Lecture 7. *Local Interconnect (LIN). Specifications, v1.3 vs. v2.0. Design principles and overview of the protocol. Frame structure. Sleep and wake-up signals. Physical layer.*

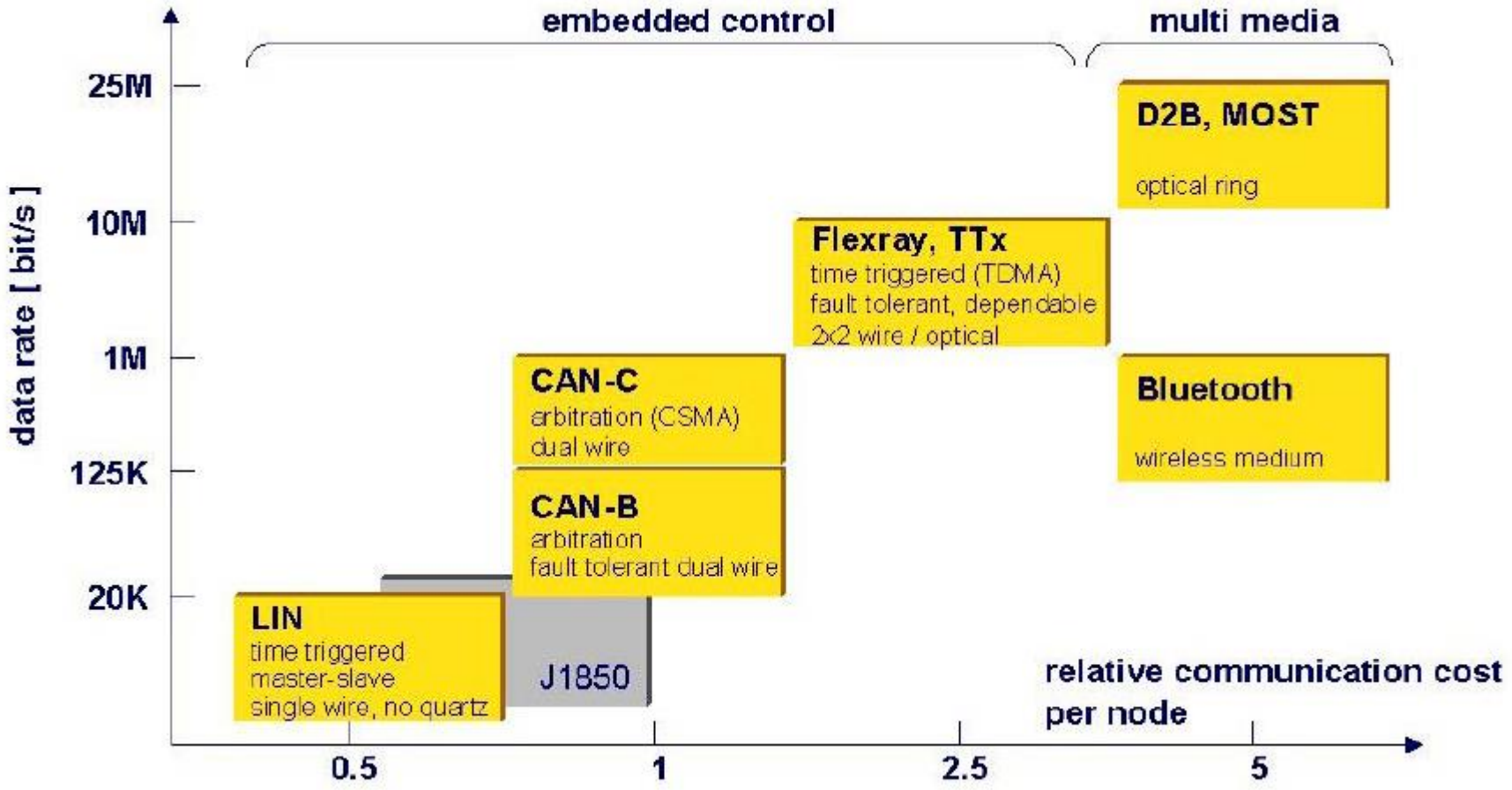
Historical context

- Motorola (now Freescale) as major developer
- First specification LIN rev. 0 in ‘99
- Latest specification LIN rev. 2.1 in ’06 (191 pages)
- Consortium formed in 2000 include: Audi, BMW, Daimler Chrysler, Volkswagen and Volvo

STEERING COMMITTEE

Company	Contact
Audi AG	Andreas Hertle Jürgen Herrle
BMW AG	Thomas Lindner
Daimler AG	Wolfgang Welja Frank Cornelius
Freescale Halbleiter Deutschland GmbH	Carl Culshaw Laure Portal
Mentor Graphics Corporation	Joachim Langenwalter Anders Kallerdahl
Volkswagen AG	Carsten Schanze Volker Struck
Volvo Car Corporation	Lennart Casparsson

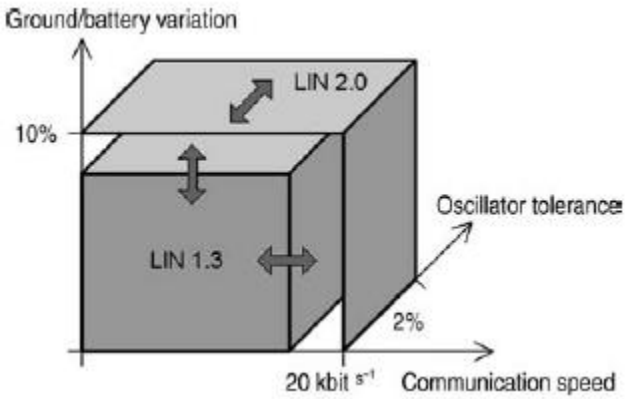
Commonly used busses in automotives



LIN 1.3 vs LIN 2.0

- Major revision step between 1.3 and 2.0

[Parret, 06]



REVISION HISTORY

Issue	Date	Remark
LIN 1.0	1999-07-01	Initial Version of the LIN Specification
LIN 1.1	2000-03-06	
LIN 1.2	2000-11-17	
LIN 1.3	2002-12-13	
LIN 2.0	2003-09-16	Major Revision Step
LIN 2.1	2006-11-24	Clarifications, configuration modified, transport layer enhanced and diagnostics added.

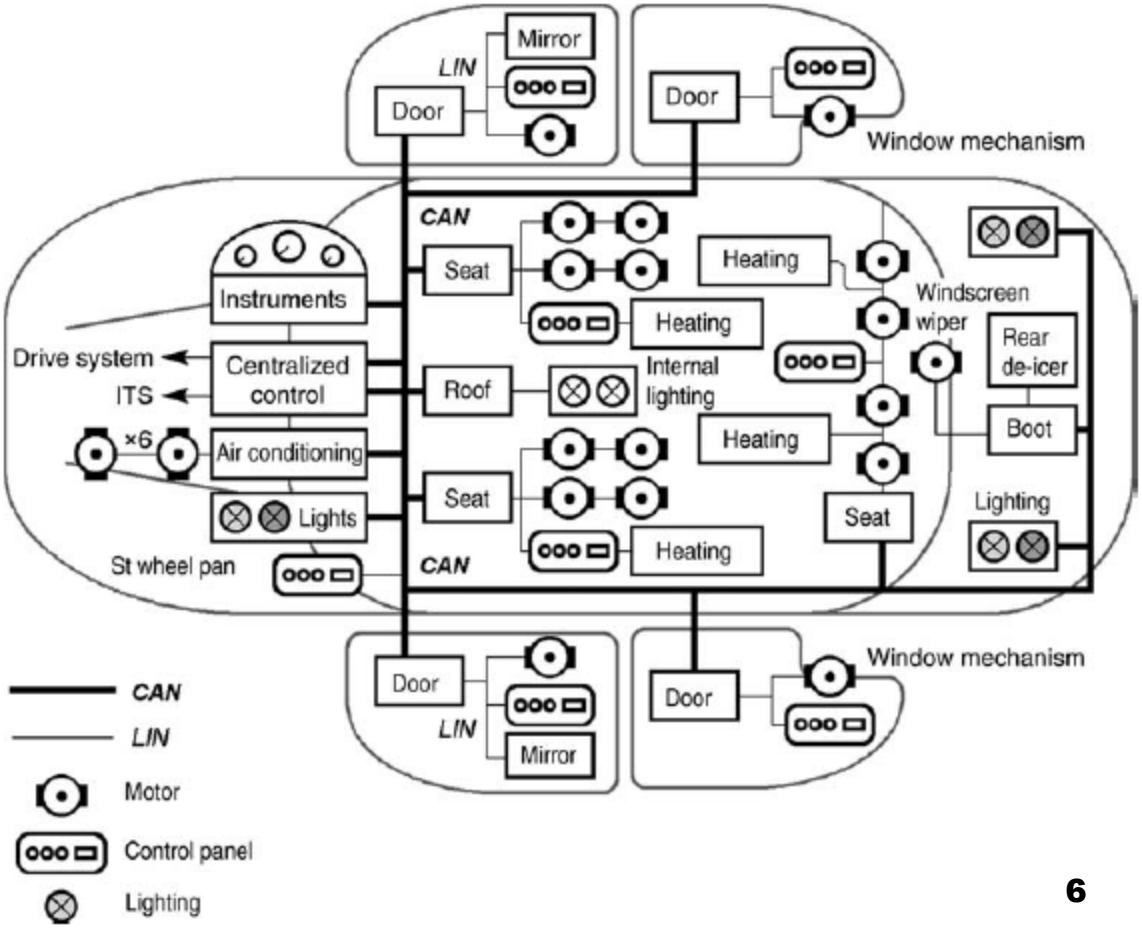
Scope

- Designed for low-cost automotive networks
- Intended to support the control of mechatronic elements
- Lower performances and lower cost compared to CAN (simpler than CAN)
- Regarded as a sub-bus for CAN
- Master-slave architecture (one master, multiple slaves)
- Deterministic behaviour
- Useful when the bit-rate and reliability of CAN is not needed

The big picture

- Several sub-systems are fit for this performance level: sun-roof, rain-detector, seats, doors, windscreen wipers, interior lights

[Parret, 06]



LIN specifications

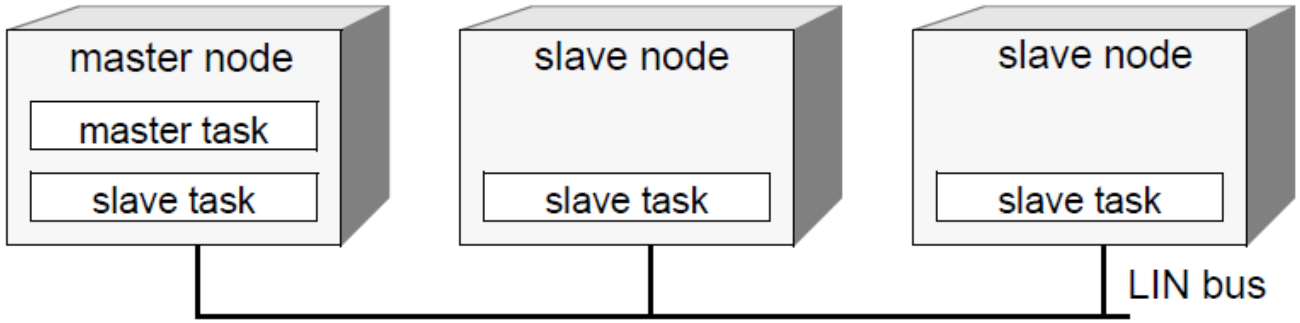
- Consist in:
  - **Protocol specification** – link layer
  - Transport layer specification – how to transport data (up to 4095 bytes)
  - Node configuration and identification – how to configure and how to identify a slave node
  - Diagnostic specifications – diagnostic services supported by a slave node
  - **Physical layer** – physical layer, bit rate, tolerances
  - Application Program Interface Specification – interface between the network and programs
  - Configuration language specification – format of the LIN description file
  - Node Capability Language Specificattion - format use to descibe node properties

Design intentions

- No bus arbitration needed
- Self synchronization without quartz or ceramic rez. in slaves
- Two layer protocol: physical and data link layer
- Operate on one wire (plus ground) => reduces wiring and connector costs
- Multicast reception
- Guaranteed maximum latency of the transmitted signal
- Flexibility of physical configuration
- Security of transmitted data (CRC)
- Detection of faulty nodes
- Speed up to 20 kbit/s
- Simplified hardware based on UART/SCI hardware interface

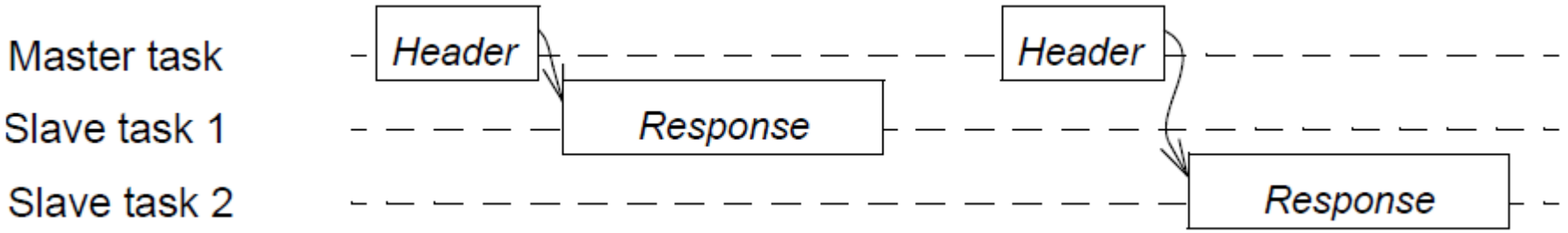
Overview

- The master task decides when and which frame is transmitted on the bus
- The master contains a master task and can simultaneously execute a slave task, other nodes execute only slave tasks



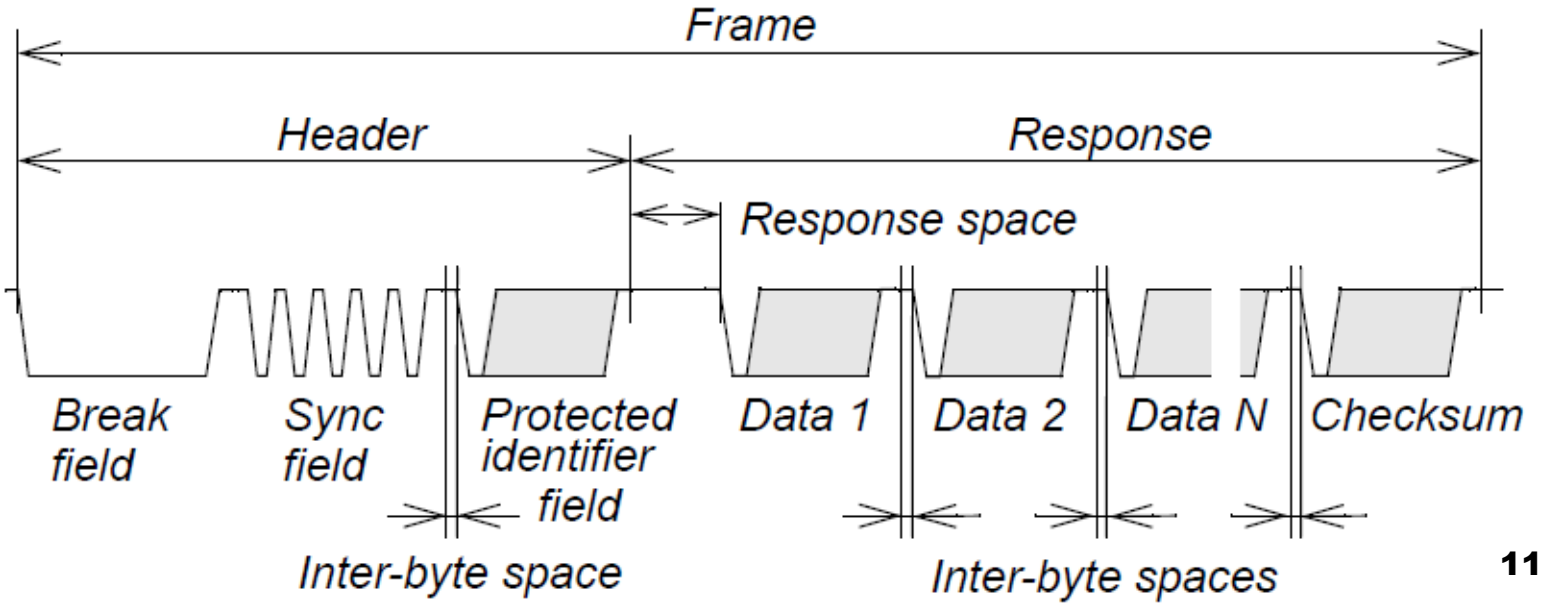
Relevant pictures from LIN specifications

- Slave nodes provide the data of each frame only if they were invited
- No arbitration => deterministic behaviour
- Frame consists in header (provided by the master) and response (provided by the slave)



Frame structure

- Header consists in break, sync segment and identifier
- Response contains the data (two types) and a CRC
- Data types:
  - Signals – scalar values or byte arrays, always present in the same position
  - Diagnostic messages – transported in frames with reserved identifiers



Remarks

- Each byte is transmitted with LSB first
- Break field is used to signal the beginning of the frame, it is at least 13 nominal bit times (dominant)
- Break field is ended by a break delimiter which is at least 1 nominal bit time
- The sync field encodes the value 0x55h

Protected identifier field

- Six bits are reserved for the identifier value, three categories:
  - 0-59 (0x3B) carrying frames
  - 60 (0x3C) – 61 (0x3D) diagnostic and configuration data
  - 62(0x3E) – 63 (0x3F) future use

- Parity bits are computed as: $P_0 = ID_0 \oplus ID_1 \oplus ID_2 \oplus ID_4$

$$P_1 = \neg\left(ID_1 \oplus ID_3 \oplus ID_4 \oplus ID_5 \right)$$

Data

- 1 to 8 bytes of data (LSB first)

Checksum

- Inverted eight bit sum of all bytes (sum all values mod 255)
- Called classic checksum if done only over data bytes
- Called enhanced checksum if includes the identifier field (for communication with LIN 2.x slaves)
- Frame id 60-61 use classic checksum

Frame types

- In LIN v1.3 (obsolete):
  - Message frames – regular data
  - Command frames – update, configuration, diagnostic
  - Extended frames - reserved
- In LIN v2.1:
  - Unconditional frames – carry signals
  - Event triggered frames – increase responsitivity
  - Sporadic frames – introduce dynamic behaviour
  - Diagnostic frames – always id 60 (0x3C) or 61 (0x3D) and 8 bytes
  - Reserved frames – id 62 (0x3E) and 63 (0x3F) not used

Sleep and wake-up signals

- To save power the master can put all nodes in sleep mode
- In sleep mode the line is recessive

- Any sleeping node may wake-up other nodes with a wake-up signal
- The wake-up signal places the bus in dominant state for 250µs – 5ms

Physical layer

- Dominant 0 – ground potential
- Recessive 1 – battery potential
- Some constraints:
  - Maximum number of nodes is 16 (theoretically goes to 64)
  - Network length should not exceed 40 m
  - Termination resistance is 1kOhm for master and 20-47kOhm for slave