EPoC (Ethernet PON over Coax): Architecture, MPCP, and DBA

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Outline

- Introduction
- EPoC Architecture
- Physical-Layer Overview
- MPCP and DBA Overview
- Ongoing Work

Introduction

- Next-generation access network technology
  - Passive Optical Networks
  - Fiber to the “x” technologies (FTTx)

- Better QoS with fiber closer to the user
  - FTTH (Home) is expensive
  - FTTB (Building) or FTTC (Curb) – options attractive to operators

EPON over Coax (EPoC)

- Ethernet Passive Optical Network (EPON) over coax (EPoC)
- EPON connecting coaxial front end to backbone network
- Why EPoC?
  - Leverages existing cable TV infrastructure
    - Installed in millions of subscribers' homes
  - Provides high-bandwidth network access with multiple services
  - Facilitates migration to All-IP network

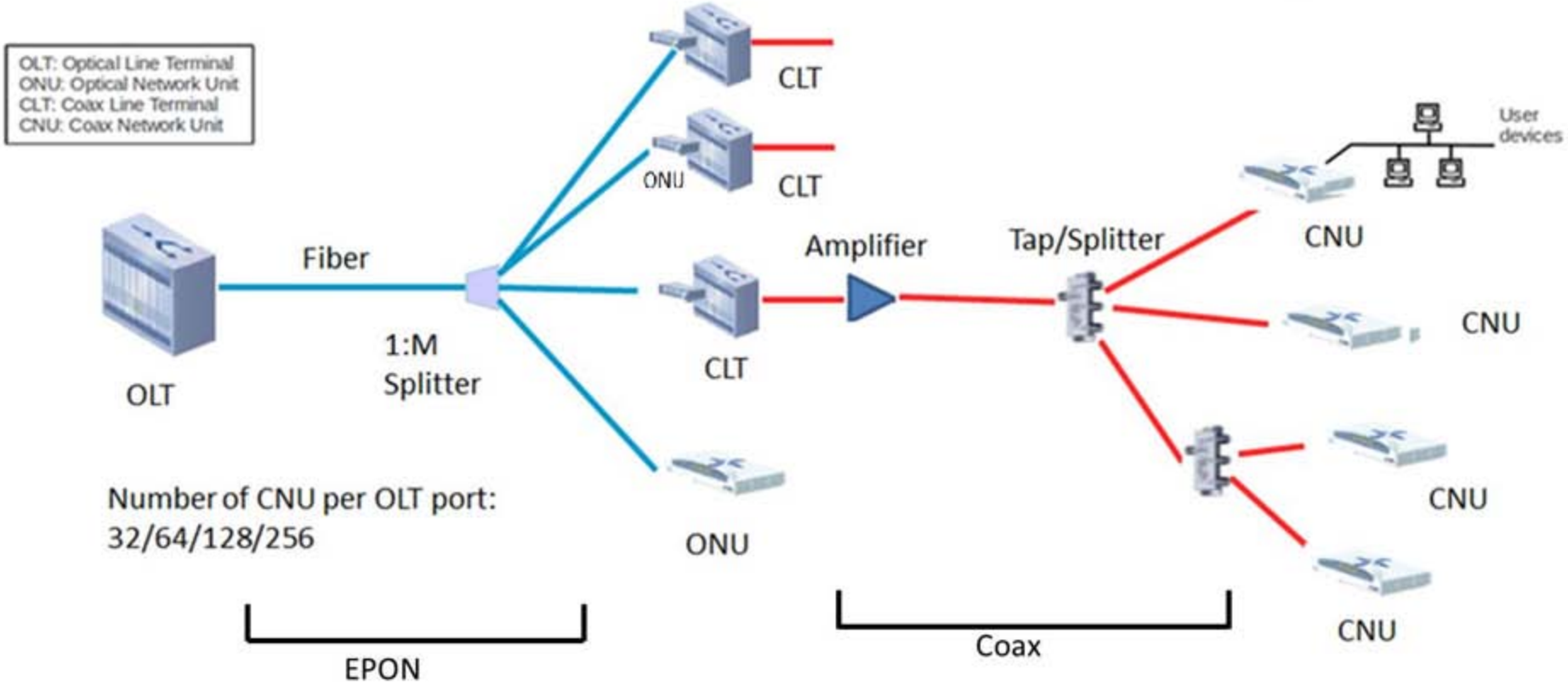
Our Lab's Research Objectives

- Many important issues need to be addressed for EPoC
  - Different modulation formats, line rates, line encoding, attenuation properties, etc.
  - MPCP, OAM, etc.

Our objectives:

- Develop an end-to-end solution architecture for EPoC
  - Timing and clock management
  - Channel and sub-carrier allocation
  - End-to-end scheduling protocol
  - Dynamic bandwidth allocation

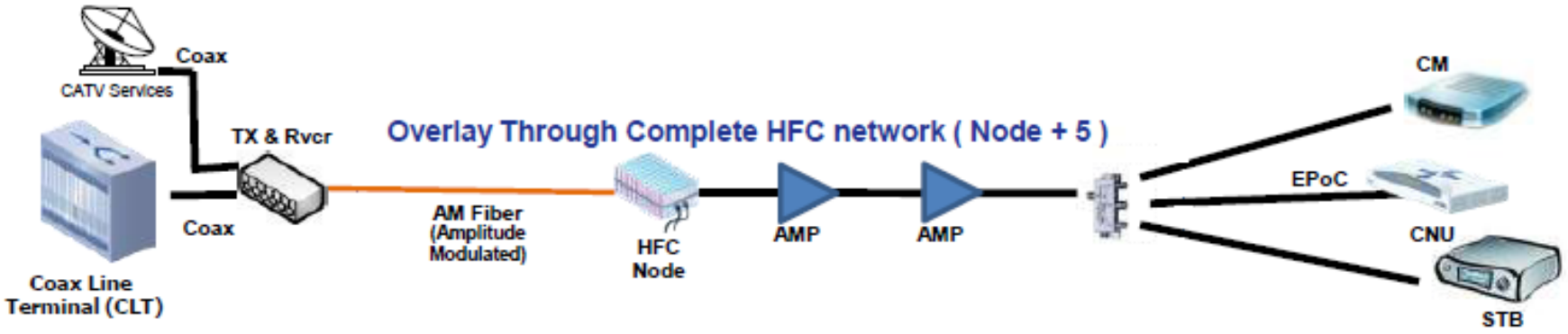
EPoC Architecture (1)



Another possible name for CLT = Optical Coax Unit (OCU)

EPoC Architecture (2)

- Another option: CLT at head-end, co-located with OLT



Key Messages

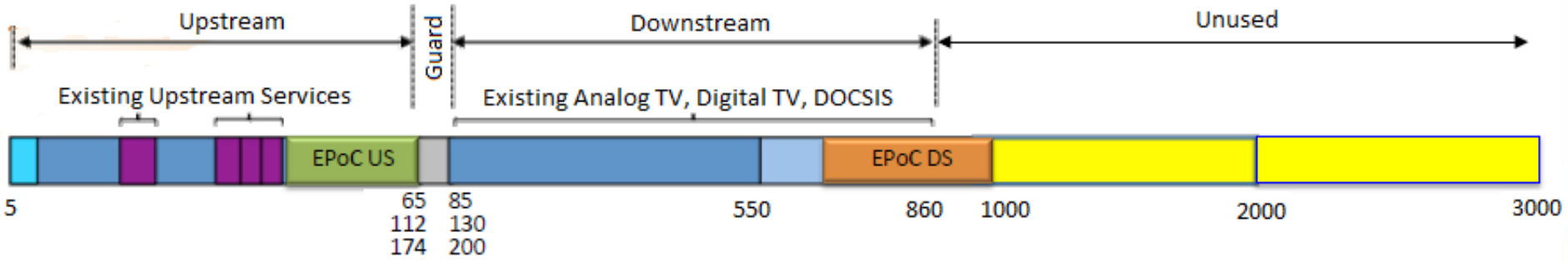
1. To enable EPoC with EPON, MPCP is extended for coax domain but unchanged from an OLT perspective
   - 1.1 Traditional ONUs are supported in EPoC architecture without any change
   - 1.2 Coax part of EPoC is transparent to OLT and OLT does not differentiate between ONUs and CNUs

2. For coax integration with EPON, CLT converts communications from optical (time) to coax domain (time, sub-carrier) and vice-versa
   - 2.1 CLT operates coax PHY negotiation for CNUs, and performs upstream and downstream data transfer in coax domain

3. CNUs register with OLT directly similar to EPON auto-discovery and registration mechanism

Example EPoC Spectrum Provisioning

Illustrative example of spectrum provisioning



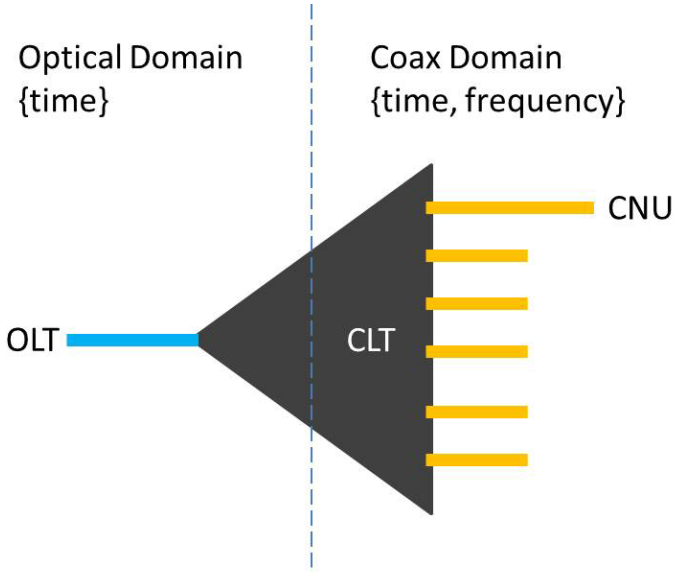
Source: Spectrum Proposal for EPoC: Dr. C. K. Sun, Peter Wolff, Titan Photonics, EPoC Study Group, Jan 2012

EPoC Characteristics

- Support compatibility with current deployments
  - Enabling EPoC on existing EPON
  - Adding traditional ONUs in EPoC architecture
- Multiple simultaneous upstream and downstream communication in coax domain
- Minimal extensions to MPCP between CLT and CNU
- CLT masks coax details from OLT

CLT

- Transparent to OLT for data transfer
- Interface for optical-to-coax conversion



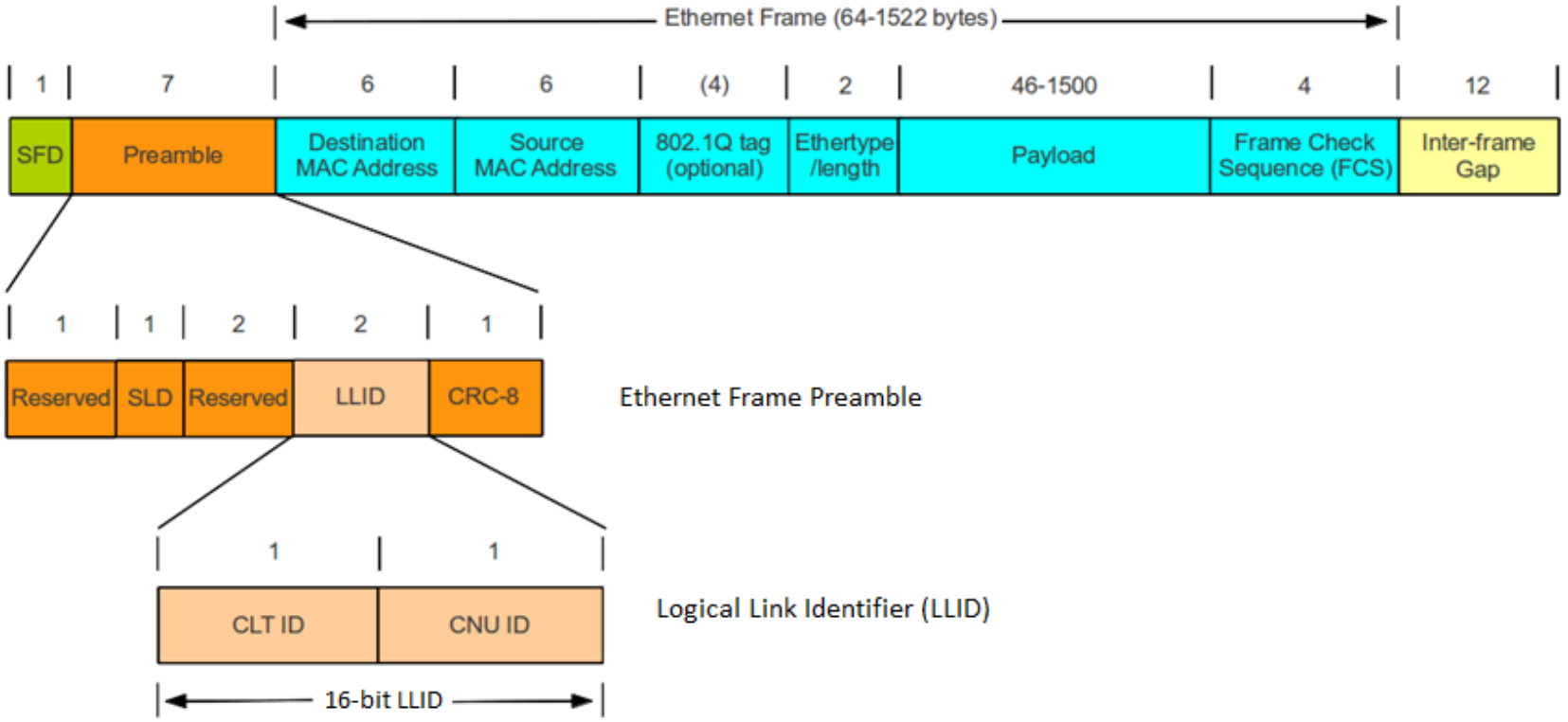
CLT acts as a multiplexer and media converter across optical and coax domains

Tasks:

- Discovers CNUs and performs coax PHY negotiation
- Converts PHY data frames
- Performs downstream data transfer
- Performs upstream data transfer (as per gate window grant)

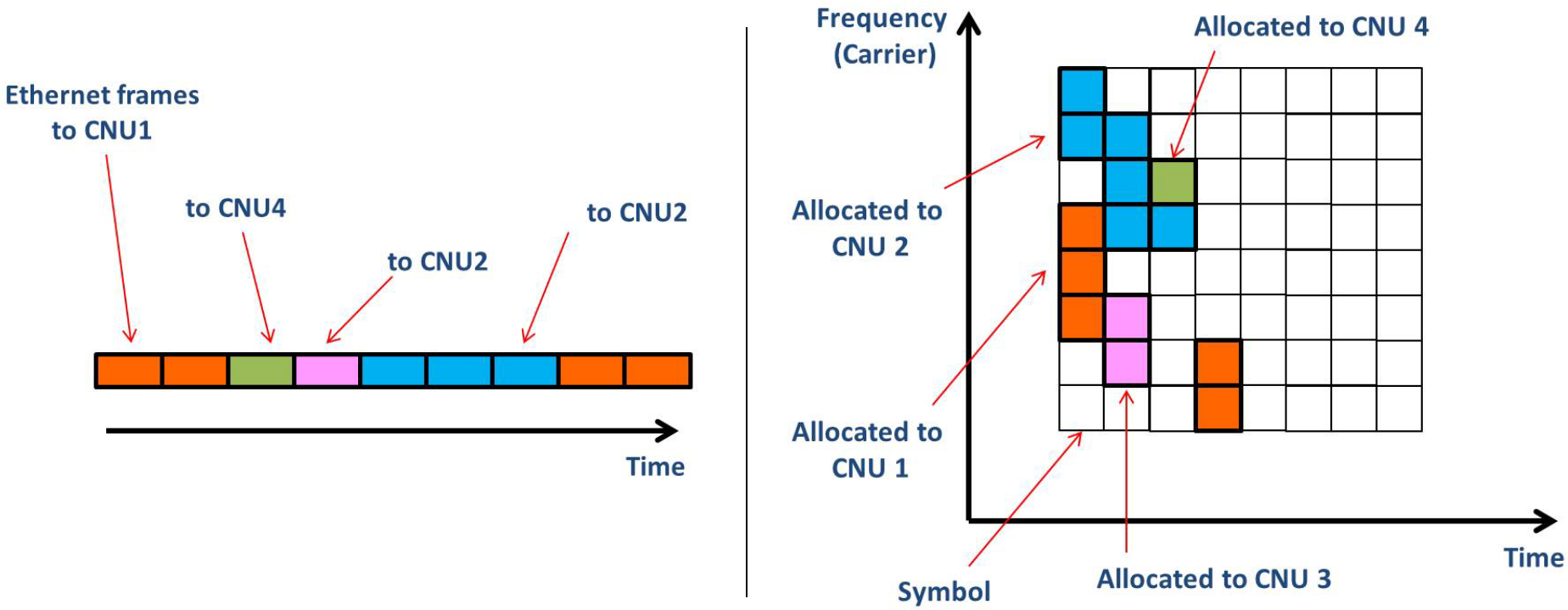
Physical-Layer Overview – Frame Structure

- In PON segment of EPoC,
  - Data is transferred as Ethernet frames
  - Preamble is modified similar to 802.ah to include a unique Logical Link Identifier (LLID) assigned by OLT



Example Data Frame Conversion

- Statistical multiplexing of sub-carriers and timeslots



Note: Two-dimensional allocation of time and sub-carrier in coax domain to support multiple simultaneous CNU transmissions upstream and downstream

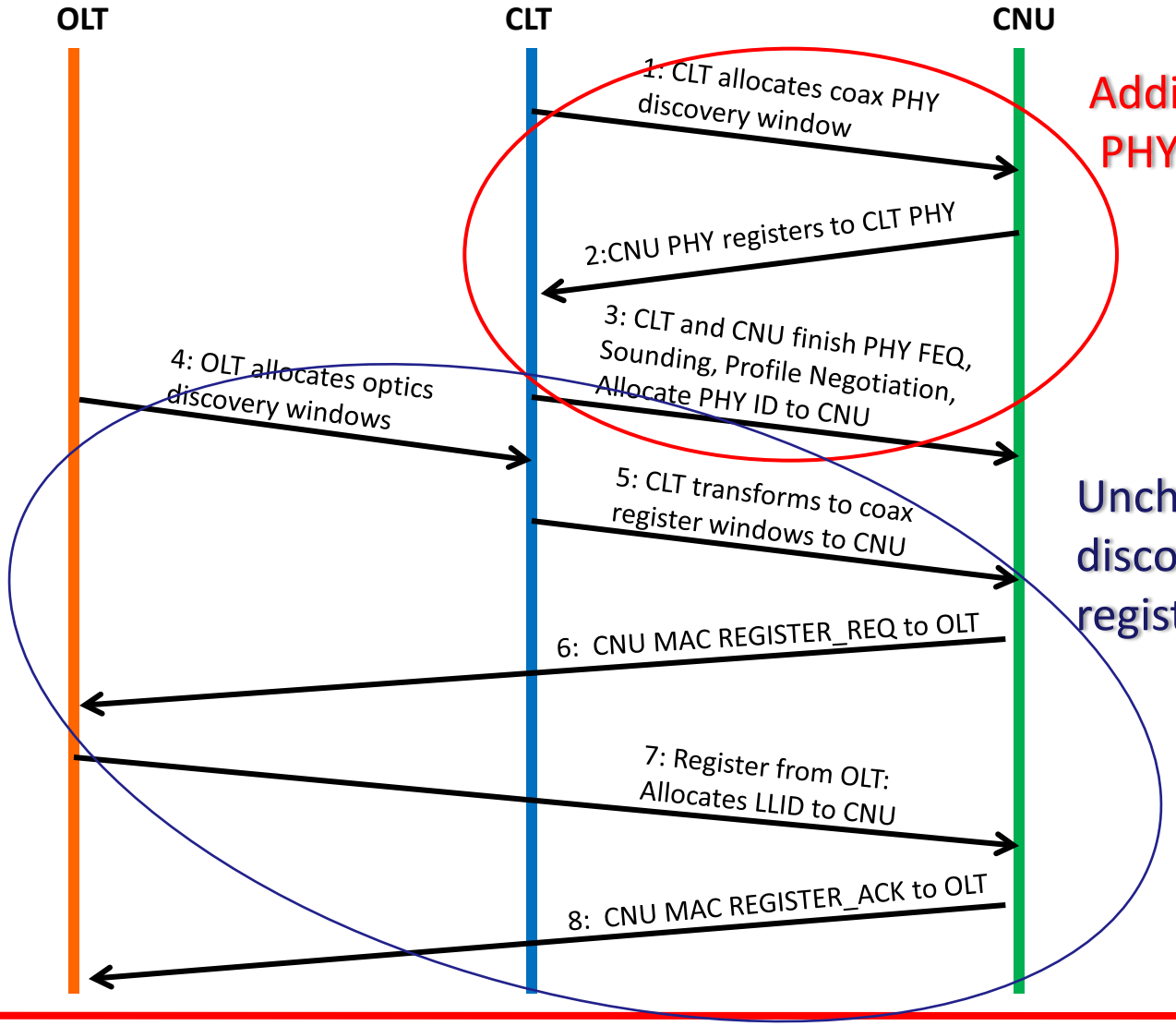
CNU Auto-Registration and Discovery

- CNU – Customer premises equipment
  - Plug-and-play device
  - User turns it on/off based on usage

- CNUs cannot transmit until they have been allocated a timeslot and a sub-carrier

- CNU registers its services with OLT and OLT assigns LLID(s) to CNU services

CNU Auto-Discovery and Registration



Additional coax PHY negotiation

Unchanged EPON discovery and registration

CNU Registration

- Applicable to existing devices (OLTs) from vendors and PON deployments
- Compatible with IEEE 802.3 std.
- Combination of EPON auto discovery and Coax PHY parameter negotiation
- No new OLT protocols are needed

EPoC MPCP & DBA: Control-Plane Overview

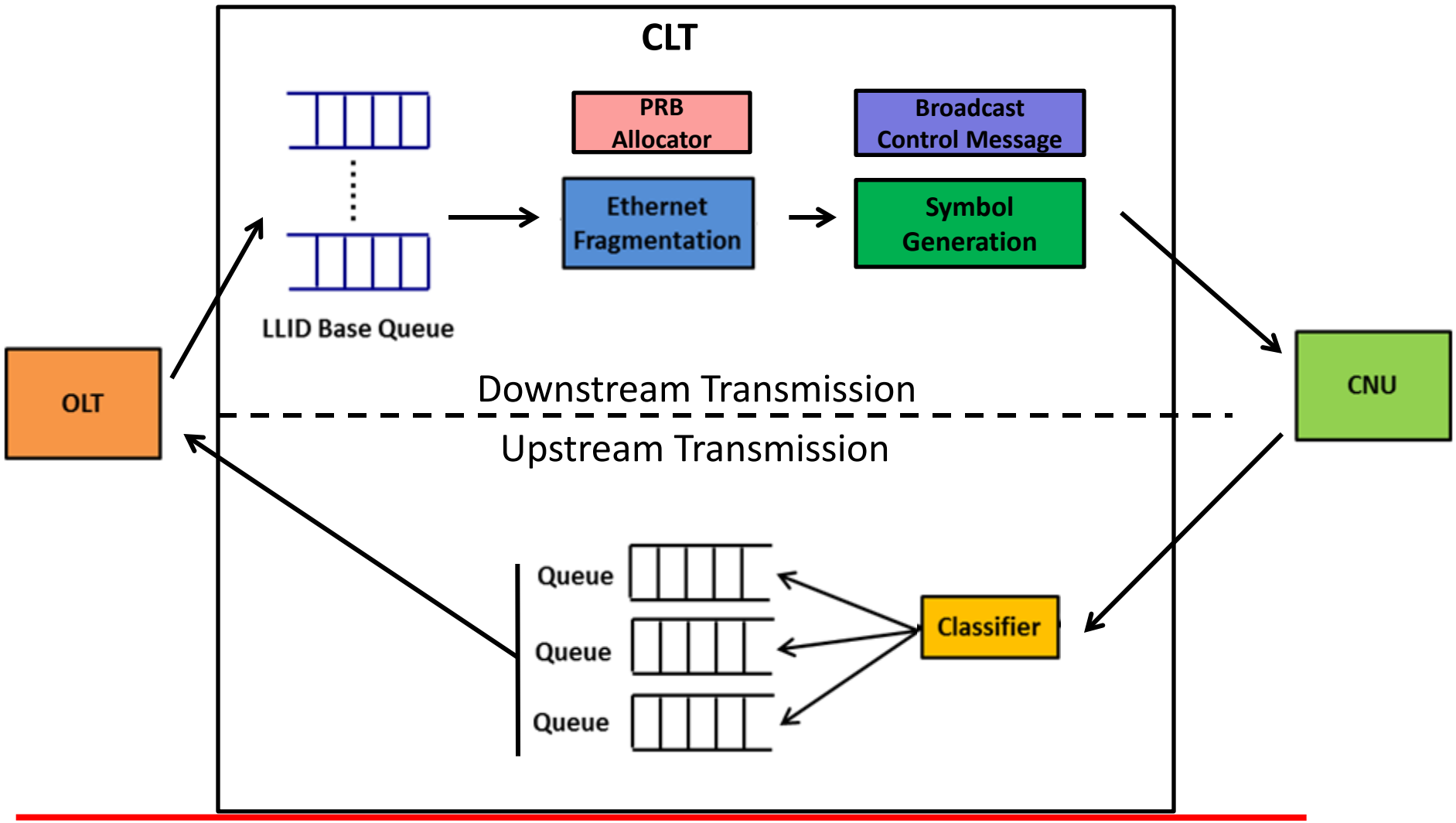
- Upstream
  - CNUs send report message to OLT requesting upstream bandwidth
- Downstream
  - OLT assigns grant window to CNUs and sends gate messages
    - {start time, length}
  - CLT converts the grant window and assigns time slots and sub-carrier
    - {time, sub-carrier}
  - CLT decides PRB size for CNUs
  - CLT broadcasts upstream and downstream control information as broadcast to all CNUs

EPoC MPCP & DBA: Data-Plane Overview

- Downstream
  - Ethernet frame fragmentation to fit PRBs
  - Ethernet frames recovered at CNU

- Upstream
  - CNU fragments Ethernet frames to fit PRBs allocated by CLT
  - Ethernet frames recovered at CLT and sent to OLT in grant window duration

EPoC MPCP & DBA: Control and Data Plane Overview



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Ongoing Research in Our Lab

- An Integrated MPCP for DBA in EPoC (coax integration is transparent to OLT)
- Scheduling traffic in coax segment to facilitate different levels of QoS
- Mismatch in data rates in optical and coaxial segments of coax
  - Intelligent upstream and downstream bandwidth allocation
- OAM extensions
  - To support higher-layer functions