Introduction to the HSMT physical layer

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Main Content

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- Background
- Objectives
- Physical layer process
  - ✓ 64B/66B
  - ✓ PLDB Framing
  - ✓ RS-FEC and interleaving
  - ✓ Scrambling
  - ✓ Retransmission
- Conclusion

Background

- HSMT is short for High-Speed Media Transmission.

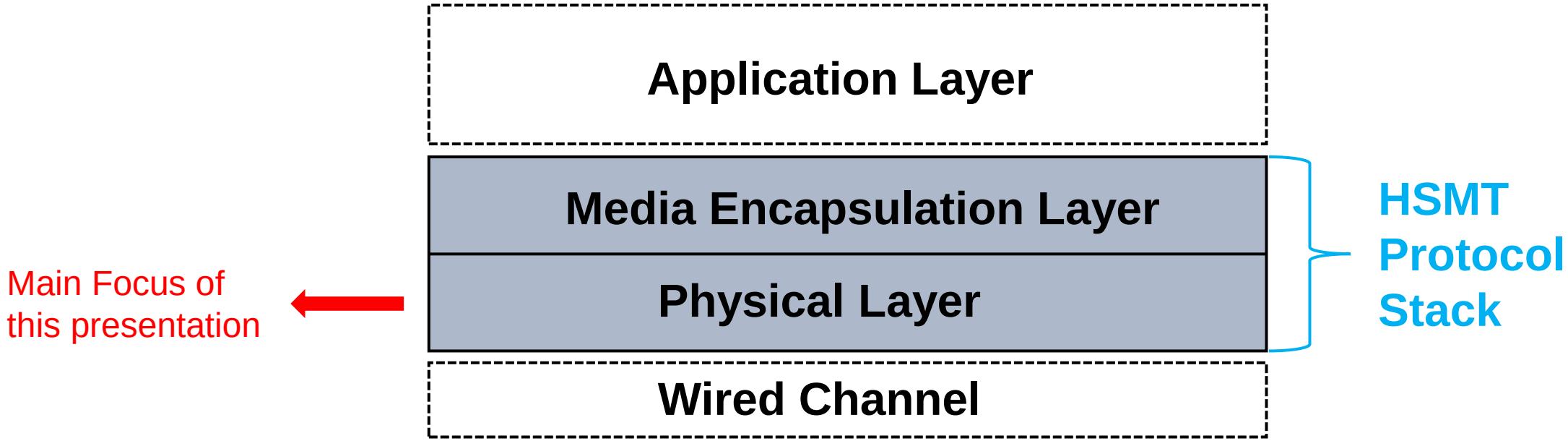
Misunderstanding: HSMT specifically refers to China's asymmetric SerDes video transmission protocol.

Truth: HSMT stands for a series of industry standards issued by the China Automotive Industry Standards Committee.

- ✓ **Video/Display transmission:**
  - ➢ **QC/T 1217-2024, published.** Full name '*Automotive wired high-speed media transmission — Multi-gigabit full-duplex system — Technical requirements and test methods*' ->For simplicity, in this presentation, HSMT specifically refers to this standard
  - ➢ **Planning to evolve to higher speeds (25.6Gbps for display). Just about to launch.**
- ✓ **Audio transmission: Two protocols under development.** Full name '*Technical Requirements and Test Methods for Automotive Audio Bus Chips*' and '*Automotive Wired High-Speed Media Transmission—100 Megabit Time-Division-Duplex-System—Technical Requirements and Test Methods*'

- The English version of the HSMT standard has also been released recently.

Background



- HSMT consists of a physical layer and a media encapsulation layer, enabling relatively independent evolution for both layers.
- The media encapsulation layer ensures flexible adaptation to different applications, and various formats can be conveniently extended and adapted, such as for new applications like millimeter-wave radar and LiDAR.

Objectives

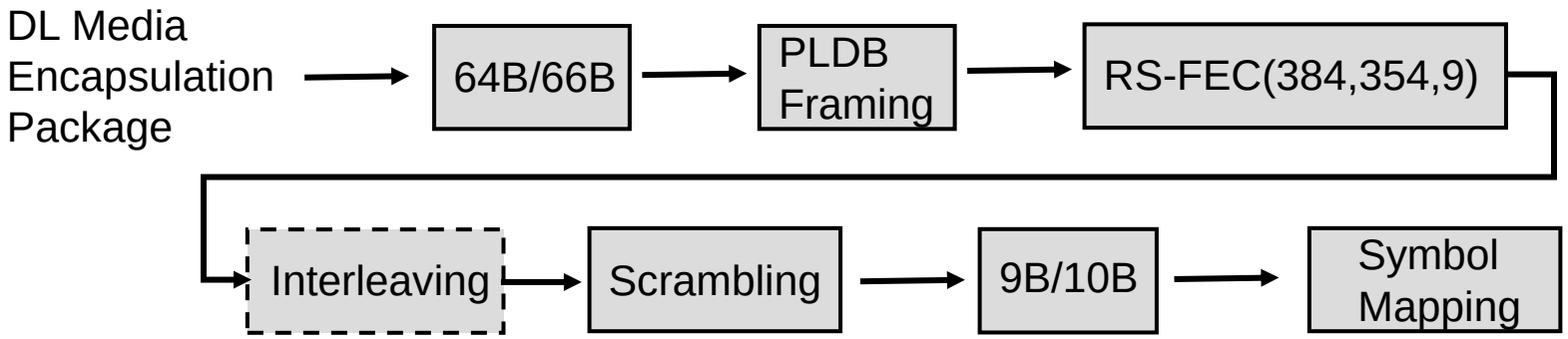
- The HSMT standard supports multiple rates in the table below

Speed Grade	Modulation	Speed
DL 1	NRZ	2 Gbps
DL 2	NRZ	3.2 Gbps
DL 3	NRZ	4 Gbps
DL 4	NRZ	6.4 Gbps
DL 4a	PAM4	6.4 Gbps
DL 5	NRZ	8 Gbps
DL 5a	PAM4	8 Gbps
DL 6	PAM4	12.8 Gbps
UL 1	NRZ	100 Mbps

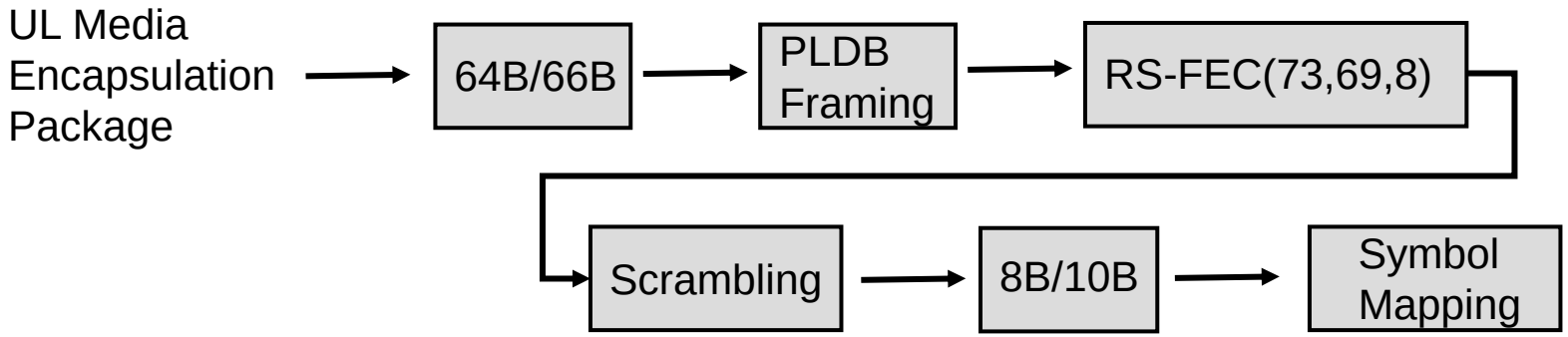
- In the downlink rate, Speed Grade 1~4 are mandatory, while 4a, 5, 5a, and 6 are optional.
- If an 8Gbps transmission rate is supported, PAM4(5a) is mandatory and NRZ(5) is optional.
- **All the speeds specified are line rates instead of net rates.**
- BER should be ≤ 10^-12.

Physical layer process

Downstream



Upstream



**The step for synchronization is omitted for simplicity.*

64B/66B

- 64B/66B process is the same for UL and DL.
- The Physical Layer divides the media encapsulation packet (MEP) into one or more 64-bit fragments, each of which is encoded into a 66B code block via 64B/66B encoding.
- The two extra bits are used to indicate the position of fragments and provide control information.

XX	66B Payload (bits 2~65)

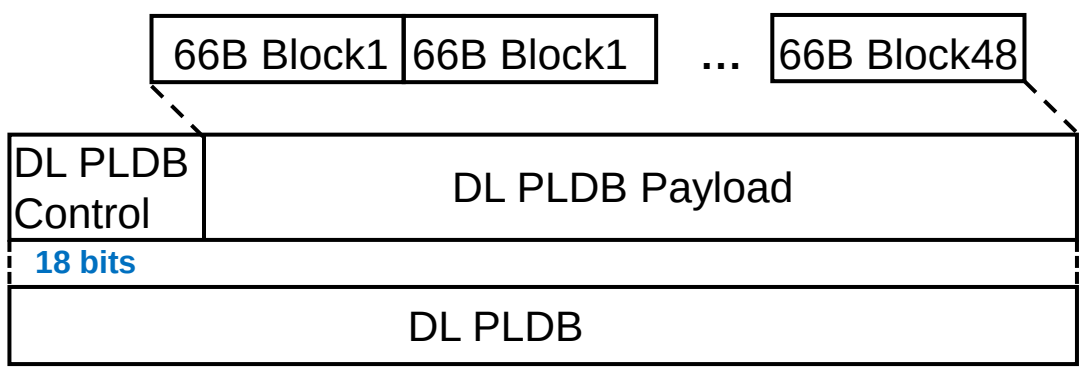
00	This 66B code block carries the **middle** fragment of the MEP
01	This 66B code block carries the **first** fragment of the MEP
10	This 66B code block carries the **last** fragment of the MEP
11	This 66B code block carries Physical Layer **padding** and **control** information

- When the two extra bits are 11, the lower four bits of the 66B payload are the sub-indicator bits.

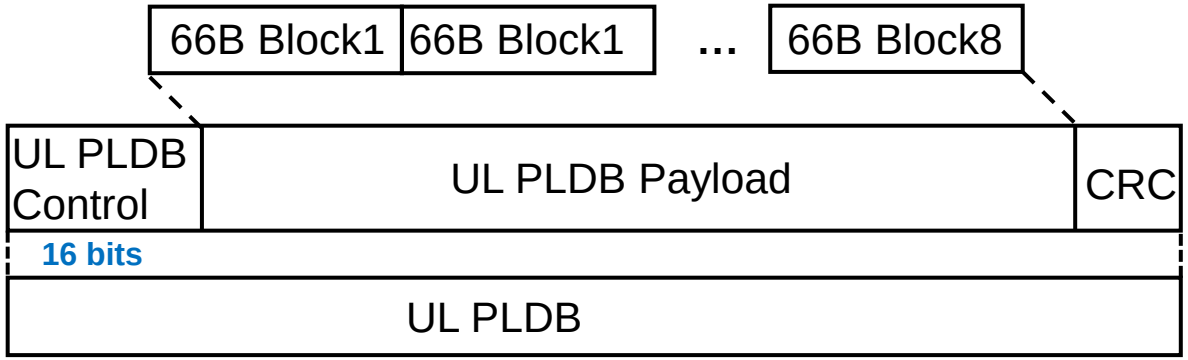
66B Payload indicator [1:0]	**Sub-indicator [5:2]**	**meaning**
11	0000	Physical layer padding, all 64bits are 0.
	xyz0. x, y, and z can be 0 or 1, but they cannot all be 0.	indicate **retransmission**, link re-establishment and other control information.
	xyz1. x, y, and z can be 0 or 1	Packet from MEP is a mini-packet.

PLDB Framing

PLDB is short for Physical Layer Data Block



DL PLDB



UL PLDB

- The PLDB control information is mainly related to retransmission function
  - ✓ The first 12 bits of DL PLDB Control and the first 10 bits of UL PLDB Control are used for indicating PLDB ID.
  - ✓ The remaining bits indicate whether the PLDB is a retransmittable PLDB, a padding PLDB, or a non-retransmittable PLDB.
  - ✓ For DL, there is even one bit (the 14th bit) that can be used to indicate whether to terminate the current pending retransmission.

RS-FEC and Interleaving

Downstream

- After PLDB framing, one DL PLDB contains 66bits*48Blocks+18bits=3186bits=354*9
- RS-FEC (384, 354, 9) adds 30 Parity symbols to each DL PLDB to form the DL RS-FEC block.
- RS-FEC blocks can be interleaved, and the interleaving depth L depends on Speed Grade.

Speed Grade	Modulation	Speed	L
DL 1	NRZ	2 Gbps	1
DL 2	NRZ	3.2 Gbps	1
DL 3	NRZ	4 Gbps	1
DL 4	NRZ	6.4 Gbps	1/2
DL 4a	PAM4	6.4 Gbps	2/4
DL 5	NRZ	8 Gbps	1/2/4
DL 5a	PAM4	8 Gbps	2/4
DL 6	PAM4	12.8 Gbps	2/4

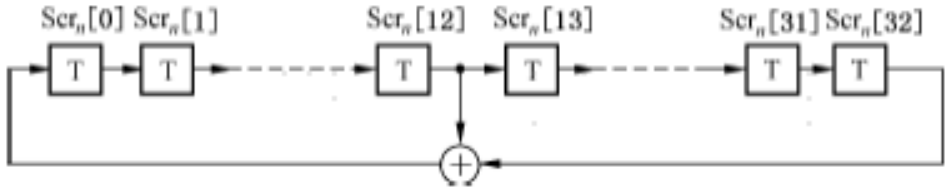
Upstream

- After PLDB framing, one UL PLDB contains 66bits*8Blocks+16bits+8bits=552bits=69*8
- RS-FEC (73, 69, 8) adds 4 Parity symbols to each UL PLDB to form the UL RS-FEC block.

Scrambling

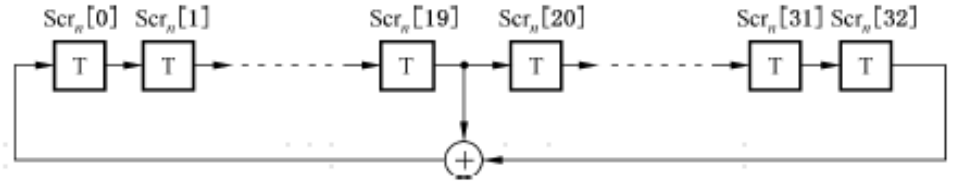
HSMT Downstream:

Scrambler generator polynomial: $x^{33} + x^{13} + 1$



HSMT Upstream:

Scrambler generator polynomial: $x^{33} + x^{20} + 1$

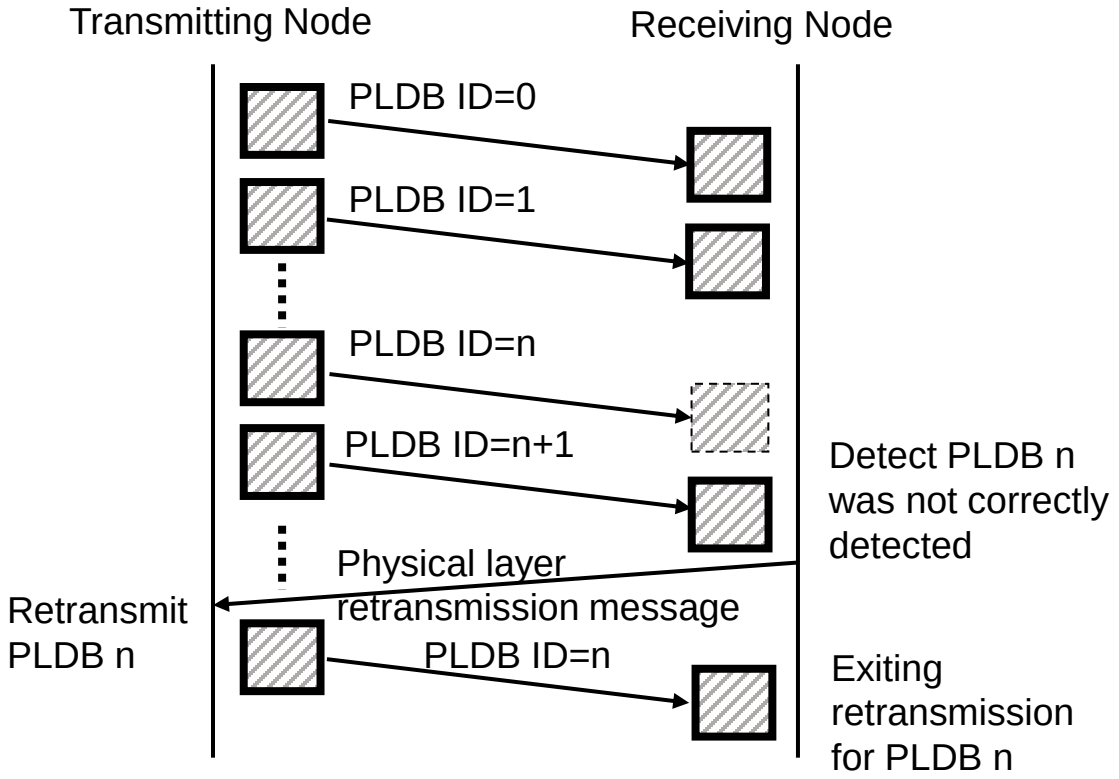


After scrambling, data transmission at the physical layer is accomplished through 8B/10B(UL) or 9B/10B(DL) encoding and symbol mapping.

Retransmission

For both UL and DL, HSMT further supports retransmission mechanism to further increase the robustness

- Retransmission can target single or multiple PLDB packets.
  - ✓ Multi-PLDB retransmission mode -> must to have for DL retransmission, not support for UL retransmission
  - ✓ single-PLDB retransmission mode -> nice to have for both DL and UL retransmission



- Retransmission is initiated by the receiver.
- The *physical layer retransmission message* will include all the information needed by the transmitter to perform the retransmission, such as:
  - ✓ PLDB ID -> the PLDB to be transmitted
  - ✓ Retransmission mode indicator M -> If M=0, retransmit the PLDB indicated by the PLDB ID. If M=1, retransmit all the PLDB packets from the one indicated by the PLDB ID.
  - ✓ Terminate retransmission indication -> Both transmitting node and receiving node can terminate retransmission

For one single transmission, HSMT can achieve end-to-end low-latency transmission within 20 microseconds.

Conclusion

- HSMT stands for a series of industry standards, but it is usually known for video transmission
- HSMT supports 8 different speed grades in DL, with line rates ranging from 2Gbps to 12.8Gbps. At intermediate rates (such as 6.4Gbps and 8Gbps), HSMT provides two optional modulation schemes—PAM2 and PAM4.
- HSMT has its unique 64B/66B, PLDB framing and retransmission functions. Retransmission offers additional robustness with small latency.

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Thank You!