AUTOSAR Security Modules

Current Status

V1.00 | 2015-05-27

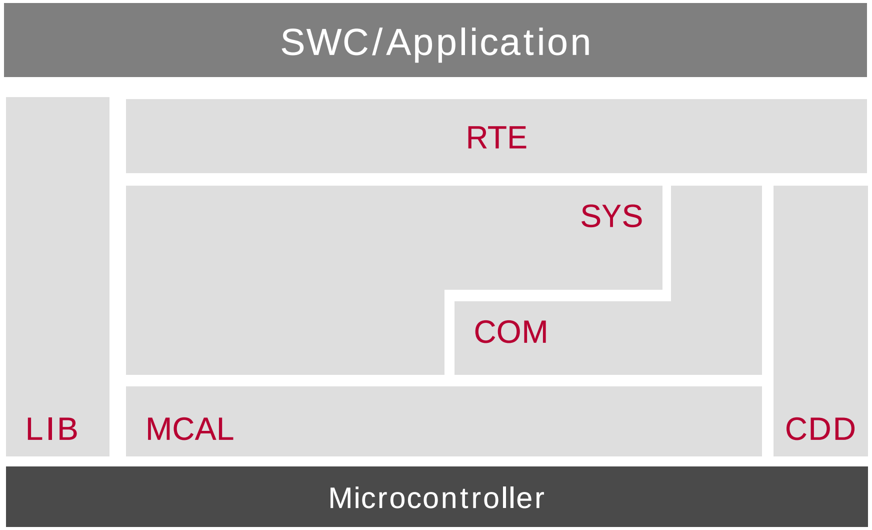
Agenda

1.	AUTOSAR
2.	CAL & CSM
3.	SecOC

Introduction

- **Aut**omotive **O**pen **S**ystem **Ar**chitecture
  - Software for electronic control units (**ECU**)

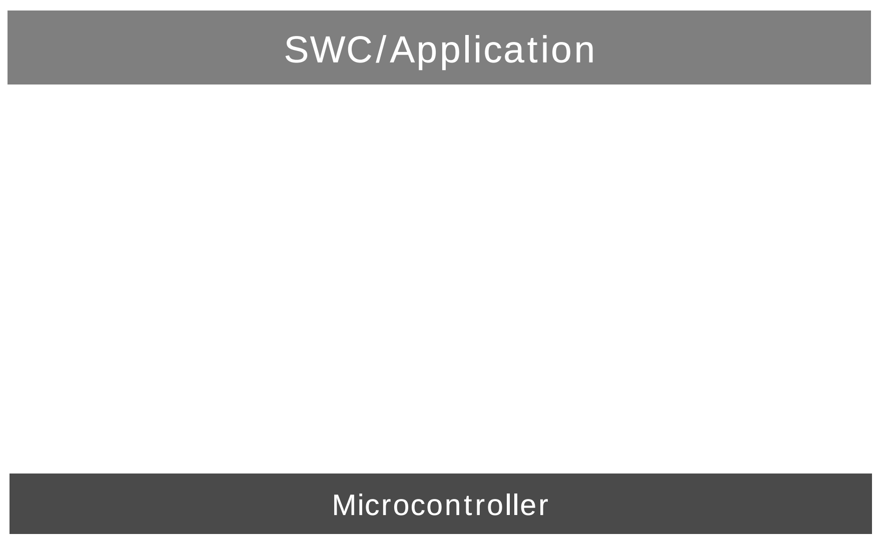
Software architecture



Introduction

Software component component (**SWC**) / Application

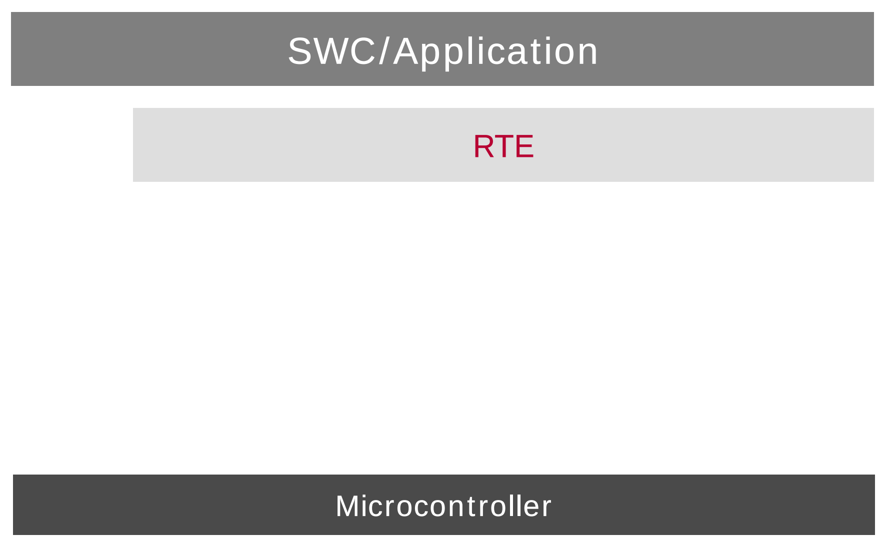
- Implementation of functionality of ECU
- Runs on microcontroller
- Sends & receives data to and from other ECUs (in network)



Introduction

Run time environment (**RTE**)

- Provides interface to basic software (**BSW**)



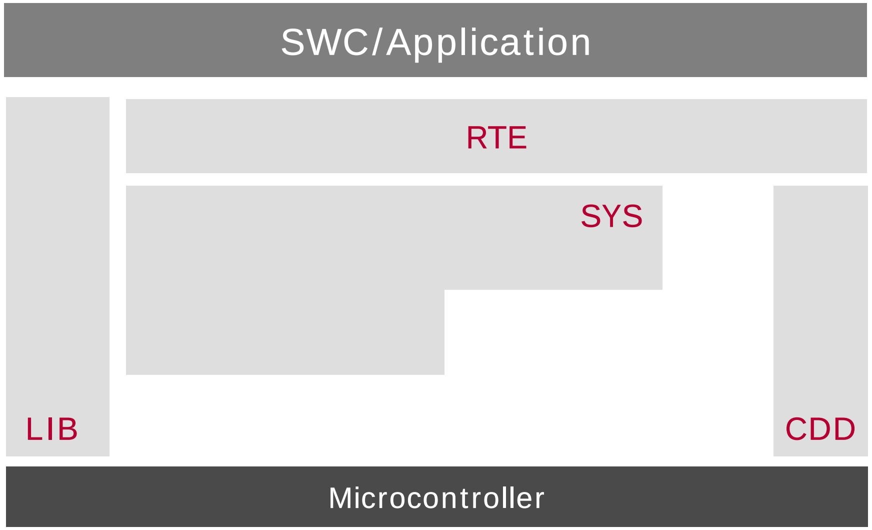
Introduction

System services (**SYS**) and libraries (**LIB**)

- Cryptographic modules

Operating system (**OS**)

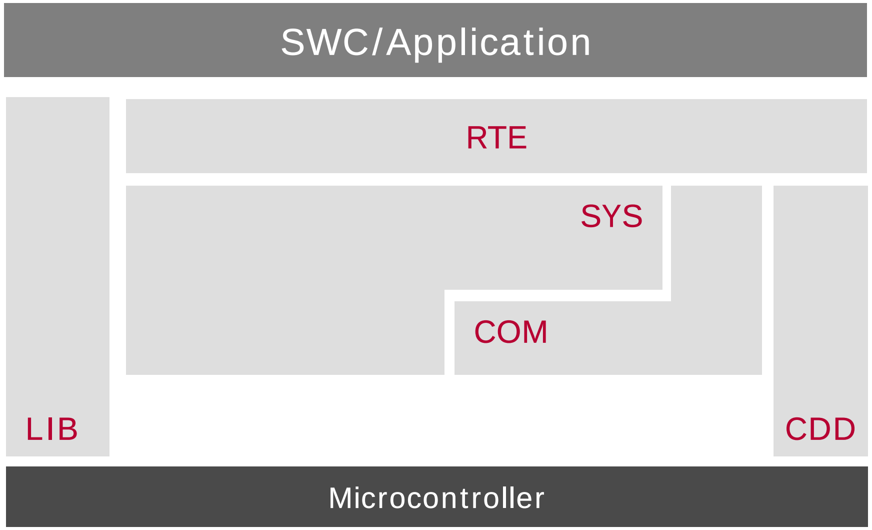
Complex device drivers (**CDD**)



Introduction

Communication modules (**COM**)

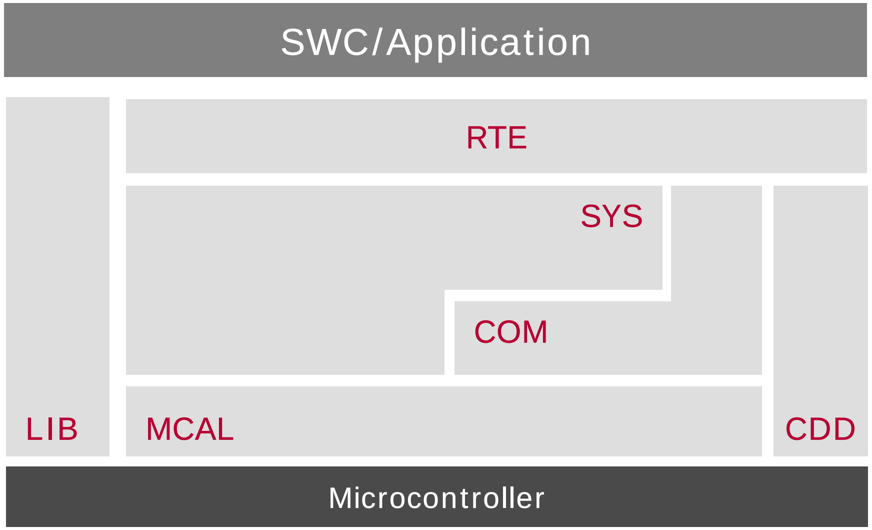
- send & receive data on automotive bus systems
  - Controller Area Network (CAN)
  - Local Interconnect Network (LIN)
  - FlexRay
  - Ethernet
  - ...



Introduction

Microcontroller abstraction layer (**MCAL**)

- BSW & SWC independent of microcontroller



Motivation for security modules in AUTOSAR

New security challenges

- Automotive software plays central role in car innovations
- Car connectivity will provide an essential part for value-added features

Car security – strict and secure access control to...

- ... the car and its parts (ECU)
- ... sensitive car data (odometer, motor characteristic)
- ... passenger's data (GPS)
- ... intellectual property of the OEM

AUTOSAR security modules

CAL & CSM

- Basic cryptographic primitives for BSW and application

SecOC

- Authenticated communication seamlessly integrated into the AUTOSAR communication stack

Agenda

1.	AUTOSAR
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3.	SecOC

Introduction

Crypto Abstraction Library – CAL

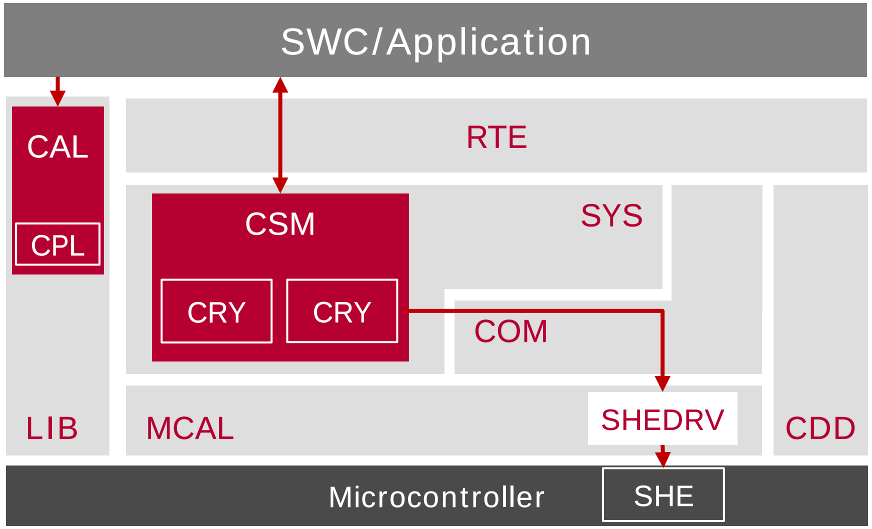
- BSW, CDD or SWC use CAL by inclusion
- Memory allocated by caller
  - Enables re-entrance

Crypto Primitive Library – CPL

- SW implementation of cryptographic primitives

Crypto Service Manager – CSM

- SWC use CSM through RTE
- BSW/CDD use CSM by inclusion
- Asynchronous operation possible
  - Callback indicates application



Crypto library module – CRY

- Implementation of cryptographic primitives
- Usage of SW or crypto HW possible

Supported Cryptographic Services

- Abstract definition of cryptographic services
- No definition for a concrete cryptographic algorithm

Basic Cryptography

- Hash
- Message authentication code (MAC)
  - Generation
  - Verification
- Random number generation
- Encryption/ Decryption
  - Symmetric
  - Asymmetric
- Signatures

Key Management

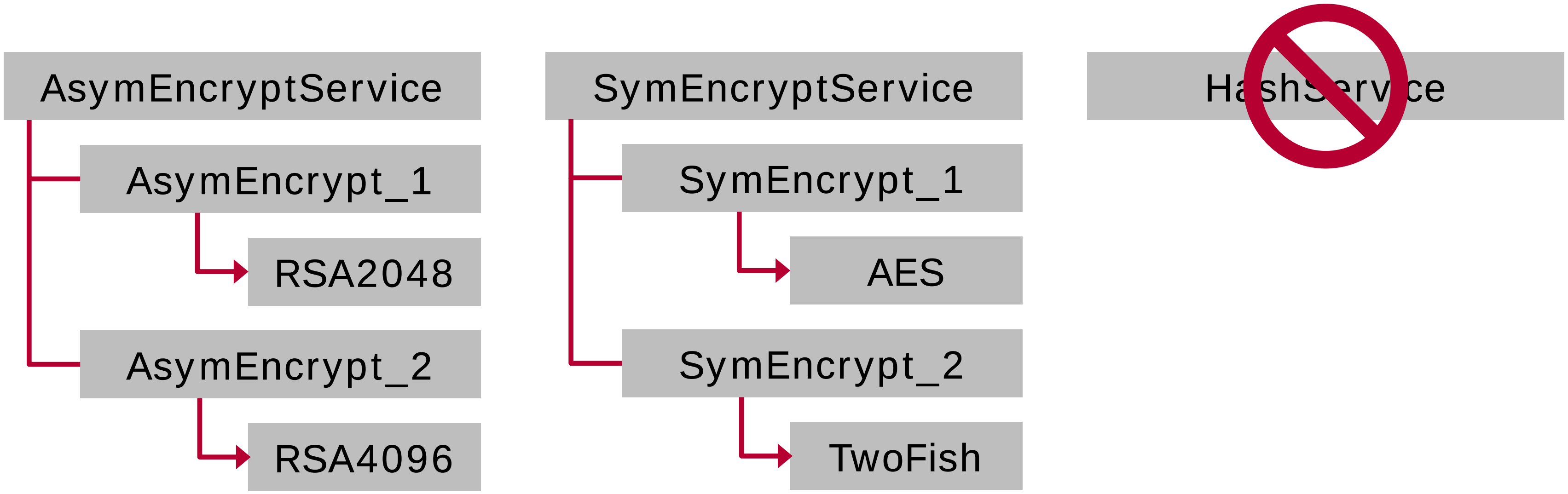
- Key derivation function (KDF)
- Key generation, update*, export, import
- Key exchange protocols

*Csm only

Miscellaneous

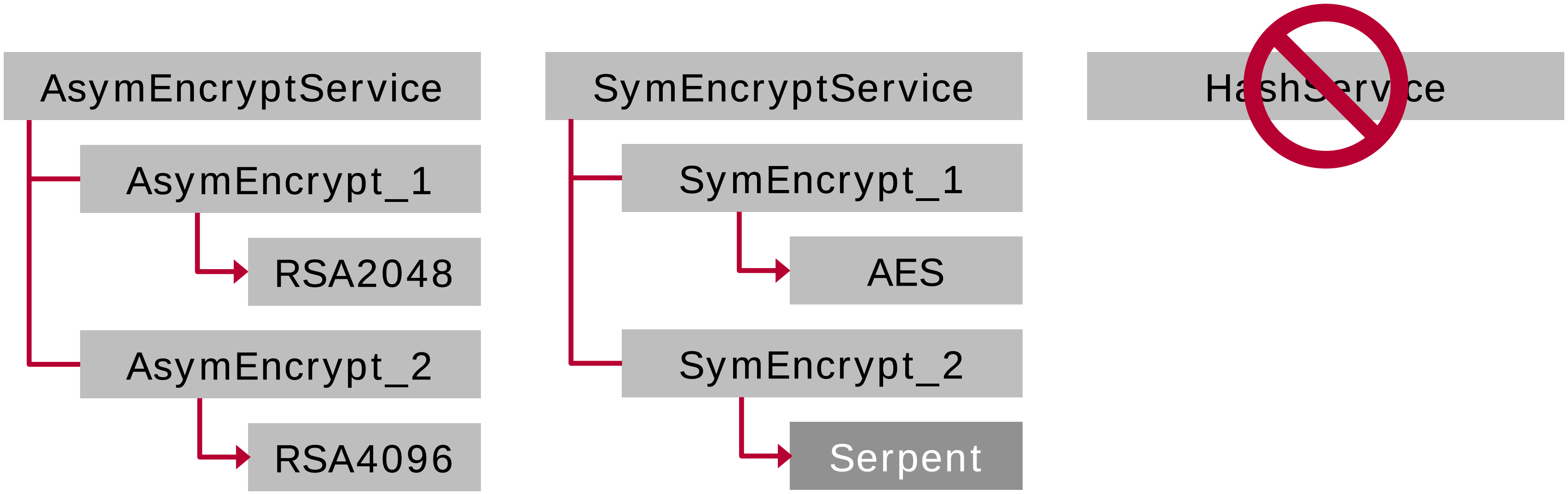
- Compression/ Decompression
- Checksum

Cryptographic Service Configuration



- Individual configuration of each required service
- Set of distinct configurations
- Specific implementation for each service configuration

Cryptographic Service Configuration



- Individual configuration of each required service
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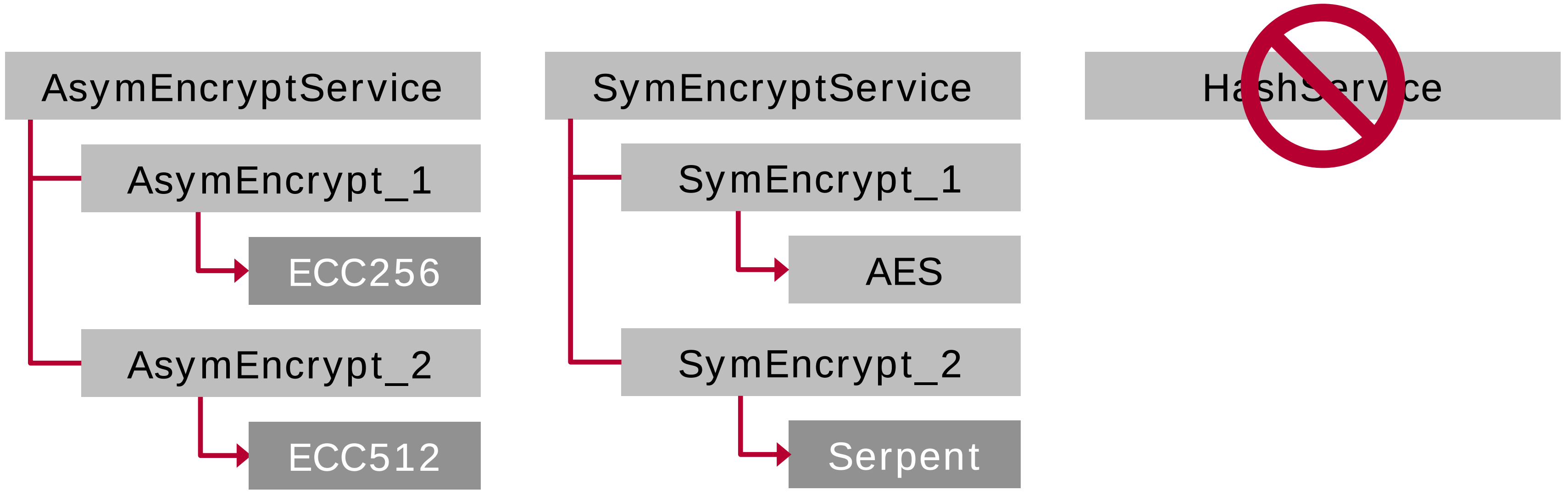
- Specific implementation for each service configuration
- Implementations may change in future

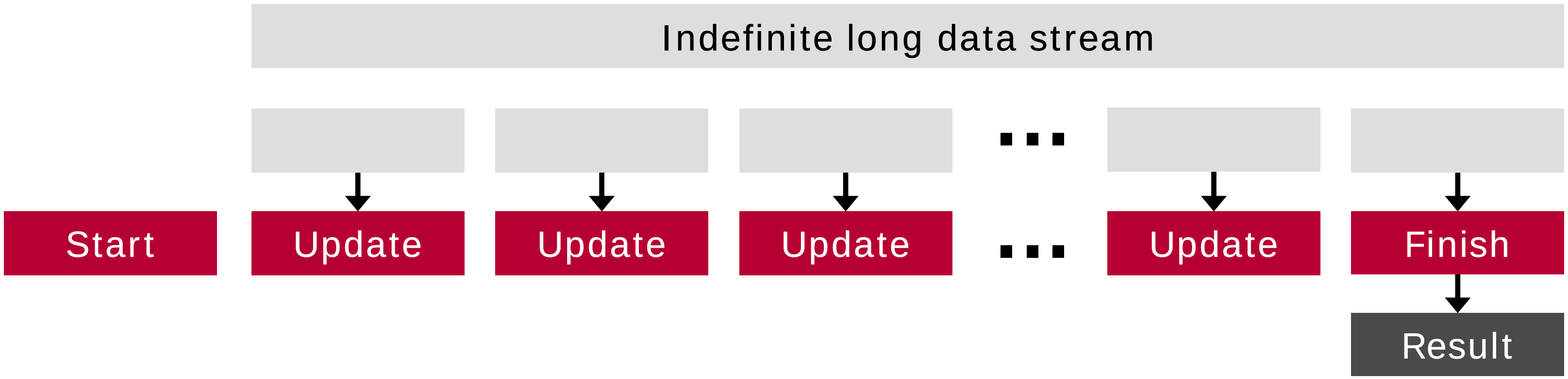
Cryptographic Service Configuration



- Individual configuration of each required service
- Set of distinct configurations
- Specific implementation for each service configuration
- Implementations may change in future
- API compatibility not ensured

General Usage

Streaming services

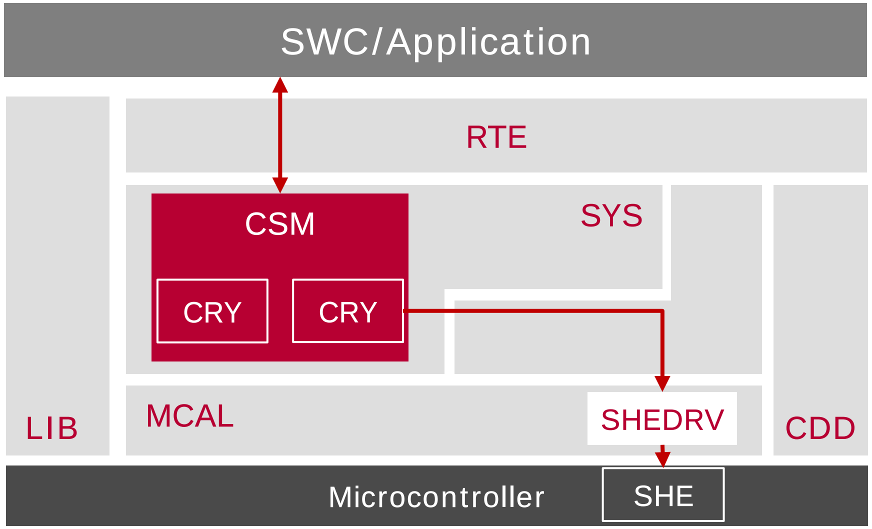


- Initialization with Start function (e.g. Csm_SymEncryptStart)
- Update function (e.g. Csm_SymEncryptUpdate)
- Finish function (e.g. Csm_SymEncryptFinish)

Non-streaming services

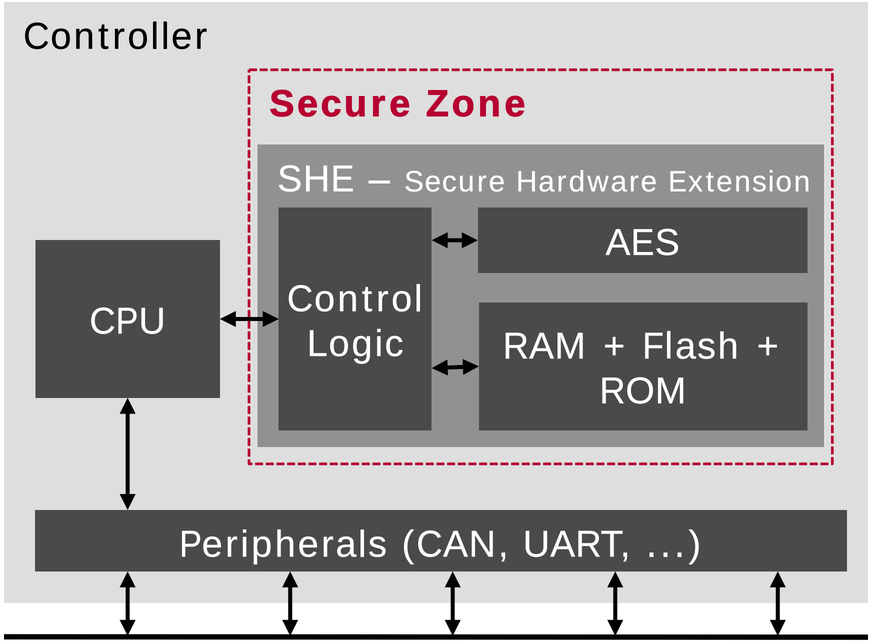
- Example: Csm_GenerateRandom

Hardware-based Security



- CSM services use cryptographic hardware **or** software implementation

Hardware-based Security

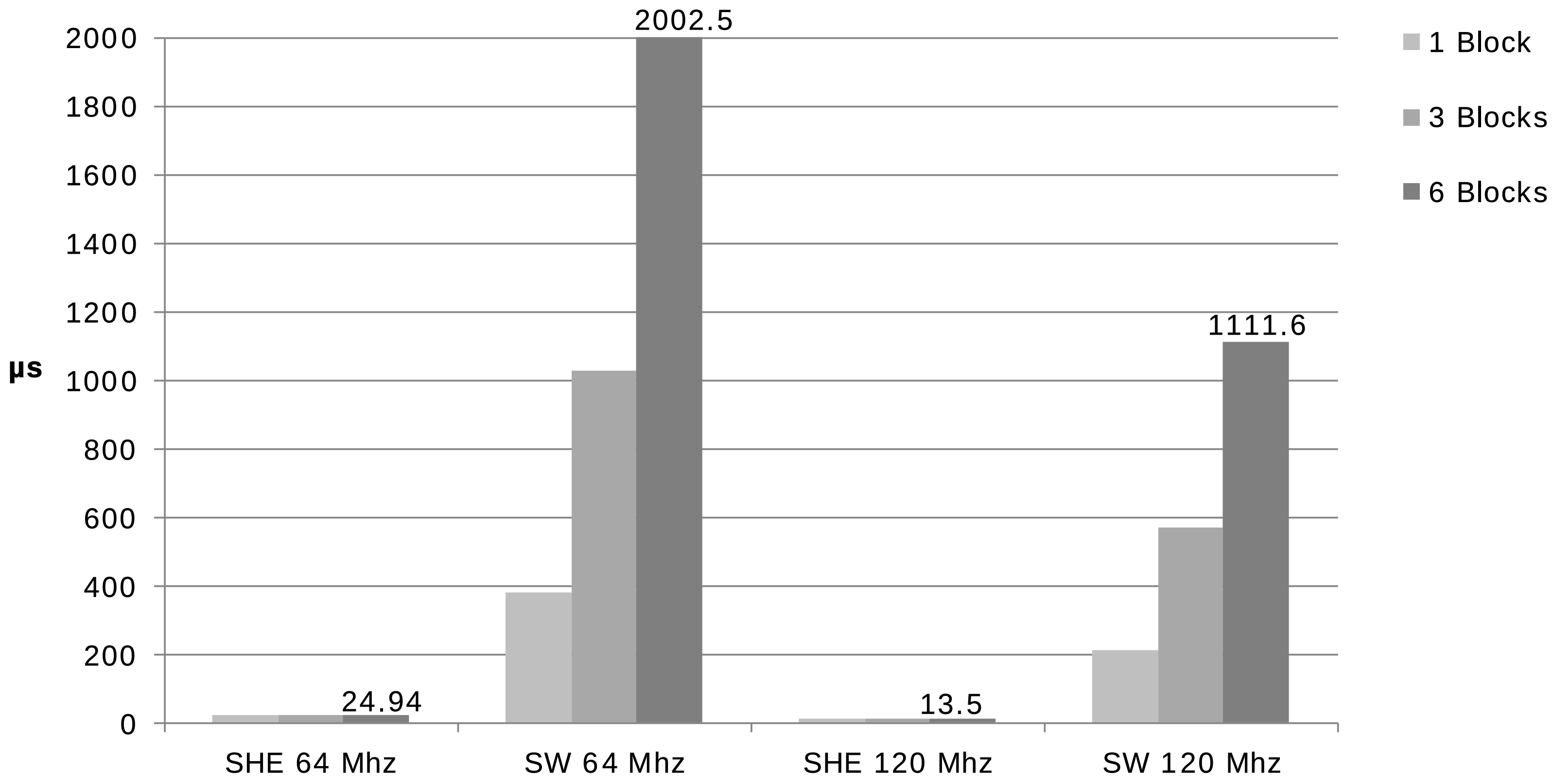


Secure Hardware Extension (**SHE**)

- On-chip extension to microcontroller
- Memory for secure storage of (cryptographic) data
- Hardware extension for cryptographic primitives
- Specified by Hersteller Initiative Software (HIS)

SHE - Performance

- AES ECB Encryption: SHE vs. Software library



Measured on a Freescale MPC5646C (w/ CSE), MICROSAR Stack with CSM and SHE driver with the Vector ‘AUTOSAR Measurement and Debugging (AMD) Runtime Measurement (Rtm)‘ Tool.

1 Block = 16 bytes

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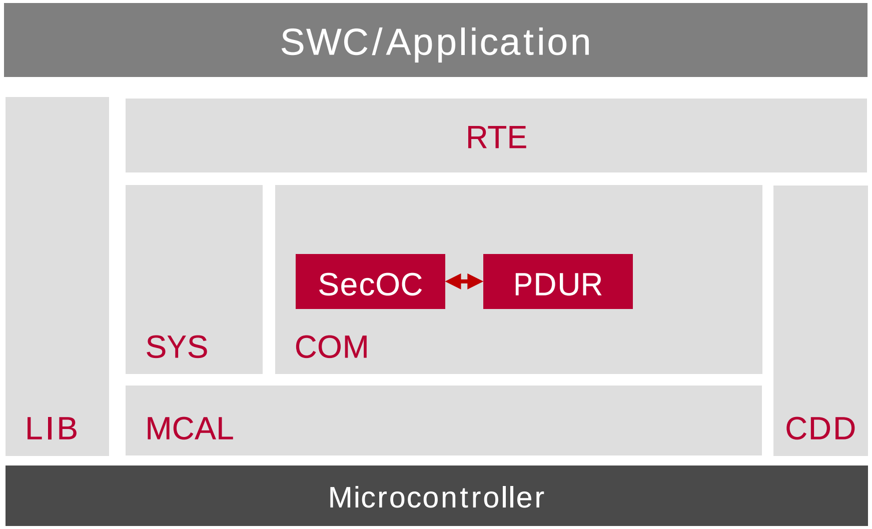
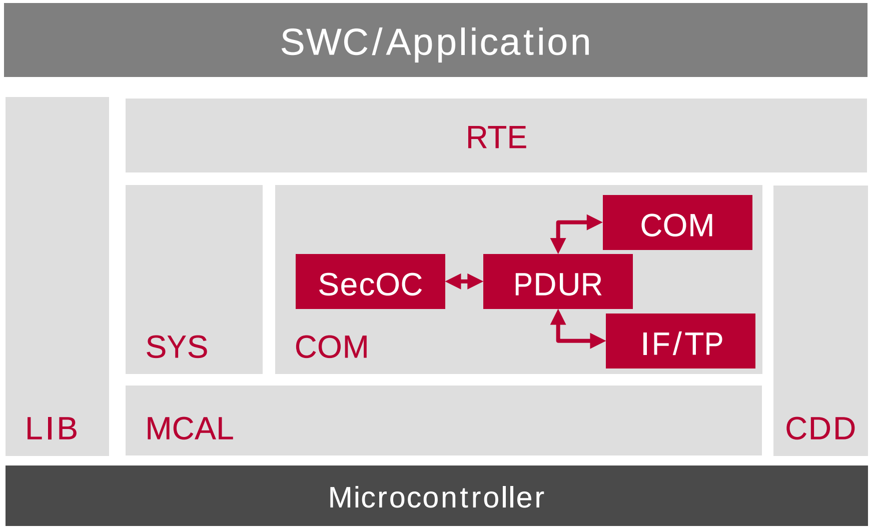
Introduction

- SecOC is parallel to PDUR
  - PDUR routes PDUs
  - PDU is a message on a bus



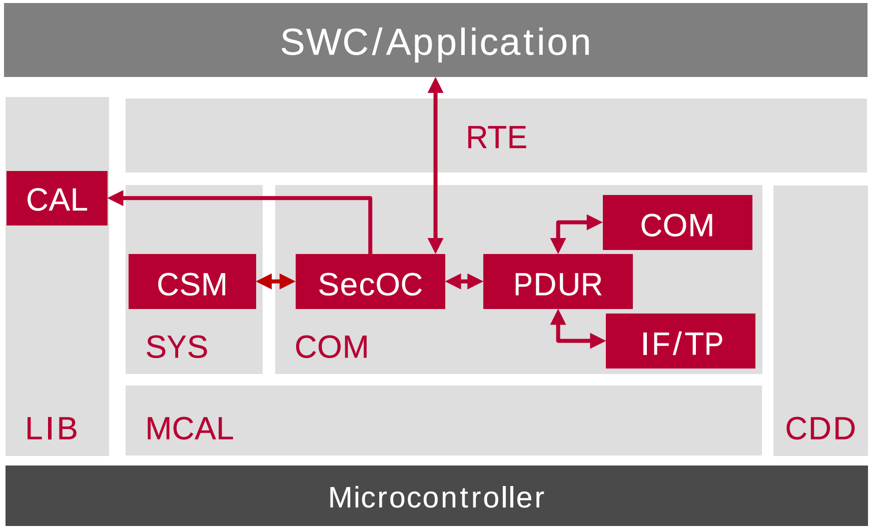
Introduction

- SecOC is parallel to PDUR
- PDUs are routed through SecOC
- PDU & authentication sent & received through IF or TP modules
  - COM module combines data into PDUs
  - IF modules send & receive atomic messages
  - TP modules manage messages longer than atomic messages

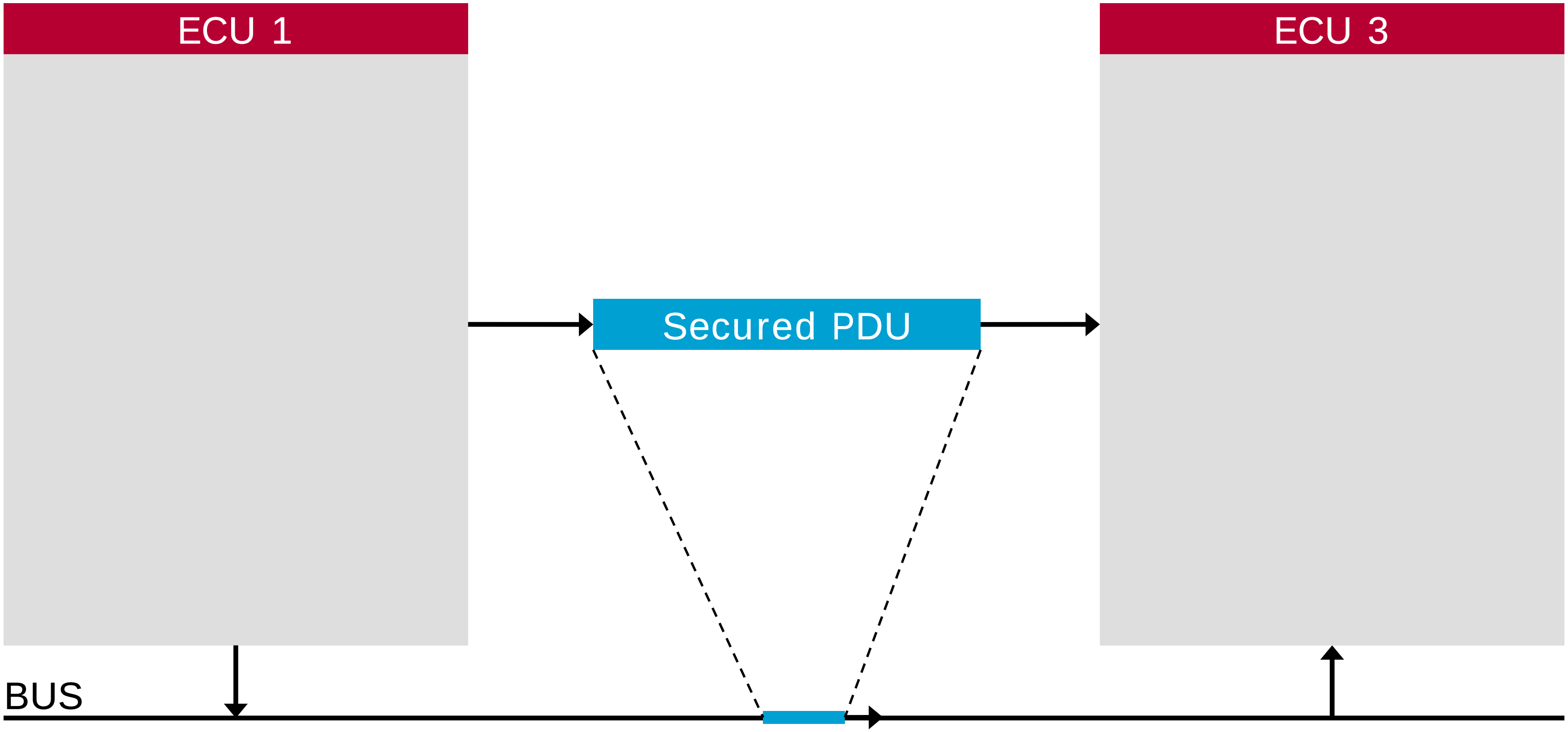


Introduction

- SecOC is parallel to PDUR
- PDUs are routed through SecOC
- PDU & authentication sent & received through IF or TP modules
- SecOC uses Cal or Csm
- RTE-interface
- Authentication: MAC or signature

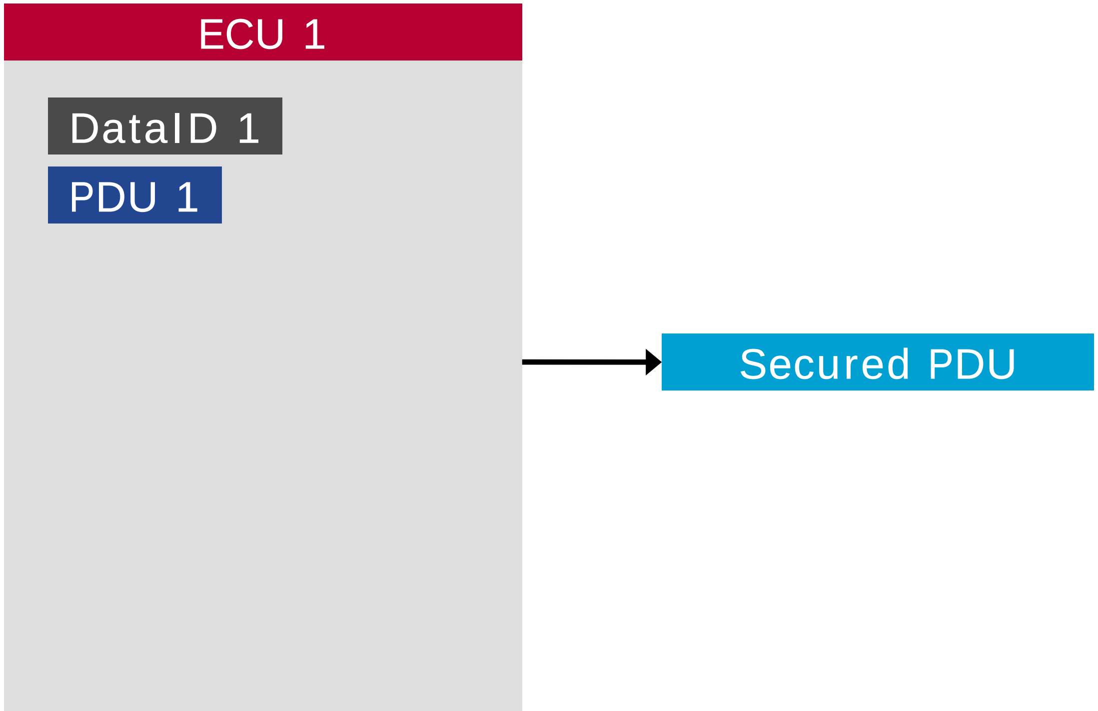


Functionality



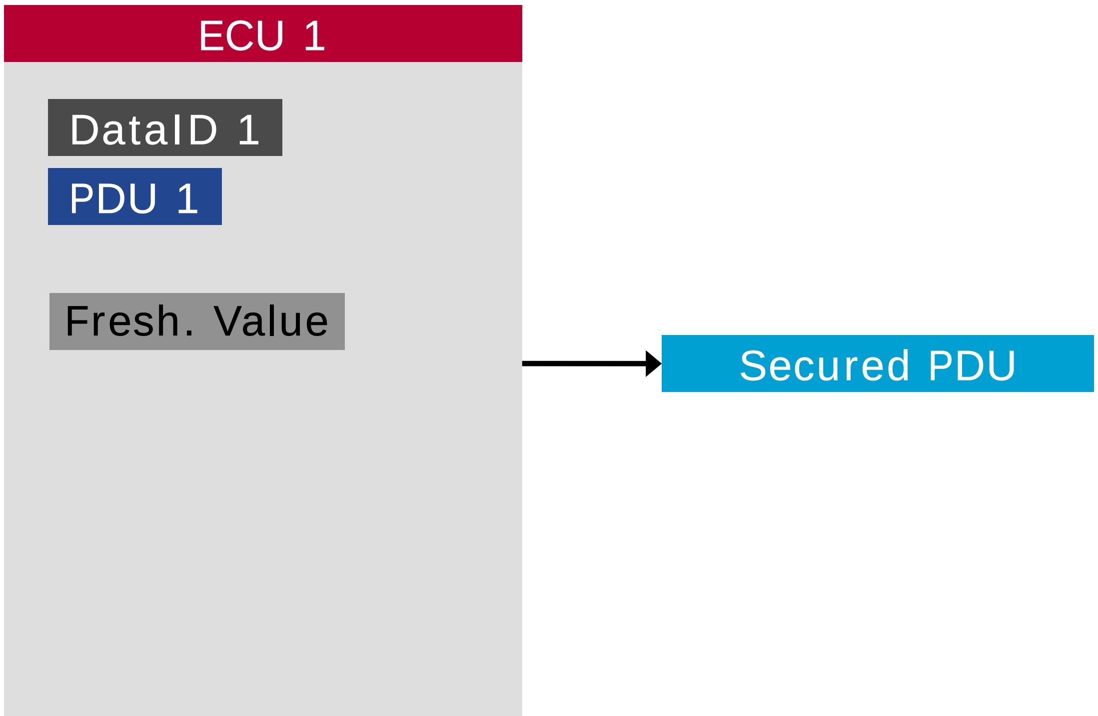
- SecOC sends & receives secured PDUs
- Secured PDUs are protected against
  - Manipulation
  - Random errors
  - Replays

Sending a secured PDU



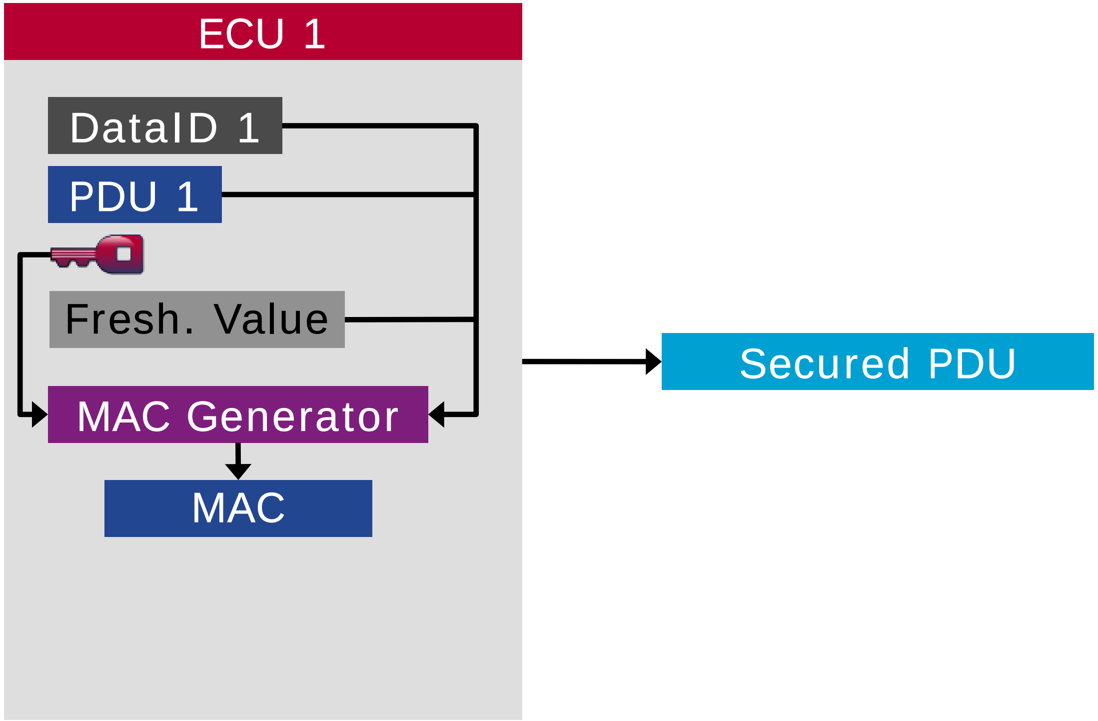
- DataID assigned to secured PDU
- Authentic PDU

Sending a secured PDU



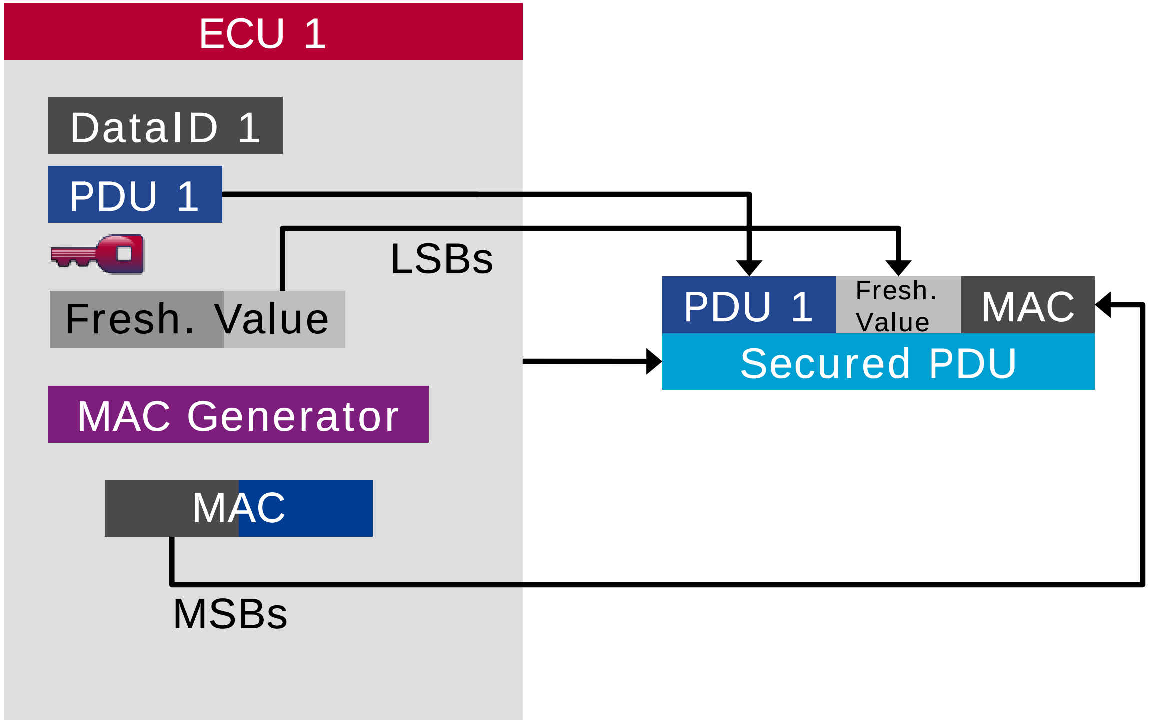
- Freshness value
  - Monotonic counter to prevent replay attacks
- Implementation
  - Timestamp
  - Counter

Sending a secured PDU



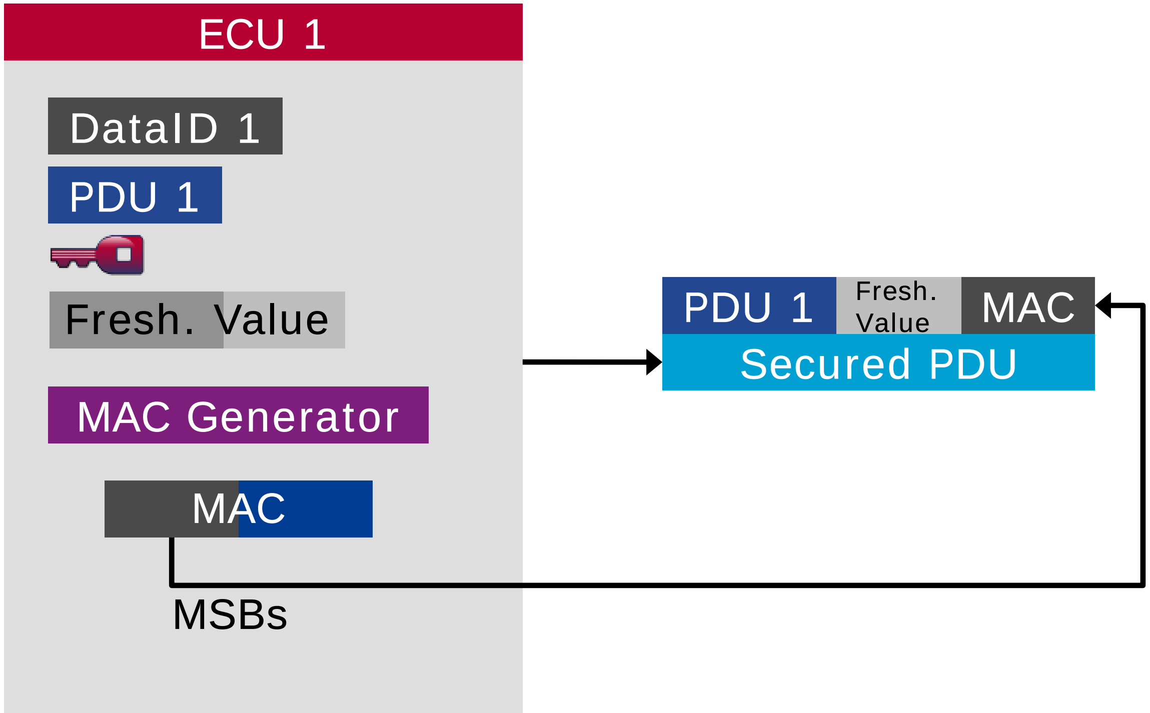
- DataID, PDU, freshness value form input to MAC generator
- Symmetric key required for MAC generation
- SecOC may use CMAC to benefit from SHE

Sending a secured PDU



- PDU, truncated freshness value, truncated MAC form secured PDU

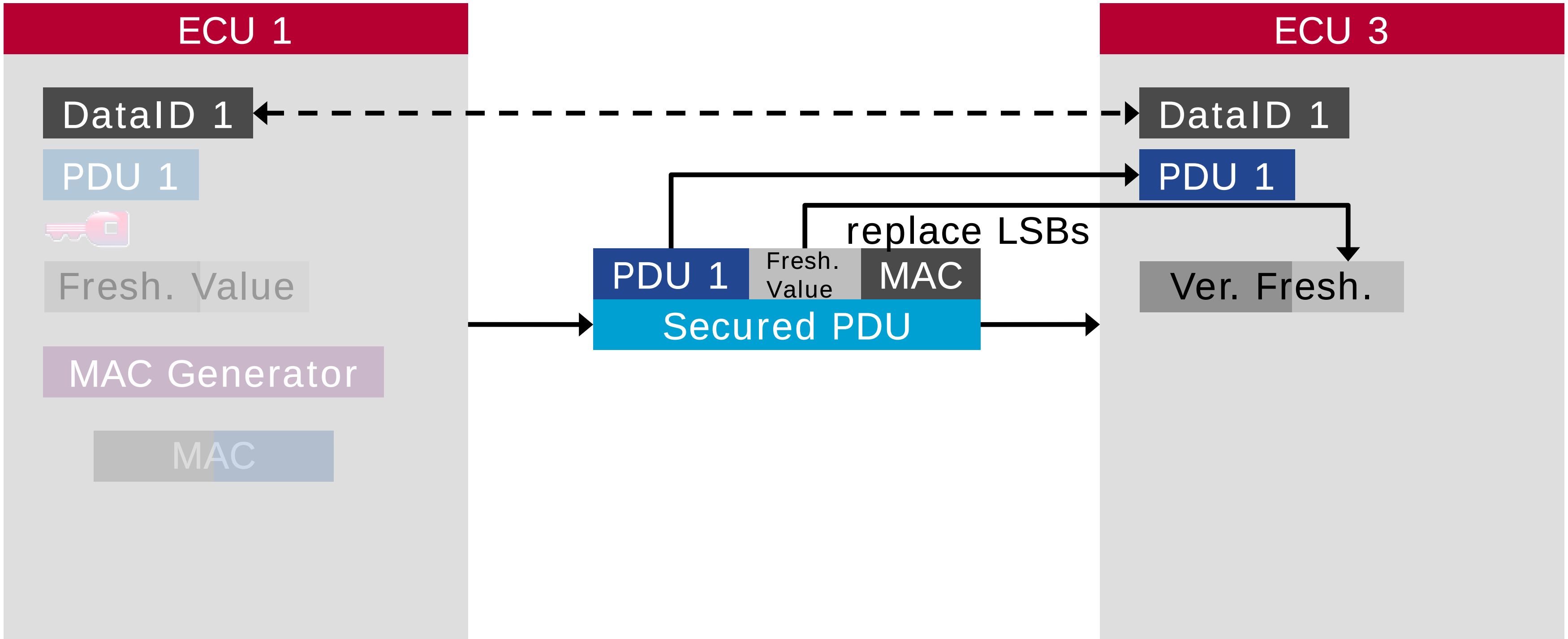
Sending a secured PDU



- NIST Special Publication 800-38B (CMAC)
  - Truncated MAC length ≥ 64 bits

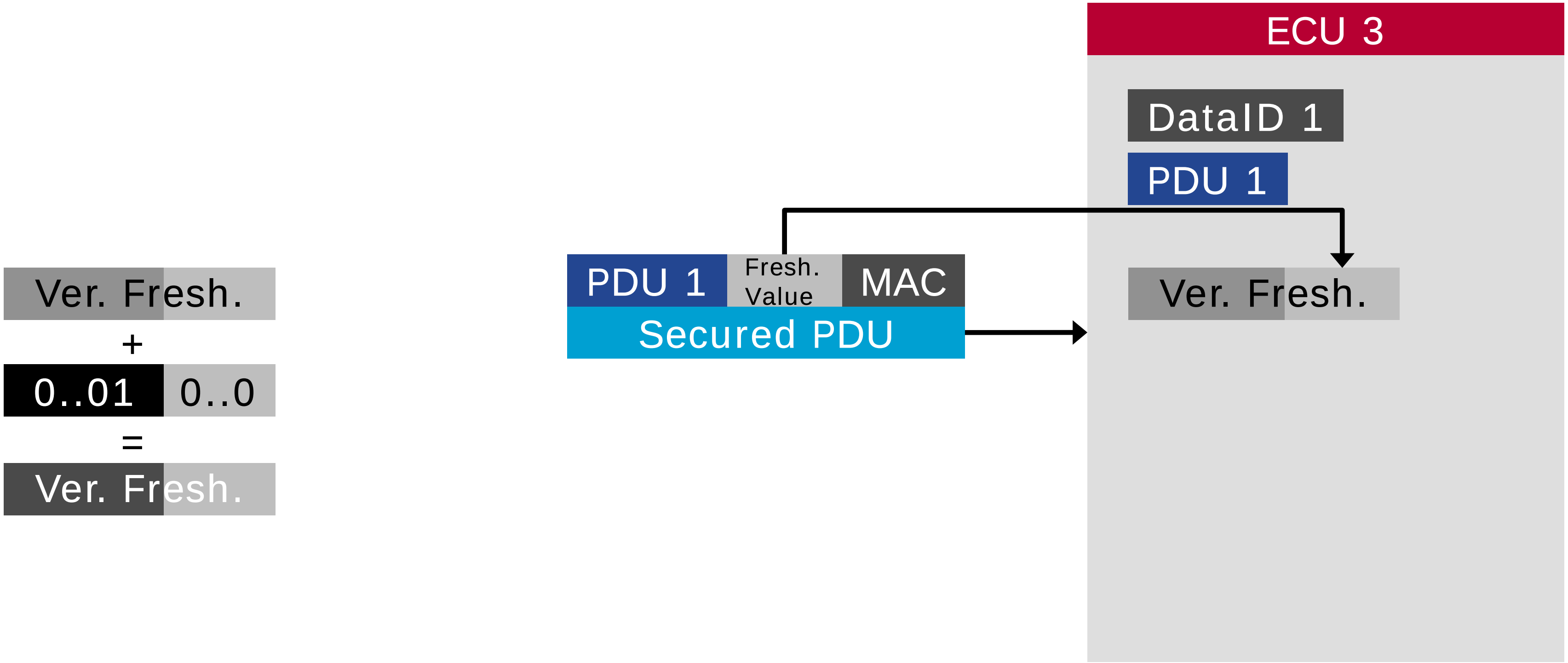
Truncated MAC length must be thoroughly chosen dependent on network attributes and security requirements

Reception of a secured PDU



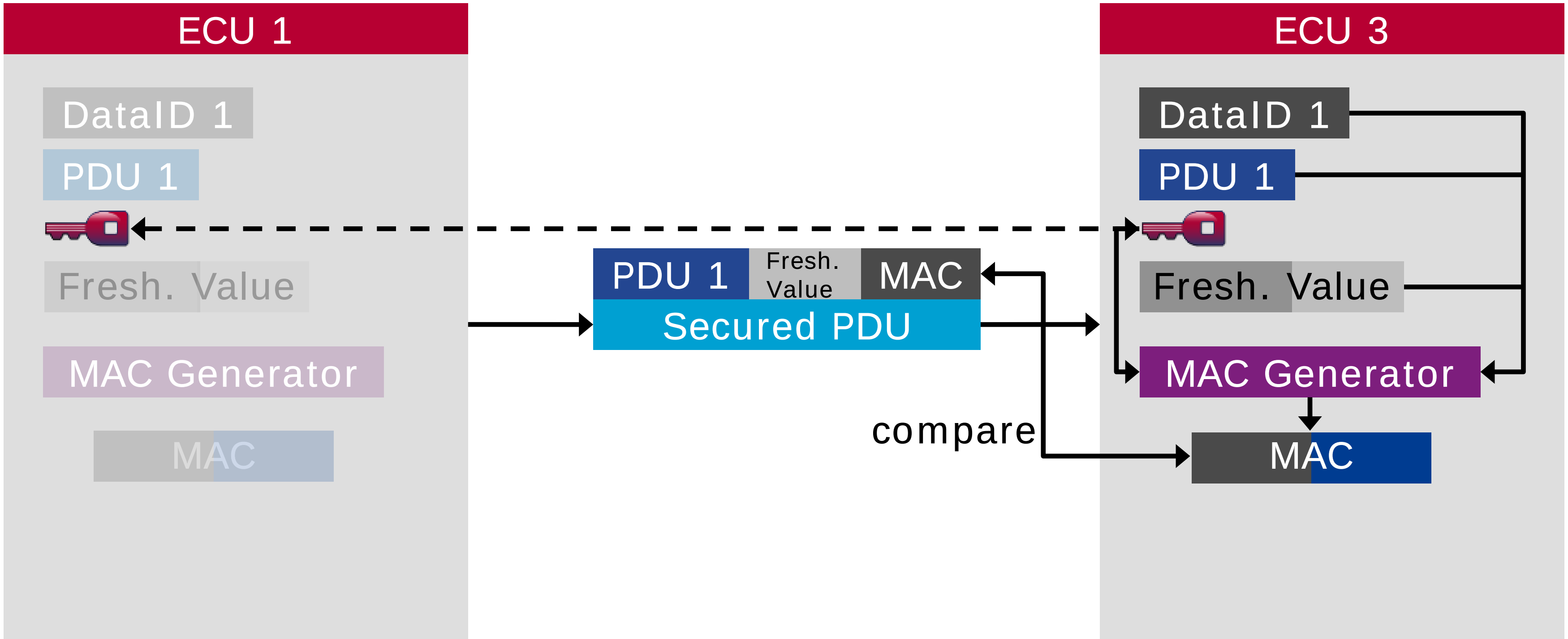
- Authentic PDU is parsed
- DataID must be identical for sender and receiver
- Truncated freshness value is synchronized to form verification freshness value

Reception of a secured PDU



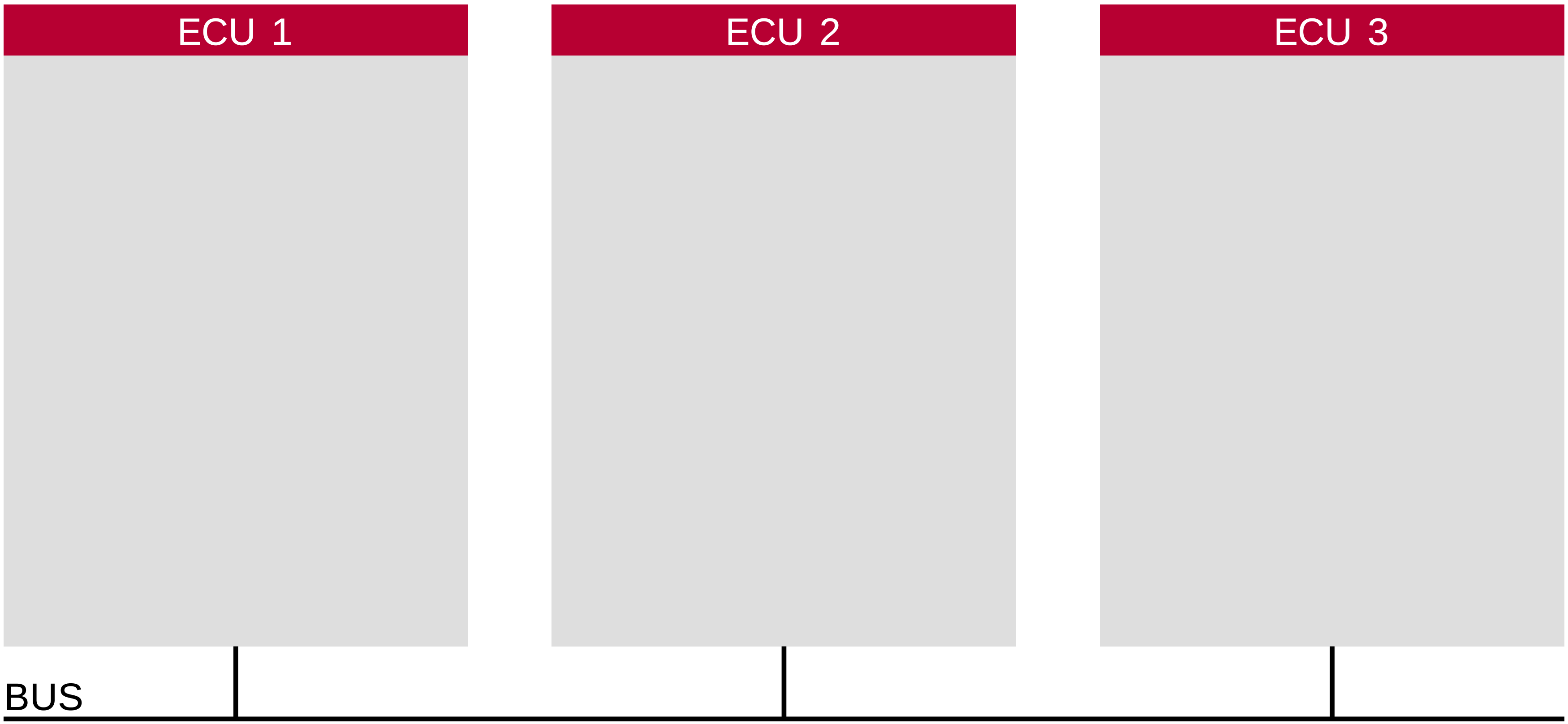
- Verification freshness value > stored freshness value (replay attacks)
  - If not: Increment MSBs of verification freshness value
- Synchronization between sender and receiver

Reception of a secured PDU

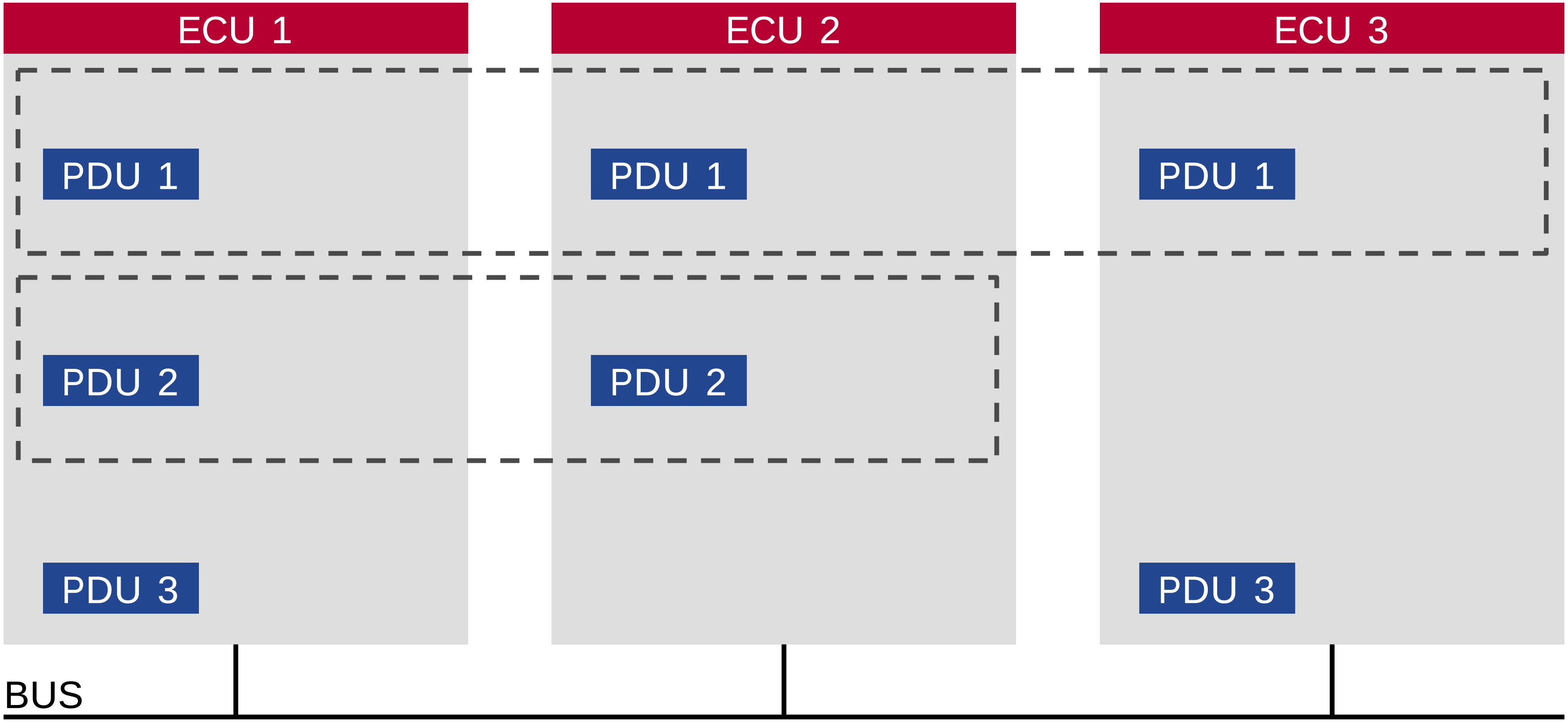


- DataID, PDU, verification freshness form input to MAC generator
- Symmetric key must be identical for sender and receiver
- MSBs of calculated MAC are compared to truncated MAC
  - If successful, PDU is forwarded
  - If not, PDU is dropped

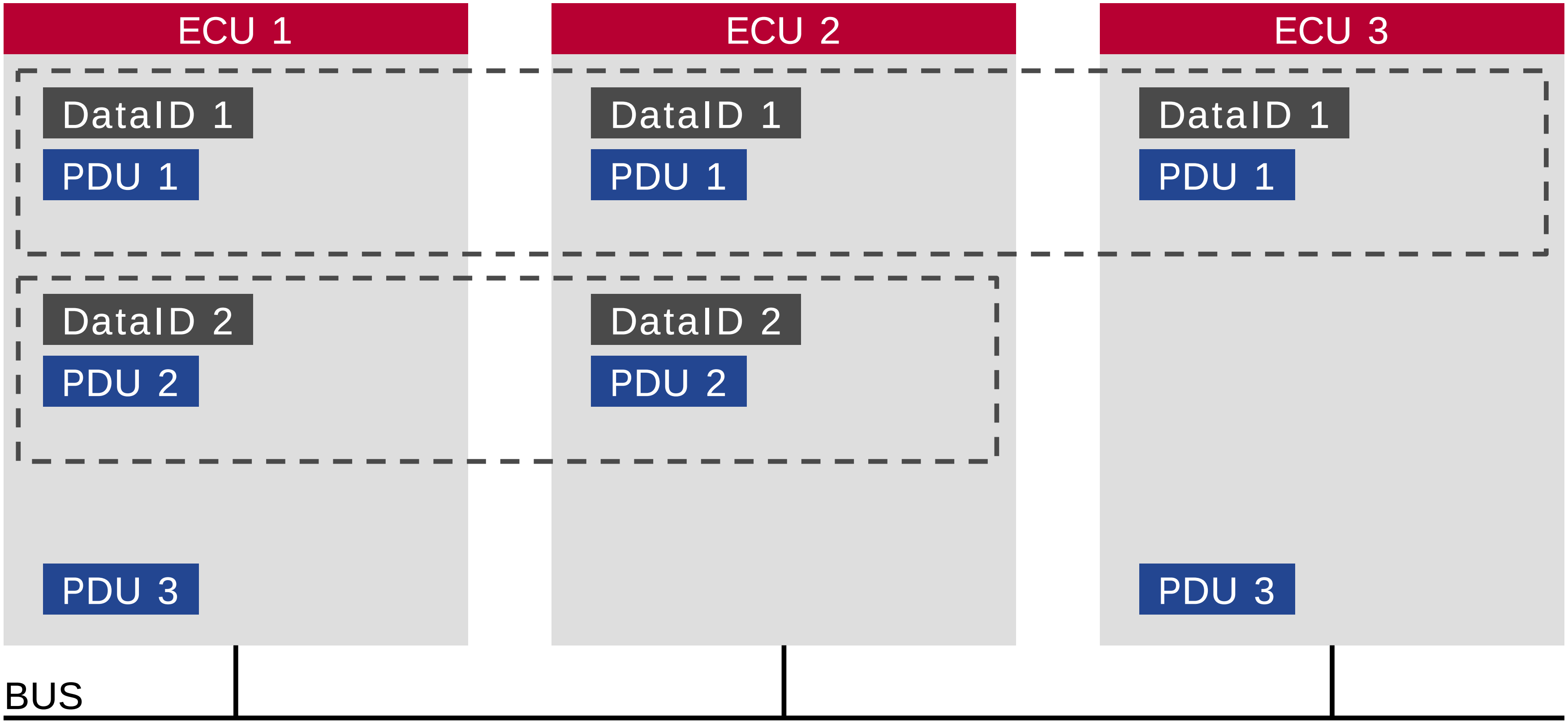
System Configuration



System Configuration

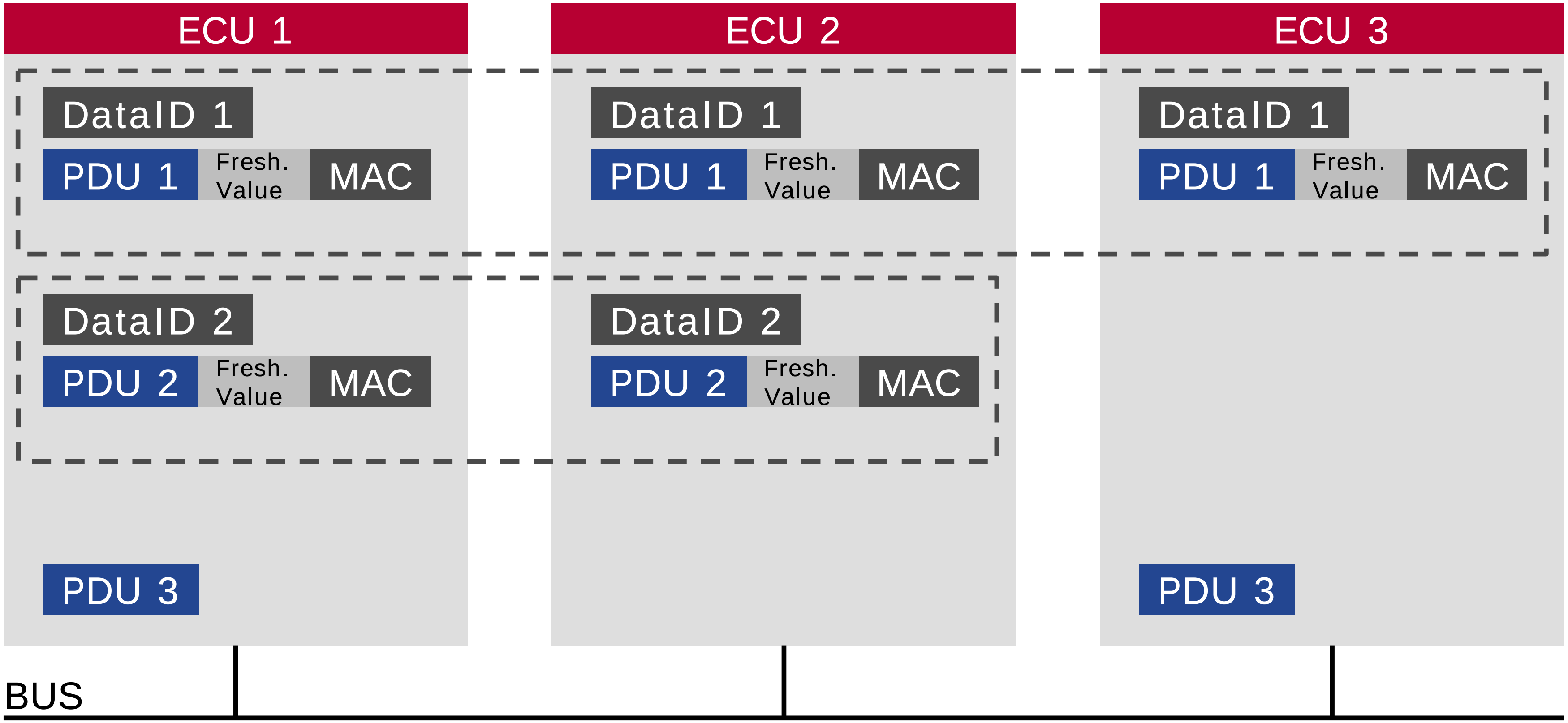


System Configuration



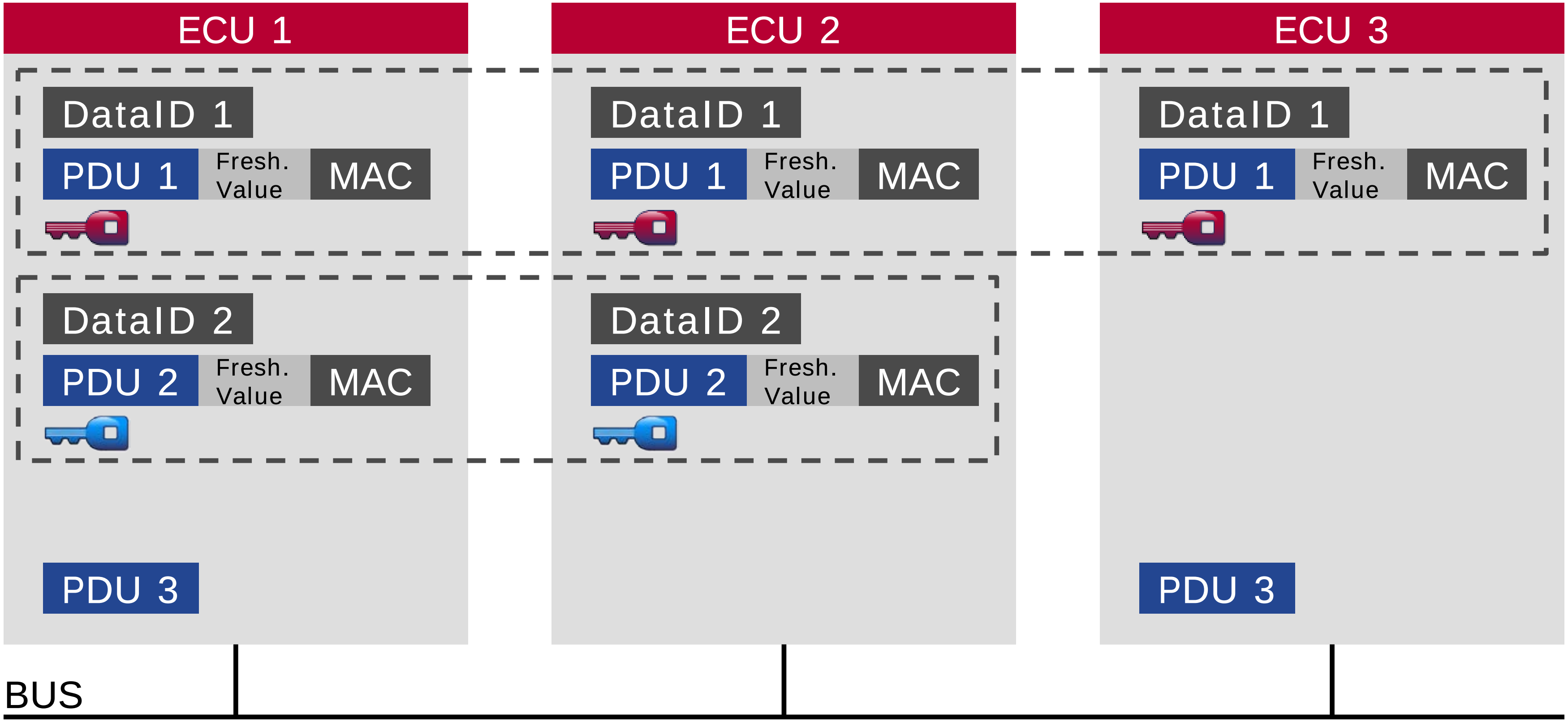
- Assignment of DataIDs to the to-be-secured PDUs

System Configuration



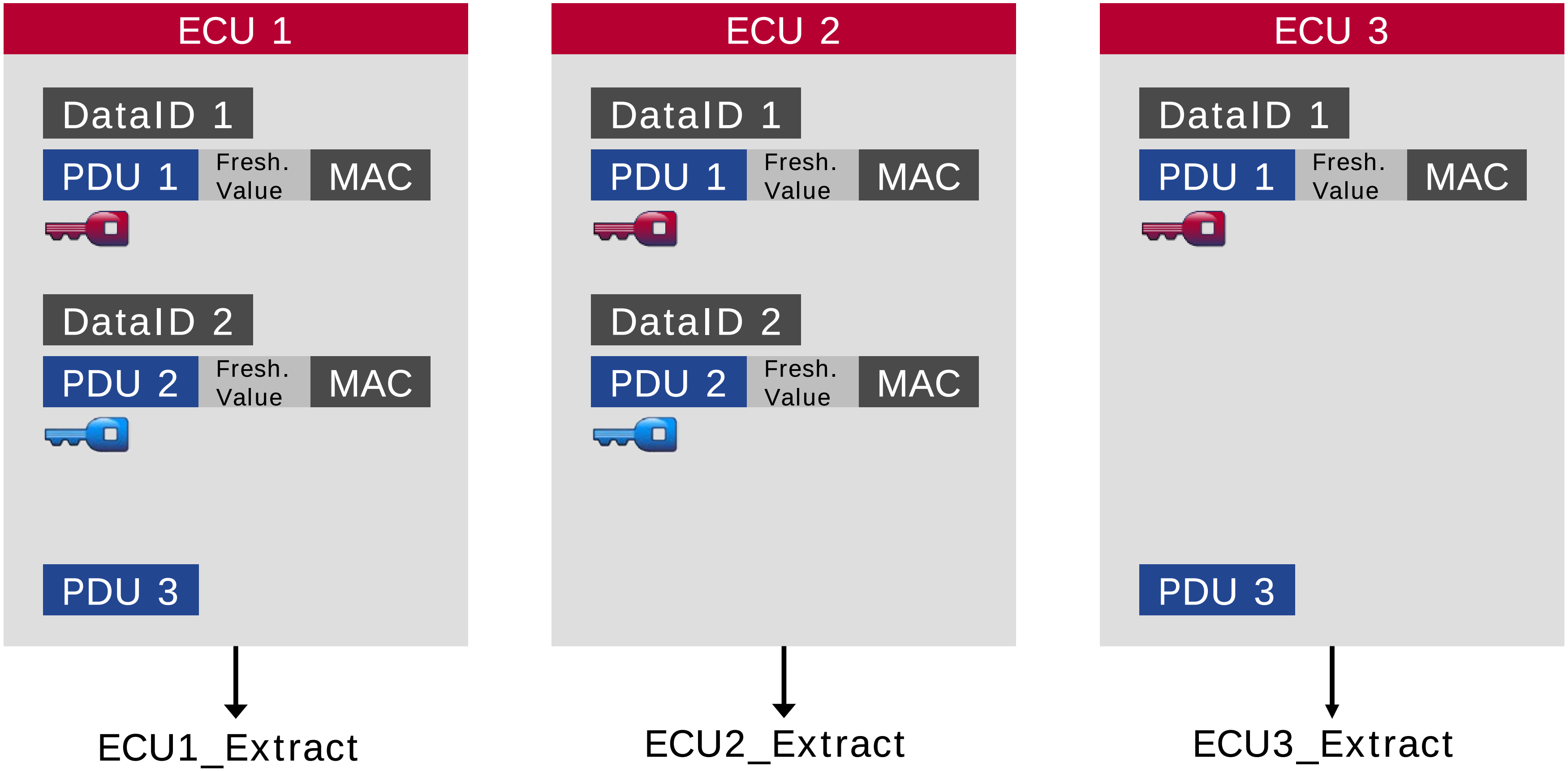
- Specification of the layout of the secured PDU

System configuration



- Assignment of keys to the secured PDUs
- Initial keying
- Re-keying

System configuration



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