Introduction of CAN FD into the next generation of vehicle E/E architectures

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Marc Schreiner, Daimler AG

Mercedes-Benz
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Agenda

- Introduction
- Future Vehicle Architectures
- Integration of CAN FD
- Constraints of CAN FD
- Future Expectations for CAN FD
- Summary

Introduction

New trends will bring about dramatic changes in automobile engineering in future:

- **Connected driving**
- **Autonomous driving**
- **Shared vehicles**
- **Electric driving**

Strong impact on in-vehicle networking is expected:

- More **bandwidth** needed
- New requirements on **communication concepts**
- Higher **complexity**

Future Vehicle Architectures

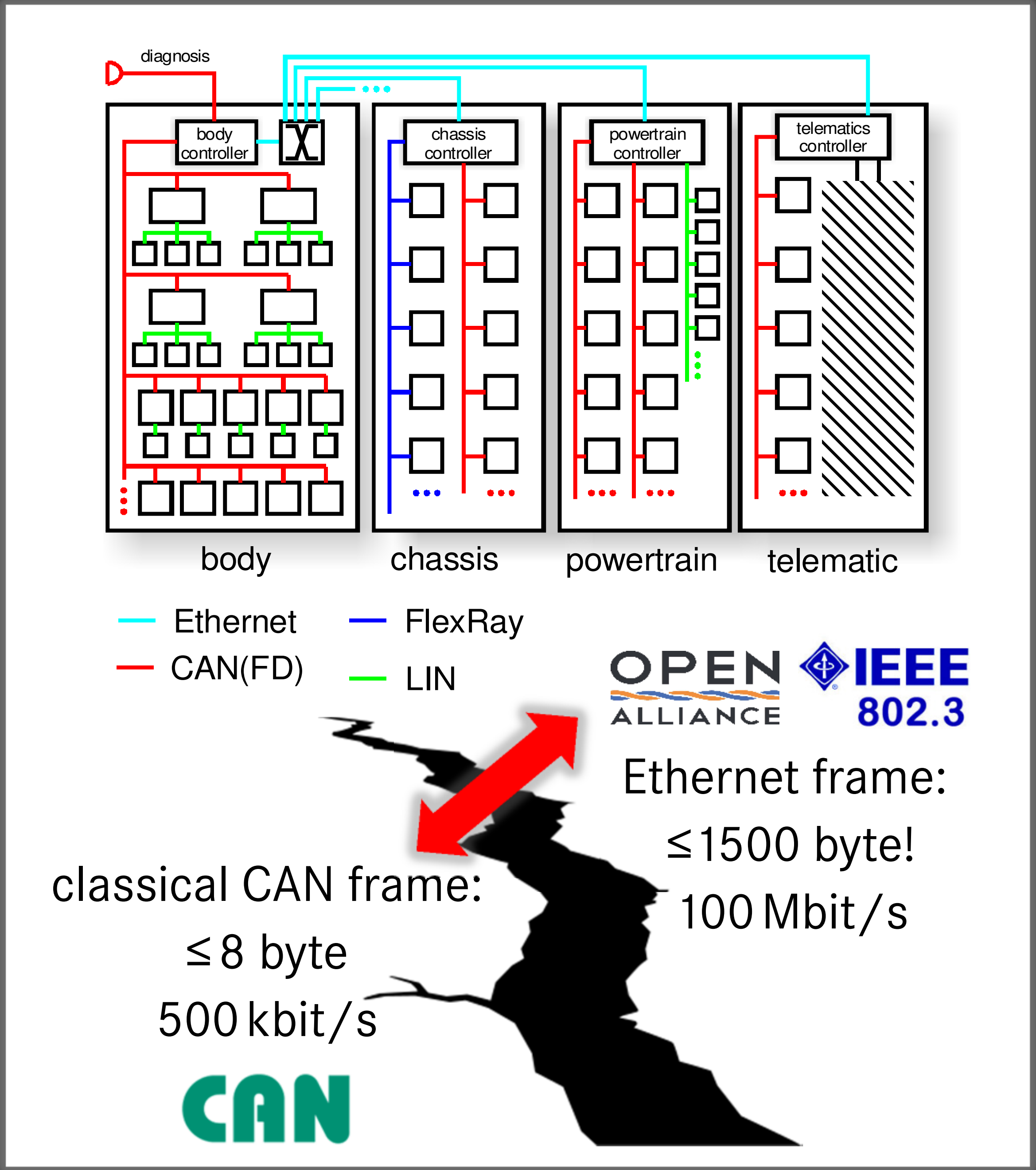
The consequence of this challenge is the introduction of **Automotive Ethernet.**

- **100 BASE-T1** physical layer
- architecture with Ethernet **backbone structure**
- **new communication concepts**:
  e.g. SOME/IP, DoIP, IEEE 1722, IEEE 1588, SecOC, E2E, iPDU Multiplexing etc.

All these mechanisms blow up **bandwidth** and PDU **payload size** but Ethernet can handle this easily.

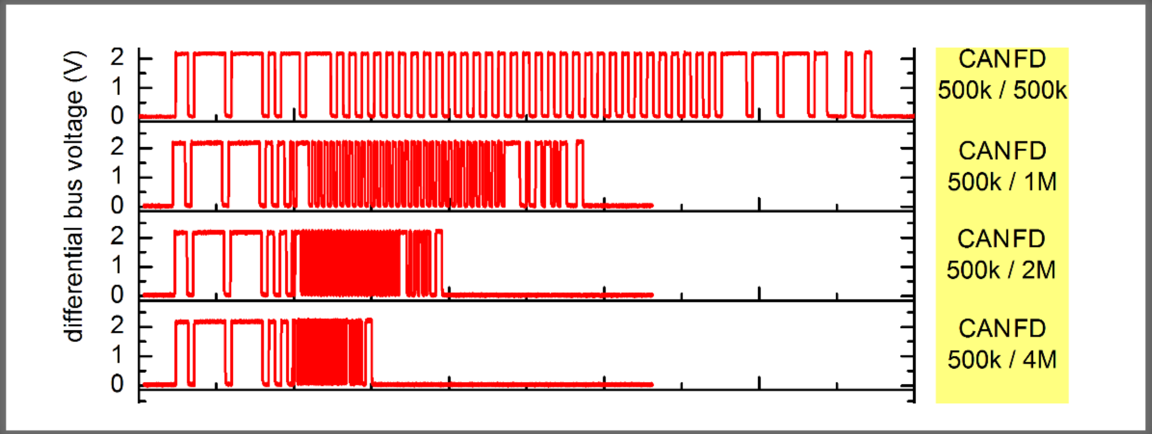
Classical CAN, LIN and FlexRay (as it is used today) cannot keep up with automotive Ethernet.

There is a big **gap** between old and new technologies.



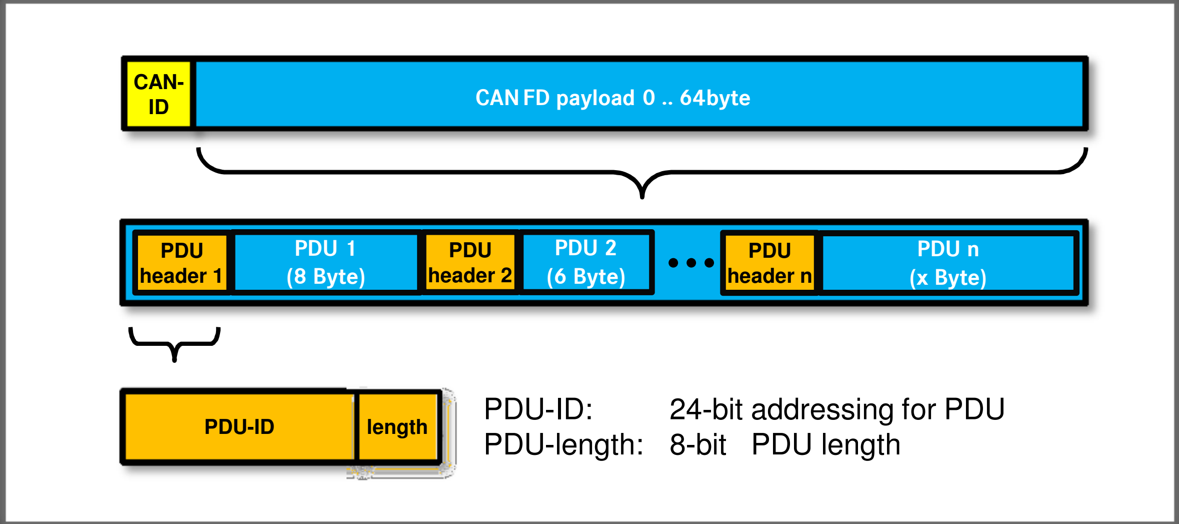
CAN FD in the World of Automotive Ethernet

CAN FD offers up to **64 byte payload** and up to **2 Mbit/s** transmission speed. In future **5 Mbit/s**?



- CAN FD bridges the gap between classical in-vehicle networking to current Ethernet communication features.
- Especially **iPDU multiplexing**, **E2E** and **SecOC** features can be introduced into the CAN world.
- Despite of this CAN remains low-priced, robust and readily manageable.

example: **iPDU multiplexing**



- **Same mechanism used for Ethernet** communication (however with larger headers).
- Multiple PDUs are **dynamically** combined into single frames delimited by **headers**.
- Makes transmission much more effective.
- Would not make sense with 8 byte frames.

Integration of CAN FD – Applications

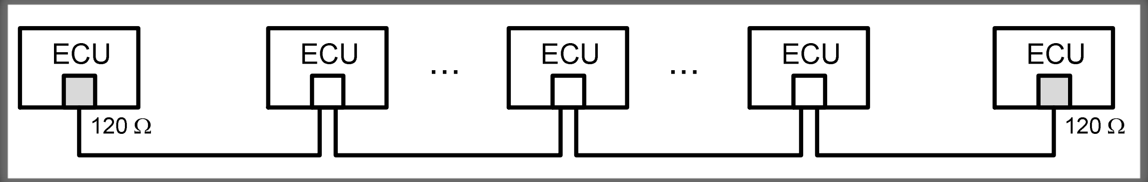
- Will be used **in all domains** of an architecture.
- There is no dedicated use case, the **use cases are universal.**
- Captures directly **new applications**, not only a **replacement** for existing classical CAN networks.
- There is **no typical CAN FD baud rate**, different combinations are reasonable.
- The **baud rate** is a trade-off between application requirements and physical capabilities.
- With current physical layer **3 baud rate ratios** are practicable to cover all use cases.
- **Classical CAN** is still used in new architectures however with declining ratio (carry-over ECUs).

topology	**arbitration phase**	**data phase**
large, few restrictions	250 kbit/s	500 kbit/s
medium, only short stubs	500 kbit/s	1000 kbit/s
small, pure line topology	500 kbit/s	2000 kbit/s

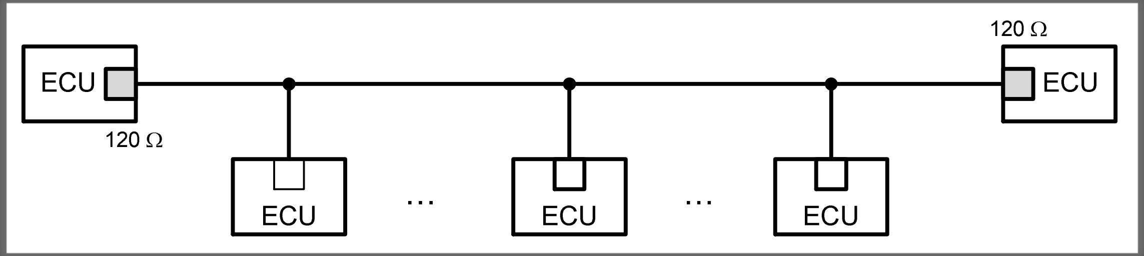
Integration of CAN FD – Topologies

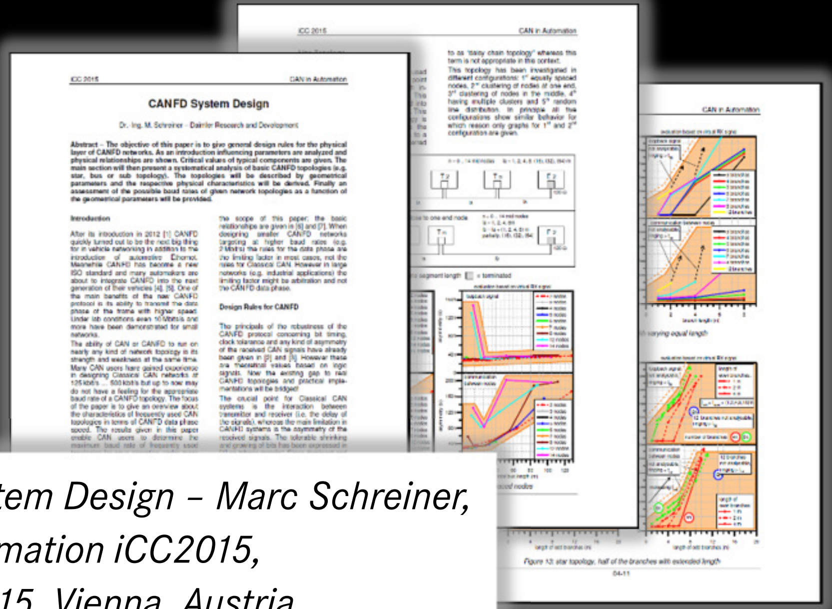
- The **highest baud rate** that can meet automotive requirements with current CAN physical layer is **2 Mbit/s**.
- The **main limiting factor** for CAN FD communication speed is signal distortion on the physical layer that imposes **asymmetry** on the received signals.
- If CAN FD should operate at **2 Mbit/s** the topology structure should be limited to a pure line topology.
- At **1 Mbit/s** it is advisable to stay with a bus and stub structure and limit the stub lengths.
- For really large and structurally undefined topologies it is advisable to stay at **500 kbit/s.**
  Just benefit from the extended payload!

pure line topology @ 2 Mbit/s



bus and stub structure @ 1 Mbit/s

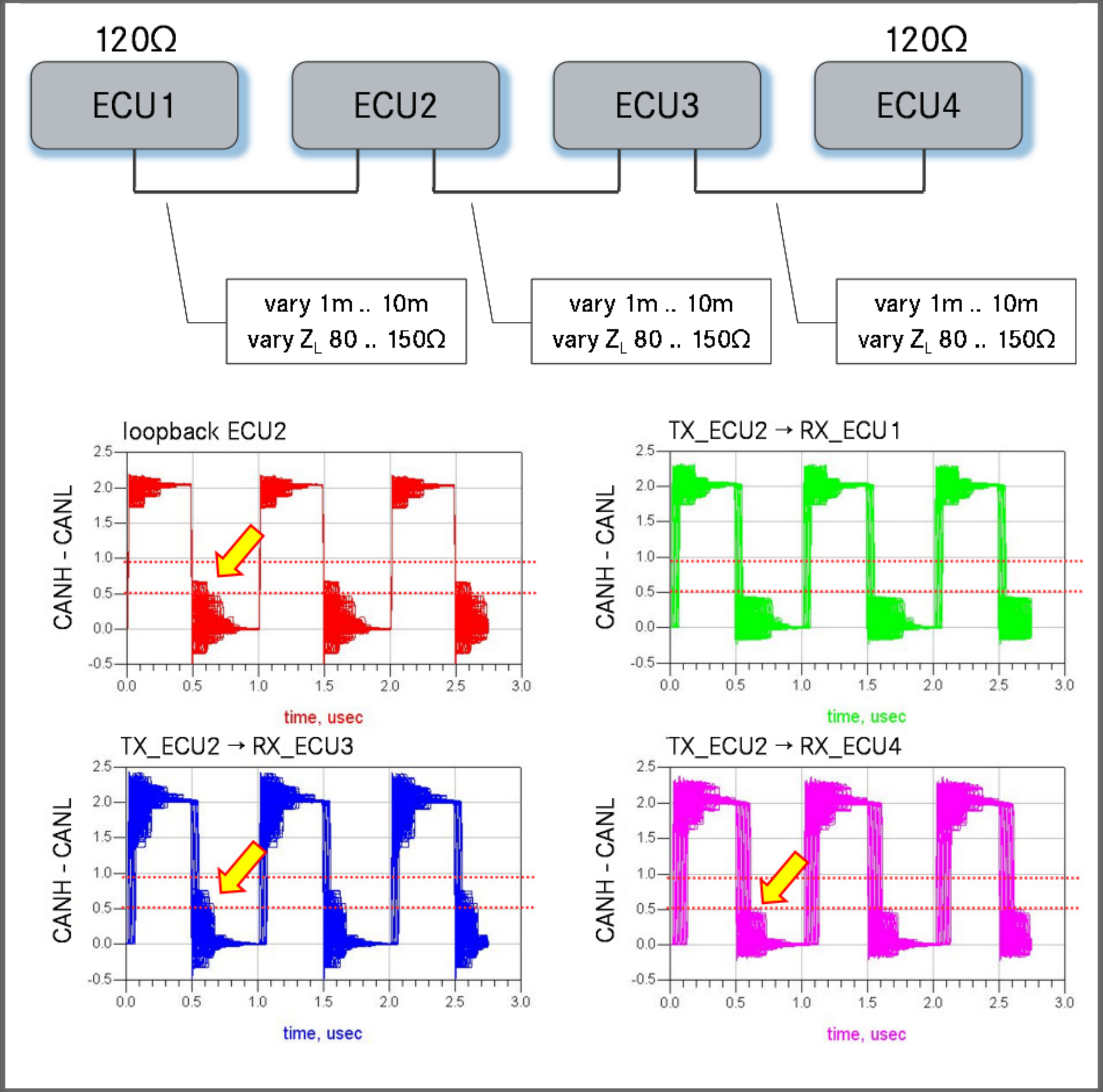




CAN FD System Design – Marc Schreiner, CAN in Automation iCC2015, 27.-28.10.2015, Vienna, Austria.

Constraints of CAN FD – CAN Cables

- There is **no ISO specification** for CAN FD cables.
- CAN FD is specified for a **system impedance** of 60 Ω (same as CAN).
- CAN FD cables should match this value in terms of their **characteristic impedance**, i.e. 120 Ω.
- However most common twisted pair cables have lower values even varying with temperature.
- This results in signal **asymmetry** even in ideal topologies limiting communication speed.
- Particular attention has to be paid for the selection of proper CAN FD cables, **conflicts between mechanical and electrical requirements exist**.

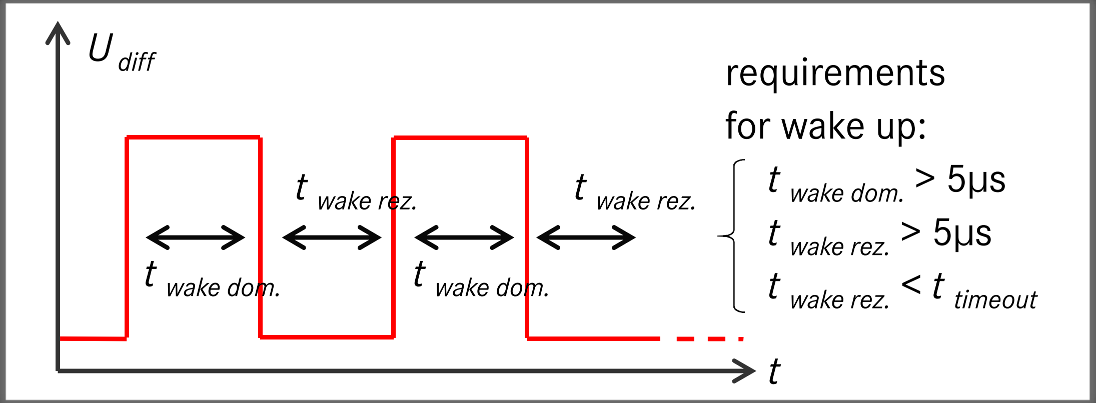


Constraints of CAN FD – Wake Up Mechanism

- CAN bus wake up was defined in ISO 11898-6.
- The wake up requirement can be met with any classical CAN message but it **cannot be met with many CAN FD messages**.
- New optional wake up parameters in ISO 11898-2:2016 have **not yet penetrated the market**.

Possible workarounds:

- Limit ID range accordingly
- Use classical CAN messages for wake up
- Use dedicated wake messages with appropriate IDs
- Use dedicated wake messages with appropriate wake pattern in payload and slow data phase



frame	consecutive dom. bits	dom. @ 500 kbit/s
classic frame 11-bit ID	RTR, IDE, FDF	6 µs
classic frame 29-bit ID	RTR, FDF, r0	6 µs
FD frame even ID, 11-bit ID	ID18, RRS, IDE	6 µs
FD frame odd ID, 11-bit ID	RRS, IDE	4 µs
FD frame even ID, 29-bit ID	ID0, RRS	4 µs
FD frame odd ID, 29-bit ID	n/a	2 µs

Expectations for CAN FD in Future

Optimize CAN FD cables !

- Create a standard for CAN FD cables and fix the issue with characteristic impedance mismatch.

Improve the CAN FD physical layer !

- Prompt introduction of ISO 11898-2:2016 features removing the work around solutions for the **wake up issue**.
- Improve signal integrity at the **dominant to recessive edge** to increase topology size and communication speed.
- Enable CAN FD for **5 Mbit/s !**
- Improve **EMC emissions**.

CAN FD – Summary

- **CAN FD was the right innovation at the right time**.
- CAN FD can **bridge the gap** between classical in-vehicle networking and **new communication concepts** introduced with automotive Ethernet.
- CAN FD continues to be a **universal bus system** that is easily manageable at a decent price ratio.
- Some **improvements** are still desirable, especially in terms of the **physical layer**.
- Further developments should go for achieving a data rate of **5 Mbit/s under automotive conditions**.

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