TECHNOLOGY

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Duplexing Methods for Ethernet Passive Optical Network Over Coax

- FDD or TDD?

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Consideration of Duplexing Methods for EPOC

- It has been suggested that EPOC may use TDD as an option because:
  - **WiMax has TDD as an option**
  - **LTE supports TDD mode as an option**
  - **HiNOC usesTDD**
- Whether EPOC should adopt TDD should not be based on WiMax, LTE or HiNOC
  - **WiMax, LTE and HiNOC accept TDD for their own good reasons**
  - **Whether those reasons apply to EPOC is still a question**
- Considerations of duplexing methods for EPOC should be based on the intrinsic factors of EPOC
  - **Characteristics of coaxial cable; HFC out plants and EPON protocols**
- Let’s first looks into why wireless adapts TDD as an option

General Considerations of Duplexing Methods

- **Duplexing methods:**
  - **Full duplex - Frequency Division Duplexing (FDD)**
  - **Half duplex - Time Division Duplexing (TDD)**

- **Spectrum Considerations:**
  - **For a given throughput FDD and TDD require similar amount of spectrum**
  - **Advantage of TDD: easier to find a single channel of unsigned frequency band**

- **Transmission Delay:**
  - **Transmission delay depends on frame lengths (applies to FDD & TDD); TDD introduces another factor - burst length**
  - **TDD introduces additional Duplexing Delay; duplexing delay affects delay sensitive services**
    - **Duplexing delay depends on both frames lengths and burst lengths**
    - **Duplexing delay in EPOC also depends on EPON scheduling protocol and DBA - more complicated than that of wireless and HiNOC**
  - **Large cable echo delay (3-7 us) results in longer OFDM symbol time (could 200us - 400us):**
    - **Larger OFDM frame size and larger TDD cycle**

General Considerations of Duplexing Methods

- Channel reciprocity
  - A TDD channel receives from the same transmission channel, therefore only needs to measure the channel once
    - only needs one antenna
  - FDD receives and transmits in two channels; needs to do channel measurement twice
    - Transmission and receiving antennas may be different; especially if one is in a higher band and the other in a lower band. This creates a problem for antenna design especially for handsets
  - Channel reciprocity is another big advantage for wireless, but does not apply to EPOC
- Implementation considerations - complexity: For a given amount of throughput:
  - A TDD system needs two times the bandwidth than that of a FDD system for symmetrical services
  - Significantly increase system and CPE cost
    - Requires two times as many transmitters and receivers

General Considerations of Duplexing Methods

- **CPE transmit power: A TDD system needs more upstream transmission power to support two times total BW (than FDD)**
  - **A typical DOCSIS 3.0 cable modem transmits upstream at max power 57 dBmV in a 6.4 MHz channel for QAM64**
  - **The DS/US ratio can be changed but the CPE transmitter/amplifier must be sized for the total channel BW available.**
  - **There is an increase in transmission power due the increased channel BW.**
    - **10 * log (Channel BW / Channel Width)**
    - **For a 600 MHz channel this results in a 20dB increase in RF power to maintain the same power within a 6 MHz channel compared to currently deployed CPE's.**
  - **Compare with FDD, TDD transmission power increase by: 10*log((US+DS)/US)**
    - **For symmetric 3 Gb/s DS and 3 Gb/s US, TDD transmitter power increase by 3 dB**
    - **For asymmetric 5Gb/s DS and 1 Gb/s US, TDD transmitter power increase by 7.8 dB**
  - **This has a significant impact on the maximum power of the upstream CPE amplifier**

Summary: Advantages and Disadvantages of TDD

- **Advantages of TDD**
  - **Easier to find a single unassigned frequency band for transmission and reception**
    - **A big advantage for wireless**
    - **Some advantage for coax**
  - **Channel reciprocity**
    - **A advantage for wireless**
    - **Does not apply for EPOC**
  - **Dynamic upstream and downstream time assignment**
    - **An advantage for wireless**
    - **Dynamic US/DS does not work with EPON protocol**
- **Disadvantages of TDD**
  - **Introduces extra duplexing delay; affects delay sensitive services**
  - **Needs 2X bandwidth compare with that of FDD for the same amount of throughput**
  - **Implementation complexity**
  - **High power consumptions**

Summary: Advantages and Disadvantages of TDD

- **For wireless the advantages of TDD are significant enough to have TDD as an option**
- **For EPOC, most of the TDD advantages may not apply**
- **On the other hand, the disadvantages of TDD for EPOC are significant**
- **Whether TDD works with EPON protocol is still a question**
  - Additional duplexing delay may break the EPON protocol

Thanks