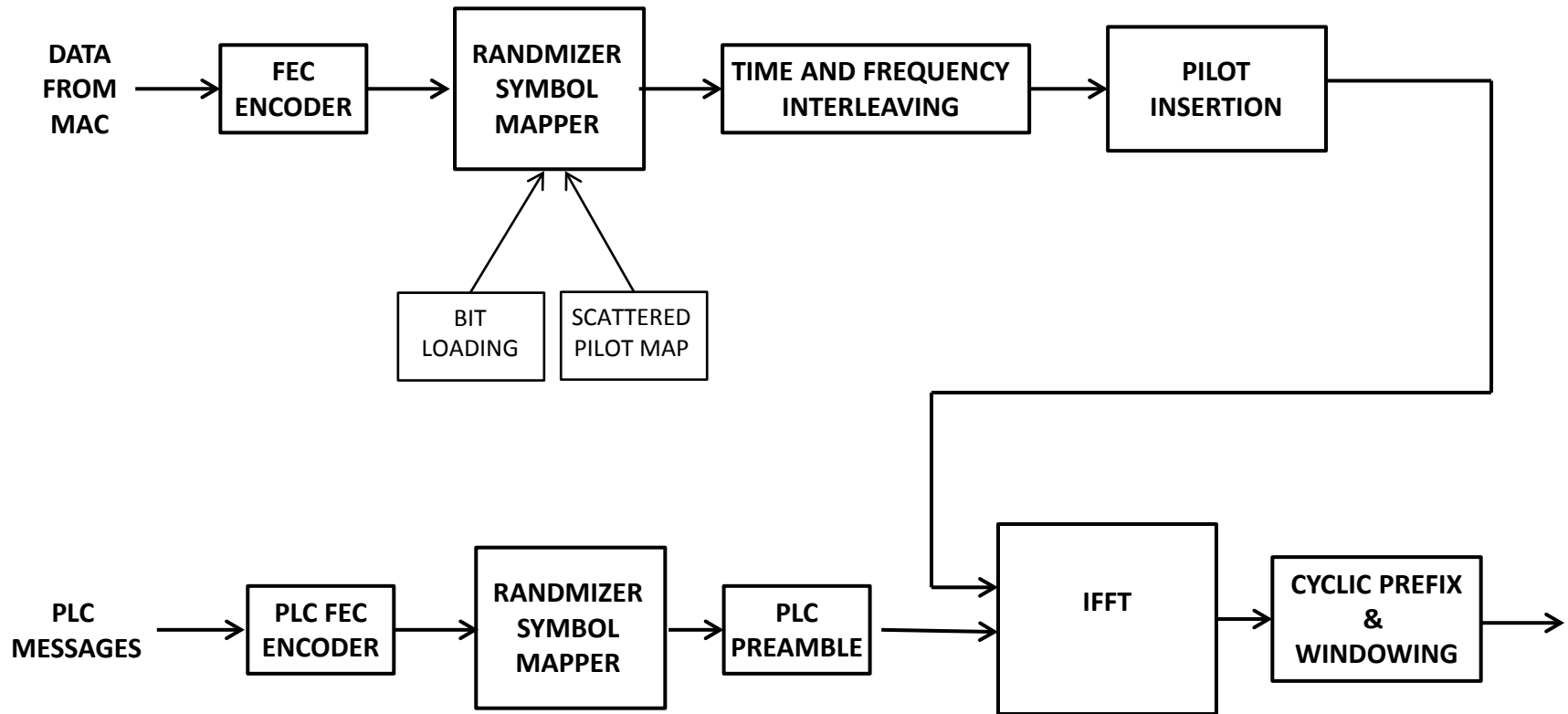


PHY High Level Block Diagrams and First Pass Look at PHY Delays

Avi Kliger, Mark Laubach

Broadcom

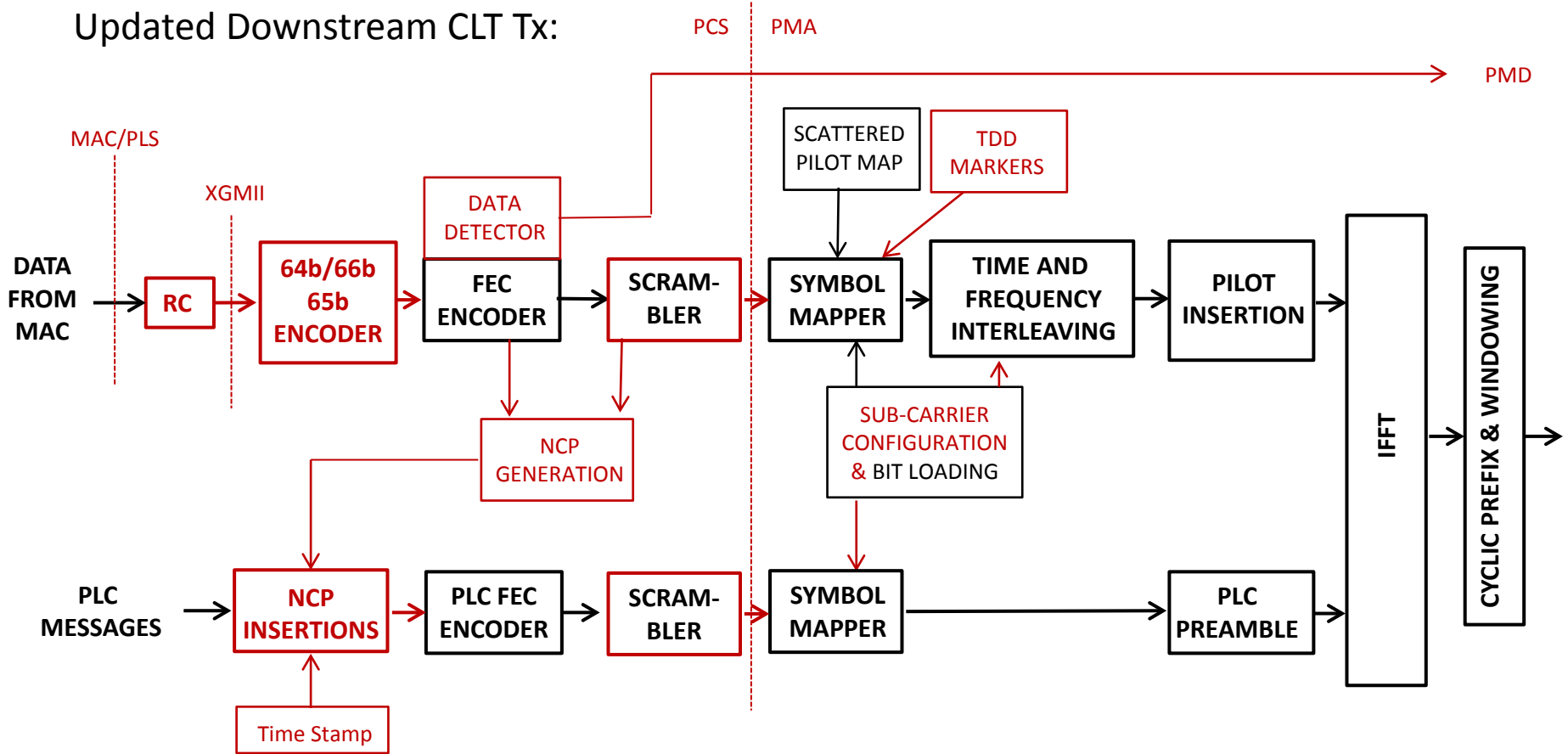
As presented at September 2013 meeting: kliger_3bn_01a_0913.pdf



EPoC Downstream Transmitter Block Diagram (starting point)

NOTE: All digital domain

Updated Downstream CLT Tx:



EPoC Downstream CLT Transmitter Block Diagram

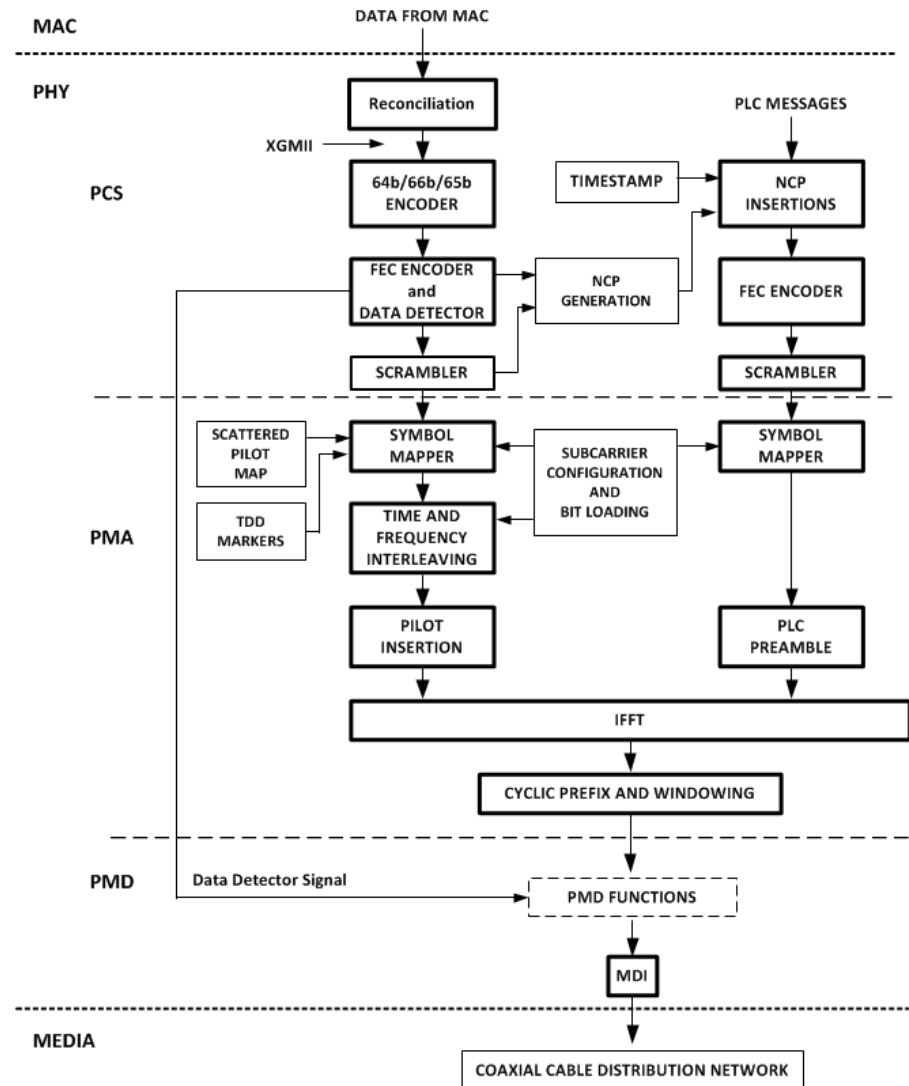
NOTE: All digital domain

NOTE: Sub-Carrier Configuration includes sub-carrier use and QAM mapping

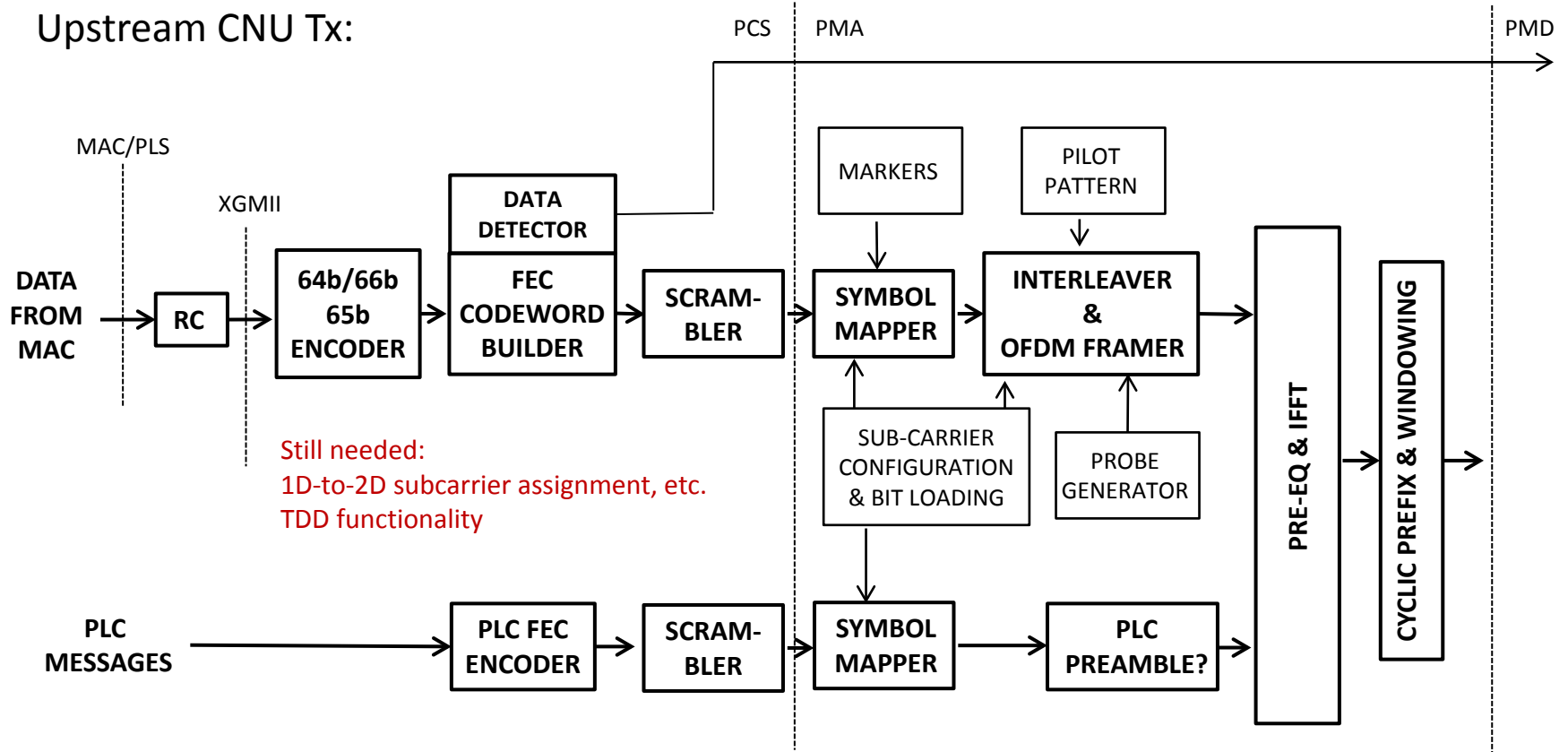
NOTE: IEEE Vertical Format in klinger_3bn_01_1113_figure.vsd

IEEE 802.3 “Vertical Normal Form”

- Refer to [kliger 3bn 01 1113.vsd](#)
- Added:
 - MDI
 - CCDN
 - “PMD Functions” box, dotted to indicate that these are likely in the vendor / implementation domain – details not part of this specification
- Editors can copy edit as needed.



Upstream CNU Tx:



EPoC Upstream CNU Transmitter Block Diagram

NOTE: All digital domain

NOTE: Sub-Carrier Configuration includes sub-carrier use and QAM mapping

NOTE: Not converted yet to IEEE 802 Vertical Form

First look at PHY delays

- This is only an initial look: “first blush”
 - Approximations only
 - More study is needed!
- PHY delays (latencies) have three main contributors:
 1. LDPC FEC encoding and decoding
 2. OFDM symbol processing
 3. Downstream interleaving
- There are other PHY delay contributors
 - Starting point: looking at these three.

LDPC FEC Encoding and Decoding

- Proportional to codeword size and line rate
 - E.g. $16200 \text{ bits} / 1 \text{ Gbps} = 16.2 \text{ usec}$
- Processing: 1x for Tx, 2x for Rx
- For example at above line rate
 - Downstream FEC processing delay:
 - $16.2 + 2 * 32.5 = 48.6 \text{ usec}$
- Impact
 - Downstream and PLC => constant per provisioning
 - Upstream requires more study due to use of multiple codeword sizes and processing techniques
 - Assuming 16200 codeword size for this first look

OFDM Symbol Processing DS

- CLT Tx – Likely 1 Symbol time delay (T_{sym})
- CNU Rx – vendor dependent
 - Estimated range min = $6 * T_{\text{sym}}$, max = $10 * T_{\text{sym}}$
 - Pilot recovery, channel estimation, timing and synchronization, etc.
- Example total downstream:
 - Min = $(1 + 6) * T_{\text{sym}} = 7 * T_{\text{sym}}$
 - Min = $(1 + 10) * T_{\text{sym}} = 11 * T_{\text{sym}}$

OFDM Symbol Processing US

- CNU Tx
 - Need to build the upstream “burst frame”
 - Pilots and complementary pilot insertion
 - Based on # of symbols (K) in the frame “resource block”
 - K likely to be settable from 6 to 18
 - Other processing adds likely 4 to 8 symbols
- CLT Rx – vendor dependent
 - Collect the RB, process pilots, estimations, etc.
 - Additional, likely based on K plus overheads
 - Min = 6 T_{sym} , Max = 20 T_{sym}

Downstream Interleaver

- Straightforward, just based on symbol depth of interleaving being used
 - Min = 0, Max = 10 (example)
- Example:
 - Min = 0 * Tsym
 - Max = 10 * Tsym

Summing It up. Goal < 1048.56 usec (16 bits * 16 usec TQ)

Parameter / Item	Comment	Value Min	Value Max
DS/US codeword size	Just largest CW for now	16200	16200
Downstream line rate	Gbps	1.0	1.0
Upstream line rate	Gbps	0.5	0.5
Symbol Time (Tsym)	20 usec + 2.5 usec CP	22.5	22.5
K symbols in RB frame	6 symbols	6	6
L Interleaver Depth	Default to 0 * Tsym	0	0
Contributors		usec	usec
Downstream FEC	$(1 + 2) * 16200 / 1.0 \text{ Gbps}$	48.6	48.6
Upstream FEC	$(1 + 2) * 16200 / 0.5 \text{ Gbps}$	97.2	97.2
Downstream OFDM	Min 7, max 11	157.5	245.7
CNU Tx OFDM	$K = 6 + 4 = 10$ to $K = 6 + 8 = 14$	225.0	315.0
CLT Rx OFDM	$K = 6 + 6 = 12$ to $K = 6 + 20 = 26$	270.0	585.0
DS Interleaving	Depth is 0 * Tsym	0	0
	Range of delay contributions	798.3	1293.3

Summing It up. Goal < 1048.56 usec

(16 bits * 16 usec TQ)

Parameter / Item	Comment	Value Min	Value Max
DS/US codeword size	Just largest CW for now	16200	16200
Downstream line rate	Gbps	1.0	1.0
Upstream line rate	Gbps	0.5	0.5
Symbol Time (Tsym)	40 usec + 2.5 usec CP	42.5	42.5
K symbols in RB frame	6 symbols	6	6
L Interleaver Depth	Default to 0	0	0
Contributors		Usec	usec
Downstream FEC	$(1 + 2) * 16200 / 1.0 \text{ Gbps}$	48.6	48.6
Upstream FEC	$(1 + 2) * 16200 / 0.5 \text{ Gbps}$	97.2	97.2
Downstream OFDM	Min 7, max 11	297.5	467.5
CNU Tx OFDM	$K = 6 + 4 = 10$ to $K = 6 + 8 = 14$	425.0	595.0
CLT Rx OFDM	$K = 6 + 6 = 12$ to $K = 6 + 20 = 26$	510.0	1105.0
DS Interleaving	Depth is $0 * Tsym$	0	0
	Range of delay contributions	1378.3	2313.3

Observations

- Upstream burst frame size likely needs to be kept to the minimum of 6 symbols
- 20 usec T_{sym} + 2.5 usec CP seems to work. 40 usec + 2.5 usec exceeds the 1048.56 usec goal
- Could tolerate some DS interleaving with 20 usec symbols, but hopefully depth can be 0 in actual deployment where RTT is an issue
- Need more in depth look and examination of system issues when RTT 1.0 msec exceeded
- Don't forget propagation delay time as well as other lesser delay contributors

Summary

- Downstream CLT Tx baseline proposal ready
- Upstream CNU Transmitter
 - Starting point, work in progress
- First look at PHY delays presented
 - Further study needed

Proposed Motion

Motion to:

- Adopt kliger_3bn_01_1113.pdf Slide 3 and kliger_3bn_01_1113_figure.vsd as baseline proposal for downstream Tx.
- Adopt kliger_3bn_01_1113.pdf Slide 5 as starting point for upstream Tx baseline.

Moved: Avi Kliger

Second: Rich Prodan

THANK YOU