



## Making gPTP Capable for Secure Time Synchronization

2018 IEEE Standards Association (IEEE-SA) Ethernet & IP @ Automotive Technology Day

## Making gPTP Capable for Secure Time Synchronization


### **gPTP is facing the same security threats like any other Ethernet protocol**


Attack scenarios, such as Man-in-the-Middle Attacks, Replay Attacks, Spoofing Attacks and Denial of Service Attacks, will also affect time synchronization acc. to gPTP, used in many automotive Ethernet applications.

Attacks, that might utilize an unprotected gPTP will be analyzed and the appropriate requirements are derived. An analyzing phase shows, which requirements are already fulfilled by the specification and how open security threats are solved.




# Contents

**Analysis** 



Analyze which specification item is vulnerable by which attack scenario


- ▶ Man In The Middle Attack
- ▶ Denial of Service (DoS) Attack
- ▶ Time Source Attack
- ▶ ...


**Coverage** 



Analyze which threats are covered by existing countermeasures


- ▶ Protocol Integrity checks
- ▶ CRC
- ▶ ...


**Open Threats** 



Identify relevant open threats

- ▶ Authentication of a Time Master [clock identity]
- ▶ Protection against Denial of Service (DoS)
- ▶ ...

**Countermeasures** 






Specify countermeasures to solve open threats

- ▶ Integrated Timesync protocol security check using Message Authentication Codes (MAC)
- ▶ Message gap check

## Approach

**Analysis**

**AUTOSAR SWS 676**

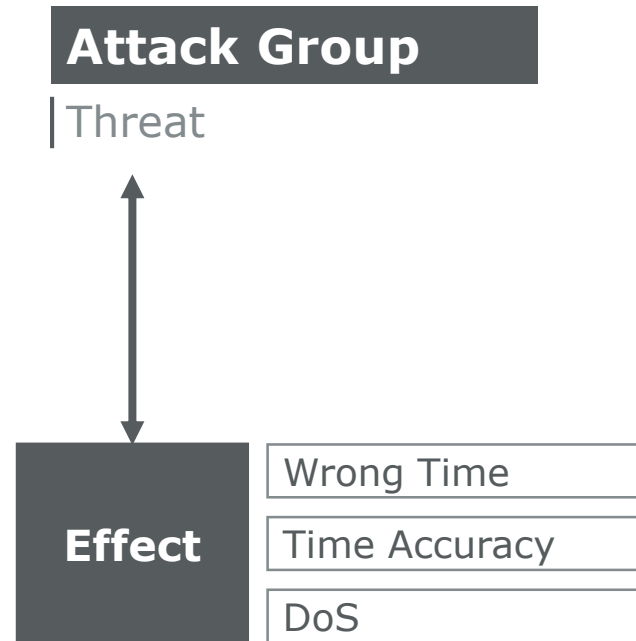
- ▶ “Time Synchronization over Ethernet”

**IEEE 802.1AS-2011**

- ▶ “Timing and Synchronization for Time-Sensitive Applications”

**IETF RFC 7384**

- ▶ “Time Protocol Security Requirements”



- ▶ Automotive time synchronization is realized acc. to AUTOSAR which references **gPTP** acc. to IEEE.
- ▶ This analysis focusses on AUTOSAR SWS 676 (**ETHTSYN**), because automotive extensions and limitations as well as protocol and software interfaces are specified in detail.
- ▶ RFC 7384 helps to group the threats and to categorize the effects.
- ▶ Each threat leads to at least one out of the given effects.
- ▶ Confidentiality is not a focus because the Time Base is a public source.

# ... of Timesync Specifications Against Time Protocol Security Requirements



Analyze which specification item is vulnerable by which attack scenario

- ▶ Man In The Middle Attack
- ▶ Denial of Service (DoS) Attack
- ▶ Time Source Attack
- ▶ ...

## Man in the Middle Attack

- | By intercepting and removing of valid Timesync messages
- | By manipulation of Timesync messages
- | By delaying legitimate Timesync messages

## Denial of Service Attack

- | By overloading the cryptographic components
- | On network at layer 2, e.g. message flooding
- | By overloading of Timesync messages

## Time Source Attack

- | Corruption of the external clock sources used by the Global Time Master, e.g. GPS fraud
- | Corruption of the internal global time reference clock

## Spoofing Attack

- | By Masquerading as a legitimate participant in the Timesync protocol

## Replay Attack

- | Of legitimate Timesync messages

## Master Selection Attack

- | Let nodes believe a time from the wrong Time Master

## Vulnerability Attack

- | By attacking exploits of Timesync protocol design and implementation vulnerabilities

## Network Backtracking

- | By using Timesync messages to identify addresses / latencies to figure out the topology

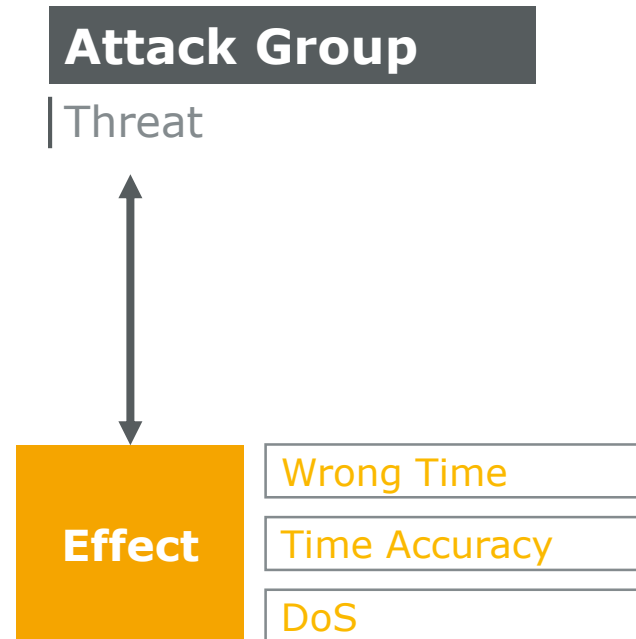
# Approach

**Coverage**




Analyze which threats are covered by existing countermeasures


- ▶ Protocol Integrity checks
- ▶ CRC
- ▶ ...



- ▶ Check, whether a threat is already covered or not.
- ▶ Uncovered threats are marked with an **X**.

## ... Regarding Already Supported Protection Against Vulnerability

**Coverage**




► Threat coverage by existing specification

### Man in the Middle Attack

- | **Protocol Integrity Checks**
- | **CRC**
- | **Timeout Detection**

### Denial of Service Attack

- X | By overloading the cryptographic components
- X | On network at layer 2, e.g. message flooding
- X | By overloading of Timesync messages

### Time Source Attack

- X | Corruption of the external clock sources used by the Global Time Master, e.g. GPS fraud
- X | Corruption of the internal global time reference clock

### Spoofing Attack

- X | By Masquerading as a legitimate participant in the Timesync protocol

### Replay Attack

- | **Time Leap Check**

### Master Selection Attack

- X | Let nodes believe a time from the wrong Time Master


### Vulnerability Attack


- X | By attacking exploits of Timesync protocol design and implementation vulnerabilities

### Network Backtracking

- X | By using Timesync messages to identify addresses / latencies to figure out the topology

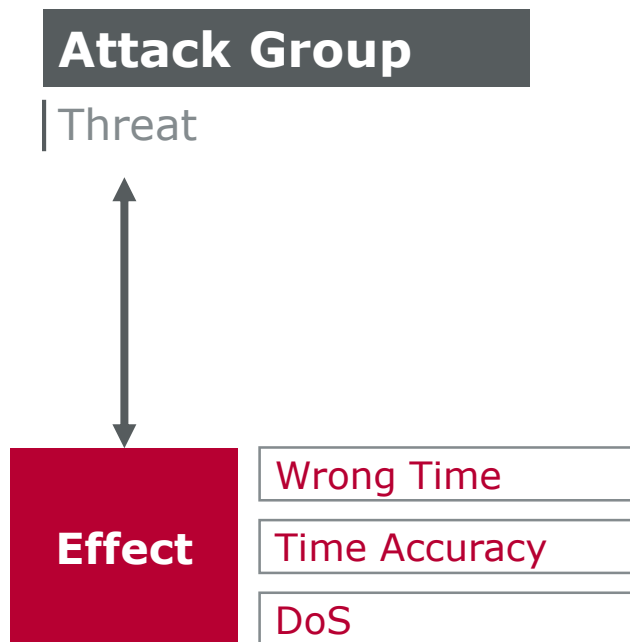
# Approach

**Open Threats** 



Identify relevant open threats

- ▶ Authentication of a Time Master [clock identity]
- ▶ Protection against Denial of Service (DoS)
- ▶ ...



- ▶ Certain threats cannot be solved on protocol-level
  - ▶ These threats are out of scope of this security concept.
  - ▶ Mark them with an **X**.
- ▶ Define focus items.



## ... With Given Focus Points

**Open Threats** 



► Define threats as focus items to prepare the countermeasure phase

### Man in the Middle Attack

Protocol Integrity Checks

CRC

Timeout Detection

### Denial of Service Attack

By overloading the cryptographic components

X On network at layer 2, e.g. message flooding

By overloading of Timesync messages

### Time Source Attack

X Corruption of the external clock sources used by the Global Time Master, e.g. GPS fraud

X Corruption of the internal global time reference clock

### Master Selection Attack

Let nodes believe a time from the wrong Time Master

### Spoofing Attack

By Masquerading as a legitimate participant in the Timesync protocol

### Vulnerability Attack

X By attacking exploits of Timesync protocol design and implementation vulnerabilities

### Replay Attack

Time Leap Check

### Network Backtracking

X By using Timesync messages to identify addresses / latencies to figure out the topology

# Approach



Specify countermeasures to solve open threats

- ▶ Integrated Timesync protocol security check using Message Authentication Codes (MAC)
- ▶ Message gap check

## Attack Group

| Threat



Countermeasures	
Authentication of a Time Master [clock identity]	<input type="checkbox"/>
Ensure integrity of Timesync messages	<input type="checkbox"/>
Prevention of Spoofing Attacks	<input type="checkbox"/>
Protection against Denial of Service (DoS)	<input type="checkbox"/>
Protection against Replay Attacks	<input type="checkbox"/>
State- and time-based refresh of cryptographic keys	<input type="checkbox"/>
Ensure high performance of Timesync protocol and SW	<input type="checkbox"/>
Protection against Timesync message delay and interception	<input type="checkbox"/>
Allow operation in a mixed secure and non-secure environment	<input type="checkbox"/>
Confidentiality of time synchronization message data	<input checked="" type="checkbox"/>



- ▶ At least one of the given countermeasures solves the threat.
- ▶ Reminder: Confidentiality is not a focus because the Time Base is a public source.

**OR**

1=OK  
0=NOK

## ... to Increase the Protection Against Vulnerability

**Countermeasures**



Specify countermeasures to solve open threats

- ▶ Integrated Timesync protocol security check using Message Authentication Codes (MAC)
- ▶ Message gap check

### Man in the Middle Attack

**Protocol Integrity Checks**

**CRG Authentication**

**Timeout Detection**

### Time Source Attack

- X | Corruption of the external clock sources used by the Global Time Master, e.g. GPS fraud
- X | Corruption of the internal global time reference clock

### Master Selection Attack

**Authentication**

### Denial of Service Attack

**Message Gap Check**

- X | On network at layer 2, e.g. message flooding

**Message Gap Check**

### Spoofing Attack

**Authentication**

### Vulnerability Attack

- X | By attacking exploits of Timesync protocol design and implementation vulnerabilities

### Replay Attack



**Time Leap Check**

### Network Backtracking

- X | By using Timesync messages to identify addresses / latencies to figure out the topology

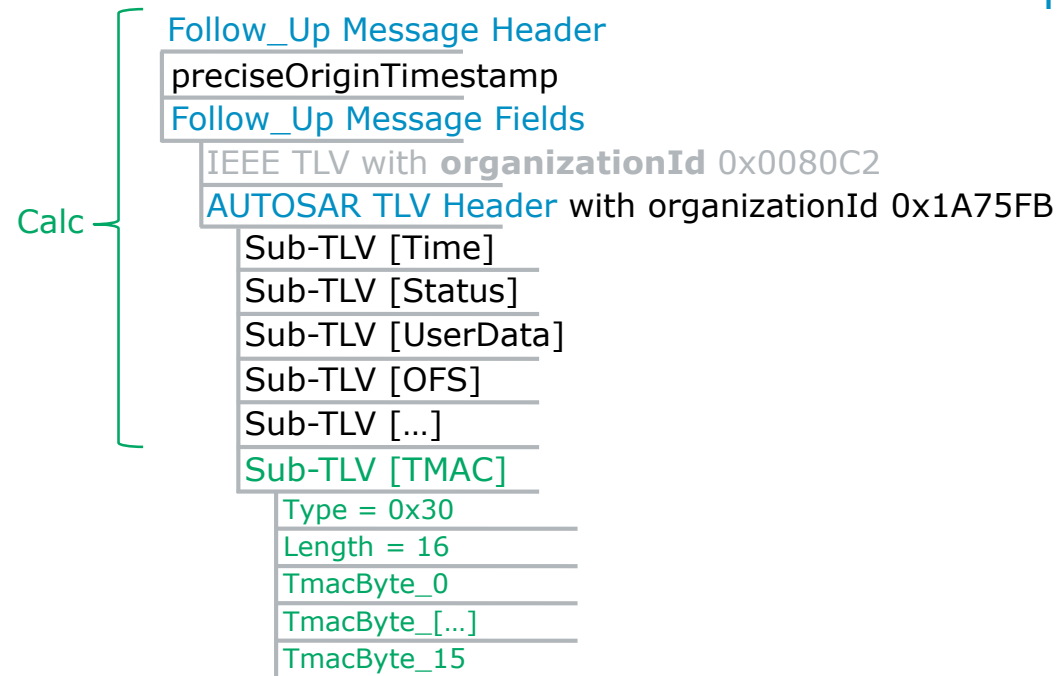
# Authentication

**Countermeasures**



Specify countermeasures to solve open threats

- ▶ **Integrated Timesync protocol security check using Message Authentication Codes (MAC)**
- ▶ Message gap check





- ▶ (T)\*MAC will be placed at the end of an AUTOSAR TLV\*\* which is a part of the Follow\_Up message.

\*truncated \*\*Type Length Value

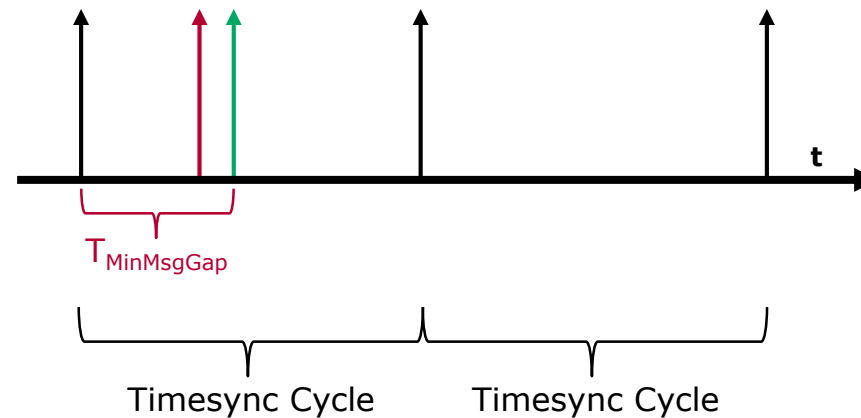
## ... Denial of Service Protection

**Countermeasures**



Specify countermeasures to solve open threats

- ▶ Integrated Timesync protocol security check using Message Authentication Codes (MAC)
- ▶ **Message gap check**



- Cyclic Timesync Message
- Asynchronous Timesync Message
- Unexpected Timesync Message

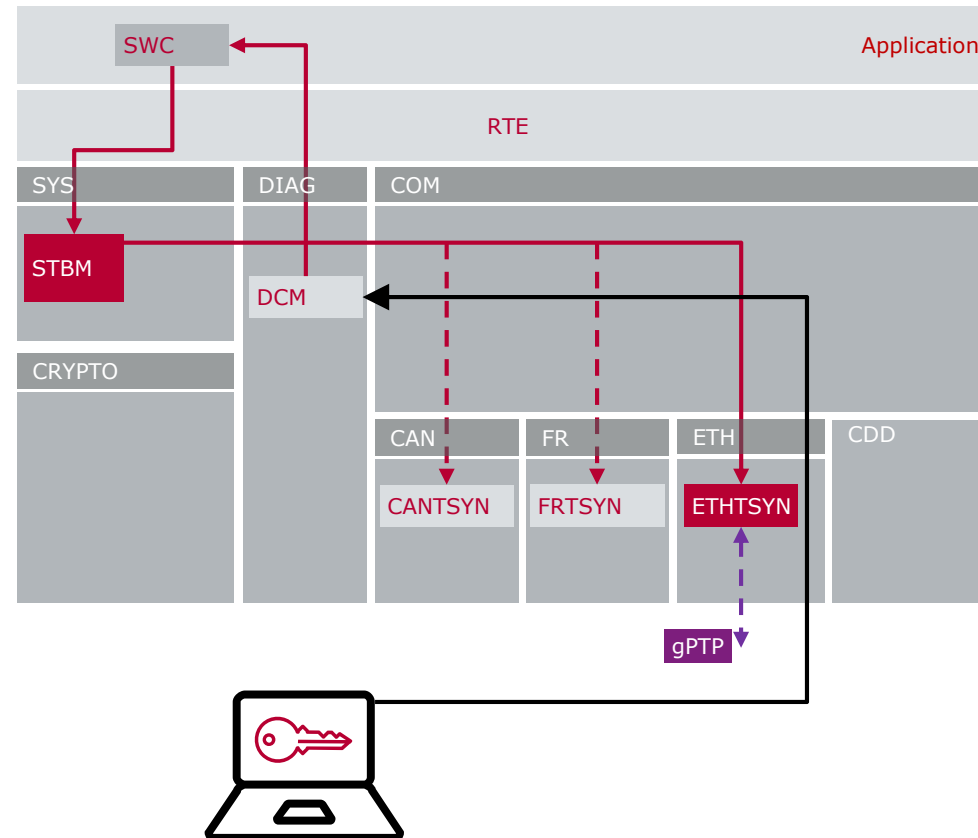
- ▶ Time Master and Time Slave are checking whether a gPTP message has been received earlier than a minimum allowed time span.
- ▶ If so, the message will be **dropped**.

# Implementation in Software on Example of AUTOSAR



Use Case:

1. Initial Secure Global Time

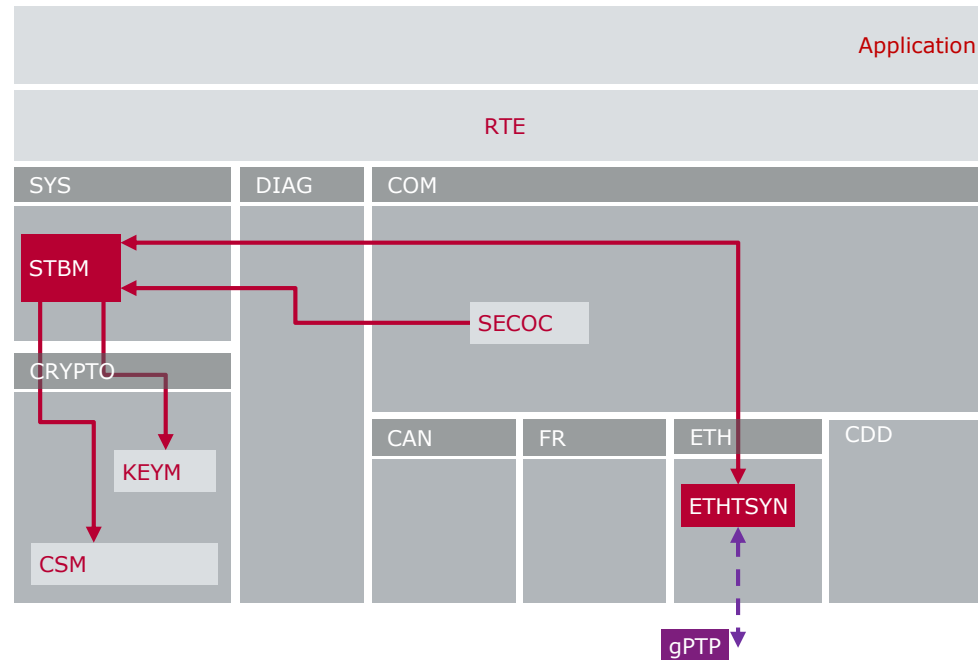


- ▶ The **DCM** triggers the modification of secured Time Bases by the diagnostic tester via **SWC**.
- ▶ The updated time will be distributed to the network.

# Implementation in Software on Example of AUTOSAR

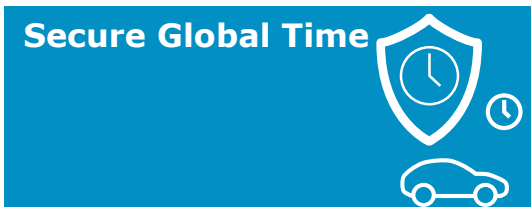


Use Case:  
**2. Authentic Global Time**



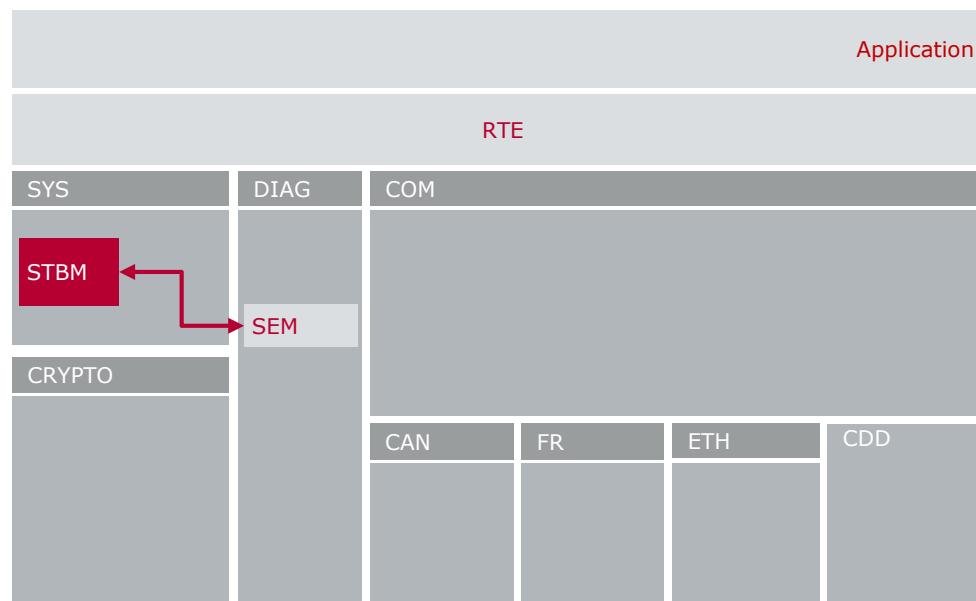
- ▶ **ETHTSYN** implements gPTP with TMAP support.
- ▶ The **STBM** calculates/verifies the TMAP by using the keys given by the **KEYM** and the methods provided by the **CSM**.
- ▶ The **SECOC** generates freshness values for secure on-board communication by using the synchronized monotonously increasing time value.

# Implementation in Software on Example of AUTOSAR



Use Case:

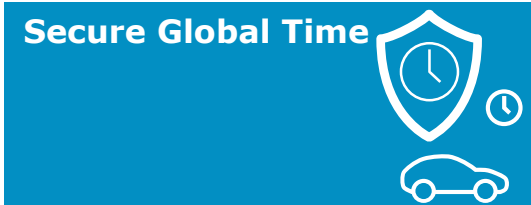
### 3. Secure Time Services



- ▶ The **STBM** logs TMAC calculation/verification events to the **SEM**.
- ▶ The **SEM** logs events along to a secure Time Base.

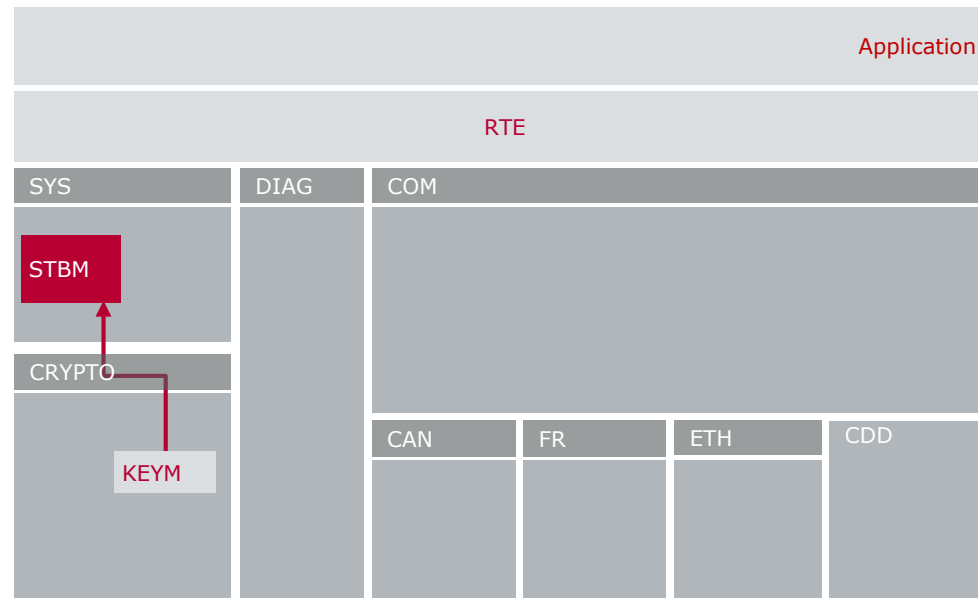


# Implementation in Software on Example of AUTOSAR



Use Case:

**4.** Global Certificate Expiration Time



- ▶ The **KEYM** verifies the certificate expiration time against the secure Time Base.

## Making gPTP Capable for Secure Time Synchronization

**gPTP is facing the same security threats like any other Ethernet protocol**

Some of those threats are already caught by the current specification.

Especially the usage of an authenticated Time Base increases robustness of the gPTP.

Nevertheless, making gPTP secure is an ongoing process.

A Layer 2 Firewall helps to increase the protection level.



Questions?

## Making gPTP Capable for Secure Time Synchronization



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