10 Mbps Ethernet Technology and the Challenges Facing Automotive Microcontrollers

Vector Automotive Ethernet Symposium 2019
Harald Zweck, Expert Automotive Communication
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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

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

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Trends in In-Vehicle-Networking

The Baud Rate Gap

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

- Cost level close to CAN / FlexRay
- Baud rates faster than CAN / FlexRay
- Technology with smooth integration into Ethernet

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
Agenda

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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

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

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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

Node ID

0 0 1 2 .. N

time

Cyclic repetition

Shared medium (twisted pair wires)

Head Node

MCU

ID 0

MCU

ID 1

MCU

ID 2

MCU

ID 3

MCU

ID 4

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
# Agenda

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10Base-T1S related Standardization Eco System

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

EPL*: Electrical Physical Layer
PLCA*: Physical Layer Collision Avoidance

AutoSAR ?
IEEE 802.3cg
OPEN TC6 / TC14
IEEE 802.3cg
OPEN TC14
IEEE 802.3cg

To / from Bus
Timeline of Standardization Eco System (Assumptions)

Planned:
IEEE 802.3cg Board approval

Planned:
IEEE 802.3cg Release to Revcom

We are here

H1 2019 H2 2020 H1
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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
Part of your life. Part of tomorrow.