The CAN protocol

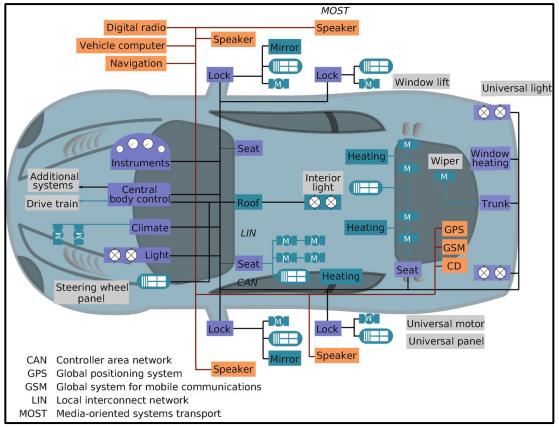
By: Yehia M. Abu Eita

Outlines

- What is CAN bus?
- Why CAN bus?
- CAN Node
- CAN bus connection
- CAN communication principle
- CAN standards
- CAN arbitration
- CAN frames
- CAN Logical Error detection and handling
- CAN Error tracking

What is CAN bus?

- CAN is referred to a **C**ontroller **A**rea **N**etwork.
- It is a **serial communication protocol** that efficiently supports distributed real-time control with a **very high-level of security**.
- It is one of the most famous protocols used in automotive industry.

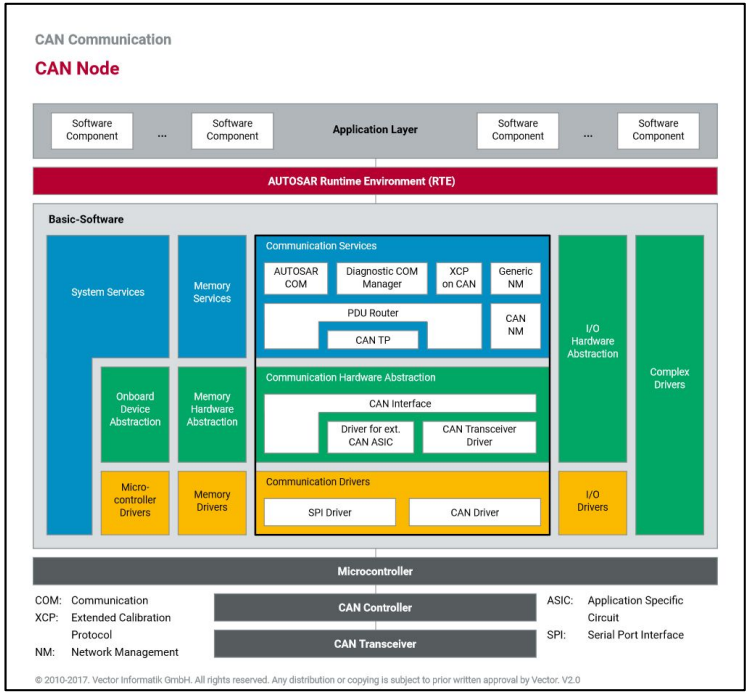


Why CAN bus?

- **Low cost**
  - ECUs Communicate via a single CAN interface.
- **Centralized**
  - Central error diagnosis and configuration across all the ECUs.
- **Robust**
  - CAN bus is robust towards the failure of sub-systems and electromagnetic interference.
- **Efficient**
  - CAN messages are prioritized based on IDs, the highest priority IDs are non-interrupted messages.
- **Flexible**
  - Each ECU contains a chip that receives all the transmitted messages, decide relevance and act accordingly.

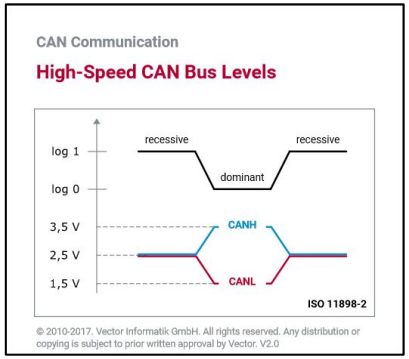
CAN node

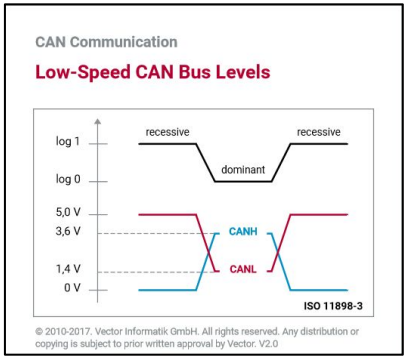
- CAN Transceiver
- CAN Controller
- Host

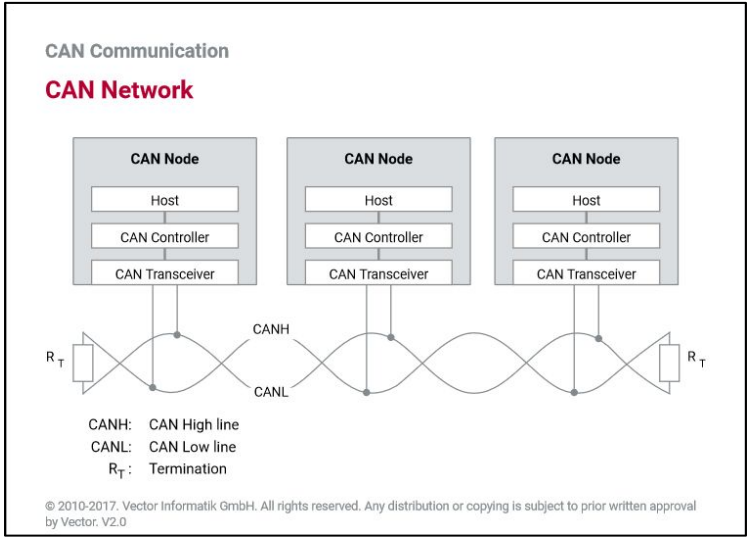


CAN bus connection

- CANH
- CANL

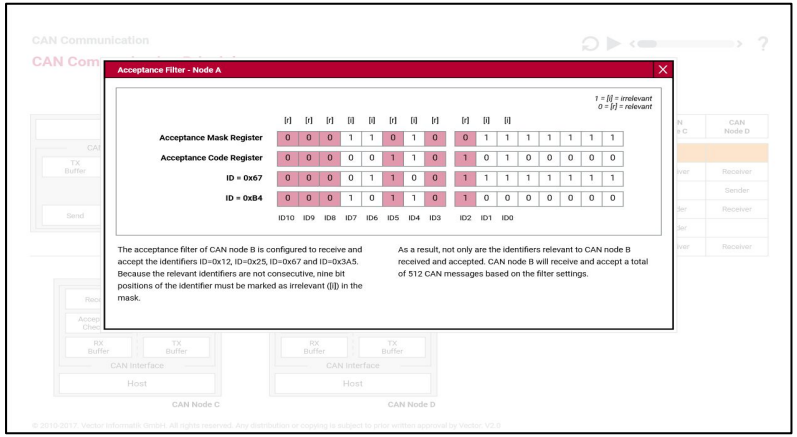






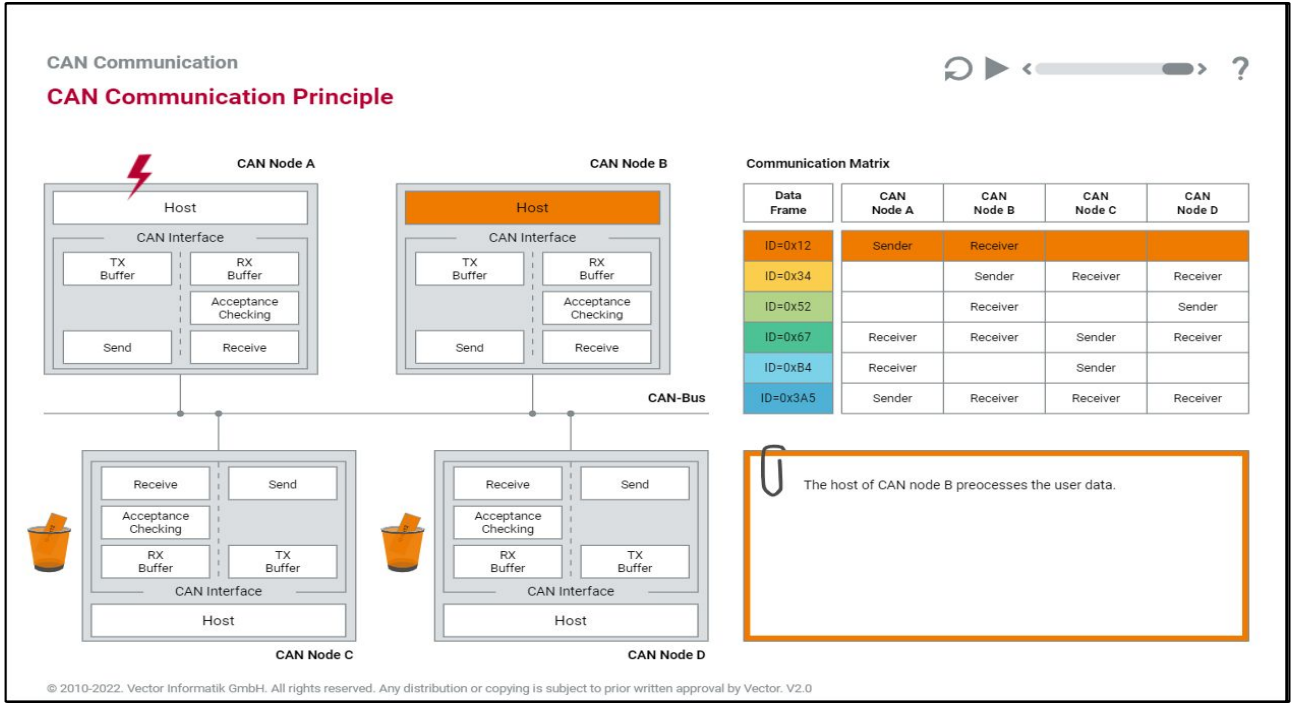
CAN communication principle

- Each CAN node has an **acceptance filter**.
- The acceptance filter contains **message IDs** for each node.
- If the **message ID** is **not existed**, **no response**.
- If the **message ID exists**, the **node will respond**.



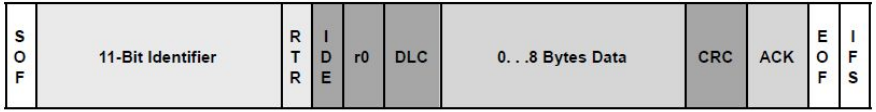
CAN communication principle

- **Use case**



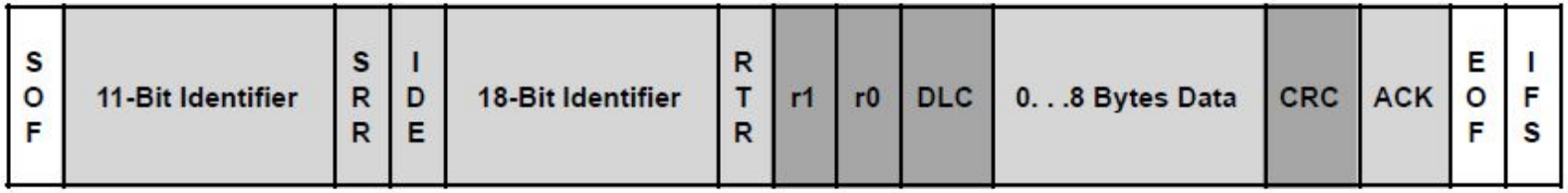
CAN standards

- **Standard CAN 2.0A**:
  - **SOF** —The single dominant start of frame (SOF).
  - **Identifier** —The Standard CAN 11-bit identifier establishes the priority of the message.
  - **RTR** — The single remote transmission request (RTR).
  - **IDE**— A dominant single identifier extension.
  - **r0** — Reserved bit (for possible use by future standard amendment).
  - **DLC** — The 4-bit data length code.
  - **Data** — Up to 64 bits of application data may be transmitted.
  - **CRC** — The 16-bit (15 bits plus delimiter).
  - **ACK** — ACK is 2 bits, (1 bit plus delimiter).
  - **EOF** — This end-of-frame (EOF) 7-bit field.
  - **IFS** — This is at least 3 recessive bits inter-frame space.



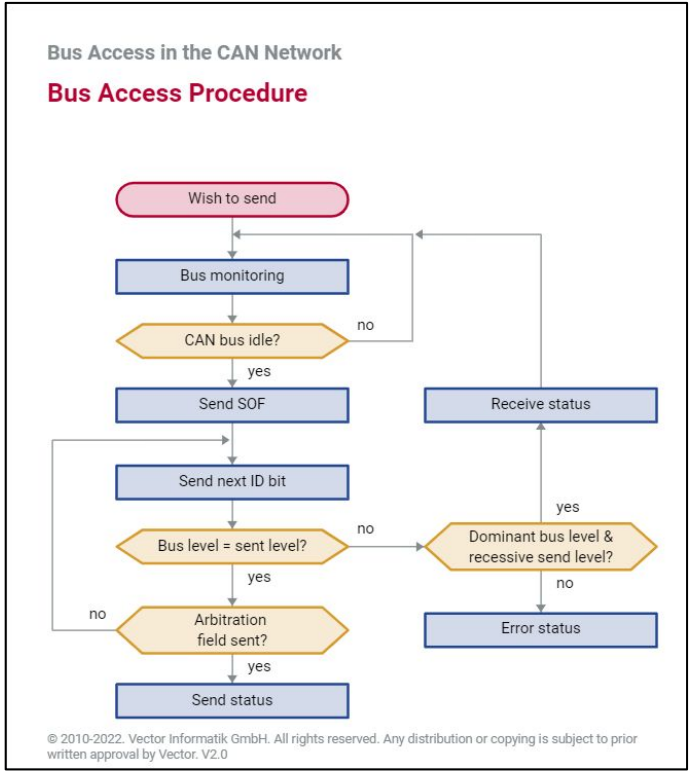
CAN standards

- **Extended CAN 2.0B**:
  - **SRR** — The substitute remote request (SRR) bit replaces the RTR bit in the standard message location as a placeholder in the extended format.
  - **IDE** — A recessive bit in the identifier extension (IDE) indicates that there are more identifier bits to follow. The 18-bit extension follows IDE.
  - **r1**— Following the RTR and r0 bits, an additional reserve bit has been included ahead of the DLC bit.



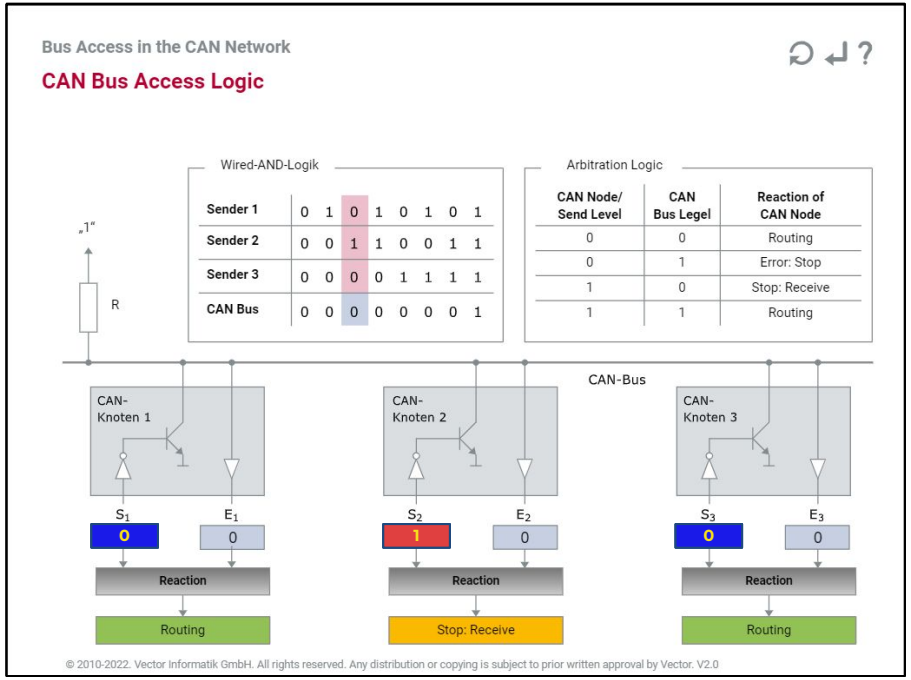
CAN arbitration

- **Bus Access Procedure**



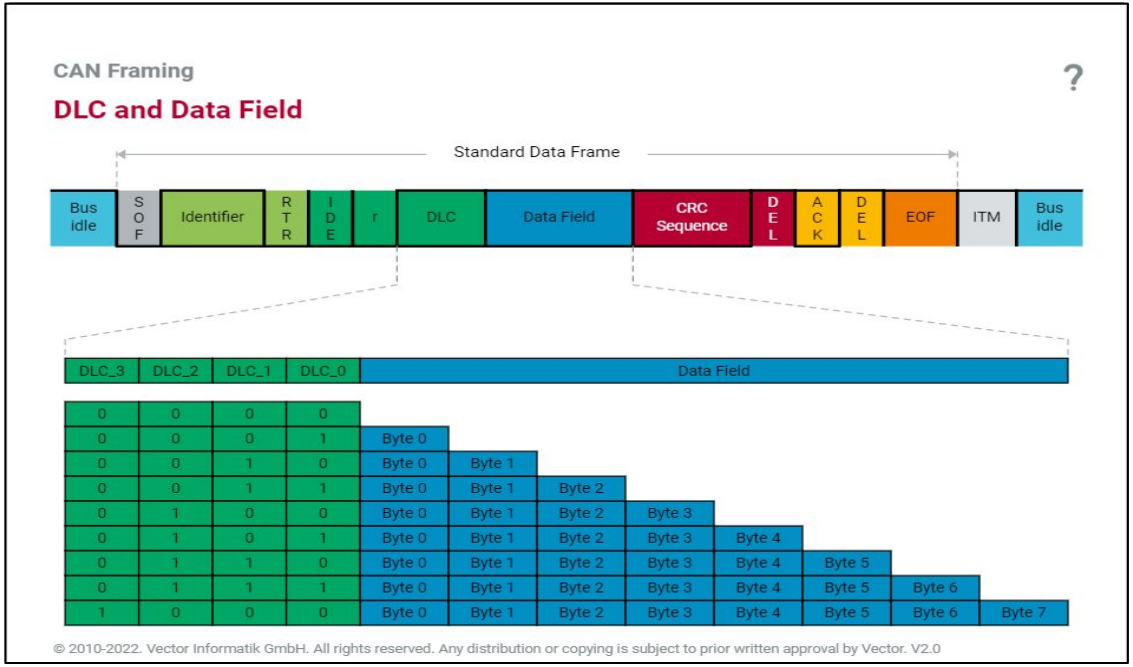
CAN arbitration

- **Bus Access Logic**



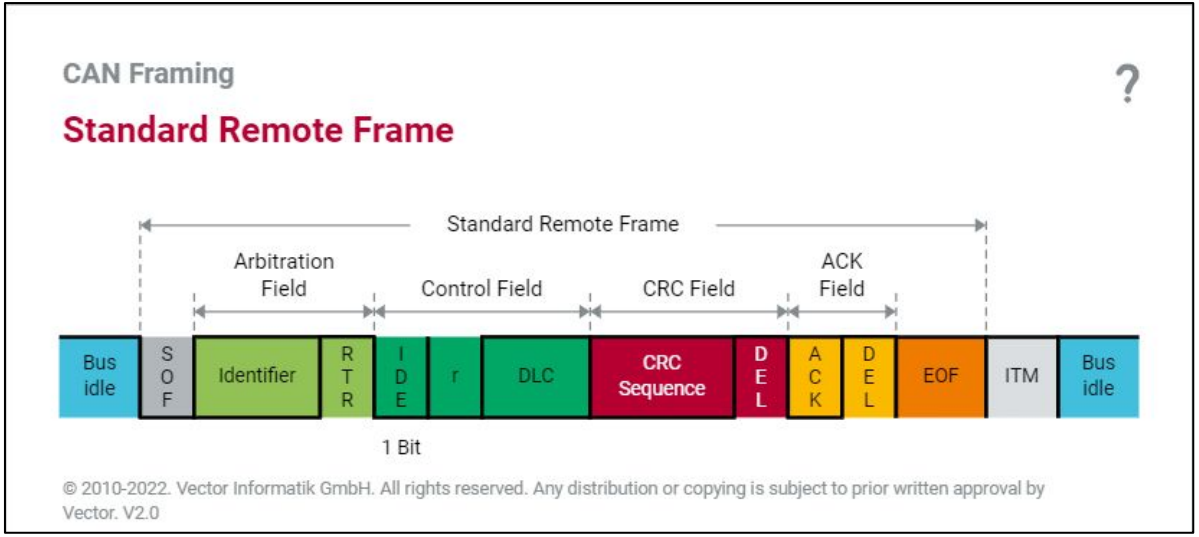
CAN frames

- **Data frame:**
  - For transmitting user data, **ISO 11898-1** prescribes the so-called data frame.
  - It can transport a **maximum** payload of **eight bytes**.



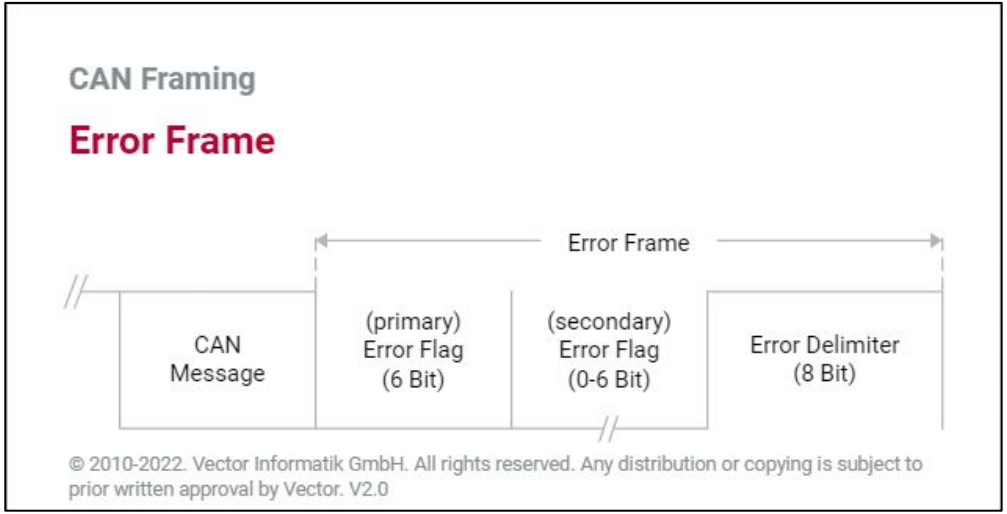
CAN frames

- **Remote frame**
  - It is a frame type with which user data, i.e. **data frames, can be requested** from **any other CAN node**.
  - **Except for its missing data field,** a remote frame has the same structure as a data frame.



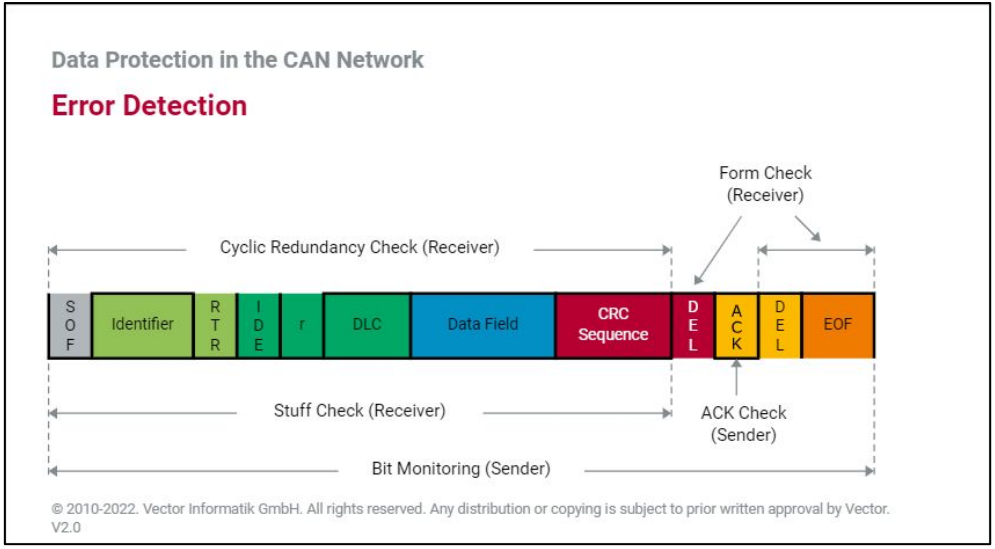
CAN frames

- **Error frame**
  - The error frame is available to **indicate errors detected during communication**.
  - An ongoing **erroneous data transmission** is **terminated** and an error frame is issued.



CAN Logical Error detection and handling

- **Logical Error Detection**:
  - **Sender tasks:**
    - **Bit Monitoring**
    - **ACK Check**
  - **Receiver tasks:**
    - **Stuff Check**
    - **Cyclic Redundancy Check**
    - **Form Check**



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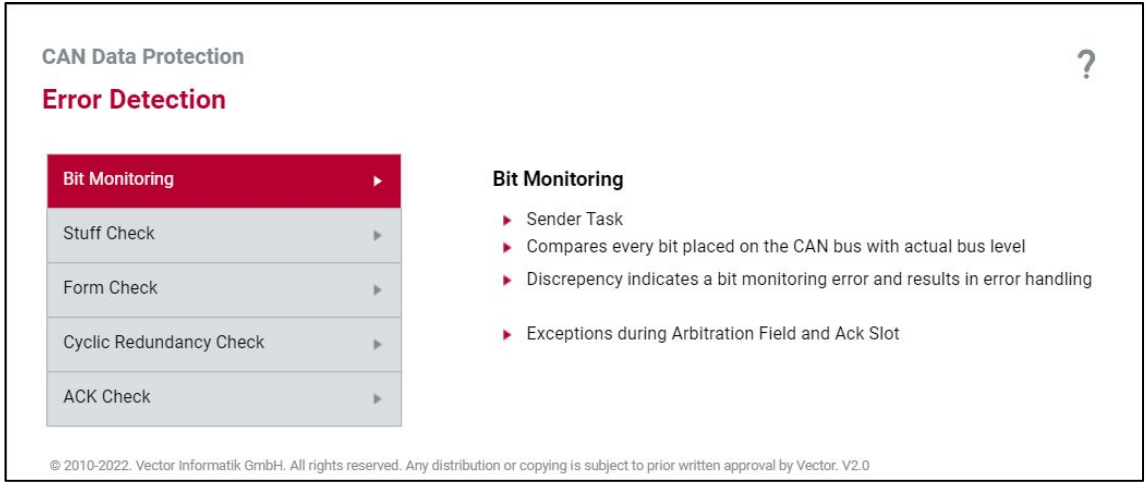

CAN Logical Error detection and handling

- **Logical Error Detection**:
  - **Receiver tasks:**
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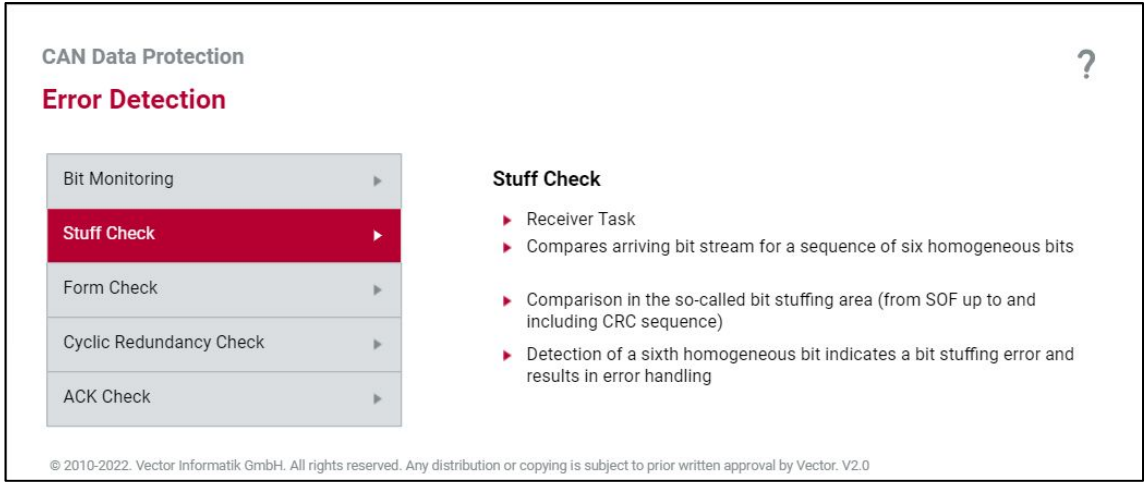

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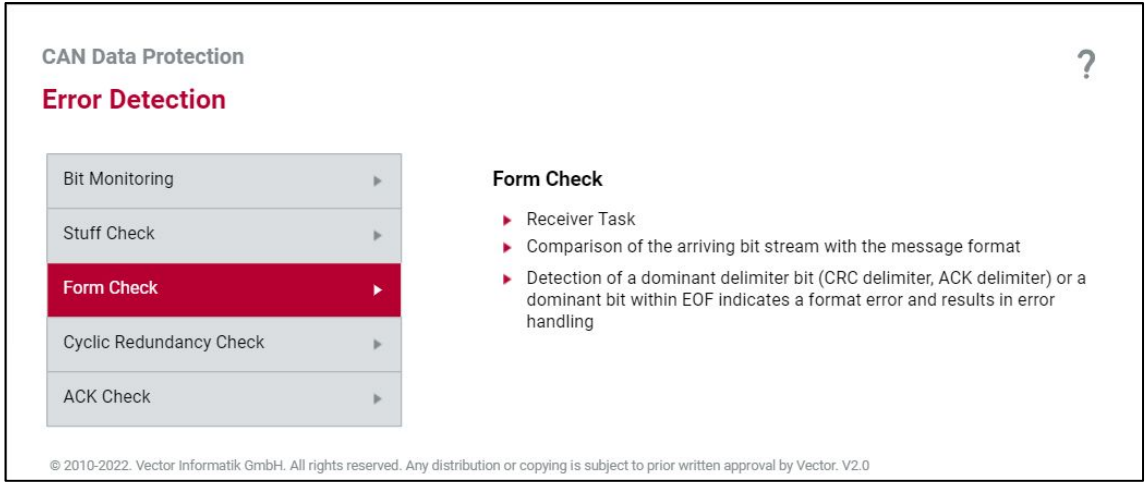

CAN Logical Error detection and handling

- **Logical Error Detection**:
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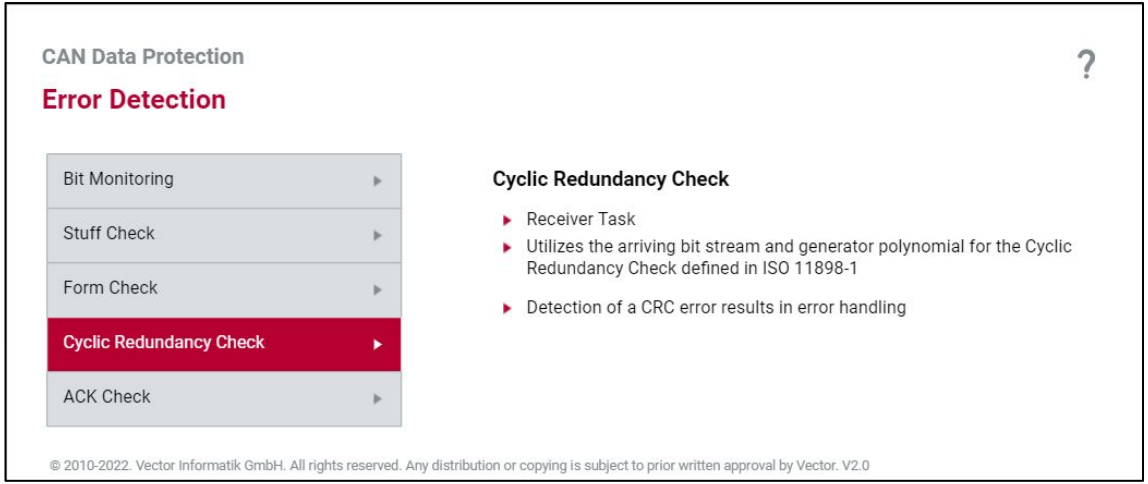

CAN Logical Error detection and handling

- **Logical Error Detection**:
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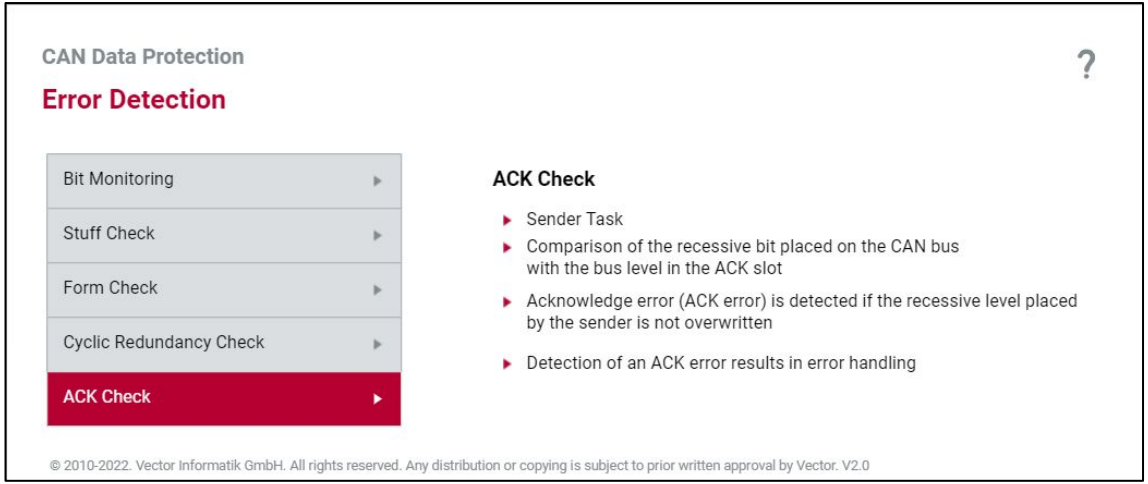
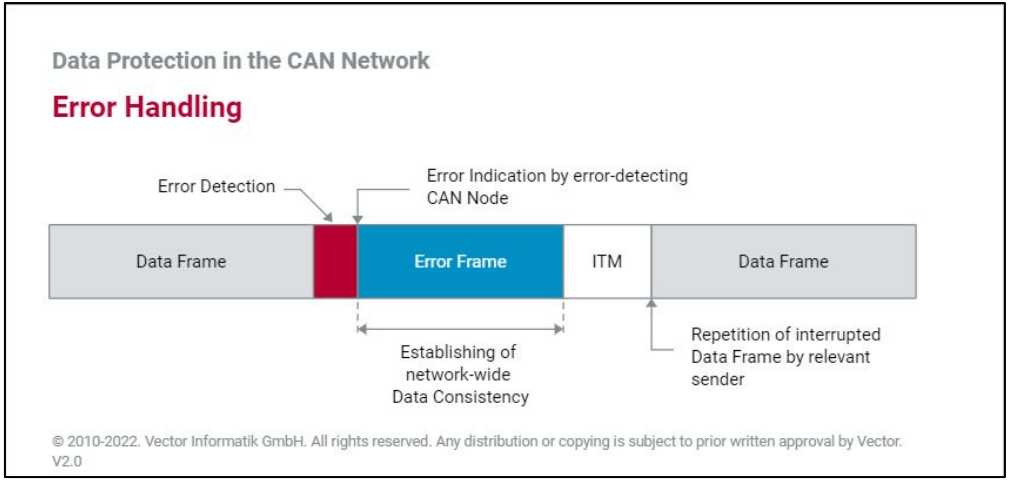
    - **ACK Check**



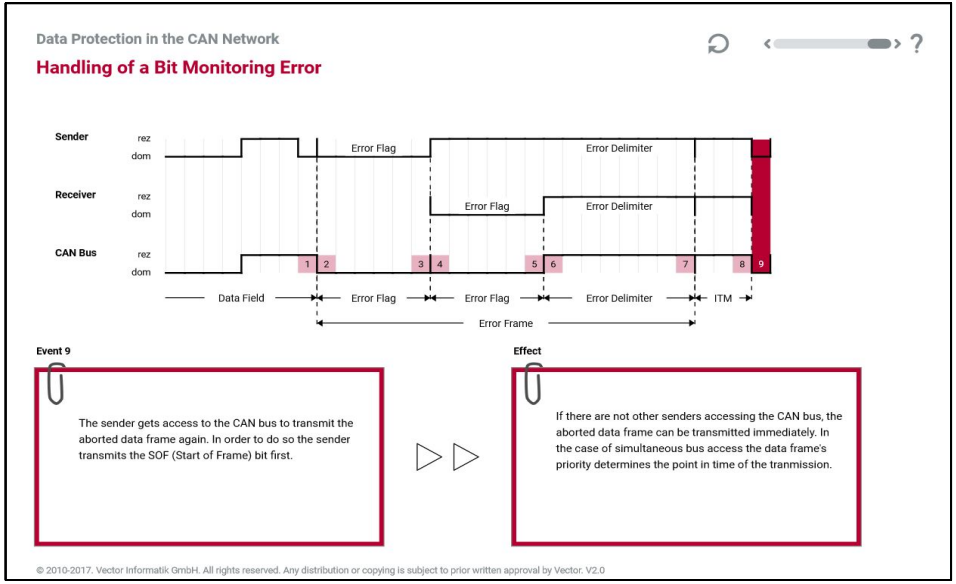
CAN Logical Error detection and handling

- **Error handling**:
  - If a CAN node is experiencing a **local disturbance**, it **must inform all CAN nodes.**
  - An error signal (**error flag**) is transmitted which is made up of **six dominant bits**.
  - This is an **intentional violation** of the **bit stuffing rule**, and it generates a bit **stuffing error**.
  - All other CAN nodes will also transmit an error flag (**secondary error flag**).



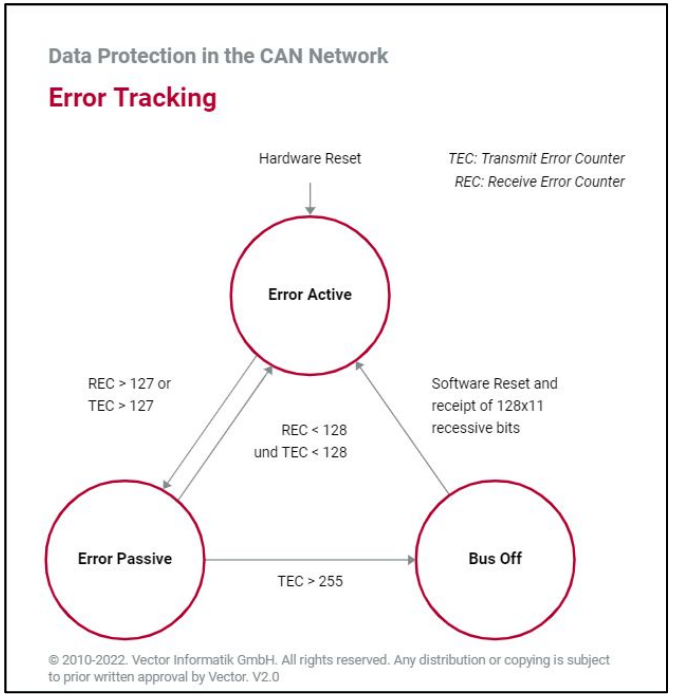
CAN Logical Error detection and handling

- **Error handling**:
  - Handling of a bit Monitoring Error



CAN Error tracking

- **Error Active**
  - After the start, it is the normal state.
  - The CAN controller sends six dominant bits (**active error flag**) after detecting an error.
  - When (**TEC>127; REC>127**), the CAN controllers **switch** over to the "**Error Passive**" state.
- **Error Passive**
  - CAN controllers can only indicate a detected error by sending six recessive bits.
  - In addition, when **sending two consecutive data or remote frames**, CAN controllers that are in the "Error Passive" state **must wait** the "**Suspend Transmission Time**" (**8 bits**).
- **Bus Off**
  - If a CAN controller **fails** or if there are **extreme accumulations of errors**, a state transition is made to the **Bus Off** state. The CAN controller **disconnects** from the CAN bus.



Summary

- You are learned what is CAN bus, its characteristics, its standards, its frame formats, and its error detection, handling and tracking techniques.
- CAN is high reliable, multimaster, low cost, flexible, and depending on message IDs not node addressing.