IEEE P802.3bn EPoC STATUS

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DISCLAIMER

- **For IEEE Standards Association (SA):**
  - This presentation represents an overview of an IEEE Standards Association activity. The views presented in this paper my personal views and do not represent the formal position of the IEEE.
- **For the IEEE P802.3bn Task Force:**
  - This presentation gives an both overview of current progress as well as my view of possible future technical approaches to illustrate areas of challenge. The Task Force will adopt / change its technical consensus decisions as a group on an ongoing basis before finalizing its draft. Current status can be viewed at: http://www.ieee802.org/3/bn/public/index.html

RELATED TECHNICAL PAPER

- **NCTA 2014 Spring Technical Forum**
  - http://www.nctatechnicalpapers.com/Paper

MOTIVATION FOR EPOC

- **Cable operator IP / data services deployment:**
  - DOCSIS®
    - Residential and business
    - Refer to CableLabs® site: www.cablelabs.com/specs/
  - EPON
    - Business, cellular backhaul, some residential
    - Fiber typically runs “next to” coaxial trunk cable
      - Fiber only to customers where cost effective
    - DOCSIS Provisioning of EPON (DPoE™) managed
- **Opportunity expressed in China and U.S.:**
  - Extend EPON over coax – extend life of coax network
    - Opportunistic, instead of $’s for fiber all the way
    - Unified management and Quality of Service
  - Increase the number of choices for providing gigabit services

WHAT'S BEEN HAPPENING IN IEEE P802.3bn

- **Call for Interest (CFI) and Study Group November 2011**
  - Reference: EPoC www.ieee802.org/3/epoc/
- **P802.3bn project approved, Task Force chartered August 2012**
  - Project Authorization Request, 5 Criteria, Objectives: www.ieee802.org/3/bn
  - Addendum to IEEE 802.3-2012 Ethernet Standard
- **IEEE P802.3bn EPoC PHY Task Force face-to-face meetings:**
  - Sep 2012, Geneva, Switzerland
  - Oct 2012 Hangzhou, China
  - Nov 2012, San Antonio, Texas
  - Jan 2013, Phoenix, Arizona
  - Mar 2013, Orlando, Florida
  - May 2013, Victoria, BC, Canada
  - Jul 2013, Geneva, Switzerland
  - Sep 2013, York, England, UK
  - Nov 2013, Dallas, Texas
  - Jan 2014, Indian Wells, California
  - Mar 2014, Beijing, China
  - May 2014, Norfolk, Virginia
  - July 2014 San Diego, California (upcoming)

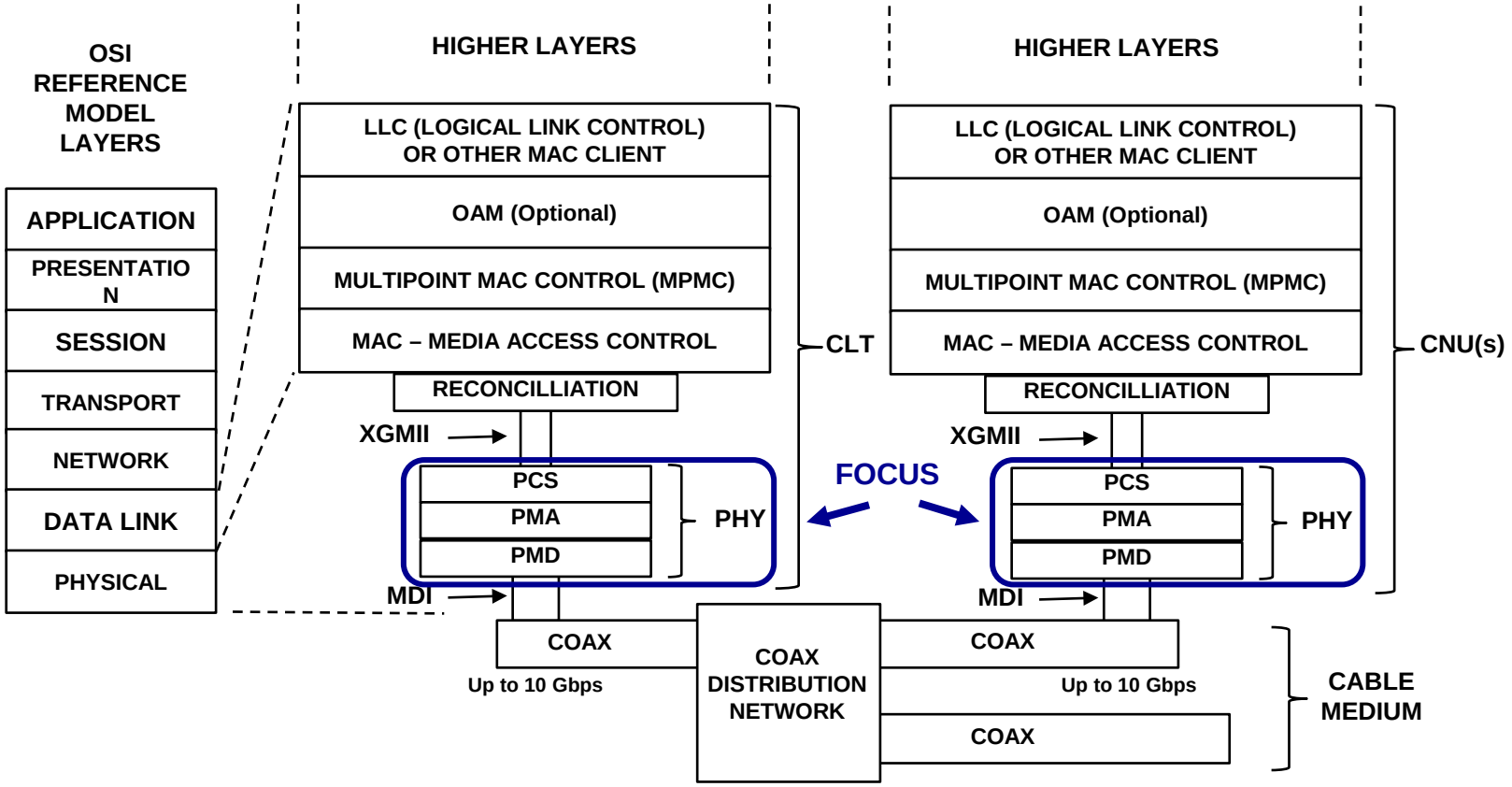
TASK FORCE PROGRESS

- **IEEE Work Product:**
  - Goal: completed Task Force Draft version 1.0, 1.x
  - Then: submit for 802.3 Working Group Ballot, and the remaining ballot approval processes through IEEE SA
- **Current Draft Status**
  - Task Force Draft version 0.5 in comment review
  - Note: IEEE copyright requires 802.3 / P802.3bn participation
- **Task Force Status: www.ieee802.org/3/bn/**
  - 132 Technical Decisions (updated 5/23/14)
  - 13 Baseline Proposals (updated 3/20/14)
  - Task Force Timeline (updated 3/20/14): Working Group ballot Nov 2014
  - Current Work Items list

PROJECT 802.3 OBJECTIVES

- **Objectives are part of 802.3 Working Group commitment**
- **Detailed objectives at http://www.ieee802.org/3/bn/**
- **Major points:**
  - Based on 10G-EPON
  - High modulation rate on coaxial cable networks
    - Downstream: to 12 bits / sec / Hz – 4096-QAM
    - Upstream: to 10 bits / sec / Hz – 1024-QAM
  - Up to 10 Gbps
  - Symmetric and asymmetric configurations
  - Efficiency and error performance goals for cable services and for Ethernet
- **Other**
  - Minimal augmentation to EPON MPCP and OAM
  - Consider of common component architecture with DOCSIS 3.1 (D3.1) PHY where it makes sense; CableLabs gave copyright permission for P802.3bn
- **NOTE: IEEE P802.3bn will standardize a PHY not a device**
  - Products will follow from market and industry implementation

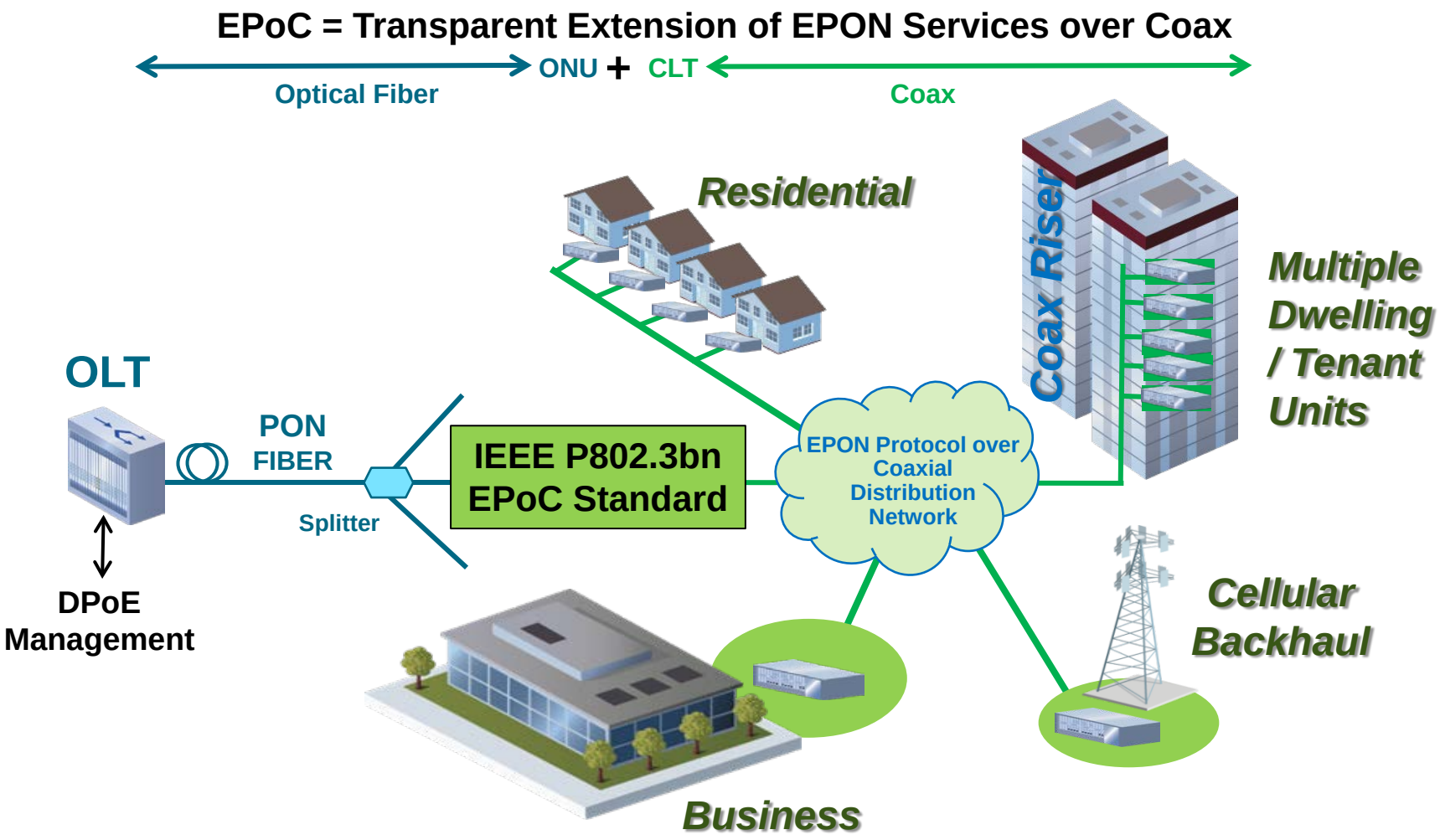
AREA OF FOCUS AND SCOPE



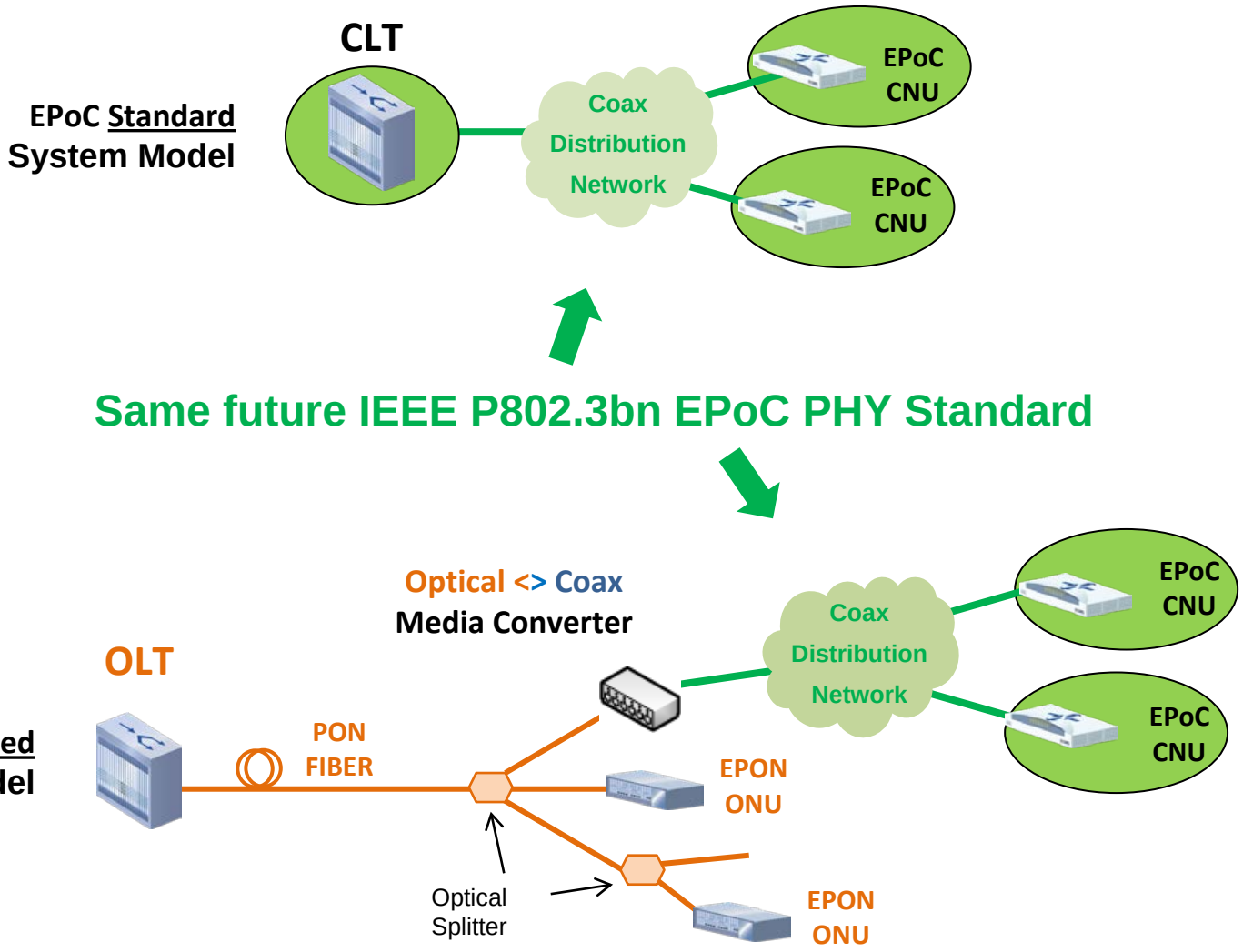
CLT – COAX LINE TERMINAL
CNU – COAX NETWORK UNIT
MDI – MEDIUM DEPENDENT INTERFACE
OAM – OPERATIONS, ADMINISTRATION, & MAINTENANCE

PCS – PHYSICAL CODING SUBLAYER
PHY – PHYSICAL LAYER DEVICE
PMA – PHYSICAL MEDIUM ATTACHMENT
PMD – PHYSICAL MEDIUM DEPENDENT
XGMII – GIGABIT MEDIA INDEPENDENT INTERFACE

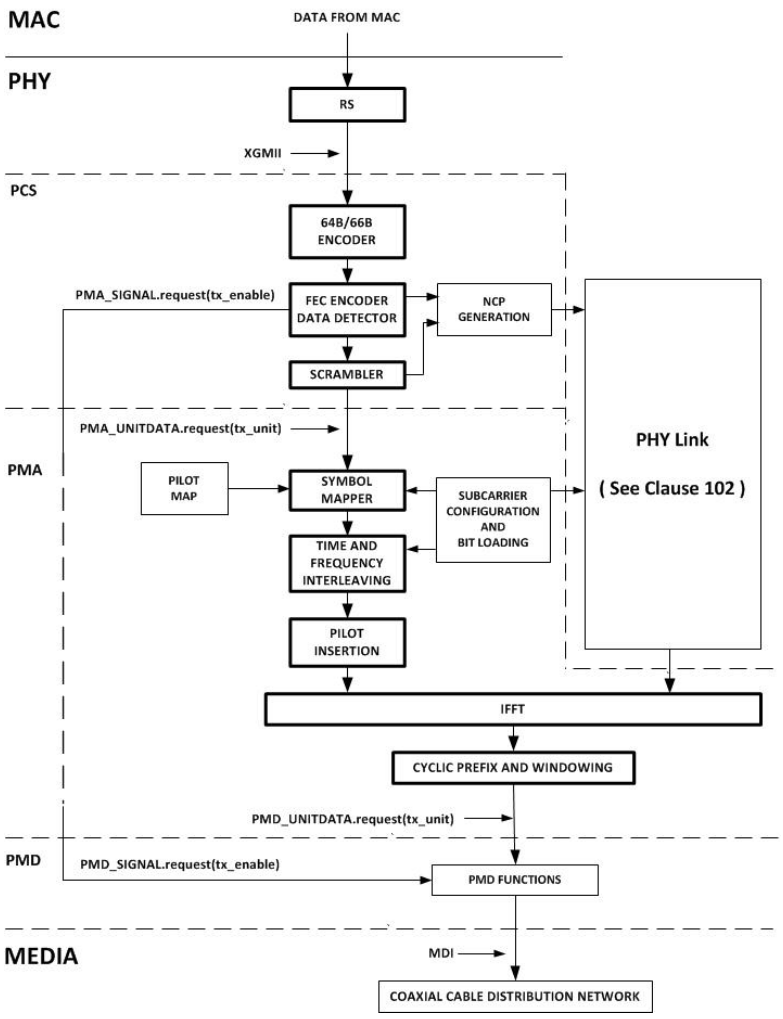
EPON/EPOC EXAMPLE APPLICATIONS



ENABLED CONVERTER PRODUCTS



DOWNSTREAM ARCHITECTURE



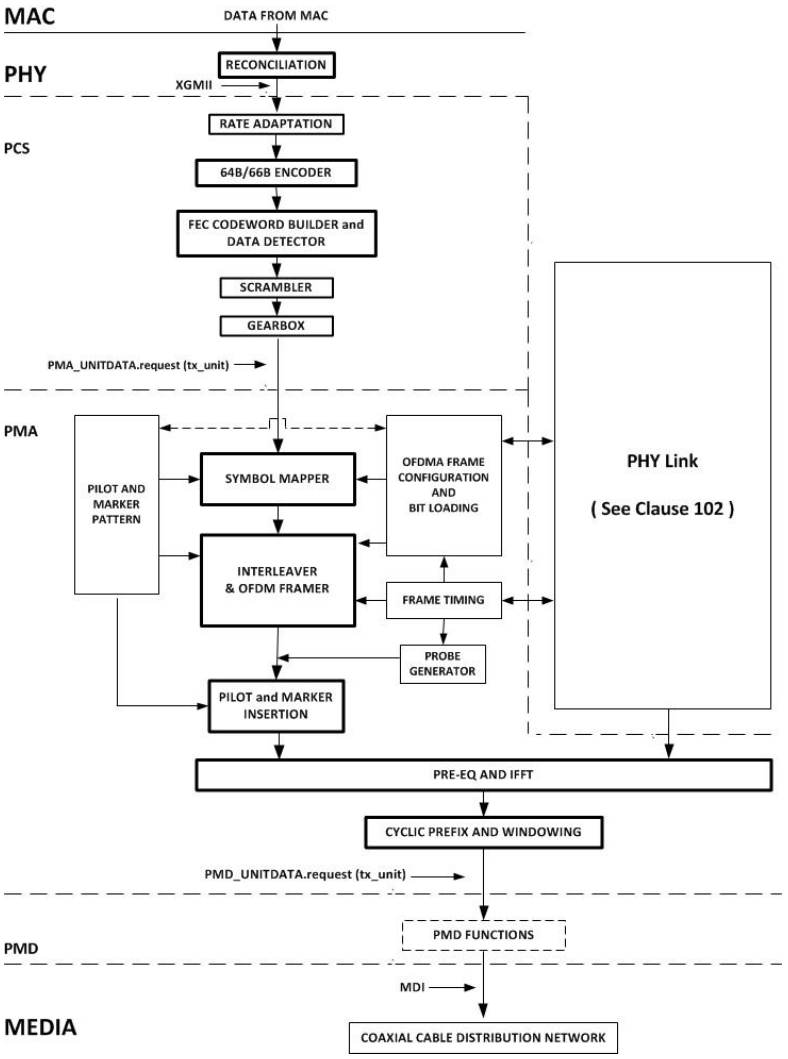
Decisions:

- LDPC FEC, single rate 14400/16200
- 40-bit CRC per information word
- 192 MHz, 4K FFT, 50 KHz subcarriers (D3.1 uses 192 MHz)
- 24 MHz minimum RF spectrum
- PHY Link channel
  - Well known configuration and placement in RF spectrum; easily discoverable
  - Used for PHY discovery, initialization, ranging, and maintenance
  - Performs Ethernet “link negotiation”
- Repeating 128 symbol cycle frame

Downstream and Upstream Challenges:

- IEEE 802.3 layer model and conventions
- Rate matching to 10 Gbps EPON XGMII
- Multiple 802.3 “lanes” for 10 Gbps

UPSTREAM ARCHITECTURE



Decisions:

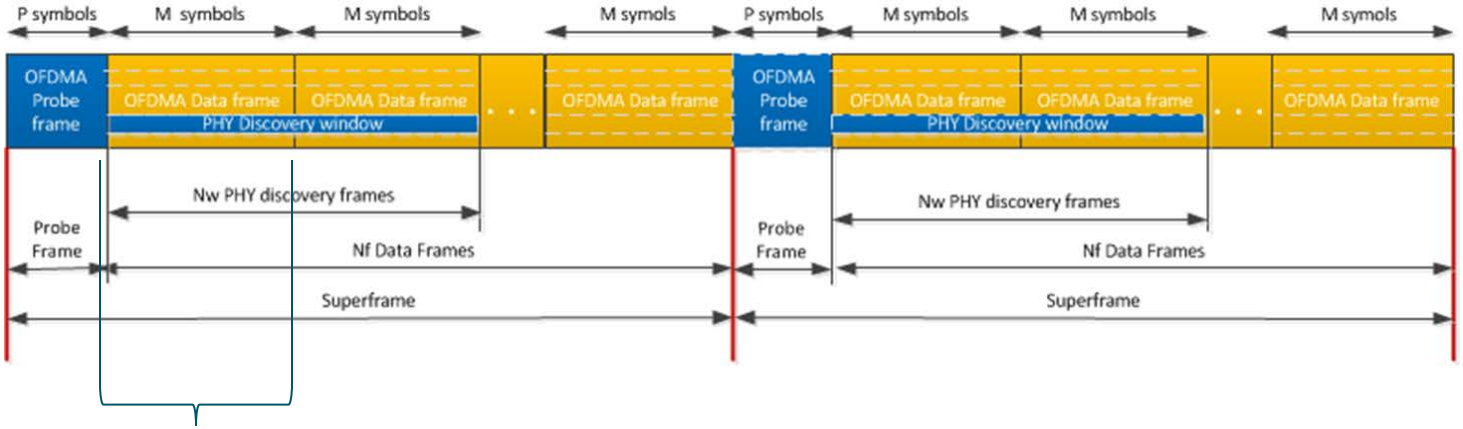
- LDPC FEC, 3 code word rates/sizes (Same D3.1)
- 40-bit CRC per information word
- 192 MHz, 4K FFT, 50 KHz subcarriers (D3.1 uses 2 x 96 MHz)

Challenges:

- OFDMA “Super Frame” concept to organize various signal types:
  - Wide band probes
  - PHY Discover (initial ranging)
  - Fine Ranging
  - PHY Link channel
  - Resource Blocks for MAC data
- Resource Blocks (RBs) contain Resource Elements (REs) (1 symbol x 1 subcarrier):
  - Data
  - Pilots
  - Start / end burst marker

SUPER FRAME EXAMPLE CONCEPT

From : kliger_3bn_01a_0314.pdf (March 2014)



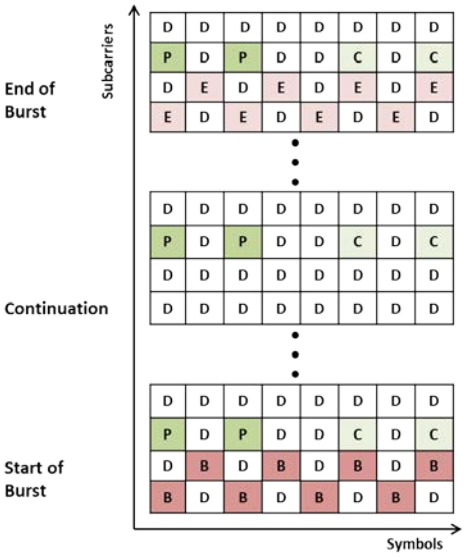


Figure 6. Example Resource Block Use

Resource Block in a 4 subcarrier by 8 symbol RE arrangement:

- D = data
- P = pilot
- C = complementary pilot
- B = start burst marker
- E = end burst marker

Challenges:

- Mapping one dimensional EPON TDMA grant start times into the 2D OFDMA frame structure
- Controlling system jitter and latency

ALIGNMENT WITH DOCSIS 3.1 OFDM PHY

- **Same/similar OFDM numerology**
  - 4K FFT size (note: D3.1 also has 8K FFT)
  - 204.8 MHz sample rate
  - Cyclic Prefix and Window sizes
- **Same Upstream LDPC FEC coding and rates**
  - P802.3bn selected a different downstream LDPC FEC
- **Same Electrical input and output requirements**
  - Downstream in draft: 54 MHz to at least 1212 MHz
    - 1212 MHz to 2610 MHz is for further study
  - Upstream pending: 10 MHz to at least 234 MHz
- **Proactive Network Management (PNM) measurements**
- **Similar System:**
  - Both: downstream up to 10 Gbps, Upstream 2 Gbps
  - Note: D3.1 can “TDMA share” the upstream between legacy and OFDM bursts

SUMMARY

- **EPoC PHY being developed by IEEE P802.3bn**
  - Public process, technical consensus is ≥ 75% on votes
  - Progress is slower than originally anticipated
    - First timeline: WG Draft Jul 2014 (later Mar 2014)
    - Now: WG Draft Nov 2014 (lot of work remains in upstream)
- **EPoC success will be based on:**
  - Published (stable) standard within market window
  - RF spectrum based on cable operator business needs
- **EPoC provides another choice for cable operators for gigabit high speed data services**
- **Ethernet is constantly evolving**