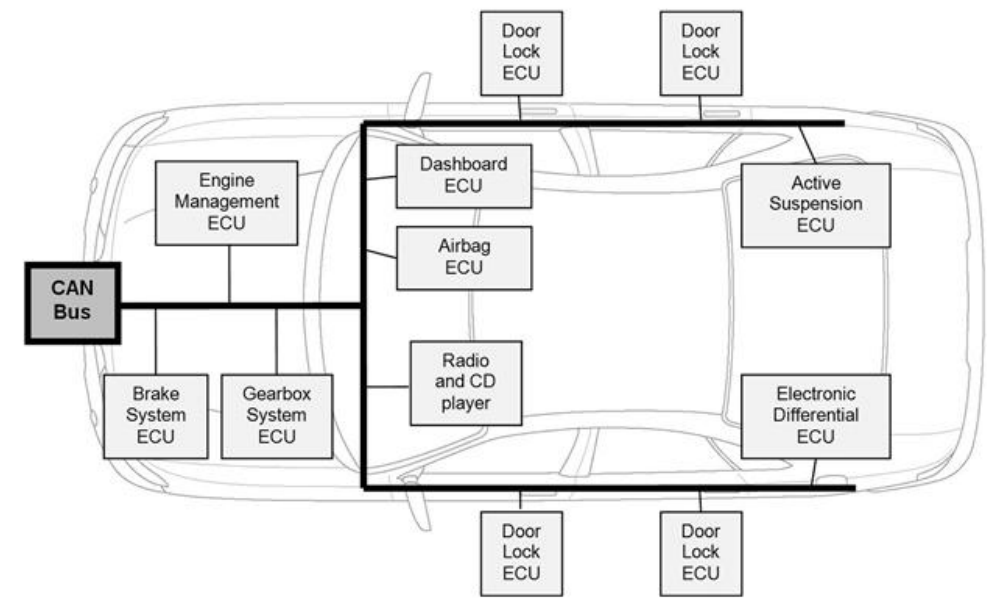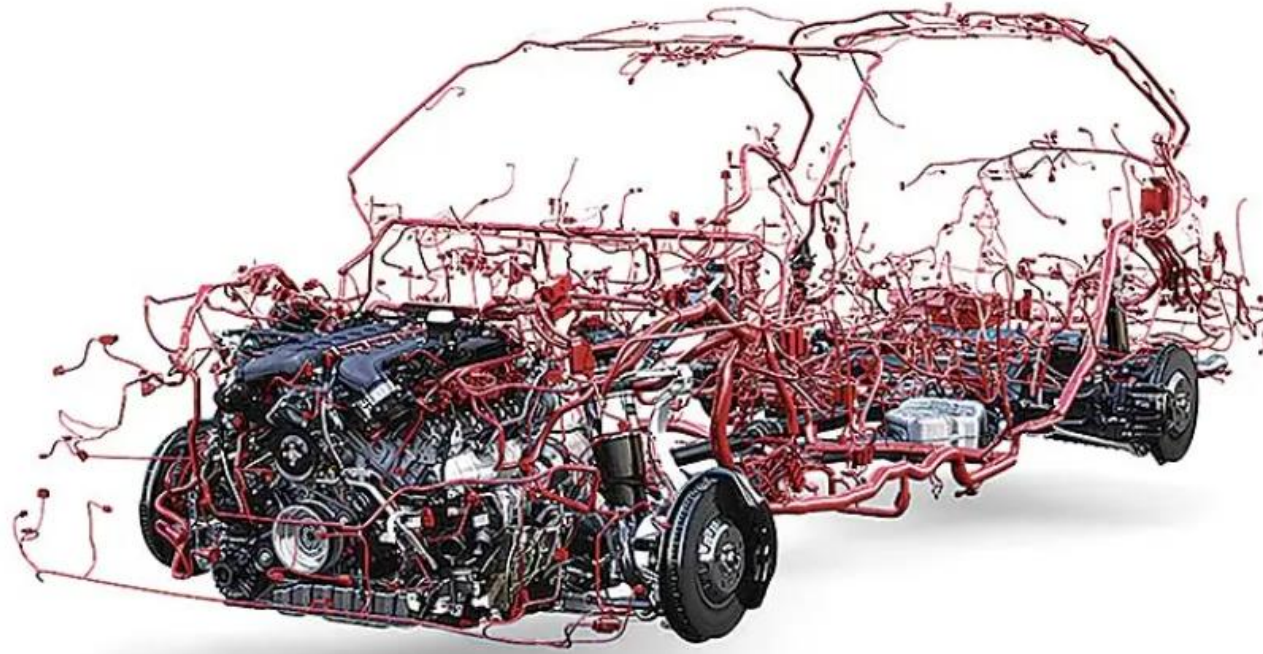# CAN bus

CAN bus (The Controller Area Network)

- a vehicle bus standard designed to allow the Electronic Control Units (ECUs) and other devices to communicate with each other

- a message-based protocol

- doesn't require a host computer

- a set of international standards under ISO 11898

History

Typical electrical wiring in a passenger car
Picture courtesy of Transparency Market Research

History

- heavy wires running throughout every vehicle
- electricity flowed from the battery through switches to the lights and other devices
- many ECUs in cars and trucks by the early 1980s

- the oil embargoes of the 1970s:
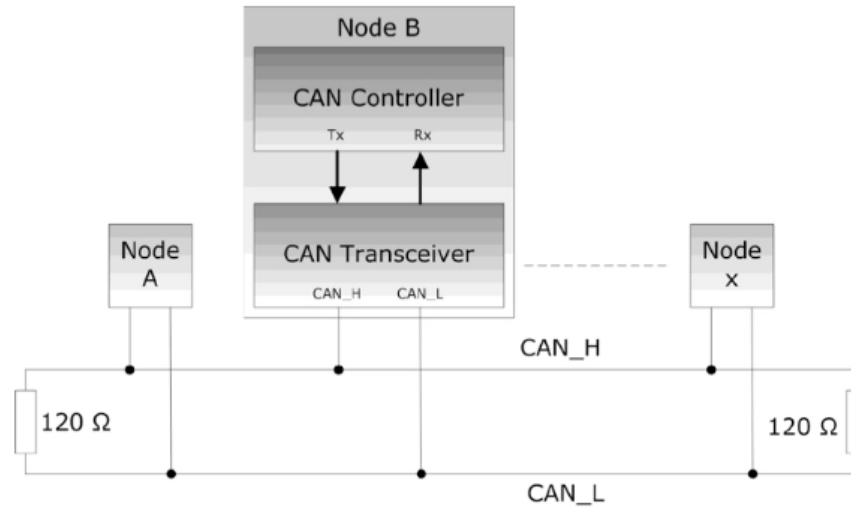 - pressure on automobile manufacturers to improve fuel efficiency

History

1983:
- started development of the CAN bus
- Robert Bosch company
  in partnership with Mercedes Benz, Intel and German universities

1986 - 1991:
- Bosch introduced the CAN standard
- Intel introduced CAN controller chips
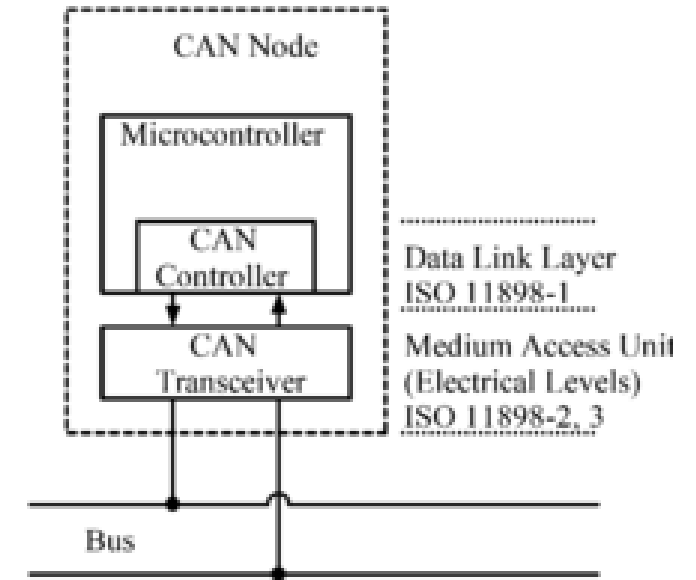- **Mercedes-Benz W140:** a CAN-based multiplex wiring system

Architecture

- a multi-master serial bus
- nodes (ECUs) connected to each other through a two wire bus

Nodes

- CPU, microprocessor, or host processor

- CAN controller
  - receiving: stores the serial bits until an entire message is available
  - sending: transmits the bits of message serially

- Transceiver
  - converts the data stream between the levels that are used by the CAN controller and by CAN bus
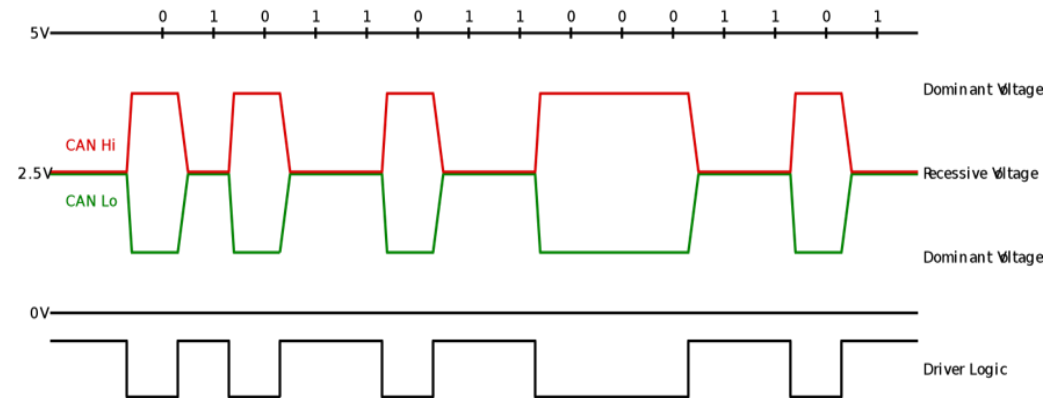
Bus

- a twisted pair with a 120 Ω characteristic impedance

- uses differential wired-AND signals

- CAN high (CANH) and CAN low (CANL)

- States
  - Dominant (0): CANH > CANL
    - Driven

  - Recessive (1): CANH ≤ CANL
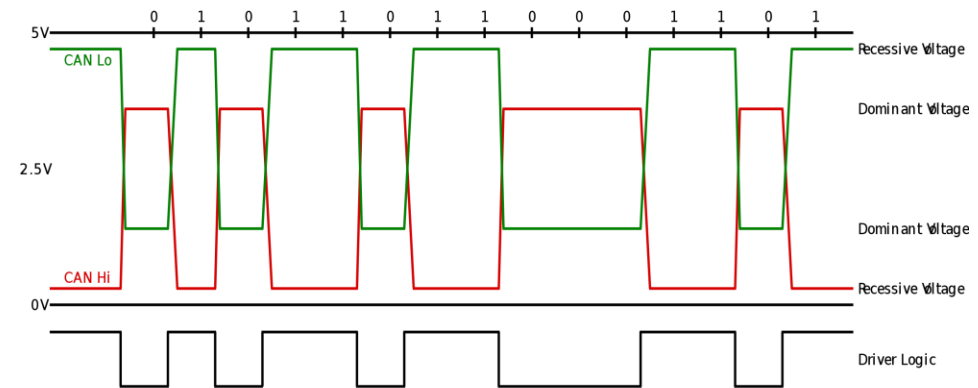   - Not driven and pulled by passive resistors

High-speed CAN (ISO 11898-2)

- up to 1 Mbit/s on CAN, 5 Mbit/s on CAN-FD

- a linear bus terminated at each end with 120 Ω resistors

- the dominant state (when any device is transmitting):
    - CANH ~ 3.5 V, CANL ~ 1.5 V
    - a nominal differential voltage of 2 V

- the recessive state
    - a nominal differential voltage of 0 V

Low-speed CAN (ISO 11898-3)

- also called fault-tolerant CAN; speed up to 125 kbit/s

- a linear bus, star bus or multiple star buses connected by a linear bus

- the dominant state
  - CANH ~ 5 V or 3.3 V, CANL ~ 0 V

- the recessive state
  - CANH ~ 0 V, CANL ~ 5 V
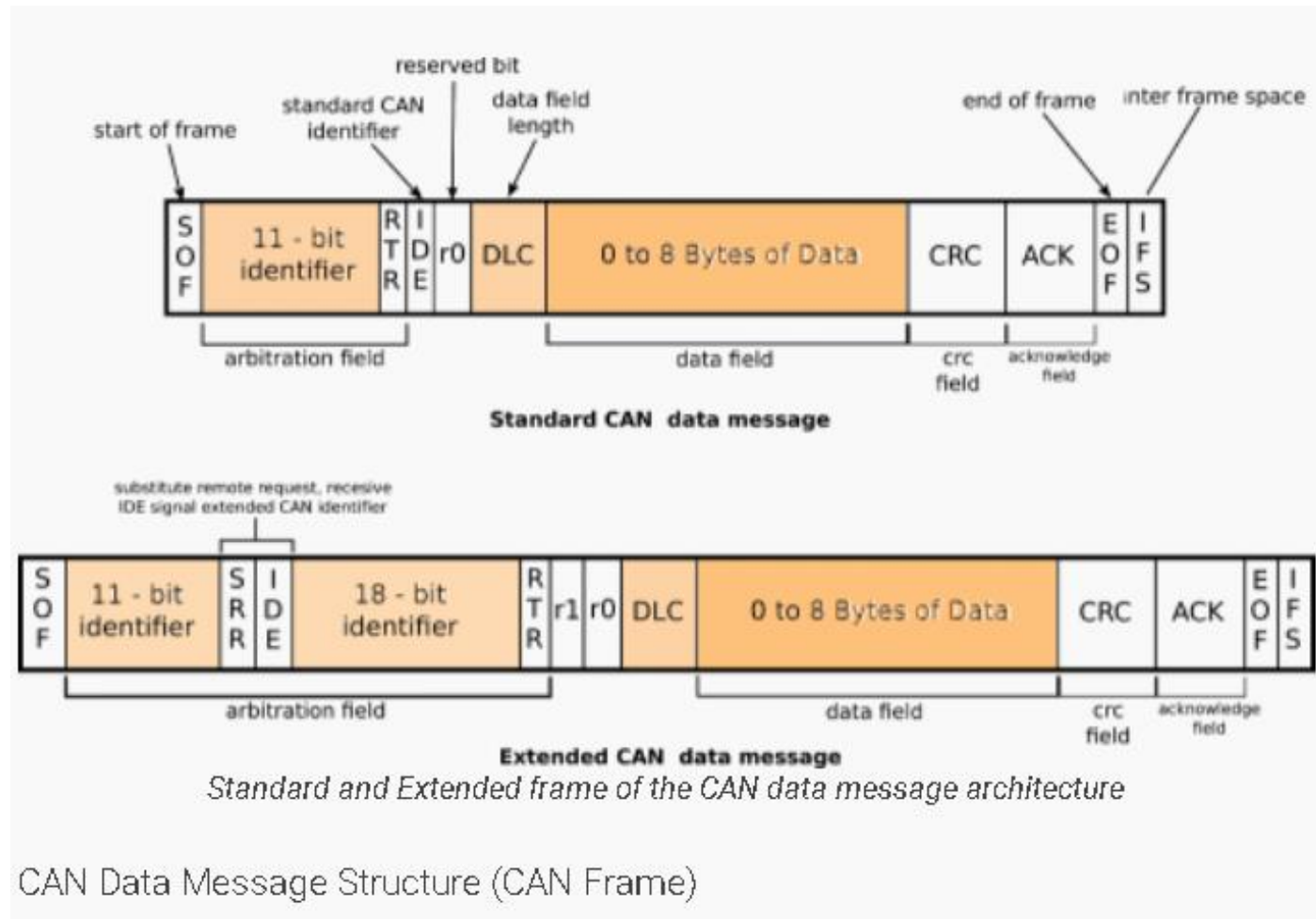 - Receivers consider the sign of CANH−CANL

Data transmission

- a lossless bitwise arbitration method
- the node with the lowest identifier transmits the first 1 and loses arbitration
- all nodes operate at the same nominal bit rate
- a separate clock signal is not used
- resynchronization occurs on every recessive to dominant transition during the frame

Frames

- **Data frames**
  - transfer data to one or many receiver nodes
- **Remote frames**
  - ask for data from other nodes
- **Error frames**
  - report errors
- **Overload frames**
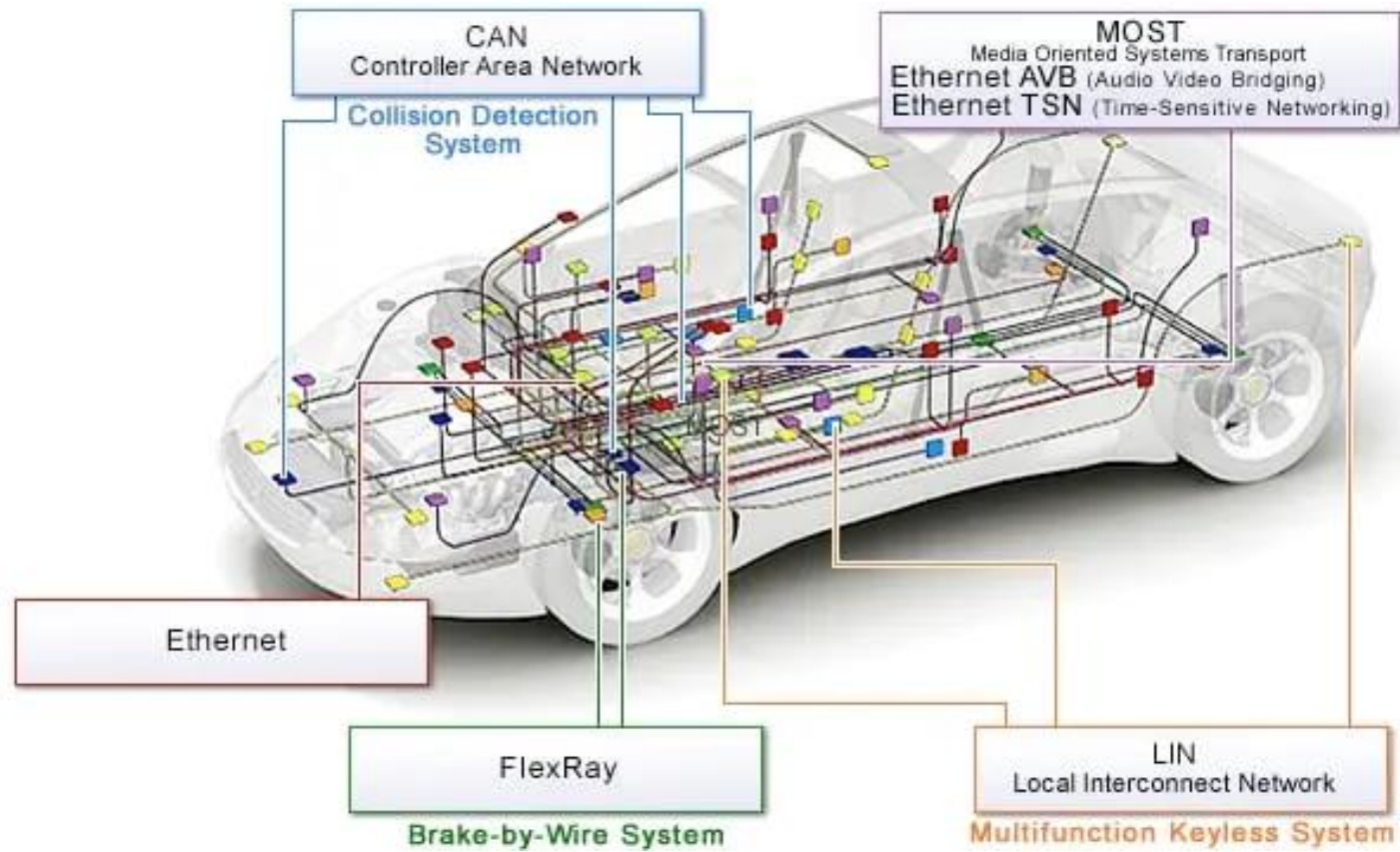 - report overload conditions

Frames

Standard and Extended frame of the CAN data message architecture

CAN Data Message Structure (CAN Frame)

CAN FD

- flexible data rate CAN
- more data per message
- higher speed transmissions – up to 8 Mbps
- allows ECUs to dynamically change their transmission rates and select larger or smaller message size

CAN in vehicles

CAN in vehicles

- OBD II
    - on-board diagnostics port is found in all cars made since 1989
    - allows to diagnose vehicle problems by connecting a scanning tool to its 16-pin connector

OBD II connector on a vehicle