EPoC rate hierarchy and rate adaption

- Baseline proposal

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Outline

- EPoC Ethernet rate hierarchy
- Rate adaption
  - General considerations
  - EPoC rate adaption

EPoC Ethernet hierarchy

- Ethernet has a well known and defined rate hierarchy – Generally10X in rate (except 40G Ethernet)
  - 10Mbps, 100Mbps, 1Gbps, 10Gbps, (40G), 100Gbps …
- The granularity of this hierarchy is much too coarse for EPoC RF PHY
  - For the rate range that applies to EPoC, there is nothing between 100 Mbps and 1Gbps, between 1Gbps and 10 Gbps.
- Currently in 802.3bn, we assume "any rate"
  - "Any rate" Ethernet sounds strange in 802.3
  - Does not help service providers in network planning, etc.
    - We have an "any rate" access network, just sounds so strange
- An Ethernet rate hierarchy for EPoC may be needed
  - IEEE 802.3 Ethernet tradition
  - Enable service provider to have better control of network
  - Simplify rate adaption for EPoC
  - Add a limit to the number of IOP/Performance tests

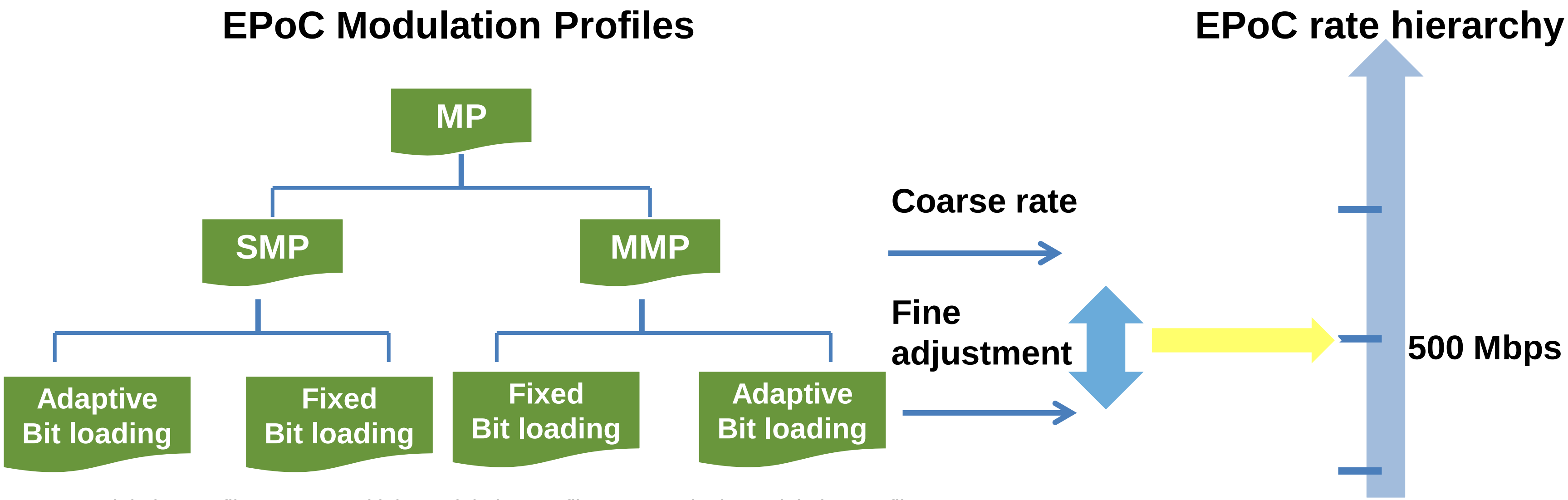
EPON MAC and EPoC RF PHY

- EPON MAC is not PHY aware
  - Both EPON MAC and PHY have a fixed rate
  - There is no mechanism nor need in EPON to report PHY rate to MAC (except REGIST_ REQ message in dual mode 10G EPON)
- EPoC RF PHY rate is, in general, lower than EPON MAC rate
  - Rate adaption is the key for EPoC
  - A CNU RF rate can not be pre-defined
    - It depends on coax plant and environment conditions
- A known EPoC RF PHY rate hierarchy will simplify rate adaption
- It also helps to define modulation profiles

EPoC PHY rate and modulation profiles

- Modulation profiles determine RF PHY rate
- A pre-determined RF PHY rate could be achieved by adjusting the parameters in MP, such as bit loading
- A chicken and egg paradox?
- Problems with MP first approach
  - An OLT does not understand MP; but understand rate
  - MP could be dynamic, such as using adaptive bit loading in response to environmental changes, that results variable bit rate of CNU
  - Manually provision MP
    - Hard to have a systematic method across industry
    - Not effective
  - Feed the variable CNU rate directly to OLT could cause problems
- Rate first approach
  - OLT understand rate; a rate hierarchy will help rate adaption in most cases
  - MP rate variation could be absorbed/screened in rate hierarchy
  - A CNU with a given MP fall into nearest lower rate in the hierarchy

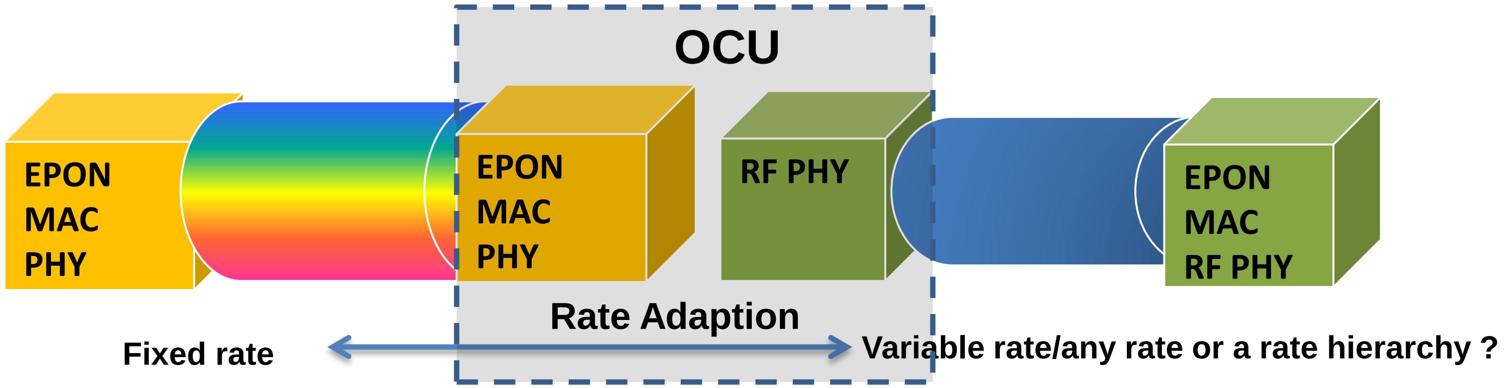
Benefits of isolate MP from OLT



MP – Modulation Profile, MMP – Multiple Modulation Profile, SMP – Single Modulation Profile

- **An OLT needs to know a CNU's line rate for traffic shaping**
  - **An OLT does not understand MP**
- **A MP only provide a coarse line rate**
  - **Bit loading changes affect line rate**
  - **Interferences affect sub-carriers and in turns affect rate**
- **An OLT assuming fixed line rate; ripples in RF PHY rate should not allowed to propagate to OLT**
- **Rate hierarchy give OLT fixed line rate info while absorbing the rate variations**

Benefits of rate hierarchy for rate adaption



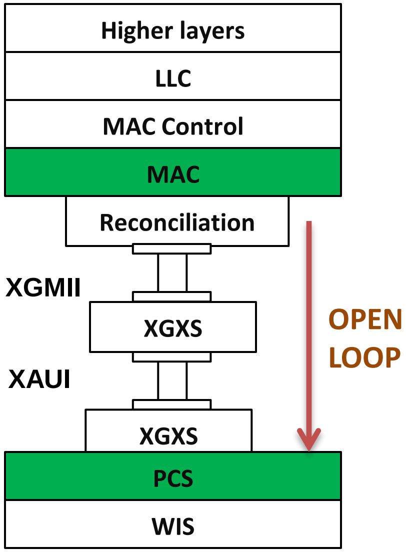
- **Knowledge of targeted rate will make rate adaption much easier in general**
  - **Adapts a fixed rate to another fixed rate or a known rate set is much easier than adapts to variable rate or any rate**
- **In EPoC a known rate hierarchy will simplify the information exchanges among OLT, OCUs, CNUs**
  - **There are limited ways for information exchange**
    - **MPCP**
    - **OAM?**
- **A rate hierarchy helps with network capacity planning**

MAC to PHY Rate Adaption

- **Rate adaption – transmission rate adapted by channel conditions or interfaces**
- **PHY aware MAC**
  - PHY reports some or all its parameters to MAC
  - MAC dynamically adapts its rate accordingly
  - EPON MAC is not PHY aware
  - EPoC supposedly reuse EPON MAC, therefore, PHY aware MAC is not an option
  - PHY aware MAC could be an option for EOC; it may be the most efficient way for RF PHY and MAC
- **MAC self-adapts its rate according to interface type (Open loop)**
  - MAC knows the predefined PHY rate
  - MAC adapts its transmission rate accordingly without the report from PHY
  - A known Ethernet rate hierarchy helps
- **State full (Close-loop) rate adaption**
  - MAC and PHY interact in a state full way for rate between MAC and PHY
- **Stateless (half close-loop) rate adaption**
  - PHY reports its parameters to MAC and MAC make decision without further notify PHY
  - A known Ethernet rate hierarchy helps
- **10G EPON rate adaption**
  - Idle insertion/deleation, traffic shaping
  - Knowledge of targeted rates simplifies the process
  - A known Ethernet rate hierarchy helps

MAC open-loop rate control

- **MAC knows the predefined interface PHY rate**
- **MAC control its transmission rate according to the interface type**
- **802.3ae self-pacing is an good example**



802.3ae WIS open loop rate adaption

- **Ethernet MAC knows WAN interface has lower rate**
- **MAC adjust IFG for each frame accordingly**
  - **Without feed back from WIS PHY**

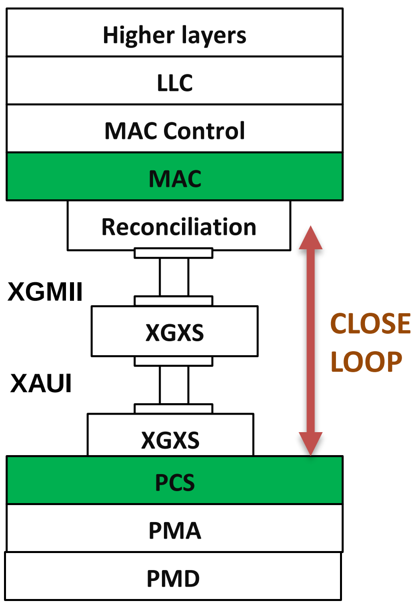
Could open-loop mechanism work for EPoC?

- **A rate hierarchy establishes a per-specified RF PHY rate set**
- **EPON MAC could know the pre-specified rates**
- **RF PHY could be able to maintain fixed rare**
  - **Isolate MP from OLT**
  - **OFDM bit load dynamically adjust to cable plant condition**
  - **RF PHY could fall into next rate when changes in plant conditions are too big**
- **However, the simple MAC self-adaption may not work for EPOC because IFG is controlled by MPCP**

MAC close loop rate control

- **MAC does not know precisely the current PHY rate**
- **MAC and PHY interact state fully way to determine transmission rate**

Close loop rate adaption



- **PHY monitors its FIFO**
- **PHY send busy idle to MAC via XGMII when its FIFO is high**
- **MAC hold next frame from transmission**
- **PHY send normal idle to MAC via XGMII when its FIFO is low**
- **MAC then release next frame for transmission**

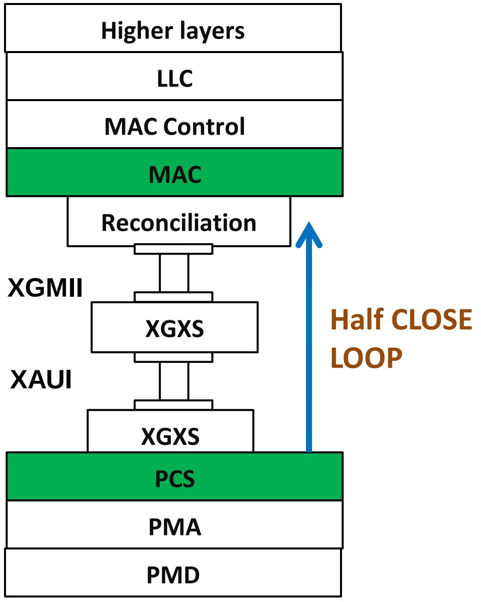
Close loop mechanism may not work for EPOC

- **The “halting” a frame is not defined in EPON MAC**

Half closed loop MAC rate control

- MAC does not know precisely the current PHY rate
- PHY send a signal to MAC via XGMII when its FIFO is high
- PHY does not keep record

Half Close loop rate adaption



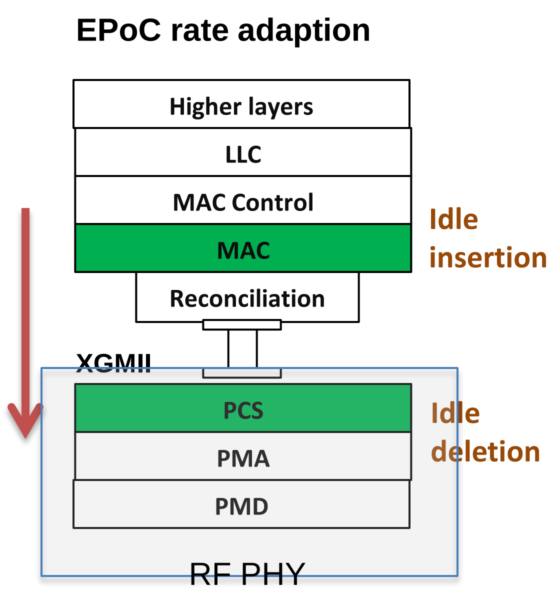
- PHY monitors it FIFO
- PHY send busy idle to MAC via XGMII when its FIFO is high
- MAC hold next frame from transmission for time delta t, then release for transmission

Could half closed loop work for EPOC MAC and RF PHY rate adaption?

- The problem is that "halting" a frame is not defined in EPON MAC

10G EPON rate adaption

- MAC knows precisely the current PHY rate
- Idles are inserted at MAC to the targeted rate
- PHY does not report to MAC
- Idles are deleted at PCS layer



10G EPON rate adaption mechanism for EPoC

- EPON MAC has fixed rate
- RF PHY could has lower rate and large rate variation, but a rate hierarchy enables fixed rates
- OLT needs to know the line rate for traffic shaping
  - The rate info needs to propagate to OLT
  - A rate hierarchy will simplify the process
- For Single Modulation Profile, no change is needed for 10G EPON rate adaption mechanism
- 10G EPON rate adaption mechanism might NOT work directly for Multiple Modulation Profiles (see presentations at Hangzhou meeting, dai_01b_1012.pdf and San Antonio meeting, dai_01a_1112.pdf)

Conclusions

- An Ethernet rate hierarchy for EPoC RF PHY is beneficial in several ways
  - Isolate OLT from RF PHY rate variations
  - Simplify OLT traffic shaping
  - Simplify rate adaption
  - Helps with network capacity planning
- 10G EPON rate adaption mechanism is the best candidate for EPoC
  - No changes are needed (except some parameters in state diagram) for SMP

Baseline Proposal

- Adapt a Ethernet rate hierarchy for EPoC RF PHY
  - Between 100 Mbps to 1 Gbps
    - For example: 100 Mbps, 500 Mbps, 1 Gbps
  - Between 1 Gbps to 10 Gbps
    - Fro example 1 Gbps, 1.5 Gbps, 2Gbps …
- The actual granularity will be further defined

Thanks