Grant Spacing Signaling at the ONU

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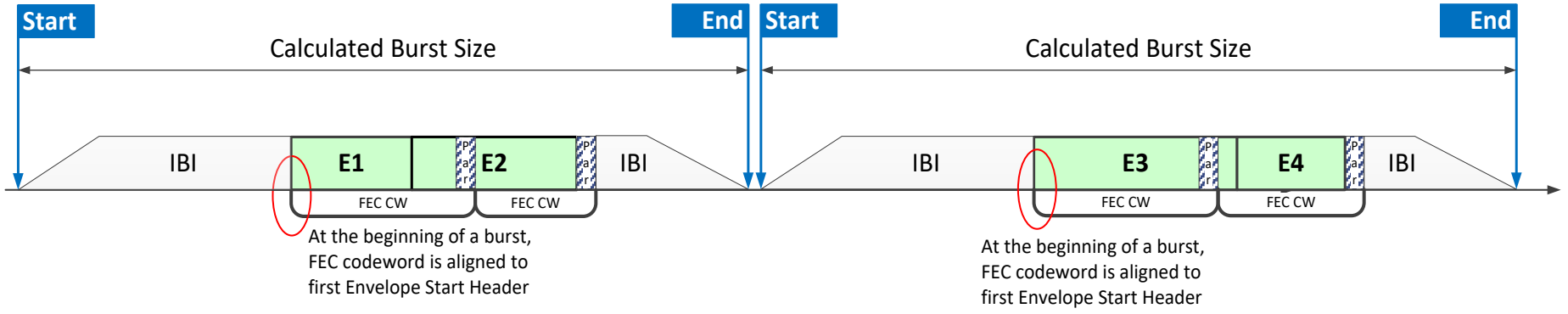
Total Burst Size

- In 802.3ca, the OLT GATE message conveys only the payload length of the burst, not the total length with the optical overhead.
- To be able to schedule consecutive bursts, the DBA at the OLT should be able to calculate the total burst time, including the FEC and optical overheads.
- To allow the deterministic calculation, the beginning of the first envelope in a burst is always aligned to the beginning of the first FEC codeword in this burst. With such alignment, the OLT can calculate the exact total burst size.
- Knowing the total burst size, the OLT DBA can schedule bursts back to back.

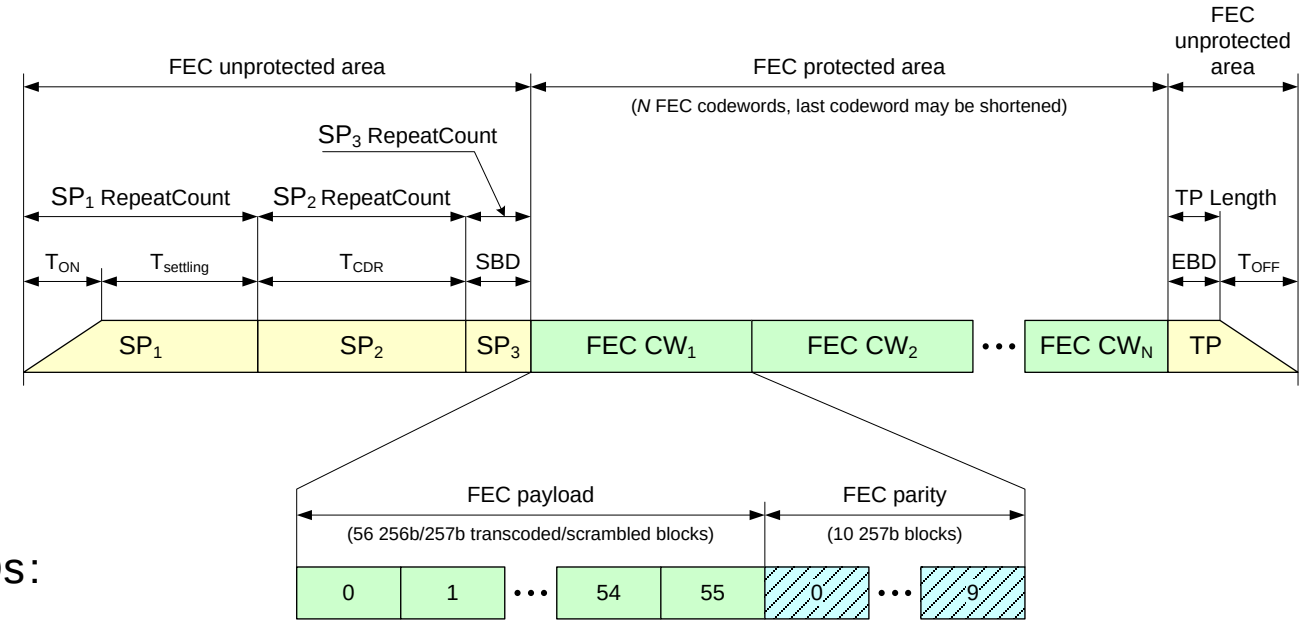


Total Burst Size Calculation

Given:

- ***L*** – total sum of granted envelope lengths (in EQ):

$$L = \sum_{i=0}^{N} env_length_i$$



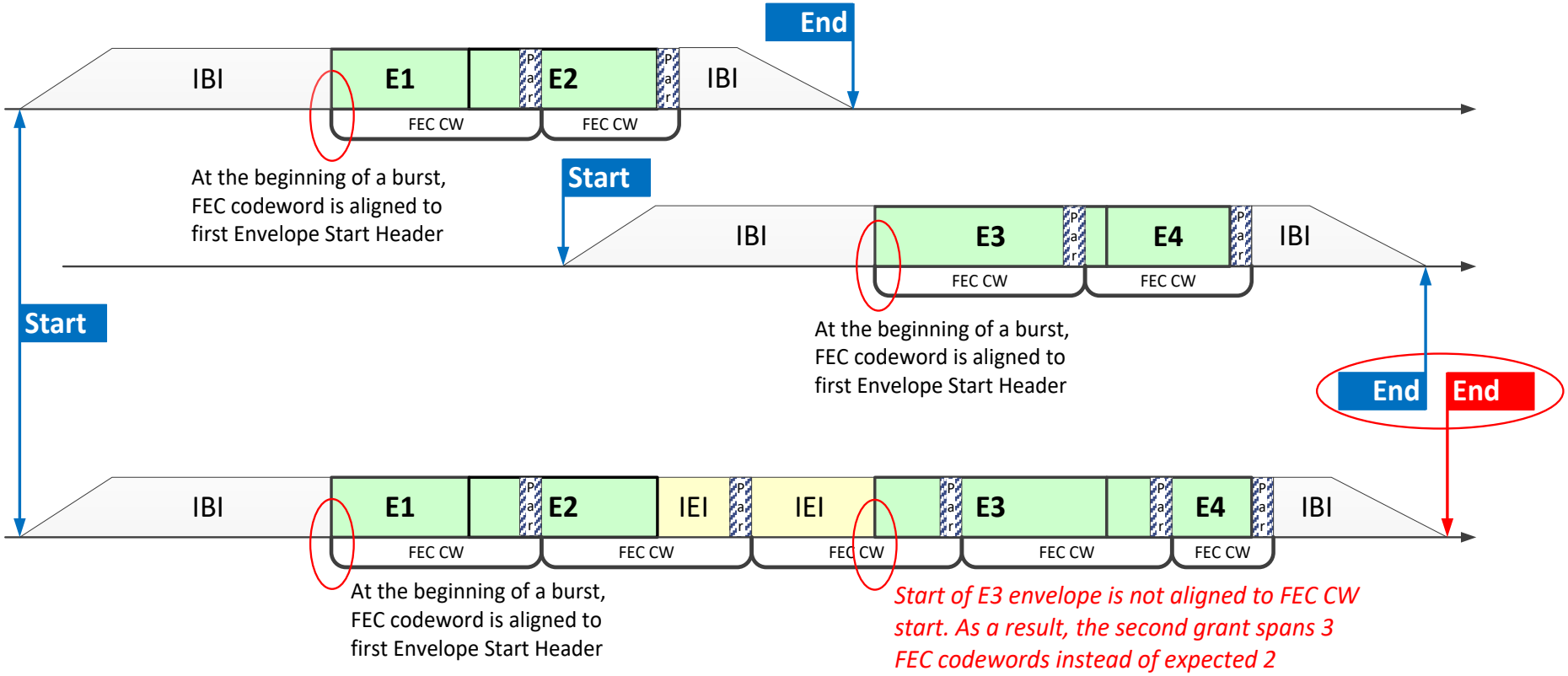
Calculations:

1. Number of 257b blocks taken by ***L*** EQs: $P = \lceil L/4 \rceil$
2. Number of FEC codewords (including possible shortened last codeword): $N = \lceil P/56 \rceil$
3. Total number of 257b blocks taken by all FEC codewords: $M = P + N \times 10$
4. Burst size (in 257b blocks): $S = SP1_Count + SP2_Count + SP3_Count + M + TP_Length + [Toff]$

- To convert S into the number of EQ times (2.56ns): $S_{EQ} = \lceil S \times 257 / 66 \rceil$
- To convert S into ns: $S_{ns} = \lceil S \times 8224 / 825 \rceil$

Overlapping Grants to the same ONU

- Bad things happen if the OLT grants two overlapping bursts (i.e., Burst #2 StartTime < Burst #1 EndTime)



- Start of E3 envelope (second burst) is not aligned to FEC CW start. As a result, in this example, the second grant spans 3 FEC codewords instead of the expected 2. This causes the end of the combined burst expand past the expected end time by one full parity region (10x257b blocks or ~100 ns)

To concatenate the grants or not?

- Grant concatenation capability was somewhat important in 10G-EPON because every LLID was granted independently, even if they were in the same ONU. This caused a very significant increase in optical overhead.
- In 802.3ca, the grant is given to an entire ONU and is expected to include multiple LLIDs. There are fewer bursts needed per unit of time, and correspondingly, much smaller levels of optical overhead.
- Current version of MPRS in D1.0 prevents two separate grants from being joined into a single burst (except for some rare corner cases).
  - OLT better not schedule the upstream transmission this way, but the DBA/scheduler is out-of-scope
  - Instead, per D1.0, the ONU is required to ignore/discard the grants that may not get aligned to start of FEC codeword due to being concatenated with the previous grant.

Current Solution

- Current version of MPRS/MPCP in D1.0 prevents two separate grants from joining into a single burst.
- This functionality was achieved in a somewhat convoluted way
  - Every time MPRS Input SD doesn't have an active envelope, it asks MPCP for one using MPRS_CTRL.indication(X) primitive, where argument X represents the space (in EQs) left in the current FEC codeword.
  - MPCP Envelope Activation SD would process such indications and occasionally issue a request to start an envelope.
  - If the new envelope is a continuation of existing burst, it can start immediately when MPRS asked for it, regardless of the value of X.
  - But if the next envelope starts a new burst (i.e., a different StartTime than in the previous envelope), then MPCP issues the request only if this indication coincides with the beginning of FEC codeword (i.e., if X = FEC_CW_SIZE). This ensures that start of every burst payload is aligned with start of a FEC codeword.

Why to change it

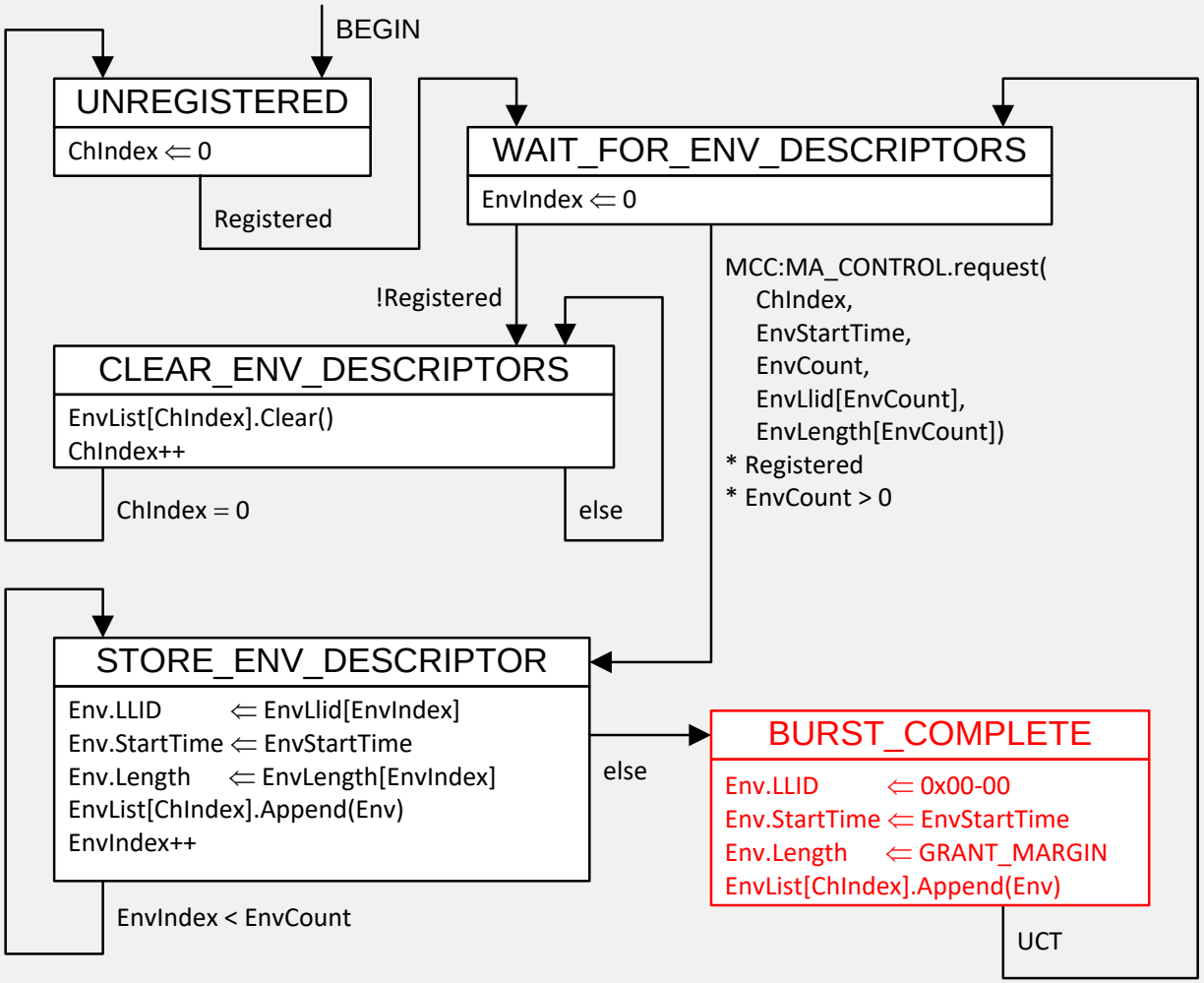
- Current solution required MPRS Input SD and MPCP Envelope Activation SD to be FEC aware and to track the space remaining in current FEC codeword.
- MPRS Input SD was not able to detect and signal PCS when a burst ended until after a long gap elapsed since the end of the last envelope.
- The PCS had to detect the end of burst on its own by adding a deep look-ahead buffer, that contributed to the internal ONU's delay.
- All of this can be done in a more streamlined way by allowing MPCP to signal MPRS when the burst has ended.

How to make this work?

- The changes are quite simple:
- **MPCP Envelope Commitment process**
  - Responsible for queueing envelope descriptors for later activation.
  - **Change:** after enqueueing all envelope descriptors for one burst, add one special Terminating Envelope Descriptor (TED)
    - LLID = 0
    - Length = GRANT_MARGIN (GRANT_MARGIN = Parity + EBD + Ton + SP1 + SP2 + SP3)
- **MPCP Envelope Activation Process**
  - Responsible for sending a new envelope descriptor to the MPRS when MPRS asks for it and if the time is right.
  - **Change:** SD became simpler, since it doesn't need to track the FEC codeword offset in the MPRS to find out whether a new burst can or cannot start at a given time.
- **MPRS Input Process**
  - A key process responsible for sourcing EQs from proper MACs based on envelope descriptors from the MPCP.
  - **Change:** Added an additional state to process TEDs. Details are on slide #13. The process doesn't need to be FEC-aware.

MPCP Envelope Commitment SD

- Special Terminating Envelope Descriptor (TED) is inserted in pending envelope queue after committing all the envelopes for a given burst (all envelopes with the same start time)
- In the OLT, a TED never gets inserted, so a “downstream burst” never terminates.
- The Envelope Activation SD and all of MPRS SDs can remain identical in the OLT and ONUs.



Changes to Envelope Activation SD

- Don't need to be aware of FEC CW alignment
  - No need to receive FecOffset from MPRS
- Don't need to keep track of StartTime of previous envelope
- Simpler transition into ACTIVATE_ENVELOPE state.

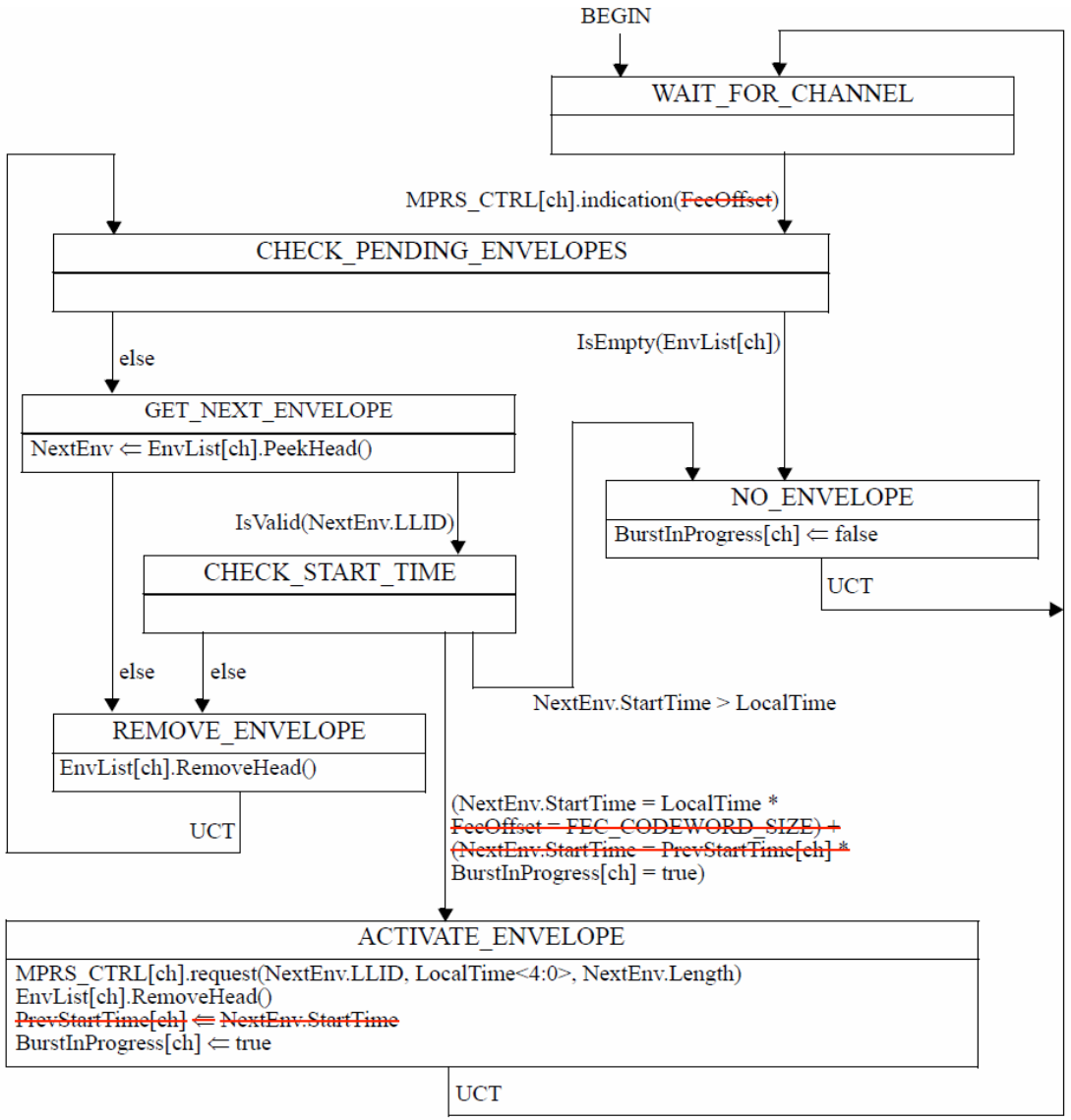
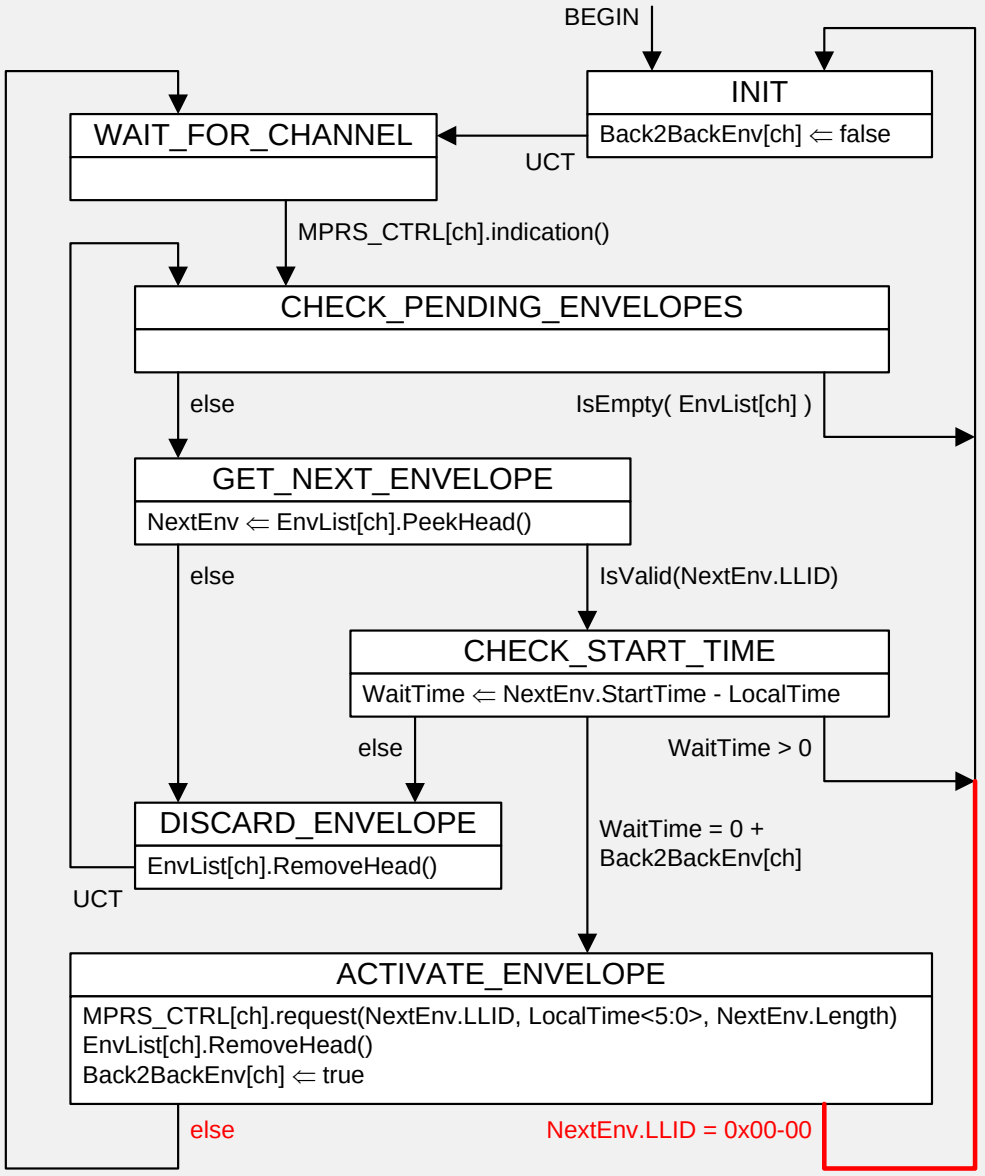


Figure 144–16—Envelope Activation Process state diagram

New Envelope Activation SD

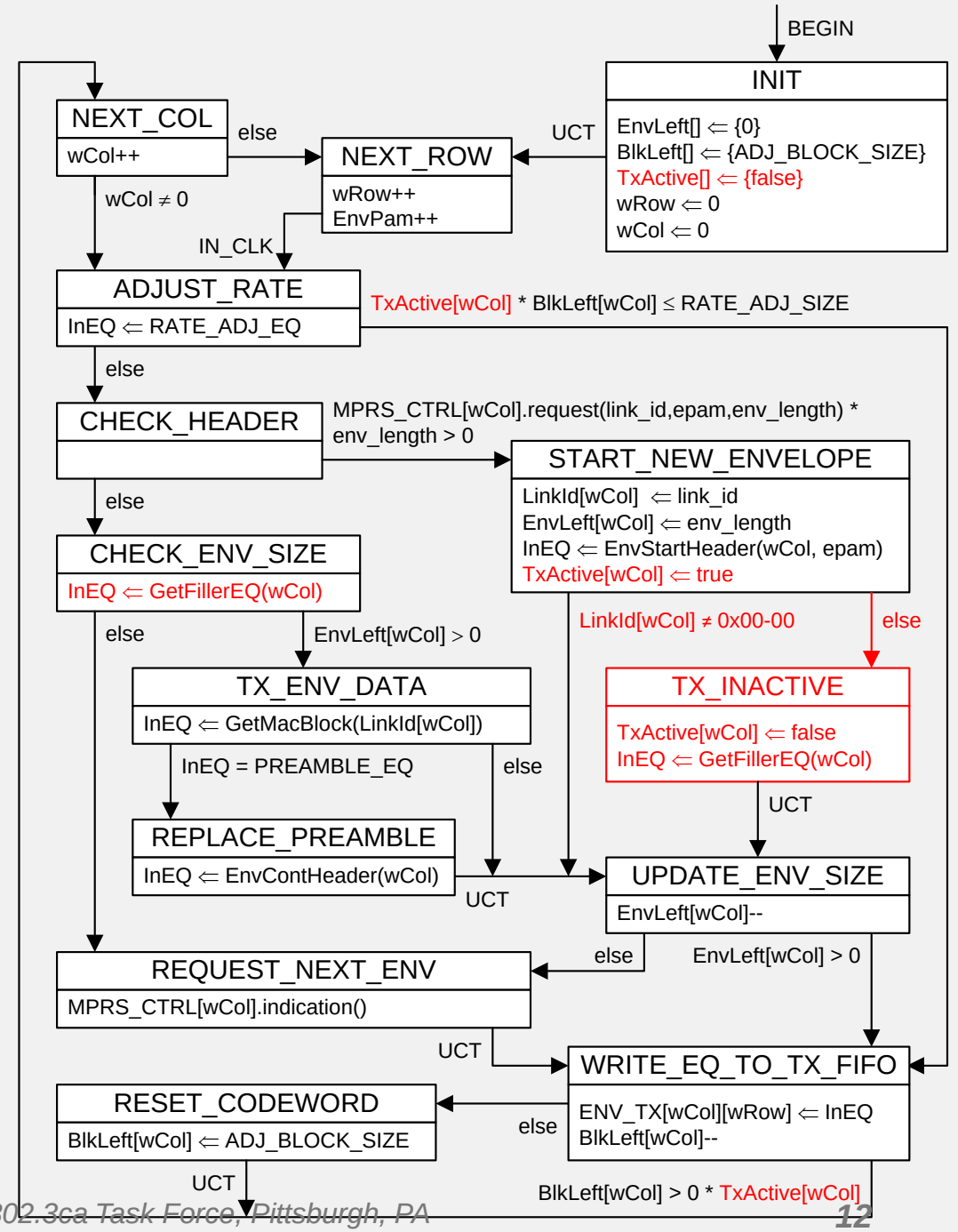
- The same SD is used in the OLT and ONUs
- Added transition from ACTIVATE_ENVELOPE TO INIT to explicitly signal the end of burst, so that the next burst can only start when its *StartTime == LocalTime*

(non-essential changes are not shown)



MPRS Input SD

- Added state TX_INACTIVE to process TEDs
- **New behavior**: When TED is received, MPRS Input Process starts generating Inter-Burst Idles (IBI_EQ) toward the 25GMII and it does not ask MPCP for a new envelope until the envelope length worth of IBI_EQ is generated.
- Another (non-essential) change is to rename FEC-related constants (MPRS as a layer does not need to be FEC aware, but instead should be capable of rate adjustment.)
  - PARITY_PLACEHLDR → RATE_ADJ_EQ
  - FEC_CW_SIZE → ADJ_BLOCK_SIZE
  - FEC_PARITY_SIZE → RATE_ADJ_SIZE



Functions

- **New**

```
EQ GetFillerEQ( wCol )
{
    if( TxActive[wCol] )
        return IEI_EQ; //Inter-Envelope Idle
    else
        return IBI_EQ; //Inter-Burst Idle
}
```

- **Modified**

```
EQ GetMacBlock(link_id)
{
    EQ eq;

    if( link_id == 0x00-00 )
        return IBI_EQ;    // Inter-burst Idle

    for( octet_index = 0; octet_index < 8, octet_index++ )
    {
        … // as in D1.0
    }
    return eq;
}
```

Summary (1/2)

- Burst spacing is a function of DBA/scheduler, which is out-of-scope for 802.3ca. We can have informative text explaining that burst spacing should be at least GRANT_MARGIN. But the formal enforcement is done by the ONU MPCP/MPRS processes (in scope).

- Simple changes to MPCP to insert Terminating Envelope Descriptors (TED) at the end of each received grant.

- Simple changes to MPRS to process TEDs and to generate "Inter-Burst-Idle" codes between bursts
  - Introduction of Inter-Burst-Idles also tremendously simplified the PCS state diagrams (see remein_3ca_3_0518.pdf)

Summary (2/2)

- The differences in the OLT and ONU behavior are confined to the MPCP layer.
- MPRS and PCS state diagrams still remain identical between the OLT and ONUs. Only in the OLT...
  - MPCP Envelope Commitment SD at the OLT never generates TED
  - As a result, OLT MPRS never inserts IBI_EQ
  - As a result, OLT PCS never turns the laser off.

Motion #x

- Accept state diagrams and function definitions as presented on slides 9-13 of Kramer_3ca_2_0518.pdf.

Thank You