Low overhead coding proposal 10GbE serial links

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Outline

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- Motivation
- Code Overview
- Code Properties
- Comparison to SONET
- Typical Application
- Summary

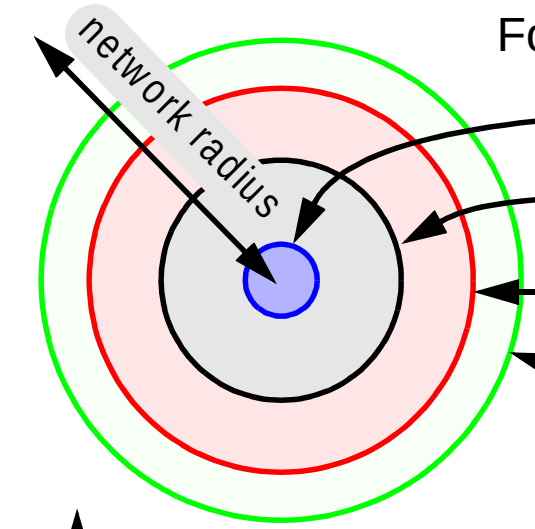
Goals

- provide full 10.000 Gb/s bandwidth for LAN applications
- provide PMD for long-distance (10km - 40km+) LAN requirements
- interface directly to common MAC/PCS/PMA interface (HARI, 4x3.125 GBaud) with control code transparency
- ensure robust DC-balance, transition-density, and frame synchronization properties suitable for either copper or fiber transmission
- achieve a low enough coded baud-rate to be compatible with existing SONET laser designs

Motivation

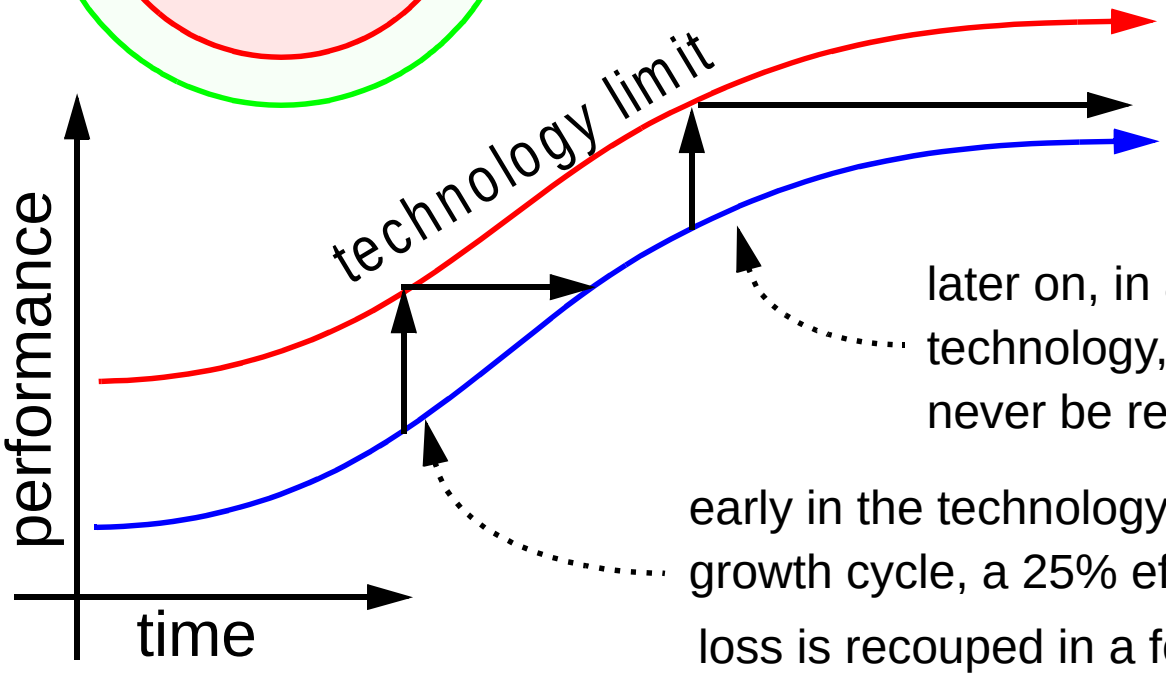
- Both optics and copper implementations become much more difficult to implement above 10 Gbaud
- An efficient code can leverage existing SONET 10Gbaud lasers rather than requiring fundamentally new technology
- A simple code can be efficiently implemented in many processes

Why an efficient 10Gb serial code?



Four markets (depending on distance):

- 10G Serial copper (0-10m)
- Parallel optics (0-100m)
- WDM 4x3.125G (5m - 10km)
- 10G Serial fiber (10km - 40km)

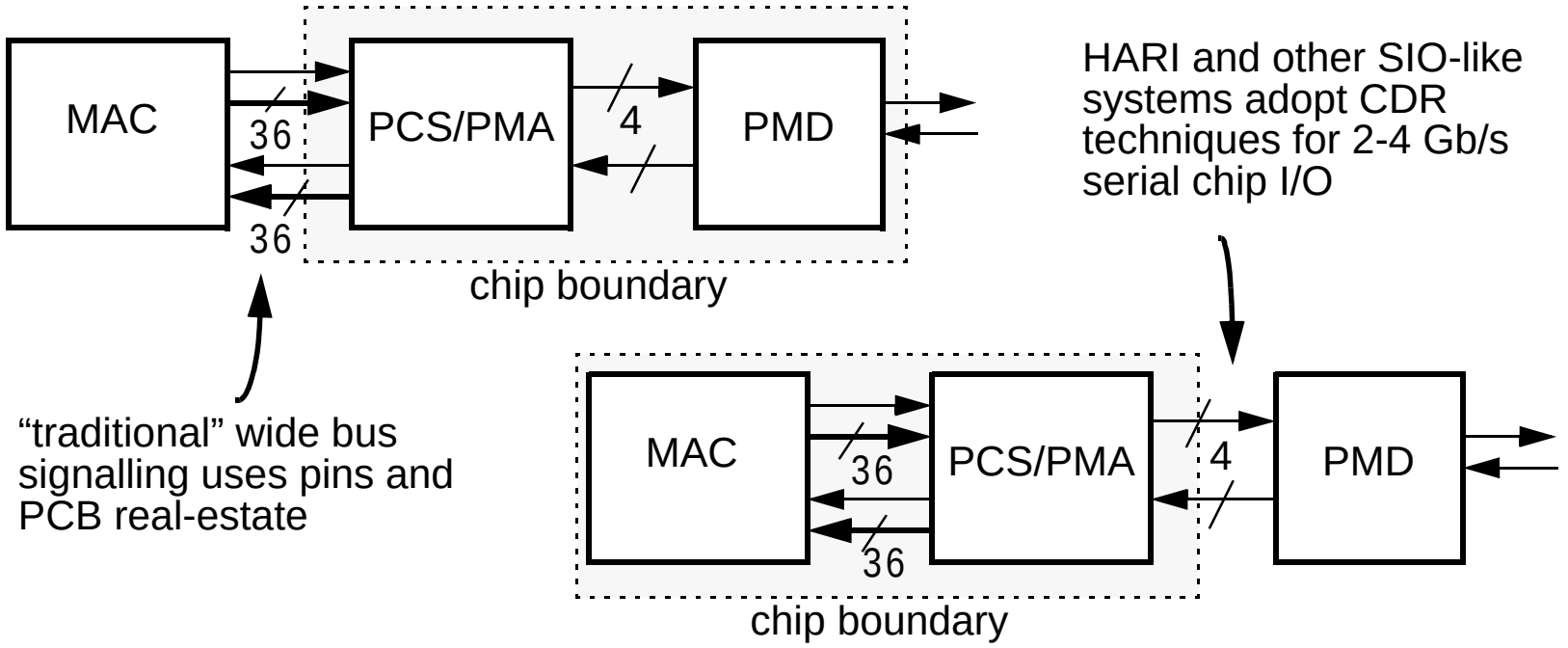


later on, in a mature technology, the 25% may never be recovered

early in the technology growth cycle, a 25% efficiency loss is recouped in a few months

Two views of the future

- System density and performance put increasing pressure on pin and package count
- 2-4 Gb/s serial links will be pervasive in future designs



Overview of Code

If octets are either data or control, then at least an 8B/9B code is required - hardly a significant improvement over 8B/10B.

Two properties of HARI 10GbE proposal allow for a more efficient code:

- Only a limited number of control characters are needed (K,R,S,T,E...) which can be coded in 7 bits.
- Data is transmitted in contiguous blocks of at least 64 octets always starting with S and ending with T.

If we code on 64 bit (8 octet)-sized blocks, each block can only contain one transition from control to data or vice-versa.

A two-bit preamble allows frame synchronization and gives a 66/64 code with only 3.125% overhead

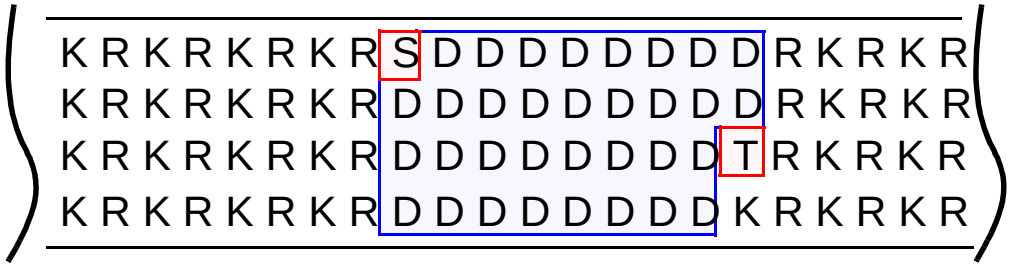
Overview of Code (cont.)

Data Codewords have “01” sync preamble

Mixed Data/Control frames are identified with a “10” sync preamble. The coded 56 bit payload and TYPE field is also scrambled.

00,11 preambles are considered as code errors

Building frames with proposed HARI 10GbE mapping



S,T = SOP, EOP
K,R = control words (Z)
D = Data octets

pure data

D D
D D
D D
D D

pure control

Z Z
Z Z
Z Z
Z Z

two possible packet startings

Z S
Z D
Z D
Z D

S D
D D
D D
D D

eight possible packet endings

D D
D D
D D
D T

D D
D D
D T
D Z

D D
D T
D Z
D Z

D T
D Z
D Z
D Z

D Z
D Z
D Z
T Z

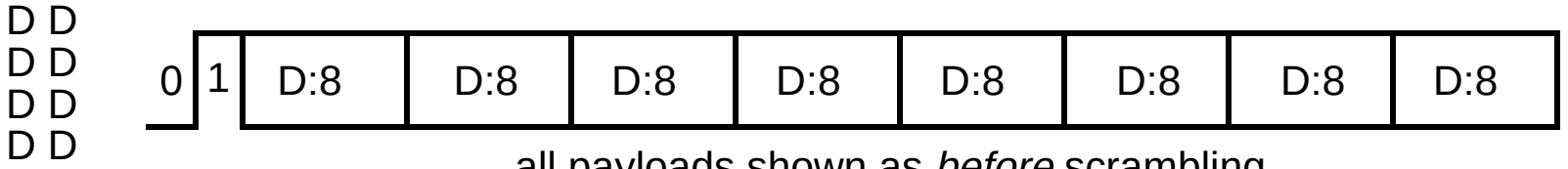
D Z
D Z
T Z
Z Z

D Z
T Z
Z Z
Z Z

T Z
Z Z
Z Z
Z Z

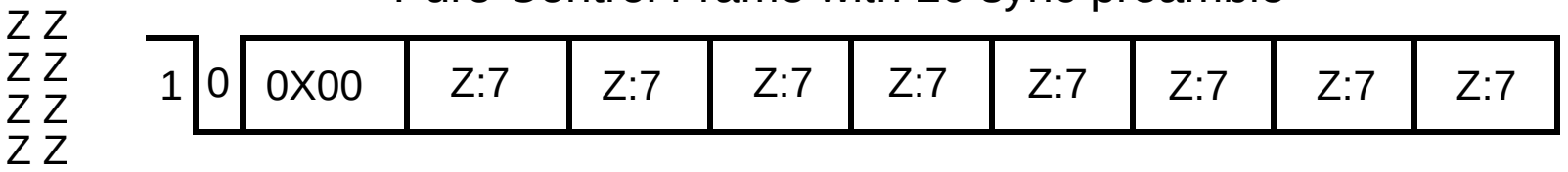
Code definition

Pure Data Frame with 01 sync preamble

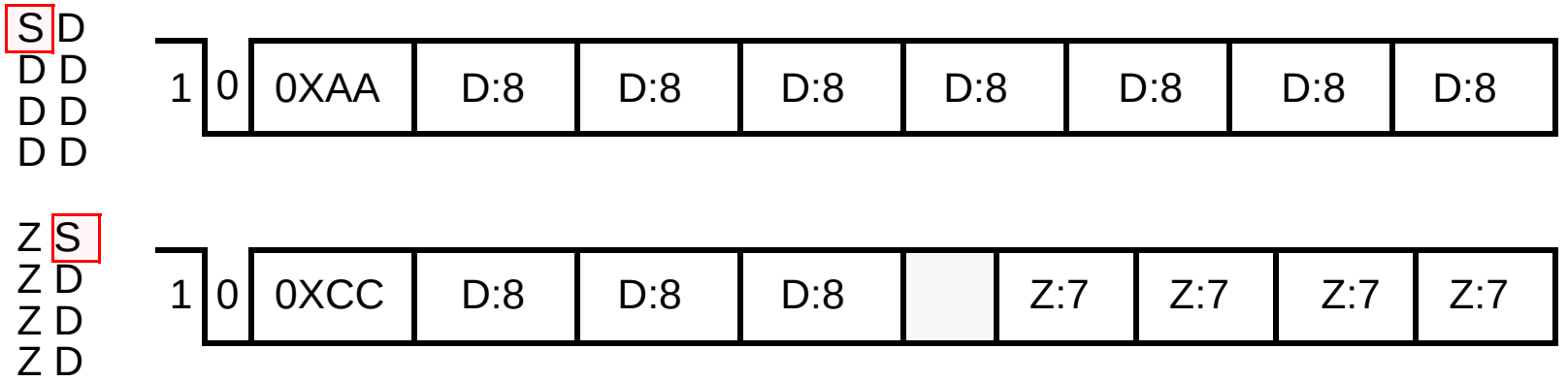


all payloads shown as *before* scrambling

Pure Control Frame with 10 sync preamble



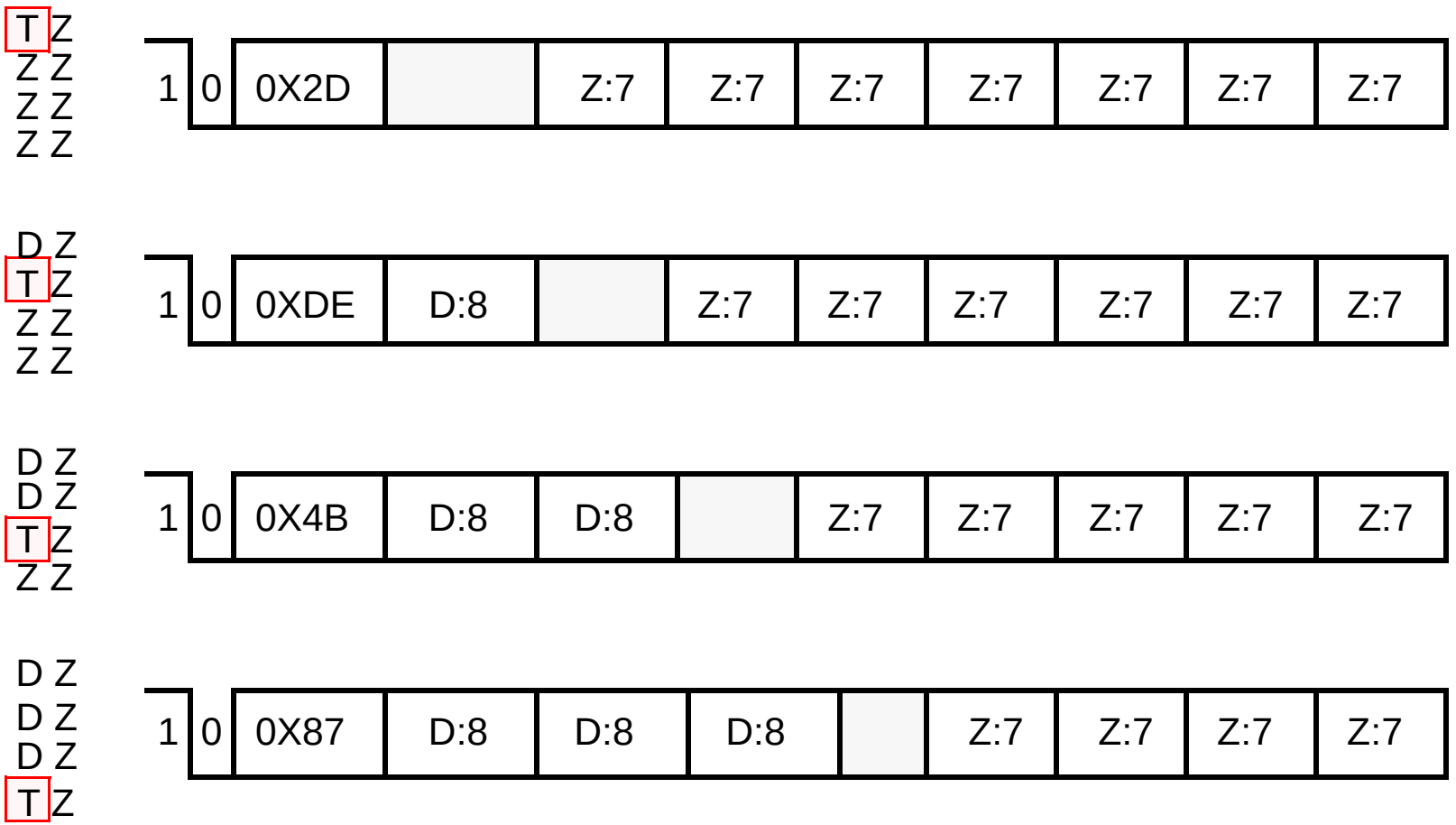
Mixed Data/Control Frames with 10 sync preamble



Code definition (cont.)

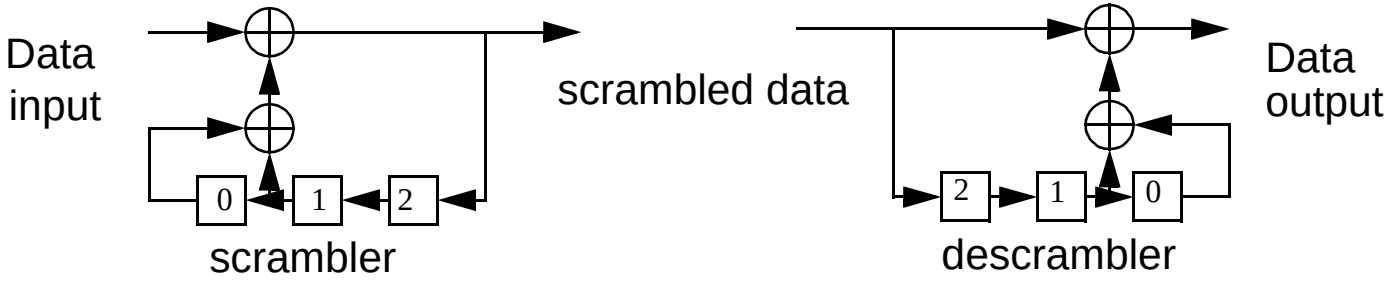
SOP (S) and EOP (T) are implicitly transmitted by the TYPE byte

Code definition (cont.)

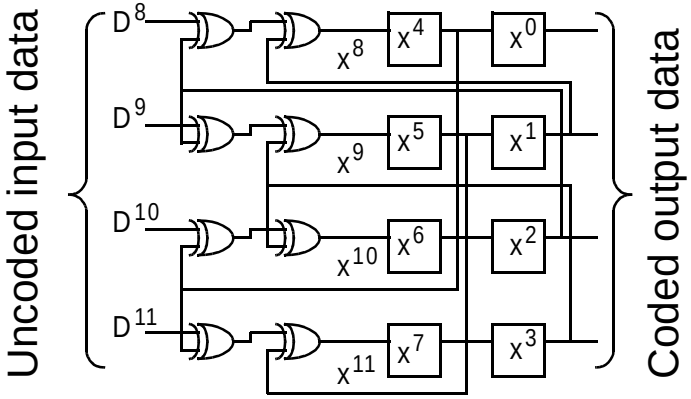


Scrambling principle

example scrambler/descrambler in serial form:



parallel form:



- Self synchronizing (Westcott-style scrambler)
- Can be parallelized for efficient implementation
- Recommend long pattern length to reduce possibility of jamming (eg: $x^{31}+x^3+1=0$)
- Long pattern length self-synchronizing scramblers exist that do not compromise Ethernet CRC coverage

Code Properties

- maximum run-length is guaranteed to be 64 or better due to 2-bit preamble (better than SONET)
- DC balance is suitable for laser transmission (slightly better than SONET)
- overhead is 66/64 = 1.03125
- frame lock is acquired by bit-slipping the de-multiplexor until the complementary 2-bit preamble bits are found to be statistically stable.
- Alternatively, 64-bit frame boundaries can be rapidly acquired using the handshake scheme in Walker, et al. “A 1.5 Gb/s Link Interface Chipset for Computer Data Transmission”, IEEE JSAC, V9 No. 5, June 1991.

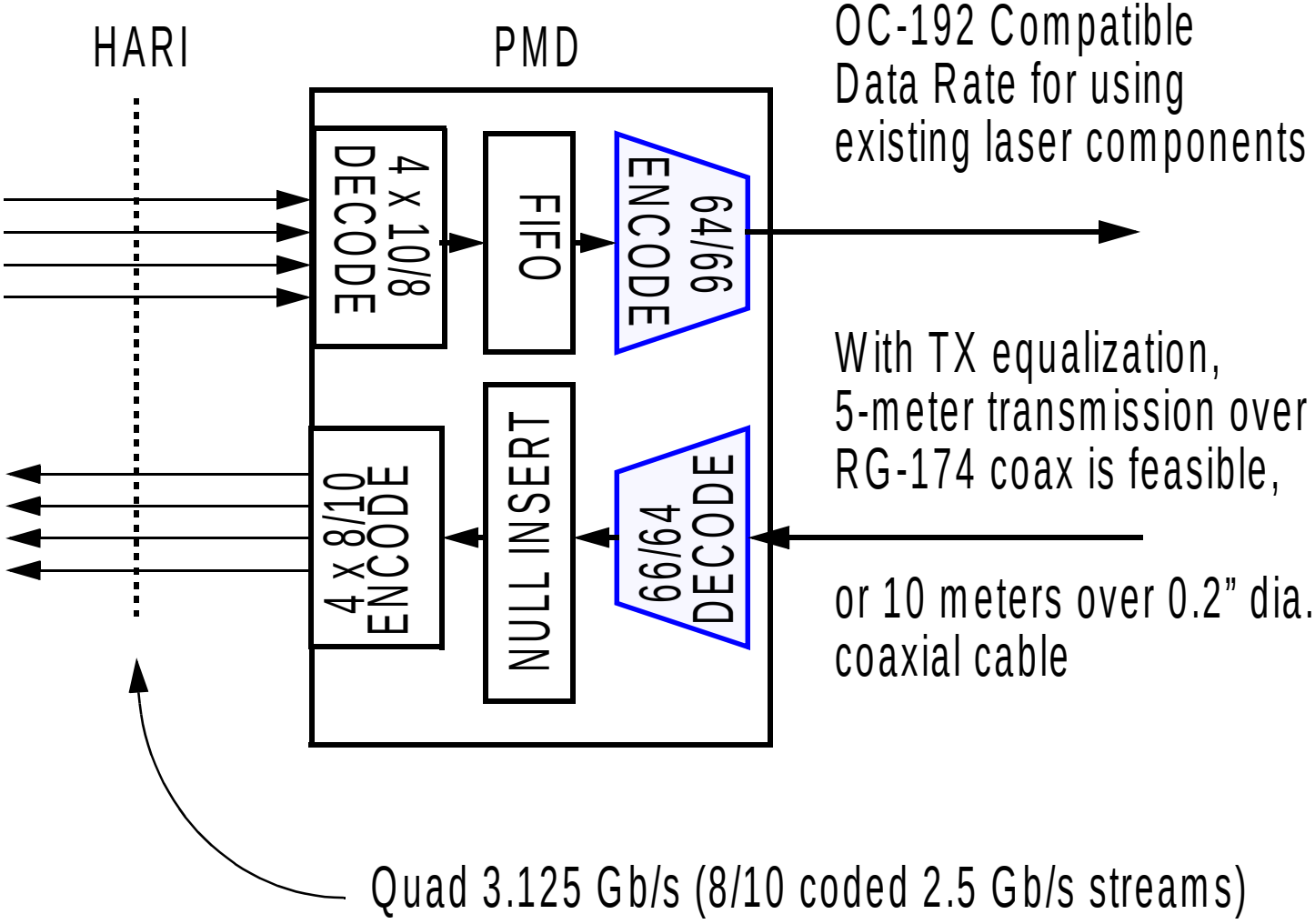
Comparison with SONET

- two-bit preamble is analogous to SONET's A1/A2 sync bytes.
- SONET CDRs are designed to accommodate an 80 bit run length. This new code is deterministically limited to 64 bit run length due to the periodic preamble bits.
- Both codes use similar bit-slipping method to acquire frame sync.
- This code is similar in spirit to the SONET code. It is not in any way compatible, but inherits much of SONET properties while being much simpler to implement.
- Much less on-chip buffering required
- Lower latency

Code Robustness

- 2 bit Hamming distance between data (01) and mixed frames (10)....code could be modified to have 3 bit distance at the cost of raising overhead from 3.1% to 4.7%
- TYPE fields within mixed frames have 4-bit Hamming distance
- There exist long-period scramblers that do not impair CRC coverage and are difficult to jam (details can be provided)

A possible implementation



Conclusion

- A simple, low overhead SONET-like code is possible
- HARI (4 x 3.125Gbaud) becomes a common interface for all PMDs:
  - 4-color WDM (Spectra-LAN)
  - Parallel fiber
  - 0.5 meter chip-chip, card-card interface on PCB
  - Serial 10.3 Gb/s (copper to 15m, fiber to 40km)