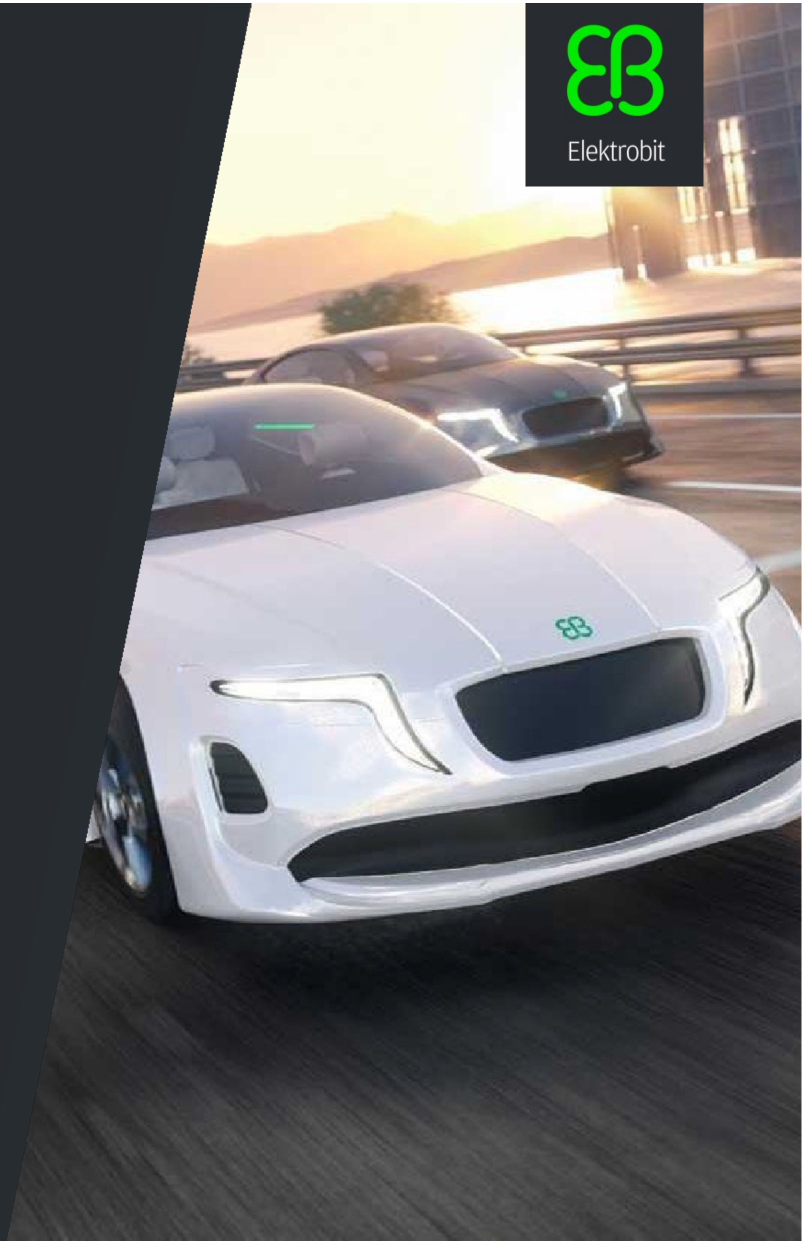
Time Validation for the AUTOSAR Classic Platform

Todd Stachowiak

October 17, 2024



© Elektrobit 2024 | Confidential information

Agenda

01 Introduction of Time Validation Concept

02 Use Cases and Limitations

03 Mechanisms to Achieve Time Validation

04 Next Steps

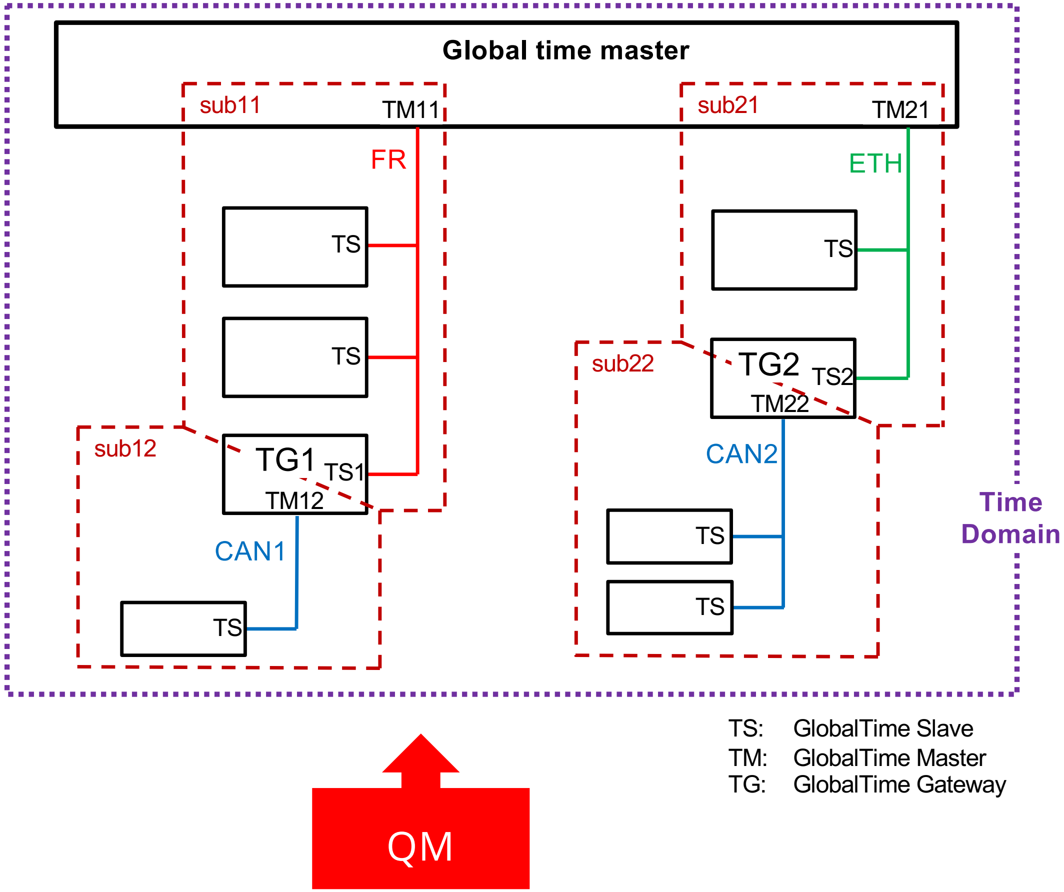
© Elektrobit 2024 | Confidential information

Introduction and Motivation

Global Time Synchronization

- Application of GTS is in safety-critical, time-critical and security-critical applications
- Use cases of Global Time Synchronization (GTS)
  - Synchronization of runnable entities
    - Synchronous sensor data read across ECUs
    - Synchronous actuator triggering across ECUs
  - Provision of absolute or relative time
    - Temporal correlation (event data recordings, data storage)
    - Time expiry monitoring (certificate-based authentication)

ADAS (to synchronize the sensor data, actuator triggering)
Secure Diagnostics, V2G (digital certificate expiry monitoring)
Intrusion Detection System (timestamping in security events)
Diagnostics (timestamping in Error events)



Time Validation Concept

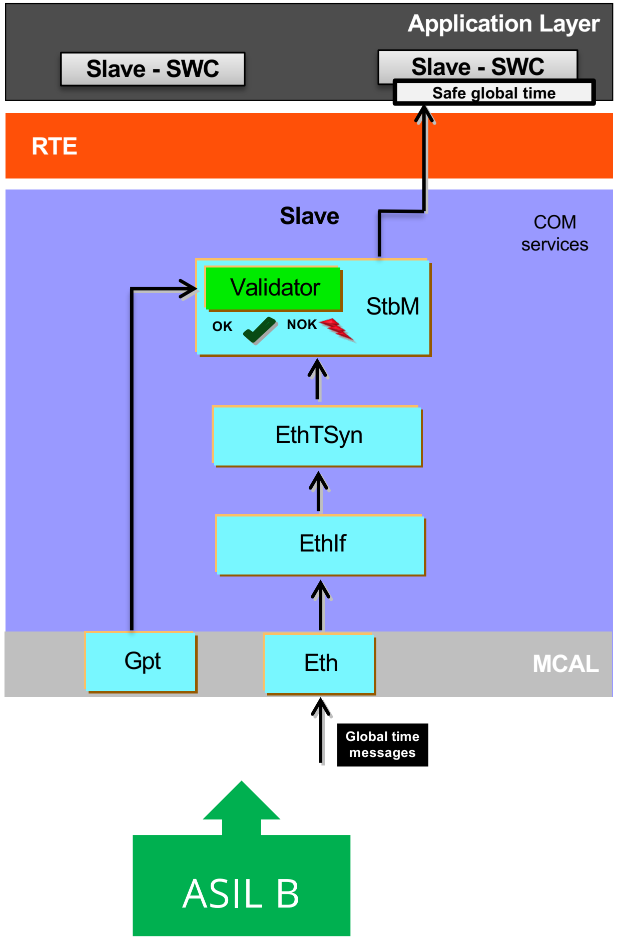
Use cases, Limitations, and Architecture

In Scope

- Monitoring the synchronized time progression.
- Provide reliable status information.
- Increase time availability.

Out of Scope

- Integrity levels above ASIL B.
- Some static failures (i.e Interrupts or scheduling issues) not supported.



Reference: [AUTOSAR_CP_SWS_SynchronizedTimeBaseManager.pdf]

Mechanisms to Achieve Time Validation

Solution Approach

Fallback Virtual Clock

Secondary virtual clock using a separate HW clock than the primary adding redundancy as well as ability to monitor virtual local time.

Rate Validation

Comprehensive validation mechanism that confirms the alignment of different clocks, promoting accurate timekeeping and synchronization across the system.

Includes checks for Rate Jitter and Rate Wander.

PDelay

Adding Propagation delay check to ensure it's within a defined threshold.

Fallback virtual local time

A secondary Virtual Local Time derived from a HW clock different than that one used for deriving the primary Virtual Local Time has been added. The Fallback Virtual Local Time can be used to monitor the primary Virtual Local Time and as local replacement of the primary Virtual Local Time, if that one is not available.

Can be derived from
- Gpt
- Os counter
- Eth free running counter

When fallback is used instead of primary → FALLBACK_TIME_EXTRAPOLATION flag is set

Inconsistency between the two HW clocks > StbMMaxProgressionMismatchThreshold → TIME_PROGRESSION_INCONSISTENCY flag is set

Rate validation

- Rate Validation is to establish a robust framework for clock synchronization, particularly in scenarios involving multiple clocks.
- Clocks in a system can experience variations in their rates from effects like rate jitter, or rate wander. Jitter describes a short-term frequency variation while the term wander is typically used to describe rather long-term frequency variations or drift. These variations, if left unchecked, could lead to inaccurate timekeeping and synchronization issues.
- The objective is to create a comprehensive validation mechanism that confirms the alignment of different clocks, promoting accurate timekeeping and synchronization across the system. Upon receiving slave timing data from the Timesync module, StbM will perform rate validation if time validation support is on. Rate validation includes check for

*Rate Jitter

*Rate Wander

© Elektrobit 2024 | Confidential information

Rate Jitter

Rate Jitter refers to the variation or fluctuation in the rate at which a clock's time drifts or deviates from the ideal time reference over time.

$$\Delta TG_{Validation\_1} = TG_{Rx(i)} - TG_{Rx(i-1)}$$

$$\Delta TV_{Validation\_1} = TV_{Rx(i)} - TV_{Rx(i-1)}$$

$$\Delta TL_{Validation\_1} = TL_{Sync(i)} - TL_{Sync(i-1)}$$

TG – Global time

TV – Virtual local time

TLsync – Interpolated local time

$$\frac{TG_{Validation\_1}}{TL_{Validation\_1}} - 1$$

$$\frac{TV_{Validation\_1}}{TL_{Validation\_1}} - 1$$

Checked against StbMRateJitterThreshold → RATEJITTERWANDER_EXCEEDED flag is set

Rate Wander

The overall Rate Wander is given by aggregating several "Rate Jitter Samples Measurements". However, for validation purposes it is sufficient to consider only the instantaneous variation by evaluating the current value of the Rate Jitter in between two consecutive synchronizations and the current value of the rate wander, i.e., the frequency variation measured via an interval of N re-synchronizations. StbM shall check both the progression of its Local Instance of the Global Time and the Global Time Master's time with its Virtual Local Time to calculate rate wander.

$$\Delta TG_{Validation\_N} = TG_{Rx(i)} - TG_{Rx(i-N)}$$

$$\Delta TV_{Validation\_N} = TV_{Rx(i)} - TV_{Rx(i-N)}$$

$$\Delta TL_{Validation\_N} = TL_{Sync(i)} - TL_{Sync(i-N)}$$

TG – Global time

TV – Virtual local time

TLsync – Interpolated local time

$$\frac{\Delta TG_{Validation\_N}}{\Delta TL_{Validation\_N}} - 1$$

$$\frac{\Delta TV_{Validation\_N}}{\Delta TL_{Validation\_N}} - 1$$

Checked against StbMRateWanderThreshold → RATEJITTERWANDER_EXCEEDED flag is set

Pdelay

Propagation delay measures time on wire between two ports. Since the Pdelay is also provided to the StbM by the lower layer (EthTSyn), it can now apply checks to see if the calculated Pdelay on the Eth network remains within a certain defined value.

Pdelay value from EthTSyn > StbMPdelayValidationThreshold → PDELAY_EXCEEDED flag is set

© Elektrobit 2024 | Confidential information

Next Steps

- Extend time validation to adaptive platform
- Applying to CAN and FlexRay protocols
- Achieving ASIL D for overall GTS mechanism by extending to time master & gateway

Contact us

Todd Stachowiak

Product Manager, Real Time Computing
Elektrobit – Driving the future of software

+1 248 819 3606
todd.stachowiak@elektrobit.com
elektrobit.com