STATUS AND OUTLOOK FOR CAN WITH FLEXIBLE DATA RATE

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Harald K. Eisele, Natalie A. Wienckowski

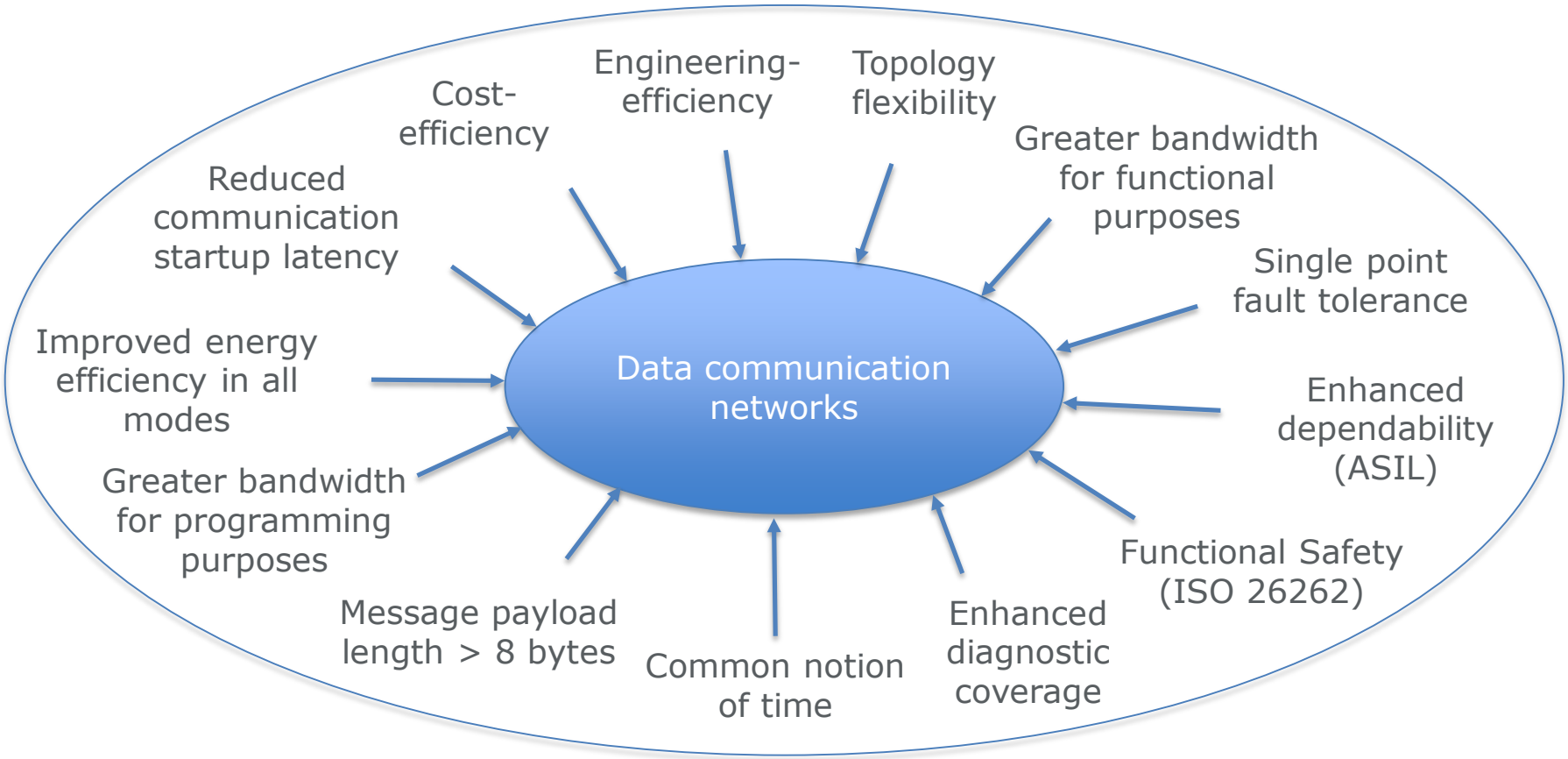
GENERAL MOTORS

AGENDA

- Automotive networking challenges and CAN FD intent
- What is CAN FD?
- Standardization – status and progress
- High-level rollout
- How to migrate from non-ISO to ISO CAN FD frame format
- Summary

Harald K. Eisele
Natalie Wienckowski

PRESENT CHALLENGES FOR AUTOMOTIVE NETWORKING



WHAT IS THE INTENT OF CAN FD?

- Facilitate additional network bandwidth for both vehicle control algorithms and device programming
- Ability to transmit larger sets of cohesive data
  additional security data bytes along with functional data
- Enhanced detection of degradations affecting the communication functionality
  self-diagnostics at run time, message time stamping, controlled degradation
- Bit error detection of FD Frame Format equal to or better than Classical CAN
- Bus wiring topology should not have to change
- First use cases powertrain controls and device programming

HIGH-LEVEL CHARACTERISTICS OF CAN

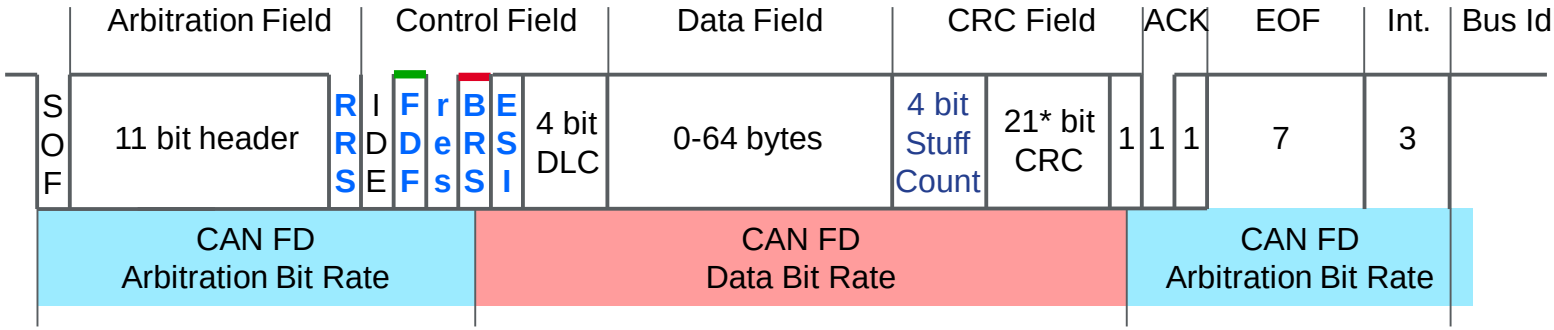
- Cost-efficient technology with established set of standards and large ecosystem
- Shared bus – nodes are connected directly to one another via a dual wire line, suitable for medium bandwidth use cases
- Bus arbitration controlled by frame headers
- Data consistency support
  instant syntax check with subnet-wide notification

CAN FD Format

- Up to 64 data bytes per message (8 bytes for Classical CAN)
- Bit rate during data phase can be configured to be greater than bit rate during arbitration phase
- Bit length in data phase can be shorter than physical layer loop delay
- Enables knowledge of message transmitter's error status
- Number of bits per message 62 to 710 for 11 bit header length

CAN FD FRAME FORMAT WITH 11 BIT HEADER

Note: FD bus messages can be used for Controls only when all devices on the subnet are CAN FD capable



* 17 bit CRC for data fields with up to 16 bytes

FDF – FD Format
Substitutes first reserved bit in classical frames
FDF = recessive indicates CAN FD frame format
FDF = dominant indicates classical CAN frame format

RRS, res – reserved bits
Transmitted dominant, reserved for future extension

BRS – Bit Rate Switch
BRS = recessive: switch to alternate bit rate in Data Phase
BRS = dominant: do not switch bit rate

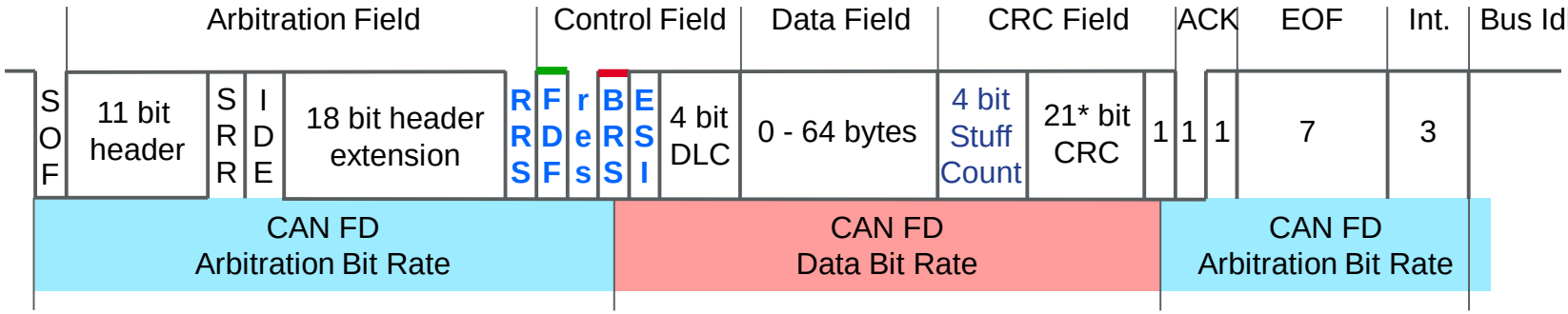
ESI – Error State Indicator
ESI = recessive: transmitting node is error passive
ESI = dominant: transmitting node is error active

Stuff Count
Reflects number of data-dependent stuff bits, Gray-encoded, modulo 8, with parity bit

Drawings on this page were created by Bosch

CAN FD FRAME FORMAT WITH 29 BIT HEADER

Note: FD bus messages can be used for Controls only when all devices on the subnet are CAN FD capable



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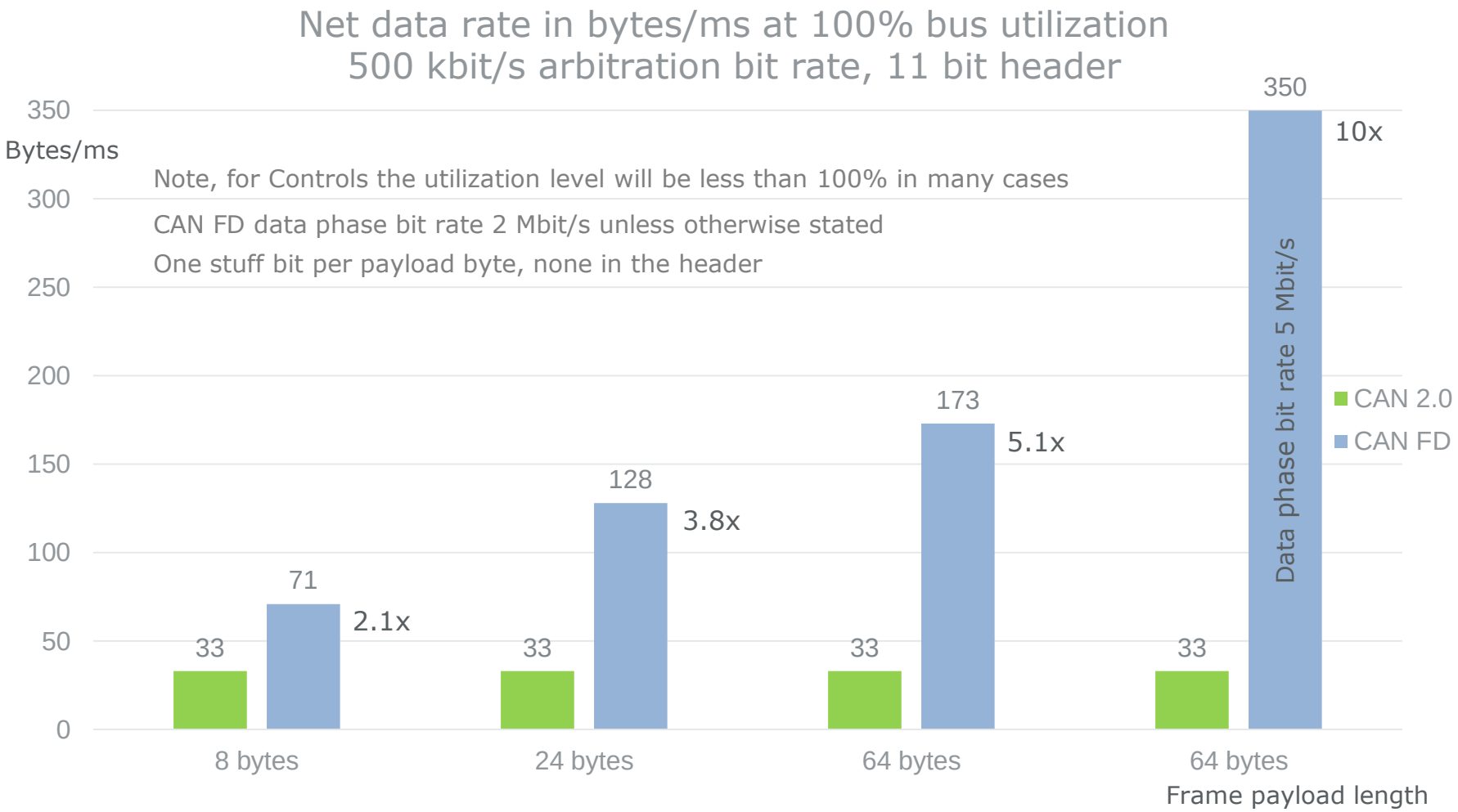
CAN NET DATA RATE EXAMPLES



Harald K. Eisele
Natalie Wienckowski

14/11/27

CAN FD STANDARDIZATION - STATUS AND PROGRESS

2013

APR
- ✓ AUTOSAR R4.1.1 supports CAN FD messages with up to 8 bytes of data

JUN
- ✓ ASAM XCP V1.2 supports CAN FD

DEC
- ✓ Draft ISO 15765-2 (Transport Protocol)
- ✓ Draft ISO 11898-1 (Data Link Layer)

2014

SEP
- ❖ ISO Task Force CAN determines a change is needed for the CAN FD frame format (stuff bit count)

OCT
- ✓ AUTOSAR R4.2.1 supports CAN FD messages with up to 64 bytes of data

NOV
- ❑ ISO 15765-2 (Transport Protocol) submitted for DIS balloting

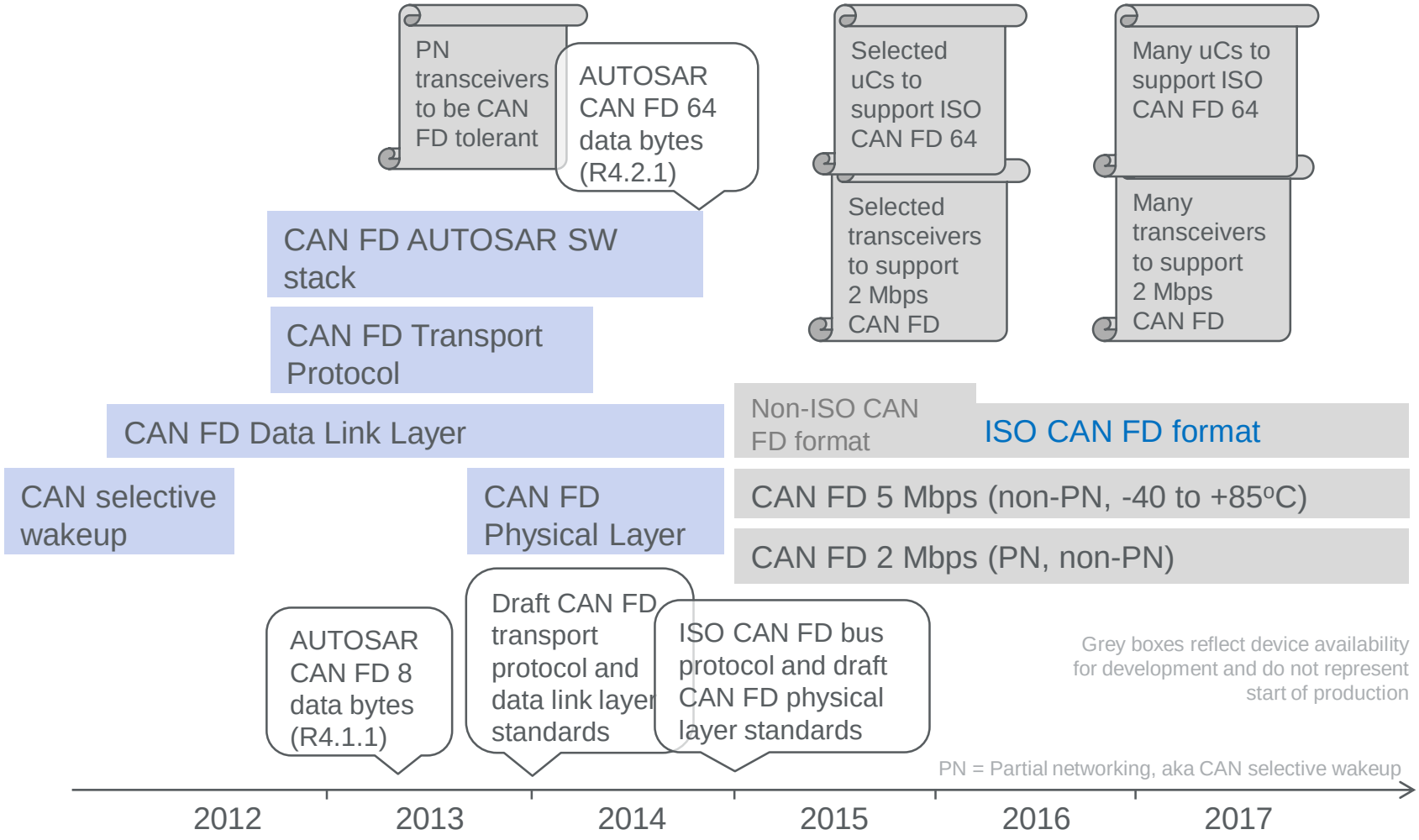
DEC
- ❑ ISO 11898-1 (Data Link Layer) submitted for DIS balloting
- ❑ ISO 11898-2 (Physical Layer) submitted for CD balloting

2015

1Q15
- ❑ Consideration of CAN FD format in the CAN conformance test plan

2Q15
- ❑ ISO 11898-2 (Physical Layer) submitted for DIS balloting

CAN FD HIGH-LEVEL ROLLOUT



HOW TO MIGRATE FROM NON-ISO TO ISO CAN FD FRAME FORMAT?

- Non-ISO CAN FD format not generally suitable for Controls
  Does not meet the requirement bit error detection equal to or better than Classical CAN
- Non-ISO CAN FD format will be needed in 2015 (interim) for early development phases reason: Late weakness discovery
- The ISO CAN FD format (i.e. with stuff bit count) should be employed for series production
- Generic timing for the CAN FD format change:

Date	Milestone
AUG 2014	A semiconductor manufacturer notifies ISO/TFCAN about a bit error detection weakness.
SEP 2014	ISO/Task Force CAN determines that a modification of the CAN FD frame format is required: Five extra bits in every CAN FD frame (stuff bit count).
NOV 2014	Bosch: VHDL Snapshot of M_CAN module supporting ISO CAN FD frame format becomes available.
DEC 2014	Bosch: M_CAN / M_TTCAN R3.2 supporting ISO CAN FD frame format becomes available. Module supports selection of ISO versus non-ISO CAN FD format per configuration.
DEC 2014	Bosch: Beta 5 release of CAN Reference Model supporting ISO CAN FD frame format becomes available.
DEC 2014	ISO/Task Force CAN concludes its work on the update of ISO 11898-1 (CAN Data Link Layer, CAN FD frame format). Draft International Standard.
FEB 2015	CAN FD frame format update accommodated in first microcontroller design.
AUG 2015	First microcontroller (functional) engineering samples available supporting ISO CAN FD frame format.
AUG 2016	Production qualification completed for the first microcontroller product supporting ISO CAN FD frame format. Completely qualified samples become available.

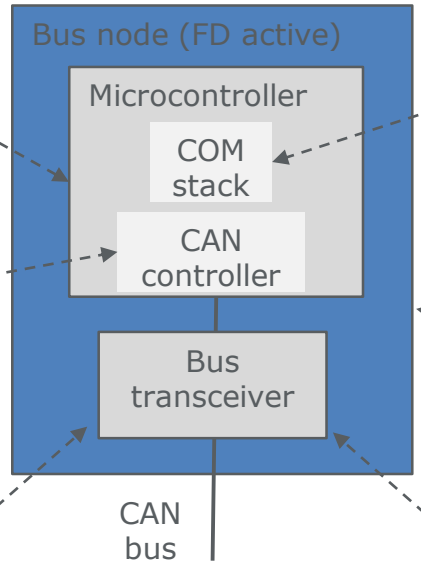
Note: Frame format modification should not require changes to AUTOSAR SW stack or MCAL

CAN FD AVAILABILITY

Supplier base is working intently on including FD message format in their portfolio

- Most microcontroller suppliers will have a first product available in sample quantity some time in 2015
- Software stack suppliers will provide software stacks with CAN FD 64 byte support in 2015
- Transceiver suppliers are testing their existing parts to check suitability for CAN FD and are creating new designs to meet CAN FD needs
- Many tool suppliers have included CAN FD in their portfolio

WHAT NEEDS TO CHANGE IN (CAN) BUS NODES?



Message time stamp mechanism for common notion of time

Protocol controller needs to support ISO CAN FD message format and transmitter loop delay compensation

Transceiver needs to support defined data edge skew characteristics at bit rates higher than 1 Mbit/s, e.g. length of a single recessive bit* 400 to 550 ns at 2 Mbit/s

* Over operating range and product lifetime

Communication SW stack needs to support message payload length longer than 8 bytes

Integrated circuits should provide detection and notifications to the host enabling that surprise communication dropout of an entire bus subnet without warning can be prevented

PN transceivers may not increase their error counters as a result of presence of syntactically correct CAN FD messages

Depending on data bit rate used there may not be any bus topology changes needed

PROPOSED ENHANCEMENT AREAS FOR CAN

- Efficient usage of the CAN FD frame format
  frame packing, multi-PDU messages
- Fast and processing power efficient forwarding of messages/PDUs from one subnet to another one
- Predictable communication startup/resume latency
- Common notion of time
  message time stamping
- Temporal predictability enhancements
  avoidance of node-internal transmit message priority inversion, transmit dominant timeout, limitation of number of retransmission attempts
- Communication dependability enhancements
  protection against inadvertent frame format mode changes, ability to disable protocol exception handling (ability to limit format variants), detection of presence of unexpected message transmitters

Harald K. Eisele
Natalie Wienckowski

WILL CAN FD CO-EXIST WITH AUTOMOTIVE ETHERNET?

Yes, in the next generation of systems

Automotive Ethernet, when

- Transfer of video or audio signals
- Required net bandwidth greater than supported by CAN (FD)
- Seamless redundancy needed

Otherwise, CAN (FD)

SUMMARY

- Automotive features will continue to grow, increasing demands on communication network resources
- CAN FD is a technology that is suitable for the next generation electrical architecture because it supports functional growth while preserving investments made
- CAN FD is attractive because it enables bandwidth and dependability improvements in a particularly cost-efficient way
- Automotive Ethernet and CAN FD will co-exist in next generation systems

Questions and comments can be turned to:
Harald.K.Eisele@de.opel.com
+49-6142-763994

QUESTIONS