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10 Gigabit Ethernet

Application Requirements

and

Proposed Layer Architecture

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Convergence of Applications

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- 10Gig is the next unifying rate
  - Telecom migration from OC48 towards OC192
  - 1 Gig aggregation
  - Decouple requirements between apps, yet provide seamless integration
- LAN Applications
  - In building networks - data centers, clusters, risers
  - Campus Interconnects
- Cross Over applications
  - Metropolitan connections to core networks (backhaul)
  - Intra city private networks over dark fiber
    - Evolution, outgrowth of 1 Gig applications
- Telecom
  - Core WDM network access rate
  - Private networks over dark λ

LAN Requirements

- In building
  - Migration from 1 G
  - Dual rate support (1 G and 10 G)
  - 300 M distance over multimode fiber
  - Why?
    - All surveys show that 300M covers well over 90% of requirements
- Campus and Backbone applications
  - Up to 5 Km distances
  - Extend the 3 Km Single Mode standard
- Distances longer than 5 Km are Metropolitan

Time for new LAN media spec

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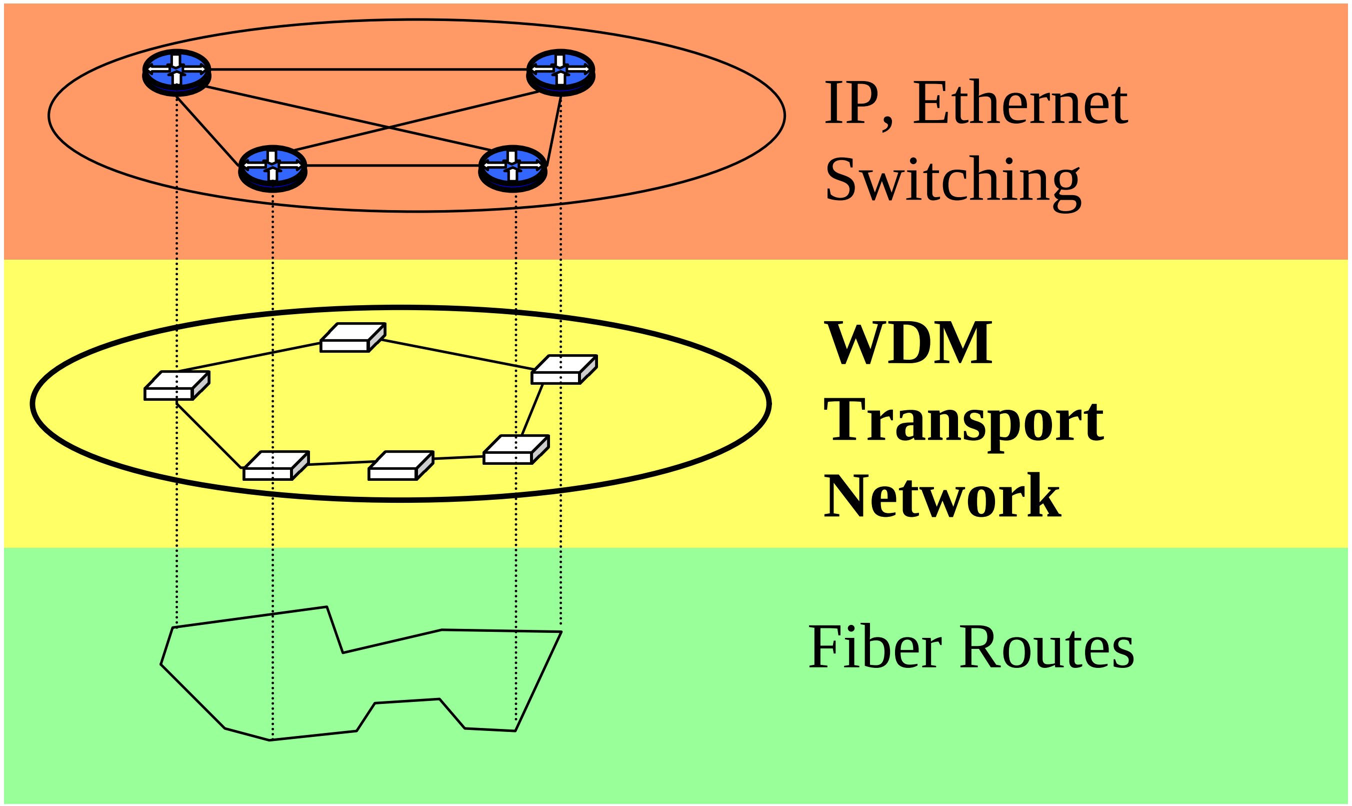
- Existing fiber specs in TIA 568 and IEEE specs refer to the state of the art in fiber manufacturing circa 1985
  - The spec of 160MhzKm was designed for FDDI
  - Does not discuss modal bandwidth and dispersion losses
  - Does not support straightforward 10 Gig ethernet operation
- Today, fiber performance levels and manufacturing tolerances are over an order of magnitude better
  - 10 Gig is two orders of magnitude faster than FDDI
  - 10 Gig will service a wider range of applications
- We must be able to include a new multimode, in building fiber specification to support 300M distance

Metropolitan/Telecom Architecture

- Each service layer has its own paths and is independent of the lower layer
- Separate control and recovery requirements



Access Infrastructure

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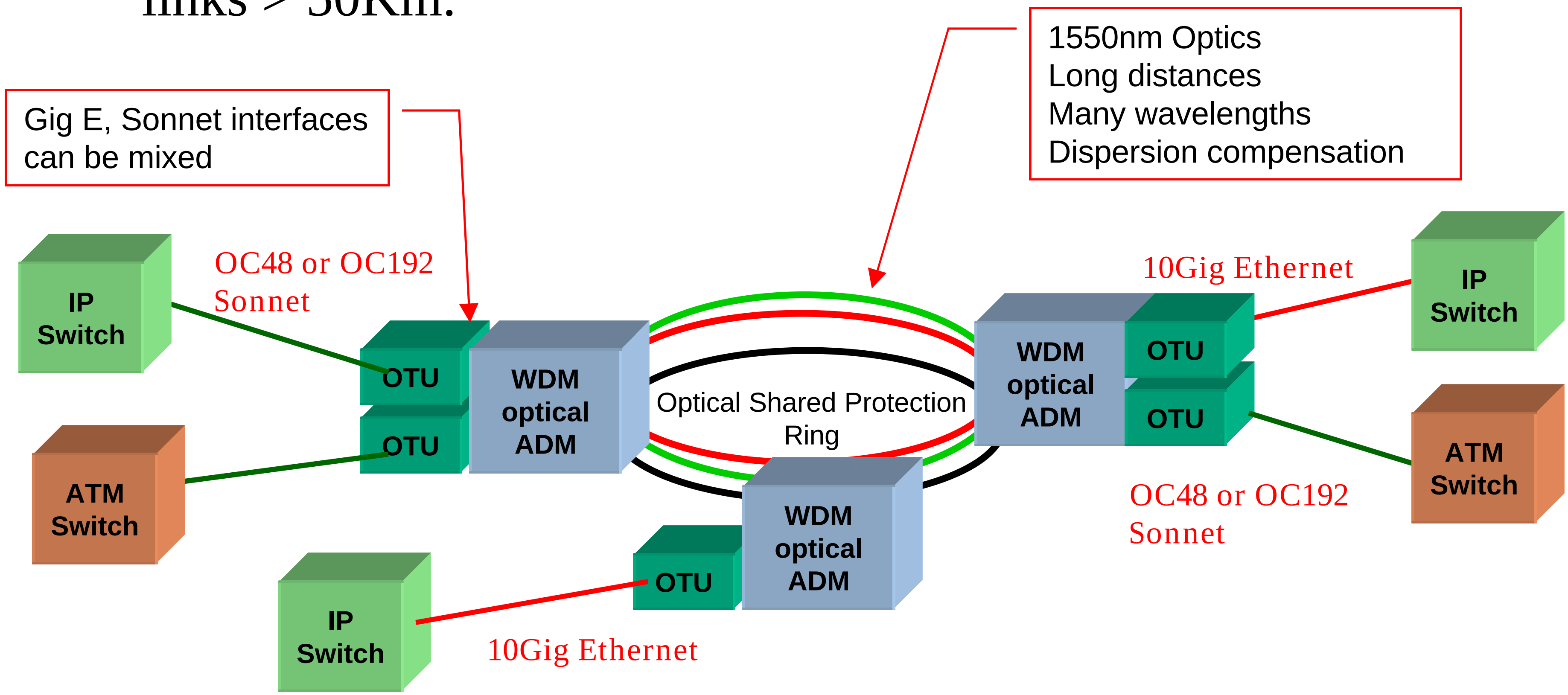
- 5-50 Km links are used to access core WDM network
  - Links operate at 1300nm
  - This technique also solves the telecom requirement for long links > 50Km.



Metropolitan Requirements

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- Single vs Multi-Segmented Link
  - From Bldg MDF to access point of the carrier
  - Or from Bldg to Bldg
  - No 3R equipment in the link
  - No need for sectionalization, OAM
  - No need for BER monitoring in real time
  - Serial datastream over single wavelength
- Reliability achieved via other means
  - Use of 802.3AD LACP looks most likely
  - Simplified, rapid recovery
  - Short topology simplifies recovery
  - SONET APS is not necessary for this access application

10GE Link Code Requirements

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- 10 Gig Payload - Packet, Tags, SFD, Preamble, CRC
- Code Functionality
  - Low overhead - excess BW is problematic
  - Rapid synchronization and frame alignment
  - BER of 10^{-12}
  - Link failure detection
  - Efficient recovery from link errors
- Transmission Aspects
  - Low Frequency cut off
  - DC baseline wander

10 GE - New Interface Structure

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- MAC Layer
  - Becomes a frame handling layer
  - Passes fully constructed frames to Transmission Control
- New Layer - Transmission Control
  - Accepts frames over 10GMII
  - Encapsulates
  - Scrambles
  - Frame Delineation
  - Passes scrambled octet stream over 10GPMA

Somewhat similar to PCS layer in GE, but also overlaps some of the PMD functions in GE

Evolution of Ethernet Architecture over the years

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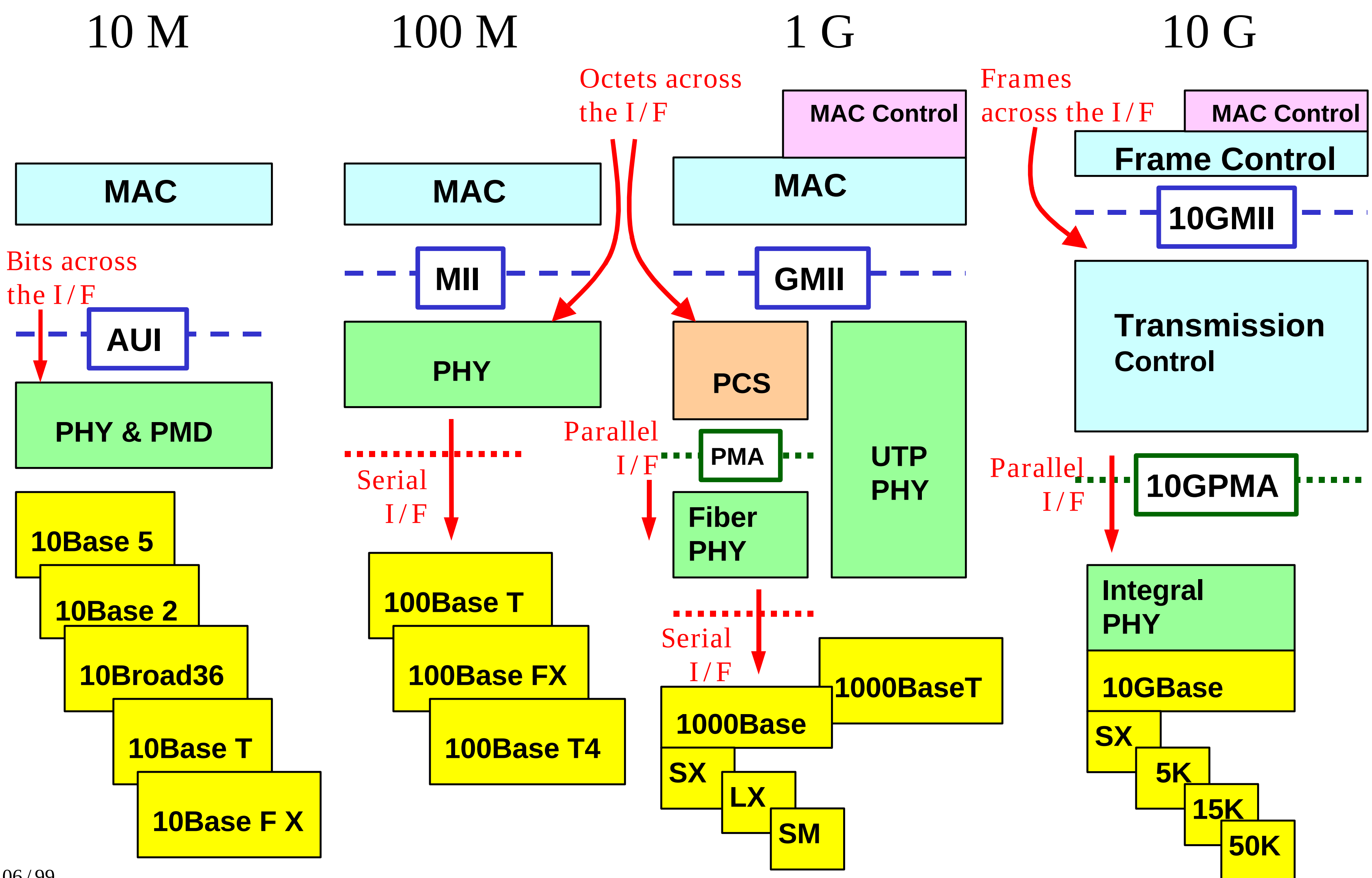

Transmission Control

- Reject block codes
  - Attractive features come at high cost of bandwidth
  - 25% increase in BW required for 8B/10B transmission
    - Beyond state of the art for most devices and fibers
  - Generates architectural disruption between LAN and WAN at OTN interfaces
    - WAN applications will NOT use block codes
    - Thus expensive interface conversion equipment will be required
    - Delays in the packet transit due to packetizing/blocking requirements
  - Difficult to apply FEC for coding gains when necessary
    - Fruitless endeavor - dB gain outweighed by overhead gain

Transmission Control Recommendation

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- Frame based Scrambling approach is in operation on long haul links today
  - Proven operating performance, with 10-15 BER
  - Distances of Thousands of miles
  - Feasible - Used by core carriers today
  - Can be used in LAN and WAN without change
  - Overhead as low as 6%
  - Meets requirements
- Easily supports MPLS, FEC, and other enhancements
- This protocol can be used seamlessly in WAN apps

Transmission Control Frame Structure

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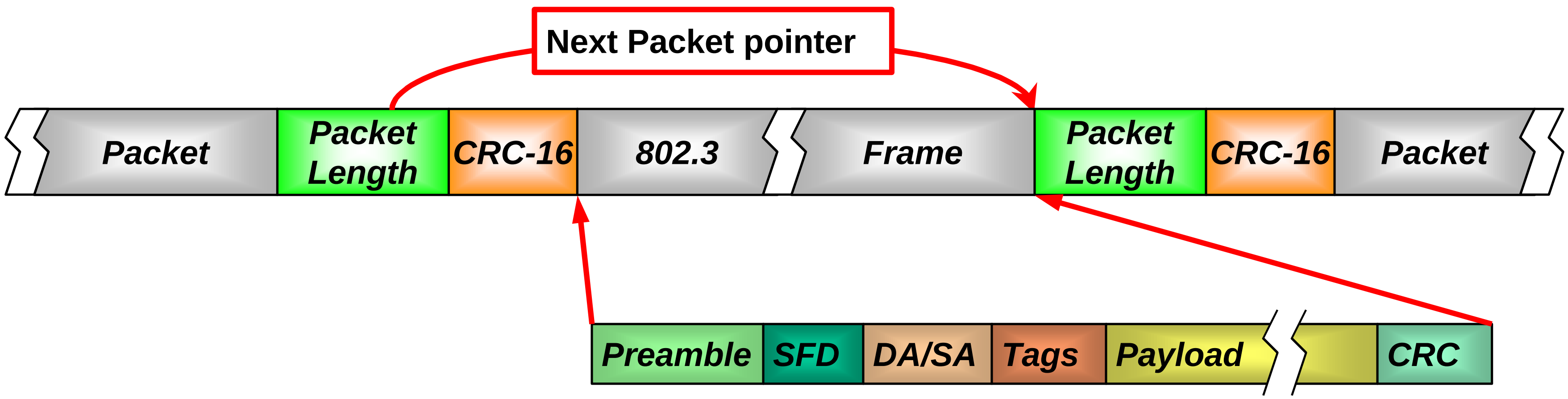
- Structural Aspects
  - Length Header - Under 4 bytes is control
  - Header CRC
    - Used as framing indicator, like a comma character
  - Short Lengths can be used for physical link control
    - Autonegotiation, OAM, Scrambler initialization, etc



Self synch with CRC Header

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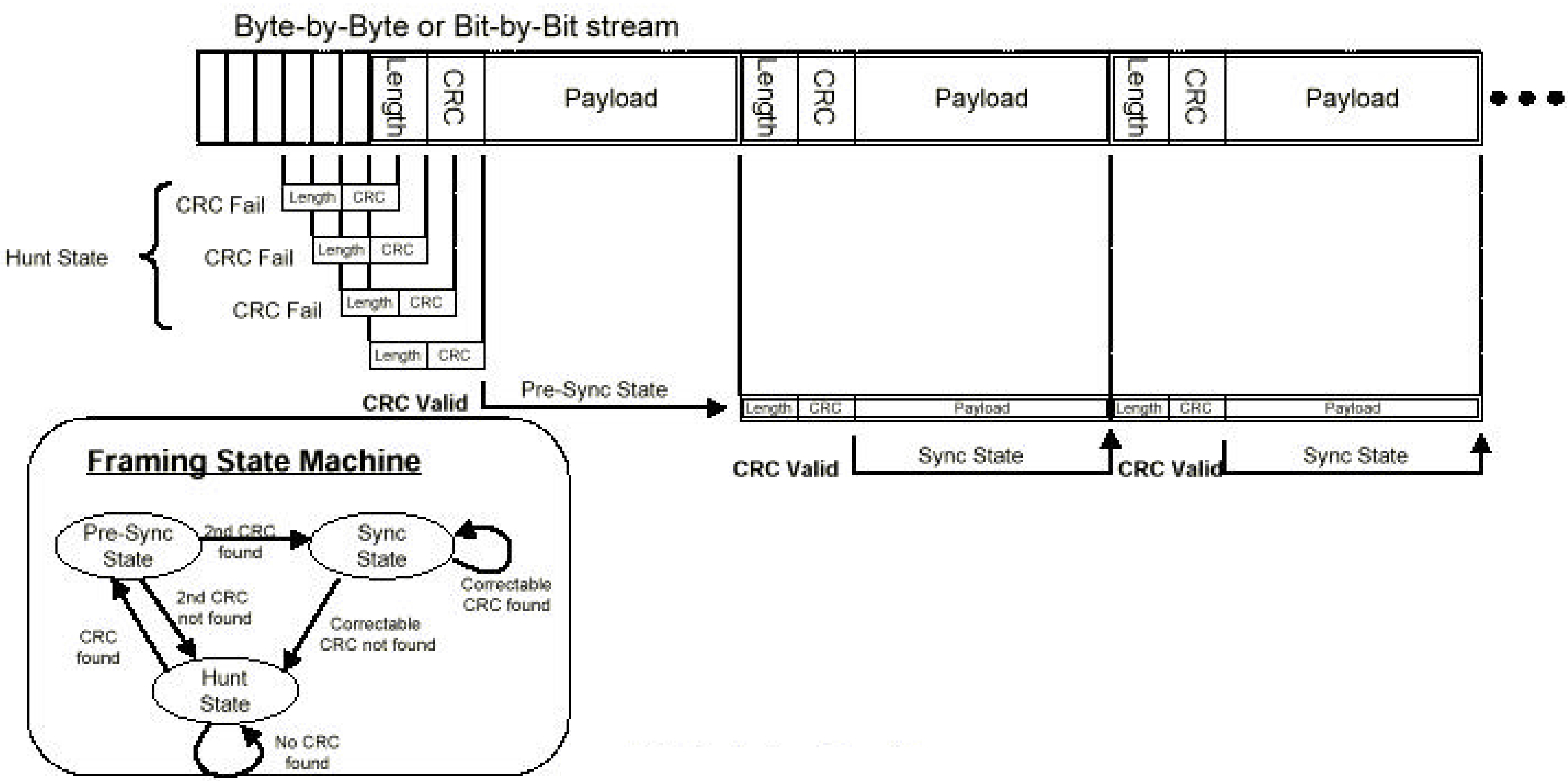
- When two consecutive CRC headers are valid, then the link is synchronized



Output data stream to PMD

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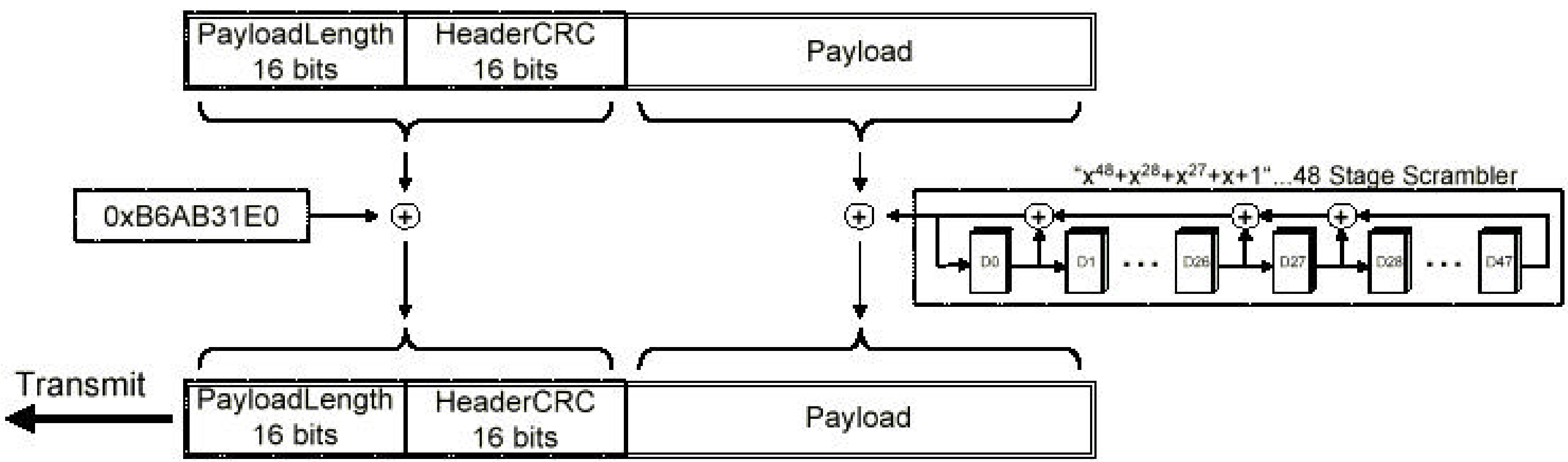
- Header is XORd prior to transmission with a 32 bit value
- Payload is scrambled through 48 stage scrambler



PMD Distance and Cost Considerations

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- Short haul (<300M) applications will be most numerous
  - Require low cost, compact solutions for dense interfaces
  - 850 nm, VCSEL technology is best suited
- Longer applications operate on Single Mode fiber
  - 1300 nm is the band of choice for flattest dispersion slope
  - 1550 nm band offers lower loss (longer distance) at the cost of dispersion compensations. Suitable for telecom applications with very long range.
  - Fabry Perot lasers are simplest, cheapest devices
  - DFB lasers are more expensive.
    - Uncooled devices are more affordable.

Summary of Objectives

- 10 Gig payload rate
- Serial Ethernet transmission
- Framed, scrambled transmission control layer with low overhead
- Multiple PMDs as follows

Summary - PMD Objectives

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- Building Applications
  - Installed Base (160MhzKm) Multimode Fiber 300 M
  - High Performance Multimode Fiber (850nm) 300 M
  - Low cost VCSEL devices
- Campus Fiber (1300nm) 5 Km
  - Fabry Perot Laser, low cost devices
- Metropolitan Fiber (1300nm) 15 Km
  - Uncooled, low cost DFB laser
- Metropolitan Fiber (1285nm) 50 Km
  - Temperature stabilized DFB laser