NOKIA

25G/50G/100G EPON architectures: 1+3 vs. 1+4

Bill Powell, Ed Harstead, members Fixed Networks CTO

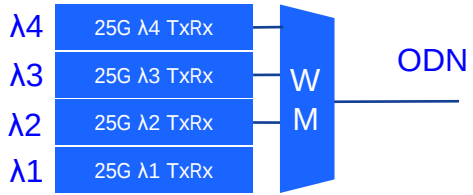
July 2016 **v1a**

Agenda

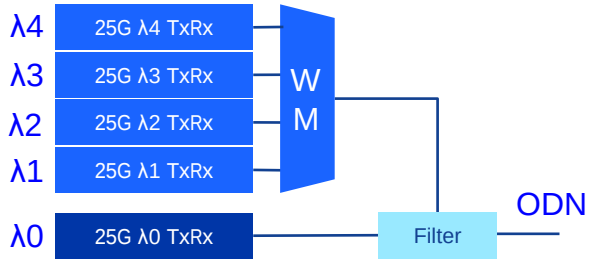
- 1+3 vs. 1+4 architecture for 100G EPON
- 25G/50G/100G EPON upgrade paths
- Channel Bonding
- Internal/External wavelength mux
- Conclusions

1+3 vs. 1+4 architecture assumption

- 1+3 Architecture
  - 4 lambda pairs
  - 25G ONU uses lambda pair 1
  - 50G ONU uses lambda pairs 1 & 2
  - 100G ONU uses lambda pairs 1, 2, 3, 4



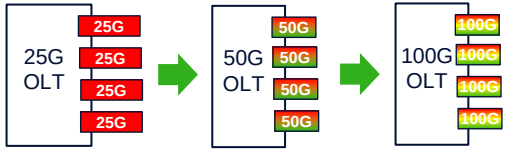
- 1+4 Architecture
  - 5 lambda pairs
  - 25G ONU uses lambda pair 0
  - 50G ONU uses lambda pairs 1 & 2
  - 100G ONU uses lambda pairs 1, 2, 3, 4



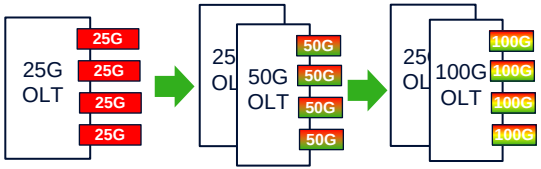
NOKIA

System Upgrade scenarios

- Some operators have expressed a preference for OLT/line card replacement for generational upgrades
  - Potentially fewer OLTs/line cards needed
- 1+3 implementation
  - Low physical implementation complexity (swap line card)
  - Out-of-service window required for upgrade
  - Provisioning upgrades needed to add new lambdas. Original lambda turn-up complexity should be able to be minimized with good OLT design (Gen 1 / Gen 2 card swap)
  - Overall “installed” cost should be lower with 4 lambda pairs vs. 5 (1 OLT line card with all 4 lambdas; move 25G card elsewhere)



- 1+4 implementation
  - Could allow decoupling low cost 25G lane 1 optical TX/RX levels from 50/100G EPON (more flexibility)
  - 25G line card stays in place. 50/100G line cards added
  - More BW for 50G and 100G ONUs
  - Would require an external combining filter
  - Would potentially allow 25->50G or 25->100G “hitless” (to 25G) upgrades (depending on whether filter already in place)



NOKIA

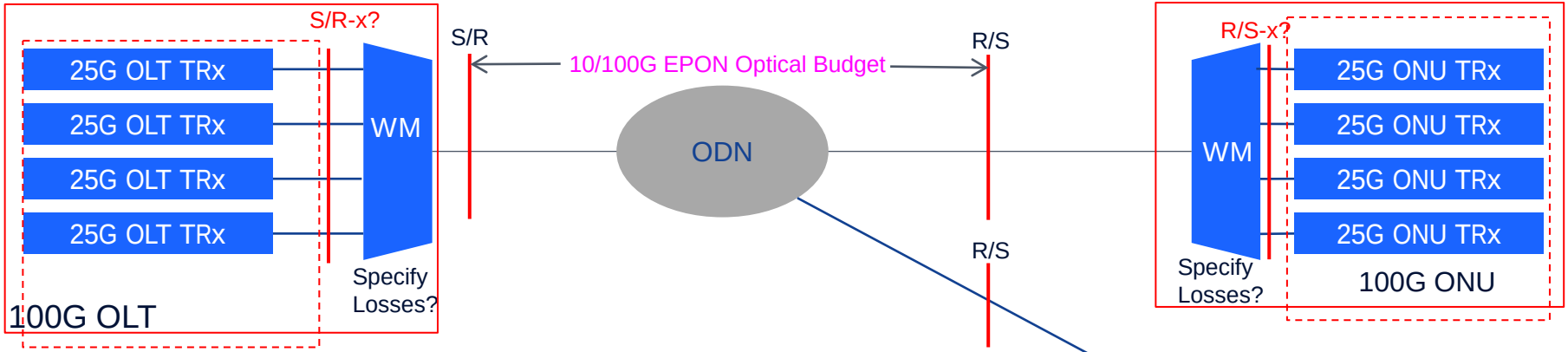
Channel bonding issues

- Bonded channels need to be sourced from a common MPCP/DBA function
- Can’t easily bond BW from different OLTs or OLT PON line cards
- Most ideal for bonding – all lambdas sourced from a common OLT PON line card
- Separate PON OLTs/Line cards not conducive to implementation of channel bonding (for either 1+3 or 1+4 architectures)

Possible wavelength mux locations
(applies to either 1+3 or 1+ 4 discussion)

[1] 25G generation 1 system - No WM needed!

[2] 50/100G OLT – WM inside or outside of OLT?



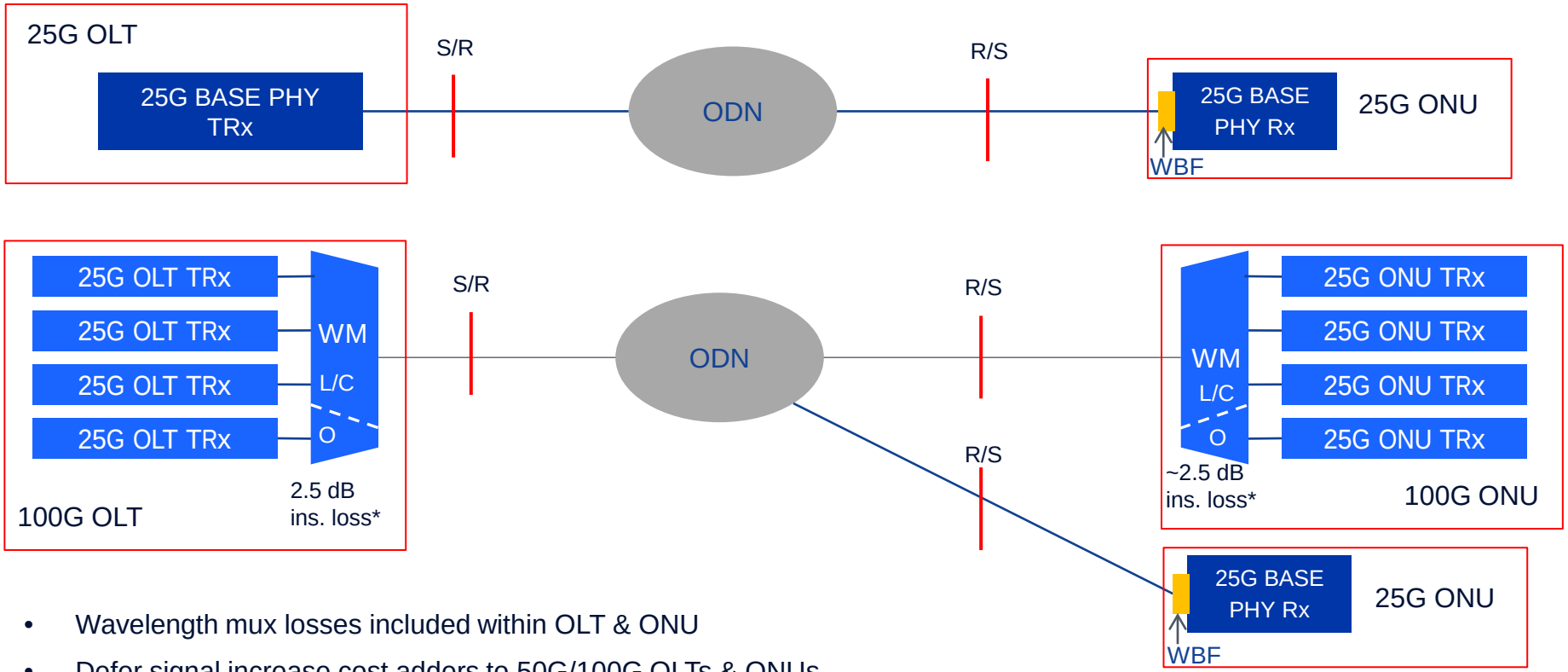
- Should wavelength mux losses be part of OLT & ONU?
- If WM is outside the OLT/ONU, then 4 sets of power measurement points are needed (WM losses, tolerances!)
- Losses of WM should probably be included within the OLT & ONU (i.e. - no S/R-x & R/S-x measurement points)

NOKIA

External vs. Internal wavelength mux

- External Mux
  - More flexibility to add P2P DWDM & other channels
  - Allows PayG architecture (may have bonding issues if on different OLT/line cards)
  - Could allow BW upgrades without service interruption to existing ONUs (possible bonding impact if additional lambdas are on different cards)
- Internal Mux
  - Allows higher optical budget for 25G OLT/ONU (no mux needed)
    - need WBF? – Easier if O/L or O/C band?
    - Lower system deployment/upgrade complexity & cost
    - Lower optical loss: Internal WM eliminates 2 Connectors
  - For 50/100G OLTs, WMs likely to be integrated into the optical module
    -> no place to measure S/R-x & R/S-x

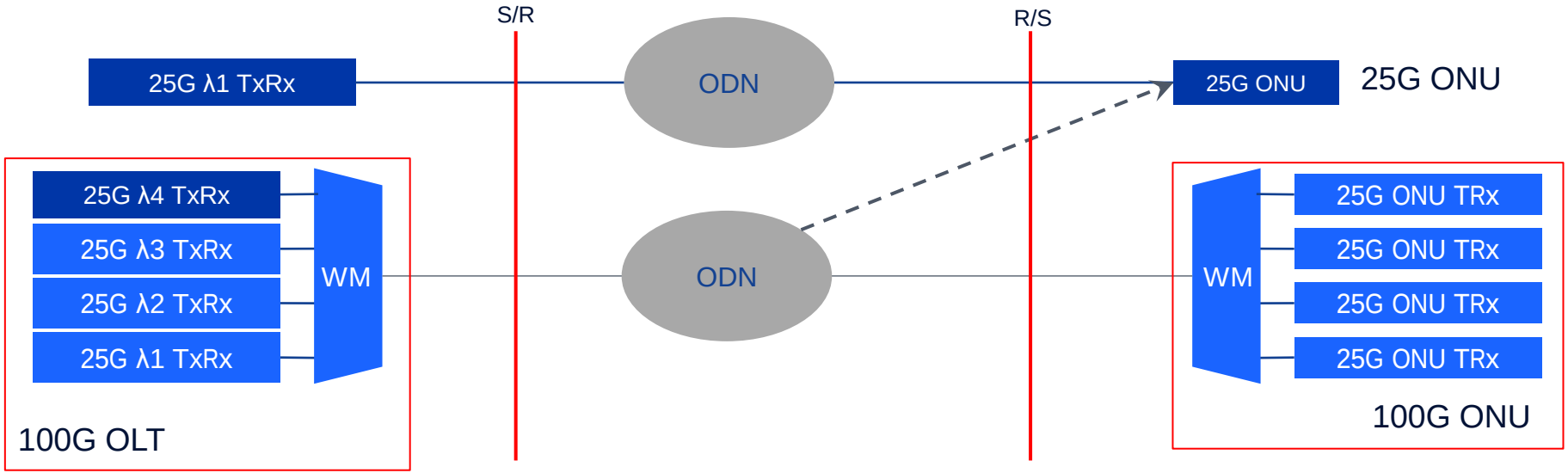
Recommended TX/RX PON power measurement points



- Wavelength mux losses included within OLT & ONU
- Defer signal increase cost adders to 50G/100G OLTs & ONUs

NOKIA

1+3 optical levels: downstream



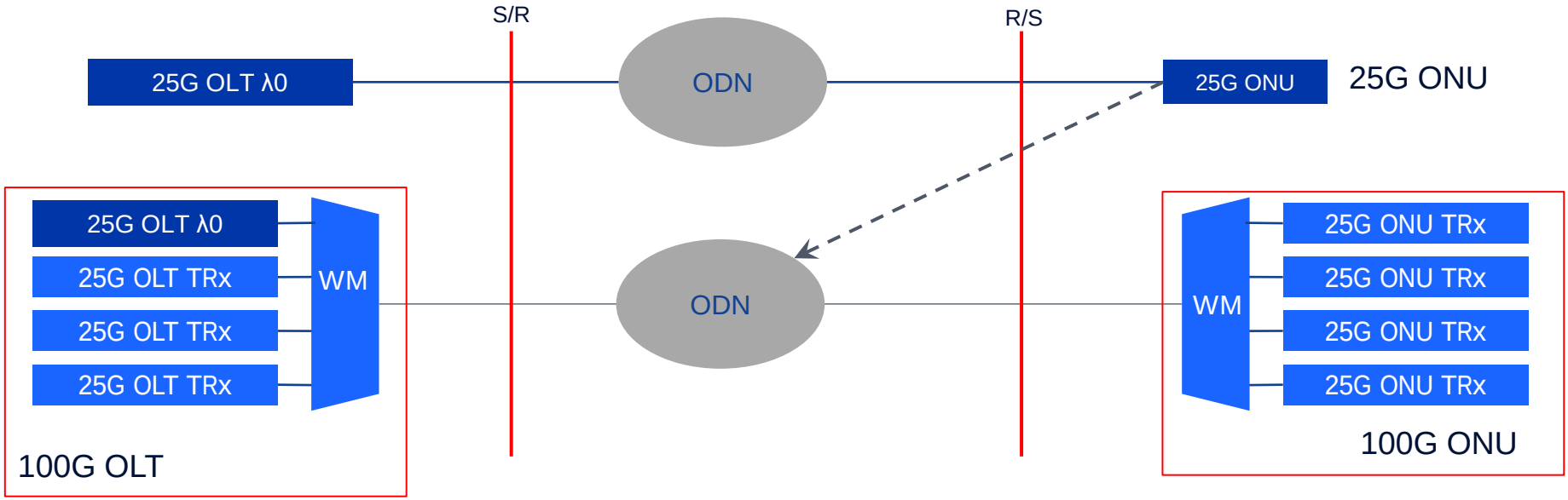
100G ONUs have WM insertion loss (IL), reducing ONU receiver sensitivity vs. 25G ONUs. How to accommodate:

1. To maintain same R/S , add optical preamp in every 100G ONU. Not clear you can get enough improvement cost effectively. Or,

2. Different R/S for 100G. Increase OLT launch power (more post-amplification; may be difficult to get 4-6 dB) for all 4 λs AND
   a. The original 25G ONUs have to support higher overload levels (by 2-3 dB) to be future-ready, or
   b. The new 25G OLT transmitter (in the 100G line card) must have narrow min/max launch power, or
   c. Reduce min/max ODN loss

NOKIA

1+3 optical levels: upstream



- 100G OLTs have WM IL, impacting receiver sensitivity vs. 25G OLT.
- Must maintain the R/S to support existing 25G ONU transmitters.
  - ➡ Need to increase 50/100G OLT receiver sensitivity with more optical pre-amplification

- Not clear whether enough improvement is possible cost effectively

NOKIA

1+3 or 1+4?

	1+3	1+4
Bonding	50G/100G EPON MAC bonds 25G EPON	25G EPON MAC is independent from 50G/100G EPON MAC
Upgrade operations	25G→50G→100G OOS line card swap	25G line card supports 25G ONUs →50G/100G - add 50/100G line card
Optics	50G/100G OLT⇔ 25G ONU creates difficult optical level problems that could add significant costs	25G OLT ⇔ 25G ONU 50G/100G OLT⇔ 50G/100G ONU No cross-gen optical level problems

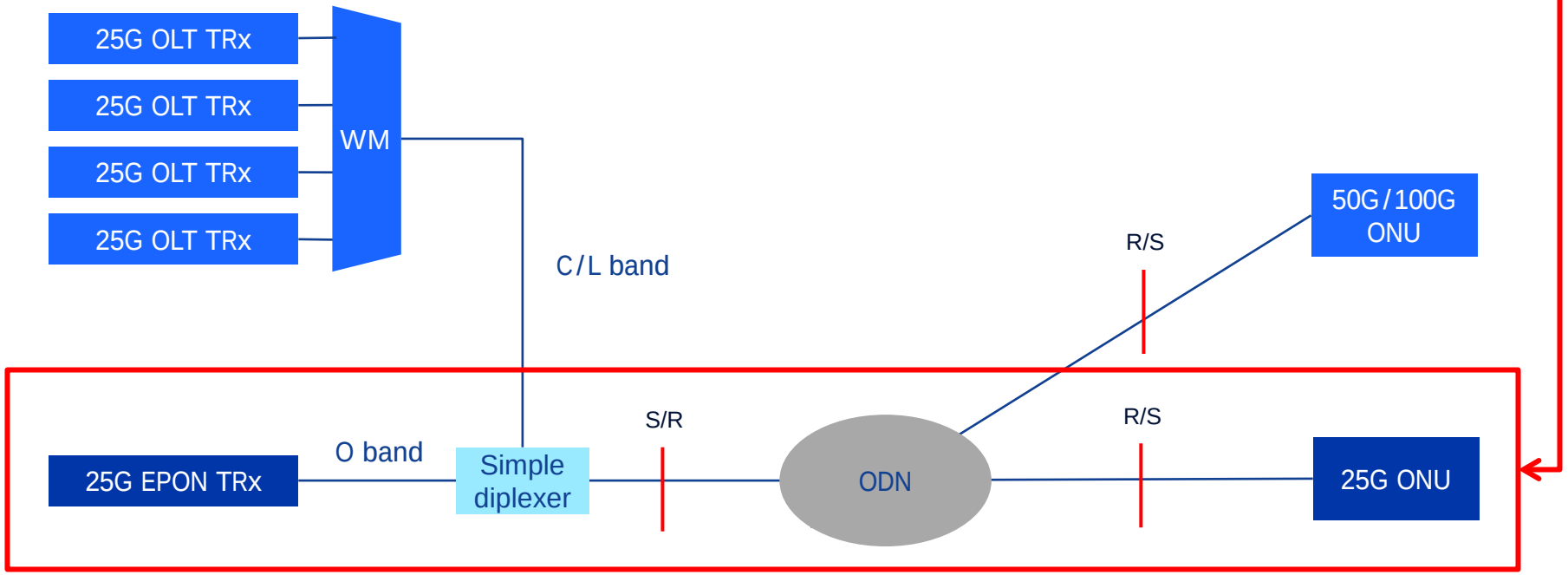
Conclusions

- Channel bonding is not practical unless all bonded channels are terminated on the same OLT line card
- The 50G/100G WM should be internal to the OLT and ONU, and not included in the ODN loss budget.

- The choice of a 1+3 or 1+4 architecture:
  - The main differences are outlined in the previous slide
  - If 1+3 is selected, the cross-generational optical level issues need to be solved first.
  - To select 1+4 means this Task Force will define two separate EPON PHYs and two independent EPON MACs
    - This does not violate our objectives
    - Such decoupling will simplify and speed up standardization.


NOKIA

Low cost optimized 25G EPON: what it looks like



Avoid pushing cost on 1st gen 25G EPON to accommodate later 50G/100G EPON

NOKIA