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H. Hutschenreiter und T. Nau | Sommersemester 2012 |
Institut für Organisation und Management von
Informationssystemen

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# Lecture Computer Networks

## Fieldbus Systems

# Content

- Introduction to Fieldbus Systems
- Controller Area Network (CAN)
  - Overview
  - Data Frame
  - Arbitration
  - Bit Stuffing
  - Examples of Higher Layer Protocols

# Areas of Application and Examples I

- Industrial communication
  - Production engineering
    - Transmission of programs to computerised numerical control machines
    - Control of plants / automation of car manufacturing
  - Process engineering
    - Control loops in a refinery
    - Control and regulation at aluminium smelting
  - Power generation
    - Conventional thermal power station / nuclear power plant
    - Hydroelectric power plant / pumped-storage power station

# Areas of Application and Examples II

- Automotive engineering
    - Distributed real time regulation in cars
    - Commercial vehicles
    - Control of special functions in work machines

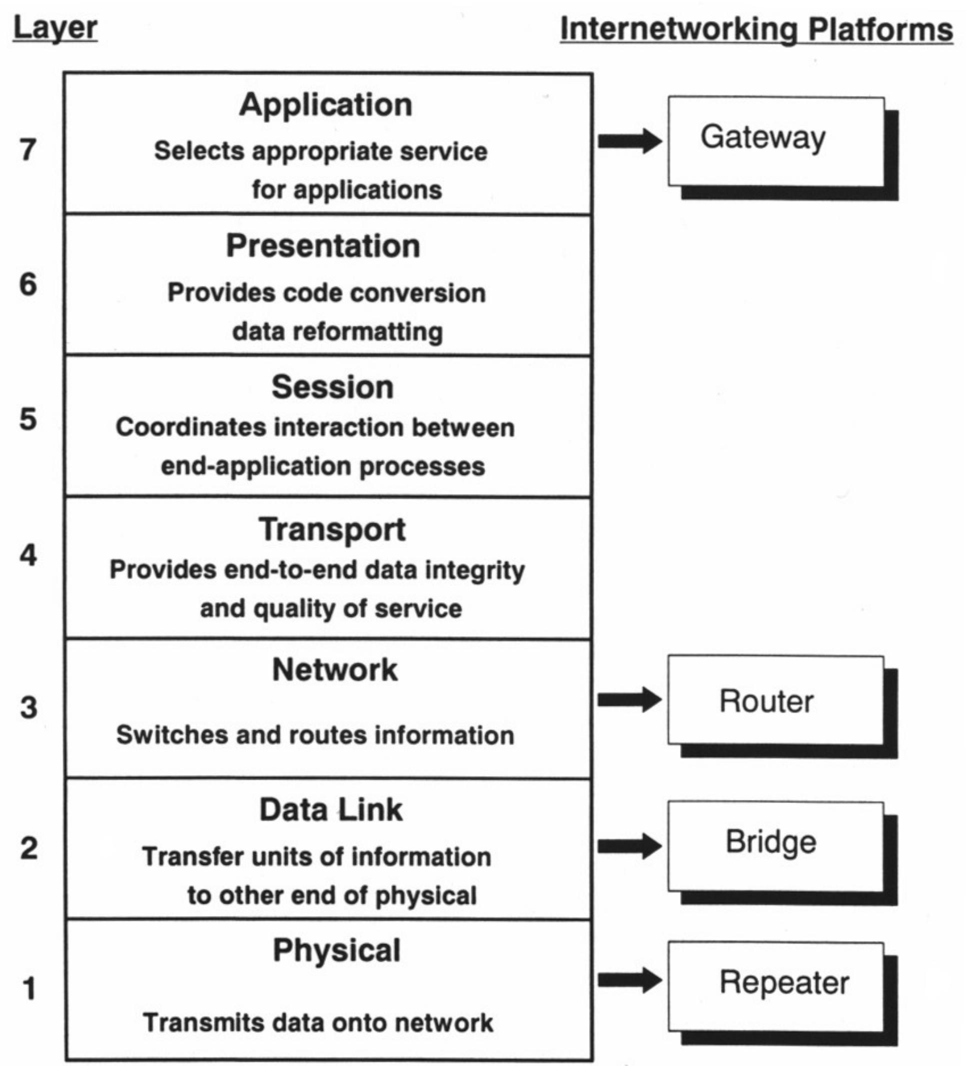
- Building services engineering
    - Light control in residential houses
    - Air-conditioning technology in functional buildings

# Requirements and Features

- Cost savings during assembly of cabling
- Reduction of weight
- Increased reliability
- Decreased amount of maintenance
- Easier and more efficient fault diagnosis
- Increased flexibility of the plant
- Network provides easy access
  - Configurable sensors/actuators
  - Readings and status from sensors/actuators available from everywhere
- Redundancy

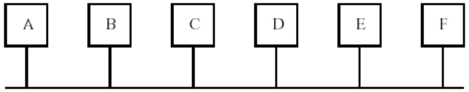
# Fieldbuses and the ISO OSI Reference Model

- Fieldbus systems often define several OSI layers in one standard
- Mostly layers 3 to 6 are non-existent
  - Efficient, fast data processing
  - No routing
  - No fragmentation
- In the majority only layers 1-2 or layers 1-2-7 are defined

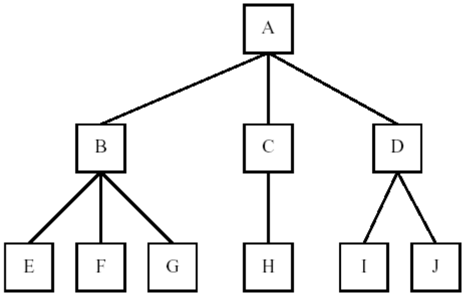


# Fieldbus Topologies

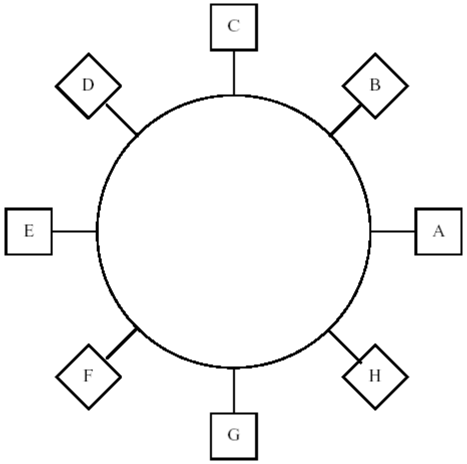
- Place of operation constrains possible topologies
  - Line, Bus



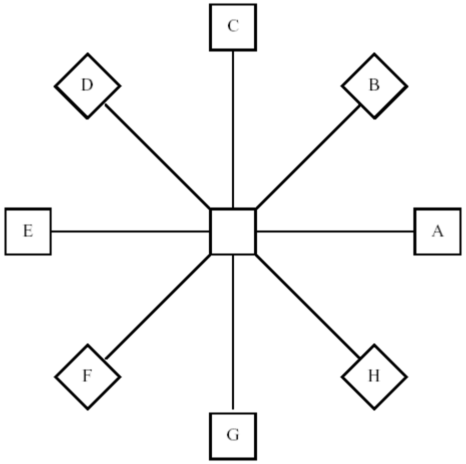

  - Tree




  - Ring

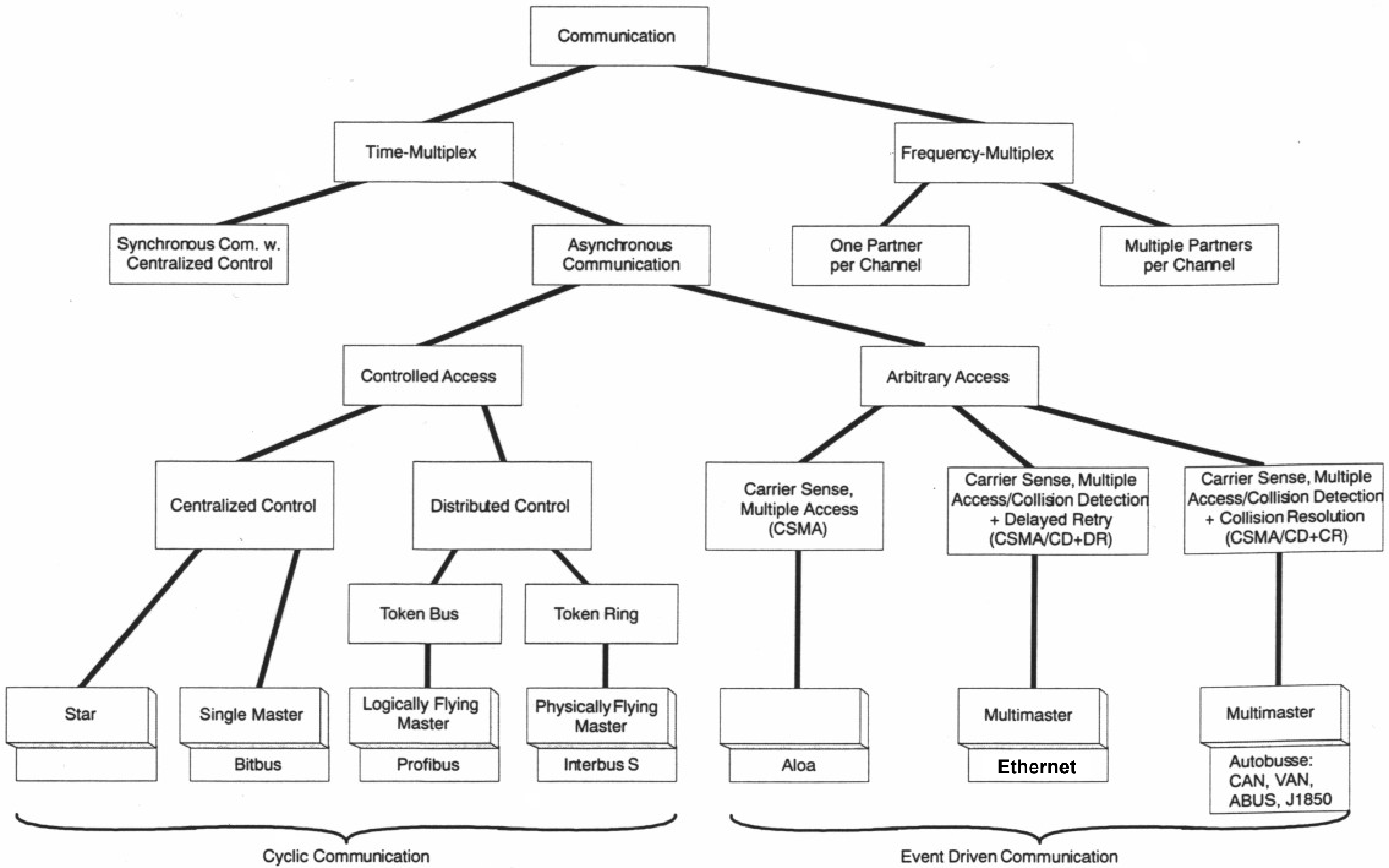



  - Star




  - Open topology

# Medium Access Methods



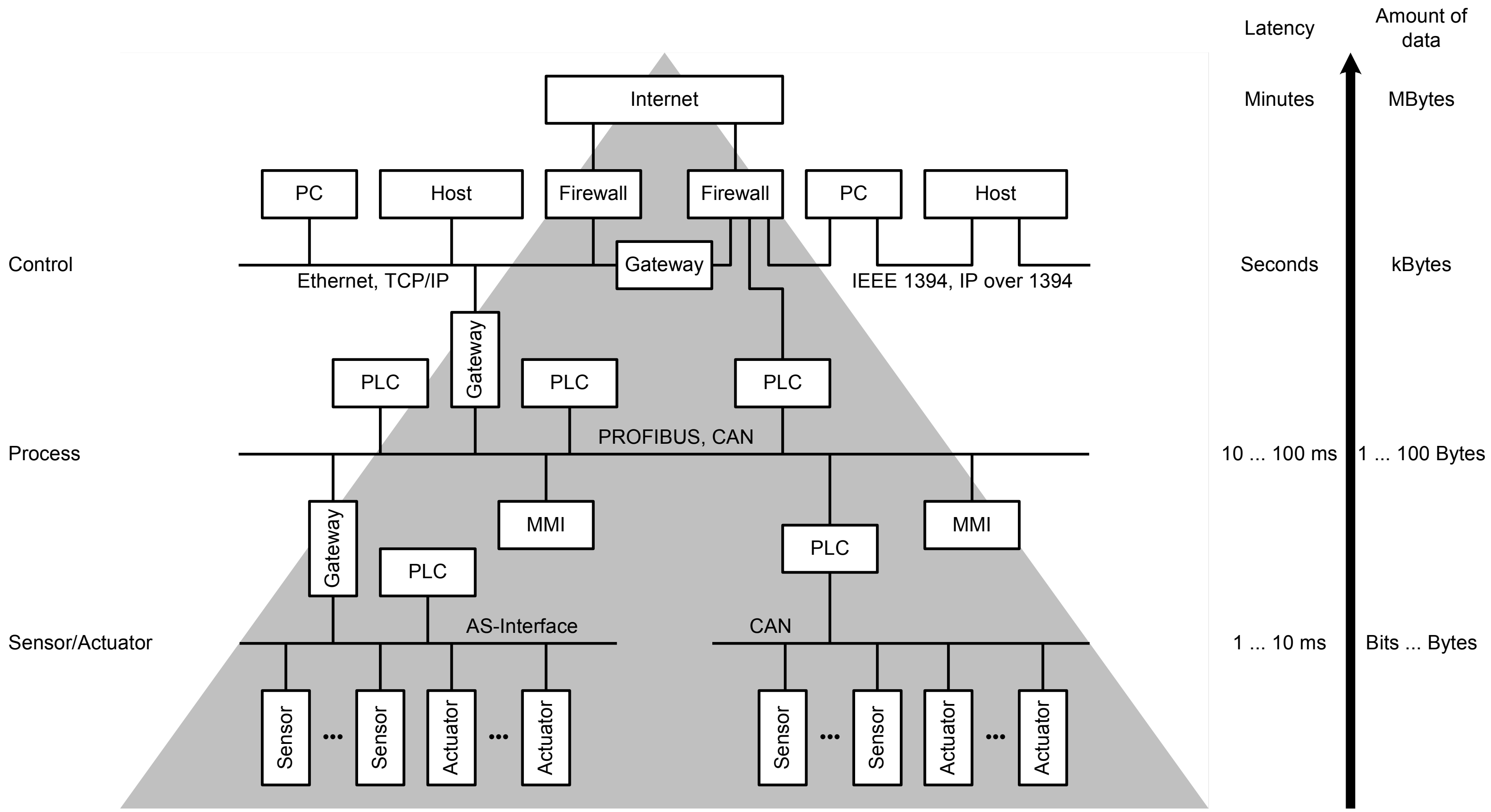
# Comparison of Amount of Data

| | ASi | CAN | | IEEE 1394 | IPv6 |
|---|---|---|---|---|---|
| | | 2.0A | 2.0B | S100 | |
| Addressing | 5 Bits | 11 Bits | 29 Bits | 16 + 48 Bit | 128 Bits |
| User data | 9 Bits | 0 ... 8 Bytes | 0 ... 8 Bytes | 4 … 512 Bytes | Max. 64 kBytes |
| Efficiency | 32 % | 14 ... 57 % | 11 … 48 % | 20 … 96 % | Max. 99 % |

- Fieldbus systems
  - Limited number of nodes
  - Often only small amount of user data
    - Binary I/O signals, e.g. push buttons, relays
    - 8 ... 12 Bit resolution signals, e.g. pressure, temperature, encoders
  - Poor or moderate efficiency of frames

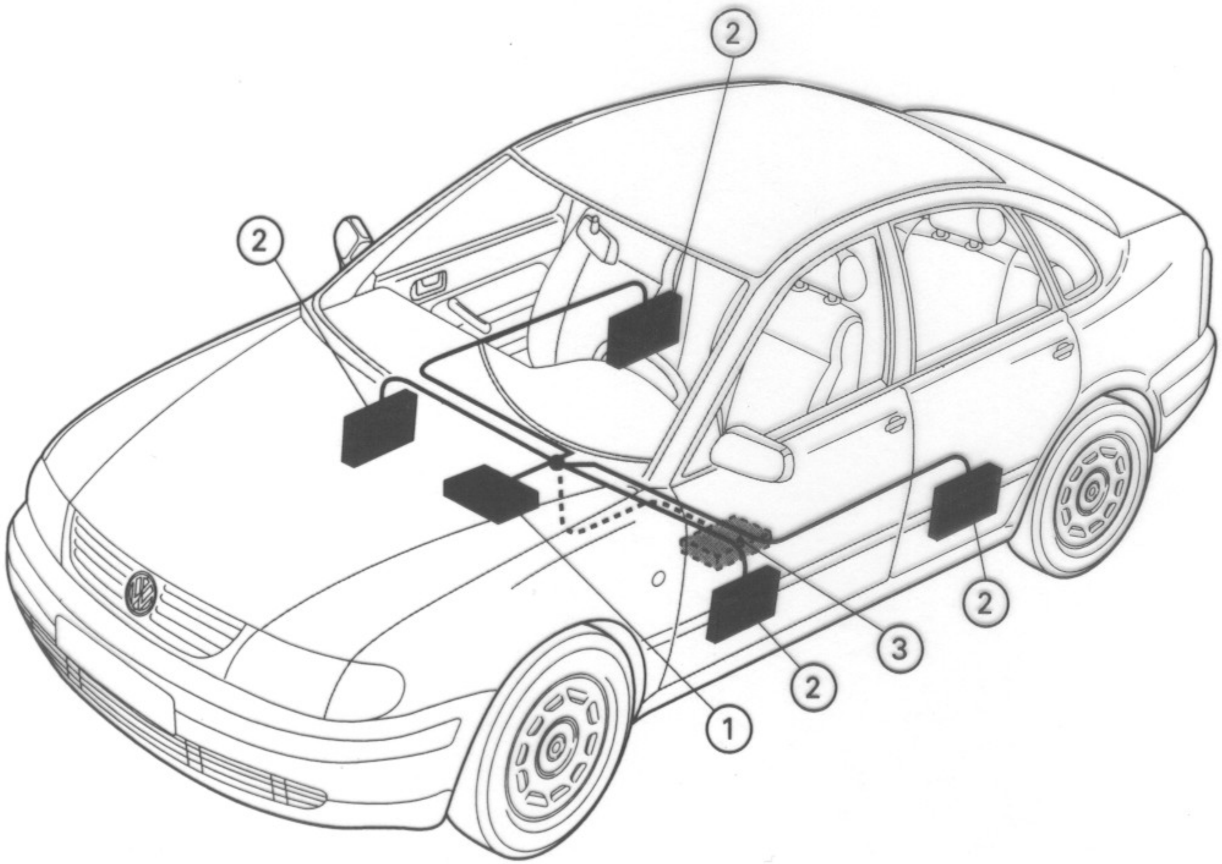
ASi – Actuator / Sensor - Interface
CAN – Controller Area Network

# Industrial Automation – CIM Model




MMI – Men - Machine - Interface
PLC – Programmable Logic Controller

# Automotive Engineering



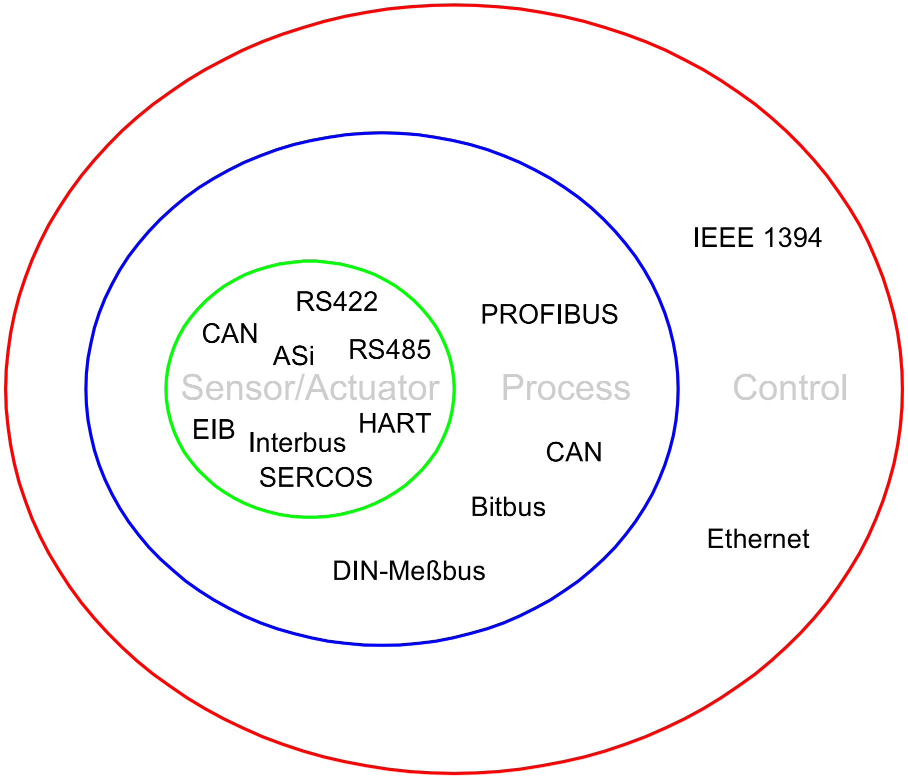

(1) Zentralmodul (ZM)
Central Control Unit

(2) Türsteuergerät (TSG)
Door Control Unit

(3) Memory-Steuergerät
Memory Control Unit

# Examples

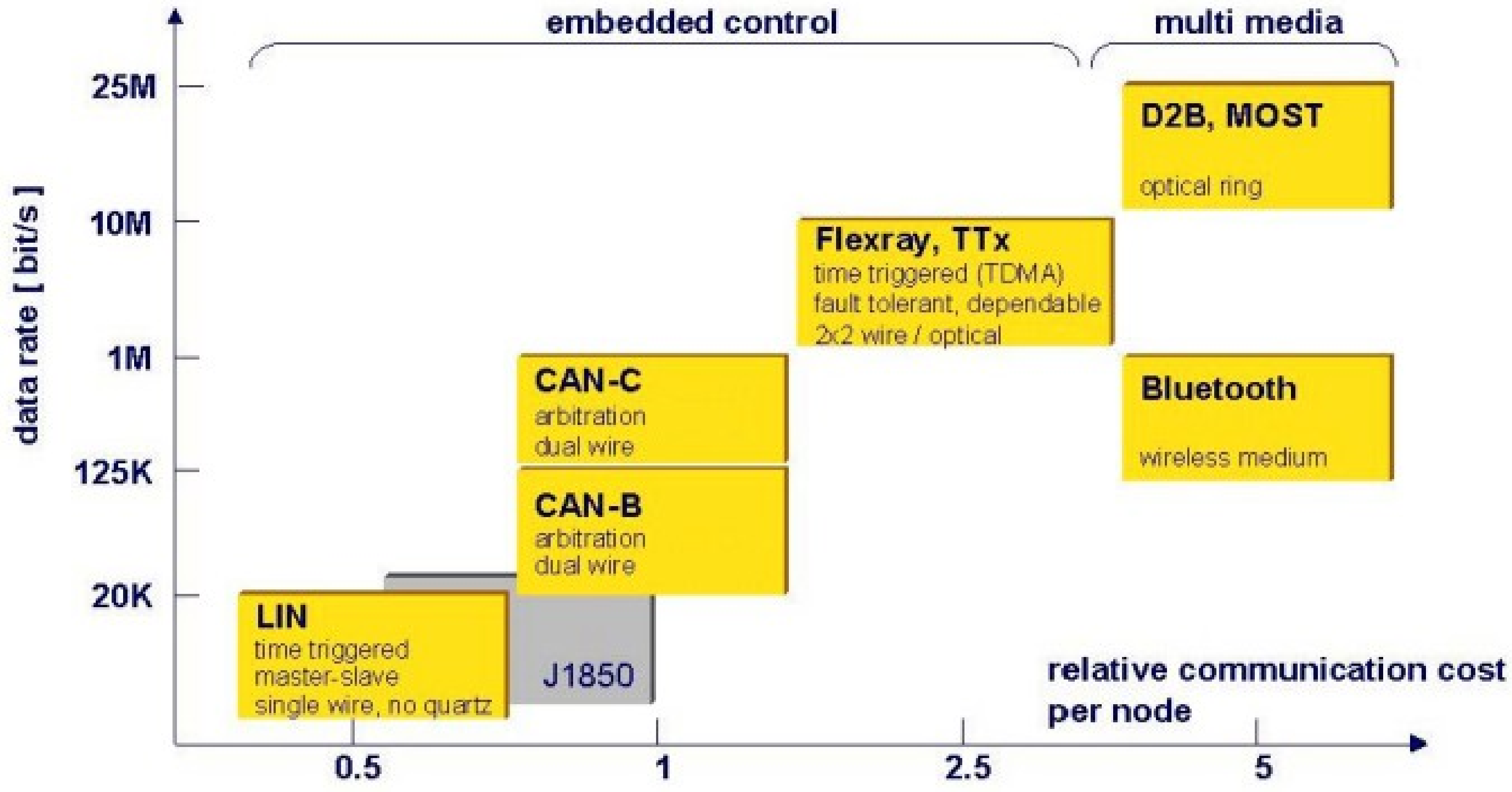
- Industrial automation




Abbreviations:
ASi – Actuator / Sensor - Interface
CAN – Controller Area Network
EIB – European Installation Bus
EHS – European Home System
HART – Highway Addressable Remote Transducer
LIN – Local Interconnect Network
LON – Local Operating Network
TTP – Time Triggered Protocol

- Automotive engineering: CAN, J1850, LIN, TTP, Byteflight, Flexray
- Building services engineering: LON, EIB, EHS

# Automotive Bus Systems

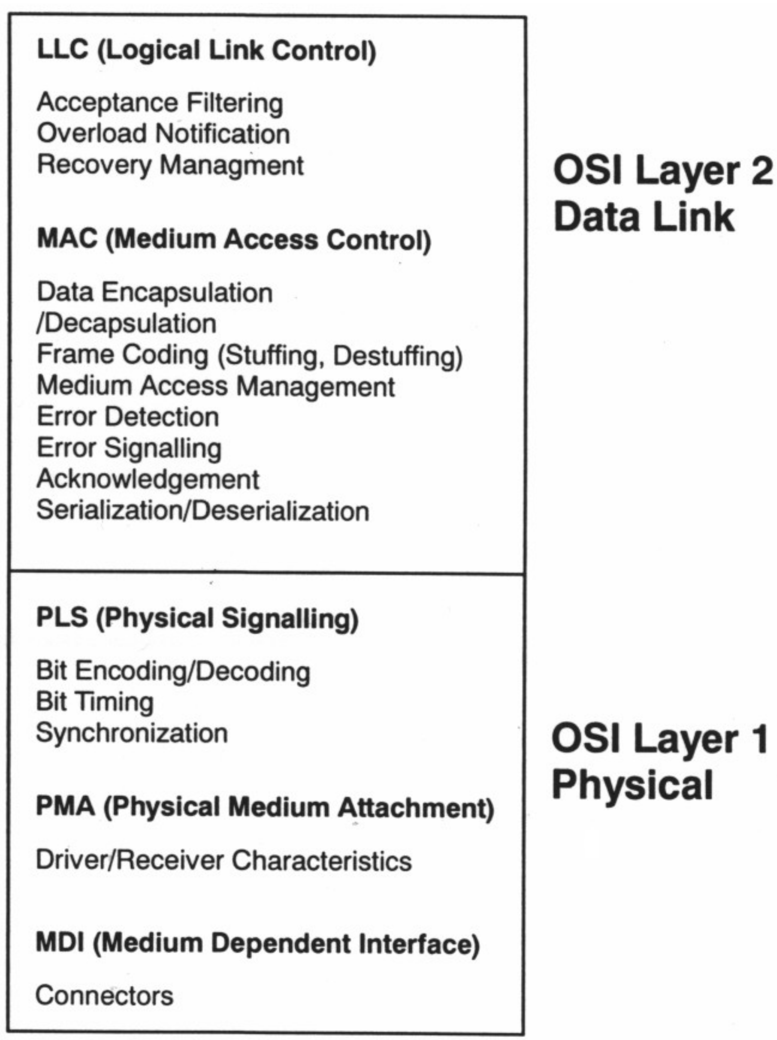



D2B – Digital Data Bus
MOST – Media Oriented Systems Transport

# CAN Overview

- Number of nodes
  - unlimited
    (but limited by physical layer)
- Type of communication
  - serial
  - asynchronous
  - object-oriented
  - multi-master
- Storing of messages
  - shared memory concept
- Topology
  - line
  - star
- Length of bus lines
  - 40 m at 1 Mbit/s (specified)
  - 620 m at 100 kbit/s
  - 10 km at 5 kbit/s
- Number of message identifiers
  - $2^{11}$ (standard frame)
  - $2^{29}$ (extended frame)
- 0 ...8 data bytes per message
- Bus access
  - CSMA/CR by AMP
  - controlled by message priority
  - non-destructive bit-wise arbitration
- Bus throughput
  - max. 1 Mbit/s (total)
  - max. 577 kbit/s (information)
- Real-time capability
  - latency time <134 µs @ 1 Mbit/s
    for highest priority message
- Reliability / Safety
  - acknowledgment of message
  - error detection, handling and
    fault confinement

# CAN ISO OSI Layer 1 and 2



# CAN Bus Media

All media, supporting

- dominant and
- recessive

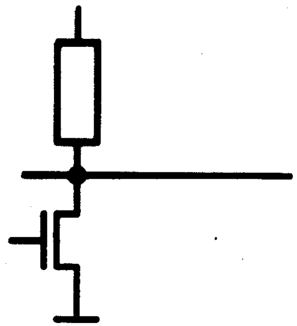
state can be used

***Examples:***

**Wires**

recessive = pull-up

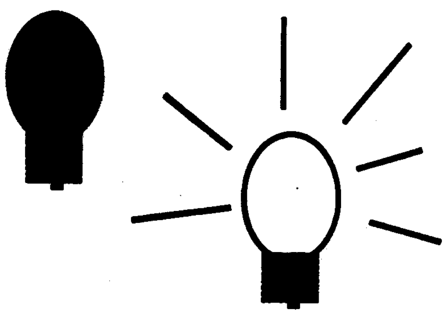
dominant = current sink to ground



**Optical media**

recessive = light off

dominant = light on

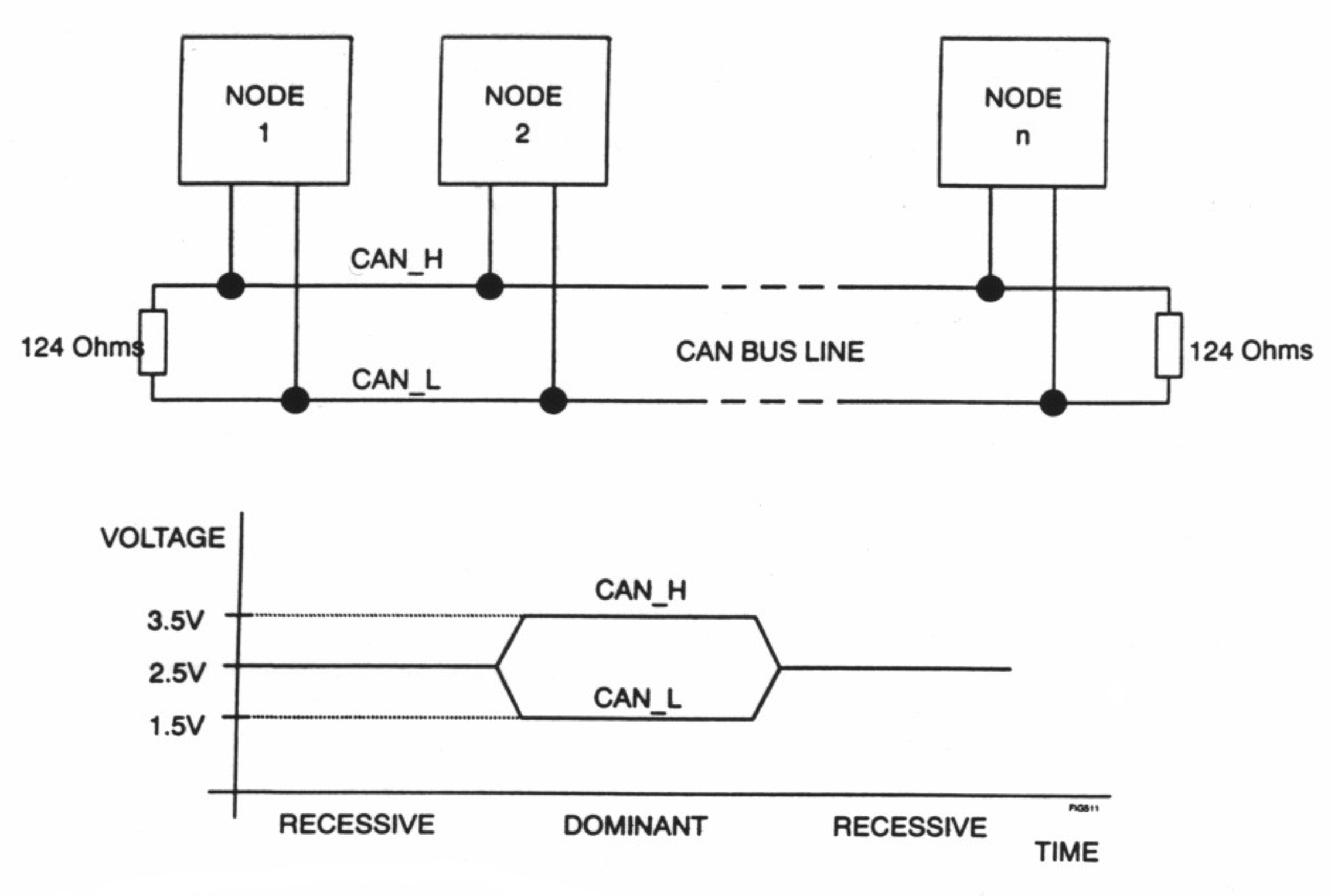


**RF media**

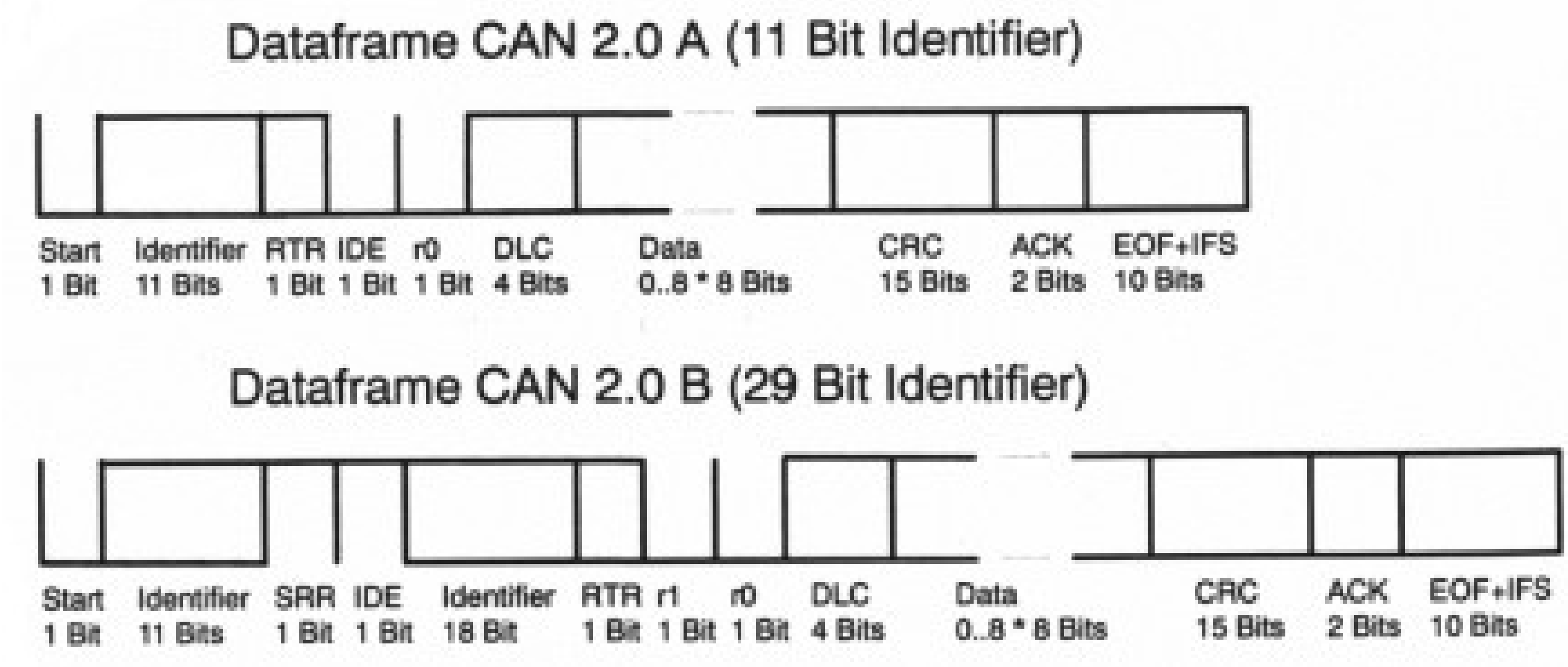
recessive = RF off

dominant = RF on (spread spectrum)

# CAN Interface nach ISO 11898

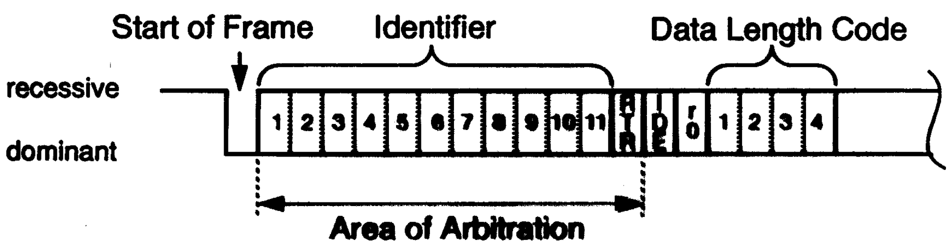


# CAN Data Frame



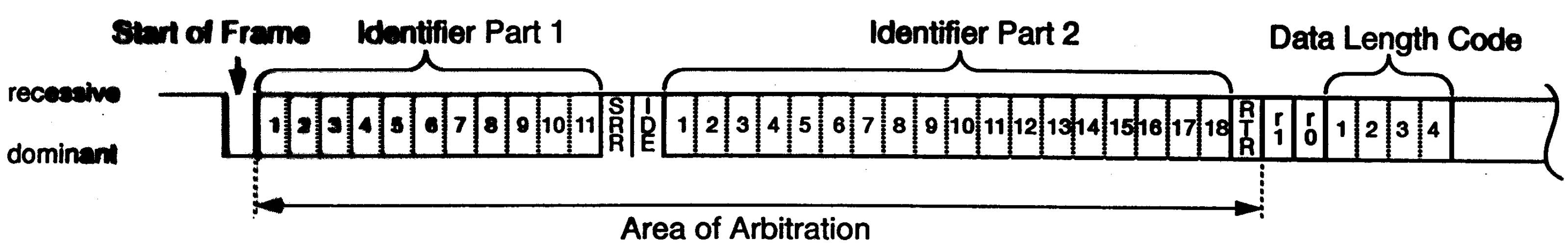

RTR – Remote Transmission Request
SRR – Substitute Remote Request
IDE – IDentifier Extension
DLC – Data Length Code
EOF – End of Frame
IFS – Inter Frame Space

# CAN Arbitration

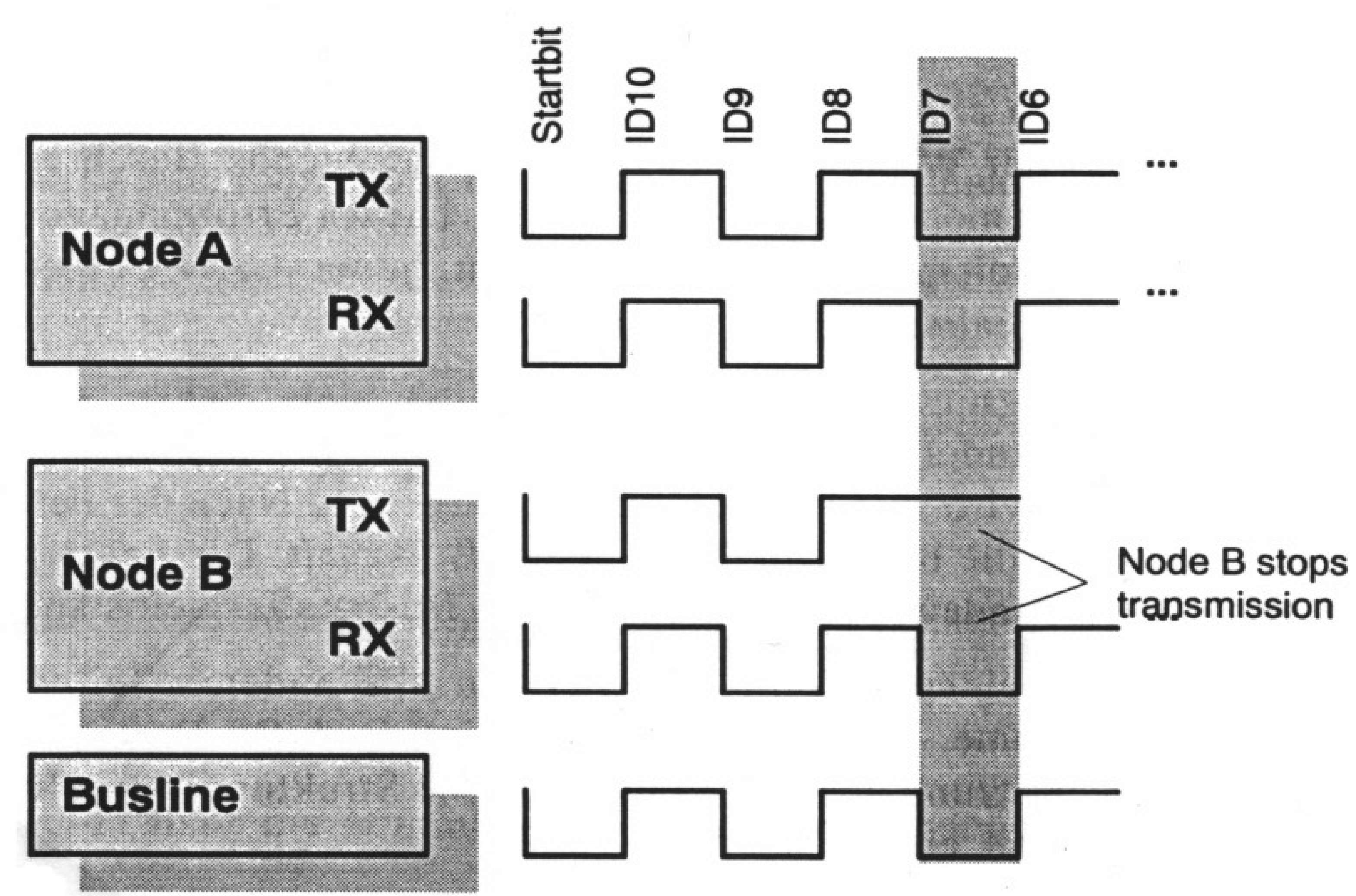



| TX | Bus ( RX ) | Action |
|---|---|---|
| rec. | rec. | proceed with arbitration |
| dom. | dom. | proceed with arbitration |
| rec. | dom. | arbitration lost |
| dom. | rec. | bit error |

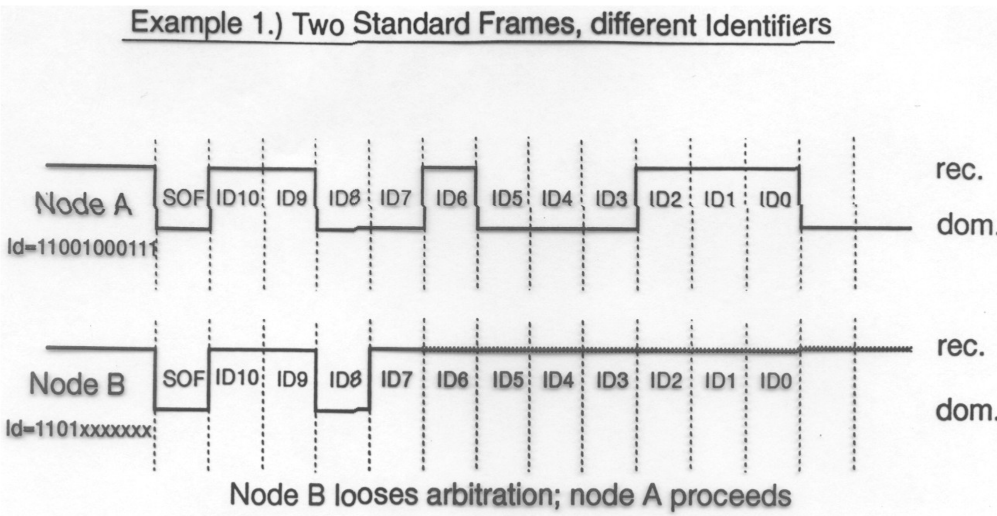
## Extended Frame Format

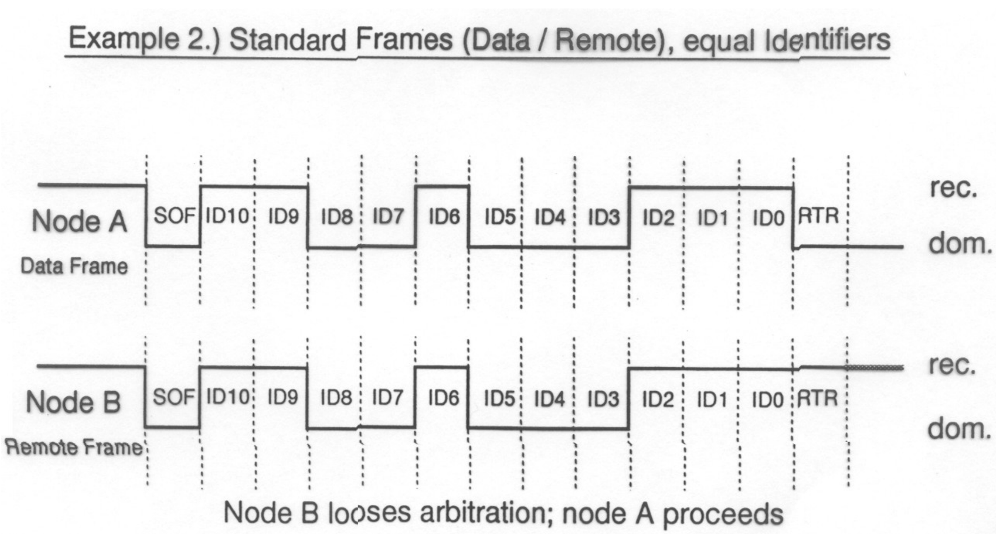


# CAN Arbitration

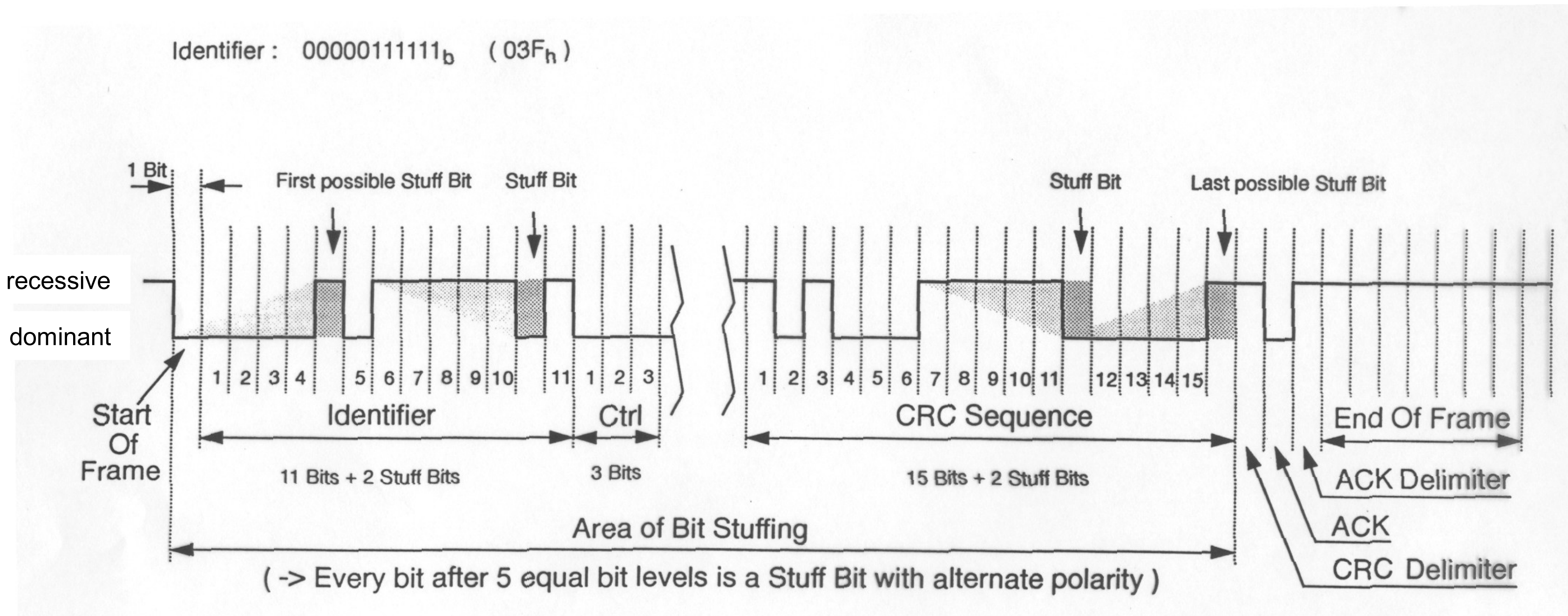


# CAN Arbitration



# CAN Bit Stuffing



# Higher Layer Protocols on OSI Layer 7

- CANopen
- OSEK / VDX
  (Offene Systeme und deren Schnittstellen für die Elektronik im Kraftfahrzeug / Vehicle Distributed eXecutive)
- DeviceNet
- CAN Kingdom