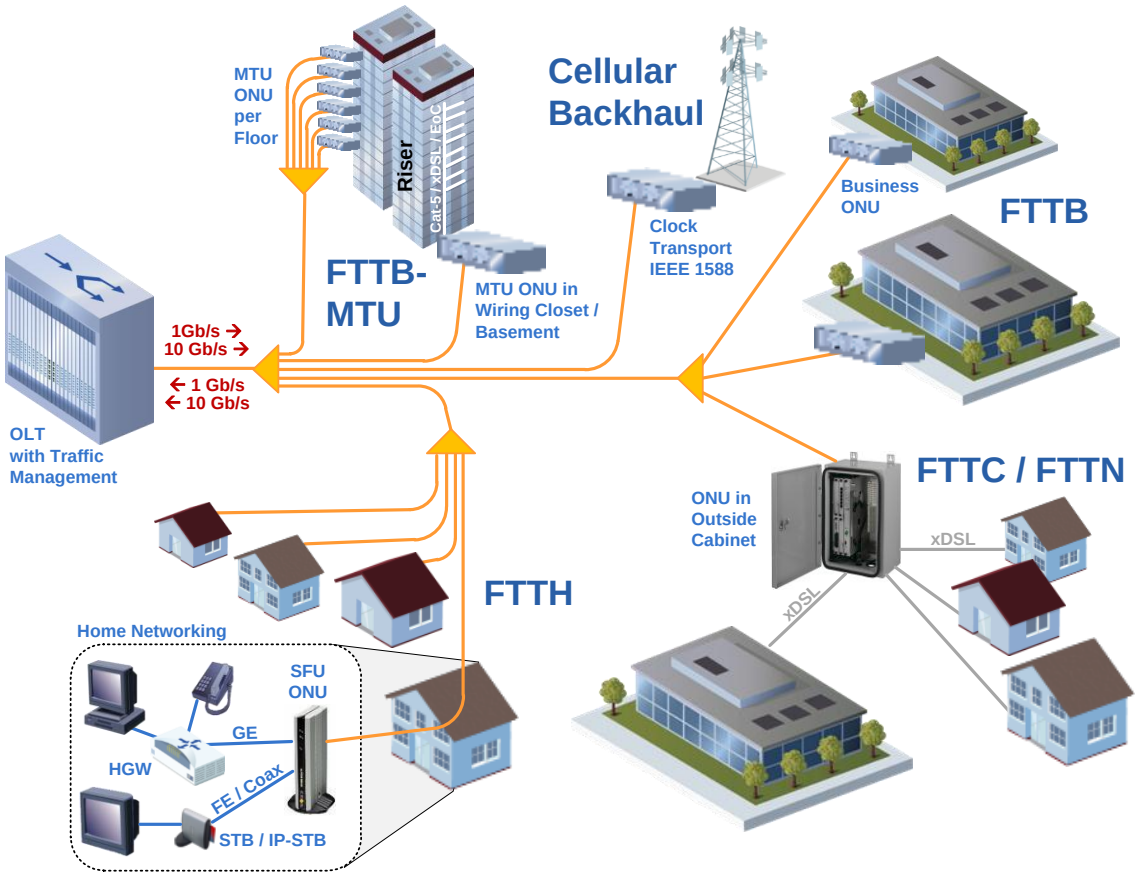
IEEE P1904.1

Standard for Service Interoperability in Ethernet Passive Optical Networks (SIEPON)

Glen Kramer, SIEPON WG Chair

EPON is a Universal Access Architecture

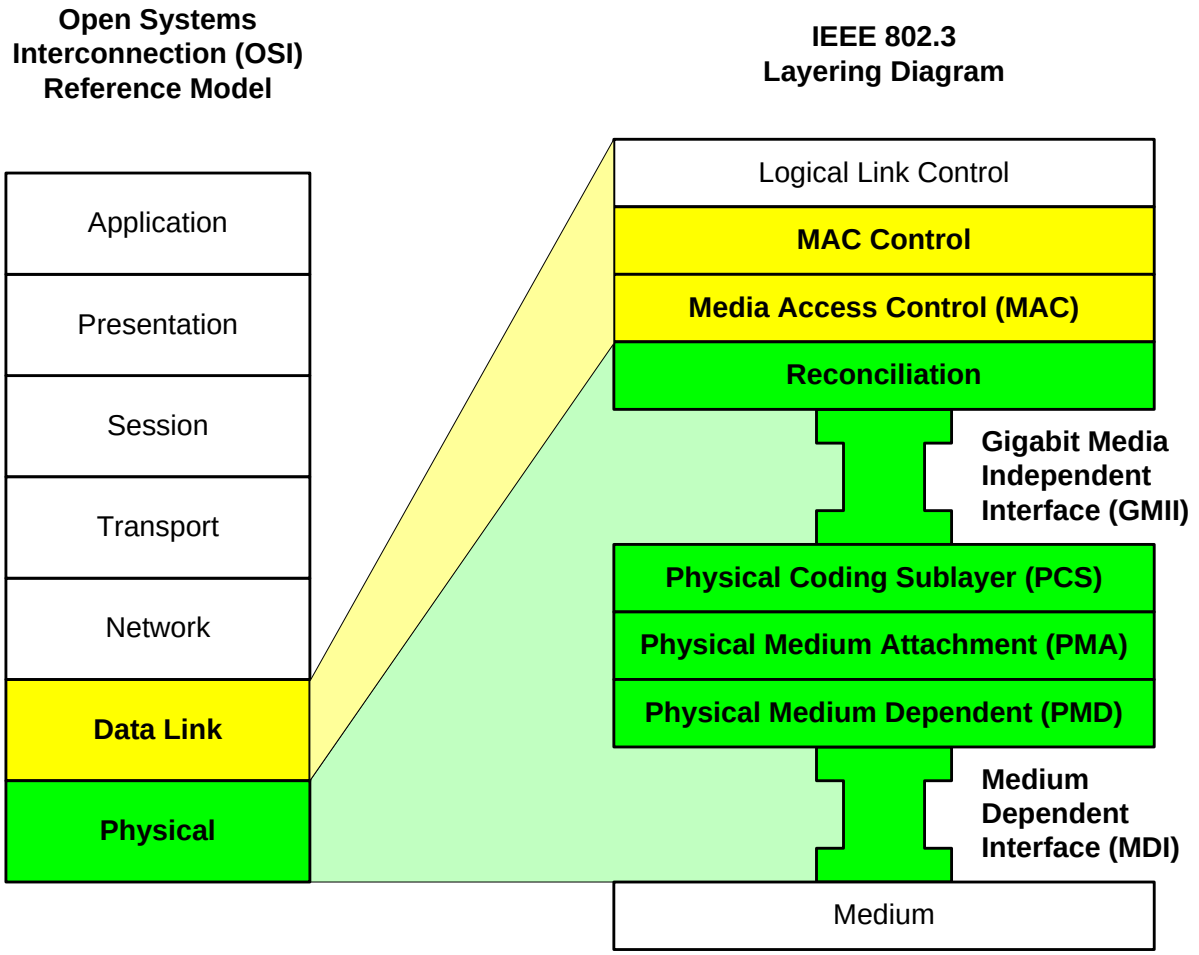
- **Deployed by all types of right-of-way holders**
  - Phone network operators
  - Cable network operators
  - Power line operators
- **Supports all user types**
  - Residential
  - Business
  - Wireless backhaul
- **All configurations**
  - SFU
  - MDU/MTU
  - FTTH
  - FTTC/FTTN
- **All Data Rates**
  - 1 Gb/s (802.3ah-2004)
  - 2/1 Gb/s (CCSA-2009)
  - 10/1 Gb/s (802.3av-2009)
  - 10/10 Gb/s (802.3av-2009)



EPON architecture simultaneously supports all user types, all deployment configurations, and all equipment generations on the same network!

Scope of IEEE 802.3 is on Lower Layers

- 1G-EPON was standardized in the IEEE P802.3ah "EFM" project (2000-2004)
- 10G-EPON was standardized in the IEEE P802.3av project (2006-2009)
- IEEE 802.3 covers only the Physical Layer and a portion of the Data Link Layer
- IEEE 802.3 focus is on transport, not on the system



Big Guns Have Developed Their Own Specs

- From a carrier's perspective, the operation of OLT and ONUs is closely coupled, yet they are separate devices which may be sourced from different vendors.
- To ensure interoperability at the system level, additional specifications were necessary:
  - QoS mechanisms for multiple services (distinct SLAs)
  - Exact DBA mechanism
  - Packet-classification rules
  - Software/Firmware download
  - Service-aware power-saving mechanisms
  - Service protection and restoration mechanisms
  - Device and service management
- To expedite 1G-EPON deployments, big carriers (NTT, CTC) have created their own system specifications and interoperability testing plans (2+ year effort).

SIEPON Working Group

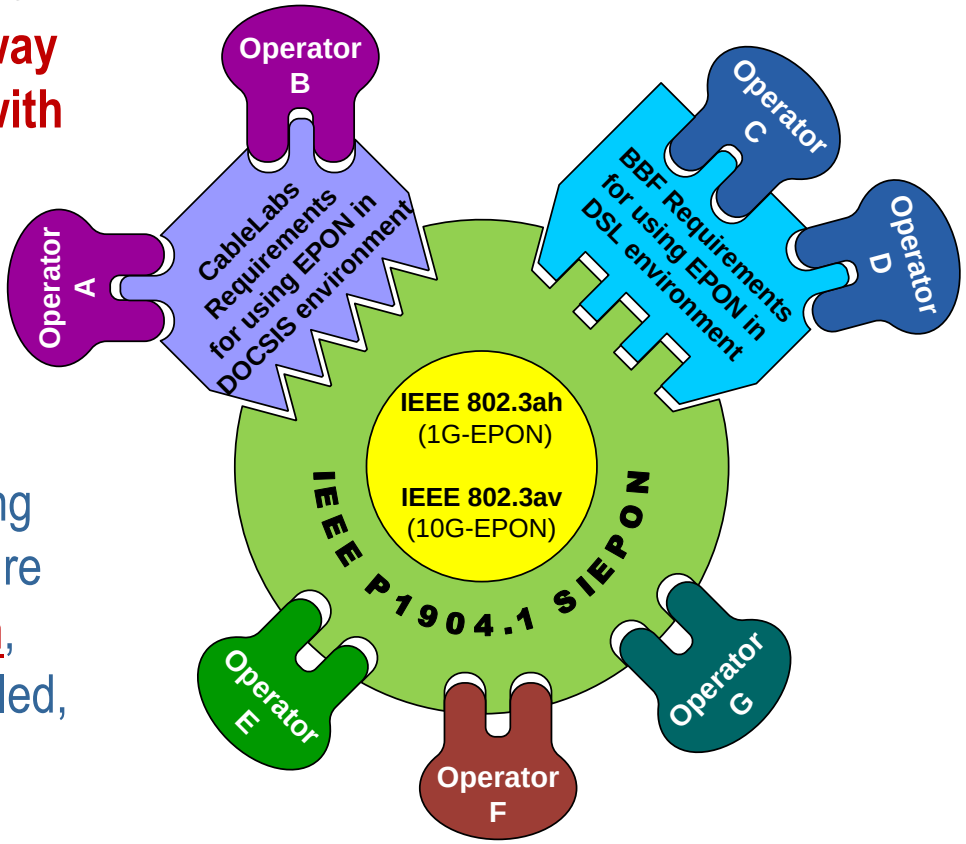
- In 2009, the industry got together and decided that going forward, the development of next-generation specifications and interoperability plans should be done at shared cost.

- The following companies were members of SIEPON WG at various times:

1. Alcatel-Lucent
2. ARRIS
3. Aurora Networks
4. Bright House Networks
5. Broadcom Corporation
6. CableLabs
7. China Telecom
8. CommScope
9. Cortina
10. Ericsson
11. FiberHome Technologies
12. Fujitsu Telecom Networks
13. Hitachi Communications
14. Huawei Technologies
15. Ikanos Communications
16. Iometrix
17. KDDI
18. KT
19. Marvell
20. Mitsubishi Electric
21. NEC
22. NTT Corporation.
23. Oki Electric Industry
24. Oliver Solutions
25. PMC-Sierra, Inc.
26. Qualcomm-Atheros
27. RITT
28. Sumitomo Electric
29. UNH -- IOL
30. ZTE Corporation

Common Rules and Principles

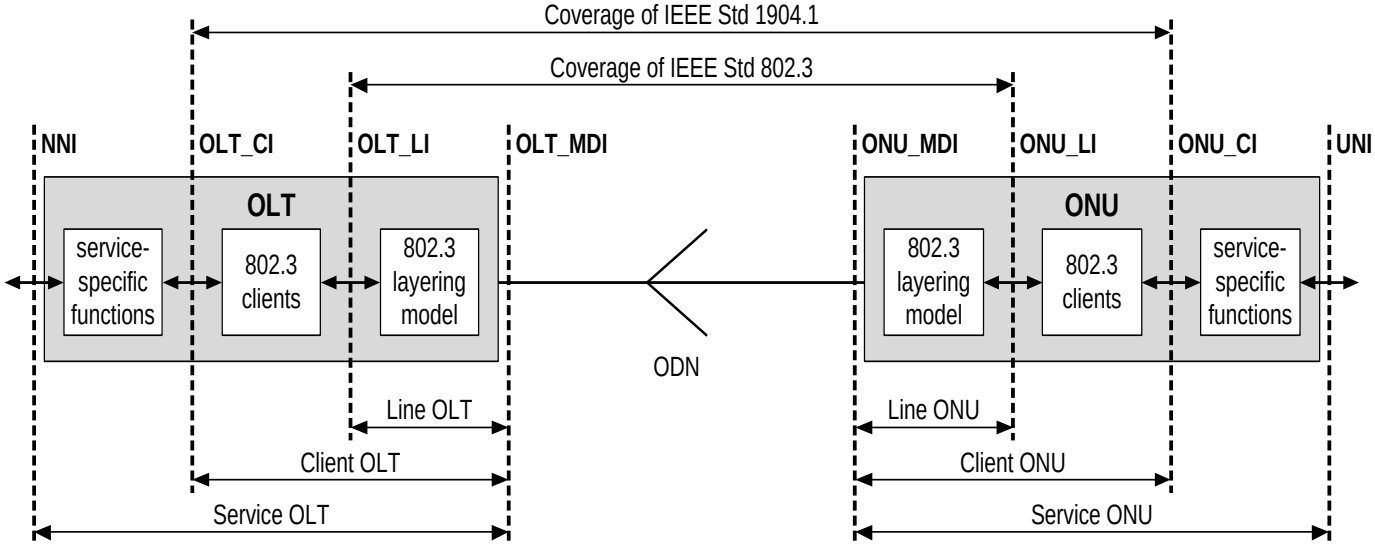
- SIEPON did not need to invent new technology or resolve technical challenges
- Various architectural features were already debugged, refined, deployed, and field-proven
- The goal of IEEE p1904.1 SIEPON project:
  Address in a consistent and uniform way the diverse requirements associated with
  - **Multiple service models**
  - **Different provisioning and management concepts**
  - **Various deployment scenarios**
- SIEPON is an "umbrella" standard defining a common reference architecture to ensure that EPON preserves a single ecosystem, as opposed to multiple, nationally-controlled, and fragmented ecosystems.



SIEPON Scope

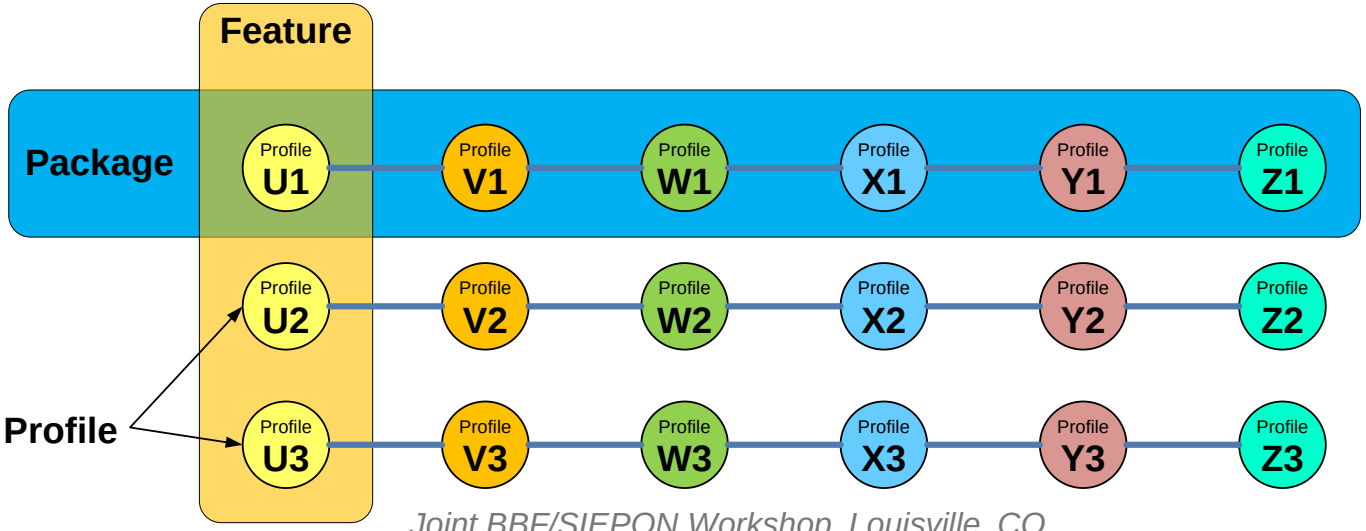
SIEPON standard describes the system-level requirements needed to provide service-level, multi-vendor interoperability of Ethernet Passive Optical Network (EPON) equipment. The specifications complement the existing IEEE Std 802.3 and IEEE Std 802.1 standards which enable the interoperability at the Physical layer and Data Link layer. Specifically included in this specification are:

- EPON system-level interoperability specifications covering equipment functionality, traffic engineering, and service-level QoS/CoS mechanisms;
- Management specifications covering: equipment management, service management, and power utilization.



Terminology

- **Feature** – a generic function or a characteristic of an EPON device.
  Examples:
  - Report Format
  - Power Saving
- **Profile** – a specific implementation or a configuration of a feature.
  Examples:
  - OLT-driven power-saving mechanism
  - Power-saving mechanism with support for ONU initiation/response
  - OLT-driven power-saving mechanism with multiple sleep cycles
- **Package** – a set of profiles that represents a complete specification for interoperable OLT and ONUs



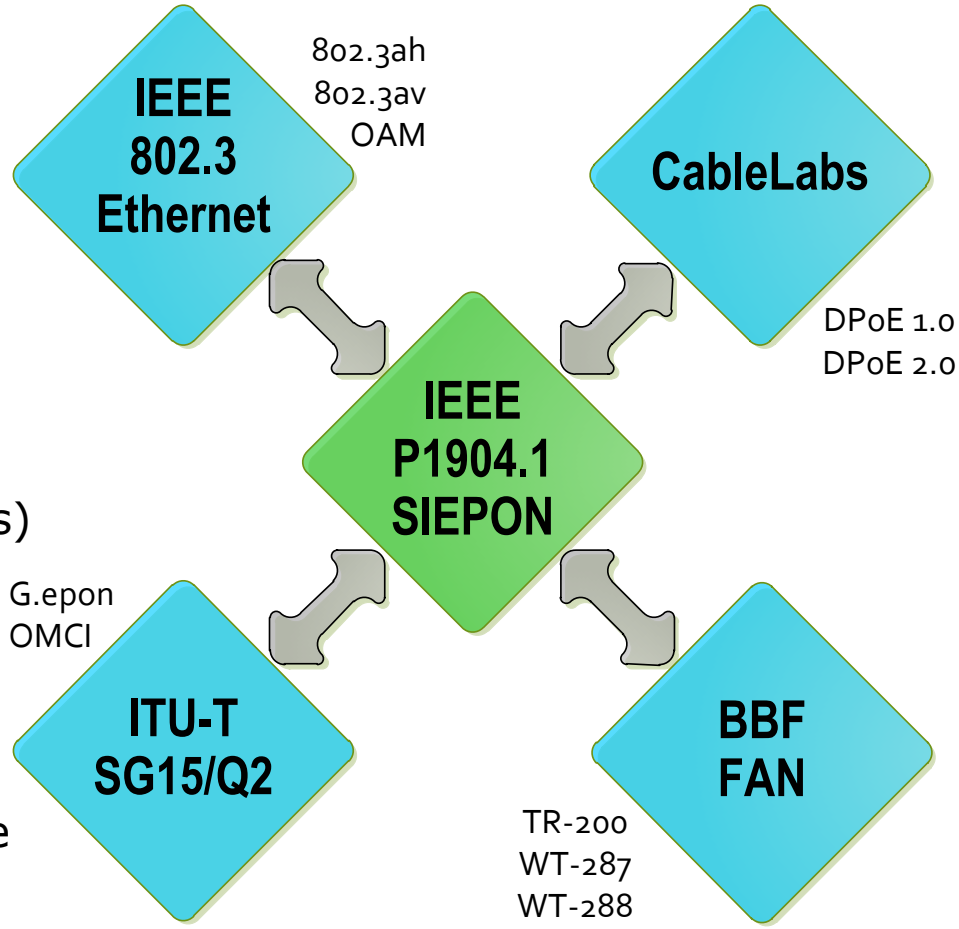
SIEPON Packages

- **Package A**: Specification targeting WW Cable Industry (aligned with DPoE)
- **Package B**: Specification targeting Japanese incumbent phone operator market (aligned with NTT spec)
- **Package C**: Specification targeting Chinese incumbent phone operator market (aligned with CTC spec)

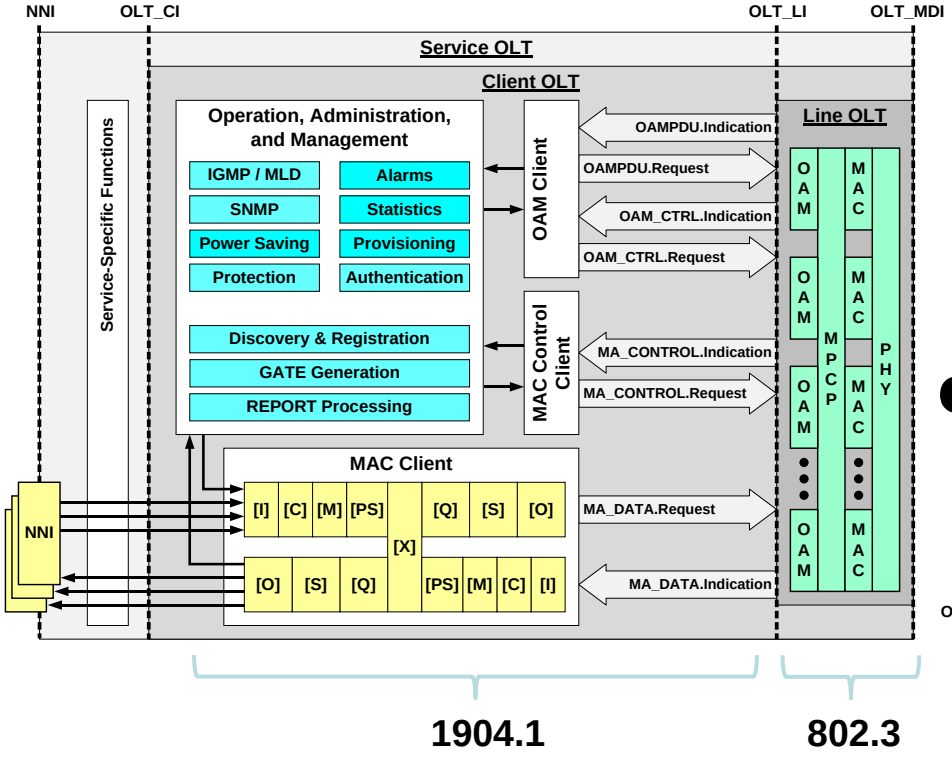
Coordination with Other Groups

IEEE P1904.1 has established close and productive relationships with

- **CableLabs**
  - DPoE provides requirements for EPON in MSO environments
- **Broadband Forum FAN**
  - TR-200 provides EPON Data Path (EDP) requirements
  - Coordinating activities of WT-287 (optical monitoring) and WT-288 (deployment requirements)
- **ITU-T SG15**
  - Coordinating activities on G.epon
- **IEEE 802.3**
  - Successfully cooperated to allow an increased OAM frame rate
  - Recently - added support for multicast LLID



OLT and ONU Reference Architecture

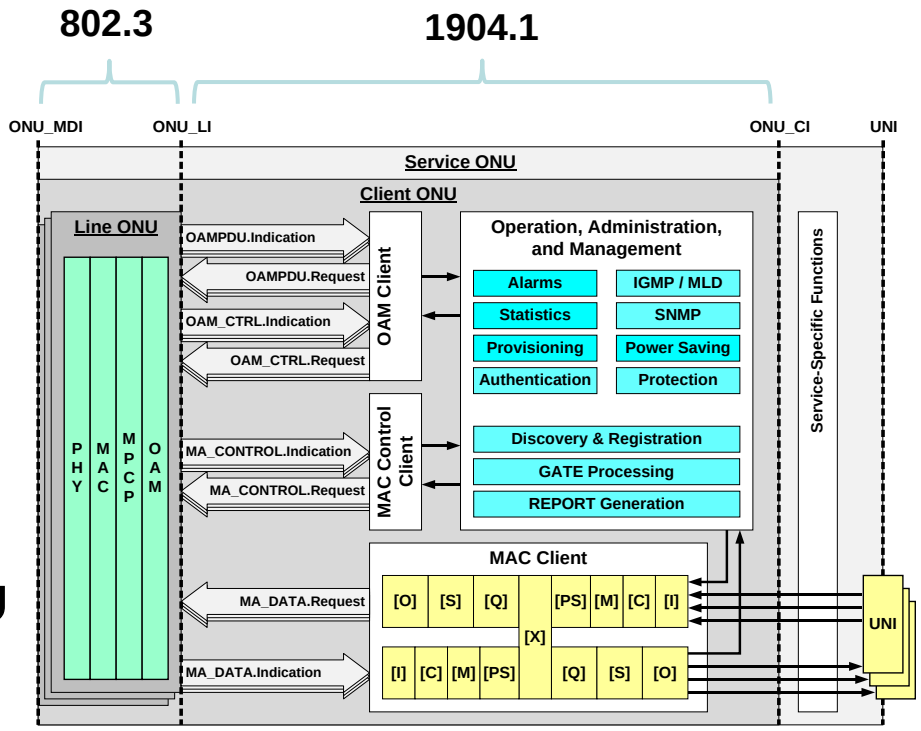


OLT

- **SIEPON covers various features:**
  - Power Saving
  - Trunk and Tree Protection
  - Software Download
  - Authentication
  - IGMP/MLD

- **SIEPON covers entire data path:**
  - Classifier
  - Modifier
  - Policer/Shaper
  - CrossConnect
  - Queues
  - Scheduler

ONU



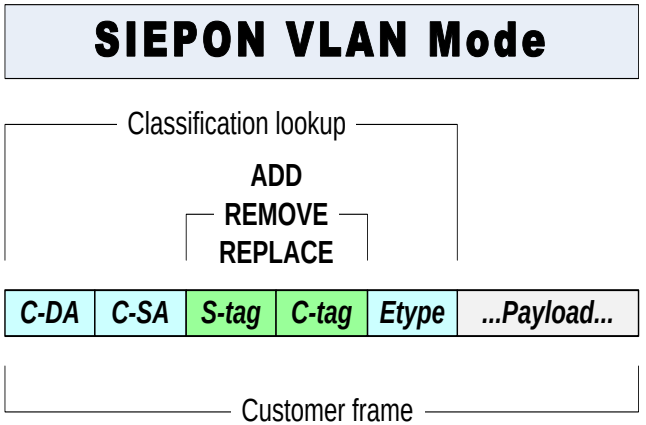
Packages at a glance

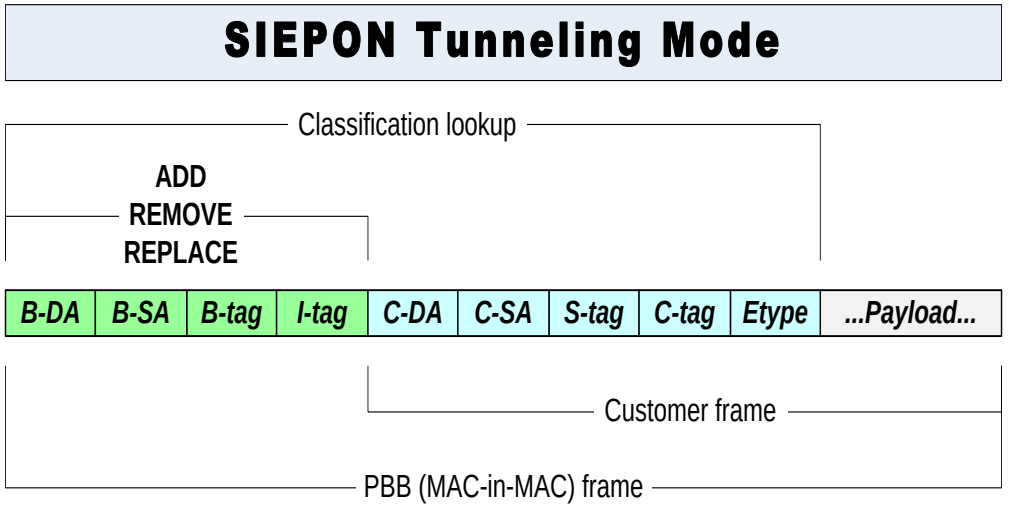
Feature	Package A	Package B	Package C
Support for EDP	N/A	N/A	✓
REPORT MPCP format	✓	✓	✓
Queue service discipline	✓	✓	✓
ONU and OLT transceiver status monitoring	✓	✓	✓
Port loop detection	N/A	N/A	✓
Remote ONU Tx power supply control	N/A	N/A	✓
Events	✓	✓	✓
Optical link protection	N/A	✓	✓
Data encryption	Ref. DPoE	Ref. 802.3	N/A
ONU authentication	Ref. DPoE	✓	✓
Management	✓	✓	✓
Device and capability discovery	✓	✓	✓
Software update	✓	✓	✓
Management entities	✓	✓	✓
Power saving	✓	✓	✓
Performance monitoring	N/A	N/A	✓
VLAN modes	✓	✓	✓
Tunneling modes (802.1ah)	✓	N/A	N/A
Multicast connectivity	✓	✓	✓

Key Features

VLAN and Tunneling Modes

Feature	Package A	Package B	Package C
VLAN modes	• Transport PB VLAN mode • Encapsulation PB VLAN mode	VLAN Modes configured per device • Transparent • Tagging • Translation • ToS/CoS Conversion	VLAN Modes configured per port • Transparent • Tagging • Translation • Filtering • N:1 Aggregation
Tunneling modes (802.1ah)	Two modes based on 802.1ah MAC-in-MAC: • Transport mode • Encapsulation mode		

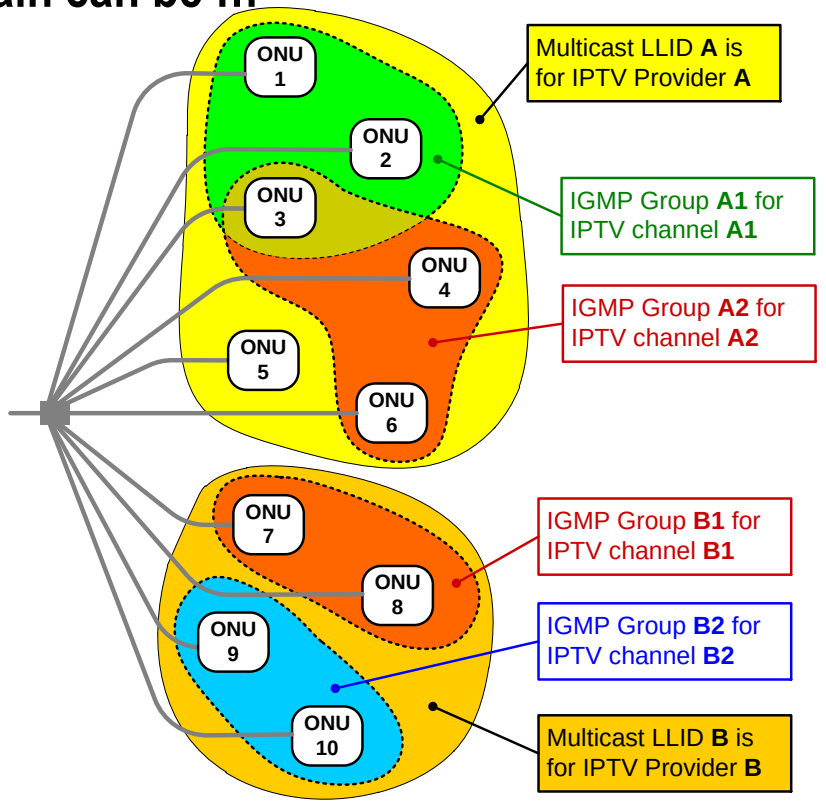




- VLAN modes operate over L2 headers of customer frames
- Tunneling modes operate over encapsulating fields and don't modify customer frame

Multicast in EPON

- **An EPON may serve multiple domains. A domain can be …**
  - A set of ONUs serving one subscriber (campus/company)
  - A set of ONUs served by one service provider (e.g., ABC, CBS, NBC)
  - Set of ONUs participating in specific operation requiring broadcast
    - Power Saving
    - Protection
    - Time sync
    - Software download (grouped by version/vendor)
- **An ONU may belong to multiple domains**

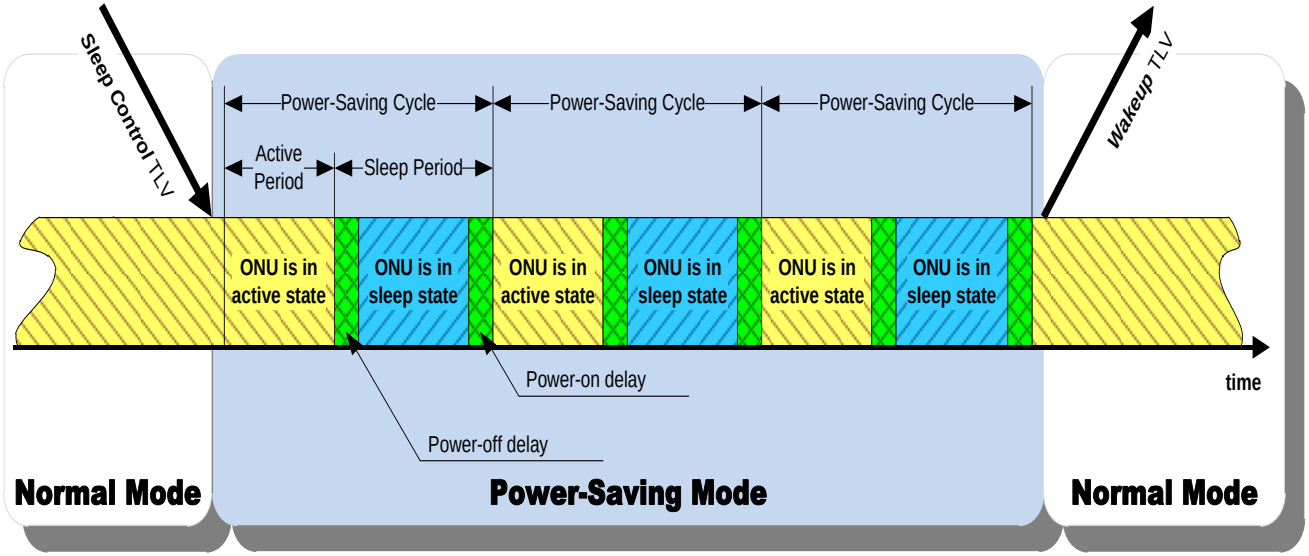


Feature	Package A	Package B	Package C
Multicast connectivity	• Multicast based on combined LLID and IP group addresses. • IGMP-based and MLD-based multicast control.	• Multicast based on VLAN and/or MAC group address. • MLD-based multicast control.	• Multicast based on combined VLAN and MAC or IP group address with and without authorization control. • IGMP-based and MLD-based multicast control.

Power-Saving in SIEPON

Main objectives

- Achieve power saving in EPON **without negative impact on user QoS**
- Support both 1G-EPON and 10G-EPON ONUs
- Coexistence of ONUs supporting power saving and ONUs not supporting it



Key characteristics

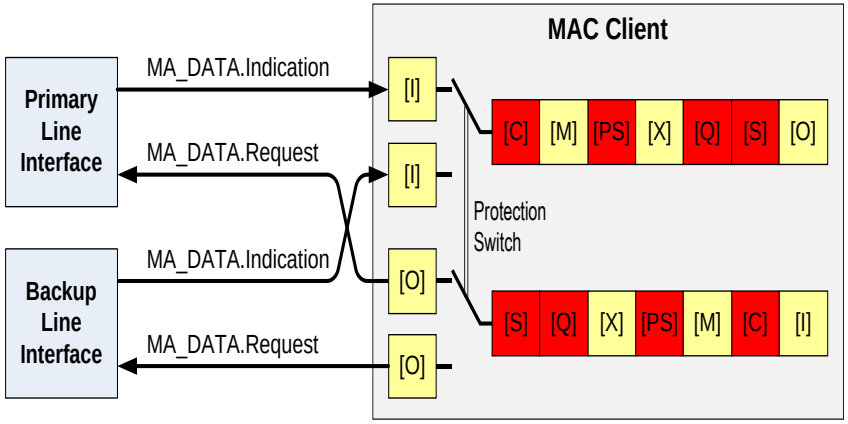
- The OLT discovers the sleep mode supported by each ONU: Tx only or Tx+Rx
- The OLT decides which of the ONUs is eligible to participate in each power-saving cycle.
- The power-saving mechanism can be **static** (provisioned by the NMS) or **dynamic** (based on data load on the given ONU, configured services, user activity, etc.)
- **Early Wakeup** function allows ONUs to exit the sleep state earlier than previously scheduled in response to the local conditions, such as off-hook condition on SIP ports, power down, etc.;
- **Synchronized Wakeup** function wakes up ONUs belonging to the same service group at the same time to facilitate multicast content distribution.

Internal Data Path Redundancy

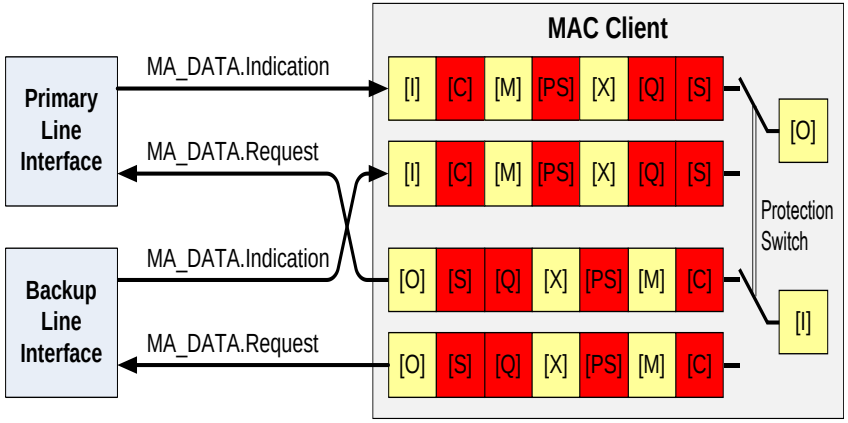
- Data path comprises the following functional elements:
  - **[I]** – Input port
  - **[C]** – Classifier
  - **[M]** – Modifier
  - **[PS]** – Policer/Shaper
  - **[X]** – Cross-connect
  - **[Q]** – Queues
  - **[S]** – Scheduler
  - **[O]** – Output port
- Blocks using combinatorial logic (yellow →)
  - The output of a functional block only depends only on the input.
- Blocks using sequential logic (red →)
  - The output of a functional block depends on the input plus past history or the internal state of the block

	Line protection	Client protection
Data path is protected	No	Yes
MAC tables, queued data, shaper tokens, and scheduling states are preserved across the protection event.	Yes	No

Line Protection



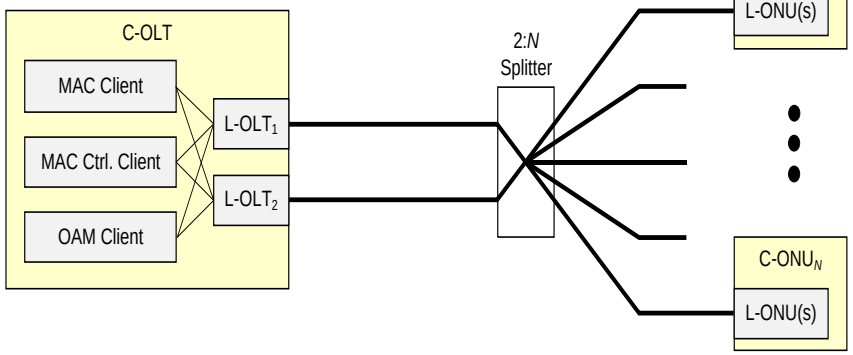
Client Protection



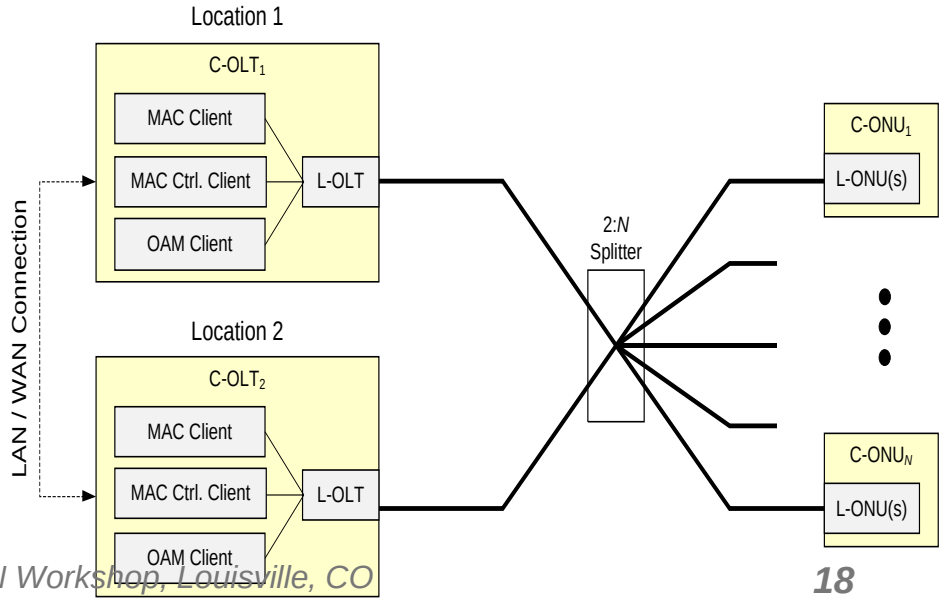
Trunk Protection Schemes

- In the trunk protection scheme,
  - The ODN span between the OLT and the optical splitter is protected.
  - The ONU and the branch fiber (ODN span between the splitter and the ONU) are not protected.
- Trunk protection is cheaper to deploy and does not add any ONU complexity
- Protection is applied only to elements that have the highest failure impact (Trunk fiber, OLT transceiver)

Trunk Protection with OLT Line Protection



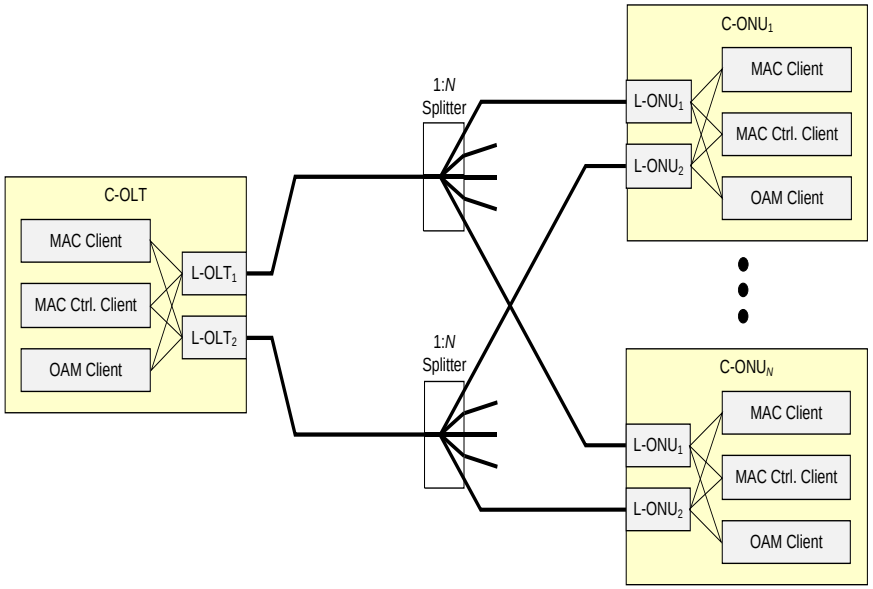
Trunk Protection with OLT Client Protection



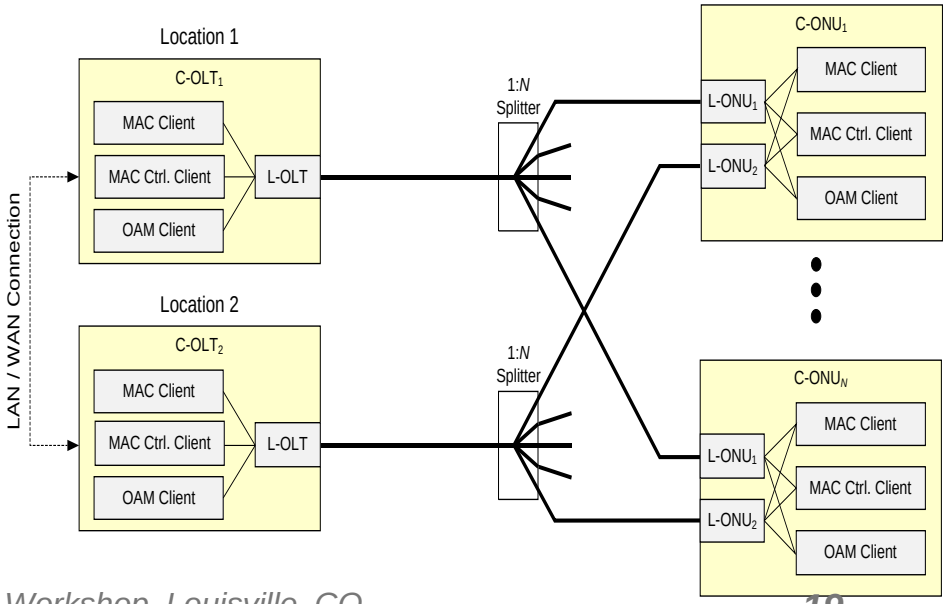
Tree Protection Schemes

- In the tree protection scheme,
  - The entire ODN (trunk segment and branch segments) is protected against failure.
  - ONUs have dual PON interfaces and implement either line protection or client protection
- Tree protection scheme provides redundancy for the entire data path and generally targets mission-critical deployments (banking/trading, control systems, corporate access, etc.)

Tree Protection with OLT Line Protection

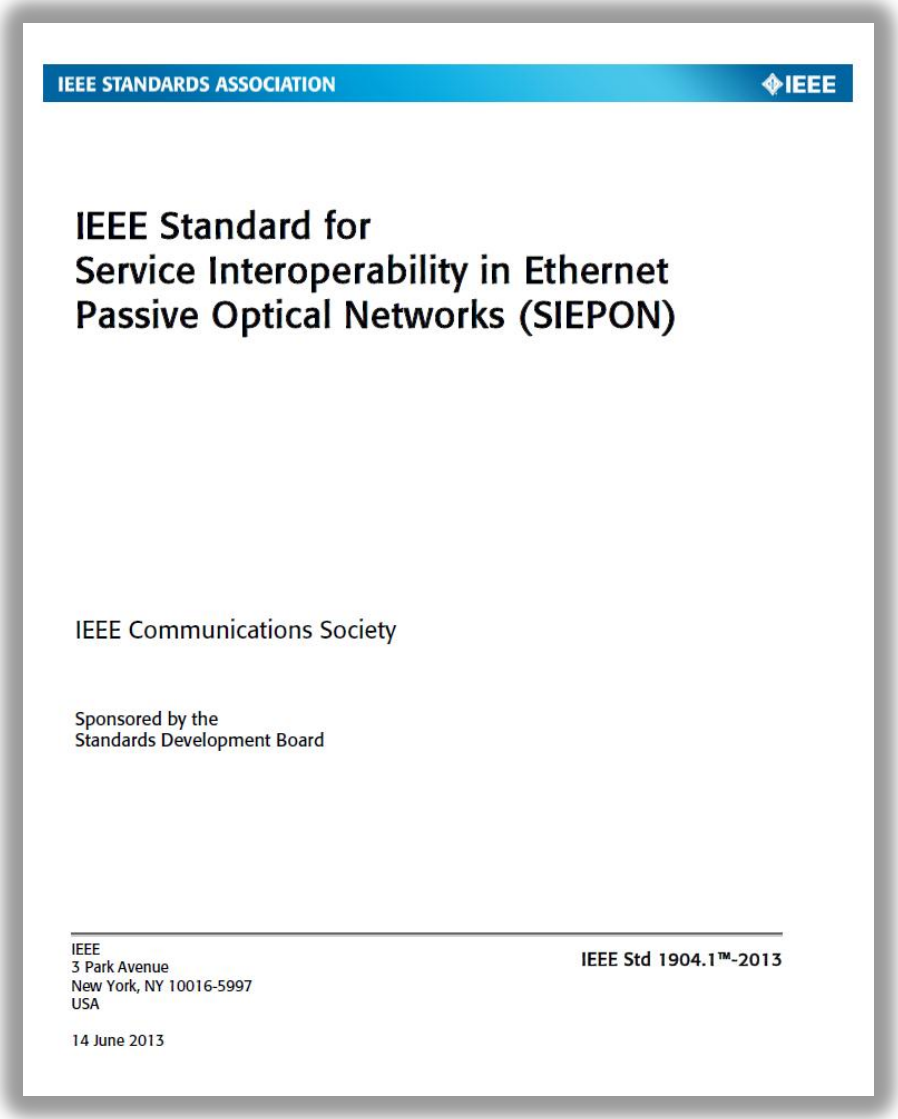


Tree Protection with OLT Client Protection



SIEPON Standard

- **SIEPON standard was approved in June 2013**
- **The standard is very broad and very detailed.**
  - 834 pages,
  - 155 figures,
  - 455 tables,
  - 30 state diagrams
- Work continues on standardizing Conformance Tests for the 3 packages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