Next Generation EPON Objectives

- Rate and extensibility

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IEEE 802.3 Interim Meeting

Next Generation EPON Study Group

September 14-18, 2015

Bonita Spring, Florida USA

The paths for achieving NG EPON rate and/or capacity and extensibility objectives

- **NG EPON MAC rate can be achieved by:**
  - Higher TDM rates, ie., 25Gb/s, 40Gb/s …, if technically feasible
  - Multi-lane Ethernet, 4 lanes, 8 lanes, 10 lanes,…, if economically feasible
- **NG EPON system capacity can be achieved by:**
  - Hybrid WDM-TDM with highest TDM rate technically and economically feasible today
- **NG EPON extensibility**
  - Multi-lane, extending the "existing" NG EPON to a higher MAC rate
  - Hybrid WDM-TDM, extending the 'existing" NG EPON to a higher system capacity
- The methods to achieve NG EPON rate/capacity today and the methods to extend the "existing" NG PON to a higher rate and/or capacity are similar

Need to consider the various architectures and the "methods" in order to have consistent and achievable rate and extensibility objectives

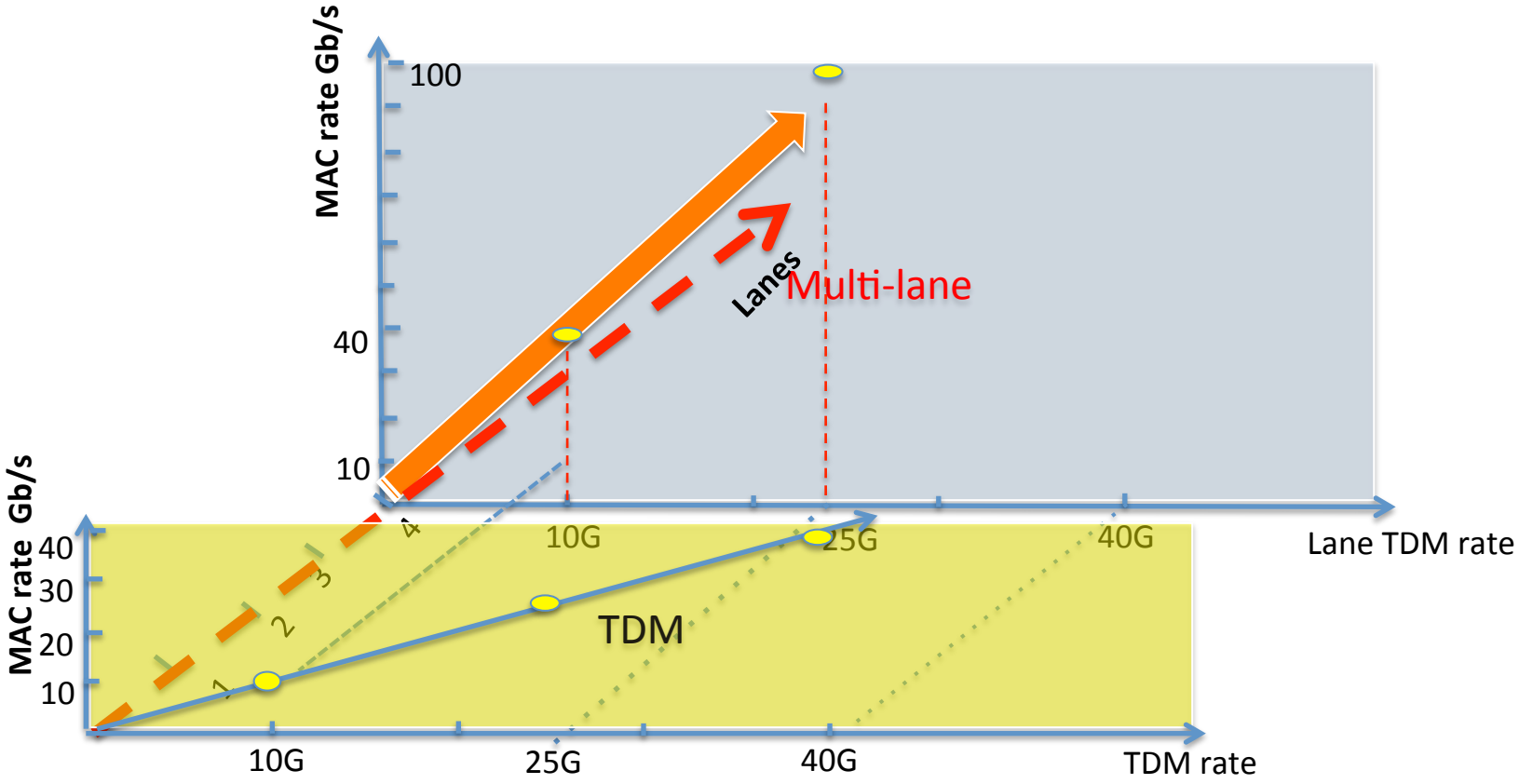
Current Rates and extensibility objectives

- **Rates objective:** Provide physical layer specifications operating over a single SMF strand and supporting:
  - MAC data rate of at least 25 Gb/s in downstream and at least 25 Gb/s in upstream
  - MAC data rate of at least 25 Gb/s in downstream and at least 10 Gb/s in upstream
  - MAC data rate of at least 40 Gb/s in downstream and at least 40 Gb/s in upstream
- **Extendibility objective:** Provide an extensible architecture that will support future higher MAC data rates of at least 100 Gb/s

Questions:

- **The 25 Gb/s EPON and 40 Gb/s EPON may have different architectures**
  - **25 Gb/s is likely single lane**
  - **40 Gb/s is likely multi-lane (4X10 Gb/s)**
- **Do we have compelling reasons that we need two NG EPON at the same time?**
- **How to "extend" the 25 Gb/s and 40 Gb/s to "at least" 100 Gb/s MAC rate? Should we study these architectures in SG or leave it to TF?**
- **Do we need 100 Gb/s MAC rate? Or it could be 100 Gb/s system capacity?**
- **Can we guarantee the 25G or 40G EPONs can be extended to 100G without change the hardware? Or what does the "extensible" objective guarantee?**

Achieve higher MAC rate by parallel "multi-lane" TDM

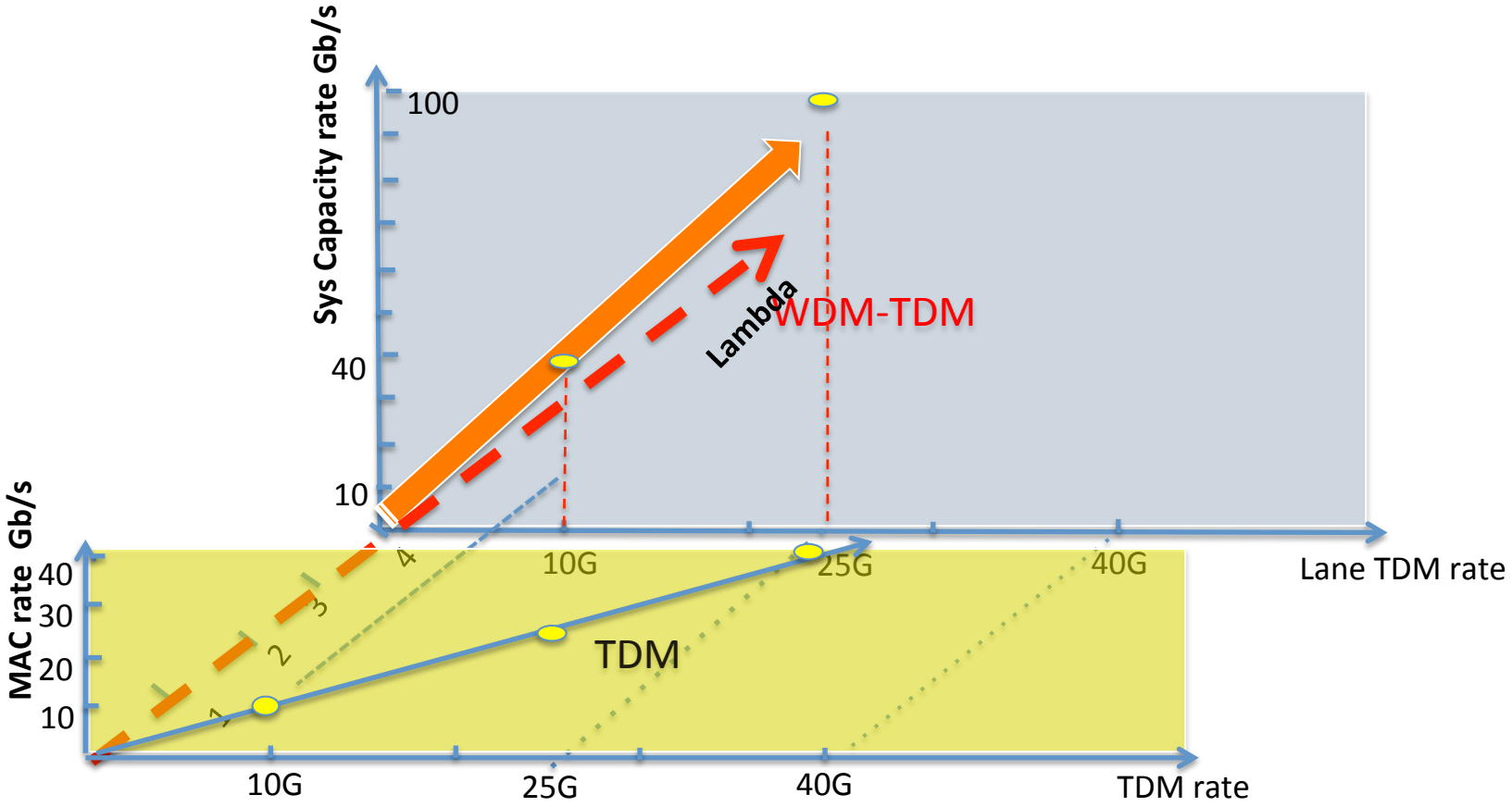


Multi-lane is "native" to Ethernet, it's a cost effective way to achieve higher rates, however it has limitations.

Achieve higher MAC rate by parallel "multi-lane" TDM (continue)

- **Multi-lane is "native" to Ethernet, it's a cost effective way to achieve high rate, especially for copper media**
  - Large number of parallel lanes are feasible
- **It has limitations for optical media**
  - The number of parallel lanes is limited by available wavelengths
- **Multi-lane Ethernet in optical access network need further study**
  - Cost and wavelength resource
  - More than 4 optical lanes in each direction may not cost effective for PON.
- **Therefore, the extensibility with multi-lane need further study.**

Achieve higher system capacity by hybrid WDM - TDM



Hybrid WDM-TDM can be used to achieve higher aggregated system capacity, but it will not normally gives higher MAC rate

Achieve higher system capacity by hybrid WDM – TDM (continue)

- **Hybrid WDM-TDM PON can be used to achieve higher aggregated system capacity, but at cost**
  - It use WDM PON mechanism for ONU wavelength assignment, there are many architectures and mechanisms, but no clear winner
  - Tunable optics (tunable laser LD, tunable optical filter) is one way; the cost is very high today
- **Hybrid WDM-TDM PON will not normally give higher MAC rate**
- **It is a rule of sum to go to highest TDM rate possible before consider WDM**
  - **Multi-lane Ethernet is preferred over hybrid WDM PON for NG EPON**
    - **Low cost although less flexible**
    - **Provide higher MAC rate**
- **However, hybrid WDM PON remain an option for expendability**
  - But will not normally give higher MAC rate, instead it gives higher system capacity

Interpretation of Rate objectives

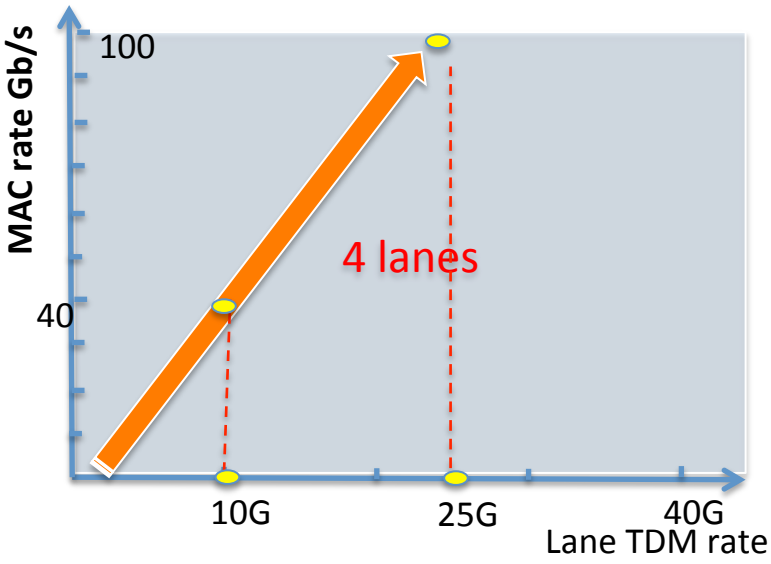
- **Ethernet rate can be achieved by single lane or multiple lanes architectures**
- **25 Gb/s Rate objective implies:**
  - Both symmetric and asymmetric are single lane
- **40 Gb/s objective:**
  - Could be implemented as single lane or multiple lanes
  - Excludes hybrid 4x10 Gb/s hybrid WDM-TDM architecture
- **However, define both signal lane 25Gb/s and signal lane 40 Gb/s at the same time does not make scenes**
  - 25Gb/s is a subset of 40Gb/s
  - 25Gb/s is not necessary has big cost benefit over single 40 Gb/s
  - Moreover, single lane 40Gb/s PON APD is not technically feasible or not mature today
- **Therefore, the 40Gb/s objective should be understand as multi-lane 4x10G architecture**

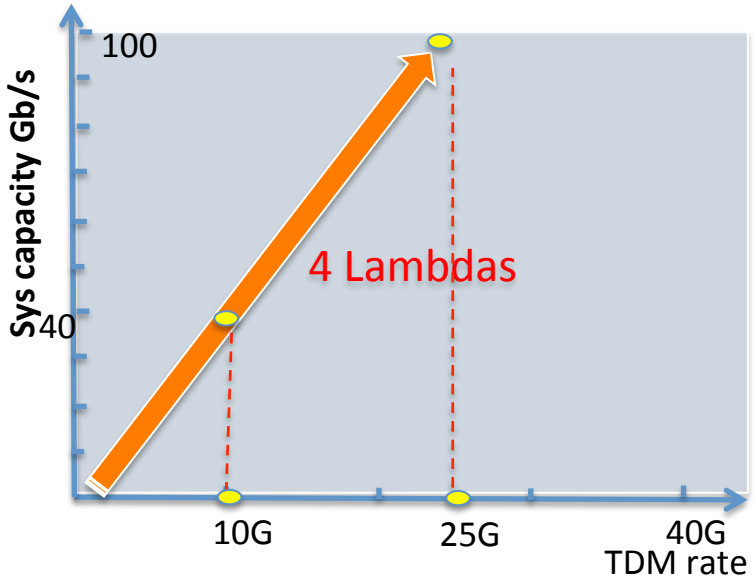
40G objective should clearly state "multi-lane".

Should consider how to extend 4x10G multi-lane to 100 Gb/s.

Extensible objective

- **25 Gb/s EPON can be extended to 100 Gb/s MAC rate by 4 lanes**
- **25 Gb/s EPON can be extended to 100 Gb/a system capacity by hybrid WDM-TDM PON**

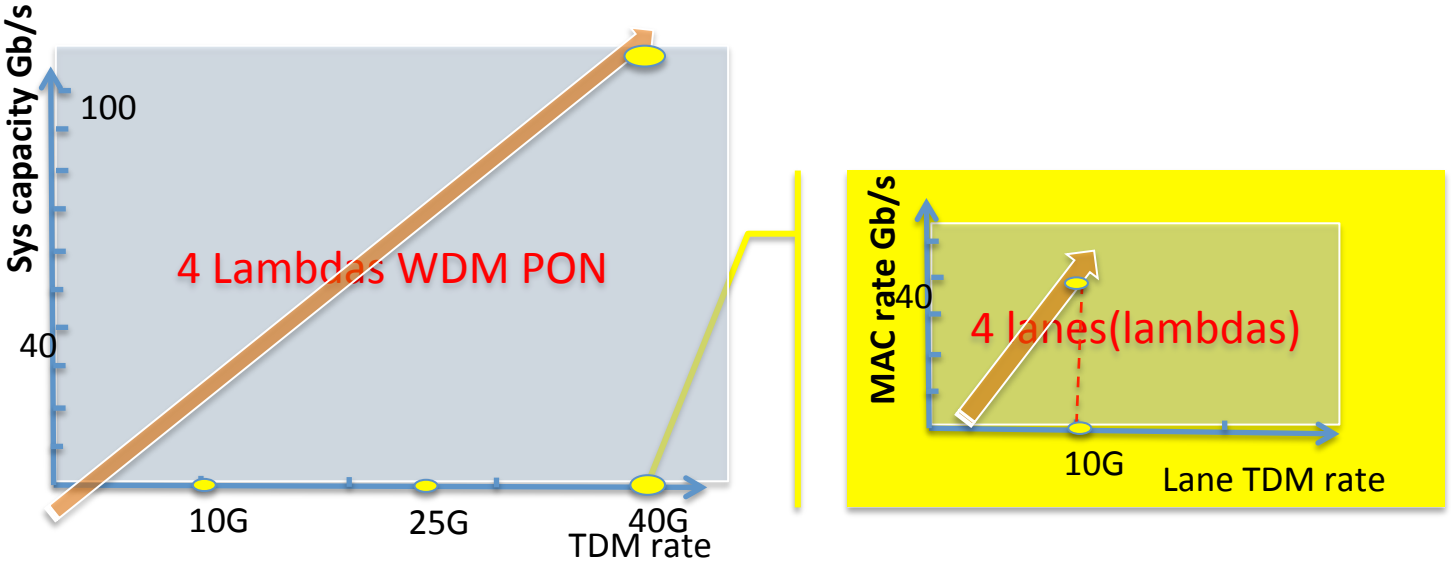




Both architectures are possible to extend 25 Gb/s EPON in the future

Extensible objective (continue)

- 40 Gb/s multi-lane EPON can be extended to >100 Gb/s MAC rate by using 10 or more lanes
- It is difficulty to extend 40 Gb/s multi-lane EPON to >100 Gb/s system capacity with hybrid WDM-TDM PON
  - The 40 Gb/s multi-lane EPON already uses 4 lambdas at multi-lane PHY
  - To use another 4 lambdas to aggregate the multi-lane, multi-lambda 40 Gb/s EPON is very difficulty, if it is feasible at all



What the "extensible" objective do?

- Given that the rates are closely coupled with underlining architectures:
  - 25 Gb/s symmetric and asymmetric EPON is single
  - 40 Gb/s MAC rate EPON is multi-lane 4x10 Gb/s
- The 100 Gb/s MAC rate EPON could be build with multi-lane 4x25 Gb/s EPON, however that is not means the future field deployed 25G EPON can be upgrade to new 100G EPON
- 100 Gb/s MAC rate EPON will be a new standard and a new product
- In theory, the 100 Gb/s MAC rate EPON could also be build with 10x10 Gb/s EPON, however, this 10x10 Gb/s EPON (need 20 lambdas) may not be upgrade form the 4x40 Gb/s EPON directly

The "extensible" objective doesn't guarantee anything, it will only bring up questions at WG ballot

Conclusions

- The NG EPON rates has underline assumption on different architectures
- These architectures may has different evolution path to the next rate level
- The NG EPON SG should study these architectures now rather than leave them to the TF
- The future PON at “at least” 100 Gb/s could be build with different technology such as optical OFDM, WDM, etc.
- The “extensible” objective is not necessary

Thanks

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