General Ethernet / EPON over Coax

- EPoC Basic Assumptions and Reference Model

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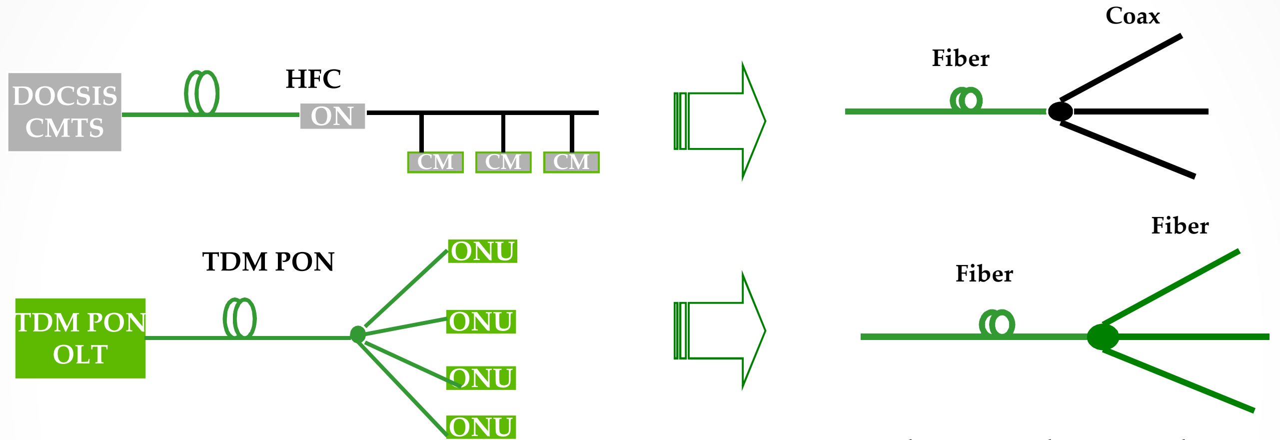
EPON over Coax – basic assumptions

PON ODN & HFC – has similar topology, different physical mediums.



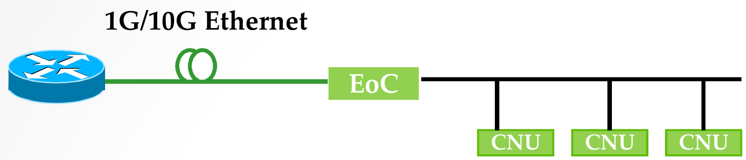
Topology sees by MAC layer

The basic assumption of EPoC is to reuse EPON scheduling protocols over HFC:

- A proven MAC for P2MP fiber
- Reuse EPON security and higher layers
- Share the large EPON MAC chip market; avoid reinventing the wheel

- **However, EPON MAC is designed for fiber, it is not optimized for coax**
  - EPoC is a trade off, any changes to MPCP, OAM must preserve interoperability with EPON ONU
  - We should keep these constrains in mind when develop EPoC

Ethernet over Cable



Ethernet & Higher Layers
EoC MAC
Coax RF PHY

Old dog with new tricks - Ethernet over Coaxial Cable

Ethernet & Higher Layers	
Convergence Sub-layer	MAC
Convergence Public Sub-layer	MAC
Coax Physical Layer	

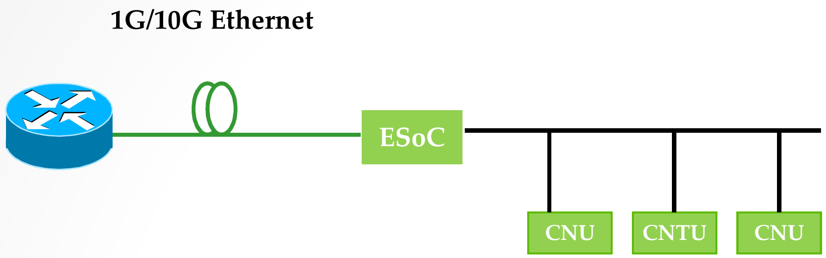
HiNOC

- The first Ethernet was "over" Coax with CSMA/CD
  - IEEE 802.3 Ethernet over thick coaxial cable (1983)
  - IEEE 802.3a Ethernet over thin coaxial cable(1985)
- EoC defines a new MAC & PHY
  - Has freedom to define both PHY & MAC for high speed full duplex
    - OFDM, OFDMA, CDMA, FM, TDD, FDD…
  - Could be optimized for coaxial cable
  - HiNOC is an example of EOC

In theory, EoC could optimized both MAC and PHY, It can "reinvent the wheel" by introducing a new P2MP MAC, however…

- It has to deal with security in a shared media and higher layer services models
- As a result most existing EoC implementations reuse some home networking protocols
  - MoCA based EoC reuse a MP2MP protocol in trust environments to an open access network; so is home-plug based EoC
  - None of these are actually "optimized" for access network

EPON Scheduling over Cable



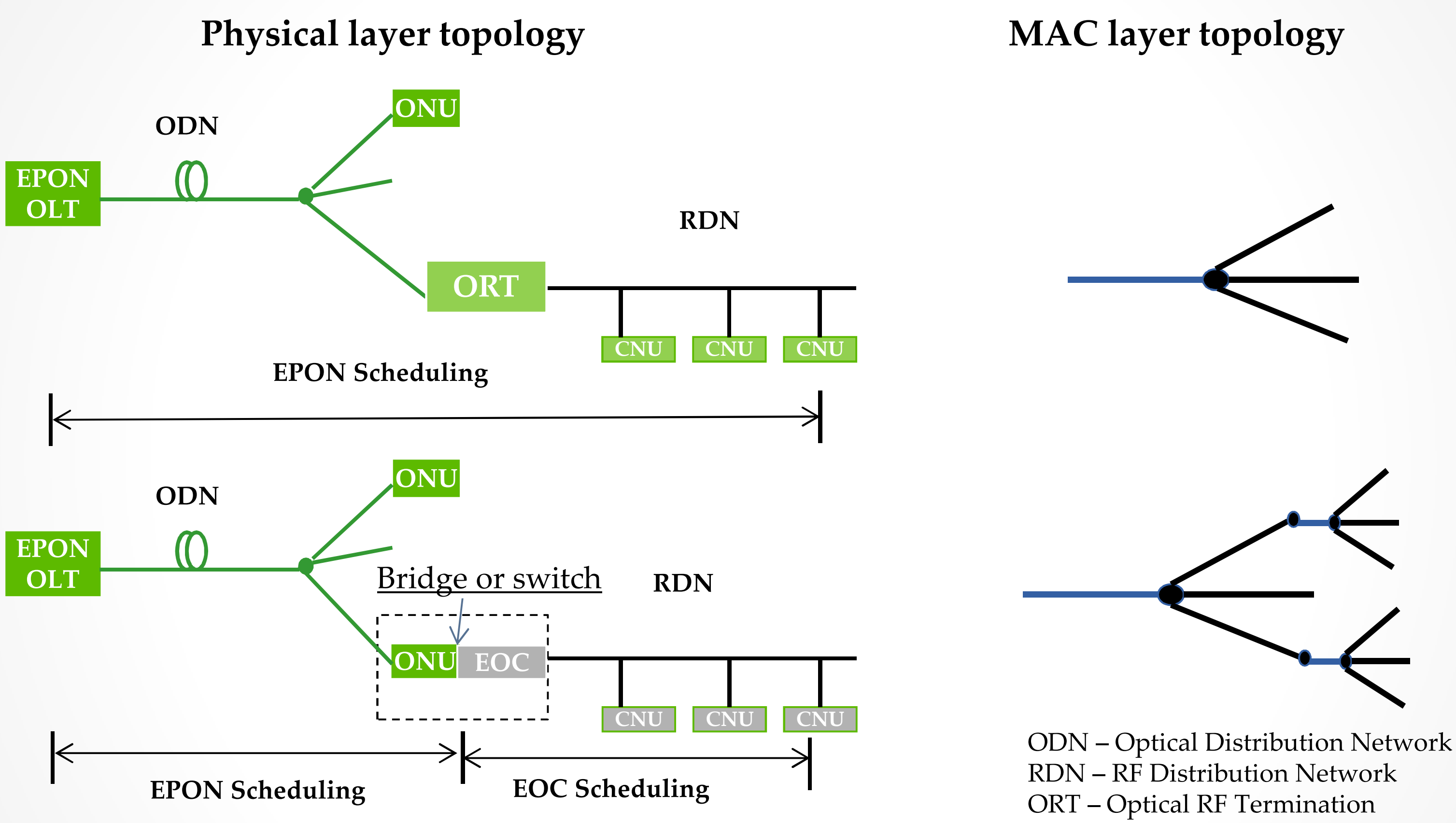
Ethernet & Higher Layers
Modified EPON MAC Control
Coax RF PHY

EPON Scheduling over Coax

- Reuse EPON scheduling mechanism for P2MP coaxial cable
- Without constraints for modification (of EPON MAC)
  - MPCP, TQ, DBA etc. all could be changed or redefined
  - Optimize MAC and PHY
  - PHY rate aware MAC could be considered
  - A new GMII/XGMII could be defined
- No interoperability requirement with EPON OLT
- Optimized MAC and RF PHY is possible, but
- Extensive work in standards and new chips
- Complex device in outside plant

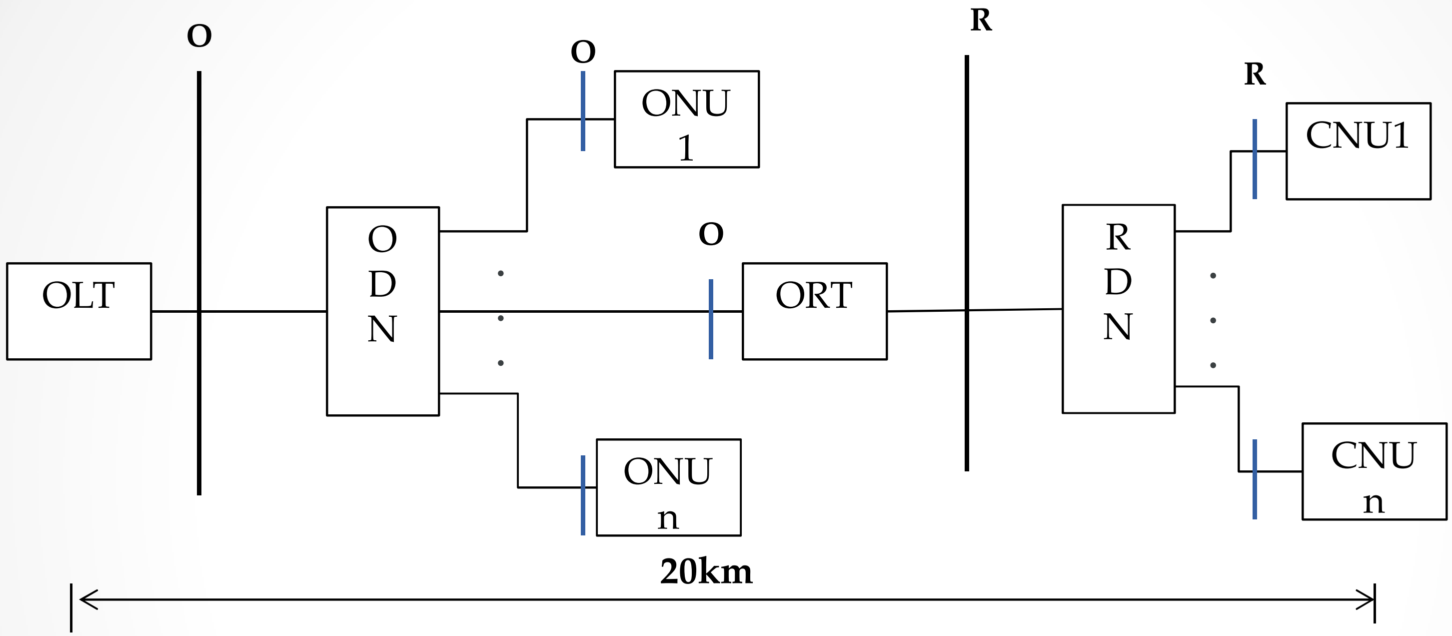
- EPoC shouldn't modify the EPON MAC
- EPON MAC could be modified for ESoC

EPON + EOC ≠ EPoC



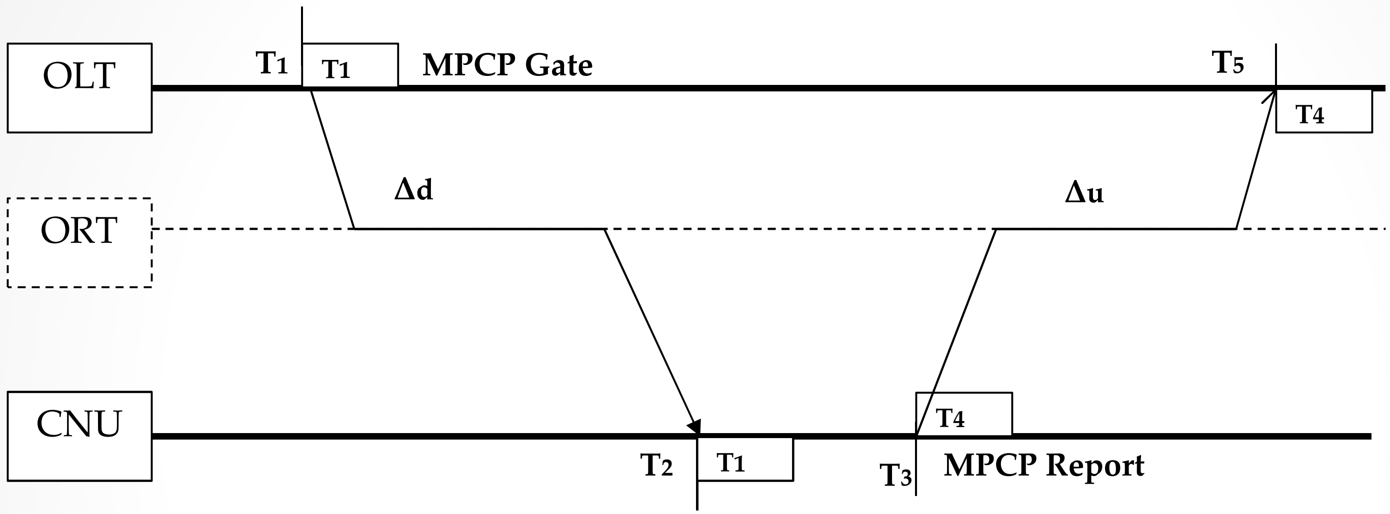
- EPOC MAC preserve a single tree topology view of a multiple tree physical layer
  - Largely preserve EPON end-to-end QOS, provisioning…
- EPON + EOC MAC layers have multiple tree view – double scheduling
  - Hard to preserve end-to-end QOS, provisioning…,

EPoC Reference Model



ORT – Optical RF termination
RDN – RF Distribution Network
CNU – Cable Network Unit
OLT – Optical Line Termination
ONU – Optical Network Unit
ODN – Optical distribution Network
O – Optical interface
R – RF interface

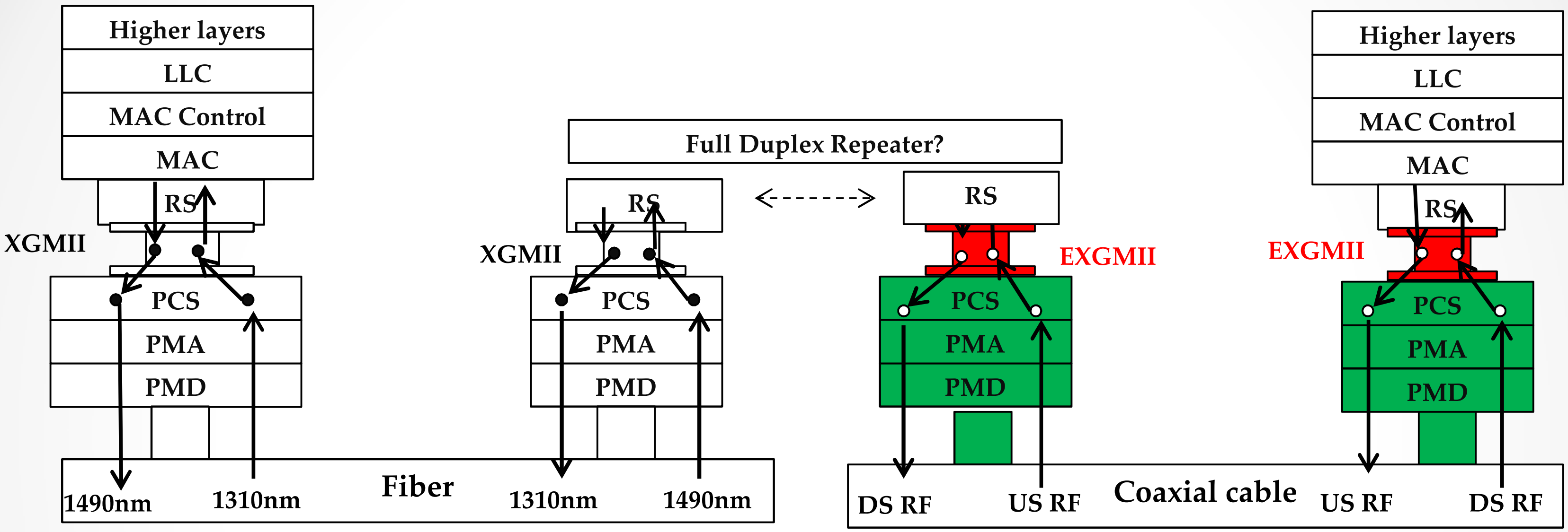
EPoC Timing Model 1



T3 - T2 = T4 – T1 RTT = (T2 – T1) + (T5 – T3) = T5-T4

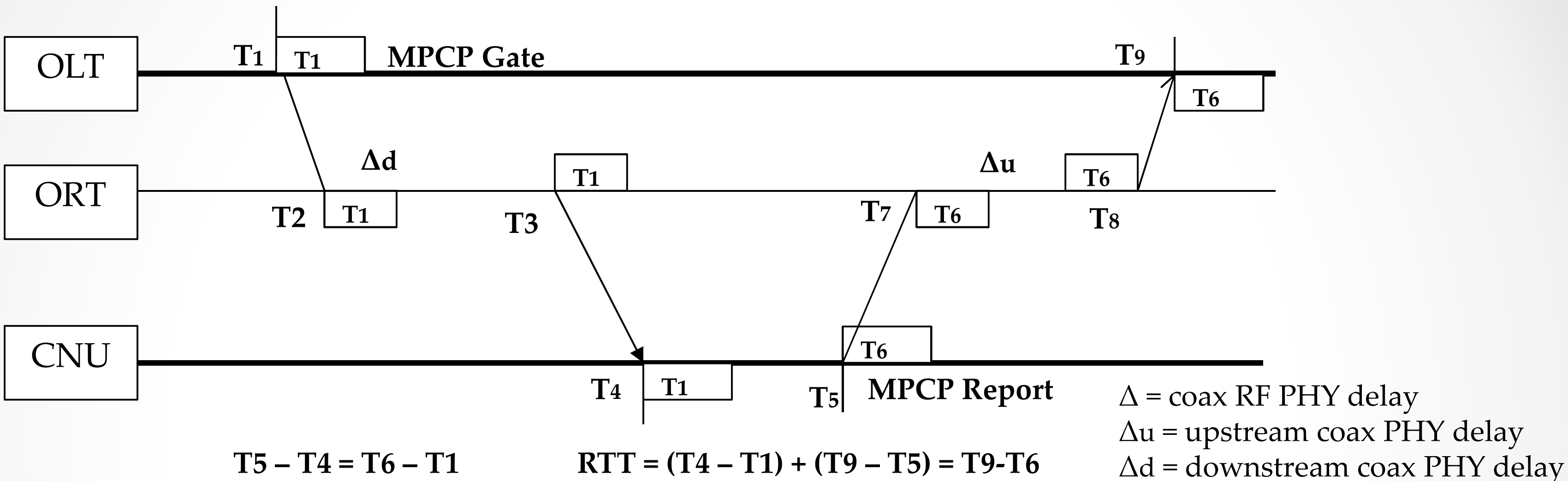
- **ORT is transparent to MAC and above layers**
- **RF PHY may introduce delay of the order of 10^3 μs**
  - Long OFDM symbols resulted from cable echo delays
  - Upstream and downstream delays could be asymmetric
  - Delays have to be constant in order for EPON ranging protocol to function
  - OLT may sees CNU out of 20km PON range; a special message (via OAM) need to be sent to OLT from CNU to indicate its not a ONU
- **Transcoding is an implementation example**

Layering Diagram with Timing Model 1



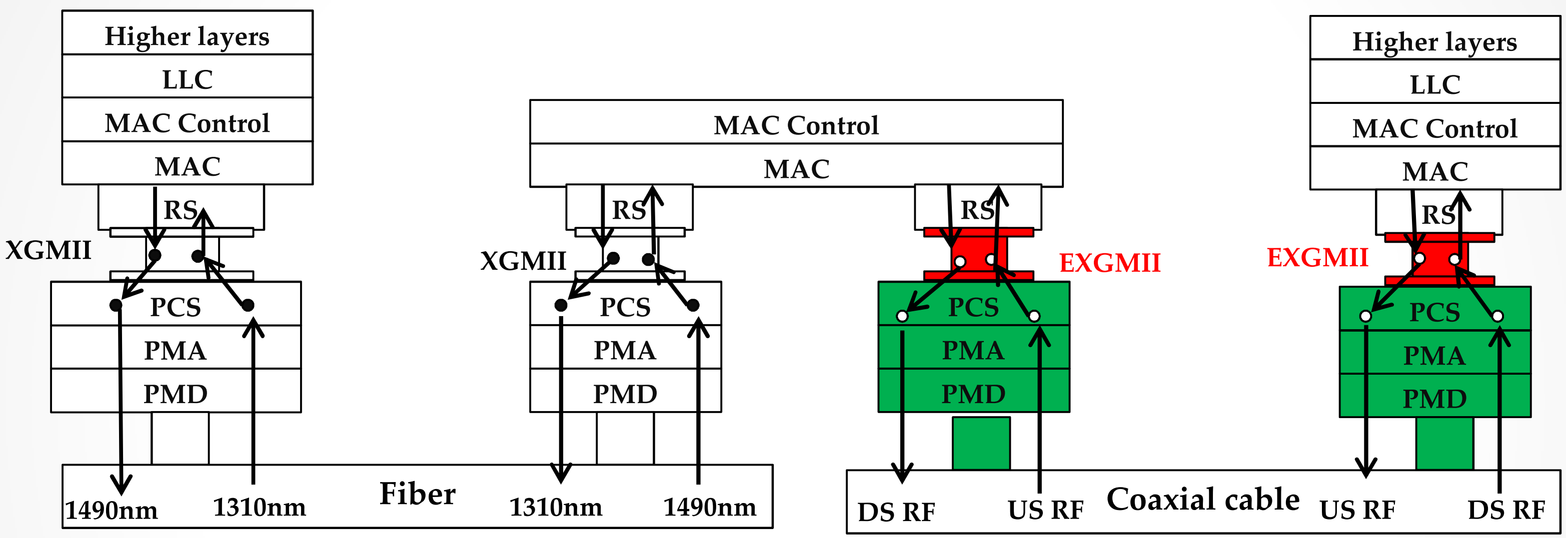
- XGMII Changes (EXGMII)
  - 802.3ah added GMII support for sub-rating and asymmetric rates
  - There is no reason XGMII can not be modified to support sub-rating
  - RF PHY can not guarantee fixed rate; rate will change over time.
- ORT needs to connect Coax PHY and Optical PHY
- Should we consider Full Duplex Repeater?
  - Do we need to specify it in 802.3?
  - Or, leave it for implementation?
  - Should we only specify management (OAM) in IEEE 1904?

EPoC Timing Model 2



- **ORT is transparent to LLC and above layers**
- **ORT intercepts MAC control packets with or without modification**
  - **Time sync with OLT**
  - **Could choose to change or not to change time stamps**
  - **Relay MPCP packets or function as a proxy**
  - **Could provide MAC, LLID forwarding and filtering to optimize RF PHY performance**

Layering Diagram with Timing Model 2



- ORT terminates at MAC control layer
- Provide more flexibility for EPON MAC and RF PHY adaption

Conclusions

- The basic assumption of EPoC is to reuse EPON scheduling protocols and MAC chip
  - Any changes to MPCP, OAM must preserve interoperability with EPON OLT & ONU
- RF PHY may introduce delay of the order 10^3 μs due to large OFDM symbols size resulted from cable echo delay and interleaver for burst errors
  - Delay must be constant for EPON ranging protocol to work
- RF PHY is unlikely guarantee constant rate, rate adaption needs to be considered
  - XGMII definition could be expanded to optimize or adapt RF PHY with EPON MAC
- Full Duplex Repeater Definition needs a home

Thank you