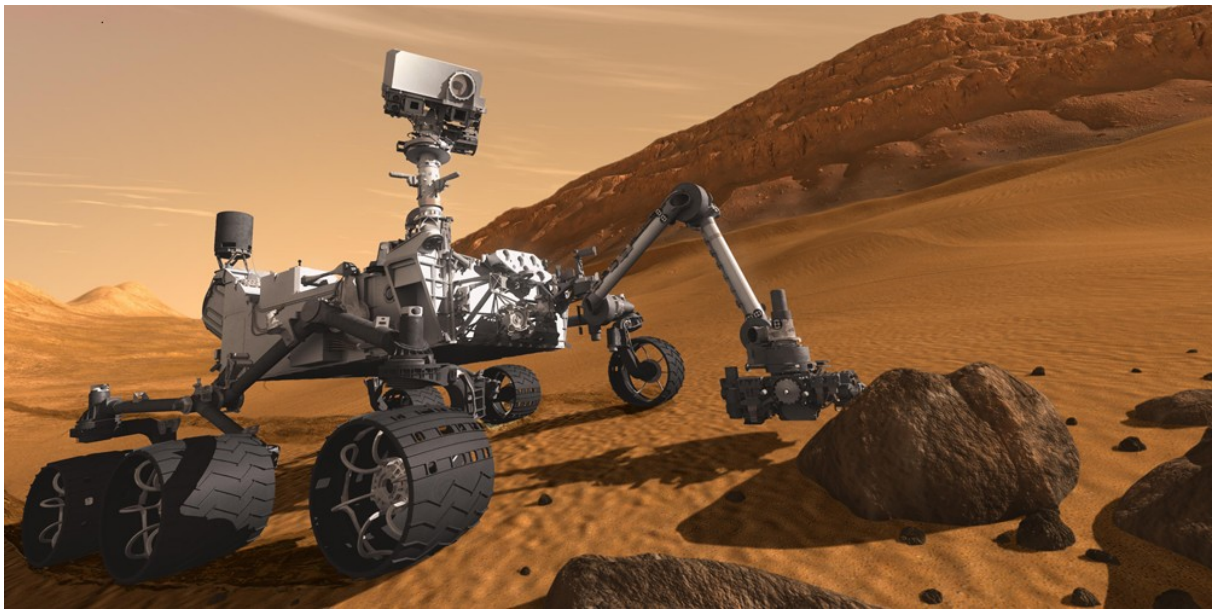
7th ADCSS workshop



CAN/CANopen applications: Past, present, and future

Holger Zeltwanger

More than 25 years CAN

"It is now 25 years since Bosch presented an effective networking solution at the SAE International Congress in February 1986 in Detroit (SAE-Paper 860391): the Controller Area Network (CAN). After the presentation of the paper, there was at first complete silence in the overcrowded meeting room. ...

... Then there came a remark from someone in the audience: "They've done it!". This was an indication – already at that early point in time – that CAN would later profoundly change automotive electronics. Today, CAN has established itself worldwide as the backbone for the networking of embedded systems – and this not only in automotive technology."

Dr. Siegfried Dais, Prof. Dr. Uwe Kiencke, Martin Litschel

First press release

BOSCH AND INTEL JOIN IN DEVELOPMENT OF AUTOMOBILE ELECTRONICS NETWORK

DETROIT, Mich., Feb. 25, 1986 -- Robert Bosch GmbH and Intel Corp. today announced that the companies are jointly developing a high-speed communication link for interconnecting electronic control units within automobiles.

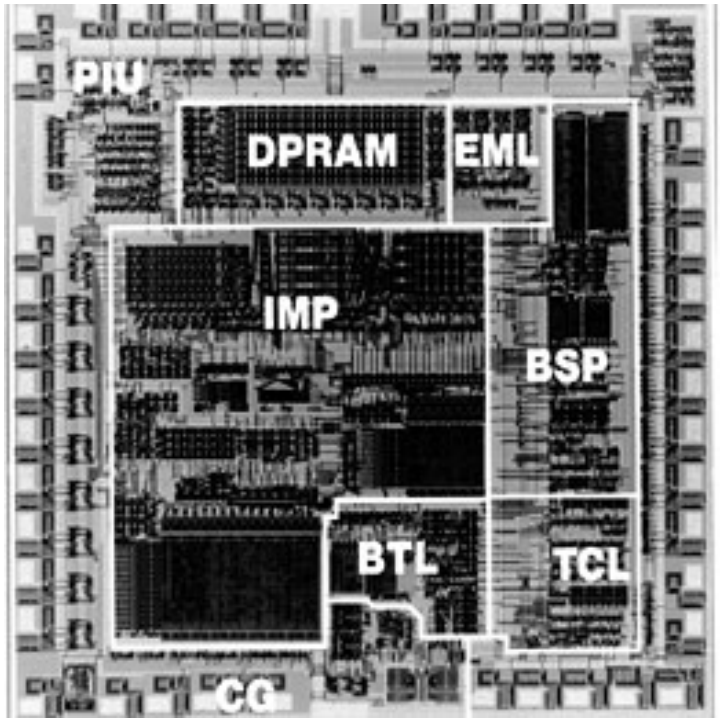
This serial communication system now in development is called the "Controller Area Network" (CAN).

Robert Bosch defined the CAN protocol architecture and is contributing its expertise in automotive system engineering, quality and reliability.

Intel is contributing to the CAN project its knowledge of automotive market requirements and expertise in design of high-reliability, cost-effective very-large-scale-integrated (VLSI) products.

The outcome of this cooperation will be a standard line of Intel products: a serial controller which interfaces between various microcontroller architectures and the serial bus; and microcontrollers with the protocol integrated within a single chip.

These Intel products will be offered to the general marketplace as standard products.



Intel's 82526 CAN stand-alone controller chip supported data-rates up to 1 Mbit/s

CAN application domains

Transportation:	Passenger cars, trucks and buses, e-vehicles, trains, ships and vessels, helicopters and aircrafts
Manufacturing:	Robot and embedded machine control
Healthcare:	Medical devices and laboratory automation
Construction:	Lift and door control; commercial vehicles
Agriculture and forestry:	Harvesting machines, cow-sheds
Retail and finance:	Vending machines
Science:	Telescopes, high-energy physics
Entertainment:	Studio equipment, moving cameras, gambling
Communication:	Embedded control in satellites
Domestic appliances:	Coffee machine, service robots

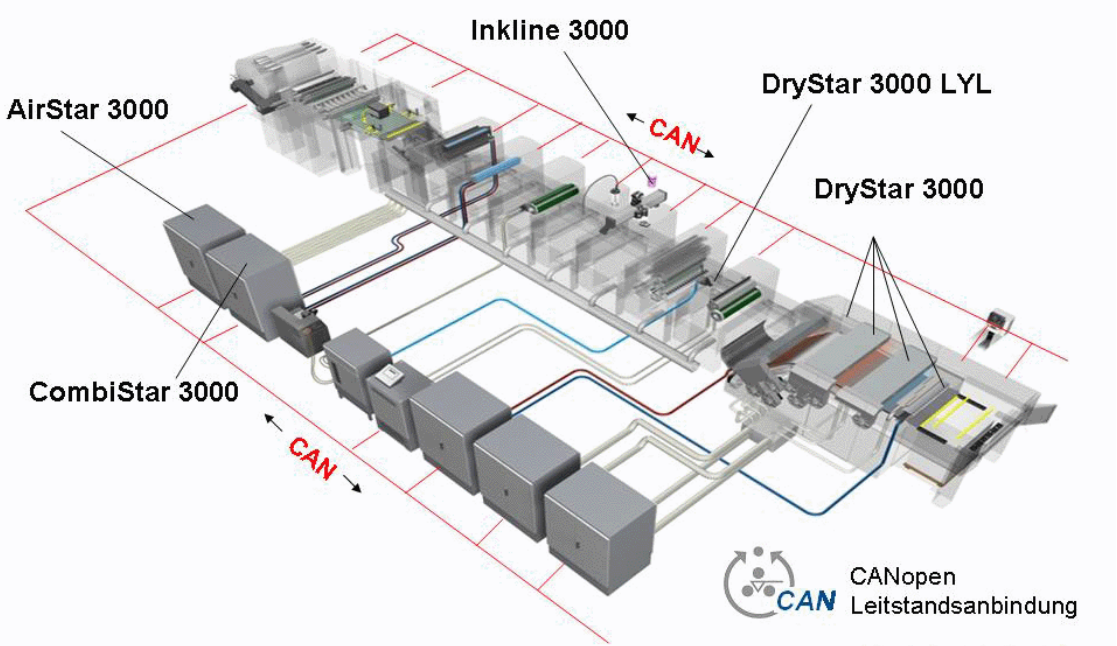
CAN-based HLPs

- *1991: CAN King*dom
- *1992: CAN Application* Layer (CAL)
- *1994: Smart Distributed* System (SDS)
- 1994: IEC 62026-3 (DeviceNet)
- 1994: SAE J1939
- **1995: EN 50325-4 (CANopen)**
- 1999: ISO 11992-1/-2/-3
- 2000: IEC 61162-3 (NMEA 2000)
- 2002: ISO 11783 (ISOBUS)
- 2004: ISO 14229/15765 (Diagnostic)
- 2007: Arinc 825

CANopen basic protocols

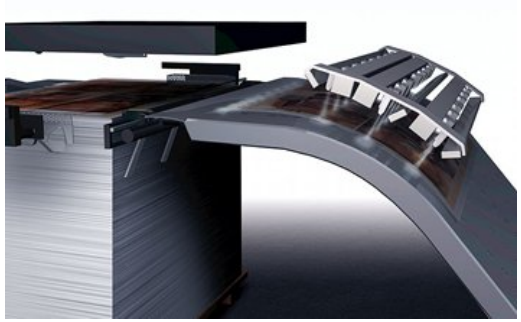
- Network management
  - NMT Message protocol
  - Boot-up/Heartbeat protocol
- Error control
  - Heartbeat protocol
- Service Data Object (SDO)
  - Standard SDO protocols
  - SDO block protocols
- Process Data Object (PDO)
- Special COBs
  - Synchronization (SYNC) protocol
  - Time Stamp (TIME) protocol
  - Emergency (EMCY) protocol

Offset printing machine



Data rate: 125 kbit/s @ 500 m (max.)

HEIDELBERG

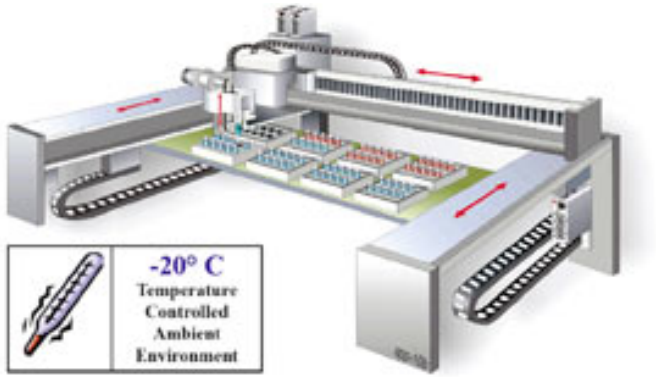


CANopen specifications

1995: 60 DIN A4 pages **2013: 15000+ DIN A4 pages**

CANopen profiles

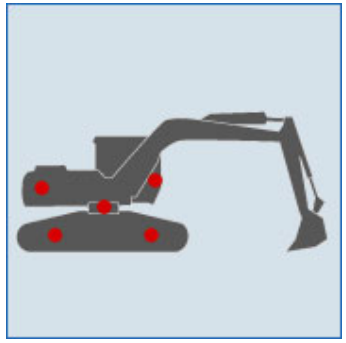
- Device profiles for *embedded* networking (e.g. internal machine control)

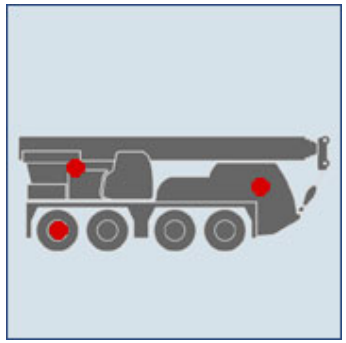


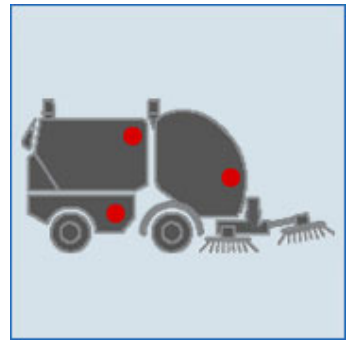
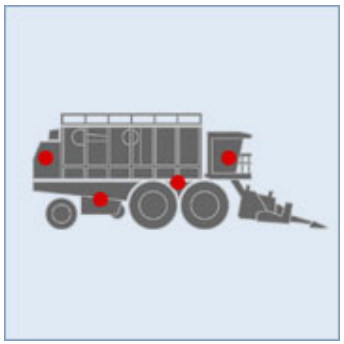
- Application profiles for *open* networking (e.g. elevator control systems)

CANopen in duty vehicles





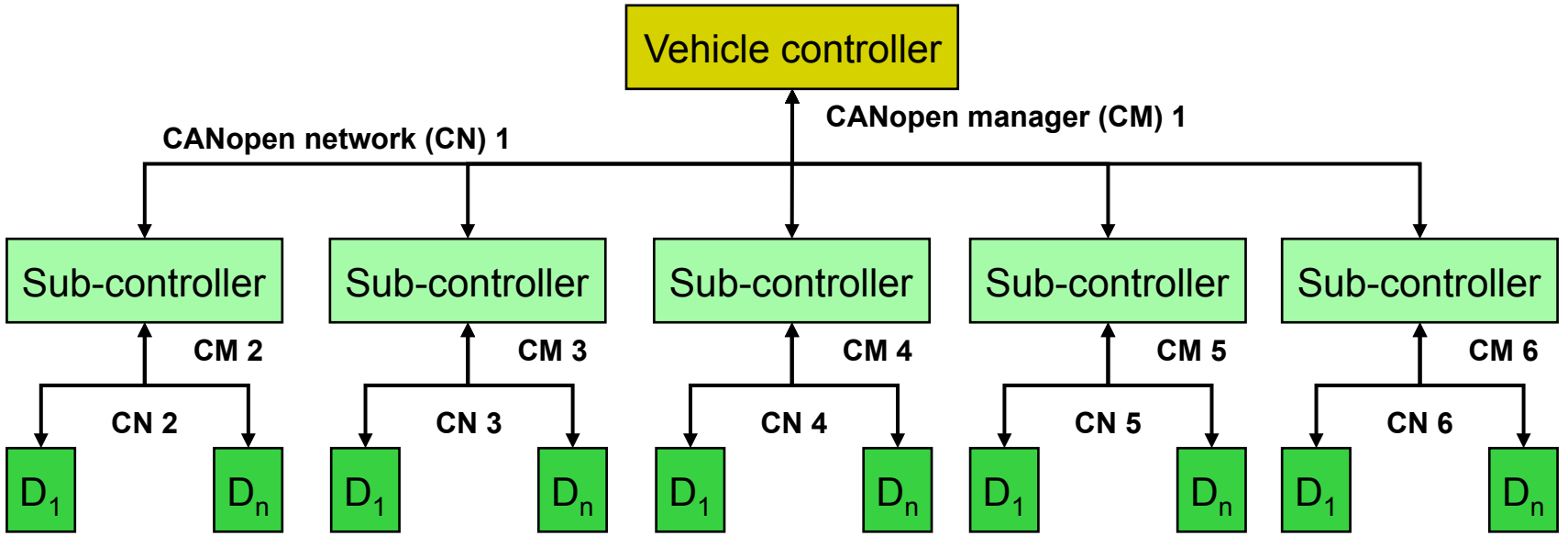



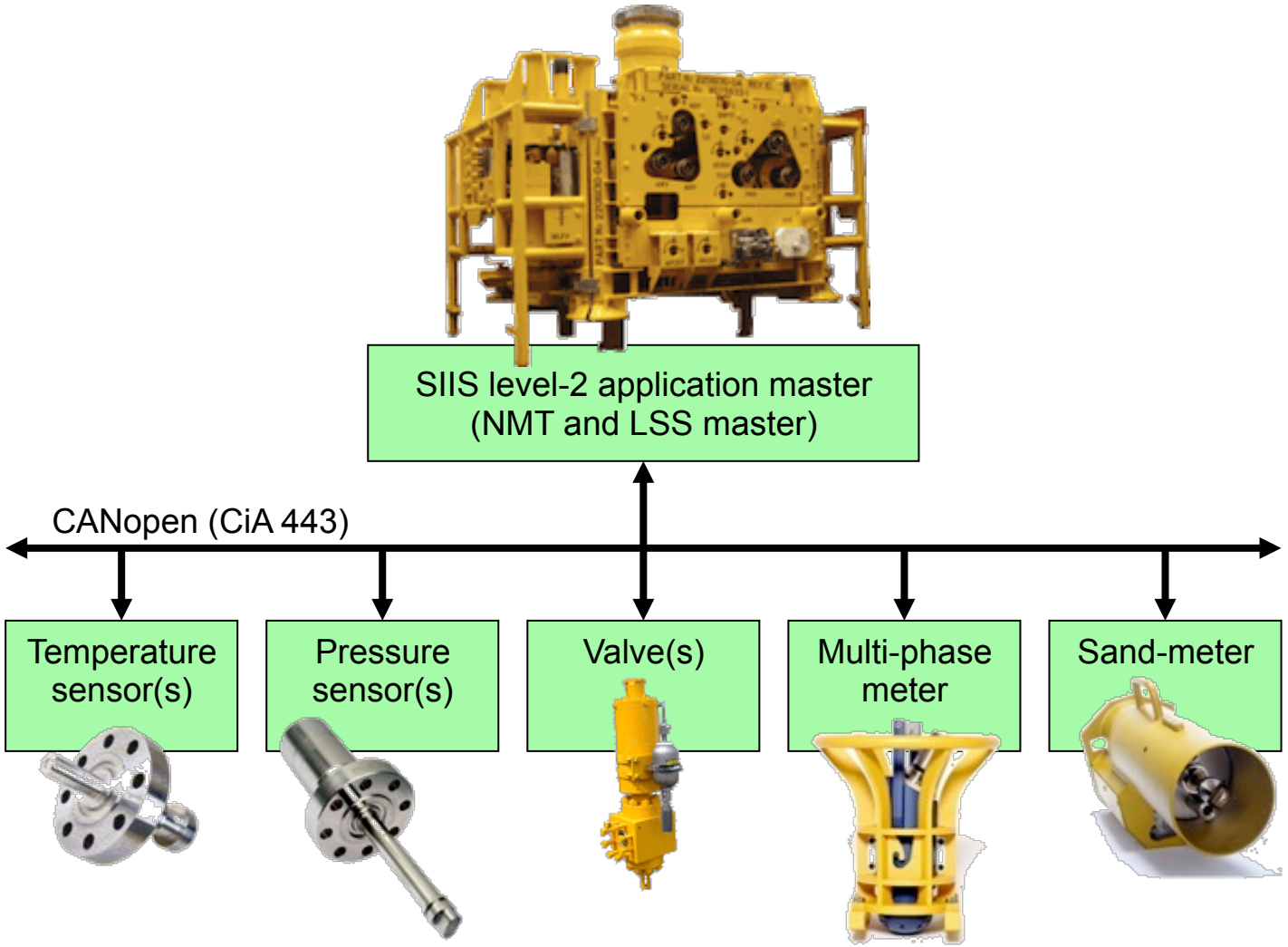

CiA 444 container handling

CANopen in mining machines

There are very complex, cascaded multi-network systems used in mining machines



SIIS level-2 network



NOTE Devices are interoperable and partly interchangeable

CAN

Medical devices

Scanner (e.g. MR, CT)

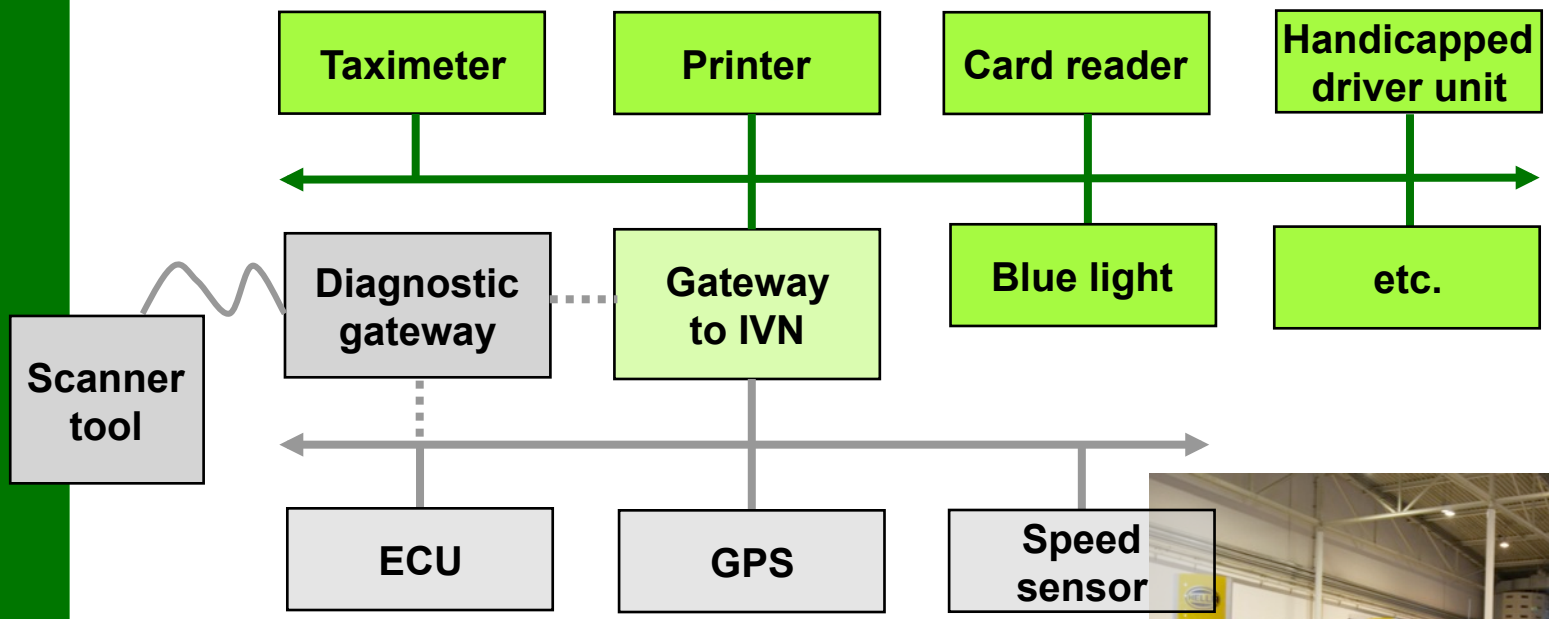
X-ray device

Lithotripter

Eye-surgery robot

Operating theaters (e.g. endoscopes)

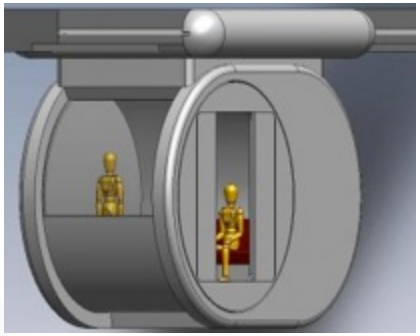
CiA 447 special-purpose car

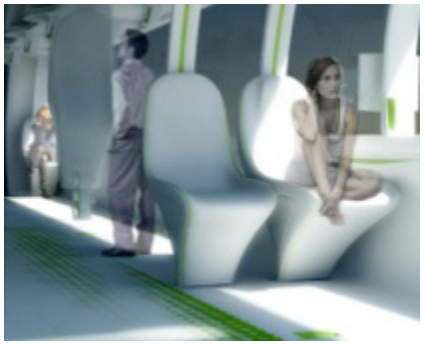


Transportation challenge

- In 2009, more than 50 per cent of the world's population lived in cities.
- By 2030, it's expected that 60 per cent will have their homes in urban areas.
- By 2050, about 70 per cent will live in still growing cities.

The main challenge is transportation: ***How to move people efficiently in congested, polluted, and densely populated cities.***


Renewable energy

- **Pitch-control in wind power** (CiA 402/408, CiA 406)
- **Sun-tracking in photovoltaic** (CiA 402, CiA 406)
- **Photovoltaic systems** (CiA 437)
- **Battery/power management** (CiA 454)

Future-proofed extensions

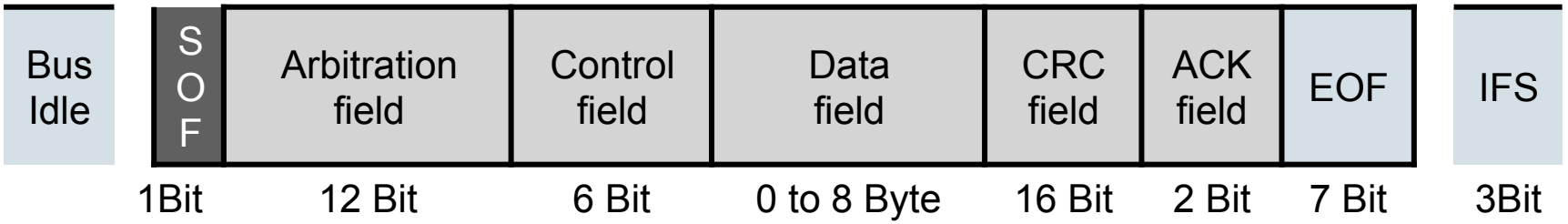
Faster and greener

ISO 11898-1 (2014)
Classic and improved (flexible data-rate) CAN data link layer protocol supporting bit-rates up to 8 Mbit/s and pay-loads up to 64 byte.

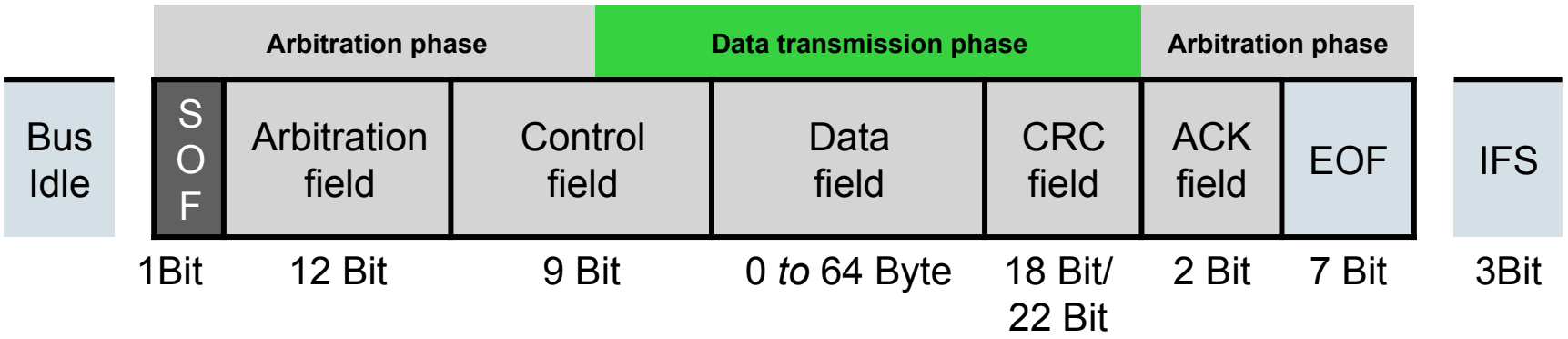
ISO 11898-6 (2013)
High-speed transceiver with low-power mode and selective wake-up capability

CAN FD data frame

CAN base frame format

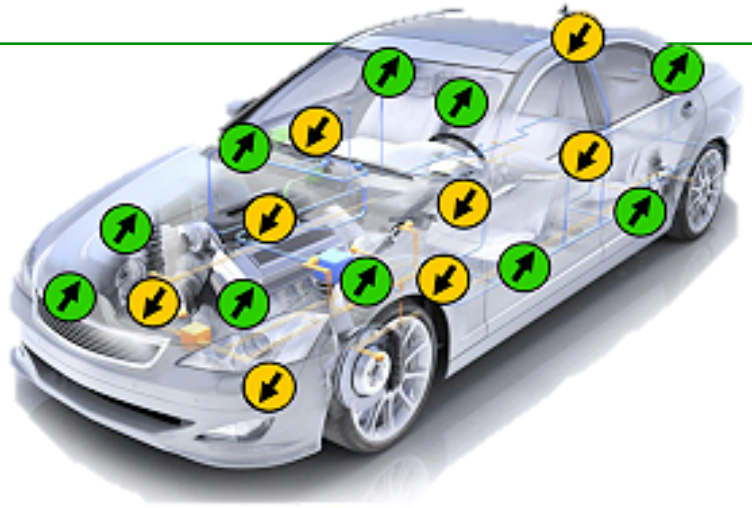


CAN FD base frame format



ACK = Acknowledge
CRC = Cyclic redundancy check
EOF = End of frame
IFS = Interframe space
SOF = Start of frame

Partial networking



- Even CAN transceiver chips can be in deep-sleep mode (ISO 11898-6)
- CAN transceiver wakes-up CPU only if a dedicated CAN message has been received
- CAN transceiver needs to implemented partly the CAN data link layer protocol
- Robustness and reliability of the communication should not be decreased

Summary

- CAN FD improves bandwidth and payload (up to 64 byte)
- ISO 11898-6 allows partial networking with selective wake-up function
- CAN is one of the most robust communication systems
- CAN is one of the most reliable data link layer protocol
- CANopen is the most flexible standardized CAN-based application layer
- CANopen profiles are wide spread providing a high interoperability

www.can-cia.org
www.can-newsletter.org

CAN

I am ready for your questions