Utilize 100G EPON Capacities with 4x25Gb/s Architecture

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Outline

- Paths to achieve 100G capacity for EPON
- Bonded and un-bonded 100G EPON
- Burst rate and average rate
- 100G EPON migration and reference models

Paths to achieve high capacities in communication networks

- **Three ways to achieve high capacity in communication systems**
  - High serial TDM rate
    - 100G to 400G serial rates are used today in long-haul optical networks with coherent technology. 1 Tb/s is feasible with OFDM with flex grades.
  - Using WDM
    - WDM technologies have been widely used in the past and today
  - Channel bonding
    - Channel bonding has been used in access networks from time to time with legacy technologies. **BUT all had been eventually replaced by new technologies in unbounded fashions**
- **Channel bonding has been the last resource to solve capacity problems, and has always been replaced by new technologies**

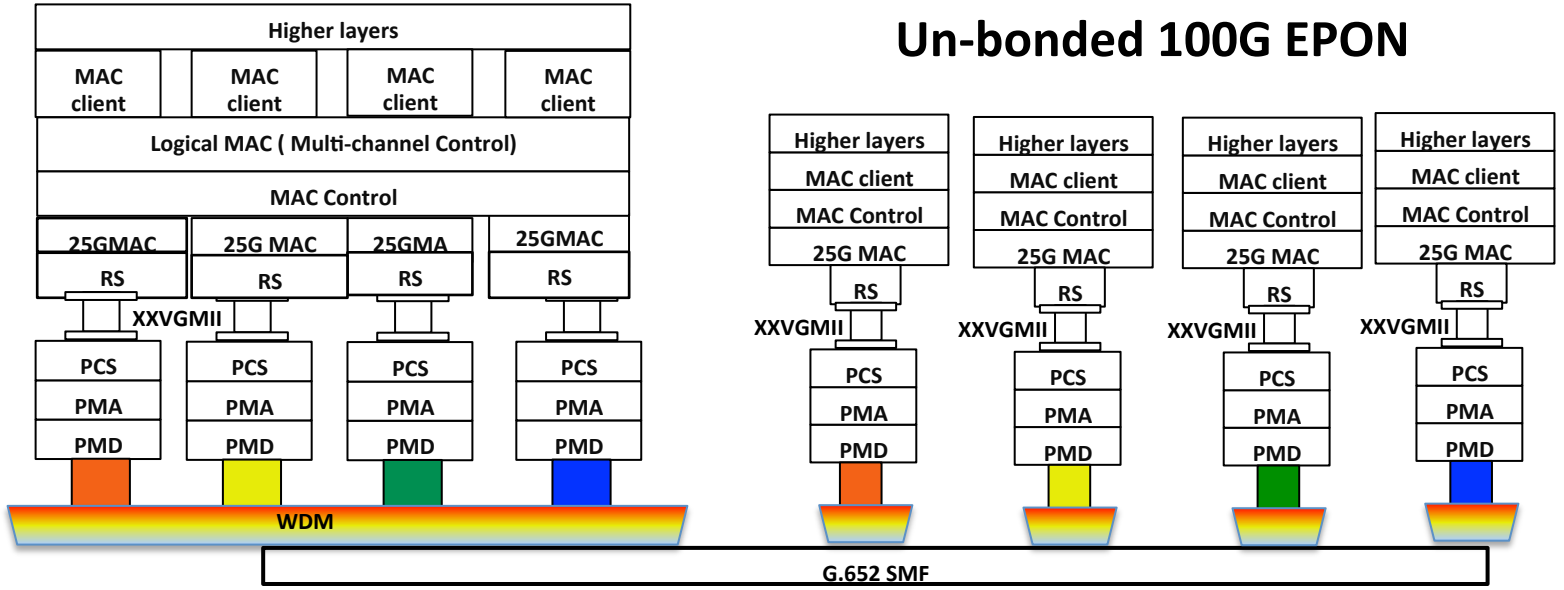
Paths to achieve 100G capacity for EPON

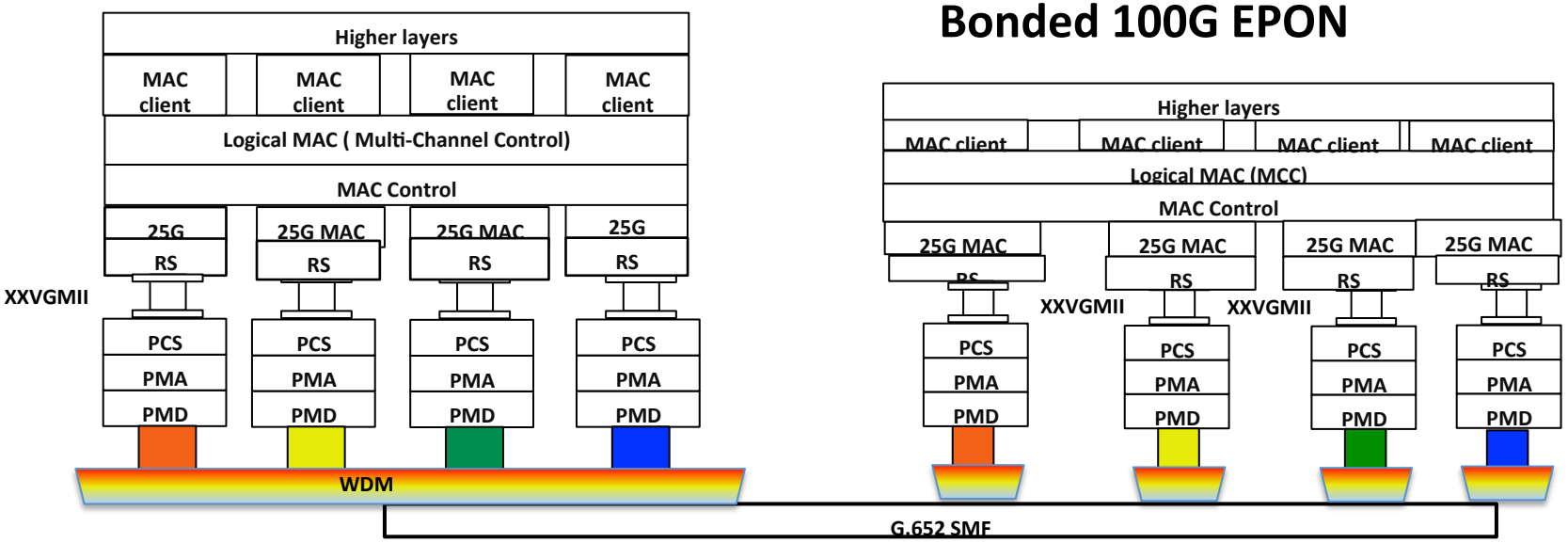
- **There are also 3 ways to achieve 100G capacity for EPON**
  - Highest serial TDM rate
    - 100G serial needs coherent technology
    - 25G TDM is considered technically feasible and 40G TDM may become feasible in the future
  - Using WDM
    - WDM is used in P2MP, such as NG-PON2
  - Channel bonding
    - Channel bonding is used in P2P Ethernet, such as 100G and 400G, but not in P2MP.
- **From 10G EPON to higher capacity NG EPON, it is natural to go through the proven evolution stages**
  - 25G, 40G TDM, WDM… , the last choice is channel bonding
- **There is the possibility new technologies may appear before we reach the channel bonding stage**

Multi-lane Ethernet and channel bonding

- **Channel bonding in P2MP optical access does create a number of challenges**
  - Mixed ONUs, ie. mixed 25G, 50G and 100G ONUs
    - Scheduling efficiency, utilization of lanes, cost …
  - Choices between tunable optics and non-tunable optics options (Discussed in another contribution)
- **Multi-lane Ethernet + WDM could be used in P2MP optical access networks, but does not necessarily mean channel bonding**
  - Multi-lane 100G EPON: Four 25G EPONs assigned to 4 lanes
  - Channel bonded 100G EPON: 4 lanes are bonded to support 100G ONUs
- From a network architecture and scalability point of view, what are the differences?
- From a service offering point of view what are the differences?

100G EPON: bonded and un-bonded

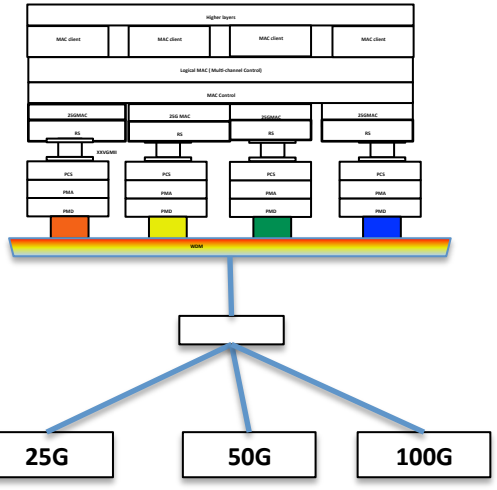




100G EPON: To band or not to bond…

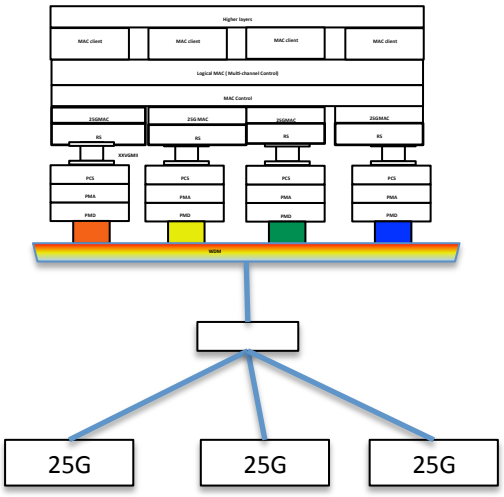
- System capacity needs to be considered with network scalability
- From an architecture point of view, 100G EPON is limited by the optical power budget.
  - 16 ONUs or 32 ONUs under current power budget target with 20km reach
- To translate higher system capacities into servers' offering ability, higher scalabilities are required

A bonded 100G EPON



6 ONUs **5 ONUs** **5 ONUs**

An un- bonded 100G EPON



16 ONUs

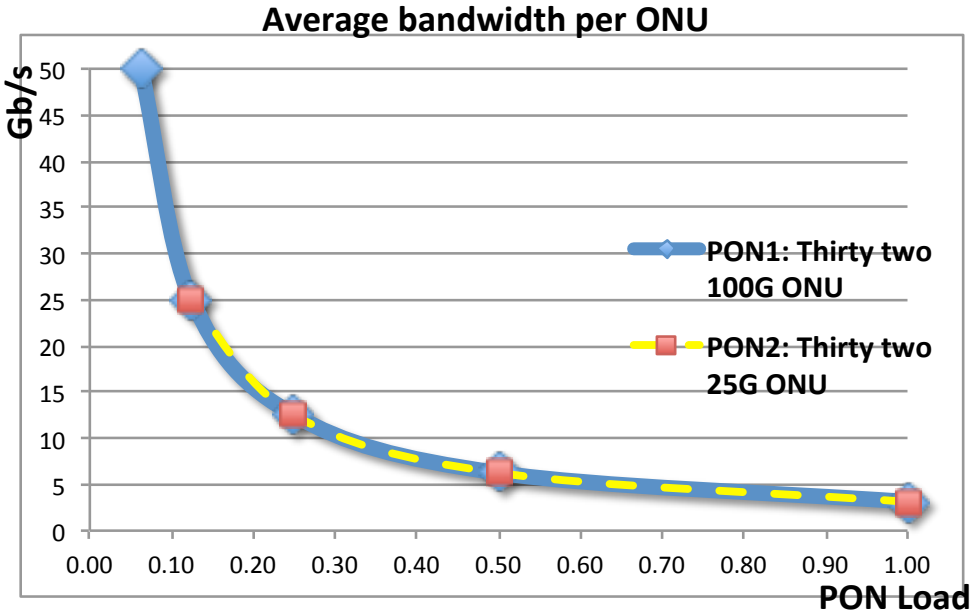
Under the current optical power budget target, an 100G EPON PON does not have required scalability to benefit from mixed types of ONUs

Service offering: average bandwidth

- From a service offering point of view, average bandwidth is what SLA offers
- The average bandwidth is also what “speed test” interprets
- A customer can not measure “burst rate”

“Burst rate” and “grand frequency” gives “average bandwidth”

Average bandwidth: bonded and un-bonded



PON load

- PON 1: Number of 100G ONU = 32
- Full load = 1, 32 ONUs; half load = 0.5,16 Onus,…,
- PON 2: Number of 25 G ONU =32
- Number of 25G ONU per lane = 8
- Full load = 1, 8 ONUs per lane; half load = 0.5,4ONus per lane, …,

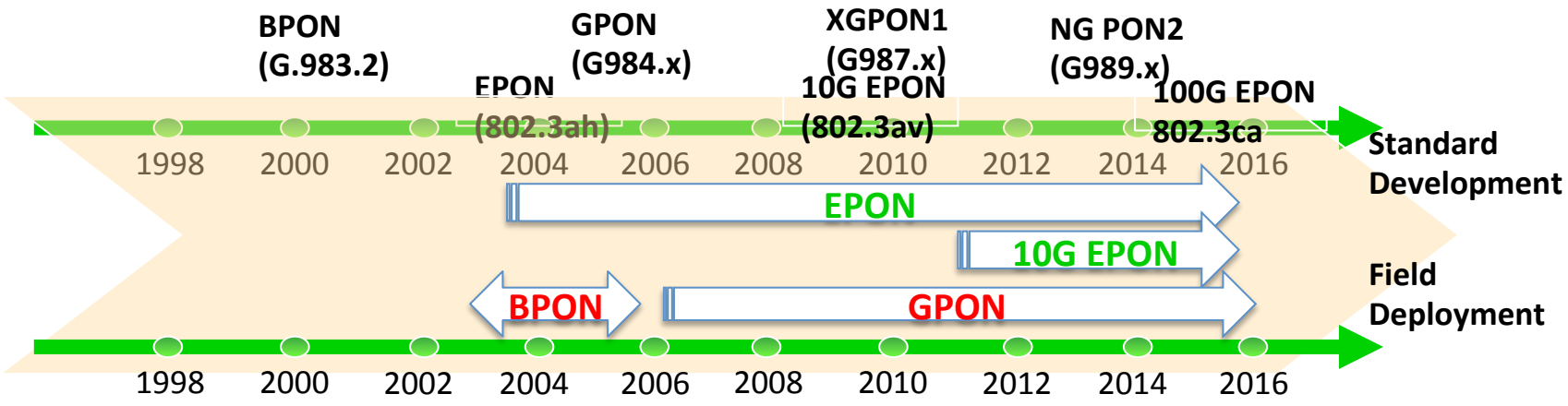
Traffic assumptions

- All ONUs have constant upstream data to transmit

- Average bandwidth per 100G ONU and per 25G ONU is identical from full PON load to 1/8 of the PON load
  - At 1/8 PON load: Four 100G ONUs in PON 1, one 25G ONU per-lane in PON2

Under heavy traffic assumption, a 100G bonded ONU does not get more average bandwidth than a 25G un-bonded ONU

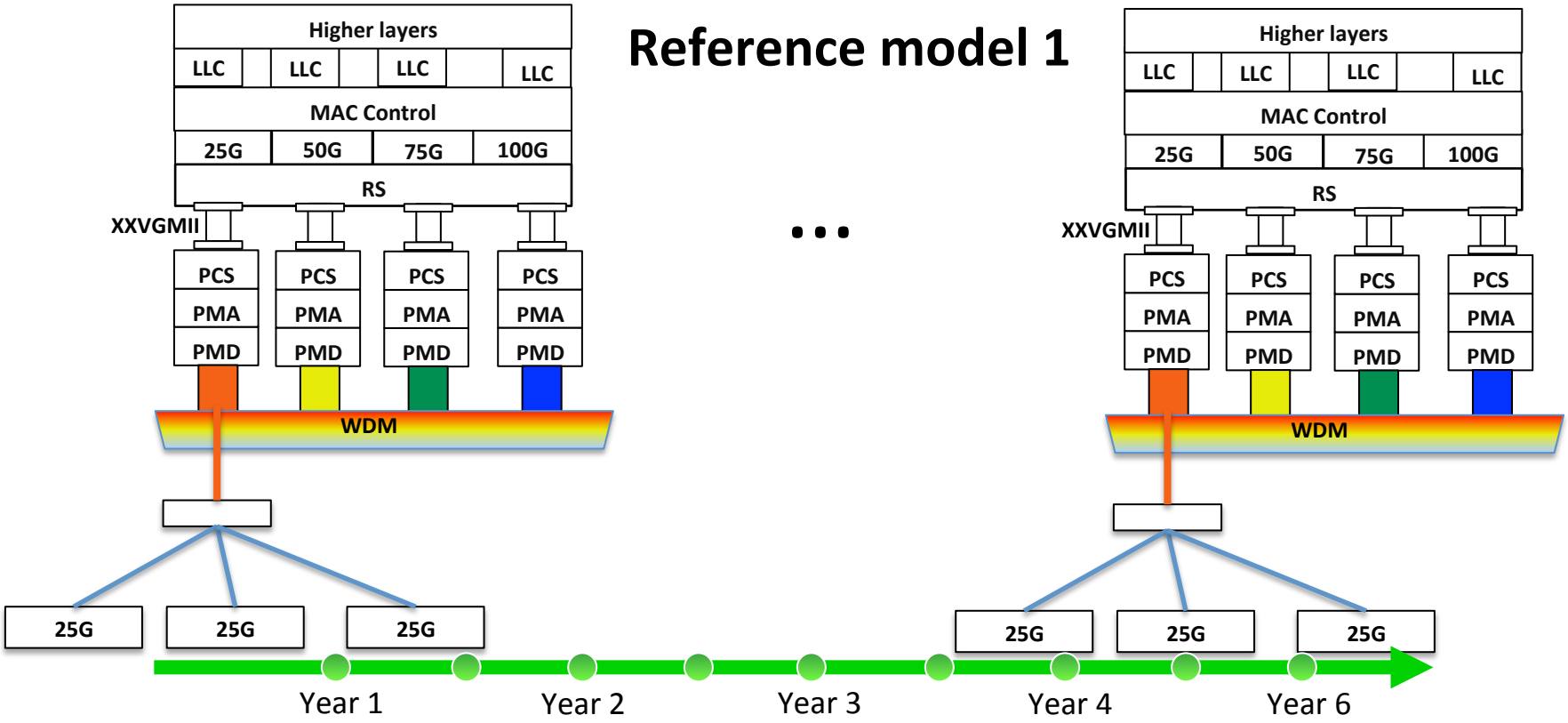
Historical views of PON deployments



- An access network rate will last for many years. A new rate will be introduced when there are service needs and a bitrate economy in favor

We expect that the 25 Gb/s access rate will also last for a number of years; the 50 Gb/s and 100 Gb/s may appear when the 25 Gb/s rate can not meet needs

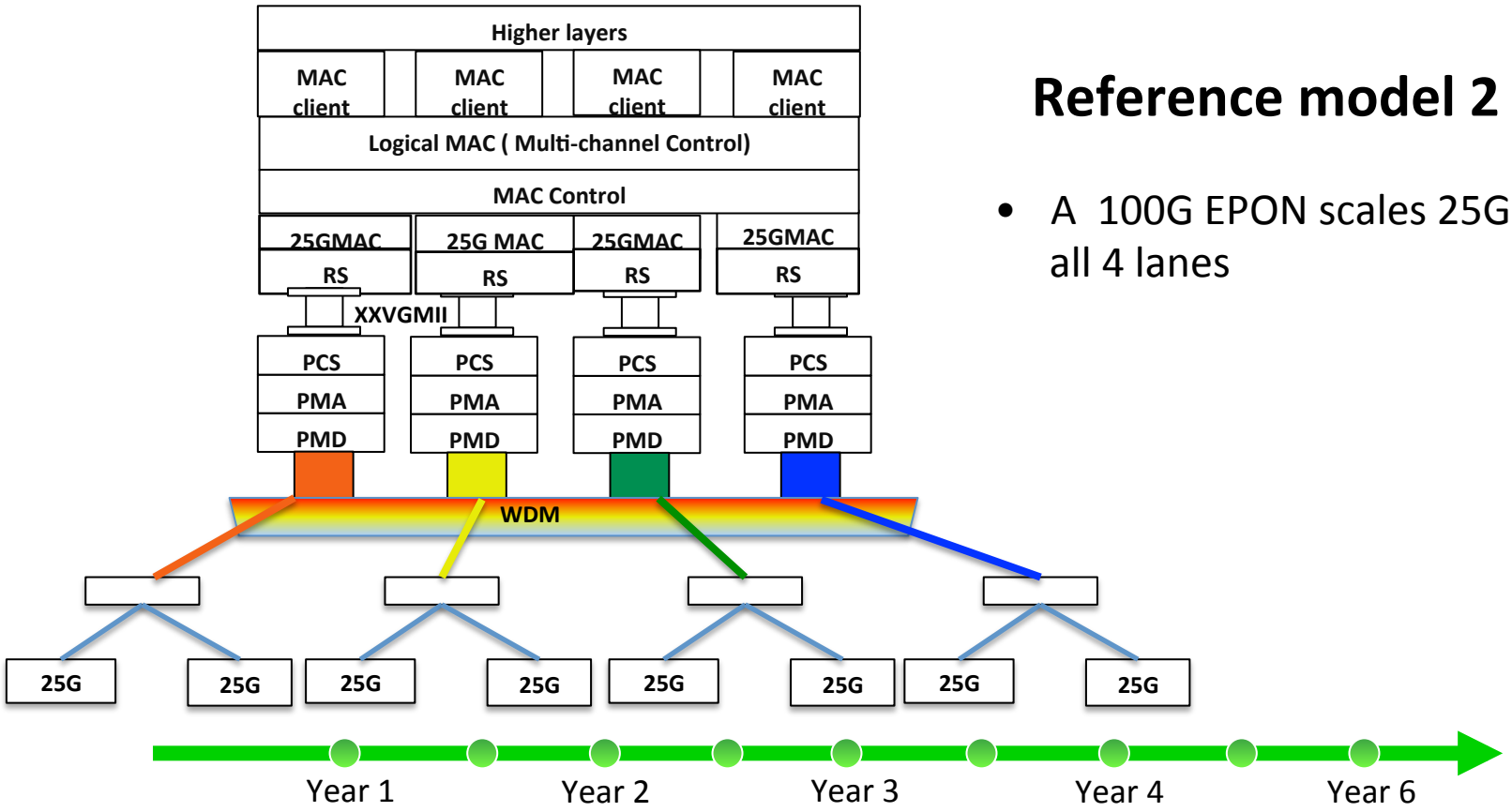
100G EPON migration scenarios and reference models



- A 100G EPON can not scale 25G to all 4 lanes
- Multiple 100G systems are needed to deploy 25G ONUs with unused lanes

Reference model 1 does scale with all 25G ONU deployment

100G EPON migration scenarios and reference models



Reference model 2

- A 100G EPON scales 25G to all 4 lanes

Reference model 2 scales well 25G ONU deployment

Conclusions

- 100G EPON should support 25Gb/s ONUs in all 4 lanes un-bonded in a pay-as-growth architecture
- Reference model 2 provides the flexibility to scale to all 25G ONUs or bond to higher rates

Thanks

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