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UNIVERSITY
DEPARTMENT OF ENGINEERING

Middleware and Communication Protocols for Dependable Systems TI-MICO

"Time Triggered Communication on CAN – TT-CAN"

Article written by

Thomas Führer, Bernd Müller et al.
Robert Bosch GmbH

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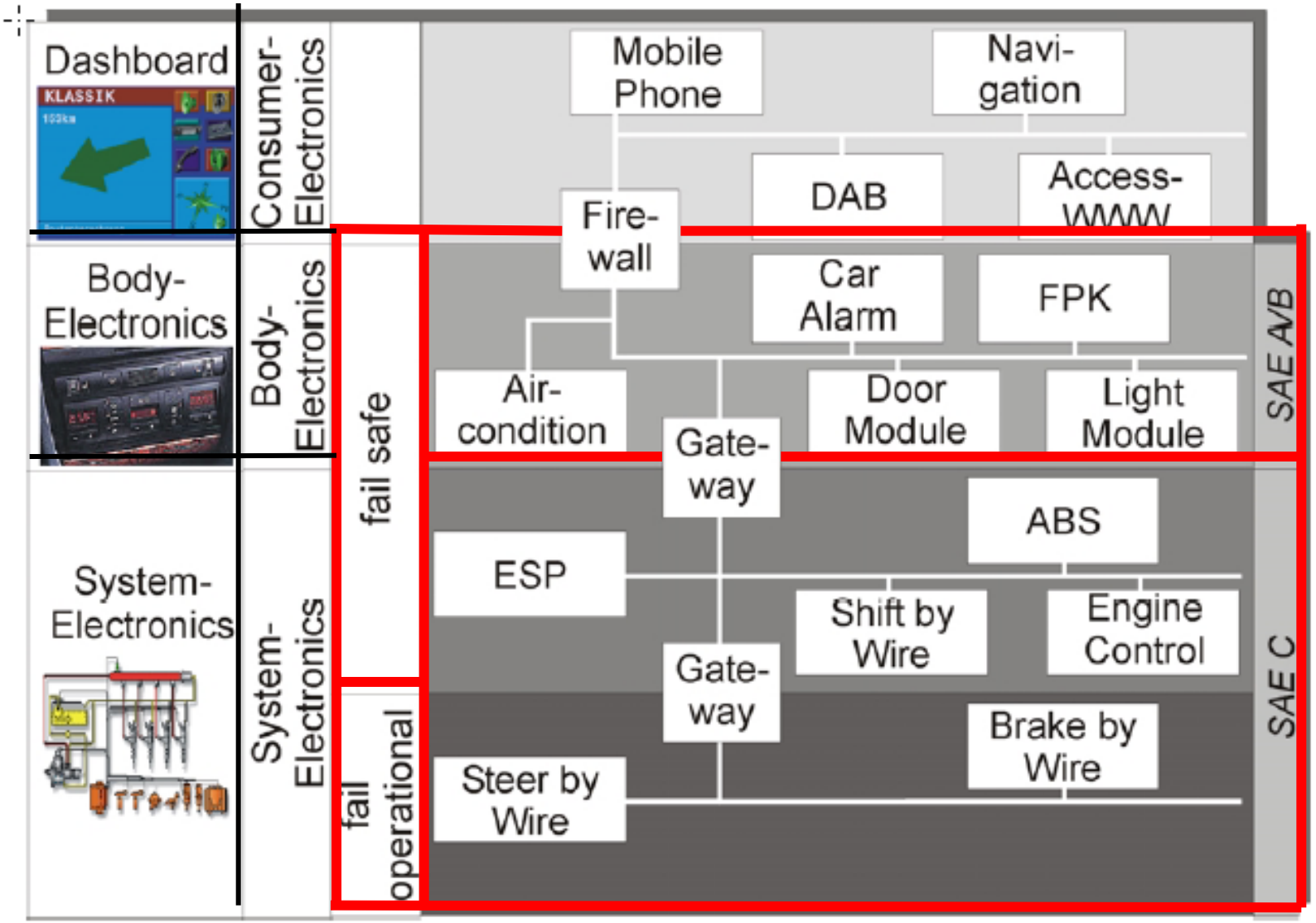
Abstract

- Introduction to a time triggered extension to CAN
  - called **TTCAN**: Time Triggered CAN
  - ISO 11898-4 standard, 2004-08-01.

Problem

- The increasing complexity of distributed real-time systems requires a **deterministic** behavior of the communication network
- Future systems will require support for fault-tolerance and safety

Overview of future Electronic Architectures

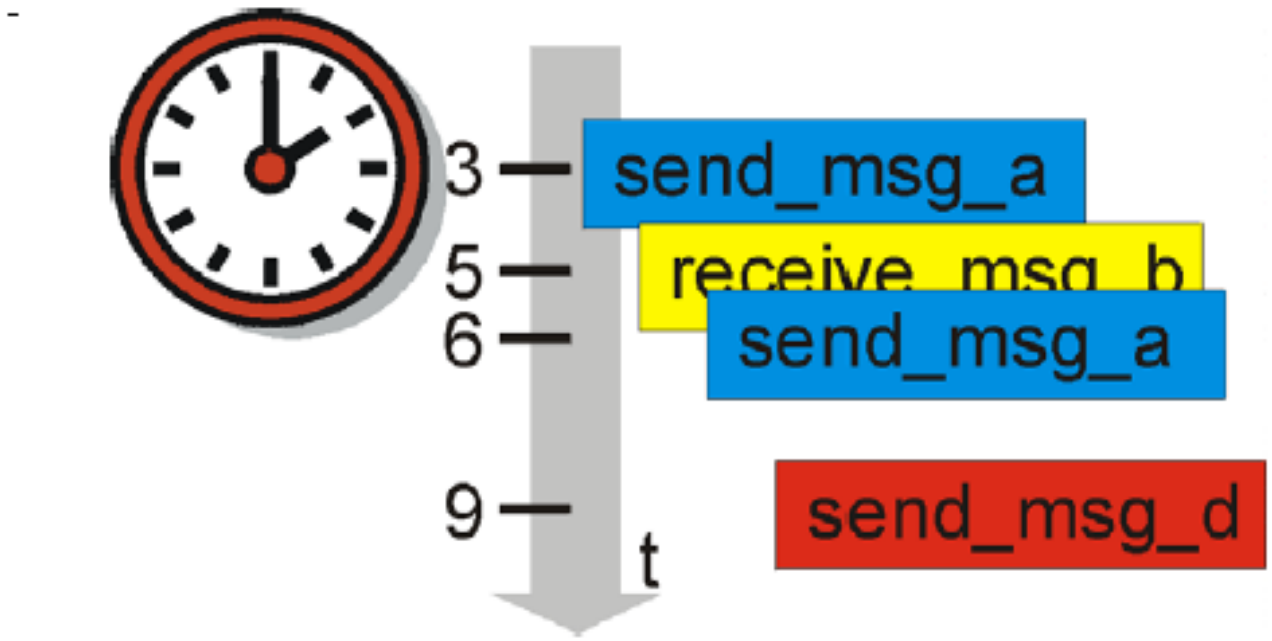


Problems with CAN

- A high priority message can be delayed by the transmission of a lower priority message
- The **goal** of TTCAN is to avoid this latency jitter and to **guarantee** a **deterministic communication** on the bus

Time Triggered Operation

A global Clock

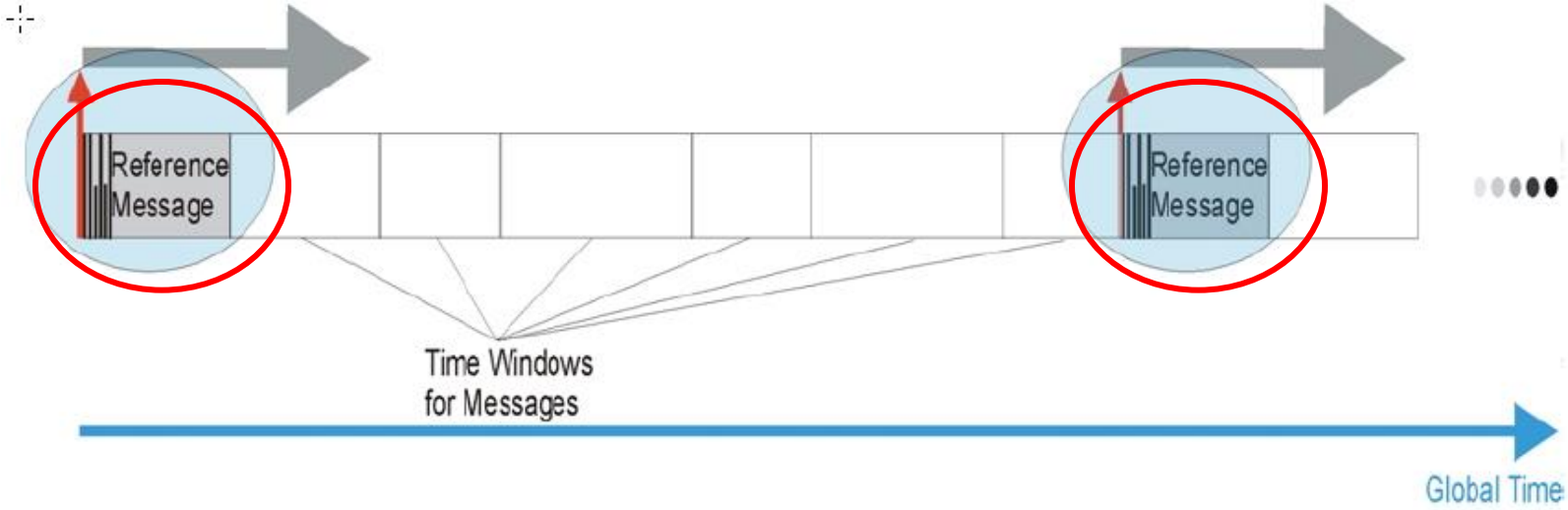


Sending time triggered messages

The Reference Message (1)

Level 1 extension to CAN:

- **Time triggering is based on the reference message of a Time Master Node**
- **Fault tolerance established by redundant Time Masters**
- **Holds only 1 byte of control information - the rest 7 bytes can be used for user data**

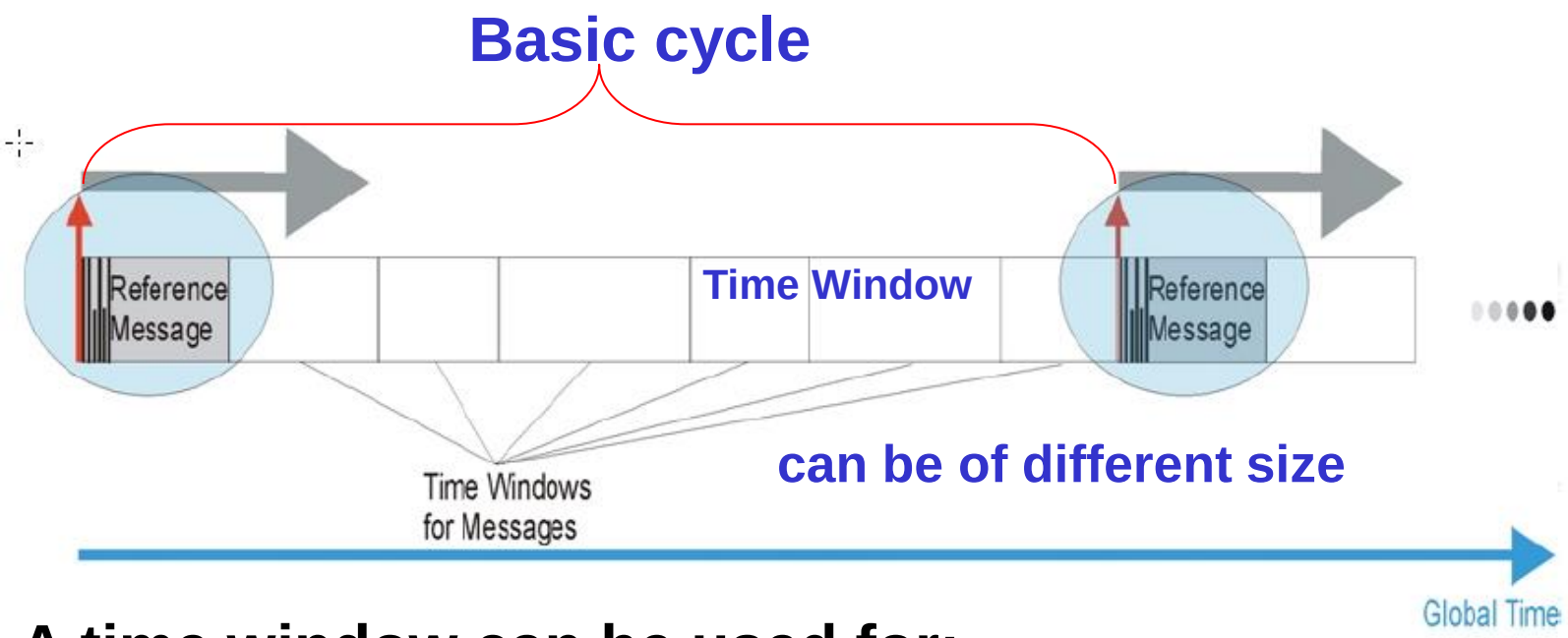


The Reference Message (2)

In level 2 extension:

- A global synchronized time base is established
- A **continuous drift correction** among the CAN controllers is realized
- The **reference message** holds additional control information (**4 bytes**)
  - e.g. the global time information of the current time master
  - the remaining 4 bytes are open for user data

The Basic Cycle and its Time Windows

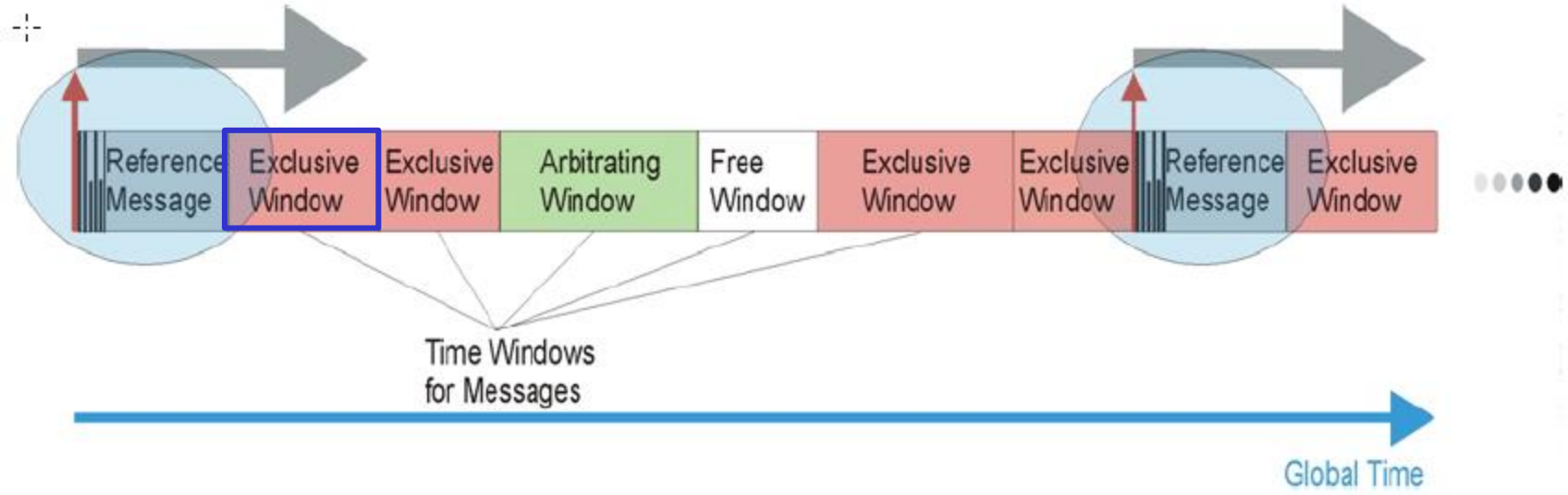


A time window can be used for:

- **Periodic state messages and**
- **Spontaneous state and event messages**

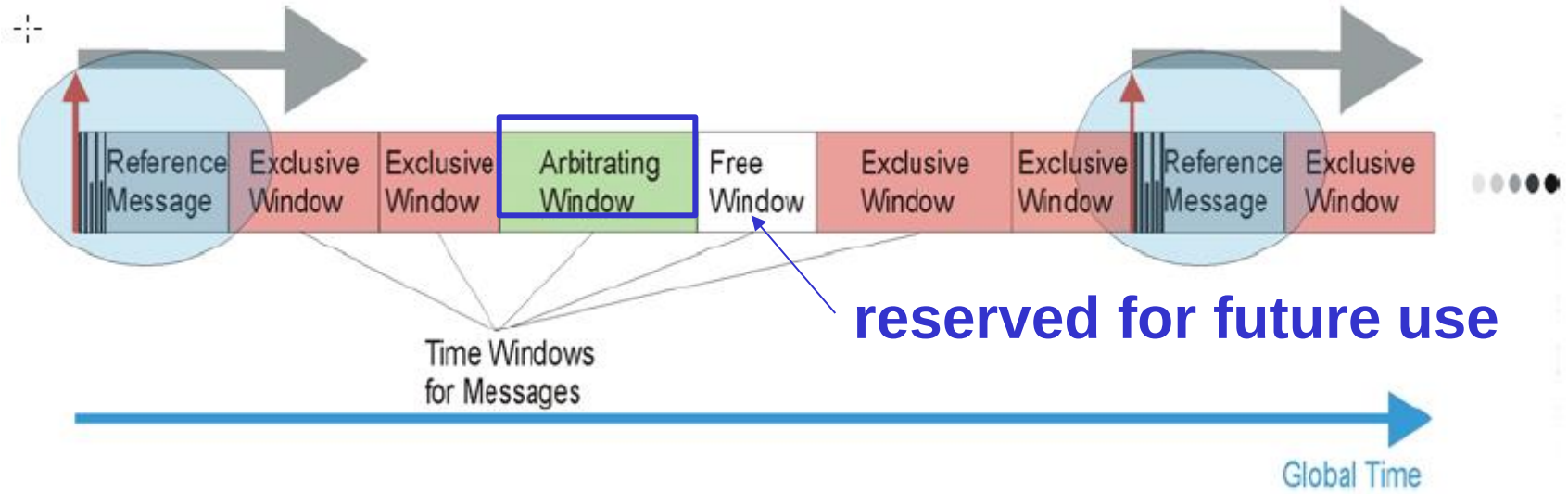
NB! Any messages send are standard CAN messages

Exclusive and Arbitrating Time Windows



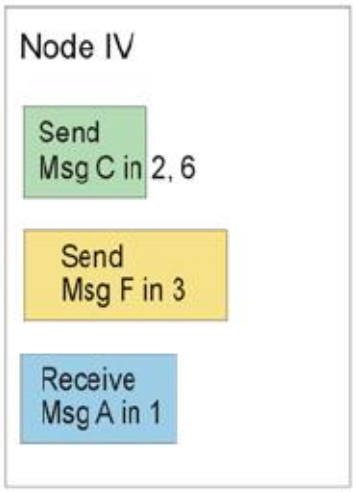
- **Exclusive windows are used for periodic messages (may be repeated)**
- **The beginning of the time window determines the sending point of a predefined message of a node**
- **Automatic retransmission of CAN messages is not allowed in exclusive time windows**

Arbitrating Time Windows

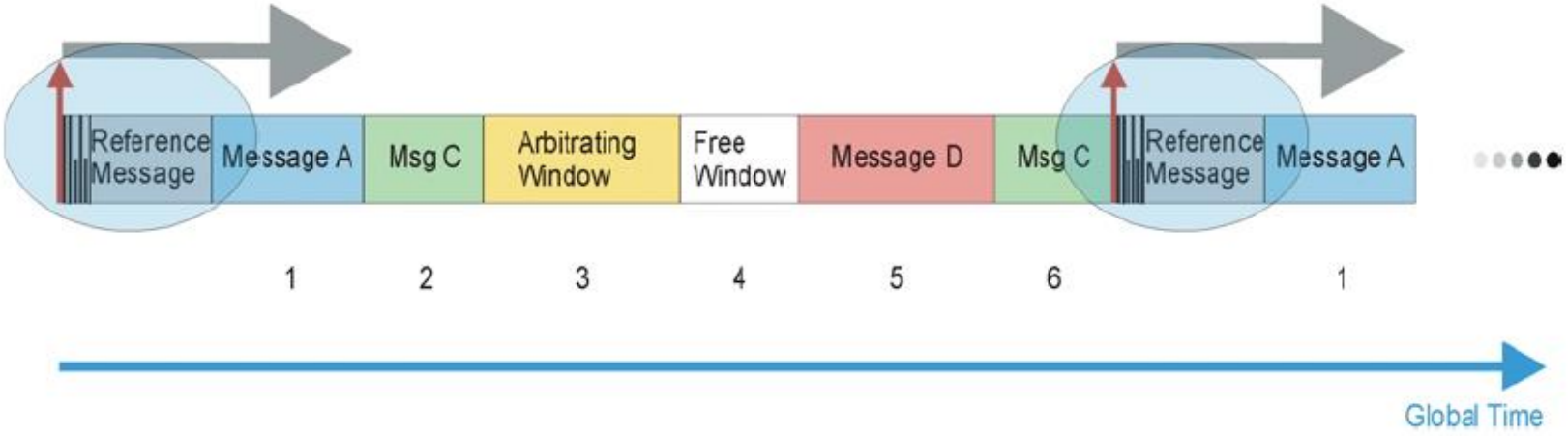


- **Arbitrating windows are used for spontaneous messages (event messages)**
- **the bitwise arbitration decides which message of which node will succeed on the bus**
- **the automatic retransmission of CAN messages is also not allowed in this arbitrating window**

The Node specific Knowledge in TTCAN

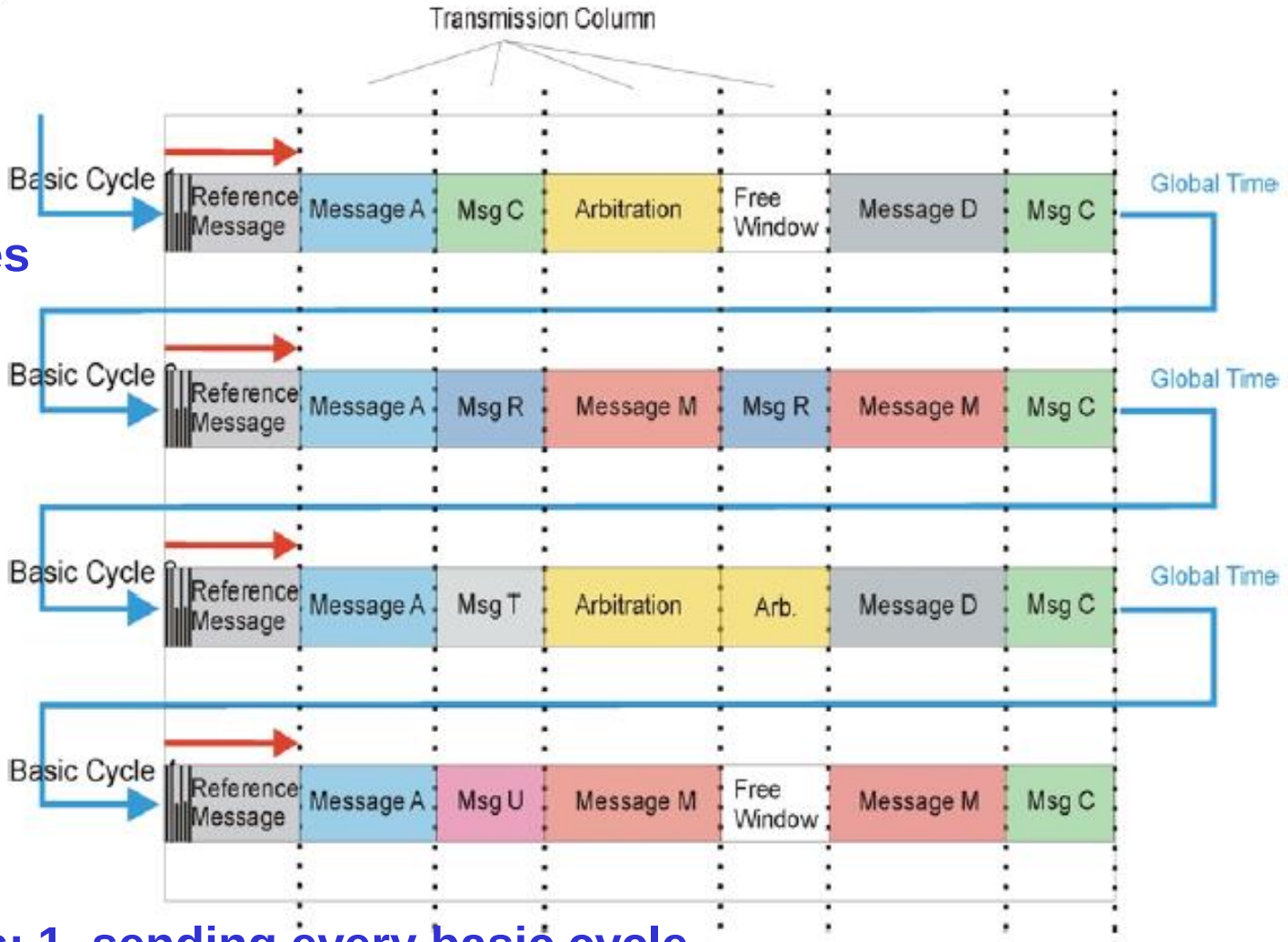


A given node need only to know times for sending and receiving of own messages and times for sending a spontaneous event message



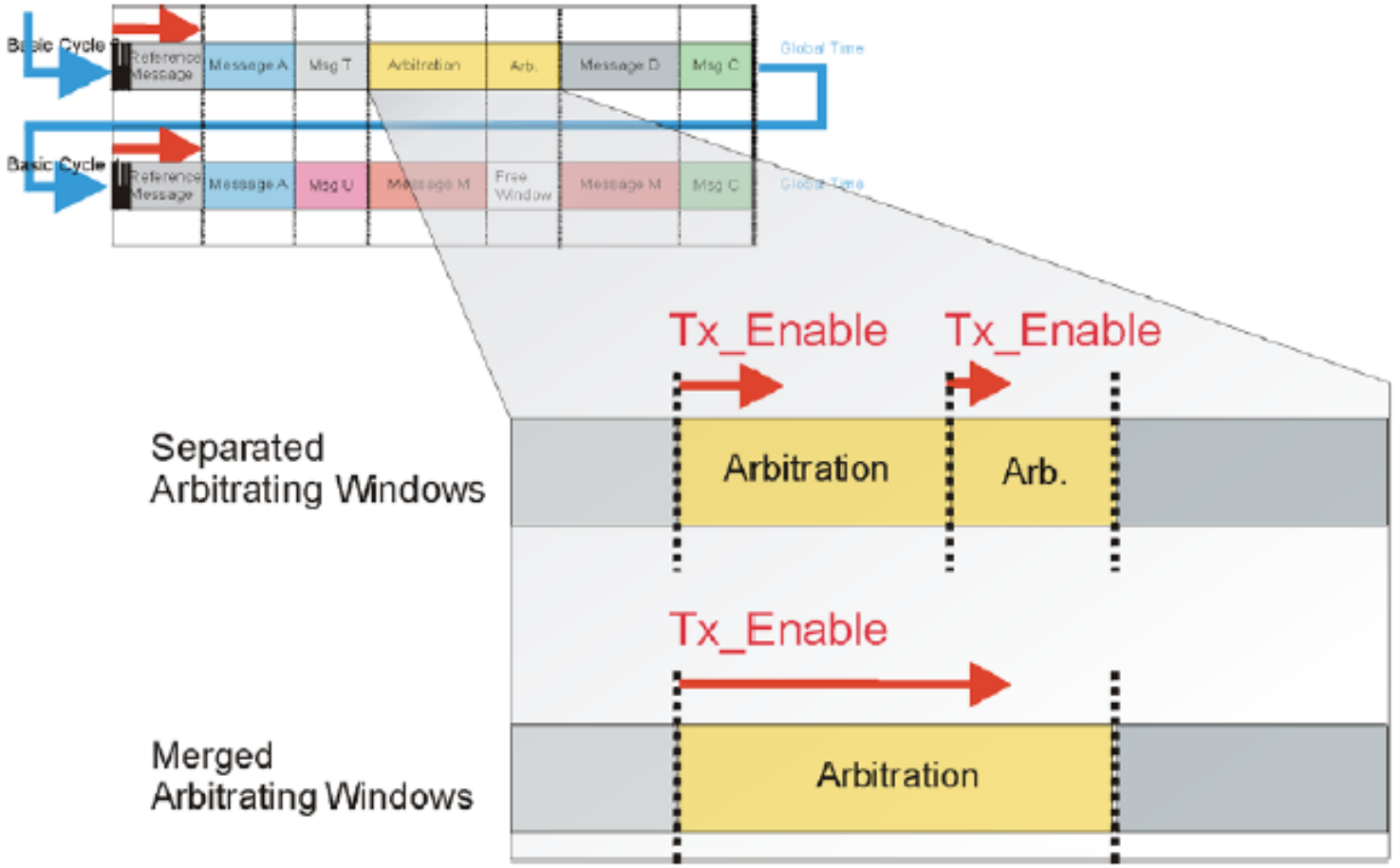
The System Matrix

Basic cycles may be combined to form a System Matrix



Examples: 1. sending every basic cycle,
2. sending every second basic cycle or 3. sending only once

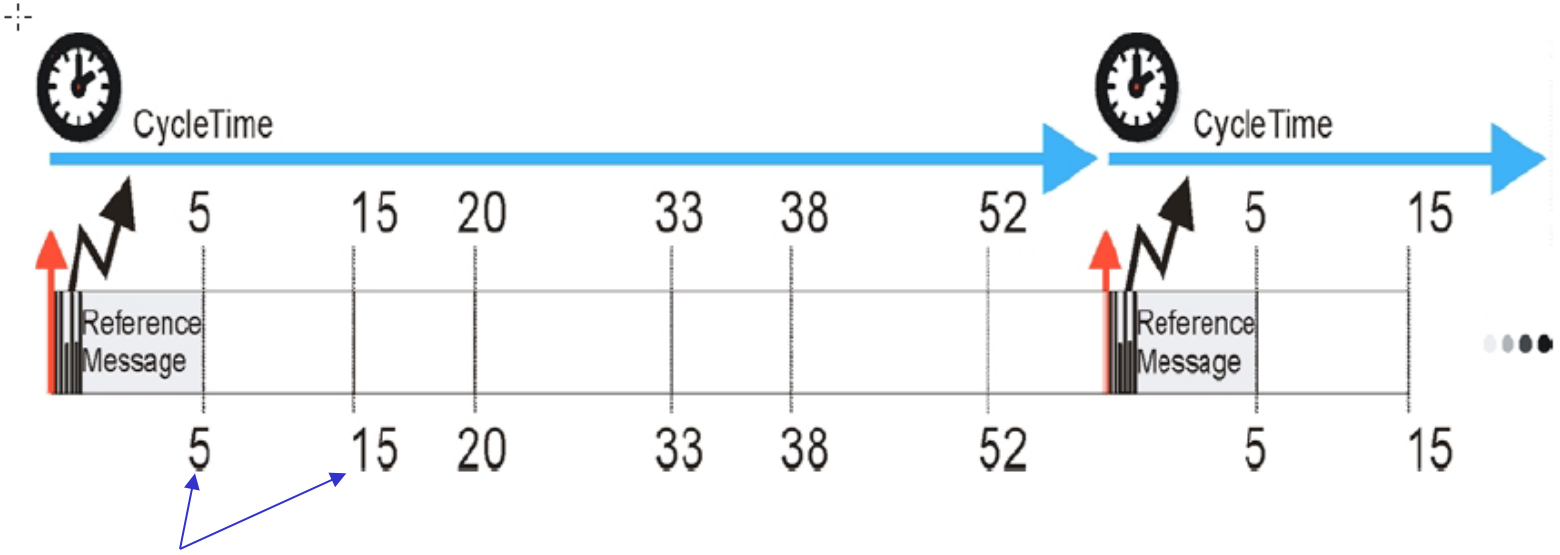
Merged Arbitrating Windows



A spontaneous message is not allowed if it will not fit in the remaining time window

TTCAN Cycle Time and Time Marks

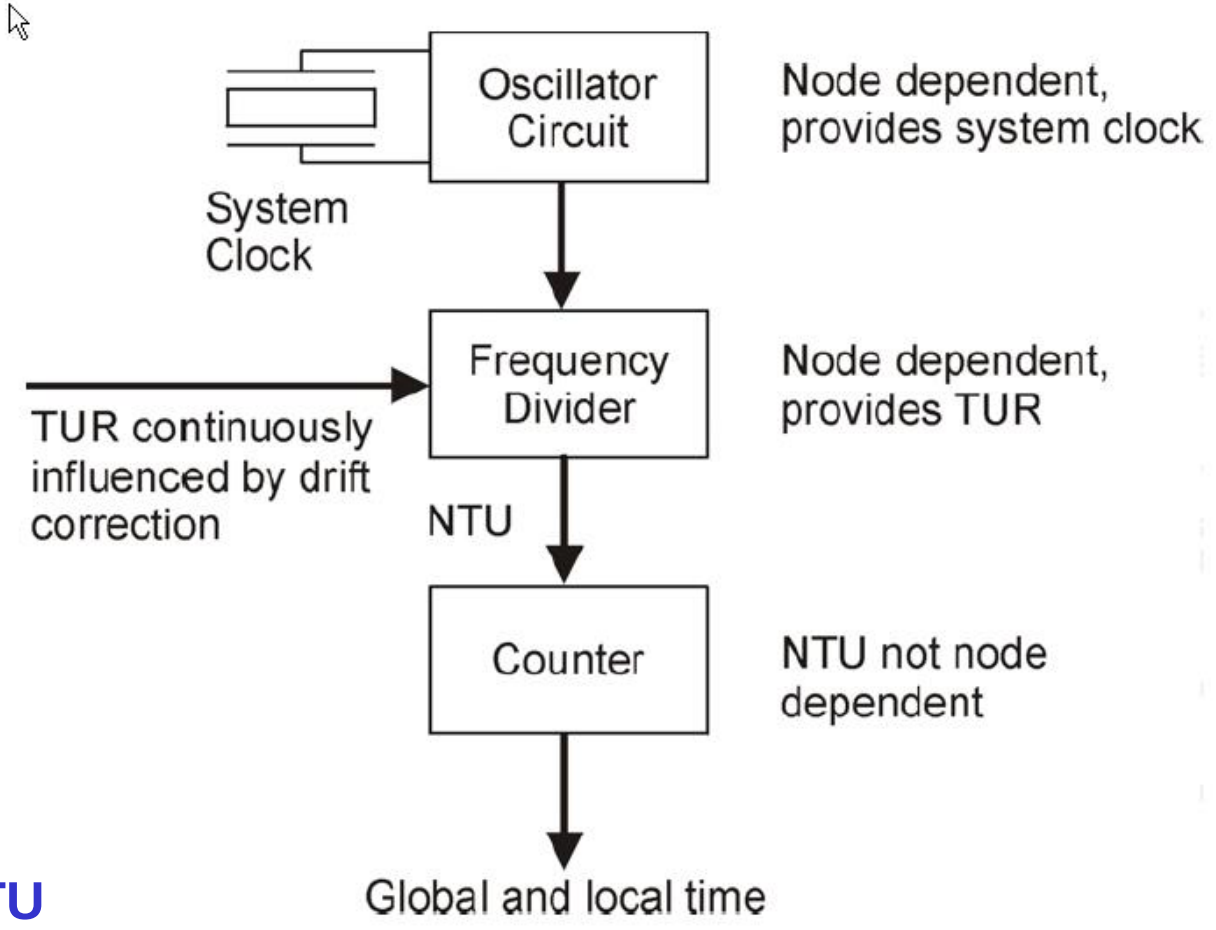
Restart of cycle Time



Time marks specify the beginning of the exclusive and arbitrating windows

Generation of Network Time Unit (NTU)

The granularity of any timing information in TTCAN is the Network Time Unit (NTU)



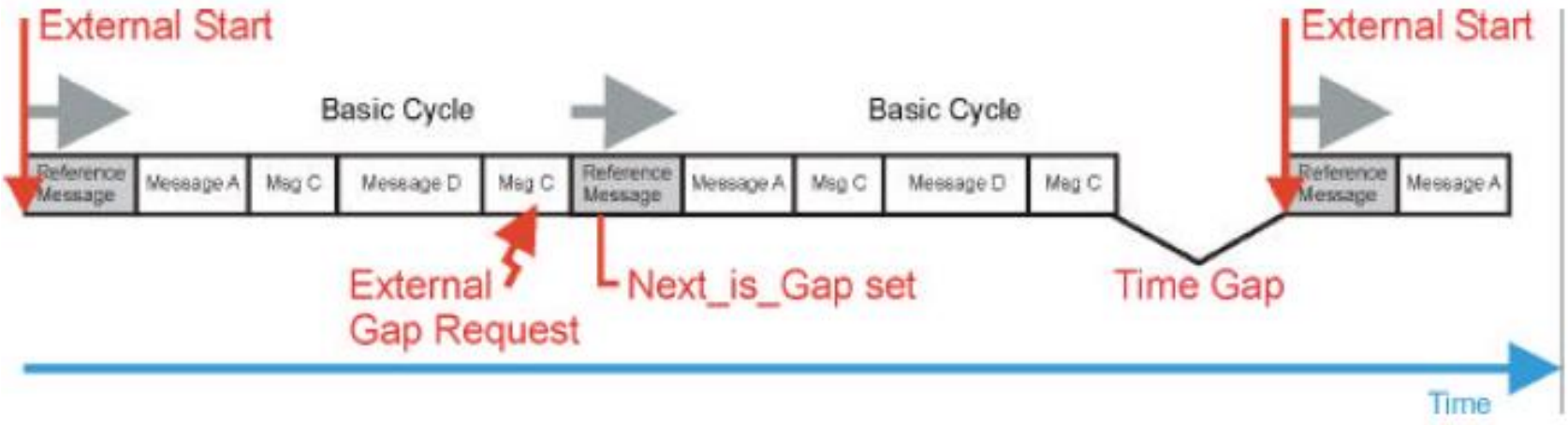
TUR= (Time Unit Ratio)

Level 2 NTU

Fault-tolerance of the Time Master

- Each potential time master has its own identifier
- **After reset:** a Time Master checks if there is traffic on the bus and no reference message send
  - if not: it sends its reference message and local time
  - if a higher priority reference message is received it stops and synchronize
- **During operation:** a missing reference message is detected by all potential time masters and another time master takes over

External Synchronization



If Next_is_Gap bit is set:

it signals a Time Gap of a undetermined length

An application specific external event initiates the transmission of the next reference message

Block Diagram of a TT-CAN Controller

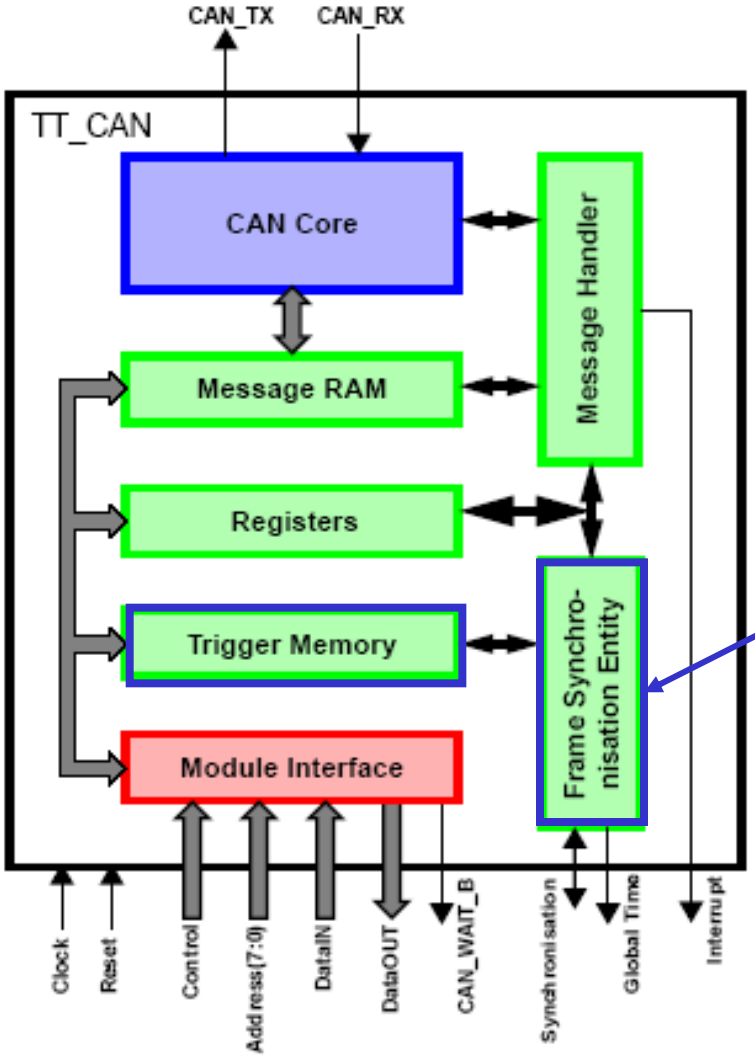


Figure 6: Block Diagram of the TT_CAN

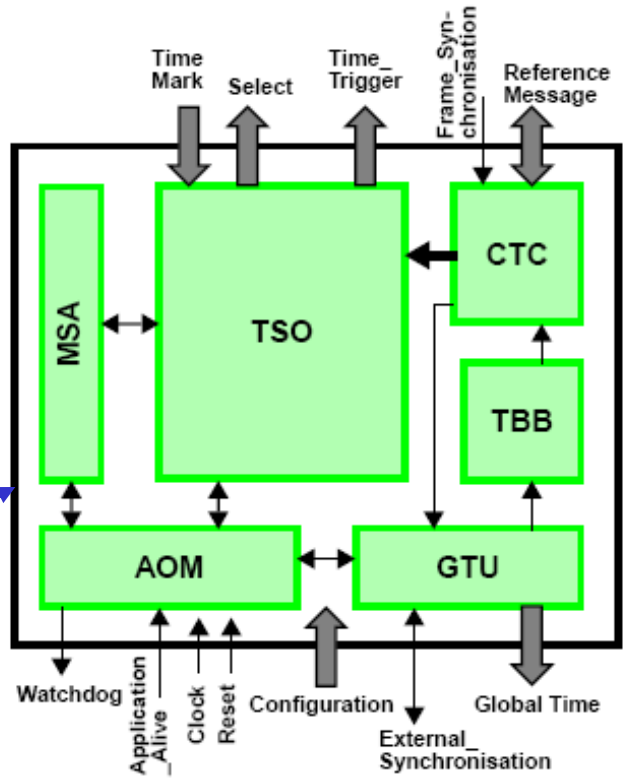


Figure 7: Frame Synchronisation Entity

The Frame Synchronisation Entity

is the state machine that controls the time triggered communication

Ref. www.can.bosch.com

Summary

- The communication in TTCAN is deterministic
  - More suitable to fulfill requirements of future applications
- TTCAN allows the use of CAN based monitoring and analyzing tools
- Engineers CAN knowledge only has to be updated with the TTCAN extensions
- TTCAN does not currently cover all requirements of safety related distributed systems
- Designed for the first generation of x-by-wire systems with mechanical/hydraulic backup

References

- **ISO 11898-4 Standard, first edition 1-08-2004:**
  - **Road vehicles – Controller area network (CAN) – Part 4: Time-triggered communication**
- **www.can.bosch.com**
  - **Bosch CAN information startpage**
- **www.ttcan.com**
  - **University of Limerick, Automotive System Research Group (ASRG)**
- **http://www.can-cia.de/index.php?id=521CiA**

(CAN in Automation) TT-CAN info