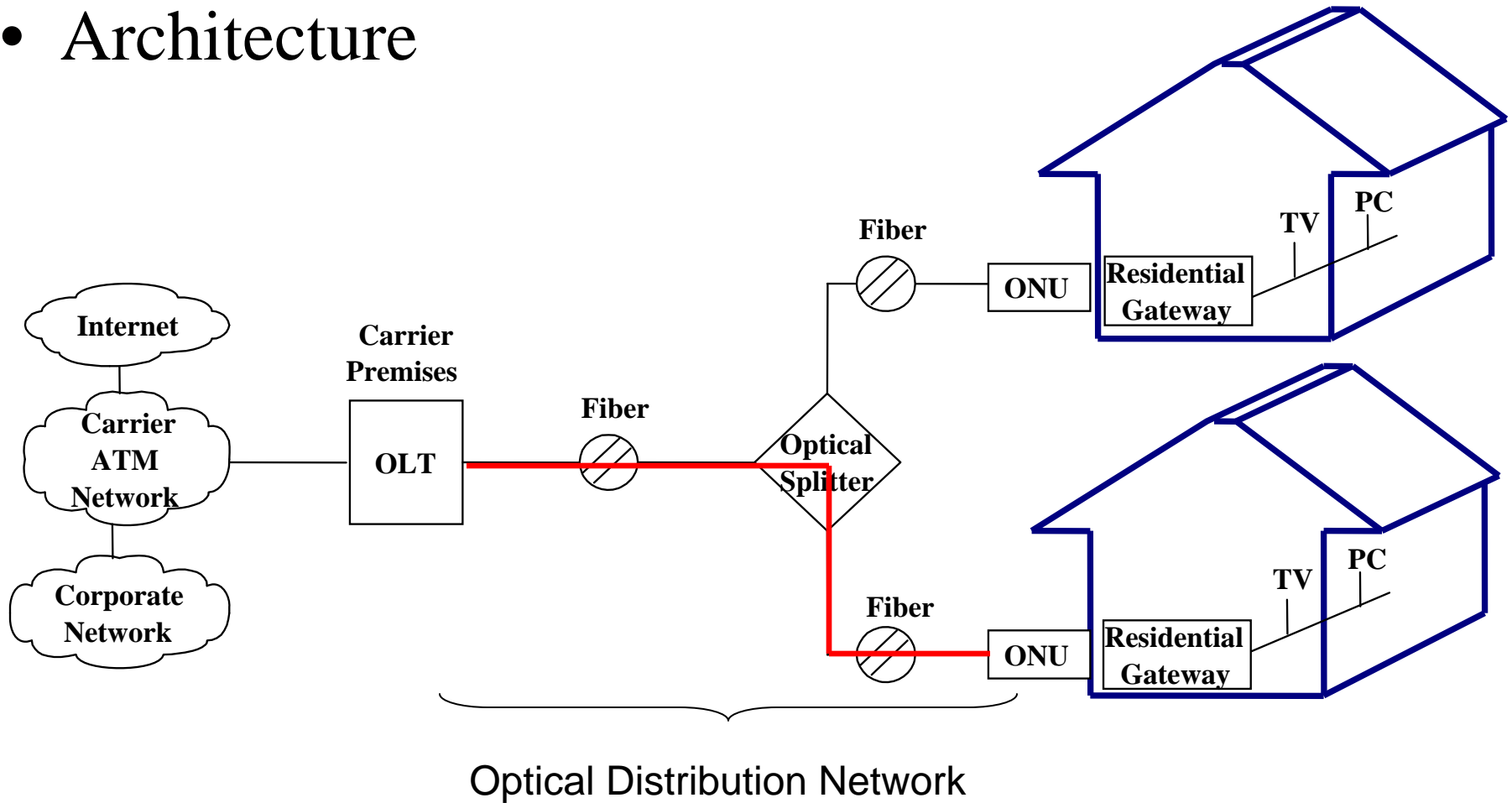
- Passive optical elements (splitter, coupler, ...) based optical distribution network
- Special form of FTTC or FTTH
- Physical star, but logical bus
- Cost effective technology for distribution services
- No powering of remote electronics
- Eliminates need for conditioned enclosures
- Transparent to signal formats
- Simplifies future upgrades

Passive Optical Network

- New loop engineering options
 - Self healing
 - Multiple access techniques
 - Ranging protocol needed (propagation delay, timing)
 - Optical power leveling
- Multiple access techniques for upstream
 - TDMA (Time Division Multiple Access)
 - WDMA (Wavelength Division Multiple Access)
 - SCMA (Sub-carrier division Multiple Access)
 - CDMA (Code Division Multiple Access)

Passive Optical Network

- Architecture



Passive Optical Network

- Optical Line Terminator (OLT)
 - Optical transmission and reception
 - Control functions in the distribution network
 - Control of transmitted power upstream, FEC, interleaving
 - Enforcement of the MAC protocol for upstream bandwidth arbitration
 - Coupling of the distribution network with the ATM transport network
 - (Optional) Enforcement of higher-level protocols
 - (Optional) Switching or cross-connection, to relieve the transport network of switching responsibilities

Passive Optical Network

- Optical Distribution Network (ODN)
 - Comprised of single-mode optical fibers and the passive optical components (optical splitters)
 - Offers one or more optical paths between one OLT and one or more ONUs
 - Attenuation (path loss): difference in path loss between two homes limited to 15dB

Passive Optical Network

- Optical Network Unit / Residential Gateway
 - Optical transmission and reception
 - Cooperation with the OLT to control transmitted power from the residence to the carrier facility
 - Enforcement of the MAC protocol for upstream bandwidth arbitration, in cooperation with the OLT
 - Coupling of the distribution network with the in-home network medium
 - ATM multiplexing

History of PON

- 1st formal PON activity in Spring 1995 (FSAN)
 - To define a common standard for PON
 - 155Mbps PON specified in ITU-T G.983 series
 - Became known as B-PON(also know as APON)
- APON enhanced to support 622Mbps
- In early 2001, Ethernet in the First Mile (EFM) established by IEEE (EPON)
 - Auspices of IEEE 802.3; developed Ethernet standards; focuses on 1.25Gbps symmetrical system
- In 2001, new PON at bit rates of above 1Gbps
 - Gigabit PON

BPON

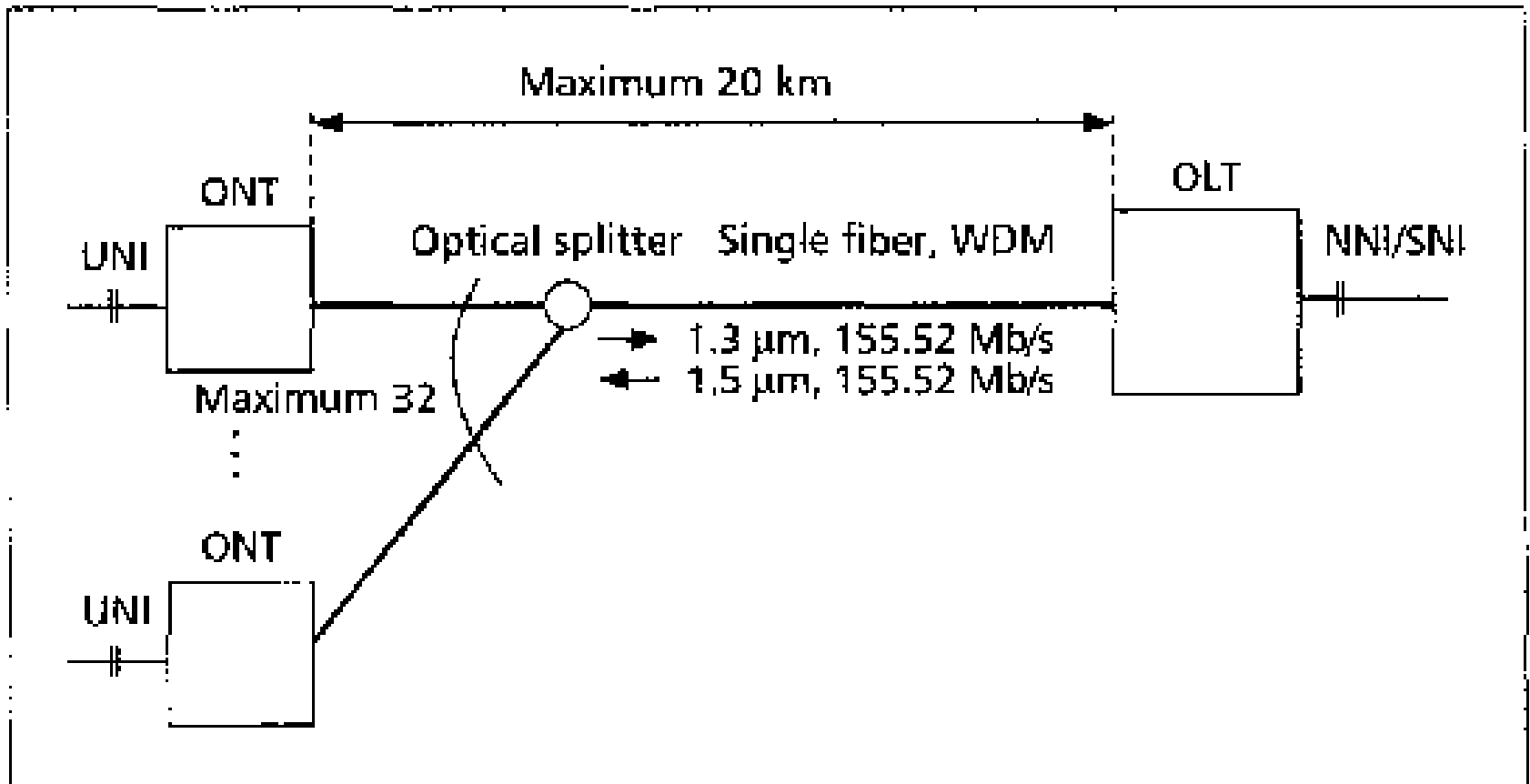
- *Broadband PON*
- Defined by FSAN committee
- Using ATM as their layer 2 signaling protocol
- So, became known as *ATM-based PON* or APON
- Term, APON, led users to believe only ATM could be provided, so FSAN decided to broaden the name to *Broadband PON* (BPON)
- BPON systems offer numerous broadband services including Ethernet access and video distribution

APON

- ATM as service-bearer layer as its basic service (ATM-PON)
- Based on ITU-T Recommendations G.983.1, G.983.2, and G.983.3
- Most promising approaches to establishing a cost-effective optical access network other than P2P or ring-based fiber architecture
- Symmetric: 155.52Mbps DS & US
- Asymmetric: 622.08Mbps DS & 155.52 US
- Bidirectional communications using wavelength division diplexing

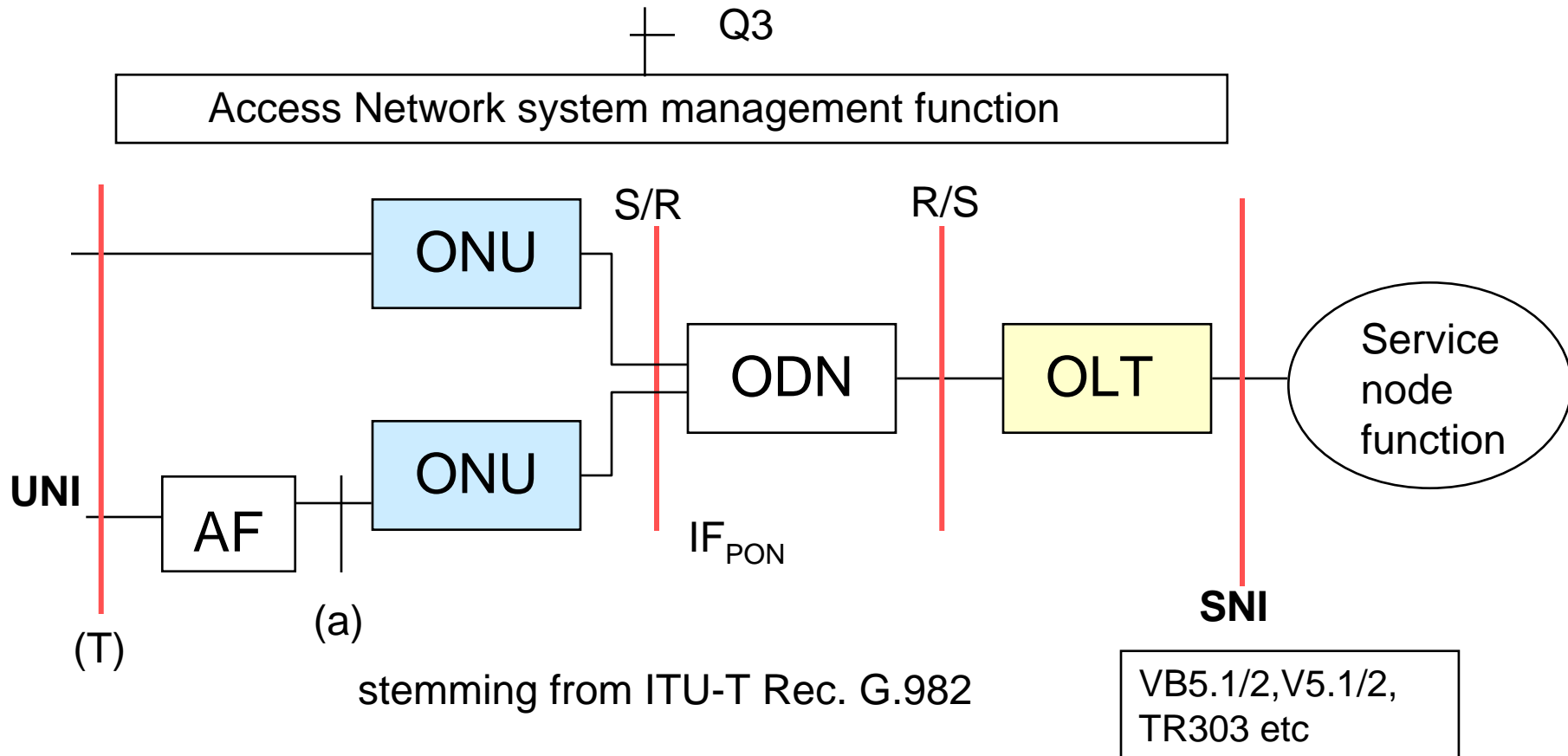
APON

- An example of system configuration (symmetric)



APON

- Framework



EPON

- *Ethernet PON*
- Motivated by disadvantages of ATM
 - Dropped cell will invalidate the entire IP datagram
 - ATM imposes a cell tax on variable-length IP packets
 - ATM did not live up to its promise of becoming an inexpensive technologies
- Ethernet
 - IP data-optimized access network
 - EPON encapsulation of all data in Ethernet frames
 - Inexpensive and ubiquitous and interoperable with a variety of legacy equipment

EPON

- Downlink

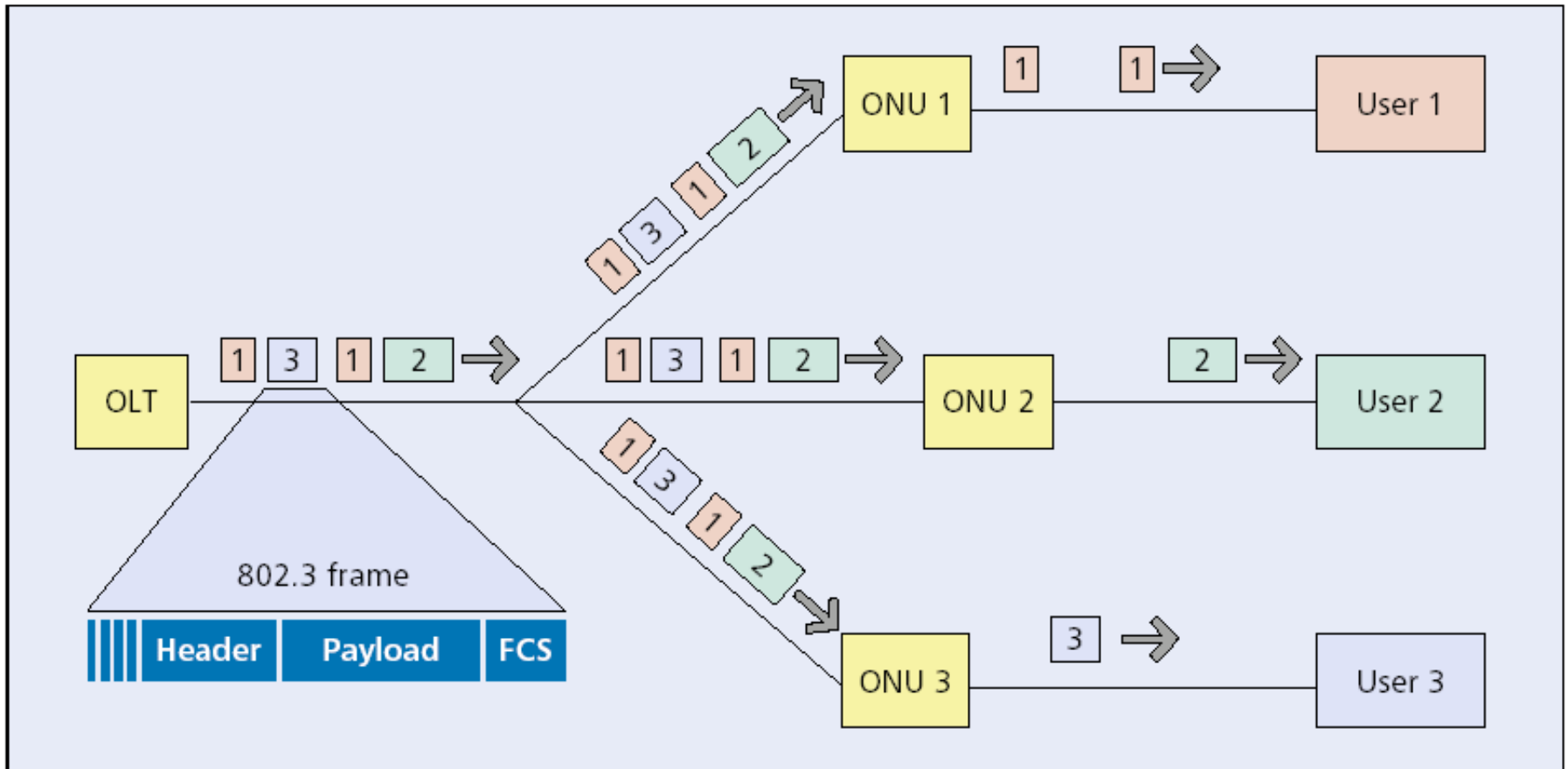
- Ethernet frames transmitted (broadcast) by OLT pass through a 1:N passive splitter and reach each ONU (with own MAC address)
- Splitting ratios are 4~64
- Similar to shared media network

Uplink

- Data frames from any ONU will only reach the OLT not other ONUs due to directional properties of a passive combiner (optical splitter)
- Similar to P2P architecture
- But, EPON frames from different ONUs transmitted simultaneously still may collide
- ONUs need to share the trunk fiber channel capacity and resources

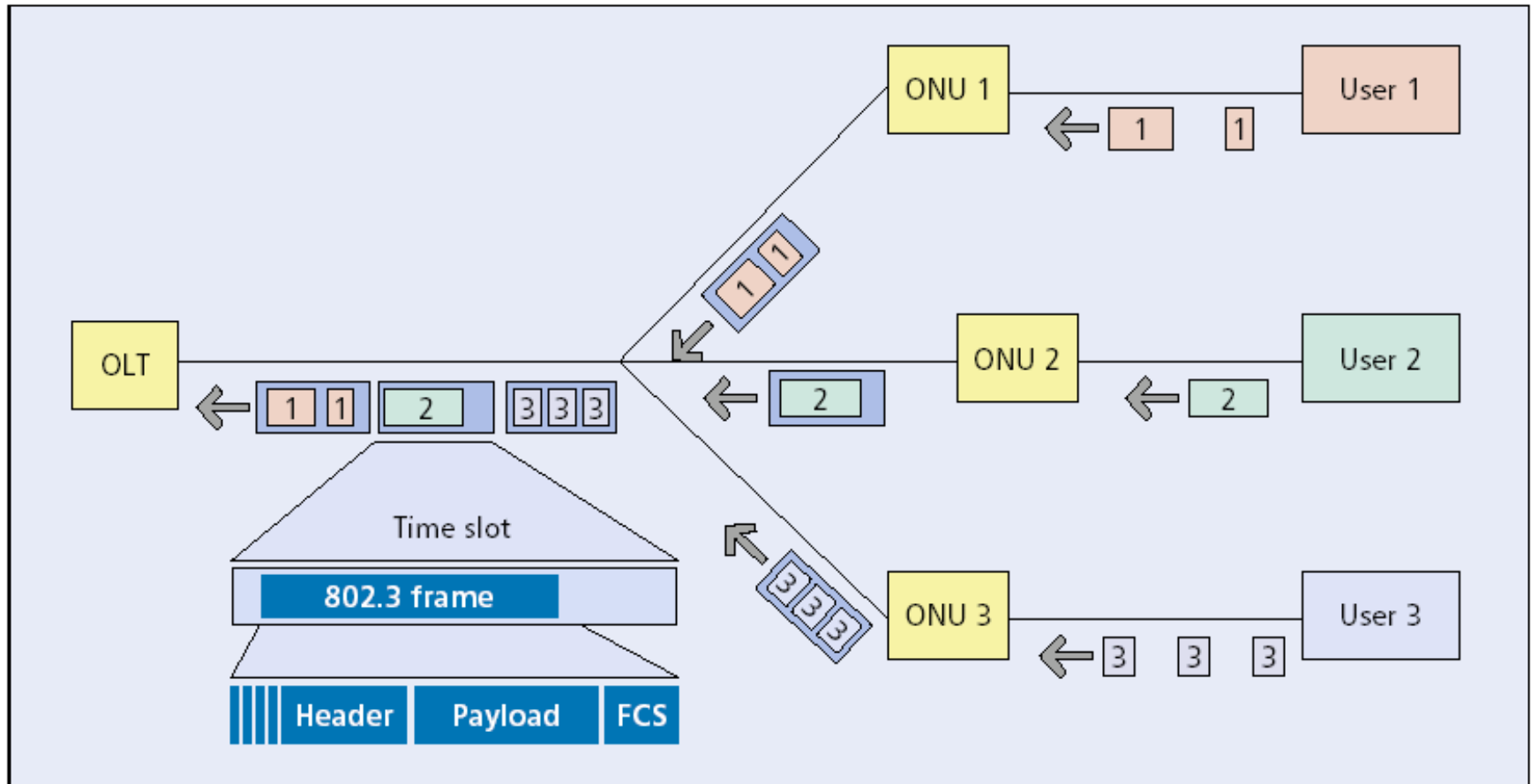
EPON

- Downstream traffic in EPON



EPON

- Upstream traffic in EPON



GPON

- *Gigabit PON*
- Initiated by FSAN in 2001 for a new effort for standardizing PON at bitrates of above 1 Gbps
- Most optimal and efficient in terms of support for multiple services, OAM&P functionality and scalability
- Multiple services, specifically data and TDM, in native formats and at an extremely high efficiency

GPON

- Main requirements
 - Full service support including voice (TDM, both SONET and SDH), Ethernet (10/200 BaseT), ATM, leased lines and more
 - Physical reach of at least 20km with a logical reach support within the protocol of 60 km
 - Support for various bitrate options using the same protocol, including symmetrical 622 Mbps, symmetrical 1.25 Gbps, 2.5 Gbps DS and 1.25 Gbps US and more
 - Strong OAM&P capabilities offering end to end services management
 - Security at the protocol level for DS traffic due to the multicast nature of PON