MPRS with preamble replacement

Toward a more proficient 100G-EPON

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Version: V2.0(Jan 2017)

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Outline

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- **Comparison & Contrast**
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  - OLT high level block diagram
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  - MPRS_CTRL Primitives

Note: this presentation is a modification of remein_3ca_1_1116, changes are noted.

A slightly different set of problems

- **Traffic patterns are different from US**
  - Traffic for ONUs does not come to the OLT grouped by ONU
    - Frames for specific ONUs/LLIDs are interspersed
  - Ideally the OLT should not require large buffers to artificially group ONU traffic to emulate US envelopes
    - DS envelopes should be able to transport a single frame without excessive overhead.
- **We have a challenging optical budget**
  - We will likely need a better (less efficient) FEC to close the budget
  - It would be nice if we could offset this efficiency loss; there are several areas we could potentially recover capacity
    - 64B/66B line code imposes a 3% overhead
    - IPG (12B) imposes an overhead of 18.75% to < 0.8% (frame length dependent)

Proposed solution

- **Enhance the envelope header solution adopted for US to solve DS problems**
  - Maintain LLID, EPAM, & Length(with modification) fields as in US
  - Each Frame Start marks the beginning of an Envelope
    - New Envelope Header replaces Preamble (no loss of efficiency)
    - Allows flexible traffic distribution to ONUs consistent with frame arrival and higher layer QoS
  - ~~Header IDs end of frame location by channel & byte within last EQ~~
- **Improve transmission efficiency**
  - Eliminate 64B/66B line code – Switch to 128B/129B (0.78% overhead vs 3.13%)
  - Minimize IPG – maximum of 8 bytes (including /T/ control code)
- **Retain MII control codes to ID FEC replacement opportunity**
  - NO_ENVELOPE_CODE not needed for DS
  - ~~IDLE code is replaced with well know data pattern~~
  - ~~Start and Terminate codes replaced with pointers (works well in other systems)~~

Comparison & Contrast

NEW

San Antonio[1]

- **Eliminated line code**
  - Used pointers
- **Header included pointers to:**
  - End of Frame channel ID (TC)
  - End of Frame byte ID (REM)
- **Header padding 9 bits**
  - Byte 3 – bits 3-8
  - Byte 4 – bits 6-8
- **Minimize IPG**
- **Minimum overhead**

Huntington Beach[2]

- **Include line code**
  - delineate control codes / data
- **Eliminated added pointers**
  - Used line code & control codes as is more traditional in IEEE
- **Header padding 6 bits**
  - Byte 4 – bit 6
  - Byte 6 – bits 4-8
- **Minimize IPG**
- **Low overhead**

1) remein_3ca_1_1116.pdf

2) This presentation

Examples of Envelope Header functionality

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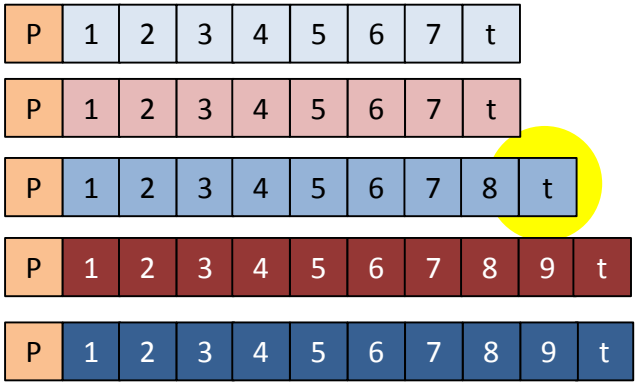
Example Transmission Order



Fm 1 - 66B, 8.250 EQ

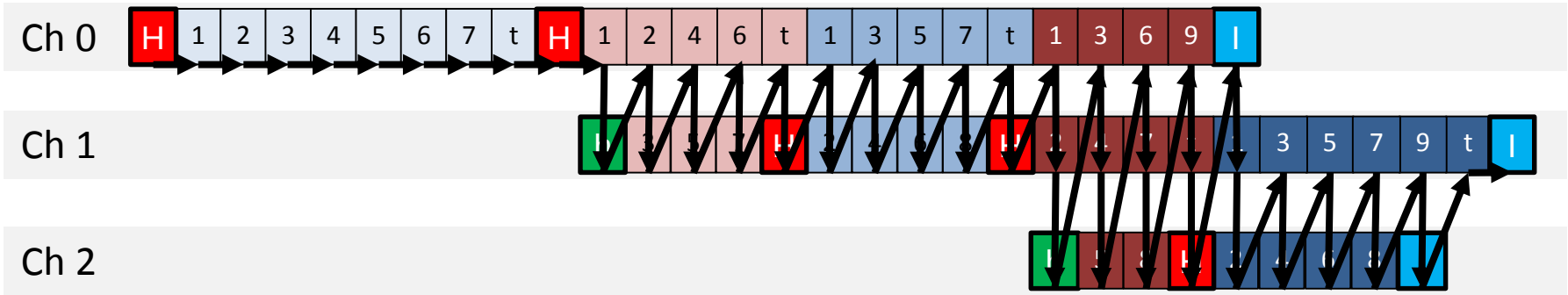
Fm 2 - 71B, 8.875 EQ

Fm 3 - 72B, 9.000 EQ†

Fm 4 - 79B, 9.875 EQ

Fm 5 - 73B, 9.125 EQ

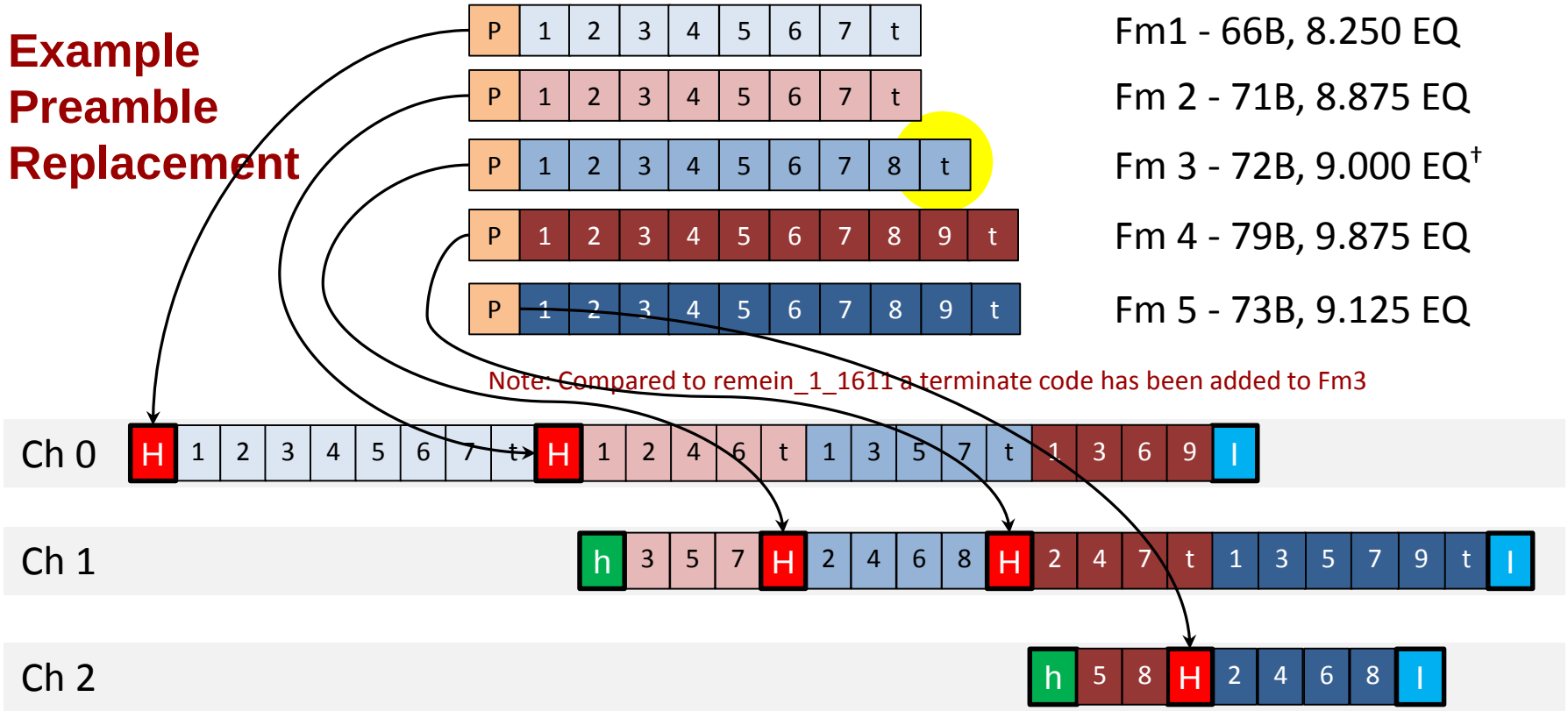
Note: Compared to remein_1_1611 a terminate code has been added to Fm3



- P — Frame Preamble
- t — EQ with /T/ control code
- H — Header of a new Frame
- h — Header of a continuing Frame
- I — Header of nothing (Idle)

Transmission order is similar to that in US – ch0 to ch3. An envelope can begin anywhere in a frame but a frame start always marks the beginning of an envelope.

Example Preamble Replacement

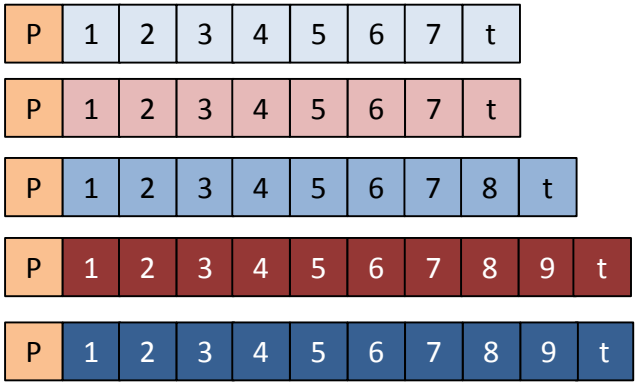


- P — Frame Preamble
- t — EQ with /T/ control code
- H — Header of a new Frame
- h — Header of a continuing Frame
- I — Header of nothing (Idle)

Each Frame Preamble is replaced with an Envelope Header

NEW

Example
Use in Upstream



Fm1 - 66B, 8.250 EQ

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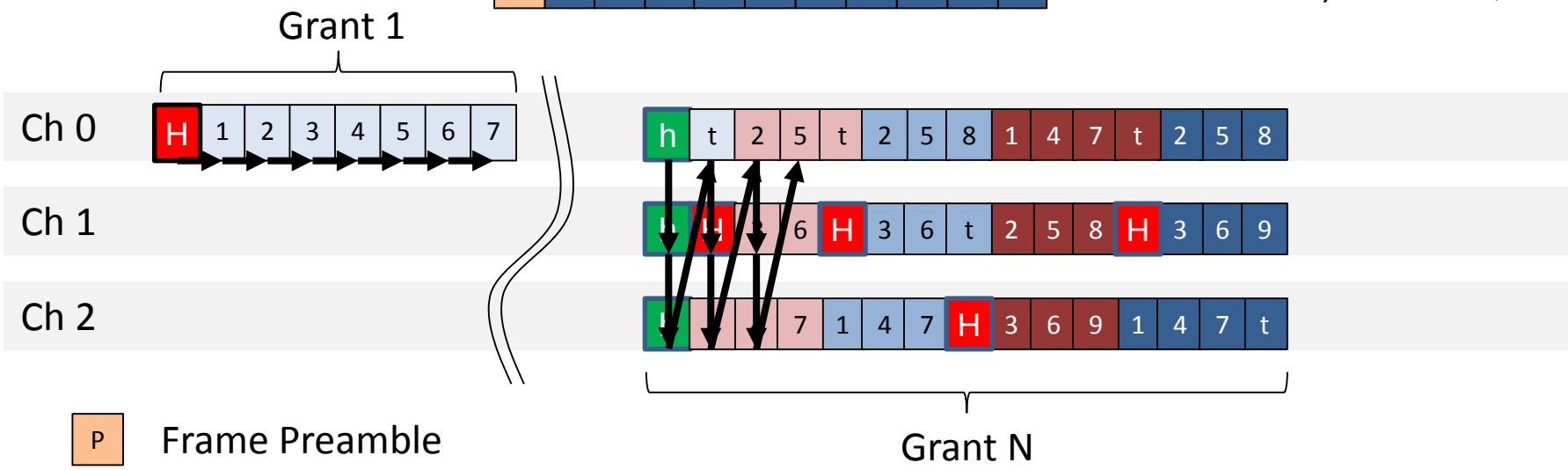

- P — Frame Preamble
- t — EQ with /T/ control code
- H — Header of a new Frame
- h — Header of a continuing Frame
- I — Header of nothing (Idle)

Preamble replacement can work just as well in the upstream direction with some slight improvement in efficiency. However the driver is downstream performance improvement, where data capacity is more important.

Details

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Header “Rules”

NEW

- **Every Preamble is replaced with a header**
  - header and preamble are the same size so this has zero overhead
- **When a channel is switched from one LLID to a different LLID it must include a header (stated another way, the first transmission of an LLID in a channel must be a header)**
  - Can be a Preamble replacement (i.e., zero overhead)
  - Can be a continuation header (i.e., 8 bytes of overhead added)

Envelope Header

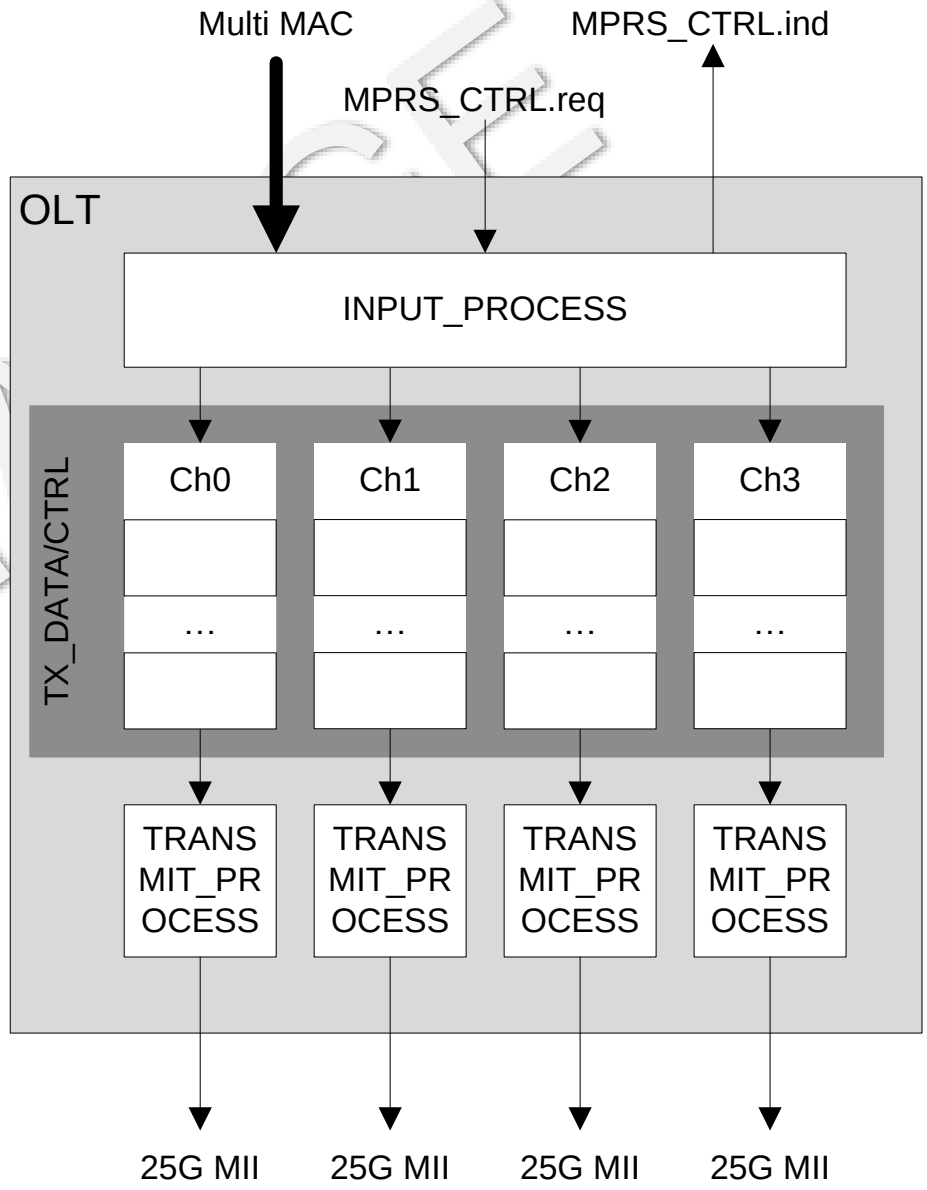
- **Start – retain from preamble**
- **LLID, EPAM, as in US**
- **LENGTH – (11b, in EQ >>10KB)**
- **Continuation Code (CF, 1b)**
  - Change of LLID in channel~~, TC & REM invalid)~~
- **Security Key (SK, 2b)**
  - Potential security key bits
- ~~**Termination Channel (TC, 2b)**~~
  - ~~Points to channel with last EQ of frame~~
- ~~**Remainder (REM, 3b)**~~
  - ~~Number of IDLE Bytes in last EQ of Frame~~
- **Header Error Correction (HEC13, 13b)**
  - Error detection & correction

Byte	4								3								2								1							
bit	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
Header	SK(2)			p(1)	EPAM(5)				LLID(16)																/S/							

Byte	8								7								6								5							
bit	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
Header	HEC(13)													CF	RC(2)		pad(5)								Length(11)							

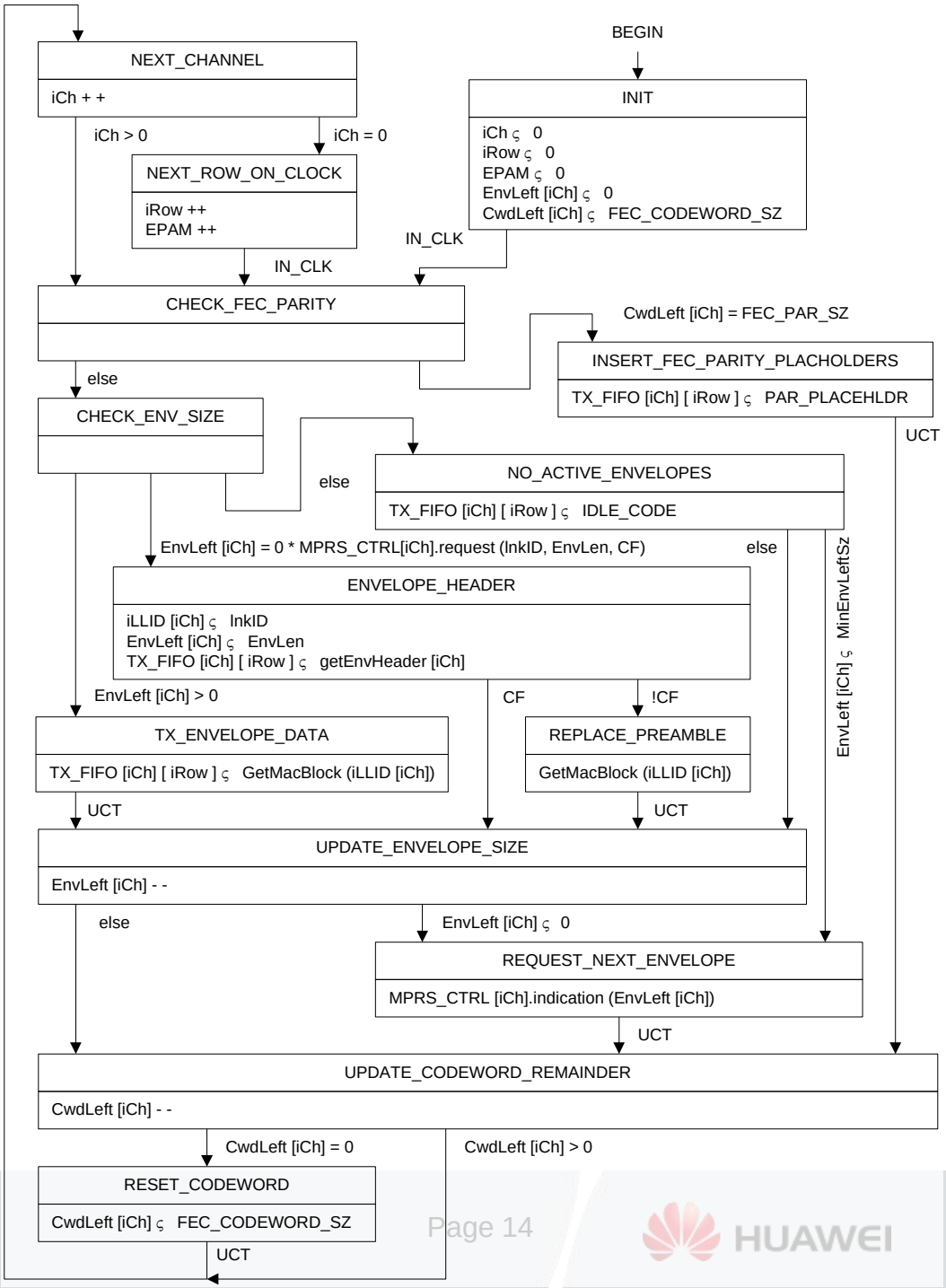
OLT DS high level block diagram

- **INPUT_PROCESS**
  - Transfers data from MAC interfaces to TX_FIFO in increments of one EQ
  - Inserts header to each envelope
  - One per OLT
- **TRANSMIT_PROCESS**
  - Outputs one 36-bit vector (TXD<31:0>&TXC<3:0> to each 25GMII interface on MMI clock edge)
  - One per channel
    - frequency & phase synchronized



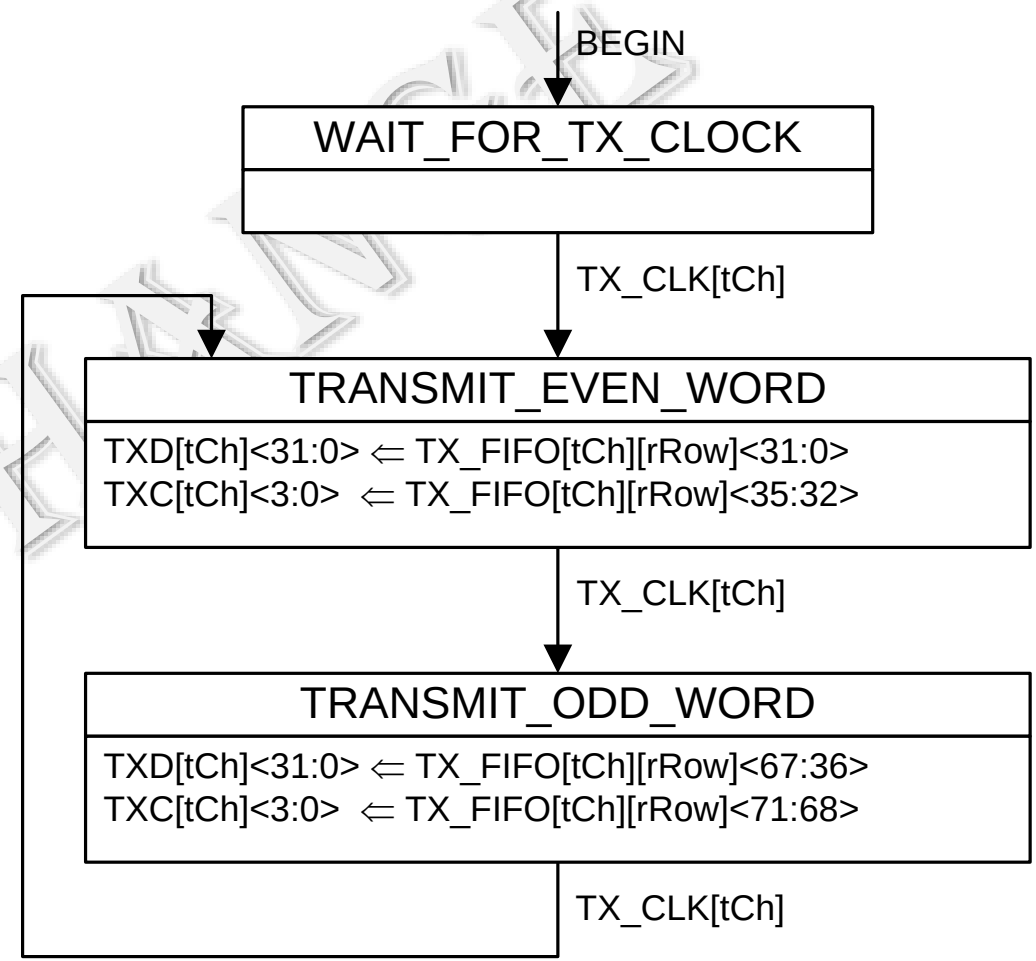
OLT
INPUT_PROCESS SD

- **Similar to US except**
  - Preamble is over written
  - GapCount eliminated



OLT TRANSMIT_PROCESS SD

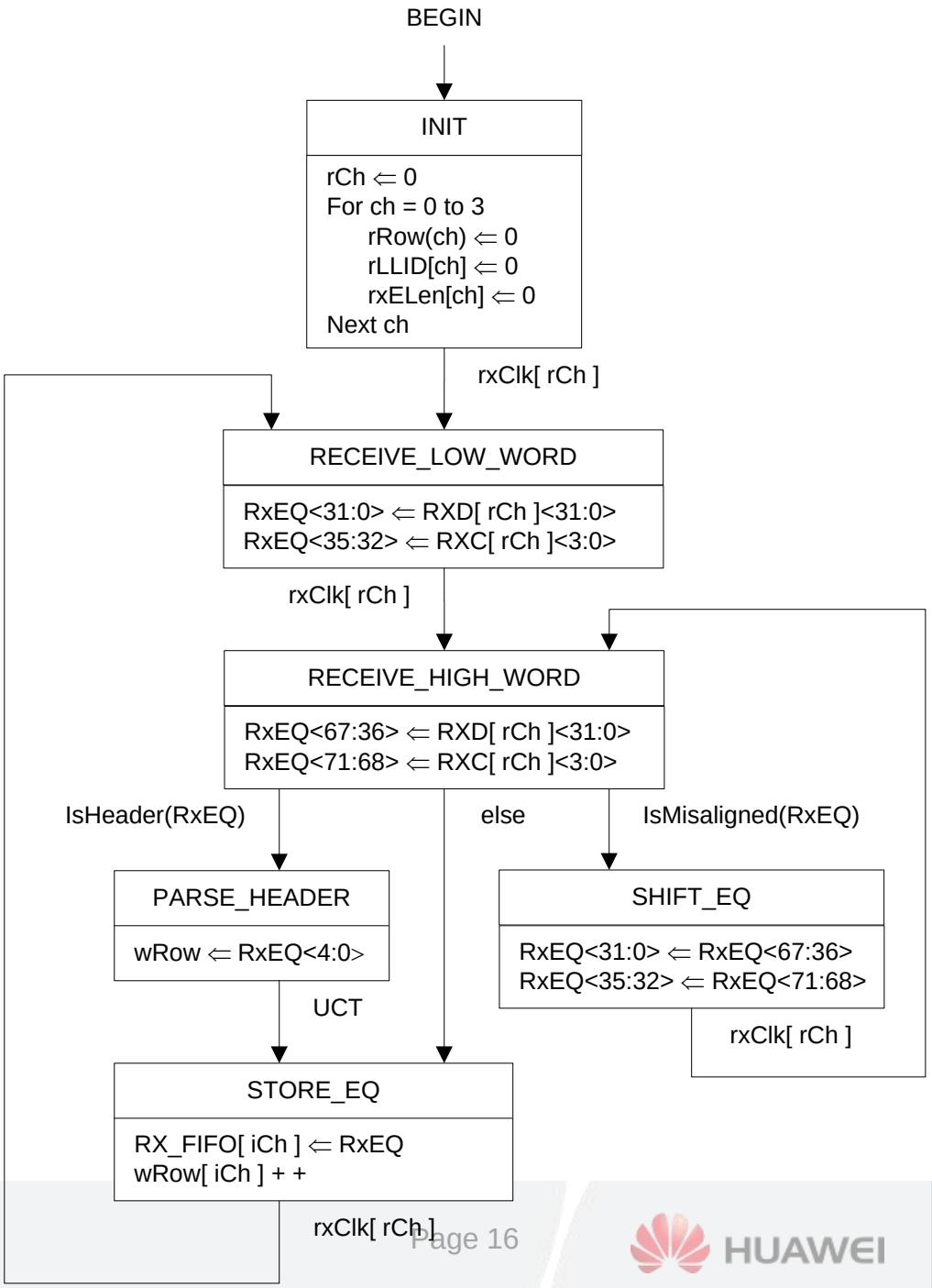
- **Same as ONU TX Process**



ONU
RECEIVE_PROCESS SD

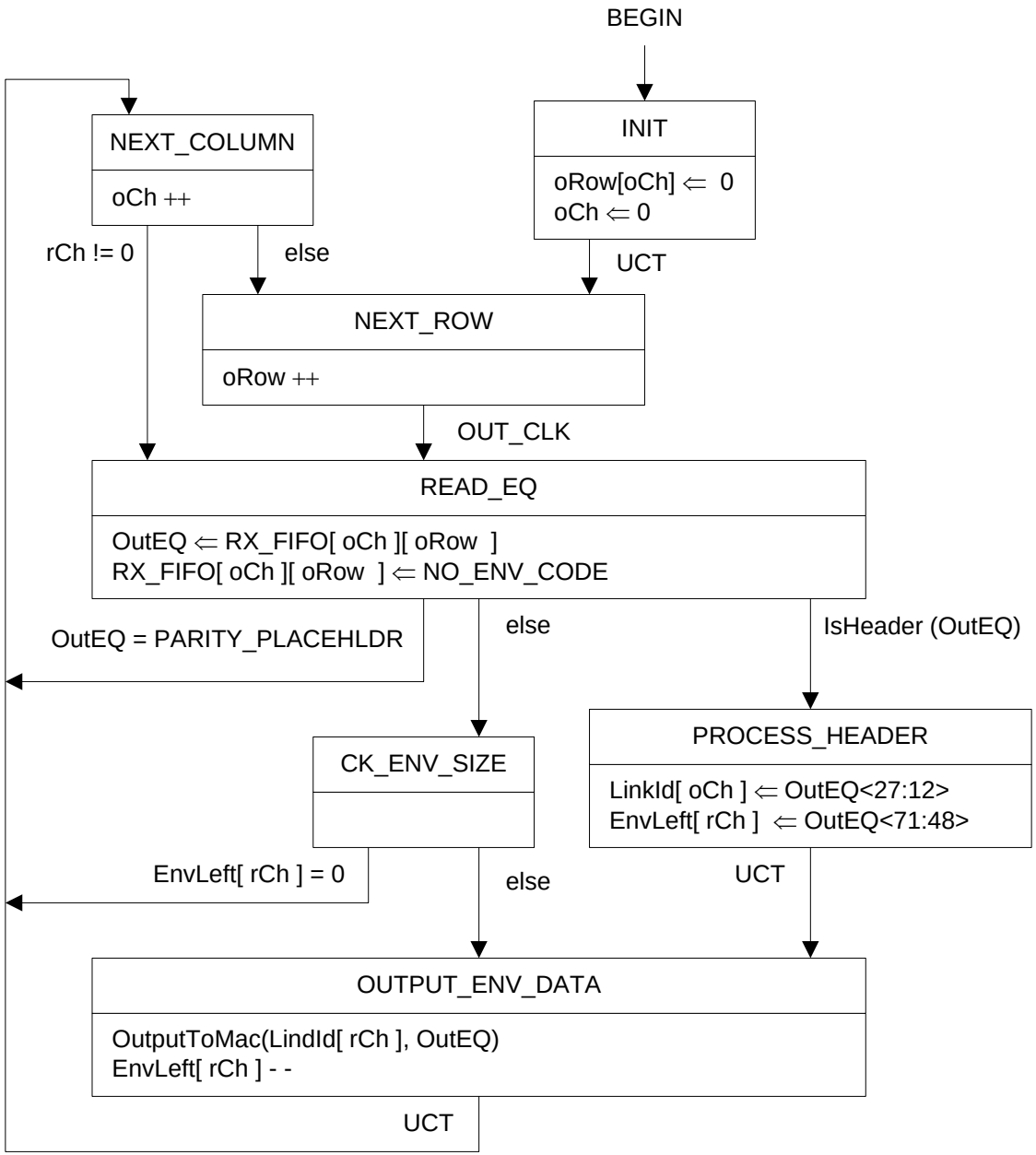
- **Similar to DS**

NEW



ONU OUTPUT_PROCESS SD

- **Same as DS**



NEW

MPRS_CTRL Primitives

- **MPRS_CTRL [ch].request**
  - Initiates a new envelope on channel “ch” and informs RS of envelope parameters
  - MPRS_CTRL [ch].request (LLID, CF, SK, TC, REM, LENGTH)

- **MPRS_CTRL.indication**
  - Same as for ONU US

Thank you

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SD variables & functions

INPUT_PROCESS

- ~~isStart (env) – function that returns True if the EQ (env) is a Preamble, else False~~
- iRow – pointer into TX_FIFO row
- iCh – channel (column) pointer into TX_FIFO row
- Others same as for US

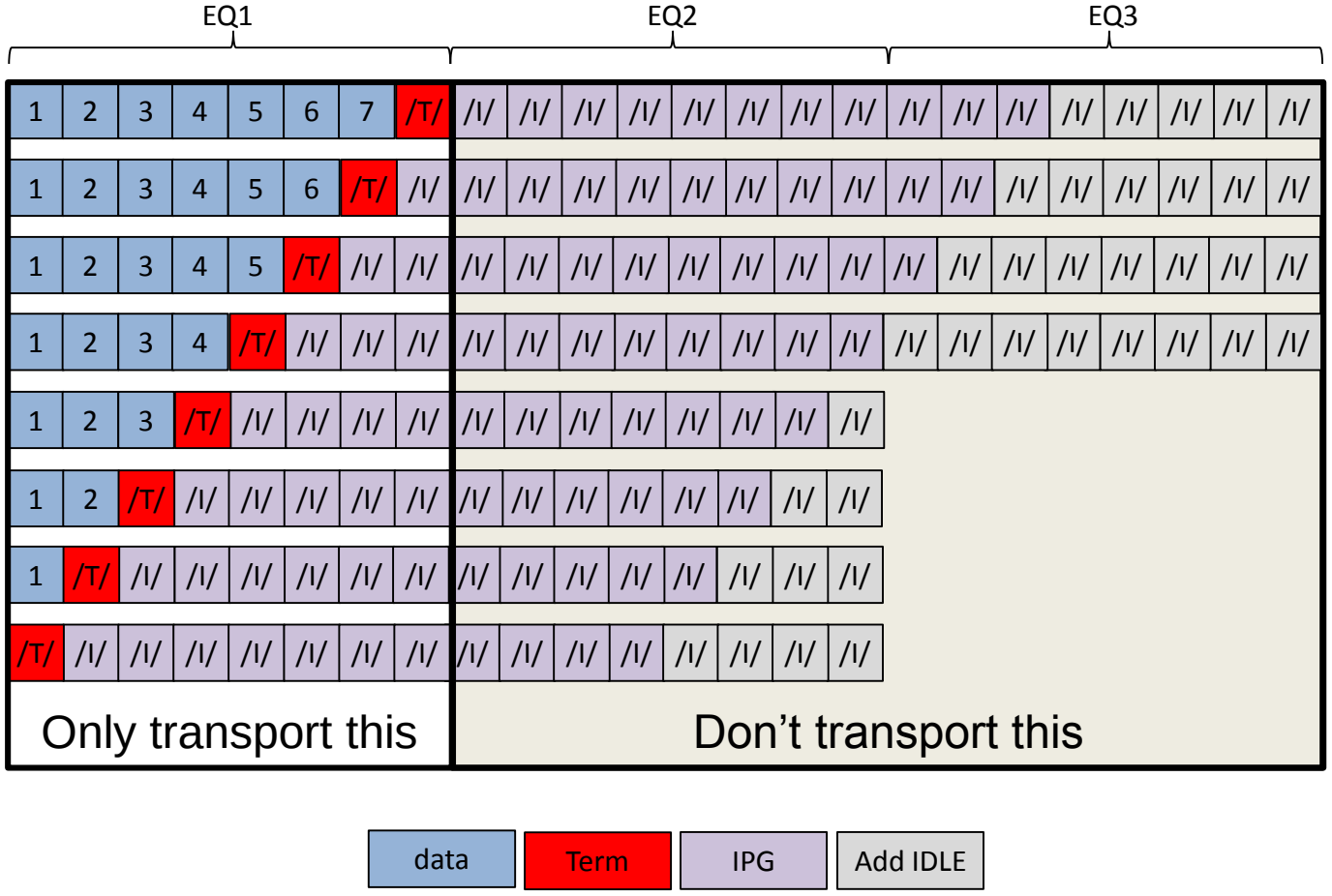
TRANSMIT PROCESS

- tRow – pointer into TX_FIFO row
- tCh – channel (column) pointer into TX_FIFO row
- Others same as for US

Minimizing overhead; IPG and /I/

Modified

- **8 possible termination sequences**



Alt Envelope Header

NEW

- **EH01/02 – as in Glens proposal**
- **LLID, EPAM, as in US**
- **LENGTH – (11b, in EQ >>10KB)**
- **Continuation Code (CF, 1b)**
  - Change of LLID in channel~~, TC & REM invalid)~~
- **Security Key (SK, 2b)**
  - Potential security key bits
- ~~**Termination Channel (TC, 2b)**~~
  - ~~Points to channel with last EQ of frame~~
- ~~**Remainder (REM, 3b)**~~
  - ~~Number of IDLE Bytes in last EQ of Frame~~
- **CRC8 (CRC8, 8b)**
  - Error detection

Byte	4								3								2								1							
bit	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
Header	SK(2)			p(1)	EPAM(5)				LLID(16)																/EH01/							

Byte	8								7								6								5							
bit	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
Header	CRC8								CF	RC(2)		pad(2)		Length(11)											/EH02/							