Multi-PHY Bonding in DSL

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Multi-PHY Bonding Advantages

- **Increases reach to deliver high speed services**
- **Low Complexity:**
  - can be implemented in multi-line DSL transceivers without extra chips.
- **No Extra Overhead:**
  - Reuse existing DSL messaging methods - no extra header bytes wasted for bonding.
- **Rapidly adapt to Line Errors and Failures:**
  - Drop (or Add) lines quickly when lines fail (or lines come up).
- **Transparent to upper layers:**
  - acts like single line, maintains byte (& packet) order
- **Improves Latency**
  - can reduce modem's end-to-end latency for bonded case
- **Coordinate x-talk cancellation**

VDSL Std sub-layers

- **VDSL modem sublayers:**
  - Transport Protocol Specific Transmission Convergence (TPS-TC) sublayer
  - Physical Media Specific Transmission Convergence (PMS-TC) sublayer
  - Physical Media Dependent (PMD) sublayer
- **TPS-TC sublayer being defined for Ethernet Transport**
  - HDLC encapsulation with byte stuffing for rate matching

Ethernet over Single VDSL/ADSL line

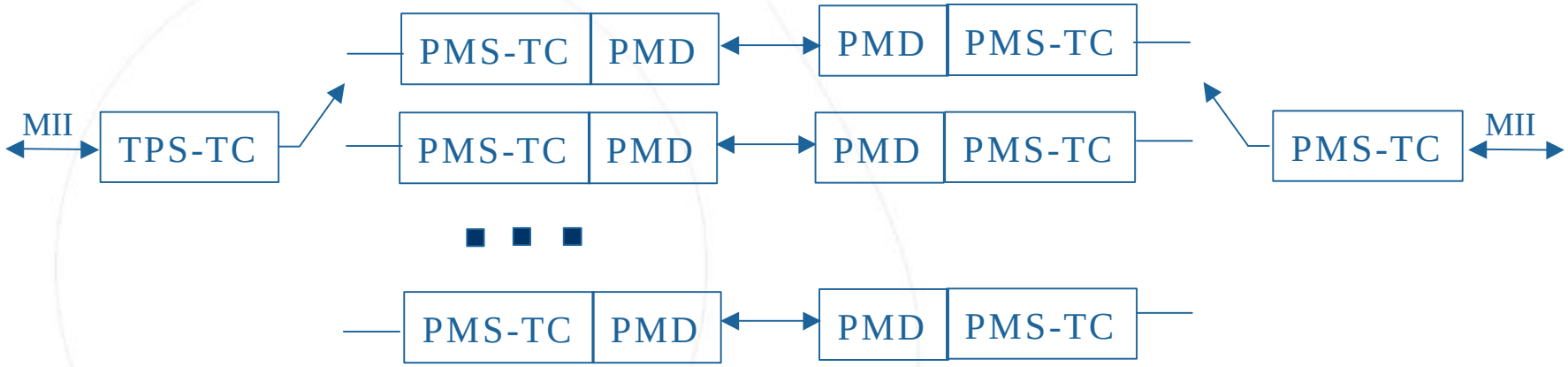
Channel Initialization

- **Single Channel Initialization, SCI**
  - Determine channel capacity
  - Determine noise margin
  - Identify presence of narowband and wideband disturbers
  - Determine bit rate
- **Multi PHY Channel Initialization, MCI**
  - Repeat n times SCI
- **Bonding**
  - Coordinate across n channels
- **Advanced features**
  - Optimize PSD by sharing channel information

Multi-PHY Bonding

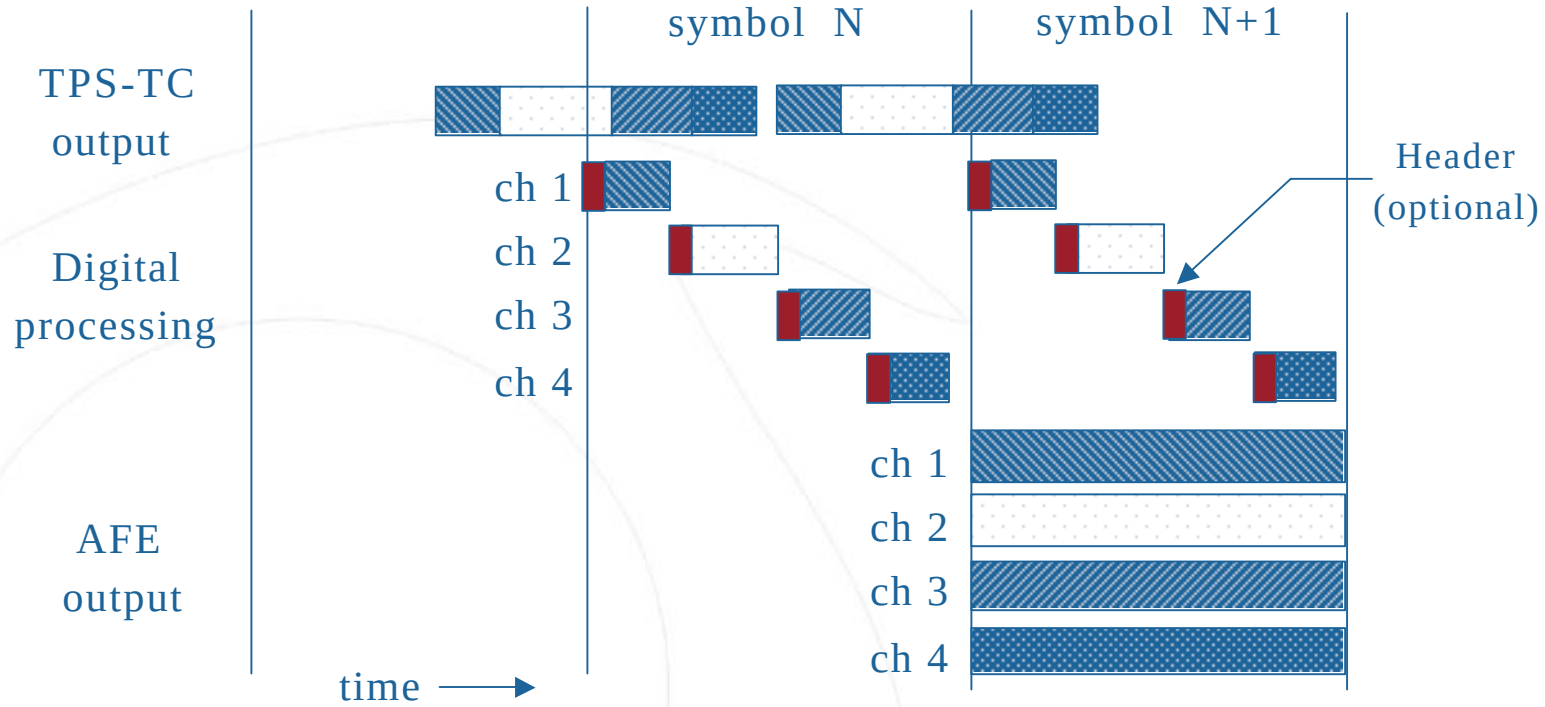
TPS-TC sublayer output muxed onto multiple lines:

- TPS-TC output is rate matched stream of bytes
- Send TPS-TC output on each line, once every symbol, in sequence
- Each line takes the number of bytes which will be sent per symbol on that line
- Receive side puts them back together in same sequence



Ethernet over Multiple Bonded DSL lines

Data Flow in Bonded System



Data flow thru 4 channel Bonded DSL system

Control of Bonded System

- **Optional header has sequence number:**
  - Sequence number used for segmenting and reassembly
- **Can work without header:**
  - When a line comes up, it is assigned an ID by CO side and a position in the line sequence used for segmenting and re-assembly
  - When a line goes down, EOC messages can be sent on other lines to drop the line from the line sequence
- **CRC check of segments not needed:**
  - Segments sent on each line already have CRC & RS encoder (DSL framing)
  - HDLC encapsulation adds its own CRC
  - Ethernet frames have their own 32-bit CRC