EPoC UPSTREAM – SYMBOL MAPPER OVERVIEW

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OVERVIEW

CNU Transmitter

- **The Symbol Mapper maintains the timing for placement of 1D to 2D data in the upstream Superframe**
- **The primary function of the Symbol Mapper is to:**
  - “Package” a burst into the Superframe structure
  - Transfer Resource Block frames (column) to the Interleaver function
- **The Symbol Mapper is one of two primary processes at any given time:**
  - Idle – “walking” through the data carrying Resource Elements, bit by bit, at the rate specified by *US_DataRate*. Null RB’s (turned off) in columns are transferred to the Interleaver and IFFT; i.e., “shooting blanks” while idling
    - All CNUs are synchronized for Superframe alignment, therefore all CNUs will “walk” the Superframe identically. See *100.2.6.2 US_DataRate.*
    - Note: passing null values to the IFFT produces no energy for that RE, RB
  - Fill – upon arrival of a burst across the PMA Service Interface, the Symbol Mapper will begin at the current “walk point” and will “turn on” RBs, i.e., placing non-null IFFT data: P and L pilots, start/end markers, and burst data
    - Note: while pilot placement follows the pilot map for the Superframe, pilot RE’s are only encoded with non-null IFFT data when the RB is “turned on”

BURST IDENTIFICATION OVERVIEW

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- **The data is a MPCP-scheduled burst and passed across the PMA Service Interface from the PMA Client (aka PCS).**
  - Bursts arrive at the PMA Service Interface based on EPON (MPCP) schedule timing
    - The Symbol Mapper has no pre-knowledge of future events
    - Likewise, MPCP and PCS have no pre-knowledge of PMA framing and timing
  - The Symbol Mapper reacts to a burst of data arriving at the PMA Service Interface
    - Bursts are identified by a stream of data bits, start of burst bit indicator, and end of burst bit indicator (See PMA Service Interface)
  - At the start of a burst
    - The “fill” position in the Superframe is known, a Start Burst Marker is placed
  - While filling, the Symbol Mapper allocates bits from the burst according to the configured bit loading of each available Resource Element and Low Density pilot
  - At the end of a burst, a Stop Burst Marker is placed and the last bit placement of the burst is encoded

TWO PROBLEMS HAVE BEEN FOUND

- **There are two problems (short comings) with the current upstream Stop Burst Marker approach:**
  1. The length of a burst is not known by the Symbol Mapper until burstEnd is signaled across the PMA Service Interface. The last bit of a burst could be on any mapped bit in a QAM symbol, in any Resource Element of the last-used data Resource Block.
     - Example: for 1024-QAM, the burst could end on bit 1 or bit 10:
       - “Last” QAM symbol could be in RE 1 through 8 or 16 of the Resource Block
       - The planned rotation sequence is not sufficient to cover all the above permutations: e.g. the 11 burst marker patterns in subclause 101.4.4.8.4 falls short of the needed 160 bit positions for 1024-QAM
     - The CLT receiver needs to reliably and unambiguously know the last bit of the burst during symbol de-mapping.
       - There should be no algorithms for “guessing”, needs to be clear
       - Simply padding out to the end of the RB doesn’t tell the last valid bit
  2. Trying to fill data RE’s within and around the current End Burst Marker is problematic
     - Requires that complicated special buffering, back tracking, and marker positioning need be described in the standard
     - This complication needs to be completely avoided
- **This presentation assumes that the above two problems will be addressed by the Task Force and updated burst markers will be adopted.**

FILLING OVERVIEW

- **The start of a burst can occur in any Resource Block**
  - More details on this later
- **Filling of burst data always begins in the first data Resource Element with the MSB that will be used to fill the QAM symbol**
  - The MSB bit position is set to the bit loading for the RE or LD, creating a fill word of length equal to the bit loading.
  - When the fill word has been filled, the value is mapped to the appropriate I_value and Q_value bin values for the symbol. See QAM mapping 101.4.5.
- **During filling, a burst will continue to the next available RB**
  - Might be on the other side of an exclusion
  - May “wrap” to the next Resource Block frame (column)
    - Could be in the next Superframe

FILLING OVERVIEW EXAMPLE, RB LENGTH = 8

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This is only an example to illustrate key items. Pilot Map / placement assumed.

- **New Burst Arrives:**
  - Walk Point was in RB Frame 1, Sub + 8
    - START_FILL(Sub + 8)
  - Start Burst Marker placed, starting Sub + 8
  - Data fill starts at Sub + 10, RB 1
    - Continues across Exclusion Band(s) and wraps to next RB Frame
  - End of burst was detected while filling RB Frame 2, Sub +1, RB 4, with bit position in QAM symbol known
    - RB number (LRB) and bit position (LBIT) recorded
    - Padding (0's through scrambler) in all remaining data bits to end of RB
  - End Burst Maker placed with encoding
    - Place_End_Marker(Sub+2, LRB, LBIT)
  - Return to Idle

Legend	
S	RBs containing Start Burst Marker
E	RBs containing End Burst Marker
F	First data carrying RE, aligned to MSB
D	Energy carrying RE's, may be P pilot, L pilot, or data
L	RE containing last bit of burst
P	REs containing all padding
<blank>	Null encoded, no energy by IFFT

Subcarriers **<- RB Frame 1 ->** **<- RB Frame 2 ->**

Subcarriers	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Sub + X +6	D	D	D	D	D	D	D	D								
Sub + X +5	D	D	D	D	D	D	D	D								
Sub + X +4	D	D	D	D	D	D	D	D								
Sub + X +3	D	D	D	D	D	D	D	D								
Sub + X +2	D	D	D	D	D	D	D	D								
Sub + X +1	D	D	D	D	D	D	D	D								
Exclusion Band (Width X subcarriers)																
Sub +11	D	D	D	D	D	D	D	D								
Sub +10	F	D	D	D	D	D	D	D								
Sub +9	S	S	S	S	S	S	S	S								
Sub +8	S	S	S	S	S	S	S	S								
Sub +7																
Sub +6																
Sub +5																
Sub +4																
Sub +3									E	E	E	E	E	E	E	E
Sub +2									E	E	E	E	E	E	E	E
Sub +1									D	D	D	L	P	P	P	P
Sub									D	D	D	D	D	D	D	D

Time ->

EXAMPLE CONTINUED

- **Some fine points:**
  - While primary in IDLE or in FILL process, when the Symbol Mapper transitions from one RB Frame (column) to another, the current RB Frame is passed to the Interleaver, and another RB Frame is allocated (e.g., think of an empty 3-dimensional array, 8 or 16 by 4096 by I/Q bin values)
    - The RB length (8 or 16 symbols) corresponds to the Interleaver depth
  - The Symbol Mapper converts bit data to I and Q bin values before moving to the next Resource Element. The I and Q bin values are consistent with the bit loading for the RB, as well as consideration for L pilot encoding, as per *101.4.5.3 Constellation structure and mapping of 2^{2n}–QAM* and *101.4.5.4 Constellation structure and mapping of 2^{2n+1}–QAM (n>0).*
  - REs marked as P pilots in the pilot map are skipped for data filling
    - P pilots are placed by the Pilot Insertion function.
  - Start and End Burst Markers overwrite the pilot map (take precedence over) when placed. Specifically, if the pilot map indicated that the RB was a Type 1 or Type 2 pilot placement, the Marker encoding takes precedence.
  - Start or End Burst Markers may straddle exclusion bands, RB Frames (or Superframes)
  - Burst overhead calculations by the DBA/MPCP must include Start and End burst marker overheads
  - Due to placement of start and end burst markers, as well as first and end RB alignment, there will always be some jitter introduced that must be corrected using a PCS timestamp for the beginning of the burst

EXAMPLE CONTINUED

- **More fine points:**
  - The scrambler will be moved from the PCS to the Symbol Mapper, similar to downstream
  - The IDLE process state machine of the Symbol Mapper is clocked at *US_DataRate.*
    - This insures 1D to 2D timing as well as transferring RB Frames at the Interleaver and IFFT “pipeline” rate to meeting on-the-wire timing requirements of the SuperFrame timing.
  - Note that the IDLE process does no writing to the RB Frame as the specification will be defined that the RB Frame array, when allocated, contains all null values
  - For the specification, the FILL state “returns” to the IDLE state on completion.
    - The IDLE state machines continues to “walk” while FILL is in progress
    - Due to placement of added start and end burst markers (placed at implementation rate) and start and end of the burst data burst (received across the PMA Service Interface at *US_DataRate)* and any added padding (placed at implementation rate), the current “walk” point will still be “inside the burst” on return
      - Since the IDLE state does no writing, there will be no usage collisions
      - While in FILL, the IDLE state does not transfer RB Frames to the Interleaver
      - There is an edge condition when the FILL state moves to the next RB frame and on return the IDLE is still walking the end of the previous RB Frame. Some state coordination will be supplied to handle avoiding duplication of transferring the same previous RB Frame to the interleaver. This can be handled in a number of ways.

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and more fine points for MPCP / DBA scheduling

- **1 RB Minimum gap time between bursts from different CNUs**
  - Greater than the TQs for one Type 0 RB at the highest bit loading in the Superframe, based on the *US_DataRate*. Example:
    - Highest bit loading: 10 bits, RB size = 16 , Bits per RB = 160
    - From laubach_3bn_15_0914.xlsx, for 3800 subcarriers at 10 bits per symbol, with 4.4% pilot overhead, *US_DataRate* is 1,734,465,190.169 bps
    - RB time = 0.0000000922 (sec)
    - TQs = 5.76546595266, use the ceiling, so is 6 minimum TQ gap time
    - For 24 MHz @ Bits per RB = 96 (16x6), ceiling(TQs) = 47 TQ gap time
- **Minimum gap time between different bursts from same CNU**
  - With assumption that MPCP has already included the start and stop burst marker overhead in individual grant times
  - 1RB minimum TQ gap time sufficient for non-overlapping bursts
  - Any overlapping grants creating a larger concatenated burst should be ok

DETAILS OVERVIEW

- **Work in progress:**
  - laubach_3bn_06_0115.pdf

PROPOSED MOTION

- **Move to adopt laubach_3bn_06_0115.pdf as the baseline starting point for the upstream symbol mapper. Complete draft text for consideration at the March 2015 meeting.**

Thank you