Next Generation PON: Lessons Learned from G-PON and GE-PON

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Introduction

- **The current PON generation consists of two systems**
  - IEEE EPON
  - ITU G-PON
- **They are essentially the same technology**
  - WDM diplexing, TDM downstream, TDMA upstream, packet-based
- **Their differences stem mainly from the style of the SDO that created them**
  - IEEE is a “grass roots” organization – Vendors drive the process
  - ITU is a “top down” organization – Operators direct the process

IEEE Positive: Readily implementable standard

- **EPON reused a lot of existing designs**
  - 8b10b line coding from GbE point to point
  - MAC control signaling mechanism from Pause function
- **EPON was designed to tolerate nearly any optics**
  - Very loose transmitter timing meant even CM optics could work
  - Very loose receiver timing allowed a wide range of designs
- **The time from initial inception to first field deployment was quite impressive (4 years)**

IEEE Negative: Vendor-dominated standards may lack operator interest

- **The flip side of easy implementation is that you often sacrifice capability**
  - 8b10b and loose timing really do use up a lot of bandwidth
- **The optical budgeting process was all wrong**
  - The optical budget belongs to the operators, not the vendors
  - The vendors had a poor idea of what real access networks look like
  - The resulting budgets were quite a bit off

IEEE Negative: Narrow scope results in a standard that is incomplete

- **The 802.3 project's scope is limited to the "PHY"**
  - Optics, line coding, and whatever logical shims are needed
- **This prevents work on many issues needed for PON**
  - Dynamic bandwidth allocation
  - Security
  - ONU management
- **The result is a standard that describes just the "engine", and not the automobile**
  - Each operator around the world has had to define their own proprietary standard to fill in the blanks
  - There is no interoperability between Japan, Korea, and Chinese EPON

ITU Positive: A complete system of standards that covers it all

- **The ITU (and its feeder organizations) have a wide mandate to work on whatever subjects are required**
- **The result is a complete standard, describing nearly every requirements and aspect of design of the PON system**
  - Physical layer
  - Protocols
  - Signaling
  - Management
- **A well established scheme to modify and augment the standard means that it can follow the trend of the market and technology**

ITU Negative: Operator-dominated standards can be gold-plated

- **Operators will naturally ask for more capability**
  - It takes discipline not to ask for everything that you've seen in an ECOC paper or in a marketing slide
  - There is a tendency to ask for the perfect system, when in fact "good enough" is much cheaper
- **Examples of this in G-PON include**
  - Support of every legacy service under the sun
  - Tight OLT timing parameters
  - Extended loss budgets
  - Power leveling

ITU Negative: Consensus often creates the “all of the above” standard

- **In ITU, consensus must be achieved**
  - Consensus is defined as the lack of sustained opposition
- **When there is opposition, the most common way to resolve it is to allow options**
  - Everybody gets what they want
- **But, the problem is that the standard then allows more than one solution to a problem**
- **Examples of this in G-PON include**
  - PIN vs. APD
  - Single vs. multiple T-Conts
  - OMCI vs. TR-69

General observation: Market effects

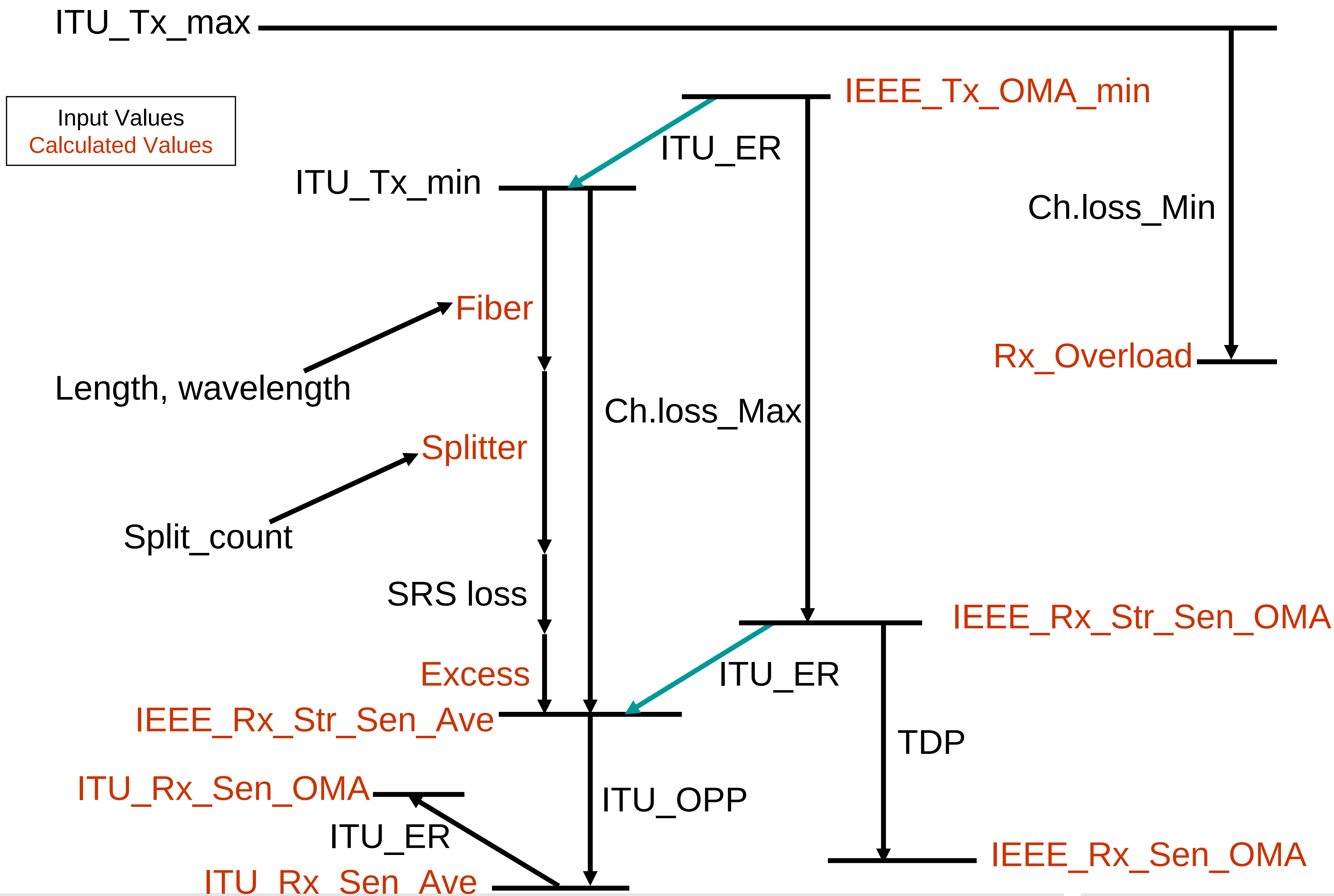
- **In both standards groups, you get "horse races" of technology developing**
  - PIN vs. APD detectors
  - FP vs. DFB lasers
- **The predictions on cost are usually not accurate**
- **They depend on many unstable factors**
  - Will the market take off, or be stuck in neutral
  - Will the vendors be aggressive, or find greener pastures
- **The best approach is probably to allow both options, and let the market truly decide the issue in the future**

Applying the lessons: NG PONs

- **IEEE 10GE-PON: Optics specifications include a high-budget option**
- **ITU XG-PON: Recognition that specifications must be relaxed reasonably**
- **Cooperative approach: The two groups have worked together to complement their efforts**

IEEE 10GE-PON

- **Optics specifications have been completely reworked**
  - Different specification method that relates to the ITU method more directly
  - Different approach where the optical link budget is given (by the operator), not calculated from first principles
  - Different results, including a high budget option of 29 dB that is more in keeping with real deployment
- **This promises to make these specifications much more relevant in the marketplace**



ITU_Tx_max
Input Values
Calculated Values
IEEE_Tx_OMA_min
ITU_ER
ITU_Tx_min
Ch.loss_Min
Fiber
Rx_Overload
Length, wavelength
Ch.loss_Max
Splitter
Split_count
SRS loss
IEEE_Rx_Str_Sen_OMA
Excess
ITU_ER
IEEE_Rx_Str_Sen_Ave
TDP
ITU_Rx_Sen_OMA
ITU_OPP
ITU_ER
IEEE_Rx_Sen_OMA
ITU_Rx_Sen_Ave

ITU XG-PON

- **The design philosophy is more balanced towards achieving economical performance**
  - Relaxed optical timing is allowed (but doing better is possible)
  - Not every last bit of efficiency must be obtained
  - Usable line rates below their “nominal” values
  - Protocol modified to make implementation easier
- **Taken together, all of these work to make XG-PON simpler to implement and cheaper to manufacture**

Cooperative approach

- The two groups have worked together to complement their efforts
- A long stream of liaison communications
- Sharing the same wavelength plan
- Perhaps sharing the same loss budgets
- IEEE providing interfaces to allow ITU functions to tie into the 10GE-PON system
- ITU moving to extend its higher-layer functions (e.g., OMCI)

Cooperation in 10Gb/s PON systems

XG-PON1	10G EPON
In-Band FCAPS: BB-F WT-155 (TR-69 for PON)	
Service Model: BB-F WT-156 (TR-101 for PON)	
Out-of-band FCAPS: OMCI	
X-PON Common functions: DBA, SEC, PLOAM	
XG-PON1 TC TDMA, Act. GEM, FEC	MAC-C: MPCP MAC: Ethernet RS: LLID
XG-PON1 PHY 10G/2.5G	PCS: 64b66b, FEC PMA: Burst mode PMD: Maximal

Thank you!