Embedded and Real-Time Systems

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Lecture 14

Automotive Communication Protocols

General Background

- **What is FlexRay?**
  - A next generation automotive network communications protocol
- **When was it released?**
  - First public release(Version 2.0) on Jun 2004
  - The latest version 3.0.1 was released on Oct 2010
- **Why uses FlexRay?**
  - High bandwidth
  - Flexibility
  - Fault-tolerance
  - Reliability

General Background

FlexRay

- 10Mbps x 2 bandwidth
- Time-triggered for real-time transmission
- Event-triggered for low-priority data
- Synchronous
- Deterministic system design

Controller Area Network(CAN)

- Bandwidth up to 1Mbps
- Contention resolved by priority
- Asynchronous
- Acknowledgment and retransmission when message is corrupted

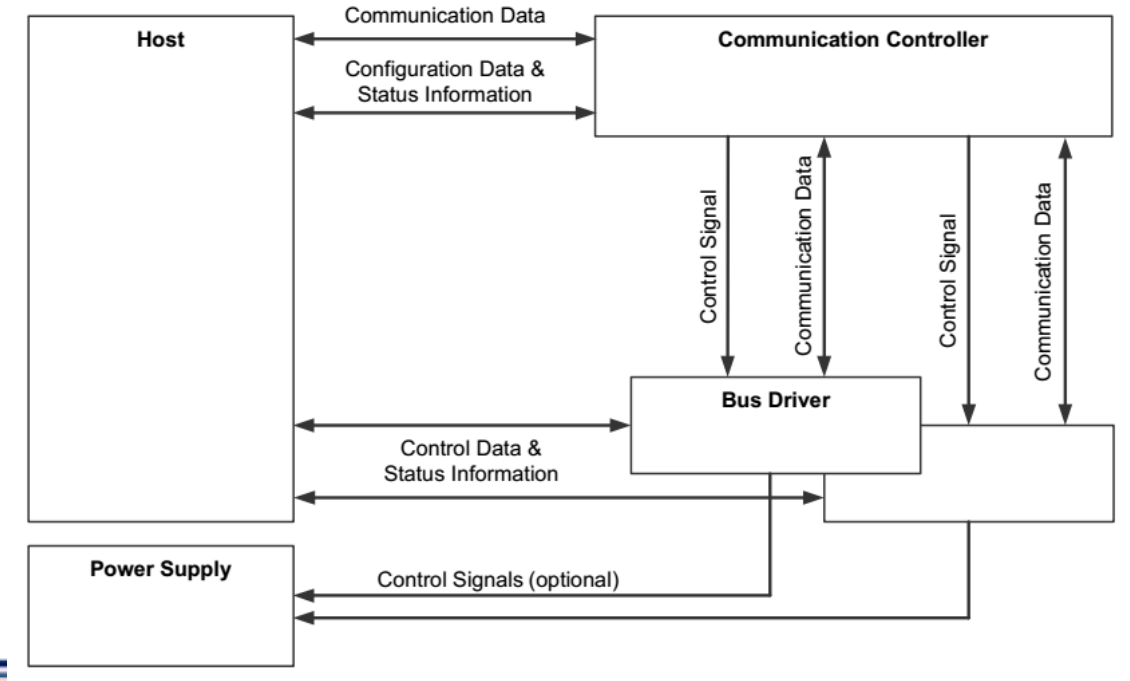
General Background

- **Who developed FlexRay?**

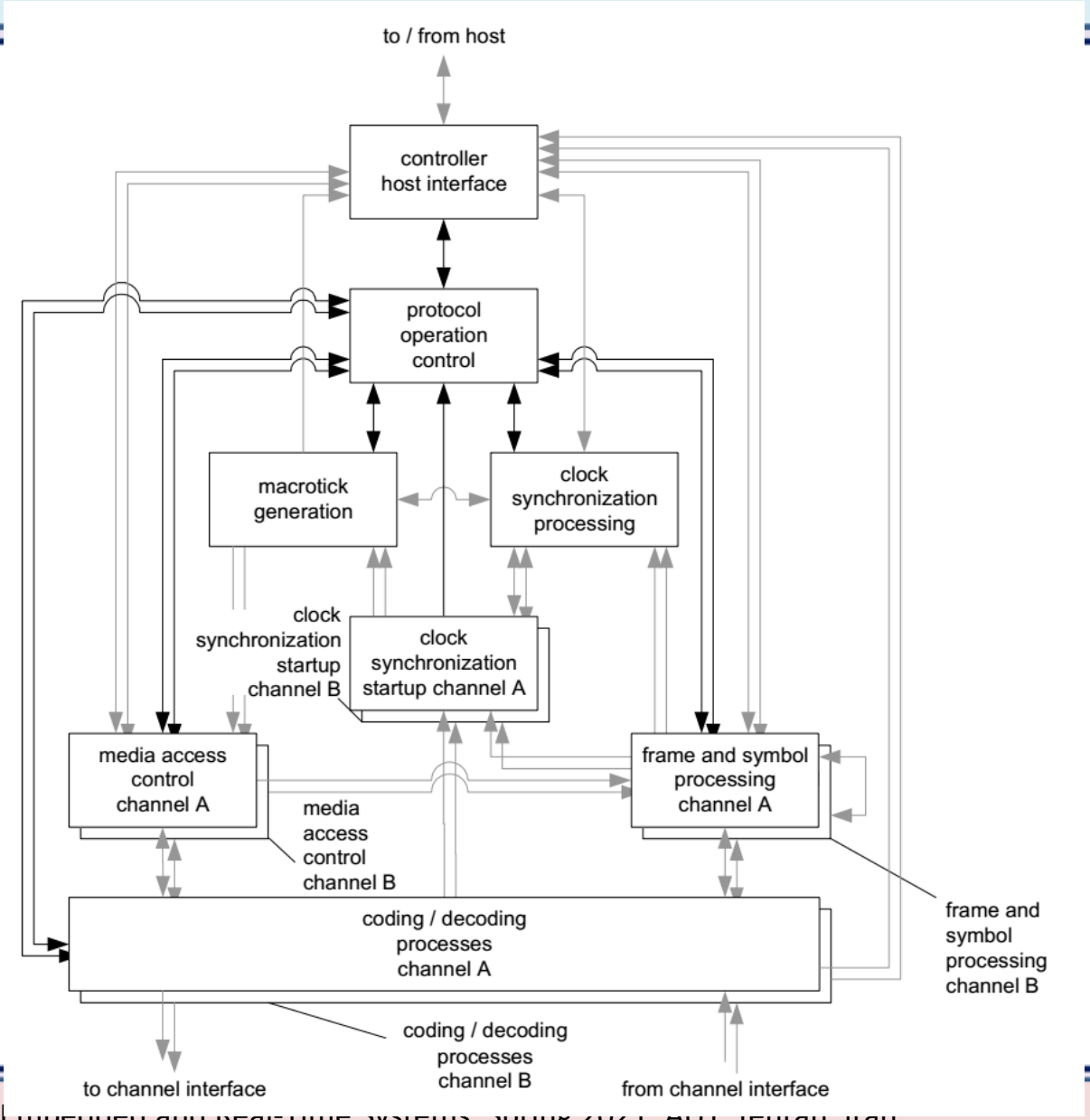
- **Where used FlexRay?**
  - BMW X5 on 2006, BMW 5-Series,
  - BMW 7-Series,Audi A8,
  - Bentley Mulsanne,
  - Rolls-Royce Ghost,
  - Lamborghini Huracán

General Background

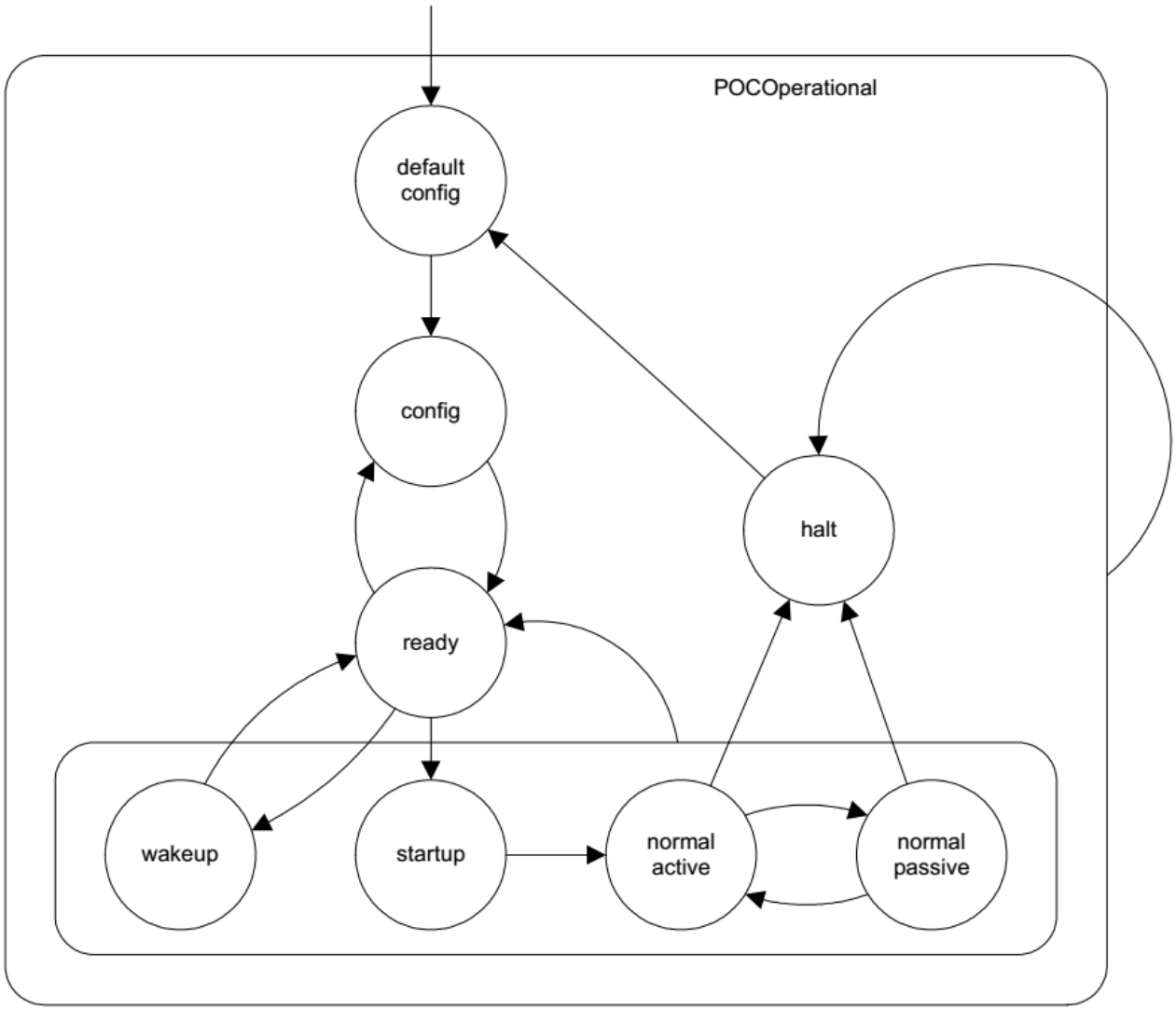
- **How does it work?**
  - Dual channel - scalable system fault-tolerance
  - Bus Guardian
  - Interconnect topologies: centralized or bus



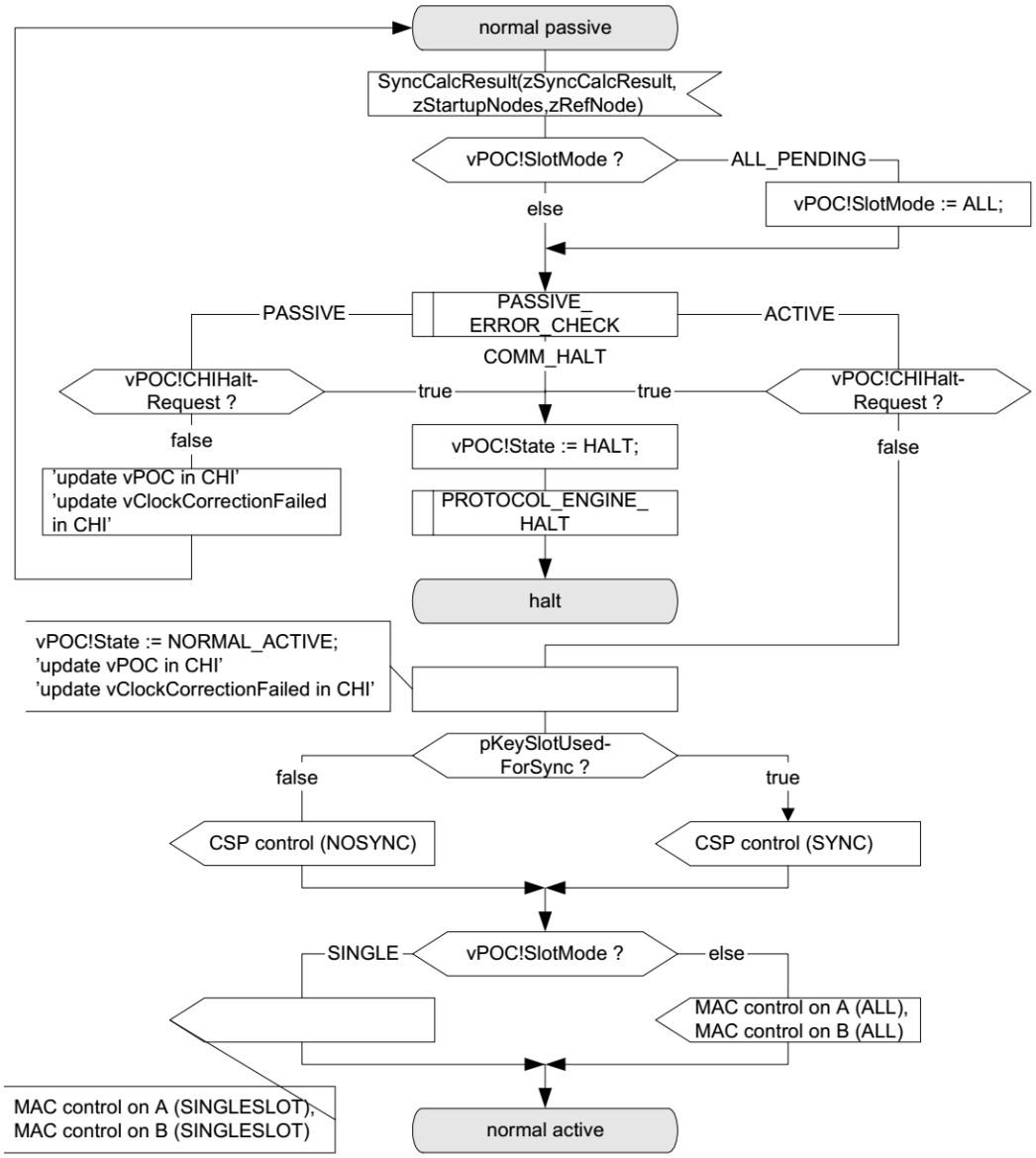
Protocol Operation Control



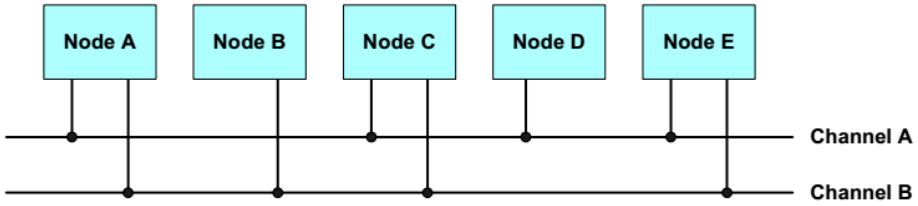
Protocol Operation Control

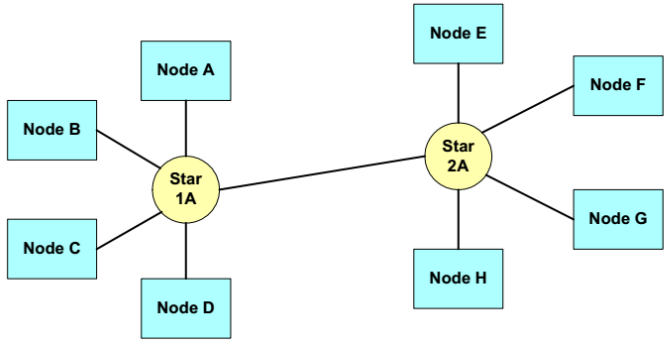


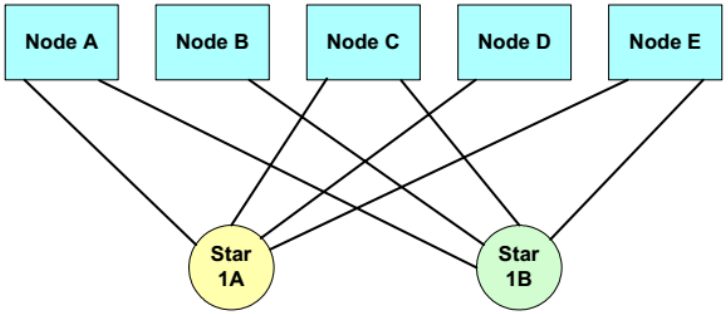
Protocol Operation Control

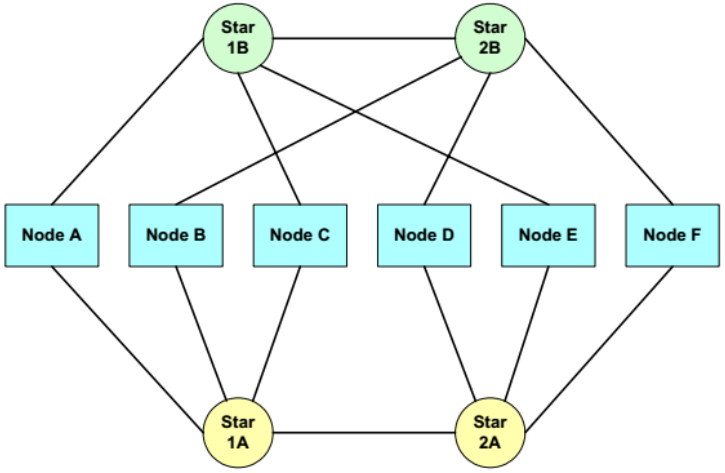


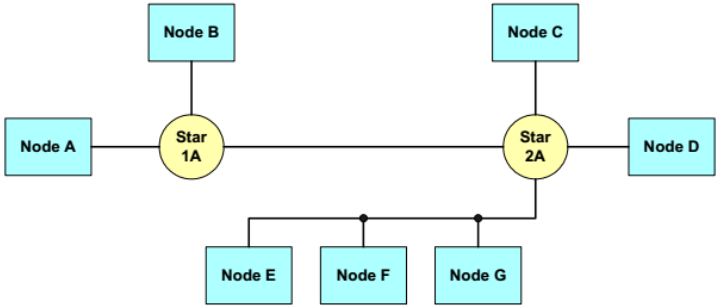
Network Topology

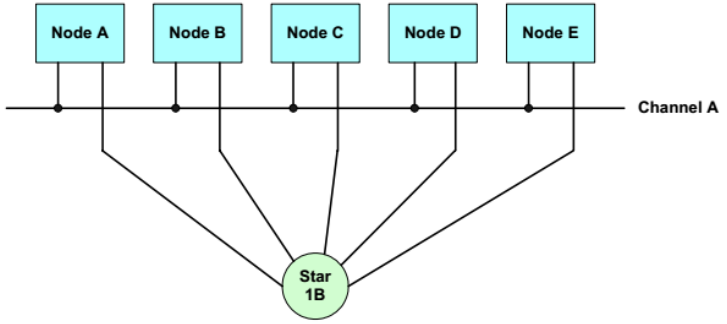






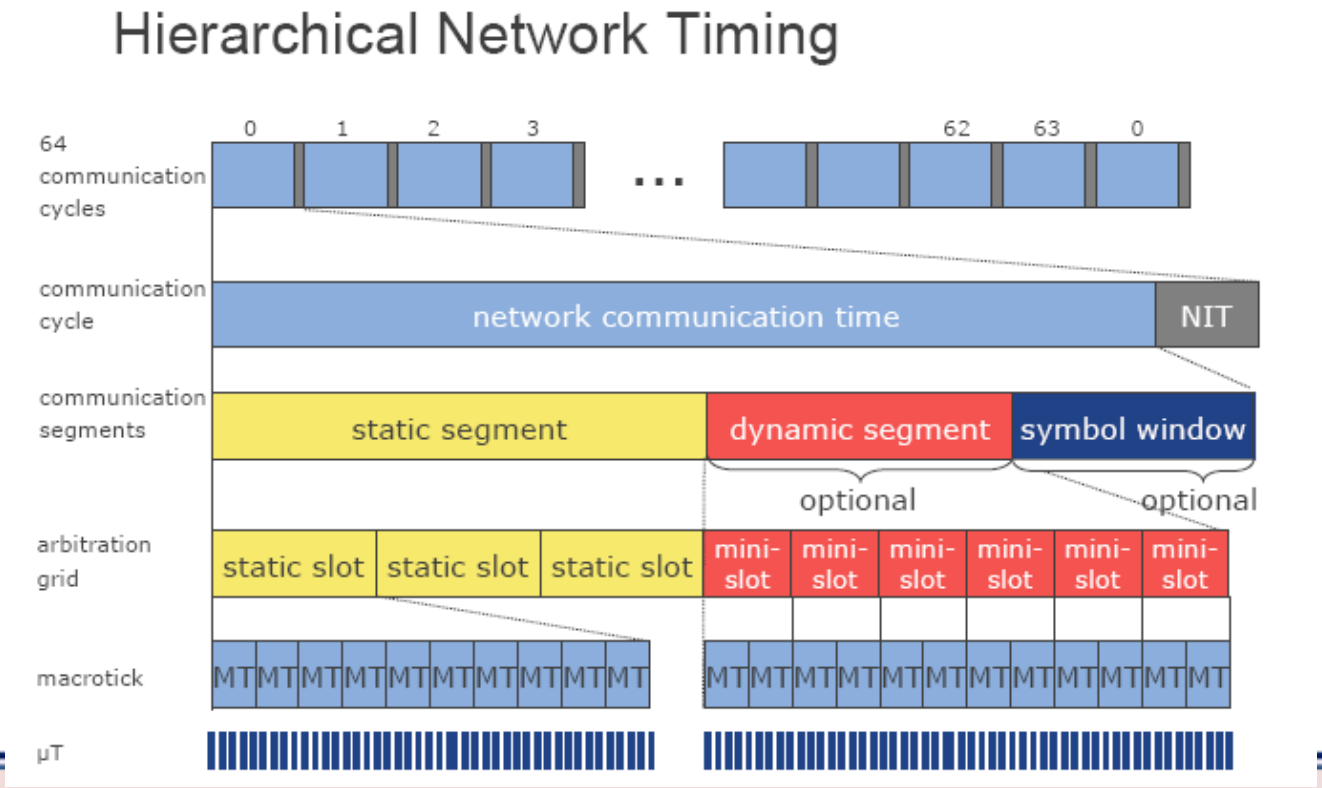






Communication

- Microtick: the node's own internal clock or timer
- Macrotick: a cluster wide synchronized clock
- NIT is stand for Network Idle Time for time corrections



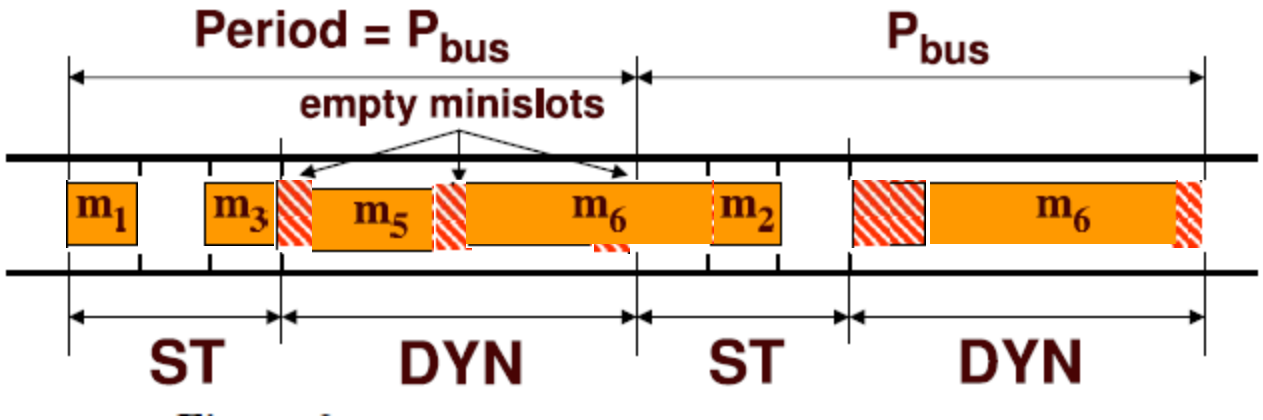
Communication

- **Static Segment**
  - Time-triggered
  - Enables a guaranteed real-time transmission of critical data
  - Periodic and Safety-critical data
  - Reserved slots for deterministic data that arrives at a fixed period

- **Dynamic Segment**
  - Even-triggered
  - For low priority data
  - Maintenance and Diagnosis data
  - does not require determinism

FlexRay Communication cycles

- The first cycle T1, T3,T5, T6, and T7 have messages to send
- The Second cycle T2 have messages to send

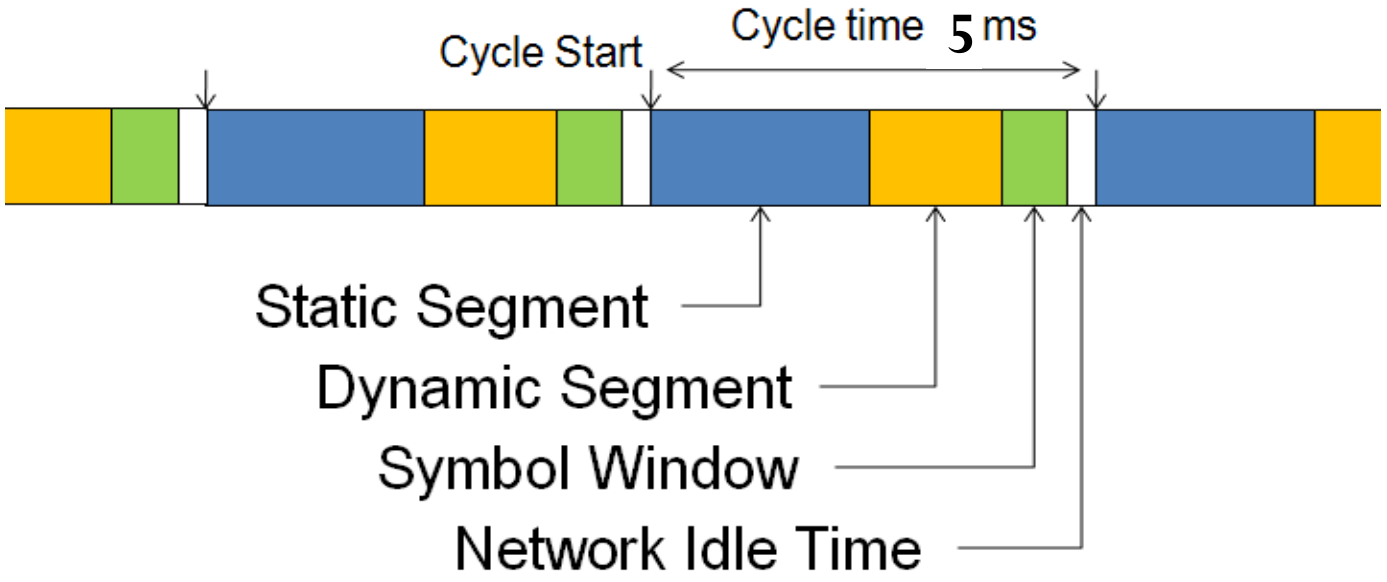


FlexRay Communication cycles

- **Communication Cycle**
  - **Symbol Window**

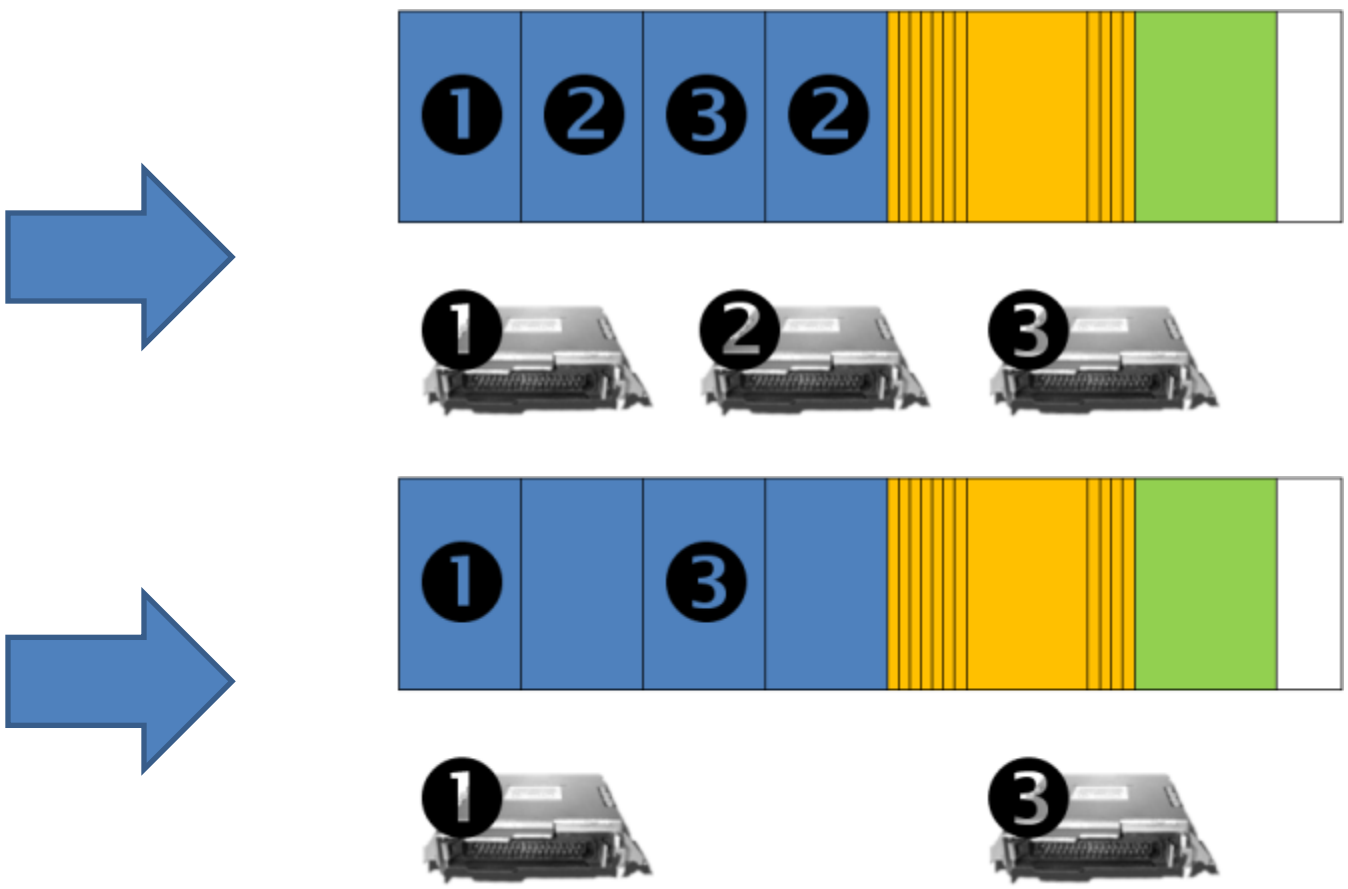
    Typically used for network maintenance and signaling for starting the network
  - **Network Idle Time**

    A known "quiet" time used to maintain synchronization between node clocks



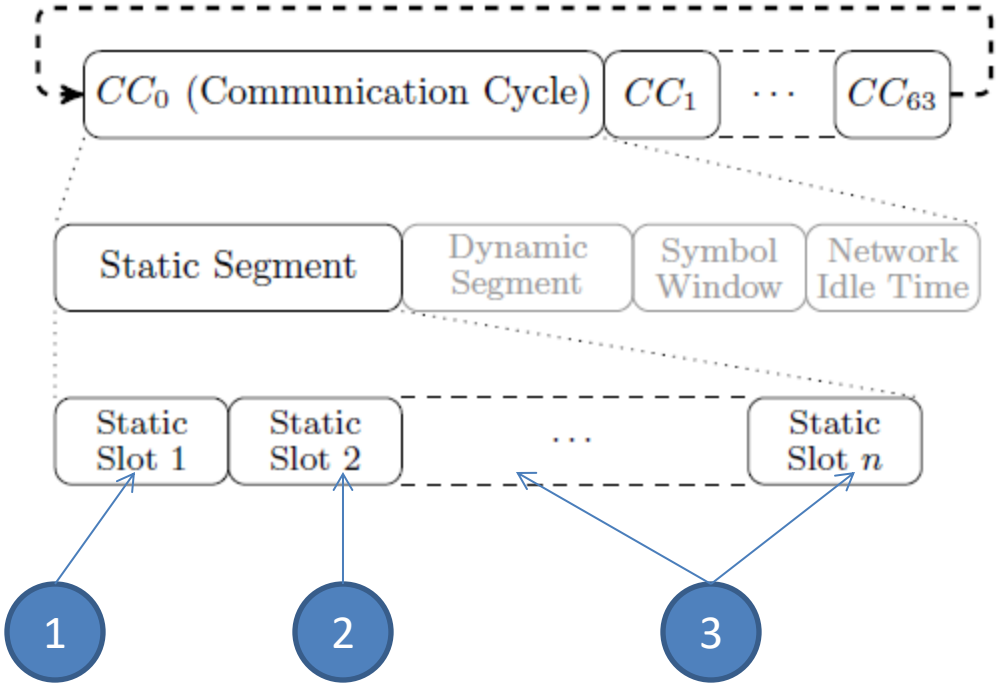
FlexRay Communication cycles

- **Static Segment**

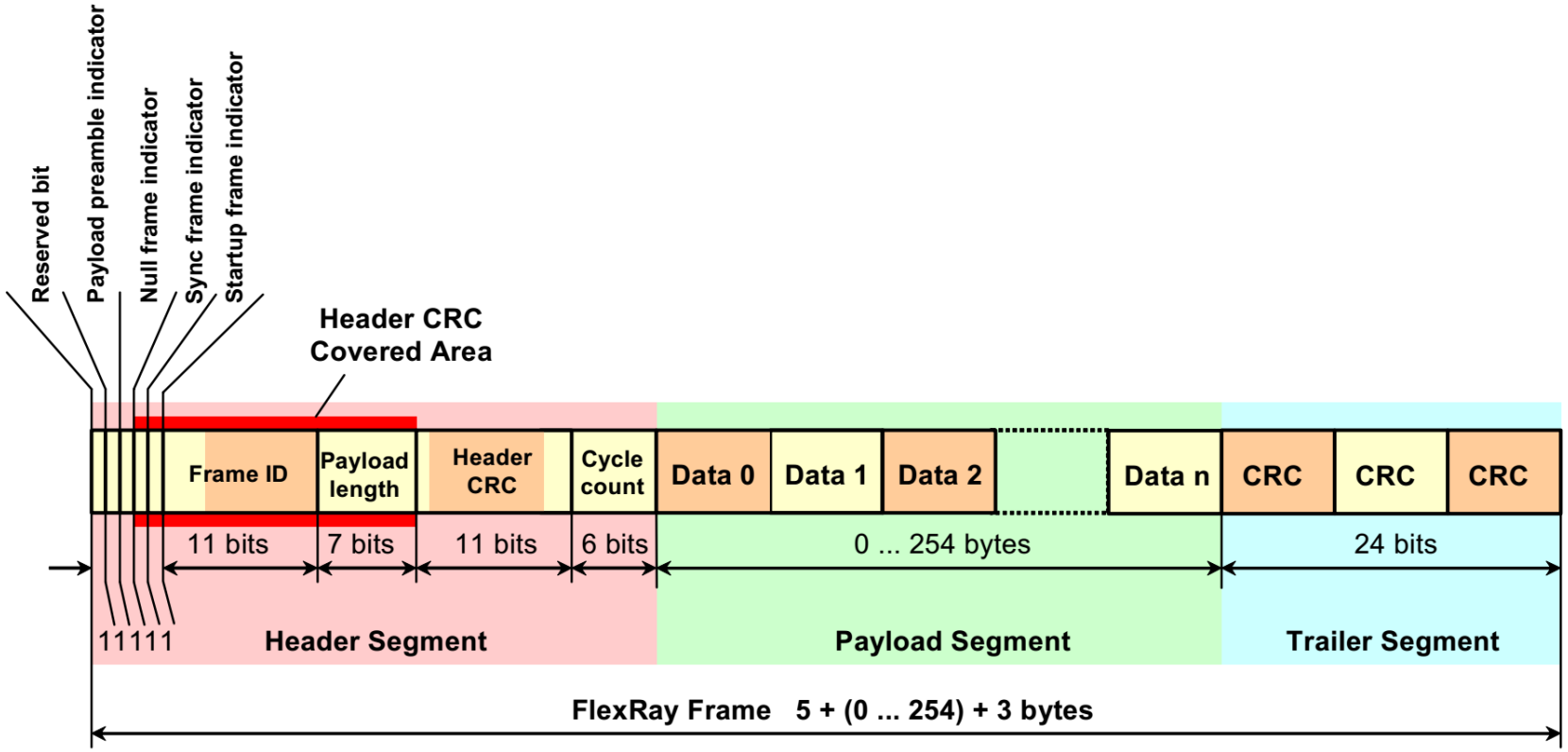


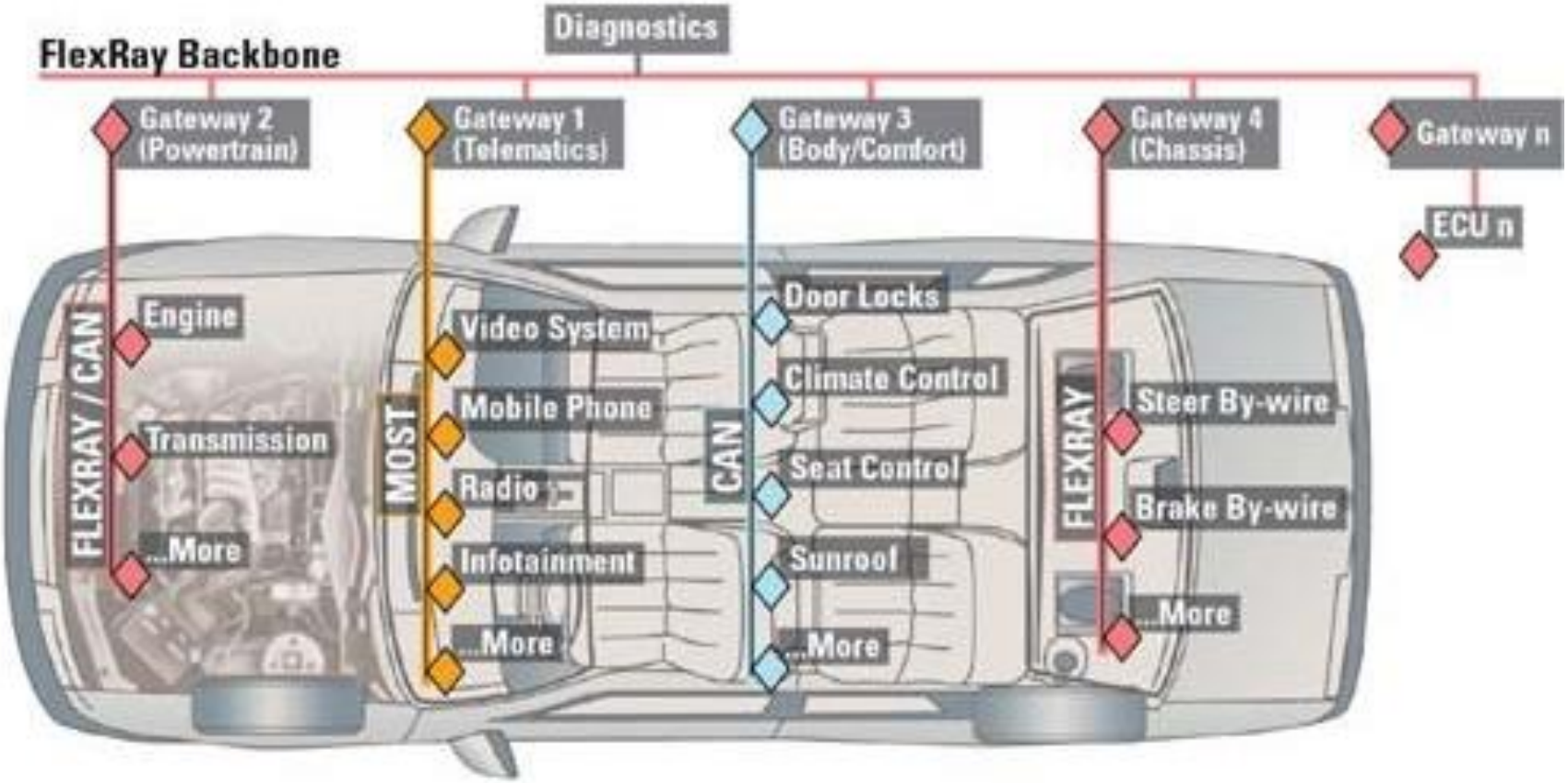
FlexRay Communication cycles

- **Static Segment**
  - Made up of n equally sized slots
  - each slots is uniquely assigned to one node
  - Node may occupy more than one slot



FlexRay Frame Format




FlexRay Backbone
Diagnostics
Gateway 2 (Powertrain)
Gateway 1 (Telematics)
Gateway 3 (Body/Comfort)
Gateway 4 (Chassis)
Gateway n
ECU n
FLEXRAY / CAN
Engine
Transmission
...More
MOST
Video System
Mobile Phone
Radio
Infotainment
...More
CAN
Door Locks
Climate Control
Seat Control
Sunrool
...More
FLEXRAY
Steer By-wire
Brake By-wire
...More