10 Mbps Ethernet Technology and the Challenges Facing Automotive Microcontrollers

Vector Automotive Ethernet Symposium 2019
Harald Zweck, Expert Automotive Communication

Agenda

1. 10Mbps Ethernet – Introduction
2. The technology behind 10Mbps Ethernet and PLCA
3. Examples and options for Hardware implementations
4. Relation to other Ethernet standards
5. The standardization ecosystem and the most recent status
6. Outlook: Integration into the Automotive communication world

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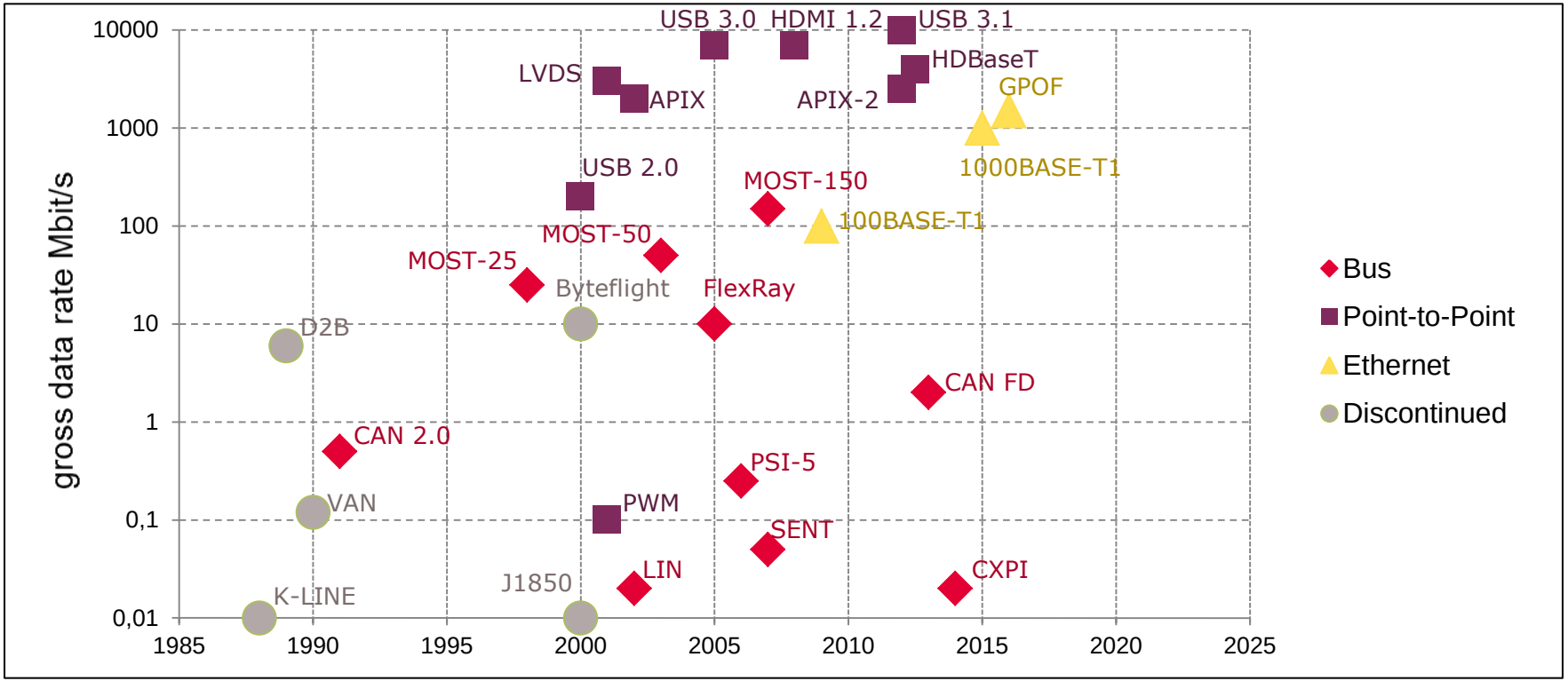
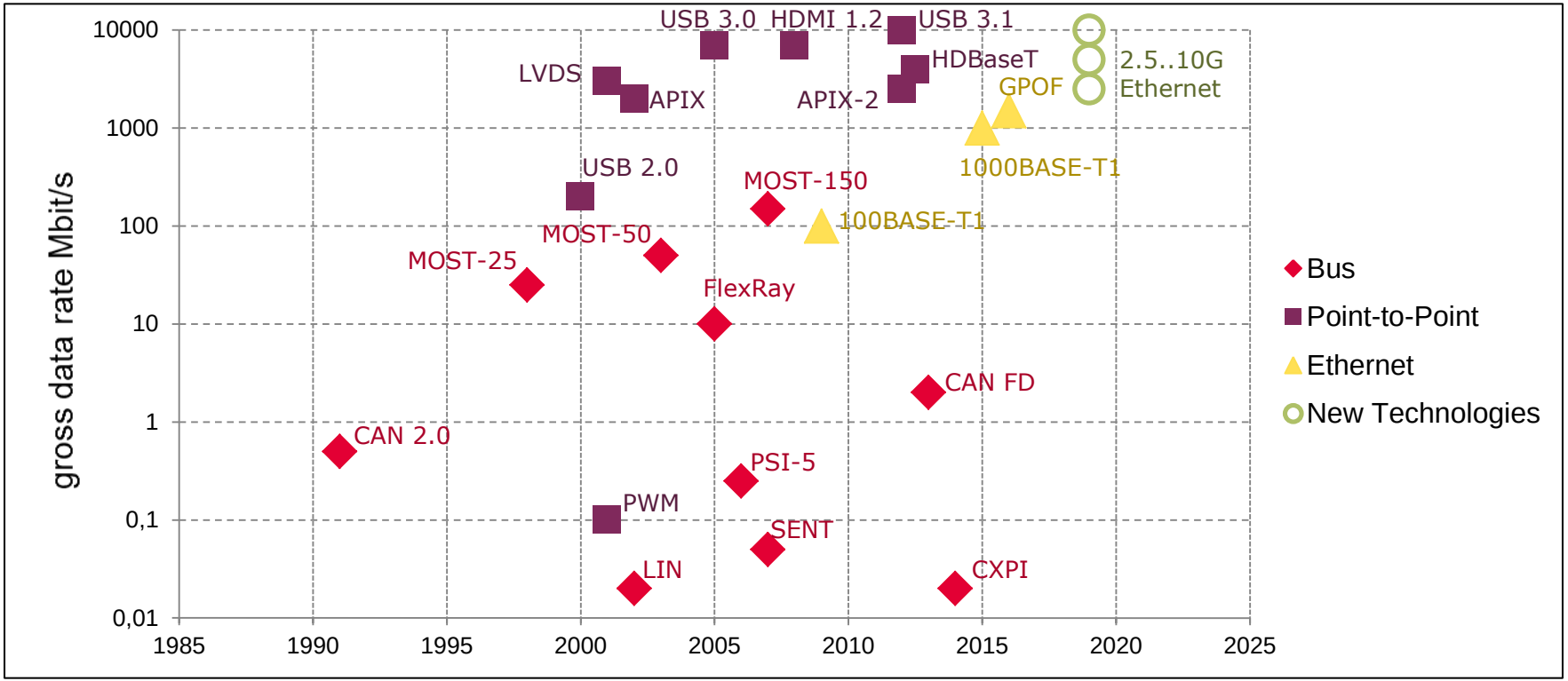
Trend in In-Vehicle-Networking
Growing number of network technologies over time



Taken from: Dr. Matheus, BMW Automotive Ethernet Congress, Munich, February 2017

Trends in In-Vehicle-Networking
New Technologies are based on Ethernet



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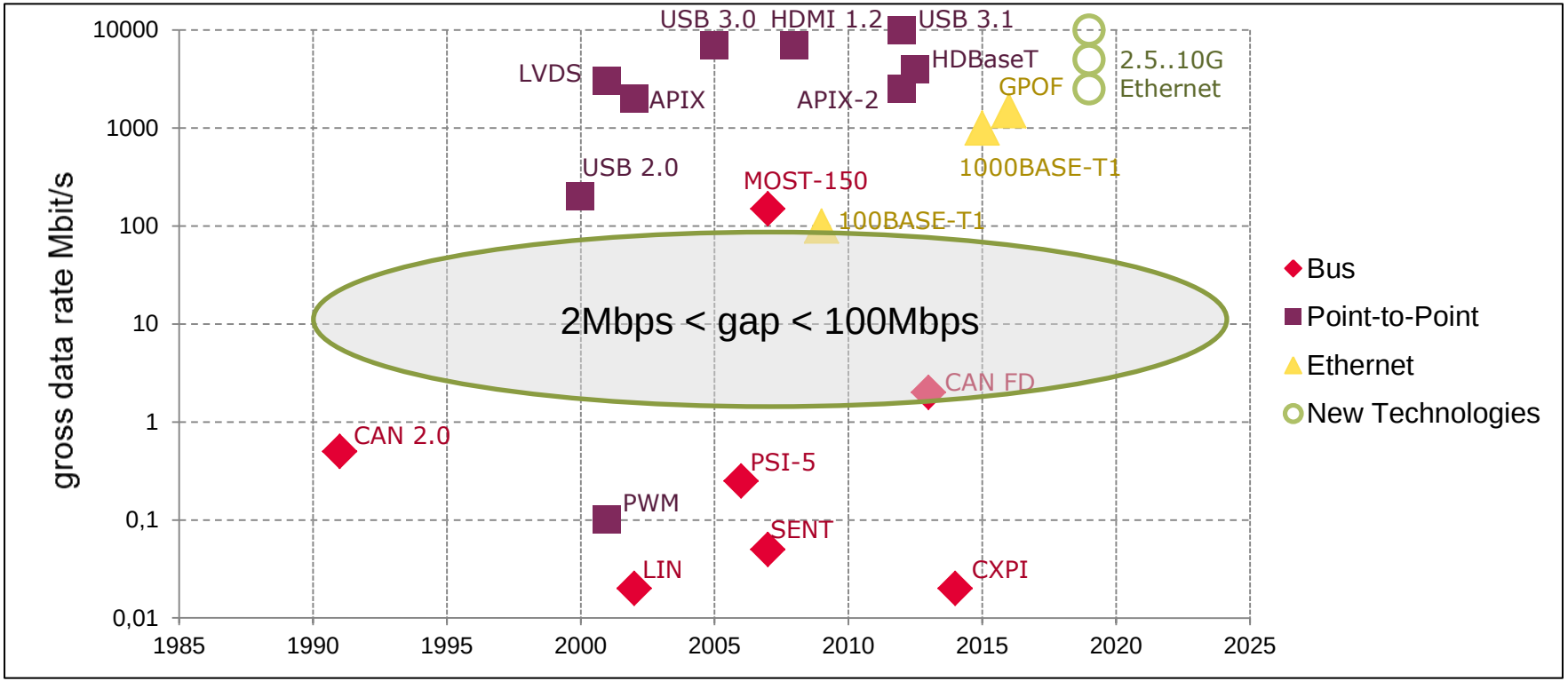
Trends in In-Vehicle-Networking
The Baud Rate Gap



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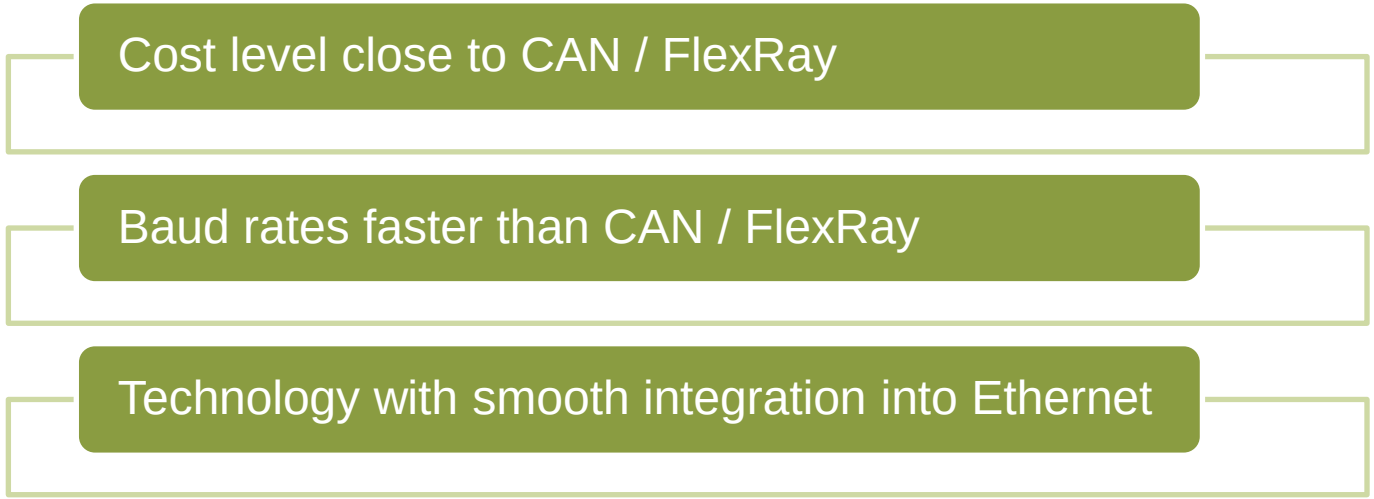
Summary

› Targets of 10Mbps* Ethernet technology



10Mbps: 10 Megabits per second

Some Clarifications

- The new 10Mbps Ethernet technology is called in IEEE 802.3: 10Base-T1S
  - 10Base => 10Mbps speed grade
  - T1 => physical layer is single twisted pair (unshielded)
  - S => short range (favorite solution for Automotive purposes)

- 10Base-T1S and PLCA (*"Physical Layer Collision Avoidance"*) and (old) 10Base-T are different

- The presentation covers 10Base-T1S multidrop version
  - The multidrop physical layer supports bus architectures (similar to CAN)

- The presentation does not cover 10Base-T1L point to point version
  - The P2P long range version targets industrial applications

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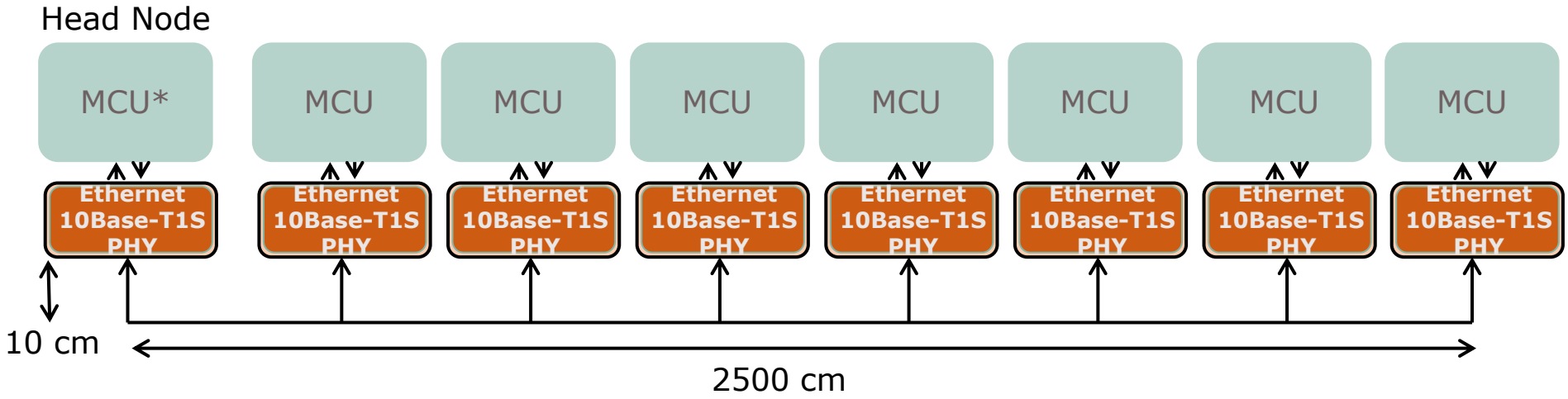
The technology behind 10Mbps Ethernet and PLCA*

- 10BASE-T1S supports bus architectures similar to CAN
- PLCA* based networks have one special node which controls the traffic on the bus -> Head Node



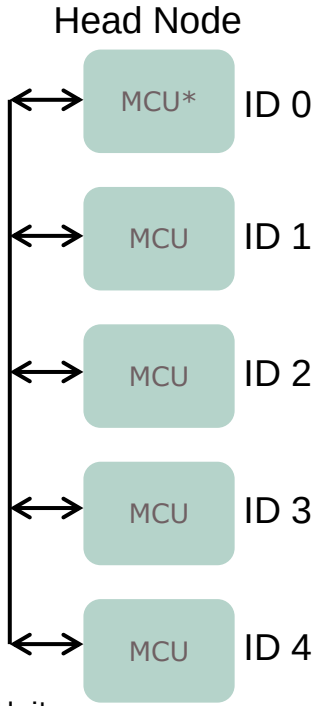
PLCA*: Physical Layer Collision Avoidance

MCU*: Microcontroller Unit

The technology behind 10Mbps Ethernet and PLCA

- 10BASE-T1S uses PLCA (*"Physical Layer Collision Avoidance"*) to resolve contentions

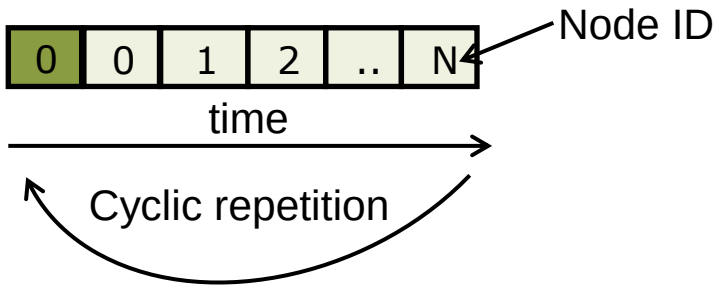
- Each node gets an ID assigned
- The head node has always the ID 0
- There is no relation to MAC / IP / VLAN addresses of the node

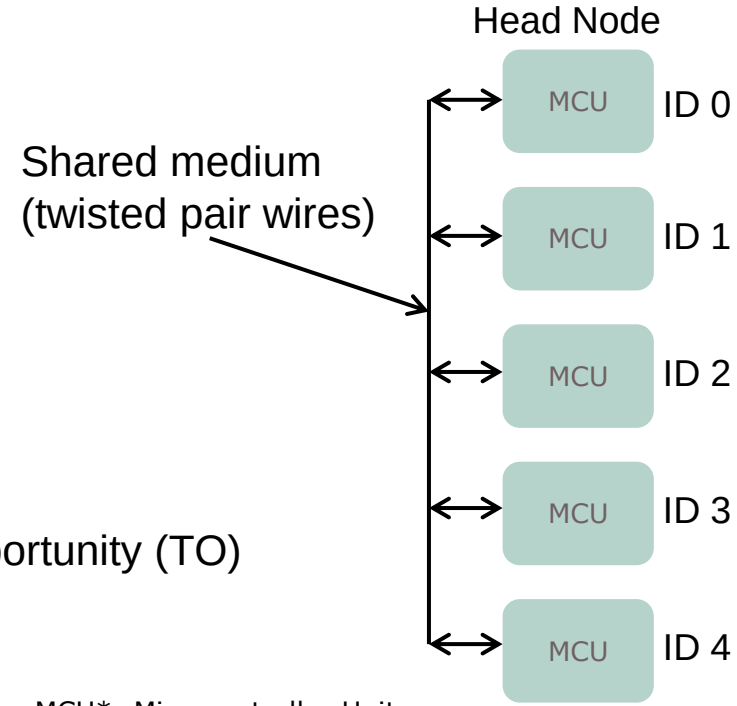


MCU*: Microcontroller Unit

The technology behind 10Mbps Ethernet and PLCA

- The PLCA* technology (basic functionality)
- PLCA* runs “cycles” on the shared medium





- Within a cycle each node is assigned a transmit opportunity (TO)
- During its TO the node is allowed to transmit data

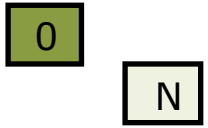
PLCA*: Physical Layer Collision Avoidance

MCU*: Microcontroller Unit

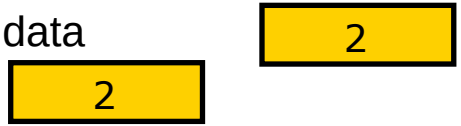
The technology behind 10Mbps Ethernet and PLCA

- PLCA* and half-duplex operation

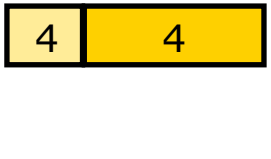
- Each cycle starts with a “beacon” sent by the head node
- A node can skip its transmit opportunity by leaving the time slot untouched



- During the time window with its node ID the node can transmit data
- The transmitting node will typically enlarge the time window



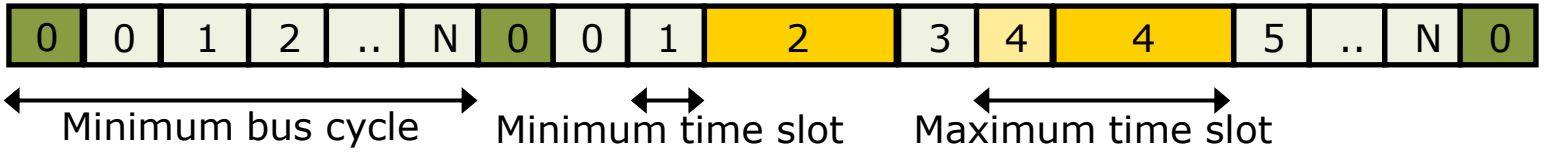
- A node can insert “idle” in its time window to extend the time slot to compensate MAC delays
- A node can burst high priority messages



PLCA*: Physical Layer Collision Avoidance

The technology behind 10Mbps Ethernet and PLCA

› PLCA* and half-duplex operation



› Minimum size of a time slot: The client does not use its slot
› Maximum size of a time slot: The client sends idle and the maximum sized Ethernet frame

› Minimum size of a bus cycle: beacon + (minimum time slot * number of clients)
› Maximum size of a bus cycle: All clients (incl. the head node) send maximum sized packet

PLCA*: Physical Layer Collision Avoidance

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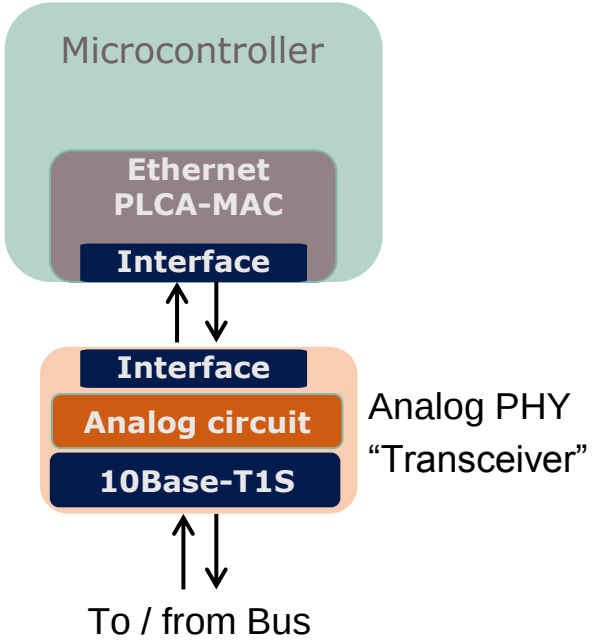
Examples and options for Hardware implementations

- Example implementation 10Base-T1S Analog PHY (“Transceiver”)

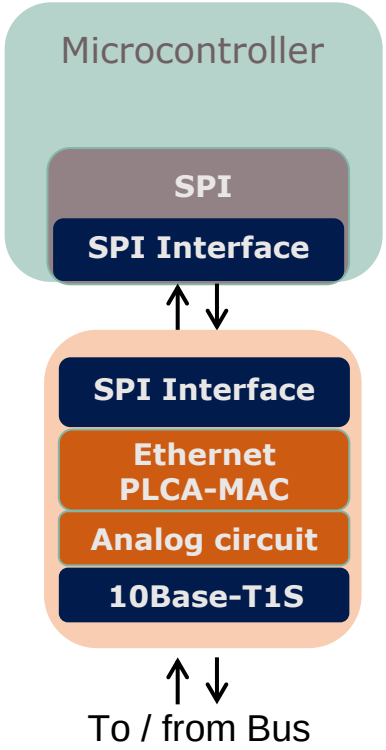
- PLCA is integrated into the microcontroller MAC
- Cost efficient PHY with analog circuits only
- Low pin count interface to MCU
- New interface between MAC and PHY required



PLCA*: Physical Layer Collision Avoidance

Examples and options for Hardware implementations

› Example implementation 10Base-T1S MAC-PHY



› MAC-PHY: PLCA function plus PHY

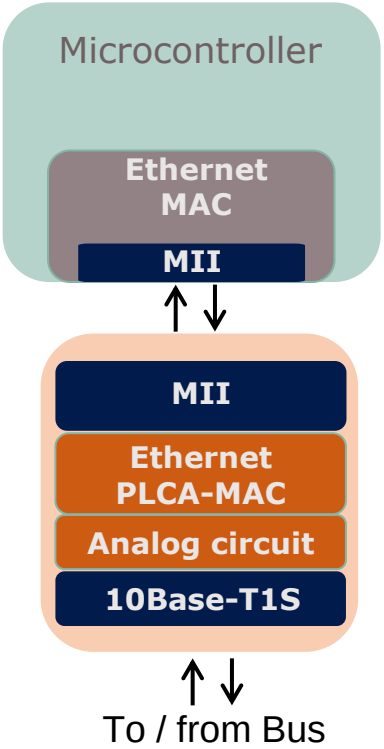
› The MAC-PHY contains digital plus analog functionality

› The interface between MC and PHY is an Automotive SPI

PLCA*: Physical Layer Collision Avoidance

Examples and options for Hardware implementations

› Example implementation 10Base-T1S MAC-PHY



› MAC-PHY: PLCA function plus PHY (“Transceiver”)

› The MAC-PHY contains digital plus analog functionality

› MC and PHY communicate via a standard MII interface

PLCA*: Physical Layer Collision Avoidance

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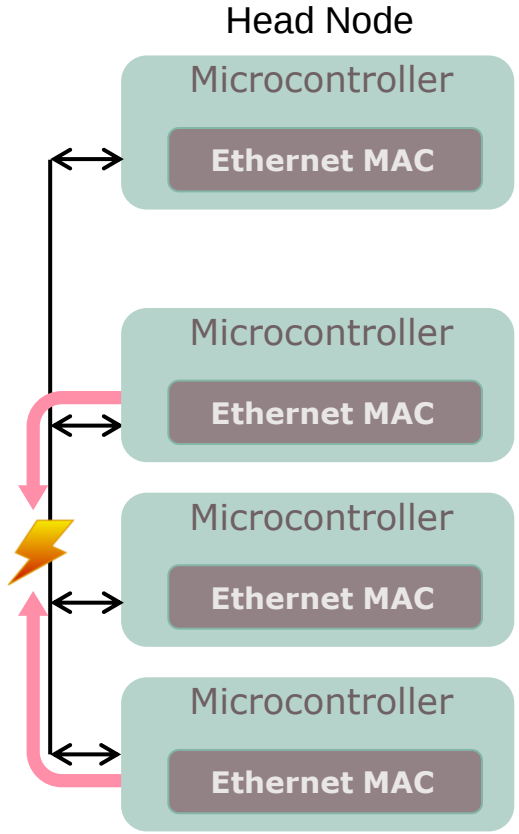
Relation to other IEEE Standards

- Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

- PLCA* is an extension of CSMA/CD
- CSMA/CD can be used to manage special exceptions like e.g. SW or HW failures

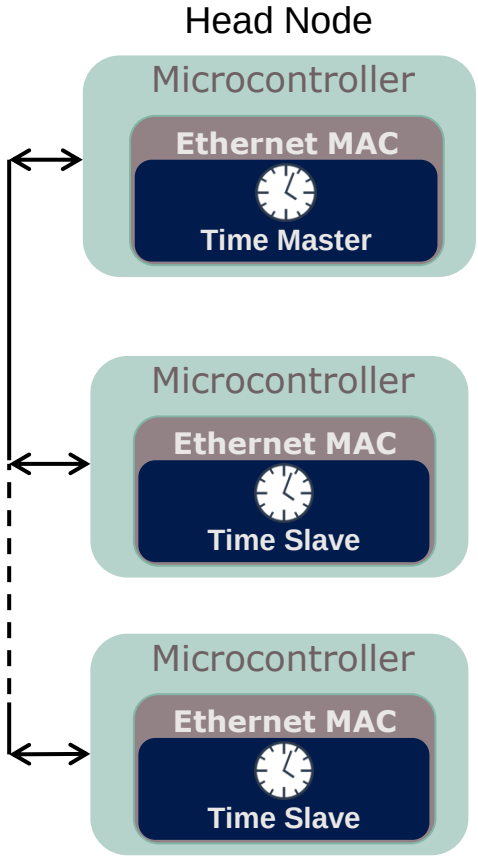


PLCA*: Physical Layer Collision Avoidance

Relation to other IEEE Standards

- 802.1AS Time Synchronization

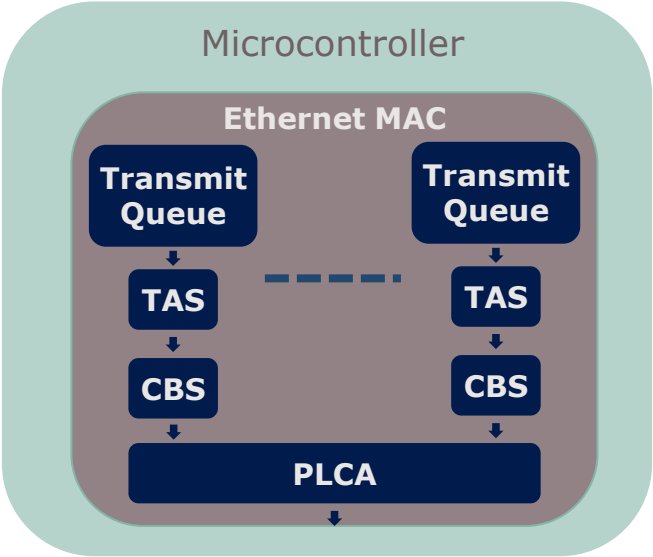
- PLCA* is not compatible to parts of the 802.1AS standard
  => not a technical issue
  => issue of how the 802.1AS standard works
- Several solutions currently in discussion (status as of today)



PLCA*: Physical Layer Collision Avoidance

Relation to other IEEE Standards

- 802.1Qbv (Time Aware Shaper - TAS)
- 802.1Qav (Credit Based Shaper - CBS)



- Shapers are independent of PLCA*
- But: PLCA* will have an impact on shaper effects

PLCA*: Physical Layer Collision Avoidance

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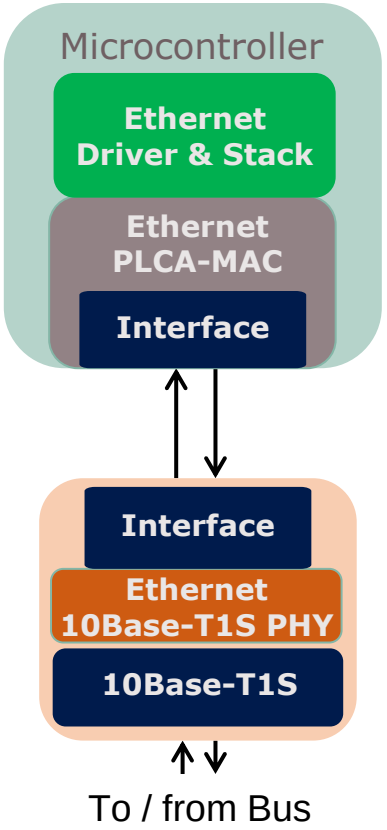
10Base-T1S related Standardization Eco System

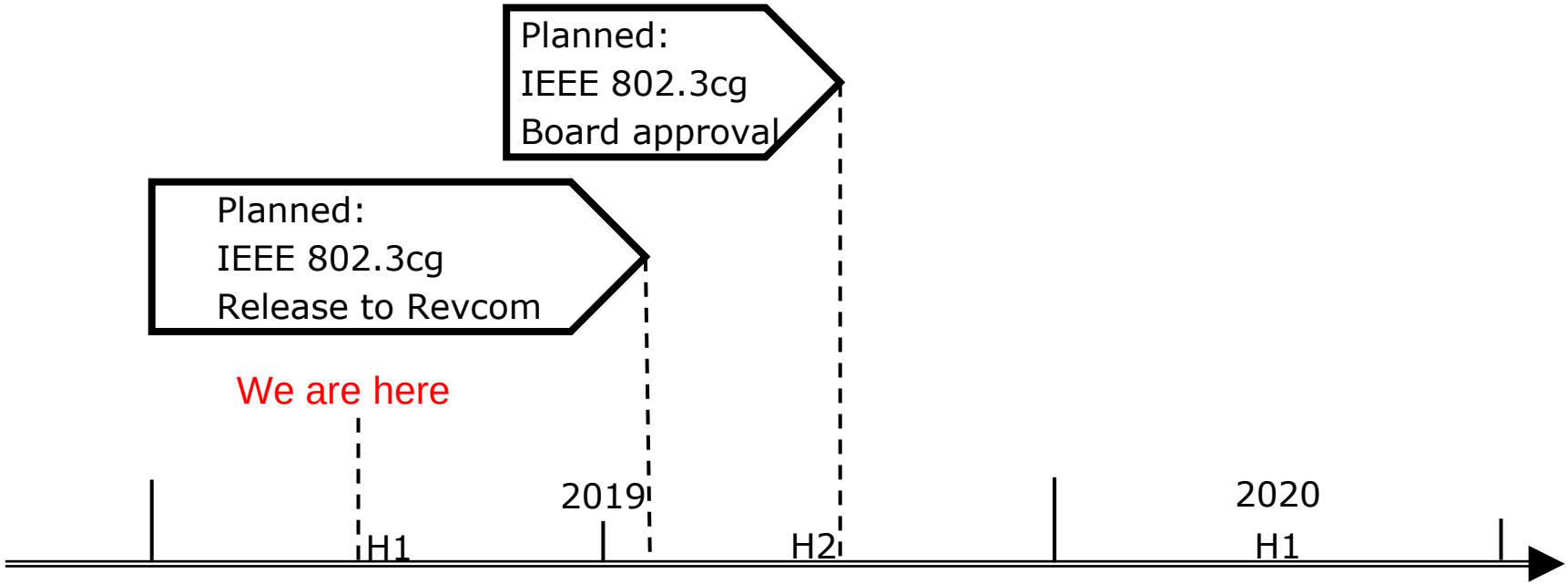
- Standardization activities for 10Mbps Ethernet
  - New SW components for PLCA: AutoSAR ? — **AutoSAR** ?
  - PLCA: IEEE 802.3cg, Clause 148 — **IEEE** 802.3cg
  - SPI interface MAC to PHY: OPEN TC6/TC14 JWG — **OPEN** TC6 / TC14
  - Analog PHY interface MAC to PHY: OPEN TC14
  - MII interface: Standard available
  - 10Base-T1S: IEEE 802.3cg, Clause 147 — **IEEE** 802.3cg
  - Test suite 10Base-T1S: OPEN TC14 — **OPEN** TC14
  - EPL*: IEEE 802.3cg, Clause 147 — **IEEE** 802.3cg



EPL*: Electrical Physical Layer

PLCA*: Physical Layer Collision Avoidance

Timeline of Standardization Eco System (Assumptions)



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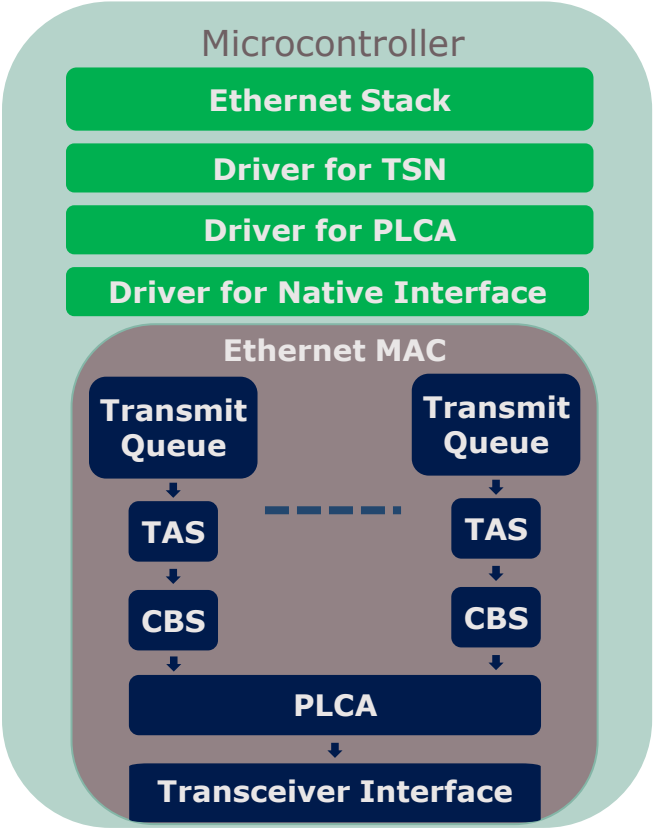
Integration into Automotive Microcontroller Ecosystem

- PLCA* compatible driver stacks – “Transceiver Interface”

- TSN drivers may have to be adapted to PLCA
- PLCA needs a driver set
- Transceiver Interface needs a new driver set

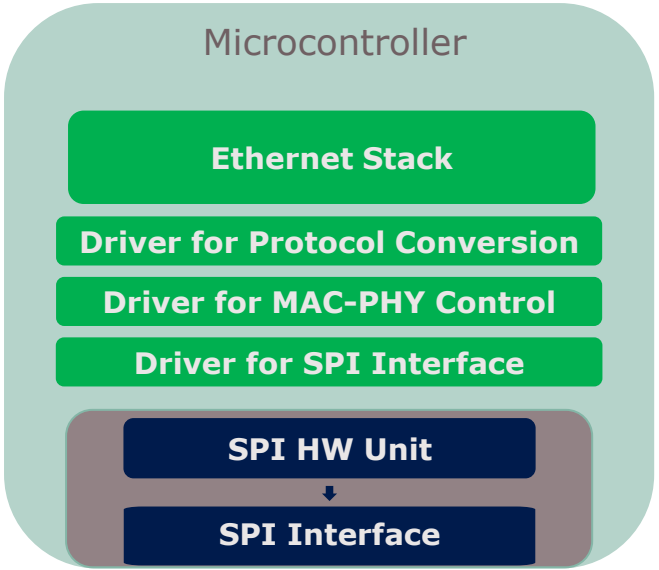


PLCA*: Physical Layer Collision Avoidance

Integration into Automotive Microcontroller Ecosystem

- PLCA* compatible driver stacks – SPI Interface

- Stack and MAC-PHY will communicate via SPI using a special protocol
- The protocol will provide access to MAC-PHY control
- The protocol will provide access to MAC-PHY data
- A new driver stack is required for MAC-PHY the protocol



PLCA*: Physical Layer Collision Avoidance

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