TDD PHY based upon the FDD Upstream PHY

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Abstract

- Even though the FDD upstream PHY is not yet complete, the TDD PHY should be derived from the FDD upstream PHY to maximize reuse
- The presentation will identify the differences between the TDD PHY and the FDD upstream PHY

Time Windows

- TDD Cycle
  - Downstream Time Window
  - Upstream Time Window
  - Two Guard Times

DS	GT	US	GT

- TDD Cycle Configuration
  - The TDD cycle is configurable [1] and [2]

Upstream PHY

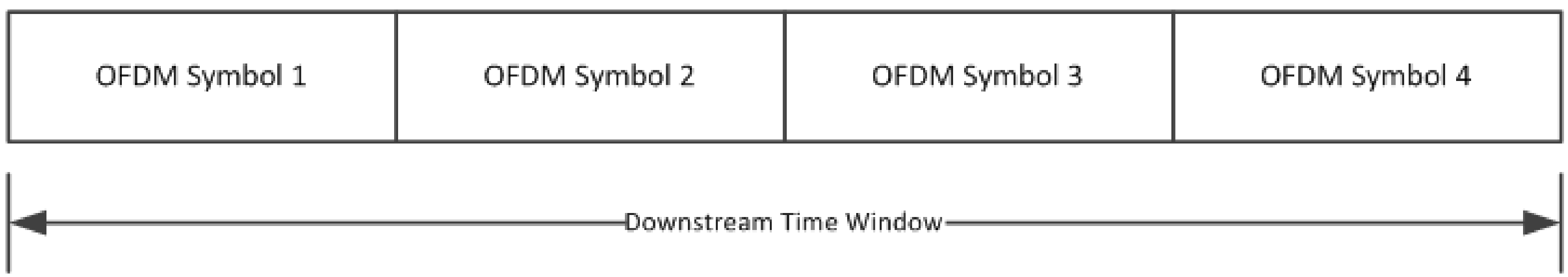
- Upstream Transmission are scheduled by the CLT for TDD just like for FDD
- The CLT must restrict scheduled upstream transmissions to within the upstream time window
  - A statement about this restriction can be added to the standard. Nothing else is required
  - Actual scheduling is outside the scope of the standard
- Upstream PLC transmissions are embedded within upstream data transmissions, just like in FDD
  - No changes required for upstream PLC

Downstream TDD PHY

- Local grant addresses MPCP burst transmission in downstream for TDD [3] [4]
  - In this presentation we address the PHY
- A new downstream data detector is required for TDD [5] and [6]
- The downstream burst last for the duration of the downstream time window [6]
- The downstream time window is designed to be an integer number of OFDM symbols (including CP) [2]
- Therefore, the downstream burst is an integer number of OFDM symbols
  - The value of that integer depends upon the configuration

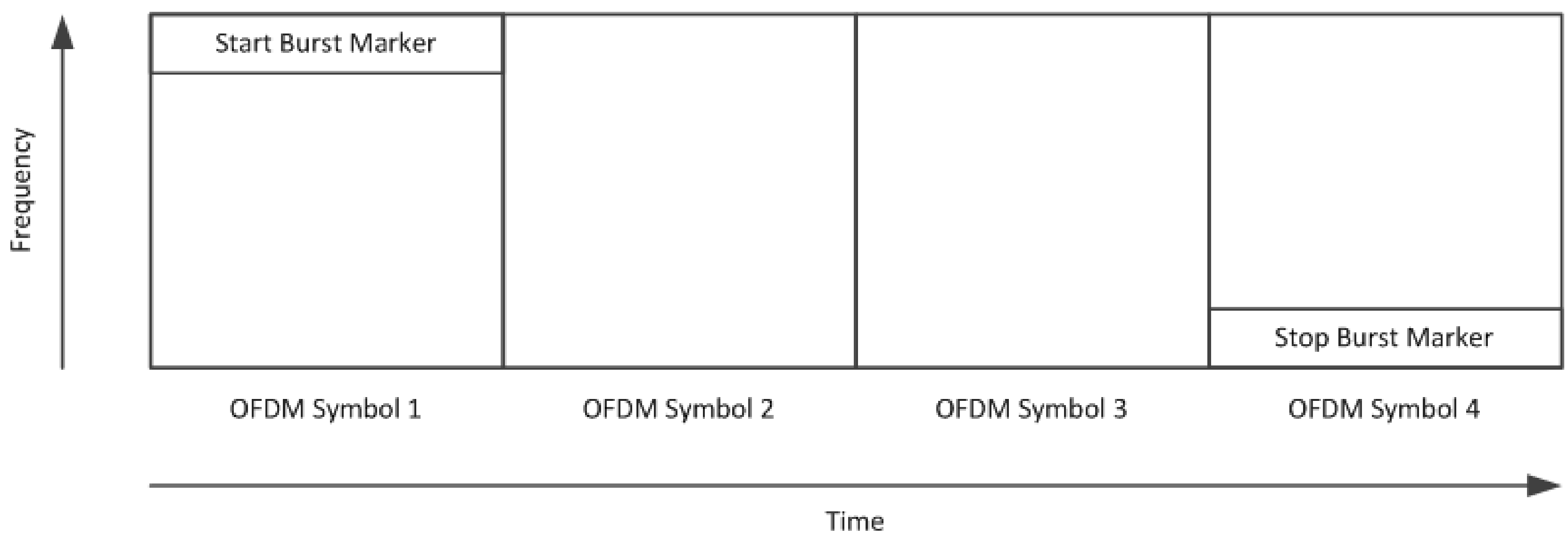
Downstream TDD PHY

- Downstream Burst of *M* OFDM Symbols
  - *M* = 4 in this example



TDD Downstream Burst Marker Locations

- In EPoC a burst begins and ends with burst markers
- Time is mapped to OFDM symbol number and ODFM subcarrier frequency
- Since the burst consists of an integer number of OFDM symbols the burst begins at the "beginning frequency" (highest subcarrier frequency) and ends at the "ending frequency" (lowest subcarrier frequency)



Modulation

- Since TDD may operate in a good channel it is recommended that both TDD downstream and upstream support up to 4096 QAM
  - Previous technical decisions are for up to 4096 QAM in downstream and 1024 QAM in upstream. I believe the intension of this decision was for FDD

FEC

- In September the Task Force adopted TDD FEC codes [7] [8]
- These codes are summarized below

Code Label	Code Rate	Codeword Length (bits)
E	41/46	16560
F	26/30	10800
G	13/15	5400
H	3/4	960

- Downstream
  - The length of downstream burst is several OFDM symbols
  - Recommended that for downstream code E is used
- Upstream
  - Recommended that the TDD upstream use codes E, F, G and H
- Codeword packing needs to be specified (as was done for FDD)

Pilot Structure

- The FDD upstream pilot spacing is designed to handle the many-to-one OFDMA PHY
  - The pilot spacing is configurable
- This FDD upstream should work well for the TDD upstream
- The TDD downstream is a one-to-many PHY and may in some conditions require fewer pilots
  - This is fine since the it is configurable
- The FDD upstream pilot structure should be able to be used in both the TDD downstream and upstream
  - Once details of FDD upstream pilots are fully specified we can review and make sure it will work well for TDD downstream

PLC

- The FDD upstream PLC should work fine for the upstream TDD PLC
- The downstream PLC is being designed to handle gaps in transmissions, so that is being addressed in the PLC ad hoc
  - One item that has been designed for TDD is that the start of frame delimiter (SFD) is placed at the beginning of the downstream time window in TDD [9]
  - Also, of course the PLC sends the values of the TDD cycle to the CNU

Frequency Bands

- In TDD the downstream and upstream operate on the same spectrum, which may be different than for FDD
- The Task Force has decided to specify the following bands for TDD [10]
  - 5 MHz – 277 MHz
  - 750 MHz – 1800 MHz

Conclusions

- Leverage the work of the FDD upstream design
- In TDD downstream
  - Start Marker always at the "beginning" of an OFDM symbol
  - Stop Marker always at he "end" of an OFDM symbol
- Support modulation up to 4096 in both TDD downstream and upstream
- Utilize TDD FEC
- Pilot structure is likely to work unmodified, particularly since pilots are configurable
- PLC ad hoc working to make sure downstream PLC works with time gaps
- Support TDD frequency bands

EPON Protocol over Coax

References

1. Steve Shellhammer, "TDD Cycle", shellhammer_3bn_03_0713, July 2013
2. Task Force Technical Decisions 83 and 84
3. Andrea Garavaglia, garavaglia_3bn_05_0513, May 2013
4. Task Force Technical Decision 52
5. Steve Shellhammer and Andrea Garavaglia, "Data Detector for TDD Downstream," shellhammer_3bn_03_0913, September 2013
6. Task Force Technical Decision 88
7. Christian Pietsch and Stefan Brueck, Performance Analysis of EPoC FEC for Passive Coax Plants, pietsch_3bn_01a_0913, September 2013
8. Task Force Technical Decision 96
9. Nicola Varanese, "PHY Link Channel for EPoC TDD Mode," varanese_3bn_01_0513, May 2013
10. Task Force Technical Decision 90