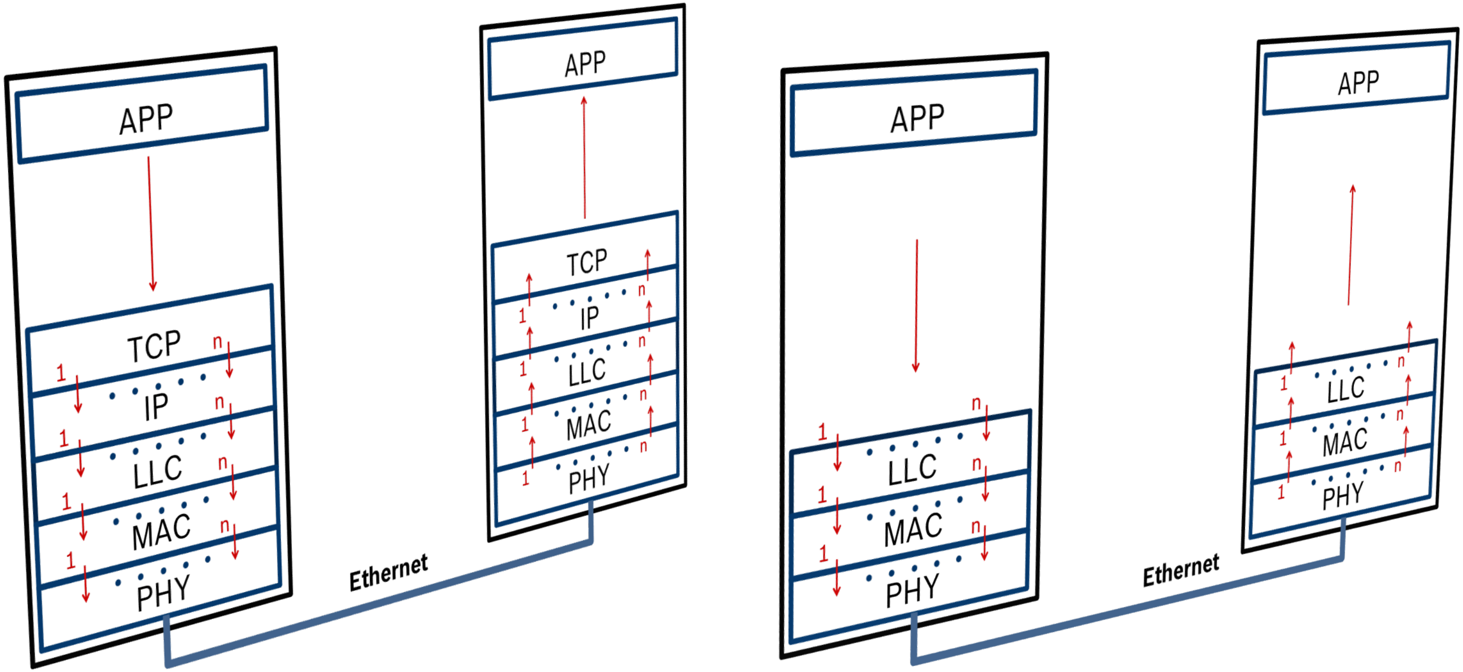
Ethernet Layer 2 Data Safety



Ethernet Layer 2 End-to-End Data Safety

IEEE 802.1 Plenary Meeting - Dallas - 2013.11.12

Abou Diarra – Robert Bosch GmbH

Outline

- ➔ Motivation
- ➔ Existing Automotive Layer 2 Data Safety Paradigms
- ➔ Automotive Use-Cases
- ➔ Current Ethernet based Data Safety Mechanisms
- ➔ Data Safety Evaluation Criteria & Next Steps

Ethernet Layer 2 Data Safety

Motivation

➔ **Why a Data Safety Mechanism?**

- Several influences such as high temperatures, electromagnetic interferences etc . in in-vehicle networks
- Errors occurrence like data corruption, packet loss & link failure.
- That is why, existing in-vehicle communication systems like CAN provide dedicated error detection & correction mechanisms on Layer 2.
- Need of Data Safety Mechanisms for Ethernet in in-vehicle networks.

➔ **Why on Layer 2?**

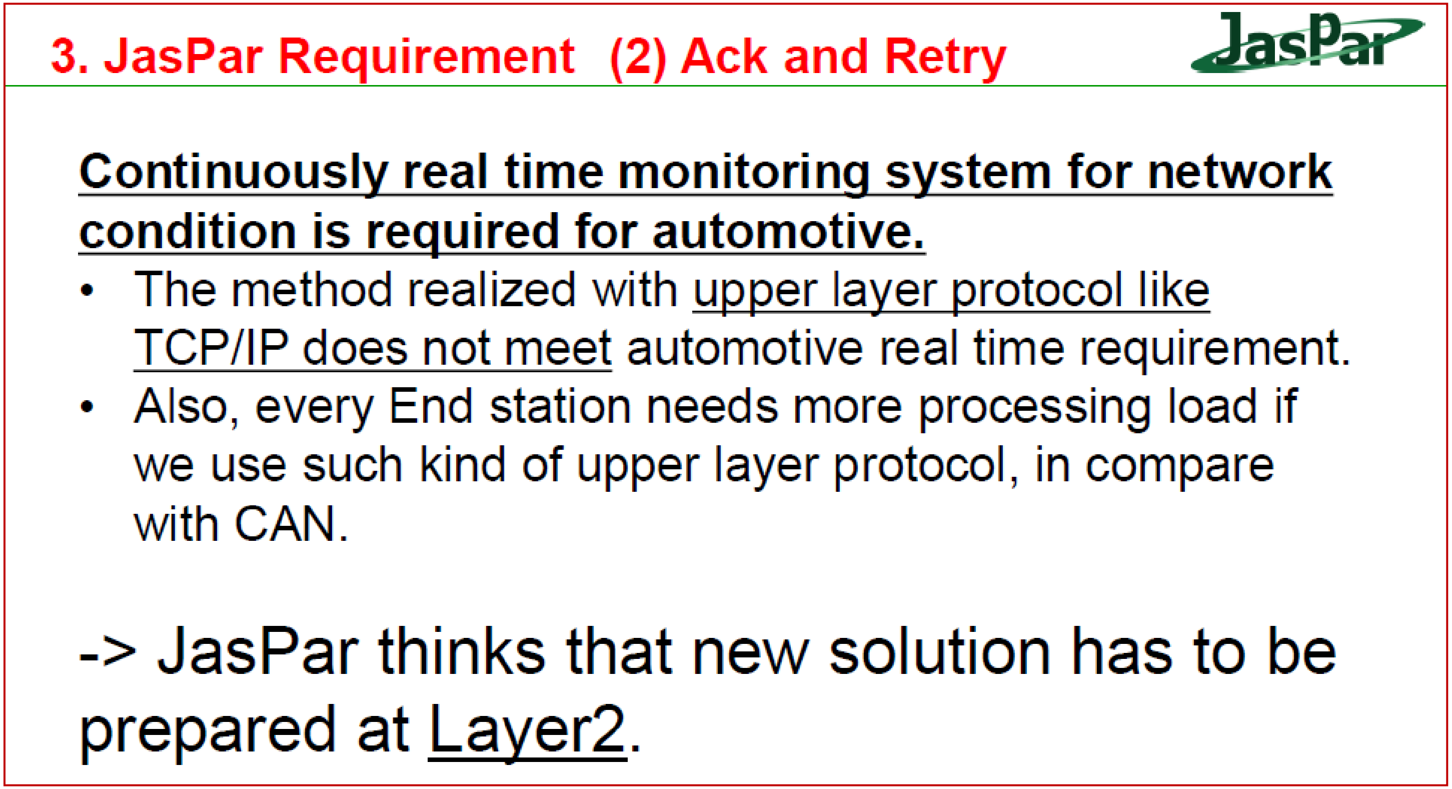
- Common automotive protocols like CAN, FlexRay & LIN run on Layer 1, 2
- CAN implements Error Handling on Layer 2.
- Layer 2 chosen mainly for performance and cost reasons

➔ **What about Ethernet?**

- Need of Layer 2 Data Safety for reliable and cost-efficient communication for in-vehicle networks (and Industrial Automation)

Motivation

➔ **The topic has been highlighted by another automotive organization**



3. JasPar Requirement (2) Ack and Retry

JasPar

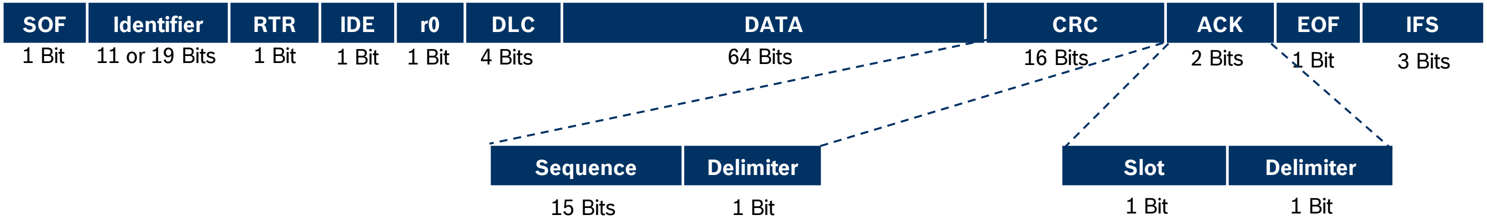
Continuously real time monitoring system for network condition is required for automotive.

- The method realized with upper layer protocol like TCP/IP does not meet automotive real time requirement.
- Also, every End station needs more processing load if we use such kind of upper layer protocol, in compare with CAN.

-> JasPar thinks that new solution has to be prepared at Layer2.

Existing Automotive Layer 2 Data Safety Paradigms (Example of CAN Error Handling)

CAN Frame Overview



SOF	Identifier	RTR	IDE	r0	DLC	DATA	CRC	ACK	EOF	IFS
1 Bit	11 or 19 Bits	1 Bit	1 Bit	1 Bit	4 Bits	64 Bits	16 Bits	2 Bits	1 Bit	3 Bits

Sequence	Delimiter
15 Bits	1 Bit

Slot	Delimiter
1 Bit	1 Bit

→ **Different types of error on a CAN Bus**

- **CRC Error :** when the computed CRC value on reception is different to the transmitted one
- **Bit Error:** when a node reads 0 (or 1) on the bus after sending 1 (or 0)
- **Bit Stuffing Error:** when more than 5 bits of the same weight are sent on the bus
- **ACK Delimiter Error :** when the field is dominant
- **CRC Delimiter Error :** same case for the ACK Delimiter Error
- **ACK Slot Error:** When a dominant bit is sent by a node during the ACK Slot

→ **Error Signaling**

- When a node detects an error, it sends an Error Frame after the ACK Delimiter

0 : dominant
1: recessive

Existing Automotive Layer 2 Data Safety Paradigms (Example of CAN Error Handling)

Active Error Frame

Active Error Flag (6 Dominant Bits)	Active Error Delimiter (8 Recessive Bits)

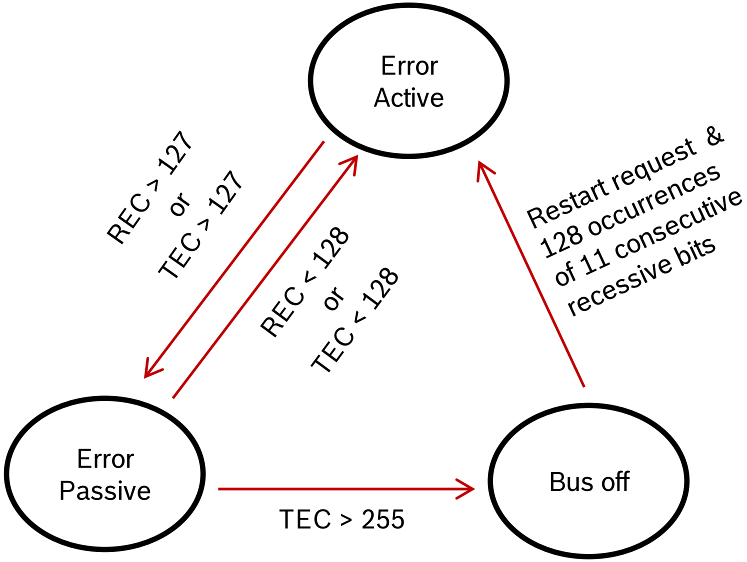
Passive Error Frame

Passive Error Flag (6 Recessive Bits)	Passive Error Delimiter (8 Recessive Bits)

Error Counters to isolate faulty nodes from the network!

Such mechanisms might maybe also be needed in automotive Ethernet based sub-networks!

Different Error States on a CAN Node

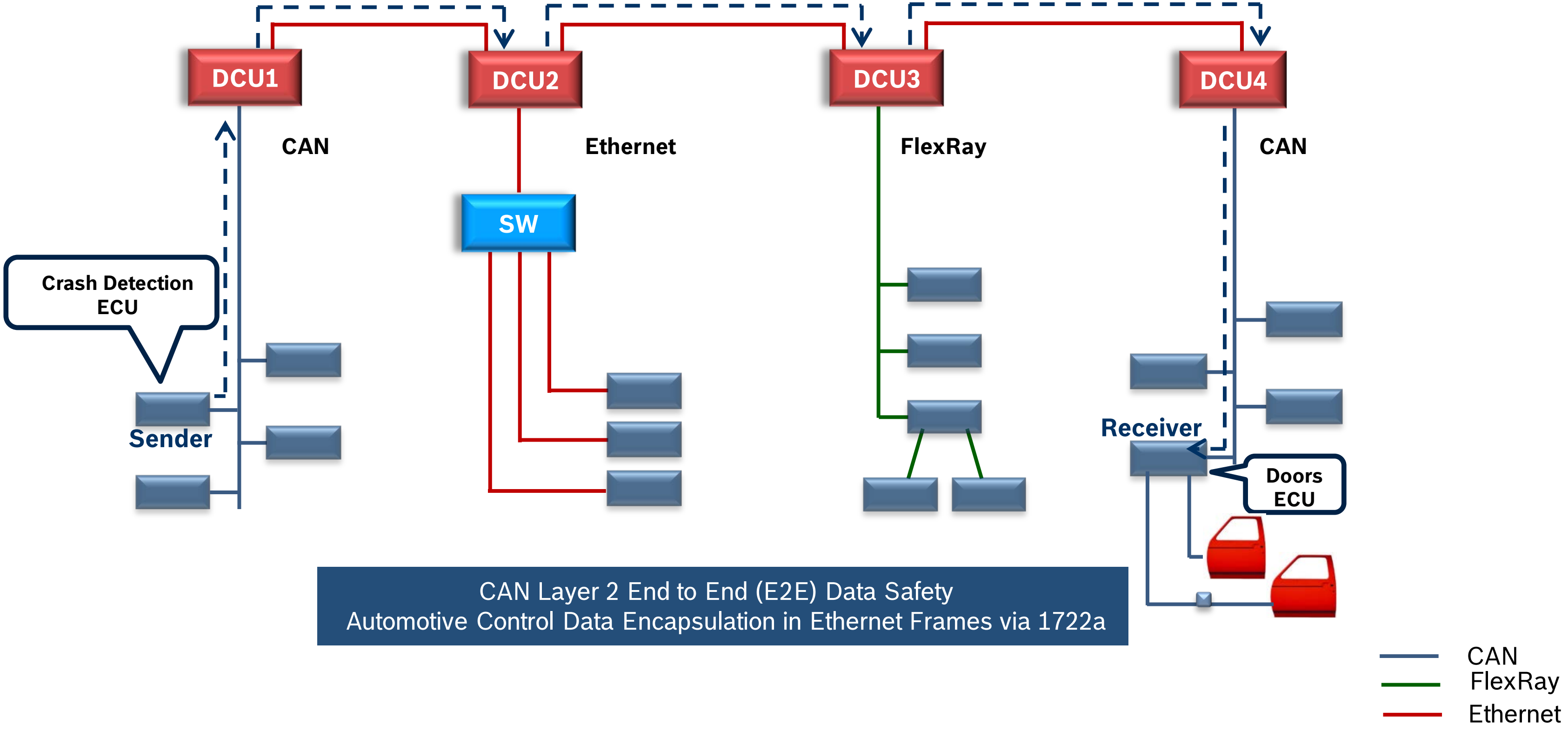


REC: Receive Error Count

TEC: Transmit Error Count

Automotive Use-Cases

- Automatic Doors Unlocking in crash situation

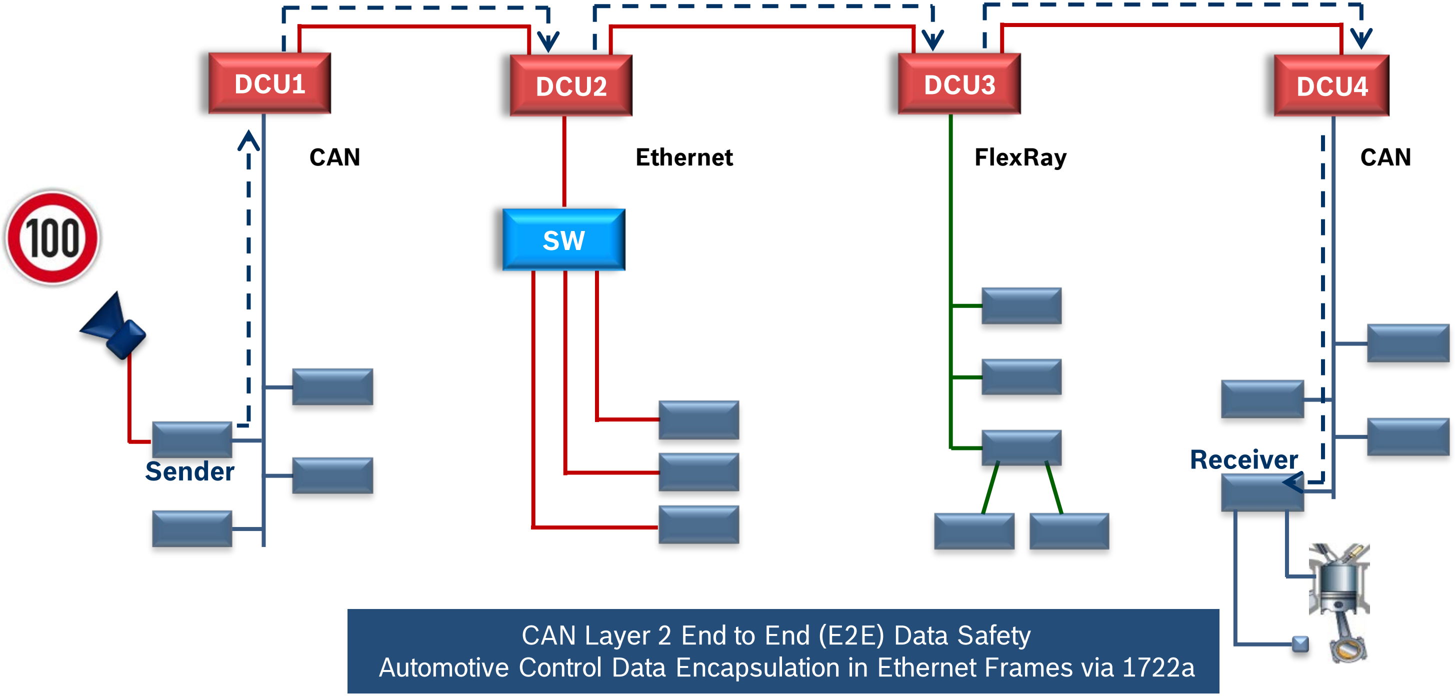


CAN Layer 2 End to End (E2E) Data Safety
Automotive Control Data Encapsulation in Ethernet Frames via 1722a

Ethernet Layer 2 Data Safety

Automotive Use-Cases

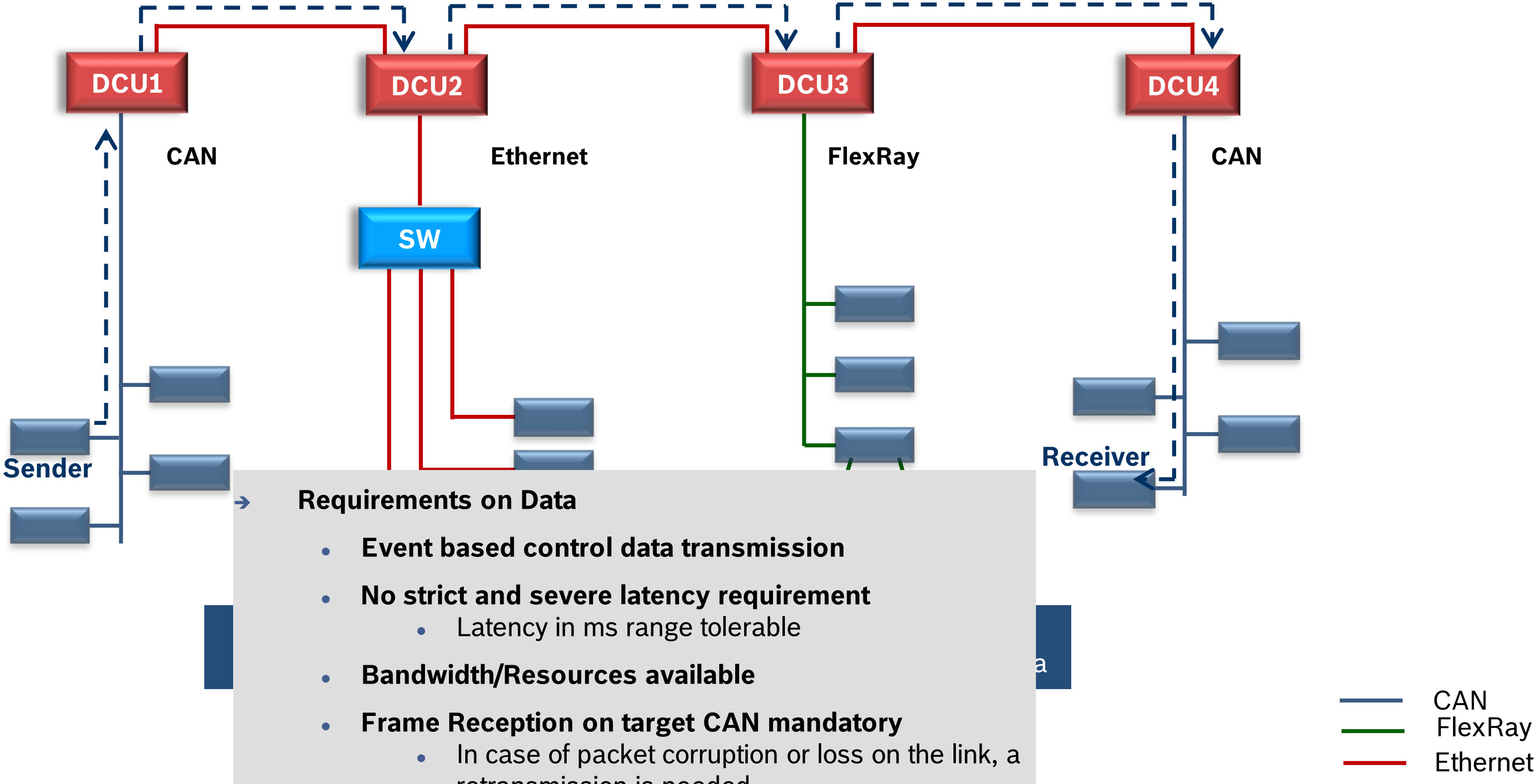
→ **Road traffic signs recognition for Automated Driving**



CAN Layer 2 End to End (E2E) Data Safety
Automotive Control Data Encapsulation in Ethernet Frames via 1722a

🟦	CAN
🟩	FlexRay
🟥	Ethernet

Automotive Use-Cases

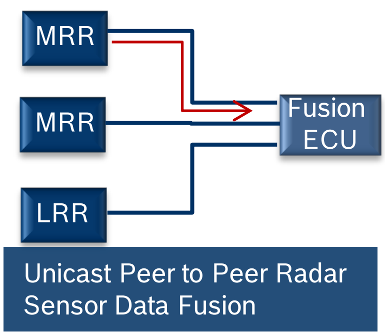


➔ **Requirements on Data**

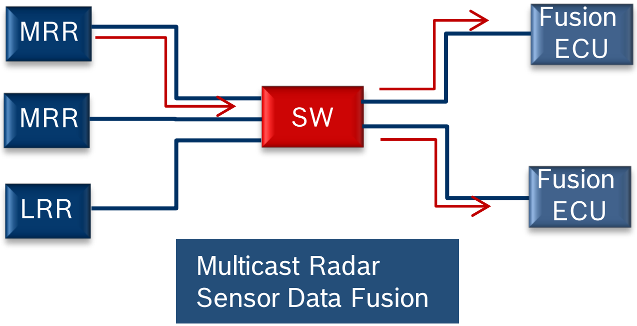
- **Event based control data transmission**
- **No strict and severe latency requirement**
  - Latency in ms range tolerable
- **Bandwidth/Resources available**
- **Frame Reception on target CAN mandatory**
  - In case of packet corruption or loss on the link, a retransmission is needed

Automotive Use-Cases

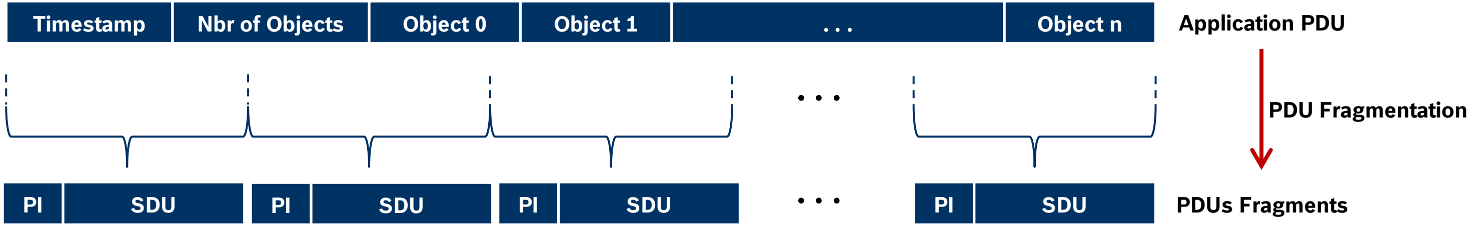
➔ **Radar Sensors Data Fusion**



Unicast Peer to Peer Radar Sensor Data Fusion



Multicast Radar Sensor Data Fusion

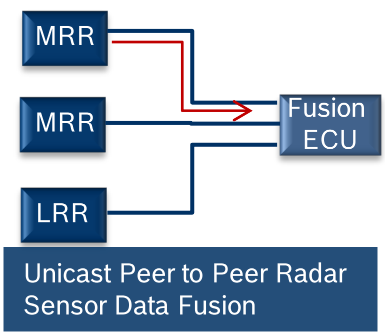


PDU: Protocol Data Unit
PI: Protocol Info
SDU: Segmented Data Unit

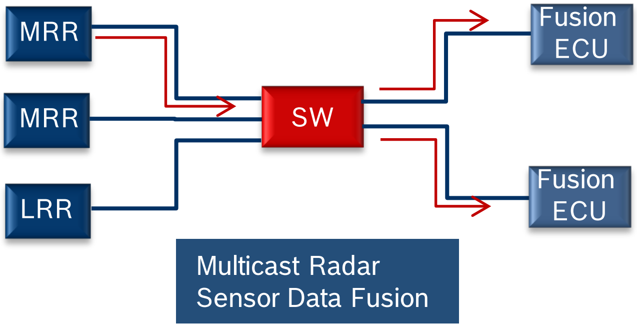
Ethernet Layer 2 Data Safety

Automotive Use-Cases

➔ **Radar Sensors Data Fusion**



Unicast Peer to Peer Radar Sensor Data Fusion



Multicast Radar Sensor Data Fusion

➔ **Requirements on Data**

- **Bandwidth Resources needed**
  - From 540 kbps to 300 Mbps
- **Data Fragmentation & Reassembly may be needed**
  - When a PDU is too large to be encapsulated in only one Ethernet Frame
  - Sequence number needed in fragments frames for reassembly
  - Any lost or corrupted fragment needs to be retransmitted
- **Packets Reception on Fusion ECUs mandatory**
  - Radar ECUs need to know that PDUs they sent are correctly received by Fusion ECUs
- **No strict and severe recovery time**

Current Ethernet based Data Safety Mechanisms

➔ **AVB / TSN Mechanisms**

- **IEEE 802.1 Qat** Stream Reservation Protocol to guarantee necessary bandwidth resources to handle a stream from the sender to the receiver.
- **IEEE 802.1 Qav** Queuing & Forwarding traffic shaper to prevent bursts during data transmission.
- **IEEE 802.1 CB** Seamless Redundancy for fault-tolerance without failover.

➔ **Other Mechanism**

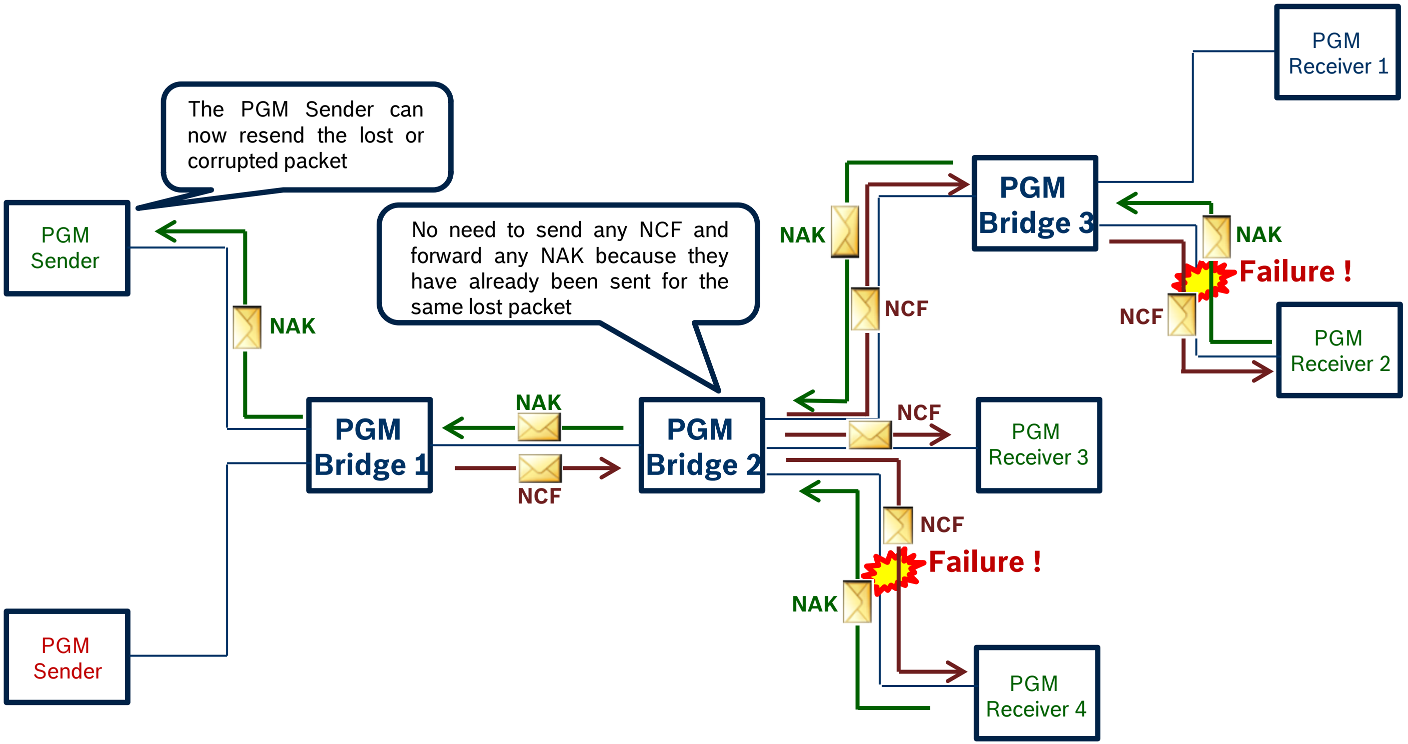
- TCP/IP that runs Layer 3/4 based Acknowledgment and Retransmission Mechanisms for Data Integrity
- Pragmatic General Multicast (PGM): a Layer 4 IETF experimental Mechanism for Data Transmission reliability via Negative Acknowledgment and Retransmission Mechanisms
- Any other mechanism ?

➔ **Scope**

- Find a solution based on PGM and/or other possible improvements and adapt them on layer 2 for in-vehicle communication

PGM Error Detection & Correction (1)

Error Signaling



The PGM Sender can now resend the lost or corrupted packet

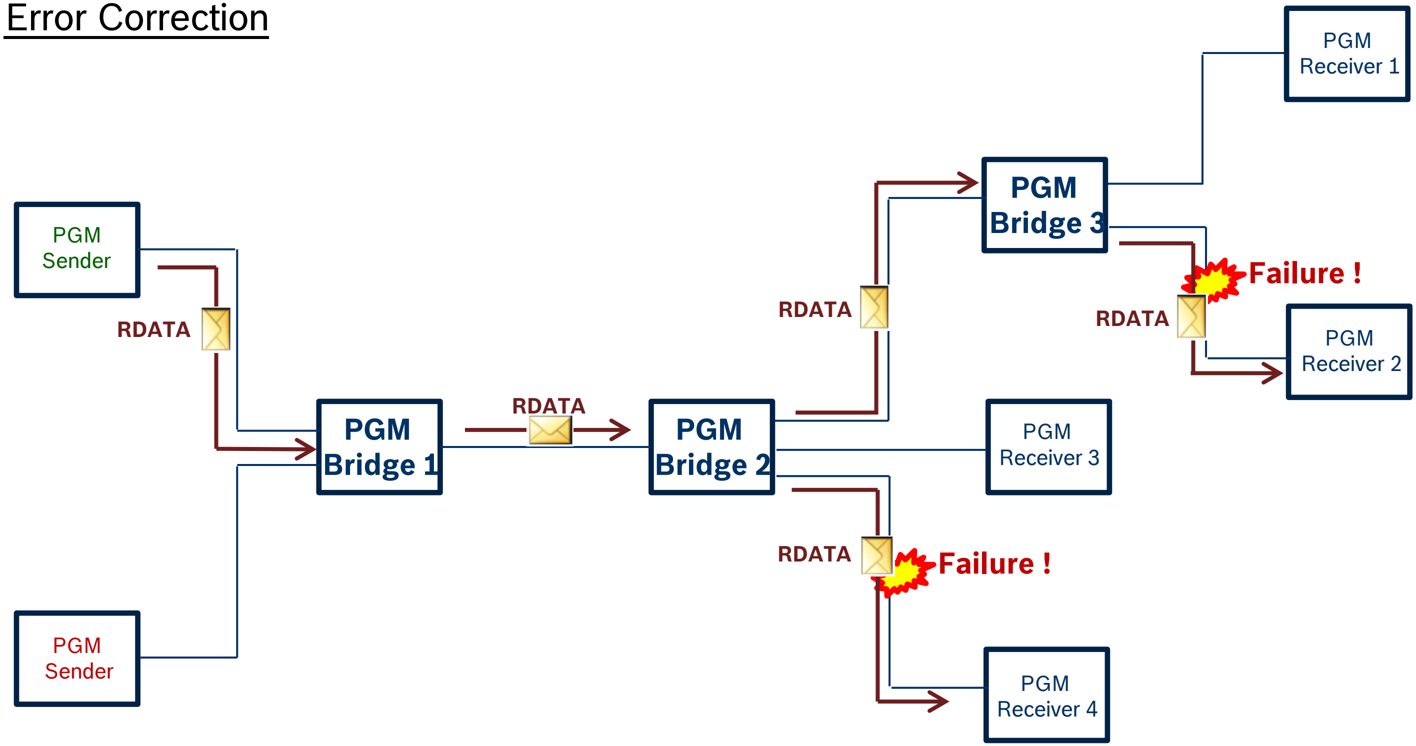
No need to send any NCF and forward any NAK because they have already been sent for the same lost packet

NAK : Negative Acknowledgment

NCF : NAK Confirmation

PGM Error Detection & Correction (2)

Error Correction



RDATA: Repair Data

Data Safety Evaluation Criteria & Next Steps

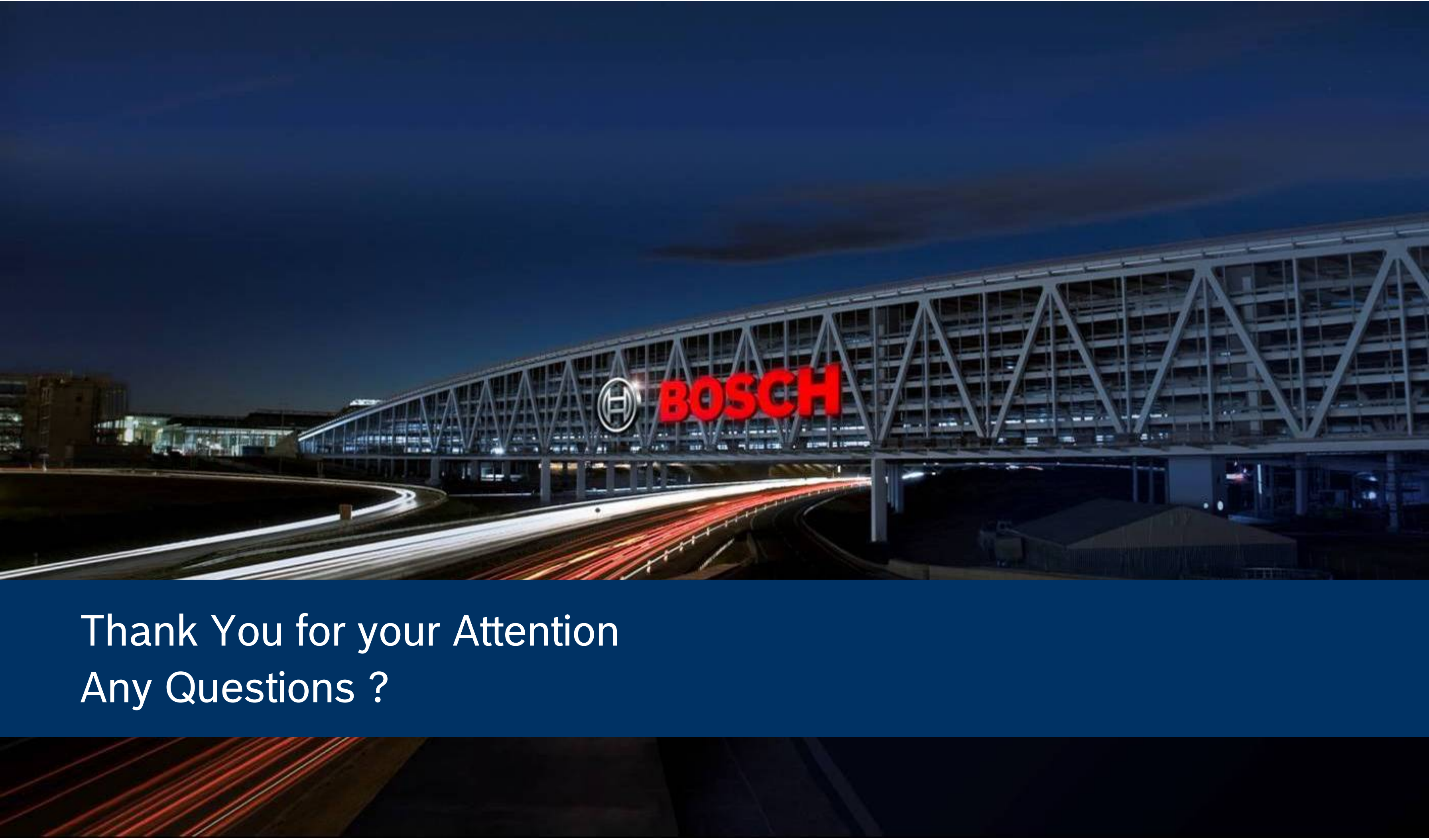
➔ **Data Safety Evaluation Criteria**

- Fault occurrence probability in a network supporting current AVB/TSN Mechanisms
- Fault recovery time
- Packet reception guaranty time
- Bandwidth needed to correct a fault
- Faulty receiver nodes isolation conditions
- Data Consistency in the System

➔ **Next Steps**

- Evaluate Data Safety Criteria
- Identify different failure scenarios in an Ethernet based network
- Analyze the necessity of a layer 2 error detection & correction process based on :
  - ACK & Negative ACK Mechanisms
  - Retransmission Mechanisms
  - Error Counter Implementation

Ethernet Layer 2 Data Safety



Thank You for your Attention

Any Questions ?