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Networked Embedded Systems

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SS2015

History

- Consortium founded 2000
- BMW, Daimler AG, Motorola und Philips
- Core-Partner: Bosch, General Motors und Volkswagen
- Consortium suspended 2010
- Standardized in ISO 17458-1 till ISO 17458-5

Outline

- Goals/Facts
- Physical Layer
  - Network Components
  - Topologies
  - Bus Driver
- Data Link Layer
  - Communication
  - Time Synchronization
- FIBEX (FIeld Bus EXchange Format)
- Comparison

Goals

- Reliability (X-by-wire)
- Flexibilty
- Real-time Capability
- Guaranteed Latency
- Redundant Communication (2. Channel)
- Increase Throughput

Facts

- Deterministic
- Synchronous and Asynchronous Data support
- Collission free (No arbitration needed)
- Decentralized time synchronization
- Up to 2 Channels 10Mbit/s each
- Bus guardians (optional)
- Nodes have equal Permissions

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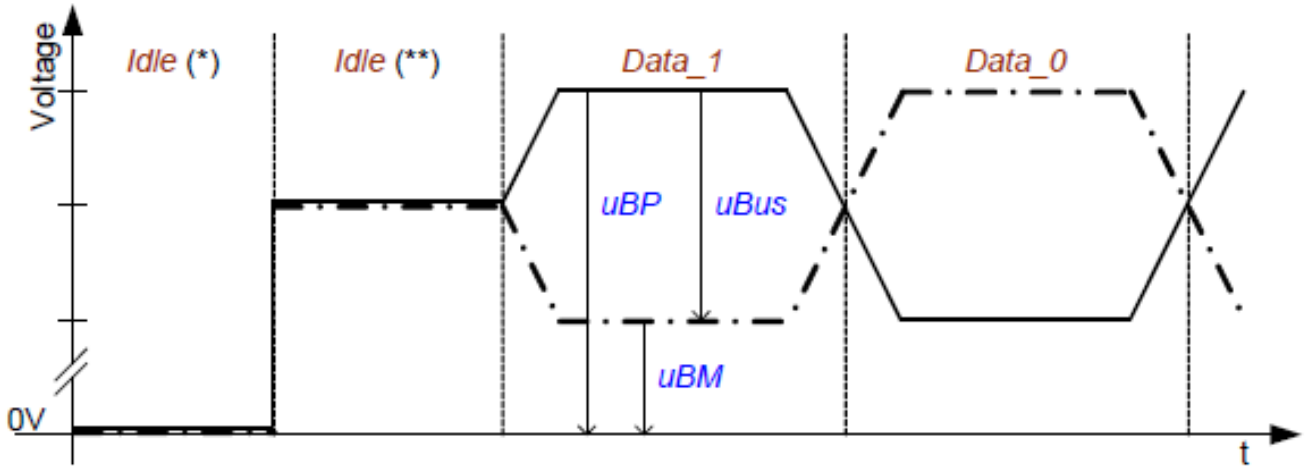
Physical Layer

Network Components

- Transmission electrical (new specified for Bus) or optical (used from ByteFlight-Bus)
- Un-/Shielded twisted cables
- Connectors not specified
- Un-/terminated

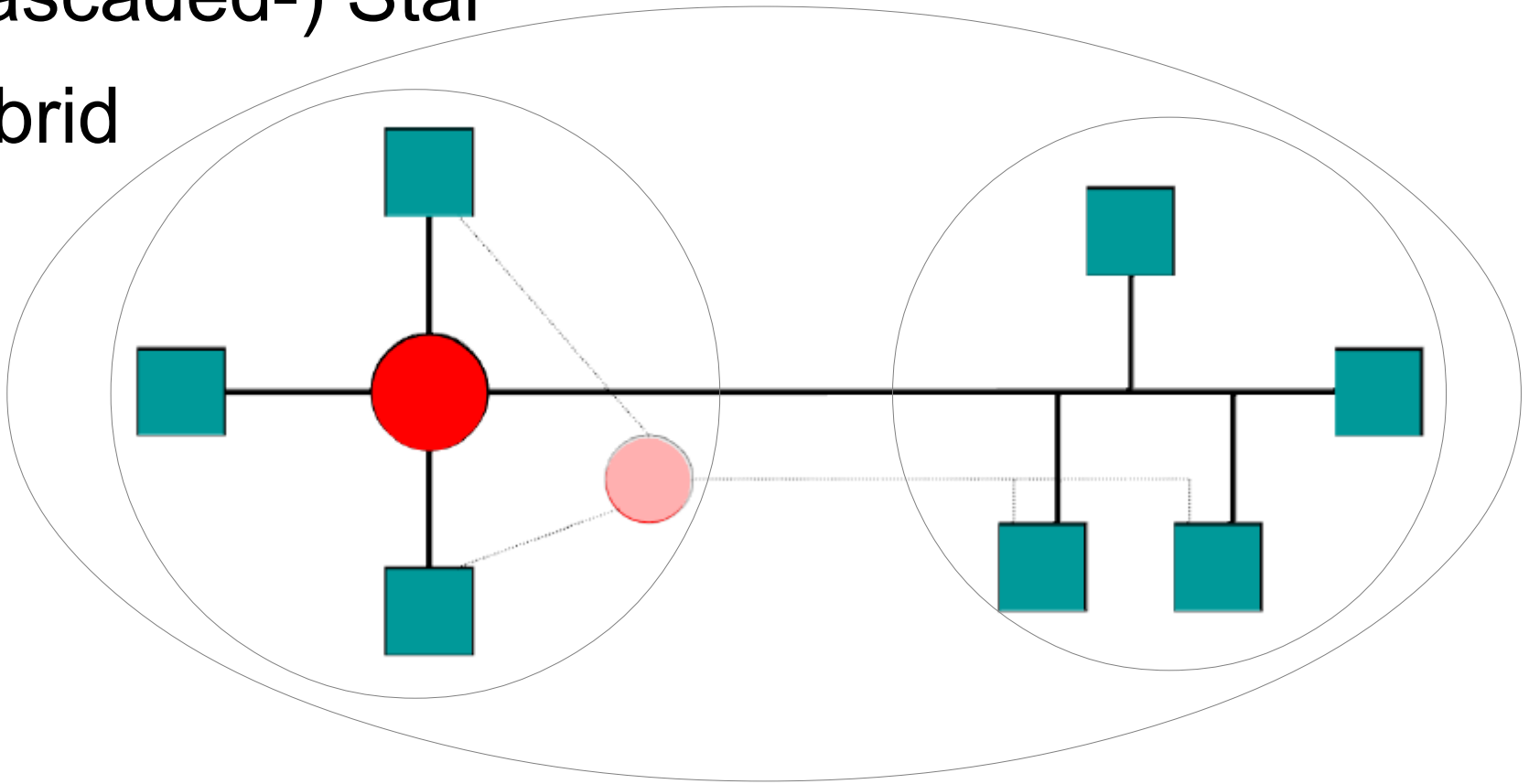


(*) in case all nodes (and active stars) are in a low power mode

(**) in case no node (and no active star) is in a low power mode

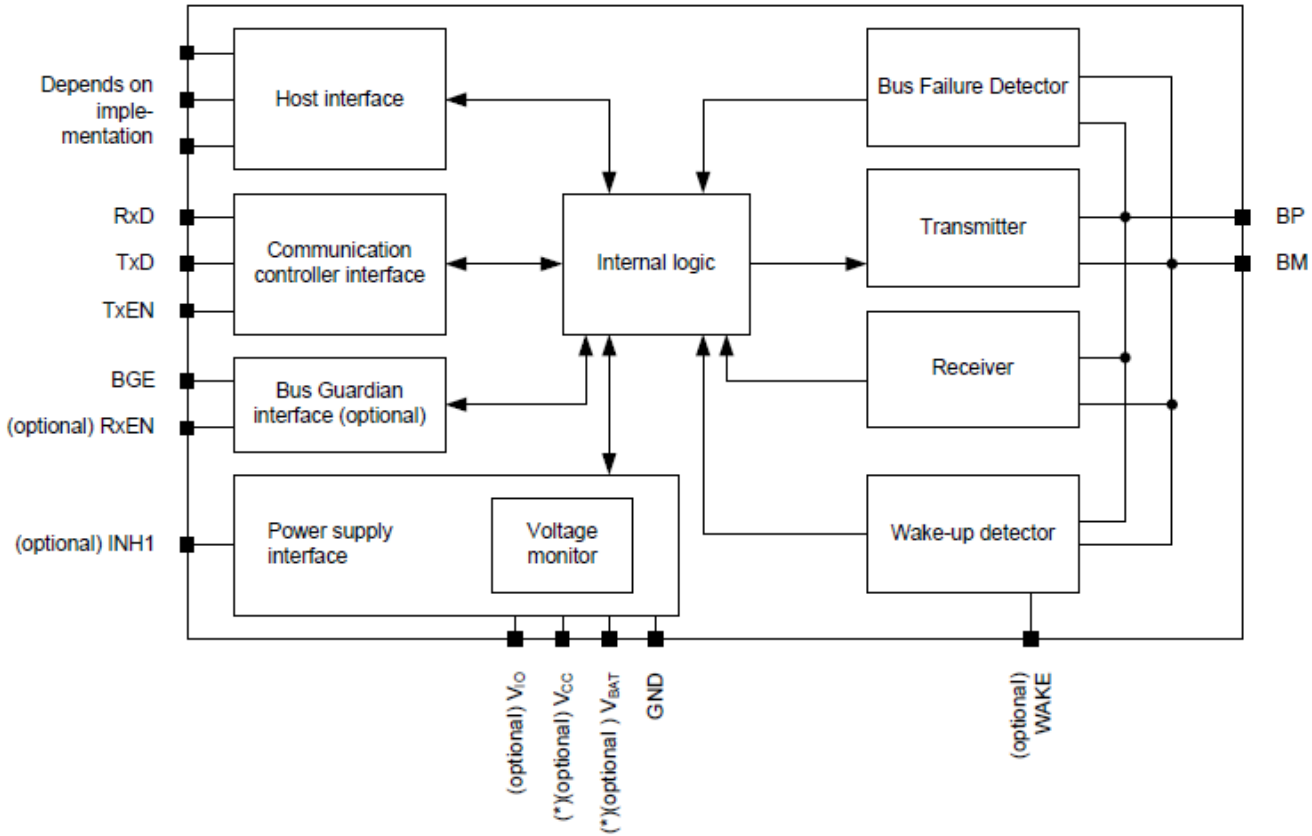
Topology

- Mulit-Drop Bus
- (Cascaded-) Star
- Hybrid



Bus Driver

- Modes:
  - Normal
  - Standby
  - Sleep (optional)
  - Receive Only (optional)
  - Off



(*) At least one of the pins V_{CC} and V_{BAT} have to be implemented.

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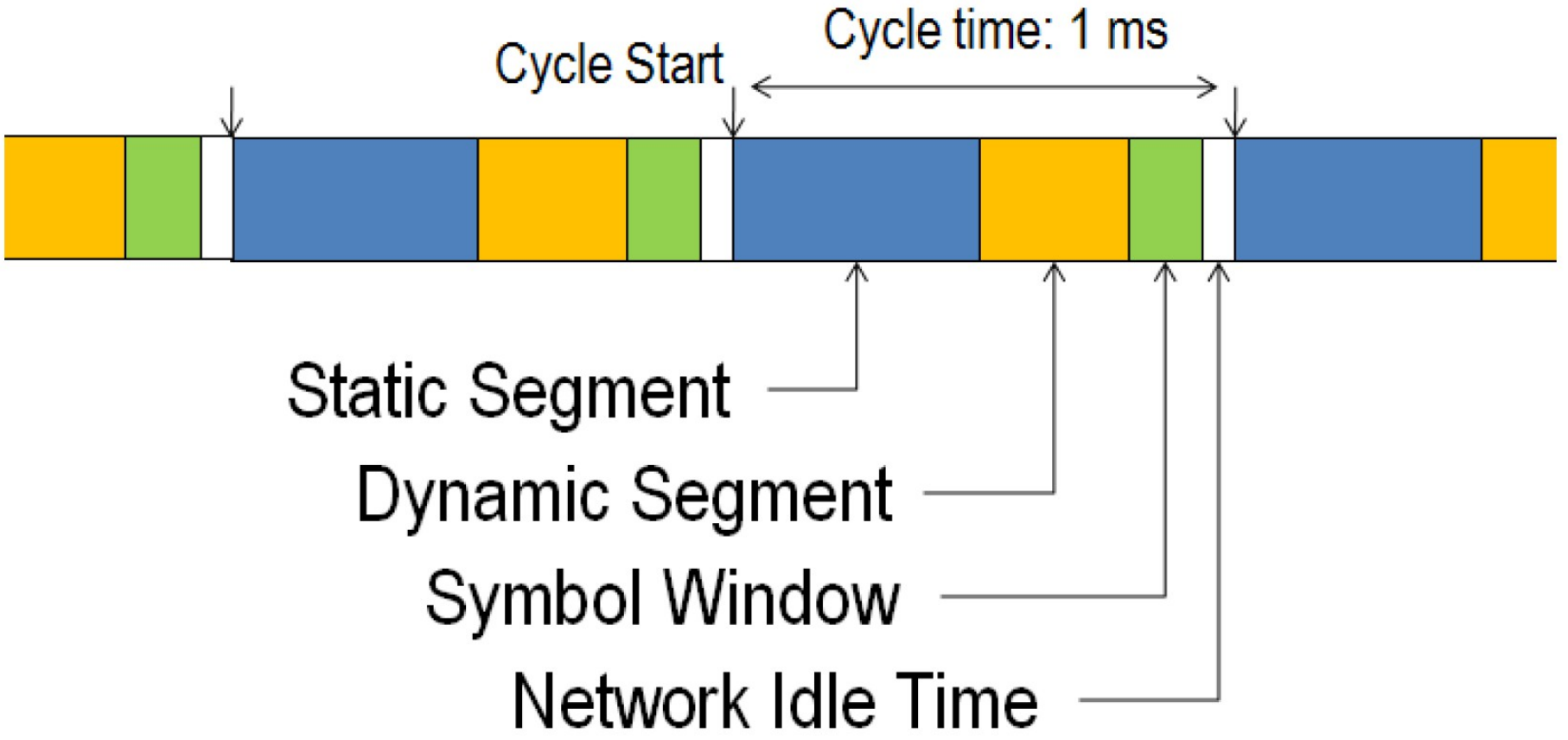
Data Link Layer

Communication

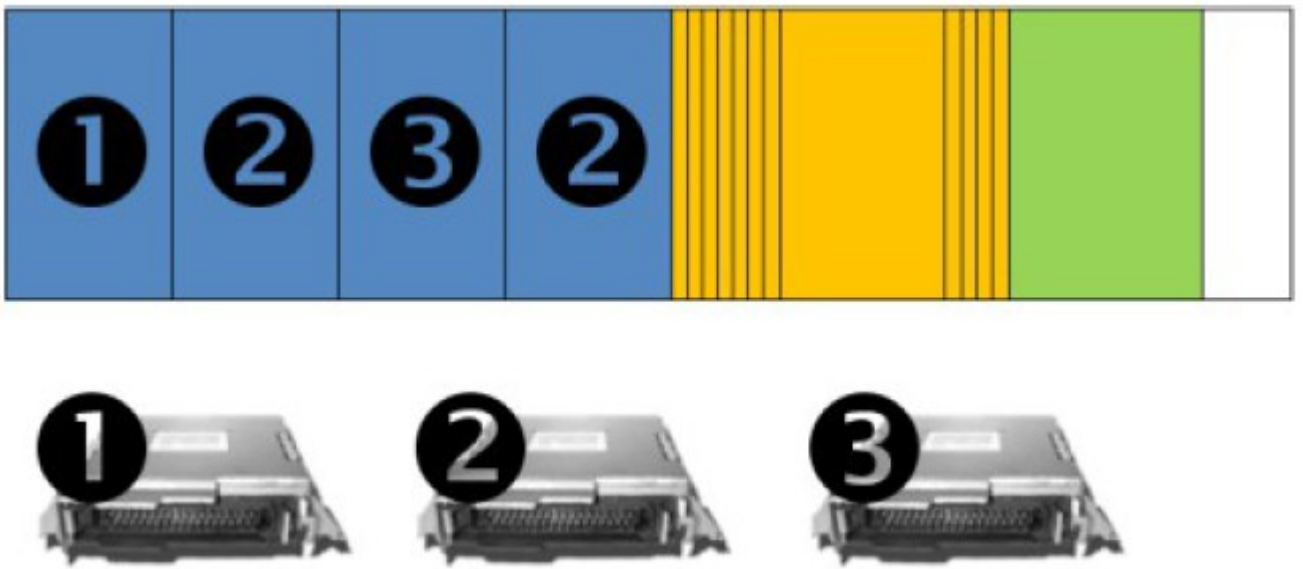
- TDMA/FTDMA (Flexible Time Division Multiple Access)
- Fixed time Slots (synchronous and asynchronous data)
- Fixed number of slots
- Guraranteed Latency
- Synchronized Clock

Communication Cycle



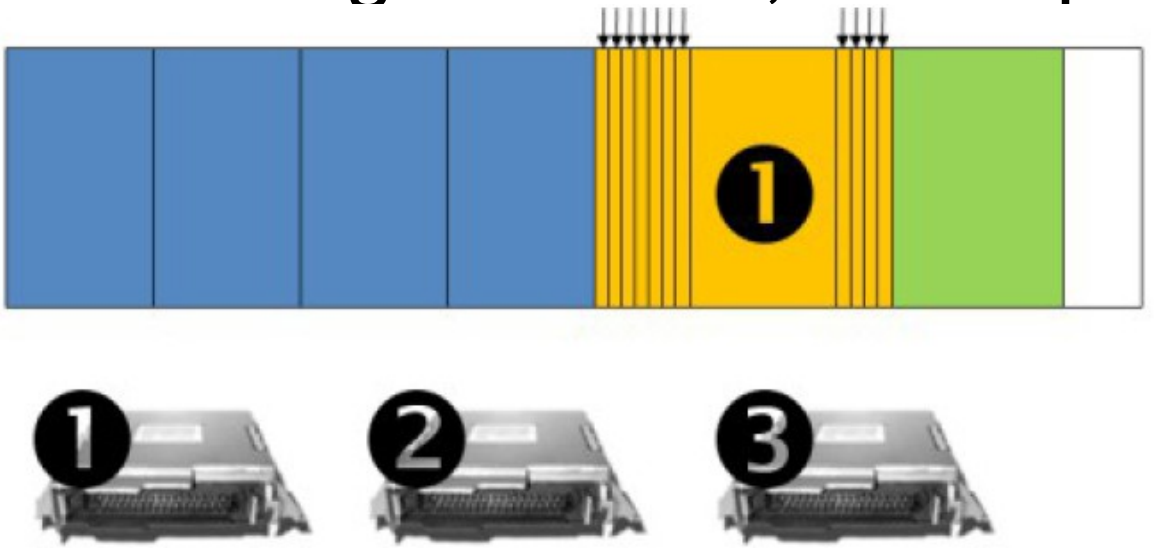
Communication Static Segment

- TDMA
- Each node has fixed timeslot(s)



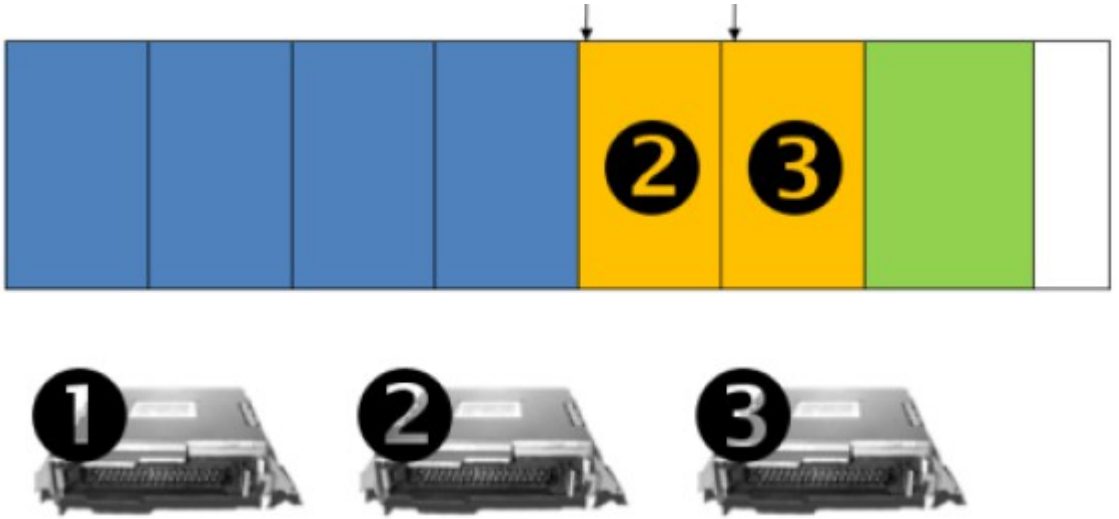
Communication Dynamic Segment

- FTDMA
- Fragmented in Minislots (typ. macrotick 1µs)
- Minislots are pre-assigned (implizit priorization)
- If node doesn't begin to send, slot expires



Communication Dynamic Segment

- High priotity data pushes off low-priority data
- Slot mulitplexing is allowed (e.g. un-/even cycle count)

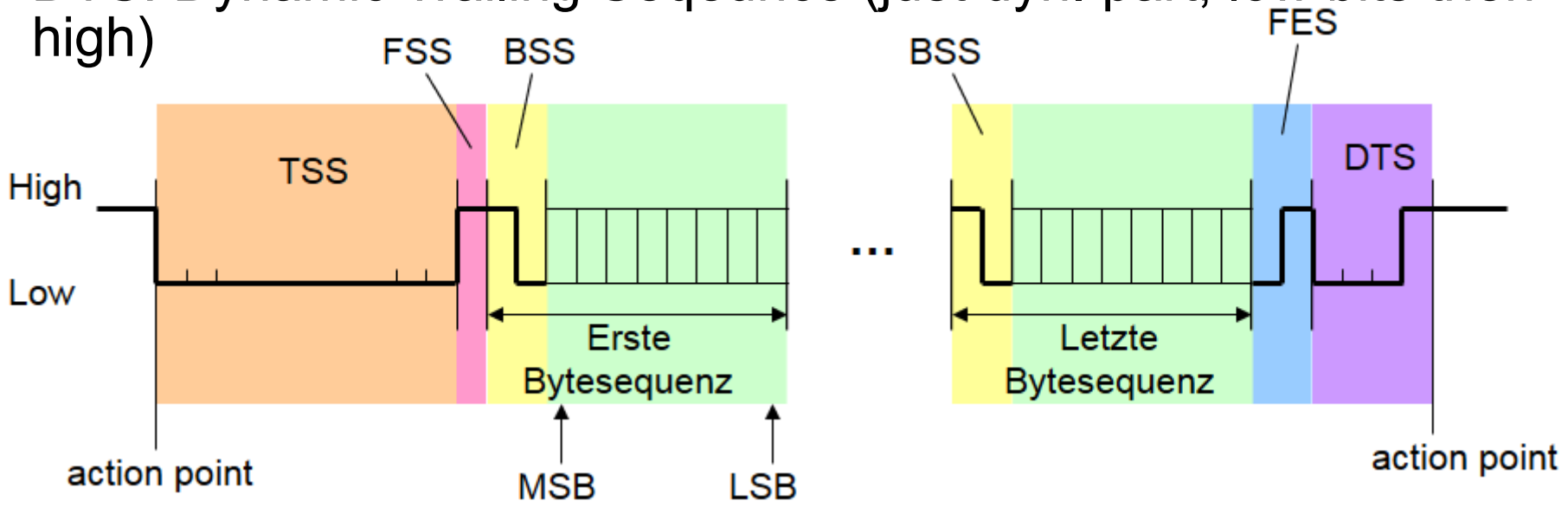


Communication System Startup

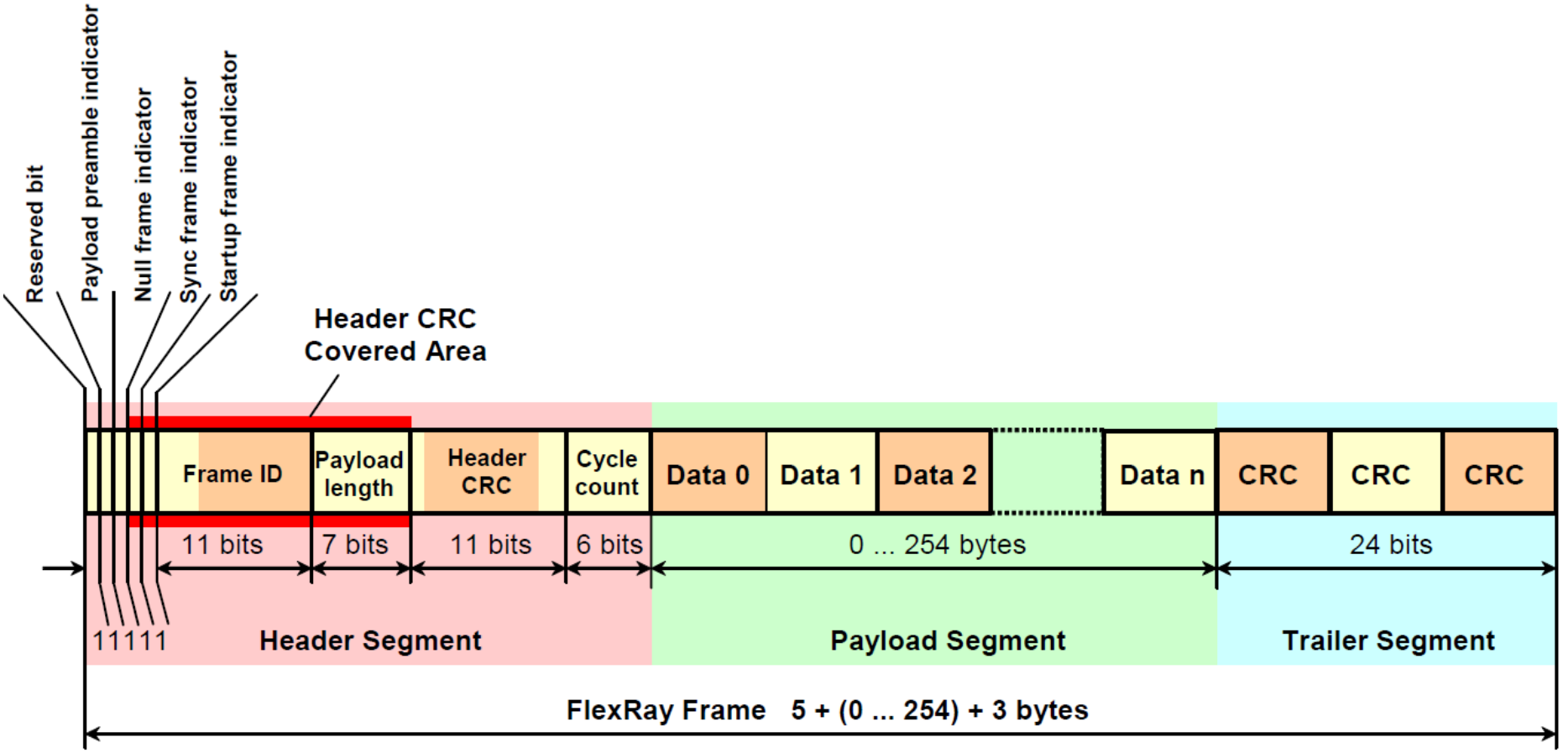
- Two logical steps:
  - Dedicated coldstart nodes start up (at least two):
    - send collision avoidance symbol CAS
    - leading and following coldstart node
  - Other nodes integrate to coldstart nodes

Frame coding

- TSS: Transmission Start Sequence (low Bits)
- FSS: Frame Start Sequence (high Bit)
- BSS: Byte Start Sequence (high then low Bit)
- FES: Frame End Sequence (low then high Bit)
- DTS: Dynamic Trailing Seqeunce (just dyn. part, low bits then high)



Frame

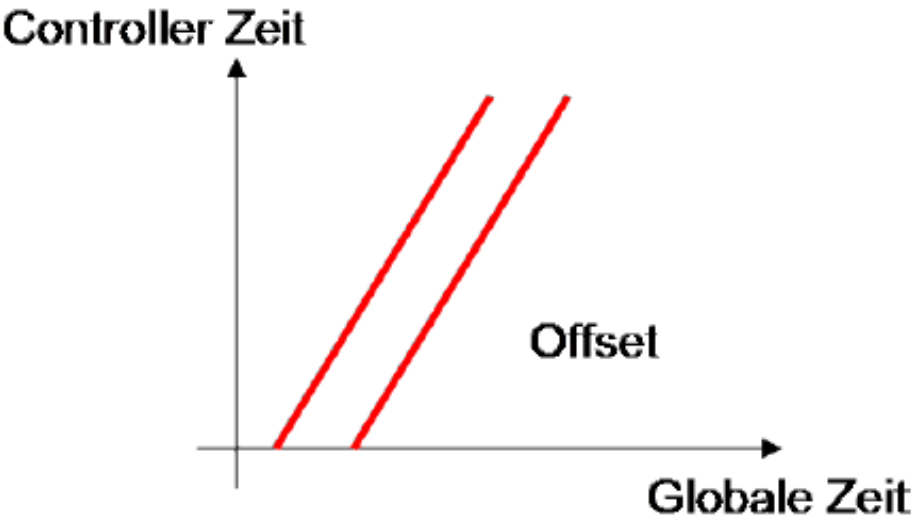

Reserved bit
Payload preamble indicator
Null frame indicator
Sync frame indicator
Startup frame indicator
Header CRC
Covered Area
Frame ID
Payload length
Header CRC
Cycle count
Data 0
Data 1
Data 2
Data n
CRC
CRC
CRC
11 bits
7 bits
11 bits
6 bits
0 ... 254 bytes
24 bits
11111
Header Segment
Payload Segment
Trailer Segment
FlexRay Frame 5 + (0 ... 254) + 3 bytes

Time Synchronization

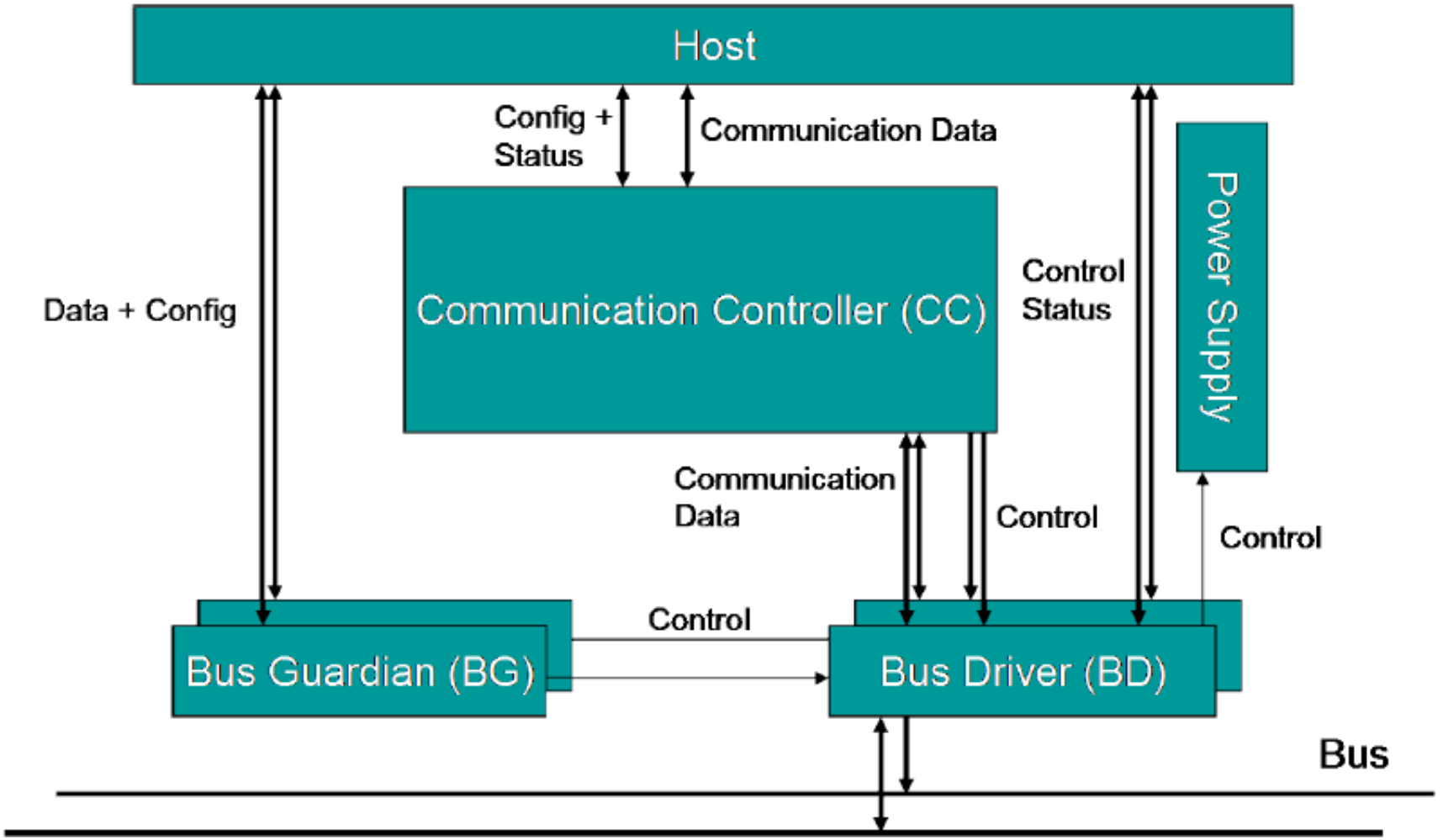
- Network is started
  - Two pre-designated nodes broadcast sync frames when turned on
  - Other nodes measure time between successive braoadcasts and calibrate clock
  - Sync frames are designated in FIBEX config file
  - When sync, network idle time is used for adjustment

Time Synchronization

- Offset (phase) difference
- Rate (frequency) difference



Protocol Integration



Bus Guardian

- Safety
- Raliability
- Just for Static Segment
- Two Types:
  - Local Guardian
  - Active Star Guardian

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FIBEX
(FIeld Bus EXchange Format)

FIBEX

- XML-Based configuration file format for automotive (compatible to other protocols)
- Contains:
  - Transmit and receive schedules
  - Frame definitions
  - Signal definitions
  - Network Configuration (baudrate, timing)
  - Network topology
  - ECU information

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Comparison

Comparison

Bus	LIN (Local Interconnect Network)	CAN (Controller Area Network)	FlexRay
Speed	40 kbit/s	1 Mbit/s	10 Mbit/s
Cost	$	$$	$$$
Wires	1	2	2 or 4
Typical Applications	Body Electronics (Mirrors, Power Seats, Accesories)	Powertrain (Engine, Transmission, ABS)	High-Performance Powertrain, Safety (Drive-by-wire, active suspension, adaptive cruise control)

Comparison

	(A) Messaging	(B) Network Synchronization	(C) Node Control	(D) Message Retransmission	(E) Error Management	(F) Bandwidth	(G) Physical	(H) Applications	(I) Cost
LIN	Deterministic, Static Message Scheduling	Global Reference Time	Master/Slave	Limited Message Retransmisison Supported	CRC Frame Field, ID Field Parity Bits, Diagnostic Frames	10 kBit/s max (variable: 600, 1200, 2400, 4800, 9600)	1-Wire	Displays, Lighting, Alarm Systems, A/C, Seat & Mirror Adjustments, Power Windows, Windshield Wipers, Headlamps	Low
CAN	Event-Triggered Messages	Priority-Based Arbitration	Autonomous	Message Retransmisison Supported	CRC Frame Field, Bit Monitoring Bit Stuffing, Error Frames, Overload Frames	125 kBit/s max	2-Wire (interference protection)		Medium
TTCAN	Event- & Time-Triggered Messages	Global Reference Time	Autonomous, Master/Slave			10 MBit/s max	2-Wire (interference protection)	Engine, Transmission, Braking, Steering, Suspension, Assistance, Safety, Diagnostics	High
FlexRay	Event- & Time-Triggered Messages	Global Reference Time	Autonomous, Master/Slave		2 CRC Frame Fields, Bus Guardian (optional)	2 Channels: 5 MBit/s, 10 MBit/s	2 Channel, 2-Wire (interference protection), fiber optic (optional)		High

Note: "Event-Triggered" messages (non-deterministic, arbitration), "Time-Triggered" messages (deterministic, non-arbitration)