WAVELENGTH ALLOCATION FOR NG-EPON

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Summary

- Free spectrum in SMF used for EPON ODN becomes very scarce when 1G-EPON, 10G-EPON, and RFoG are used simultaneously
- To make room for NG-EPON, some concessions from operators will be necessary
- A proposal of NG-EPON wavelength allocation plan is made, building on mature Rx/Tx technology and characteristics of existing 1G-EPON / 10G-EPON devices

Current Wavelength Allocation

System	Downstream [nm]	Upstream [nm]
1G-EPON	1480-1500	1260-1360[1] 1290-1330[2] 1300-1320[3]
10G-EPON	1575-1580	1260-1280
GPON	1480-1500	1260-1360 (regular) [1] 1290-1330 (reduced) [2] 1300-1320 (narrow) [3]
NGPON2 (TWDM)	1596-1603	1524-1544
NGPON2 (P2P WDM)	1524-1625	
RFoG	1550	1310 / 1590 / 1610

[1] Typical for Fabry Perot lasers
[2] Typical for DFB lasers without temperature control
[3] Typical for DFB lasers with temperature control

- Most desirable transmission windows for upstream / downstream already occupied by 1G and 10G systems
- NGPON2 was pushed into high 1500s and will likely require new laser / receiver development efforts.

Coexistence options for NG-EPON

- Option A: coexistence with 1G-EPON and 10G-EPON
- Option B: coexistence with RF overlay (DS only) and 10G-EPON
- Option C: coexistence with RF overlay (DS only), 1G-EPON, and 10G-EPON
- Option D: coexistence with RFoG and 10G-EPON
- Option E: coexistence with RFoG, 1G-EPON, and 10G-EPON
- Option F: coexistence with 10G-EPON (only)
- Option G: coexistence with 1G-EPON (only)

- RF overlay is unidirectional (downstream only), with return channel implemented over digital upstream EPON path

- RFoG uses a bidirectional analog transmission, with downstream operating at 1550nm and return at 1310nm or ~1610nm
  - 1610nm return channel is deployed over ODN in coexistence scenario with 1G-EPON; 1310nm channel is already occupied by 1G-EPON

NG-EPON in greenfield scenarios

- By 2017 (and beyond) it is unlikely that analog delivery will continue to be used in new deployments
  - 10G-EPON and NG-EPON offer enough bandwidth to broadcast most common analog lineup and use selective unicast for the rest of lineup
  - Cost of RF equipment remains high, while cost of digital equipment is constantly driven down
  - Scenarios B, C, D, and E are very unlikely in greenfield scenario
- Conclusion: for green-field scenarios for NG-EPON, assume ***NO*** support for RF / RFoG
  - 1550nm for downstream and 1610nm for upstream could be then used for NG-EPON
  - All artifacts of analog transmission over the same ODN are gone
  - Filter design for NG-EPON devices could build on RFoG filter designs

NG-EPON in brownfield scenarios (1)

- Not all brownfield areas will be upgraded to NG-EPON
  - Brownfield migration scenarios are based on operator margins
  - Areas with lower margins typically use the currently existing technology until financial, competitive, or technical factors force the upgrade
  - In such areas, 1G-EPON + RFoG will be used in the foreseeable future
- Depending on upgrade timelines, two scenarios are possible
  - (1) replace 1G-EPON with 10G-EPON and leave RFoG in place, or (2) upgrade to 10G-EPON and remove RFoG
  - Scenario (2) depends on migration to all-digital distribution for voice and/or video, backoffice solutions, availability of customer-side equipment, in-house cabling, etc.
- Brownfields with a mix of residential and business customers are more likely to be upgraded
  - Business customers drive bandwidth demand !

NG-EPON in brownfield scenarios (2)

- It is unlikely operators will perform blanket upgrade to 10G-EPON and then to NG-EPON in all brownfield scenarios
  - This process will be gradual (cherry picking) and eliminate RFoG only in deployments where it makes economic and technical sense to do so
- NG-EPON in brownfield will be rolled out selectively, most likely in areas where RFoG has been already removed during migration to digital distribution
  - Support for scenarios B, C, D, and E is not critical

Scenario A (1)

- Coexistence with 1G-EPON and 10G-EPON provides most flexibility to operators with deployed EPON
  - Some customers will never need to be migrated off 1G-EPON (their services do not demand that)
  - 1G-EPON will continue to be deployed where spare OLT port capacity is available / ODN with 1G-EPON is already available
- Migration to 10G-EPON will be mostly done via overlay rather than replacement
  - 10G-EPON wavelength will be added to selected ODNs, and will supplement capacity, but not replace 1G-EPON
- Only greenfield builds might switch exclusively to 10G-EPON only at some point of time
  - That will happen sooner for business customers than for residential
  - Residential CPE devices for 1G+ data rates are still very limited

Scenario A (2)

- NG-EPON downstream should reuse RFoG downstream band (1550nm), which has mature Tx / Rx technology already in place
- NG-EPON upstream has two available options:
  - Reuse upstream RFoG band (1610nm)
  - Reuse part of 1G-EPON upstream band (1340nm – 1360nm) and narrow down 1G-EPON upstream band to 1290nm – 1310nm
- The reuse 1G-EPON upstream band would force NG-EPON to support triple-rate burst-mode mode operation in upstream
  - Extend the TDM-coexistence model from 10G-EPON
  - This covers operators who deployed wide-band upstream 1G-EPON
  - Operators who deployed narrow-band 1G-EPON could opt for WDM-coexistence model

Scenarios F & G

- Coexistence with only 1G-EPON or only 10G-EPON is already covered under scenario A
- It is not likely that an operator with existing 1G-EPON deployments will move to NG-EPON directly, without stepping through 10G-EPON on the way
- An operator with only 10G-EPON deployments will move to NG-EPON at some point of time, but wavelength plan from scenario A would guarantee seamless coexistence.
- No specific wavelength plans is needed for scenario F and G

Conclusions

- Full coexistence with 1G-EPON and 10G-EPON is neccessary
- No coexistence with RF overlay (downstream only) or RFoG
- Suggested wavelength allocation plan for NG-EPON
  - Downstream: 1550nm +- TBD
  - Upstream: 1350nm ± 10 nm, with 20 nm separation from 1G-EPON
- TDM-coexistence with 1G-EPON and 10G-EPON, where broadband upstream 1G-EPON ONUs are deployed
- WDM-coexistence with 1G-EPON and 10G-EPON, where narrowband upstream 1G-EPON ONUs are deployed
- Specific wavelength grid (number of wavelengths within the window) is TBD at this time

THANKS !