



EEEN 464 – DIGITAL COMMUNICATION

GIGABIT PASSIVE OPTICAL NETWORK (GPON) - STUDY GUIDE/REVISION

1. OBJECTIVE

Understand the architecture, protocols, and operation of Gigabit-capable Passive Optical Networks (GPON) for modern broadband access.

2. INTRODUCTION TO GPON

Definition

GPON is a fibre-to-the-premises (FTTP) technology delivering high-speed data, voice, and video over a passive optical distribution network (ODN). GPON is the dominant FTTH technology globally, leveraging passive splitters, encapsulation, and dynamic bandwidth allocation to deliver cost-effective high-speed broadband.

Key Features:

- Downstream: **2.488 Gbps**, Upstream: **1.244 Gbps** (asymmetric).
- Supports up to **128 subscribers** per optical line terminal (OLT).
- **Passive splitters** reduce power/space requirements.

Advantages

- High bandwidth, long reach (20 km), low OPEX.
- Triple-play services (Internet, VoIP, IPTV).

3. STANDARDS & KEY ORGANIZATIONS

ITU-T Standards

- **G.984.1**: General characteristics.
- **G.984.2**: Physical Media Dependent (PMD) layer.
- **G.984.3**: Transmission Convergence (TC) layer.
- **G.984.4**: OMCI (ONT Management Control Interface).

Key Bodies

- **FSAN** (Full Service Access Network): Drives GPON standardization.

- **IEEE:** Competes with **EPON** (Ethernet PON).

4. GPON ARCHITECTURE & COMPONENTS

- **Optical Line Terminal (OLT):**
 - Located at the ISP's central office.
 - Aggregates traffic, manages ONTs, allocates bandwidth.
- **Optical Network Terminal/Unit (ONT/ONU):**
 - User-premises device (e.g., home router).
 - Converts optical signals to electrical (Ethernet, Wi-Fi).
- **Passive Optical Splitter:**
 - Splits downstream signal to multiple ONTs (1:64 typical).
 - Combines upstream signals (TDMA).
- **Optical Distribution Network (ODN):**
 - Fiber cables (single-mode), connectors, cabinets.

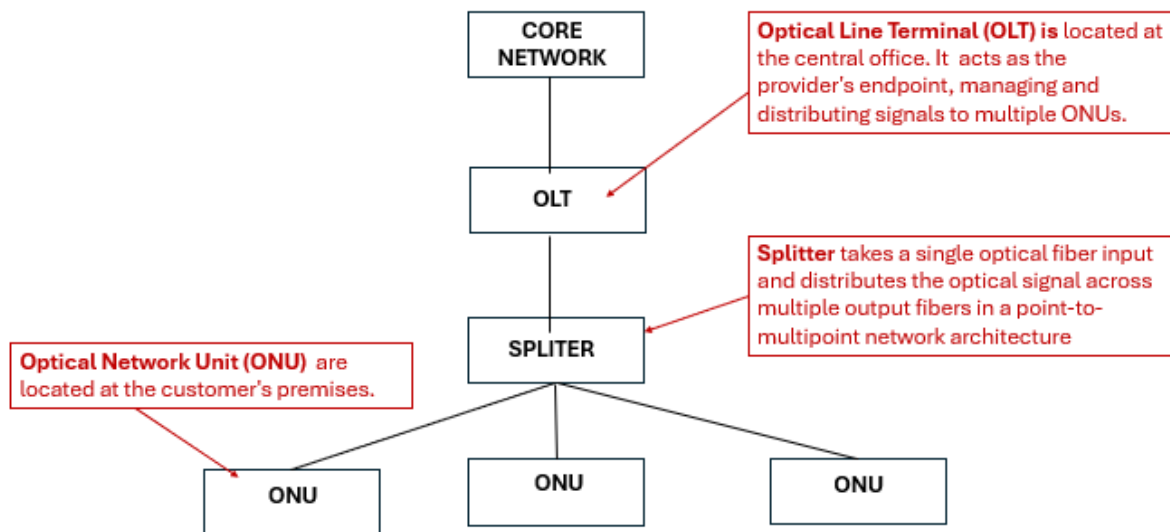


Figure 1. GPON architecture

5. GPON PROTOCOL STACK

- **Physical Layer (G.984.2):**
 - **Wavelengths:** Downstream (1490 nm), Upstream (1310 nm), Video (1550 nm).
 - **Optical Budget:** Class B (20 dB) to Class C+ (32 dB).
- **Transmission Convergence (TC) Layer (G.984.3):**
 - **GEM (GPON Encapsulation Method):**
 - Fragments packets into 125 μ s frames.
 - Uses **Port IDs** (12-bit) to multiplex traffic.

- **Frame Structure:**
 - Downstream: **PCBd** (Physical Control Block) + Payload.
 - Upstream: **Burst-mode** TDMA with grants.

6. KEY TECHNOLOGIES & OPERATION

- **Upstream Multiplexing:**
 - **TDMA:** OLT grants timeslots to ONTs via **BWmap** (prevents collisions).
- **Dynamic Bandwidth Allocation (DBA):**
 - **Types:** Status-reporting (SR-DBA), Non-status reporting (NSR-DBA).
 - OLT adjusts grants based on ONT queue reports (T-CONT types).
- **Activation Process:**
 1. **Serial Number Discovery:** OLT identifies new ONTs.
 2. **Ranging:** Measures ONT distance (compensate delay).
 3. **Authentication:** Via OMCI or SN.

7. FRAME STRUCTURE & ENCAPSULATION

- **Downstream Frame:**
| **PCBd** (30B) | **GEM Payload** (38880B) |
 - **PCBd Fields:**
 - **Psync** (4B): Frame sync.
 - **Ident** (4B): Superframe counter.
 - **PLOAMd** (13B): Management messages.
 - **BWmap** (8B): Upstream grants.
- **GEM Encapsulation:**
 - Segments packets into 48B fragments (similar to ATM).
 - Uses **GEM Port ID** for service multiplexing.

7. MANAGEMENT & SECURITY

- **OMCI (G.984.4):**
 - Protocol for OLT to manage ONTs (configuration, diagnostics).
 - **MIB (Management Information Base):** Stores ONT parameters.
- **Security:**
 - **AES-128 Encryption:** Secures downstream traffic.

- **Key Management:** OLT updates keys via PLOAM messages.

8. GPON VS. OTHER PON TECHNOLOGIES

Feature	GPON	EPON (IEEE 802.3ah)	XGS-PON
Standard	ITU-T G.984	IEEE Ethernet	ITU-T G.9807
Speed	2.5G/1.25G	1G/1G	10G/10G
Encapsulation	GEM (ATM-like)	Ethernet	GEM/XGEM
Use Case	Residential	Enterprise	5G Fronthaul

9. APPLICATIONS & FUTURE

- **Current:**
 - FTTH (Fiber-to-the-Home), mobile backhaul, smart cities.
- **Evolution:**
 - **NG-PON2:** Wavelength stacking (TWDM) for 40G+ speeds.
 - **SDN/NFV Integration:** Programmable PONs.

10. KEY STUDY TOPICS

- Memorize:** GPON rates, wavelengths, frame structure.
- Explain:** DBA, GEM encapsulation, activation sequence.
- Compare:** GPON vs. EPON vs. XGS-PON.
- Calculate:** Bandwidth per user (e.g., 2.488 Gbps / 64 users).
- Draw:** GPON protocol stack, ODN topology.