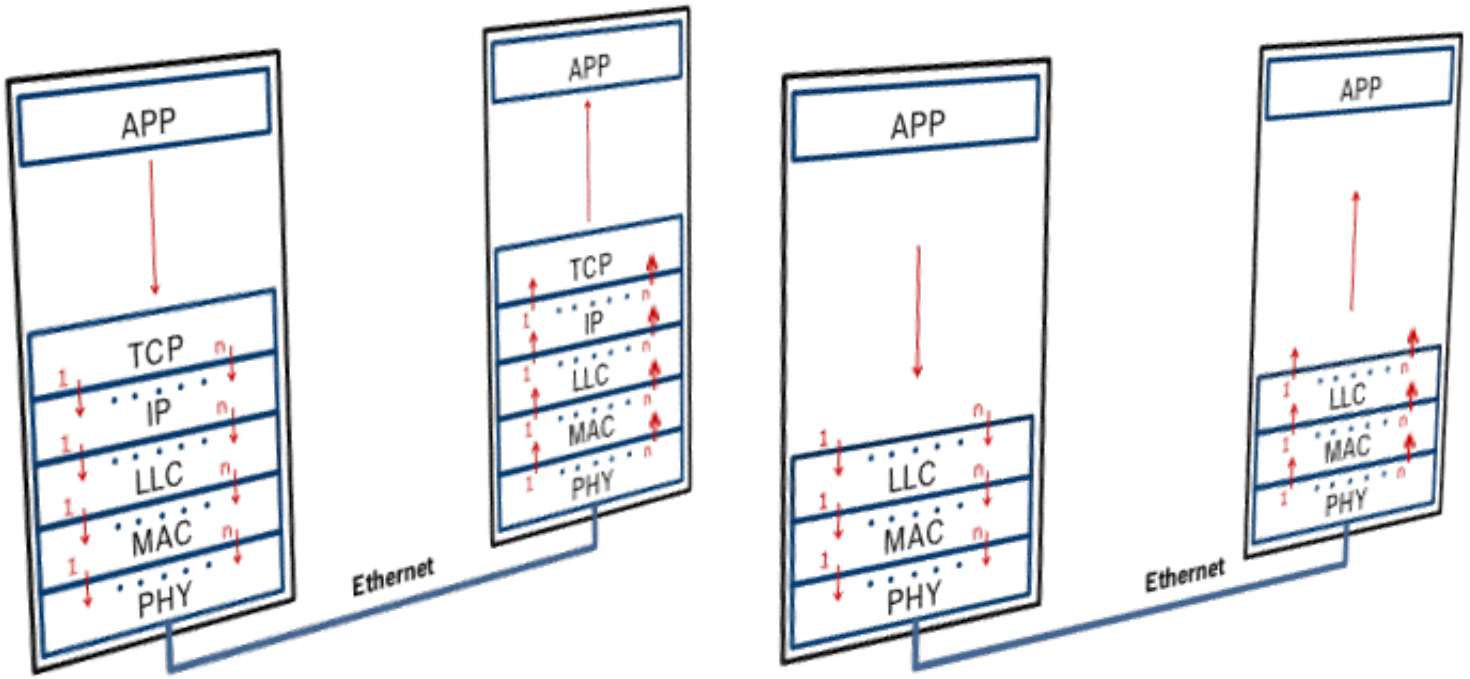


# Ethernet Layer 2 End-to-End Data Safety

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# Outline

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

# Motivation

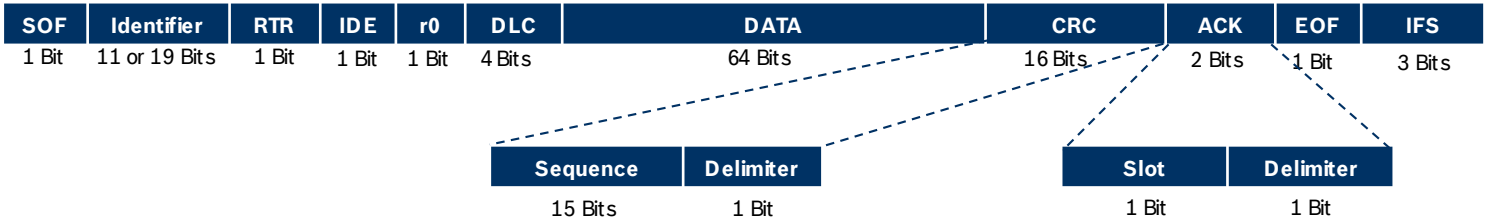
- **Why a Data Safety Mechanism?**
  - Several influences such as high temperatures, electromagnetic interferences etc . in in-vehicle networks
  - Errors occurrence like data corruption, packet loss & link failure.
  - That is why, existing in-vehicle communication systems like CAN provide dedicated 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)

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

CAN Frame Overview




- **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

# 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) |
|---|---|

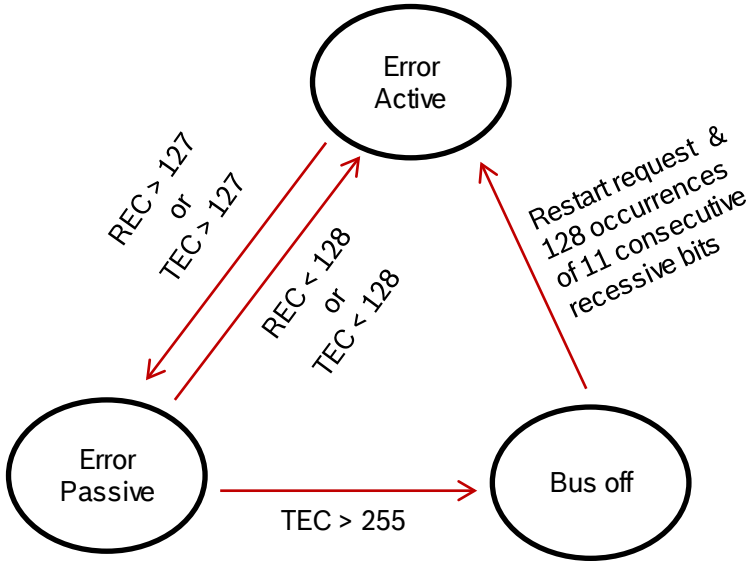
**Passive Error Frame**

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

Error Counters to isolate faulty nodes from the network!

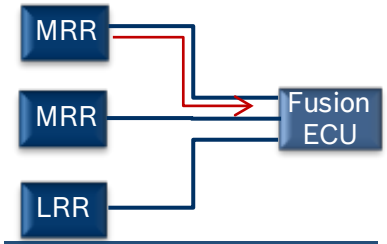
Such mechanisms might also be needed in automotive Ethernet based sub-networks!

Different Error States on a CAN Node

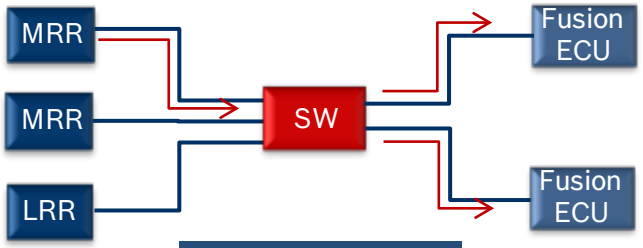



**REC: Receive Error Count**
**TEC: Transmit Error Count**

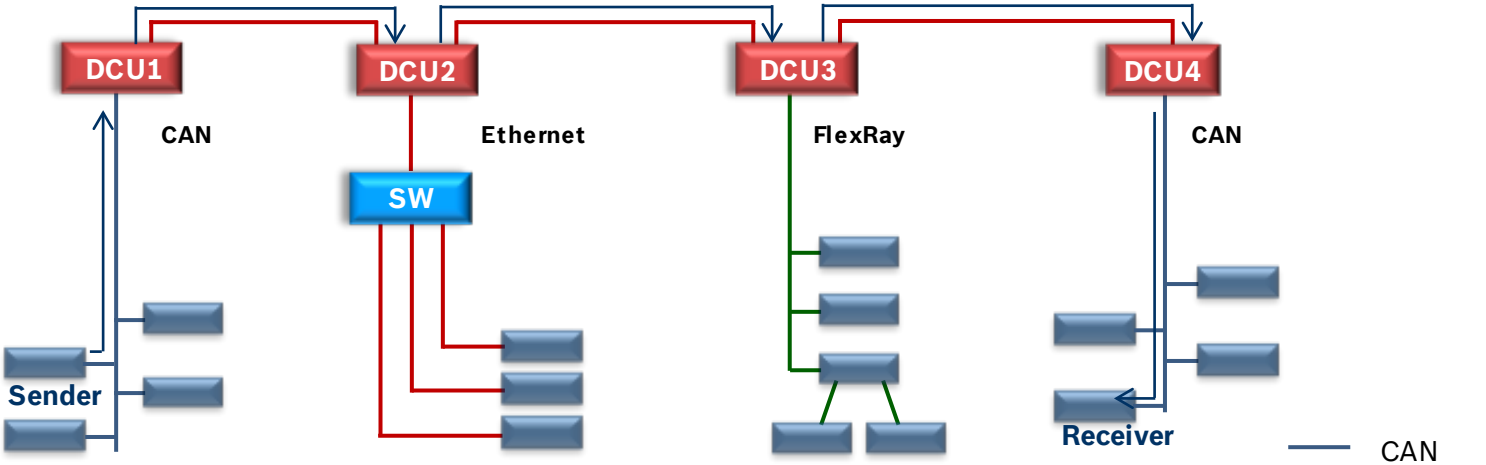
# Typical potential Layer 2 Data Safety Use-Cases




Unicast Peer to Peer Radar Sensor Data Fusion




Multicast Radar Sensor Data Fusion




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

# Current Ethernet based Data Safety Mechanisms

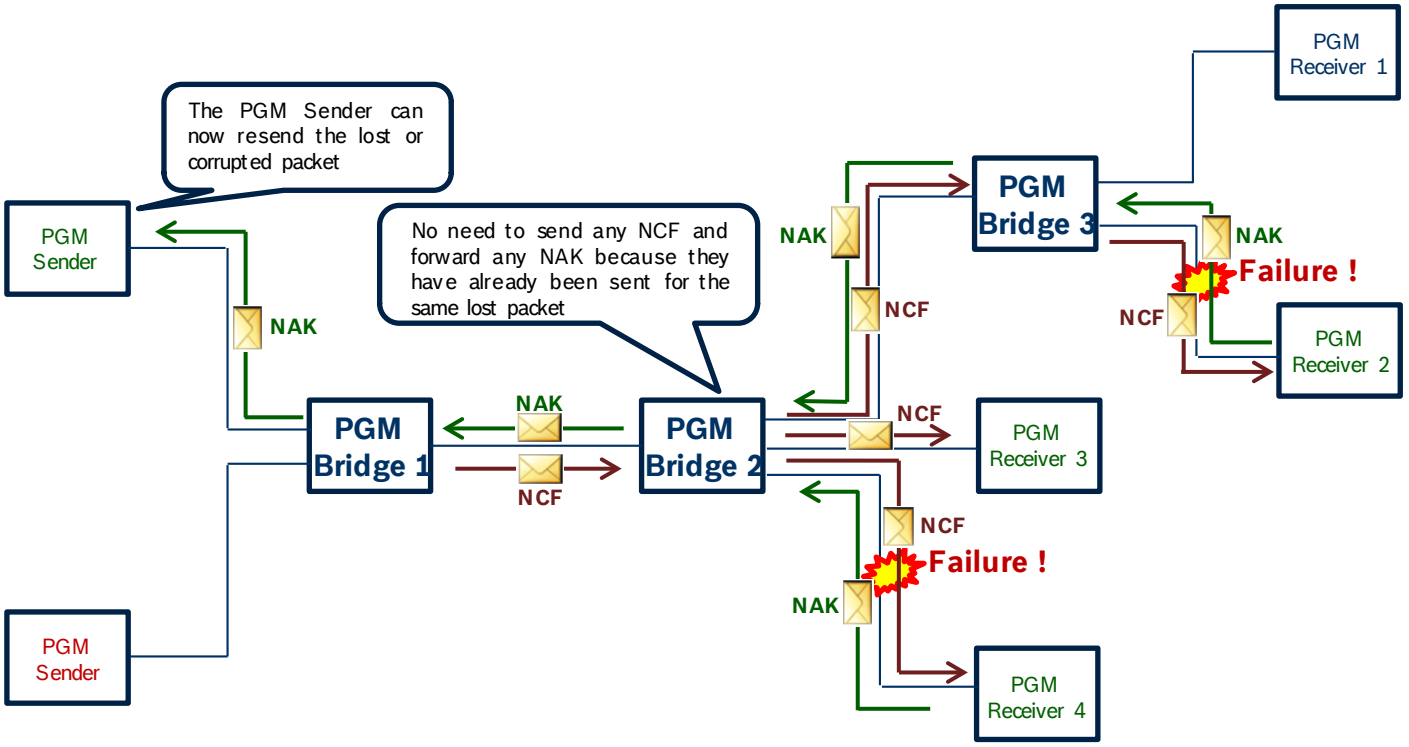
- **AVB / TSN Mechanisms**
  - **IEEE 802.1 Qat** Stream Reservation Protocol to guarantee necessary bandwidth resources to handle a stream from the sender to the receiver.
  - **IEEE 802.1 Qav** Queuing & Forwarding traffic shaper to prevent bursts during data transmission.
  - **IEEE 802.1 CB** Seamless 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**
  - Focus on the PGM & improve it on layer 2 for in-vehicle communication

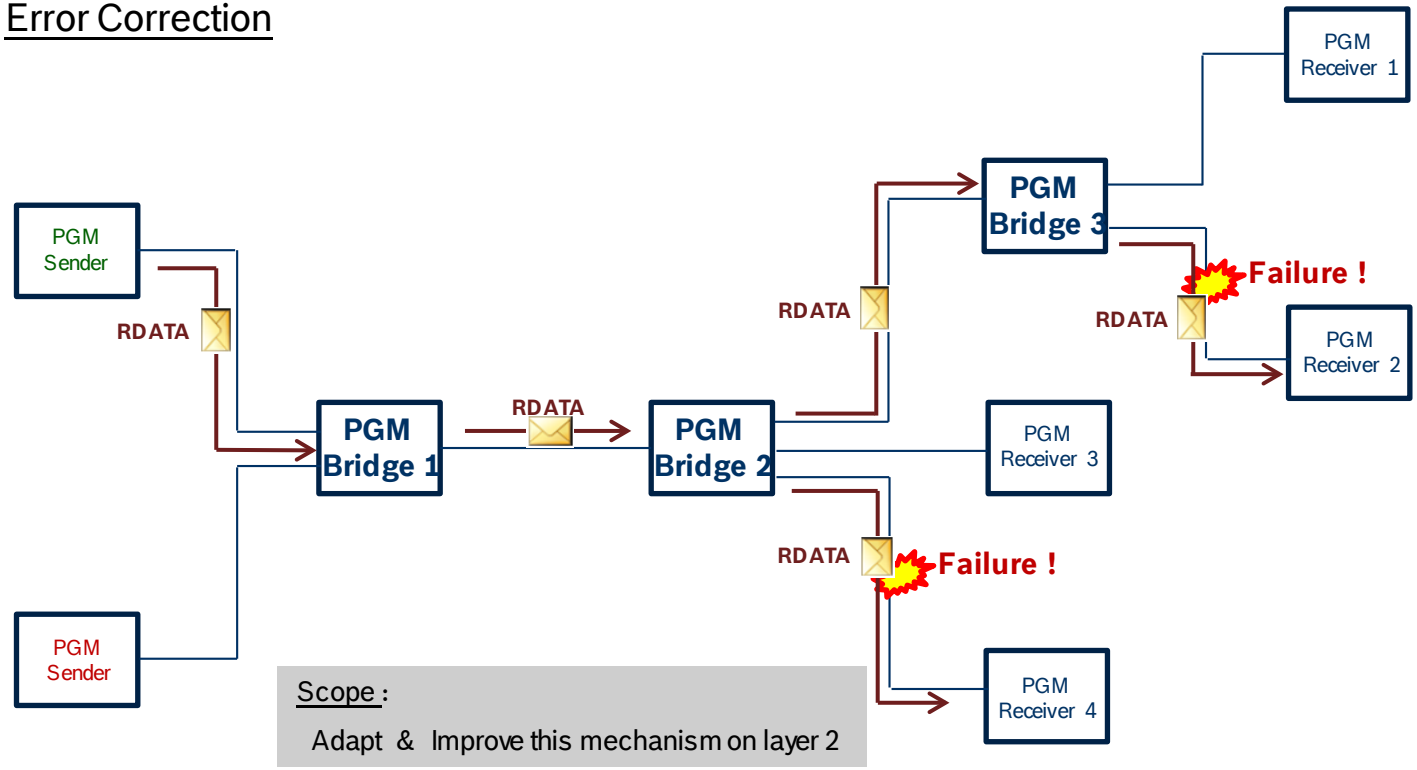
# Focus on PGM Error Detection & Correction (1)

## Error Signaling



# Focus on 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


Thank You for your Attention
Any Questions ?