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Communication Systems and Protocols

Exercise 6

Controller Area Network (CAN)

- 1981 developed by Bosch and Intel
- Goal: Cross-linkage of complex controllers and control units
- International dissemination in the automobile area, the sector of home appliance, in textile machines, in medical engineering devices, …
- Low priced bus transceivers through high volume number

Bus Arbitration

- Participants are connected to the bus via open collector drivers
  - Dominant LOW, logical ‚0‘
  - Recessive HIGH, logical ‚1‘
    → „Wired-AND“
- Arbitration scheme: CSMA/CA
- Arbitration is done with the help of the identifiers of a message
  - Identifier with the lowest value has got highest priority (dominant ‚0‘)
  - Every identifier can exist only once within the whole system

Task 1: CAN bus

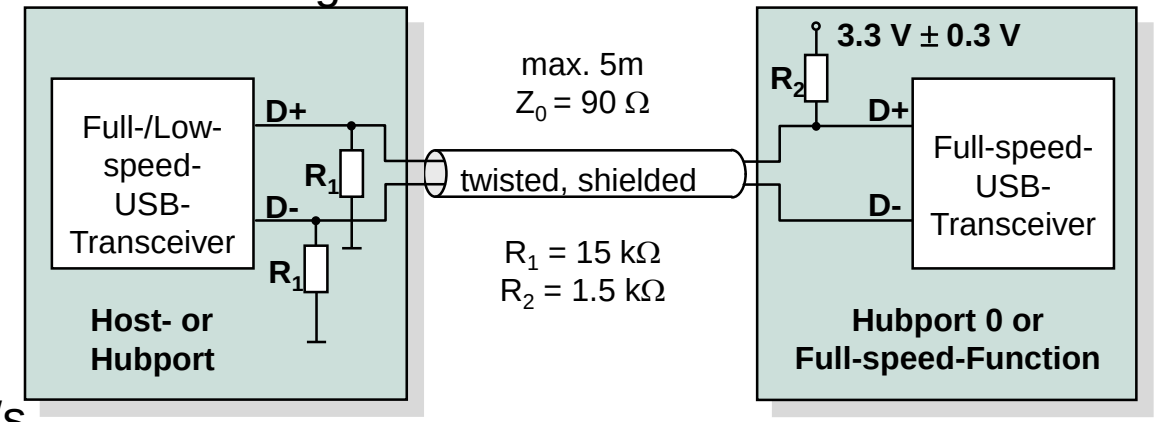
Time Allocated 10 min

Universal Serial Bus (USB)

- Serial Bus
- NRZ-I Encoding
- Single Master / Multi Slave
- Hot-Plug Capability

Transmission speed detection

- Devices announce their transmission speed using different pull-up resistors at the data wires
- Example for resistor configuration at 12Mbit/s



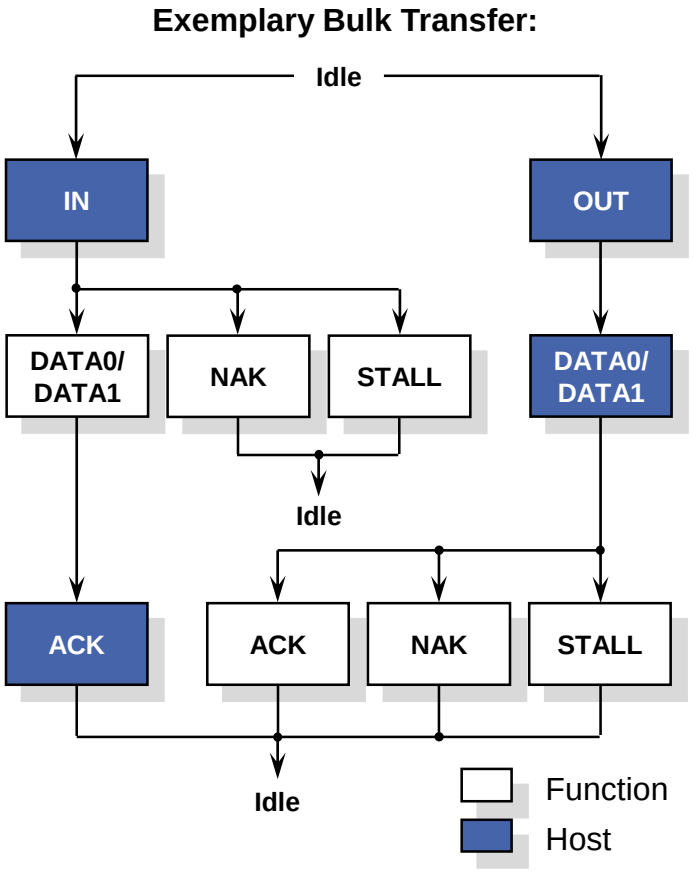
- At 1.5Mbit/s
  - Low-Speed Transceiver
  - R_2 at D-
  - Cable does not need to be twisted/shielded
  - Z_0 arbitrary
  - Max. 3m wire length
- High-speed devices announce themselves as Full-speed devices (12Mbit/s) first
  - At configuration time, the host is informed about the higher transmission rate possible
  - In normal operation, the resistor is disabled in order to provide symmetrical wire behavior

Energy consumption

- Devices can be supplied with energy (5V) over the bus
- 3 different classes have to be distinguished
  - Low-power devices: max 100mA
  - High-power devices: max 500mA
  - Self-powered devices: max 100mA from the bus, the rest has to be fetched from their own power supply during operation → otherwise they can be disabled by the host
- Devices have to announce their power consumption at configuration time and are not allowed to go beyond this limit
- Devices have to support standby mode
  - Maximum power consumption of 500µA
  - Devices have to go into standby after 3ms of inactivity on the bus or by dedicated command of the host

Transfer process

- The host starts a transfer by sending a corresponding token packet
- Then one ore more data packets are transmitted
- Each packet is acknowledged by a handshake packet
- If errors have occurred during a transmission, no handshake packet is send. The sender has to retransmit the packet
  - For isochronous transfers there is no handshake. Defective data is not transmitted again!



Task 2: Universal Serial Bus (USB)

Time Allocated 10 min

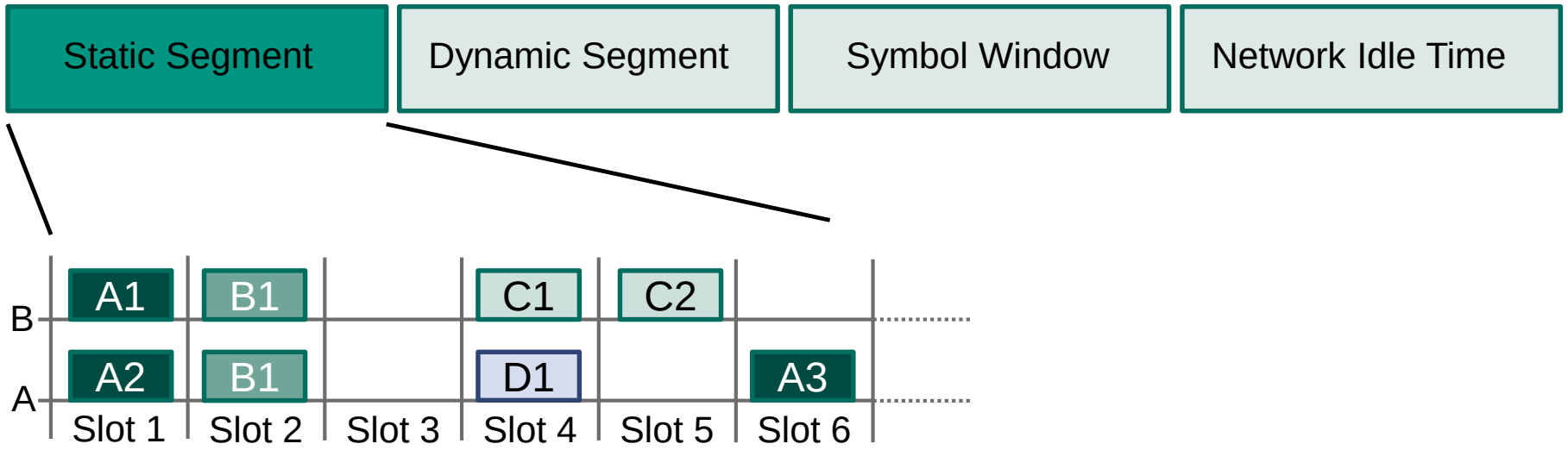
FlexRay

- Consortium founded in 1999
- Motivation: increasing requirements concerning bandwidth and transmission safety within automobiles
- Goal: Development of deterministic, fault tolerant communication system with 10 MBit/s bandwidth
- Basis for X-by-Wire systems
- Basically the protocol can be used for optical as well as electrical media.

Basic features

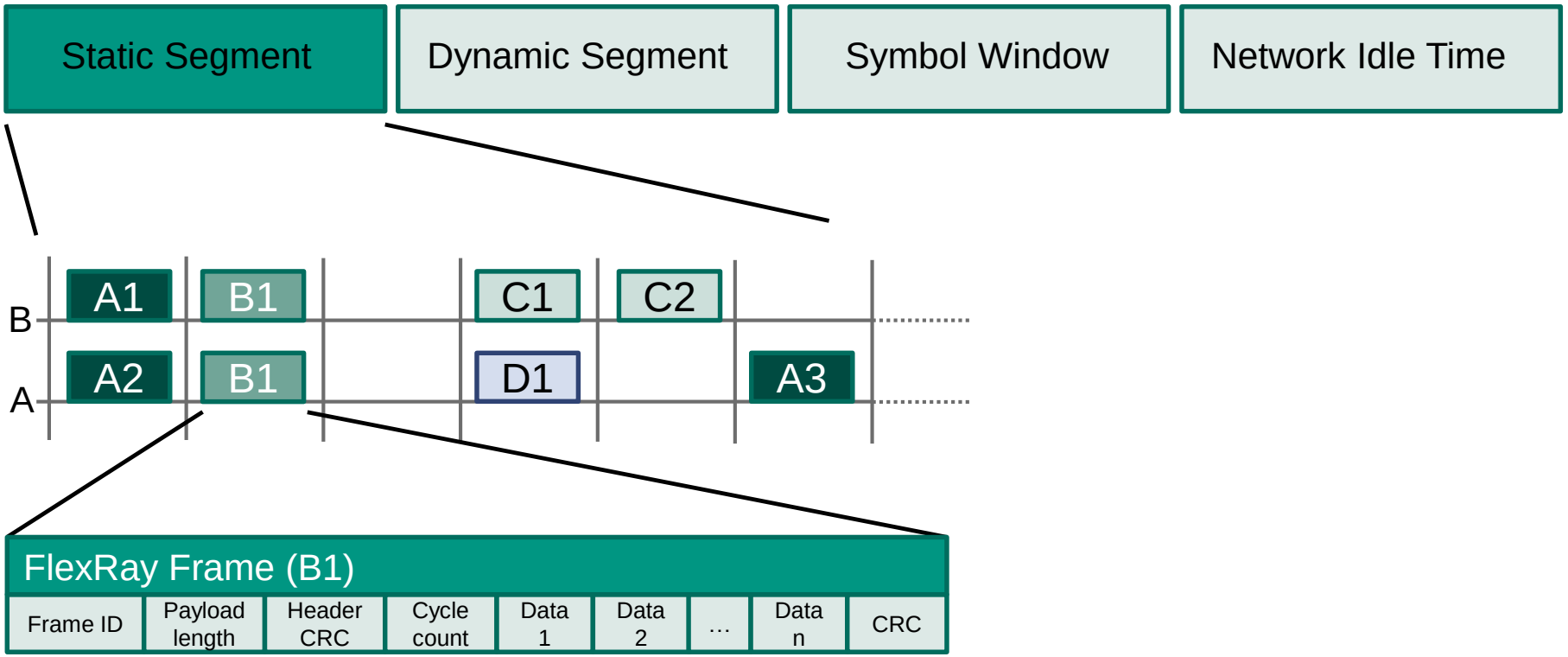
- Multi-master system
- Beside basic star like structure also line and bus structures possible
- Allows operation in channel mode with (10 MBit/s) or double channel mode (20 MBit/s)
  - Single channel mode to increase reliability. The second channel is used as a redundancy.
  - Double channel mode to raise throughput but less reliability
- Mechanisms to increase fault tolerance
  - Deactivation of sub-networks in the case of an error
- Deterministic message transmission by using communication cycles
  - Communication cycle is flexibly configurable
  - Global time base for synchronization
- Physical layer: Differential signalization on a twisted pair
- In contrast to CAN „logic 1“ and „logic 0“ are equitable

Static Segment (1)



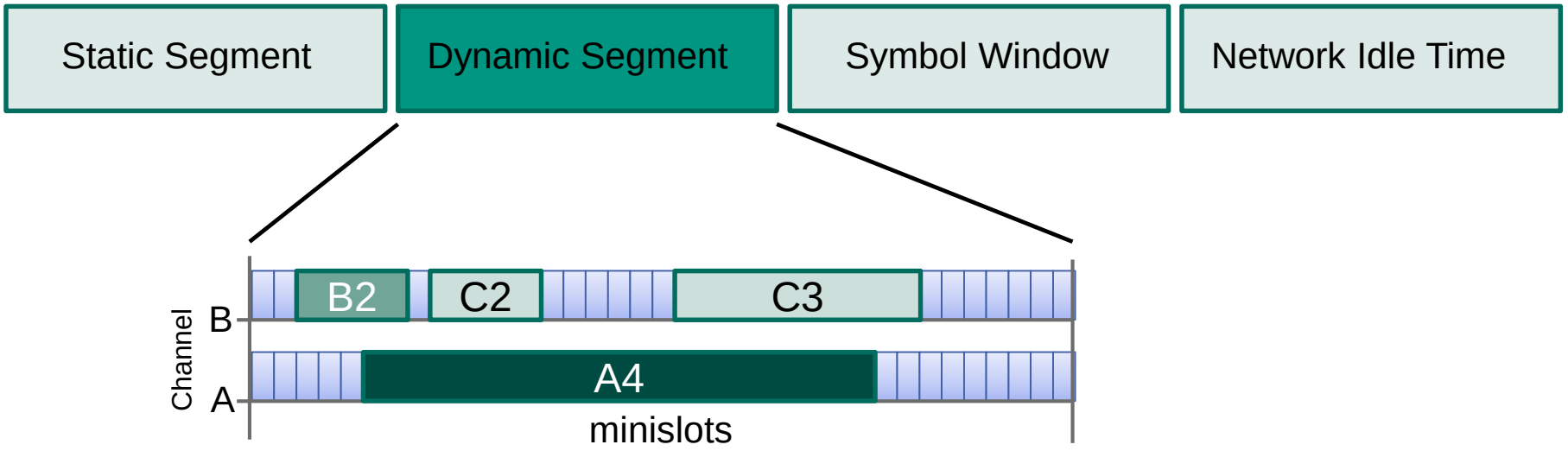
- Nodes are assigned to fix time windows in which frame transmission can be performed
- Bus access within the static segment via TDMA
  - Realization of realtime capability within this segment (deterministic)
  - Every message within this segment is transmitted at defined points in time

Static Segment (2)



- Each frame is assigned to slots in which only that frame is allowed to be send
- If using two channels, frames can be transmitted redundantly

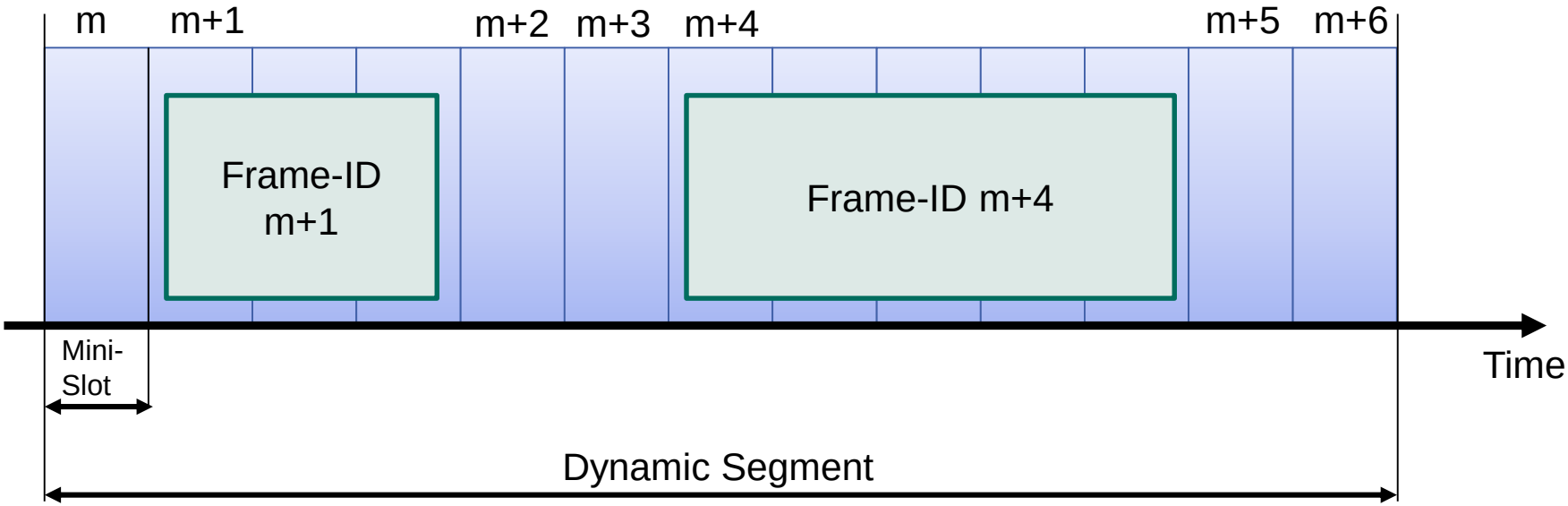
Dynamic Segment



- For frames with lower requirements concerning predictable latency
- Bus access via FTDMA (also called Mini-Slotting)
- Used for event based transmission: Event based data to be transmitted does not depend on a static slot

Mini-Slotting (FTDMA)

- Prioritized bus access within the dynamic segment controlled with a **slot count**
  - If a Minislot is not used the slot counter is incremented and the Minislot elapses unused
  - If the actual slot count corresponds to the Slot-ID of the frame, the frame occupies a certain number of Minislots. After the next free Minislot the slot counter is immediately incremented
- Space within the dynamic segment can be used efficiently that way



Task 3: FlexRay

Time remaining 10 min