Feasibility Framework for 10SPE Automotive

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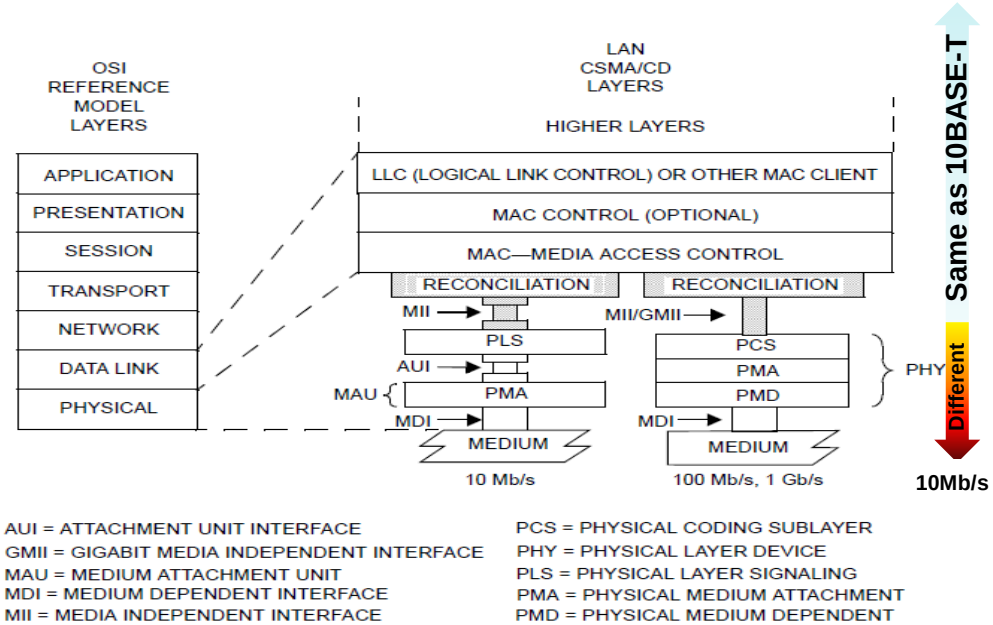
Purpose of this presentation

- Establish and agree on a framework to discuss Economic and Technical Feasibility for 10Mb/s SPE
- Show an initial analysis for various technical options for the given cost constraint
- To that effect this presentation will propose terms and a framework. This presentation ***will not*** propose a specific solution
- *Goal is to show the feasibility and agree on a framework that allows for an “apples-to-apples” comparison across the various technology choices*

Where do we start with the system?

- Start with 10BASE-T & 100BASE-T1 as baseline
- What is really different for 10SPE
  - Above the PHY: Same as 10BASE-T from RS to MAC & above (e.g. switch)
  - PHY: A portion will be different. A portion the same
    - E.g. PCS will be different
    - E.g. PMA will be different due to the definition of a new channel and cost constraint
    - TX/RX-AFE will change
    - DSP may be optional
  - Below the PHY: Different
    - MDI and medium (channel)
    - MII is optional



AUI = ATTACHMENT UNIT INTERFACE
GMII = GIGABIT MEDIA INDEPENDENT INTERFACE
MAU = MEDIUM ATTACHMENT UNIT
MDI = MEDIUM DEPENDENT INTERFACE
MII = MEDIA INDEPENDENT INTERFACE

PCS = PHYSICAL CODING SUBLAYER
PHY = PHYSICAL LAYER DEVICE
PLS = PHYSICAL LAYER SIGNALING
PMA = PHYSICAL MEDIUM ATTACHMENT
PMD = PHYSICAL MEDIUM DEPENDENT

Thus, consider from the PHY downwards

Framework: Methodology

- **Economic feasibility**
  - List of all components and number of components per link partner pair
  - Cost relative to a baseline of 10BASE-T & 100BASE-T1
  - Complexity can be assigned a percentage over a baseline subsystem
  - Savings (e.g. weight) can be assigned a percentage over baseline
- **Technical feasibility**
  - Line signaling (baud rate, modulation, PCS encoding/decoding, error correction, etc.)
  - Margin with respect to immunity
  - Emission properties
  - Receiver complexity
- **Other factors**
  - **Cable**
    - Size: If a constraint can be considered separately (distance supported vs. IL vs. wire diameter)
    - Jacketed vs. unjacketed: Unjacketed cable is preferred from an economic feasibility point of view
  - **EMC properties (**radiated & conducted emissions / immunity)
  - **Application assumptions**
    - If underlying application requirements change the channel or the constrains, more than one set of comparisons may be needed. E.g. if industrial requirements differ from automotive.

Economic Feasibility Framework: Sample Relative Comparison to 100BASE-T1 & 10BASE-T Baseline

- **Components**
  - **PHY**
    - **PCS**
    - **PMA**
      - **TX**
        - » **AFE**
        - » **Digital**
      - **RX**
        - » **AFE**
        - » **DSP**
  - **MDI / Channel**
    - **Magnetics**
    - **Connectors**
    - **Cable**
    - **PCB**
- **Other drivers**
  - **Cable harness weight**
  - **Latency, Link Acquisition Time**
  - **EMC properties**

	100BASE-T1		10BASE-T		10SPE	
PHY	Quantity	Complexity	Quantity	Complexity	Quantity	Complexity
PCS	1	1	1	0.25	1	0.25
PMA	1	1	1	0.25	1	0.25
TX	1	1	1	0.25	1	0.25
AFE	1	1	1	0.25	1	0.25
Digital	1	1	1	0.25	1	0.25
RX	1	1	1	0.1	1	0.25
AFE	1	1	1	0.1	1	0.1
Digital & DSP	1	1	1	0.1	1	0.25
MDI/Channel						
Magnetics	1	1	2	1	1	1
Connectors	1	1	2	2	1	0.5
Cable	1	1	2	2	1	0.5
PCB	1	1	1	0.5	1	0.5
Weight		1		2		1
TOTAL COMPLEXITY		1		1 * x% > 1		1 * z% < 0.5

- **Packaging is an important factor as well but it is strongly dependent on the implementation. Therefore, it is part of absolute cost analysis for x% and z% and not relative cost comparison as provided here.**
- **It is economically feasible to attain a 10SPE PHY with less than 50% cost of 100BASE-T1 PHY**

Technical Feasibility Framework:

- **Baseband FDX, TDD, FDD**
- **Line Signaling**
- **PCS Encoding/Decoding**
- **EMC Properties**
  - Radiated & conducted emissions
  - Margin with respect to immunity
- **Receiver Complexity** → low-pin-count, low-power is desired
- **Other factors**
  - Existing cables & connectors
  - PoDL
  - Application assumptions
    - If underlying application requirements change the channel or the constrains, more than one set of comparisons may be needed. E.g. if industrial requirements differ from automotive.

Line Signaling Options

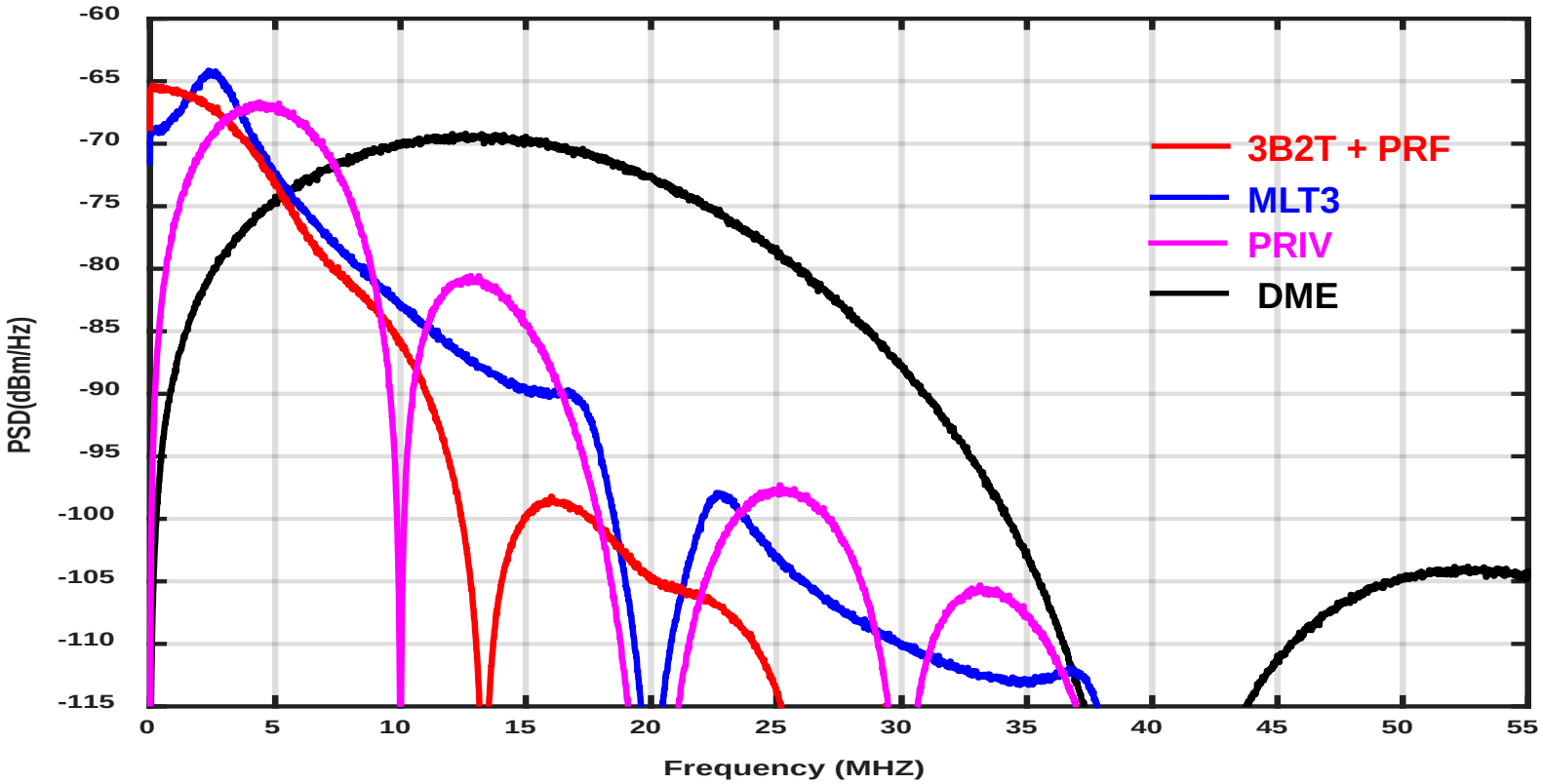
- Baseband Time Division Duplexing (TDD) amenable from cost objective perspective.
- Echo cancelled full-duplex baseband transmission makes
  - PHY MDI design more complicated both for the analog front end and the DSP → Cost-constraint cannot be achievable.
  - BOM more costly through tighter specification requirement of return loss for cabling connectors, and chokes → Economic feasibility may not be possible.
- For this feasibility study, Full Duplex 10Mbps at MAC layer for point-to-point links achieved by transmitting MDI data at 20MBps with “Ping-Pong” TDD.
  - Ergo, the cost constrain can be attained!
- Point-to-Multipoint is not precluded by Baseband TDD.

Line Signaling Options (cntd.)

	PAM-3 (3B2T) [1]	MLT-3 [2]	DME [3]	PR-IV [4]
Bits Per Baud	1.5	1	0.5	1
$T_{symbol, nsec}$	75	50	25	50
Vpk-pk, TX (next slide)	1	1	1	1
DAC Levels	9	3	2	3
Peak to Average Power Ratio	1.65	1.57	1.42	1.77
Self-Synchronizing	No	No	✓	No
Error Detection?	No	Possible	Possible	✓
DC Free?	No	No	Yes	Yes
Compatibility with PoDL	Difficult	Difficult	Very Good	Good
Compatibility with extended reach	Good	Ok	Difficult	Good

References [1] 802.3 Clause 96 [2] 802.3 Clause 25 [3] 802.3 Clause 98 [4] Signalling Terminology: PAM-M and Partial Response Precoders

Line Signaling Options (cntd.)



Conclusions

- **Framework to discuss feasibility has been established**
  - Consider deltas from 10BASE-T & 100BASE-T1 → Portions of PHY and below vs. MAC and above.
  - Overall system cost and feasibility has to be considered → PHY, channel, relative cost, EMC.
- **Economic feasibility**
  - The analysis for this presentation is done based on the channel models available from IEEE 802.3bw and chini_buntz_10SPE_01a_0916.pdf.
  - As shown in sample comparison chart, it is economically feasible to build 10SPE PHYs with relative cost 50% less than 100BASE-T1.
  - There may be further cost reductions in the channel components (E.g., magnetics).
- **Technical Feasibility**
  - In part dependent on the channel definition. Need to agree on some basic parameters of the link segment.
  - There exist low-pin-count, low power media independent interface options (cordaro_thaler_10SPE_01a_0916.pdf).
  - There exist line signaling techniques to achieve 10Mbit/s over single twisted pair channels within the given performance, cost and power constraints. Therefore, 10SPE is technically feasible.

Thank You!