Universität Rostock
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Institut für angewandte Mikroelektronik und Datentechnik

SLIDE: Evaluation of a Formalized Encryption Library for Safety-Critical Embedded Systems

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Most Common Cryptography Mistakes [1]

After all "Crypto wont save you either"[2]

#1 Don't roll your own

#2 Security shall not be negotiable

#3 Passphrases do not make keys

#4 *Un*qualified Random Number Generators

#5 Encryption without authentication

#6 Encrypted traffic still leaks inf. (e.g. timing)

#7 Hashing concatenated strings

#8 Key re-use, Nonce re-use

(*1: David Wagner, UC Berkley, 2016)

([2] Peter Gutmann)

Motivation

- Applications with critical safety require (e.g. EN50128: “highly recommend”)
  - formal methods for implementations
  - formal verification techniques
- Trial feasibility
- Estimate the performance deficits in implementation of dataflow-model-based versus imperative language
- Extend (own) existing models with integrated, non-bypassable cryptographic methods

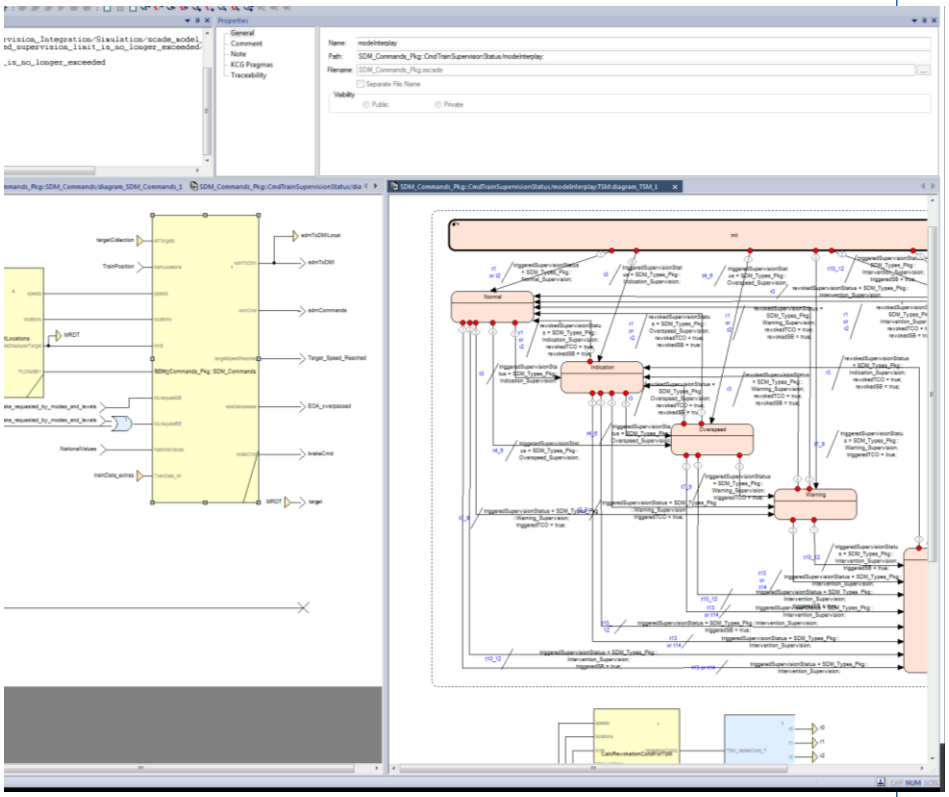
Approach

- Elliptic curve cryptography based on Curve25519 are proven algorithms originating from research by Daniel J. Bernstein with many implementations
  - **N**etwork **a**nd **C**ryptography **L**ibrary "salt" (reference impl.)
  - TweetNaCl (very concise ANSI-C)
  - µNaCl (8 bit-µC)
  - libsodium (POSIX)
  - ➢ Google QUIC, Apple iPhone encrypt, openSSH, WhatsApp … …
- ➢ **In this work**: Formalized Implementation in SCADE:

  "*SLIDE*" – Safety Leveraged Implementation of Data Encryption
- ➢ **Goal**: improve development / verification process for safety-critical systems.

Modelling Tool: ANSYS® SCADE Suite

- Synchronous reactive programming language Scade for data- and control-flow modelling
- Qualified: DO-178C (avionic), EN-50128 (rail), IEC-61508 (industrial), ISO 26262 (autom.)
- Relevant, commercial toolchain:
  - Airbus, Eurostar train, many nuclear power plants, Siemens (trains), Pratt & Whitney (turbines)



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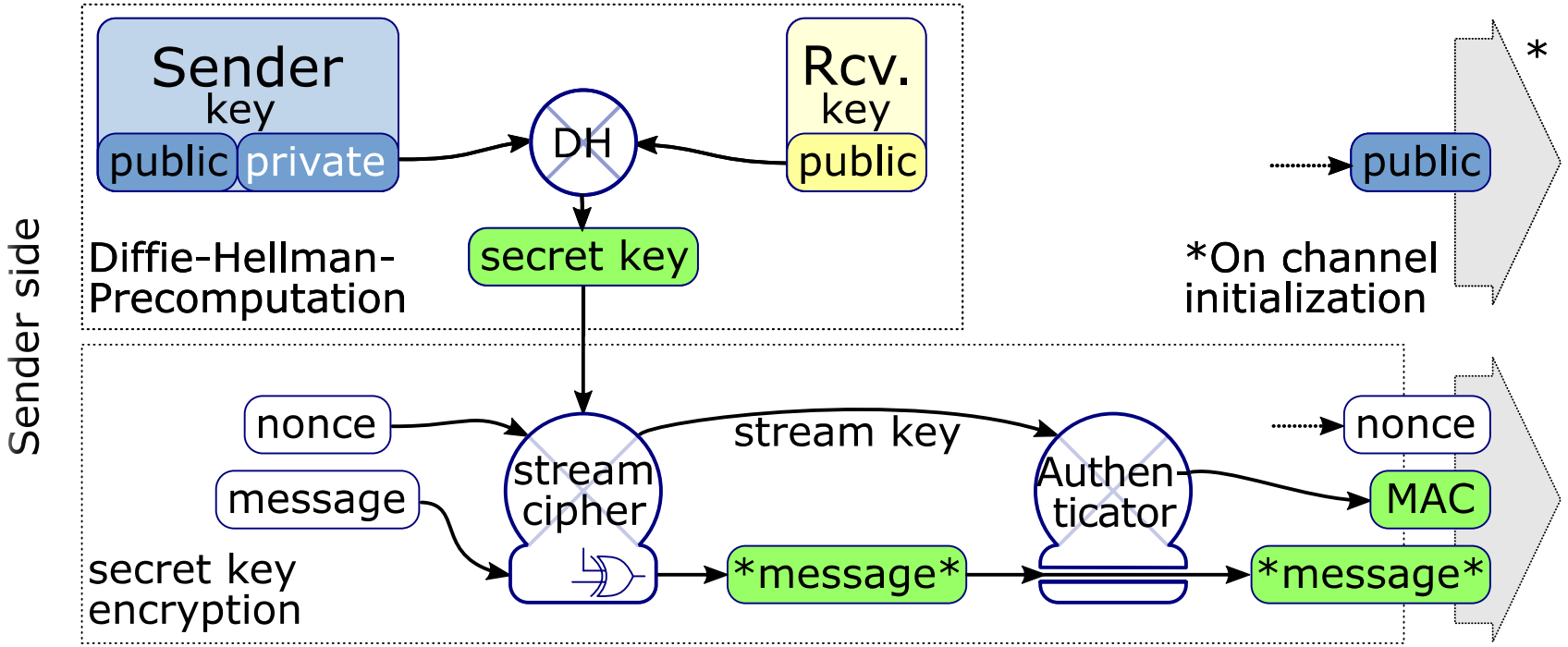
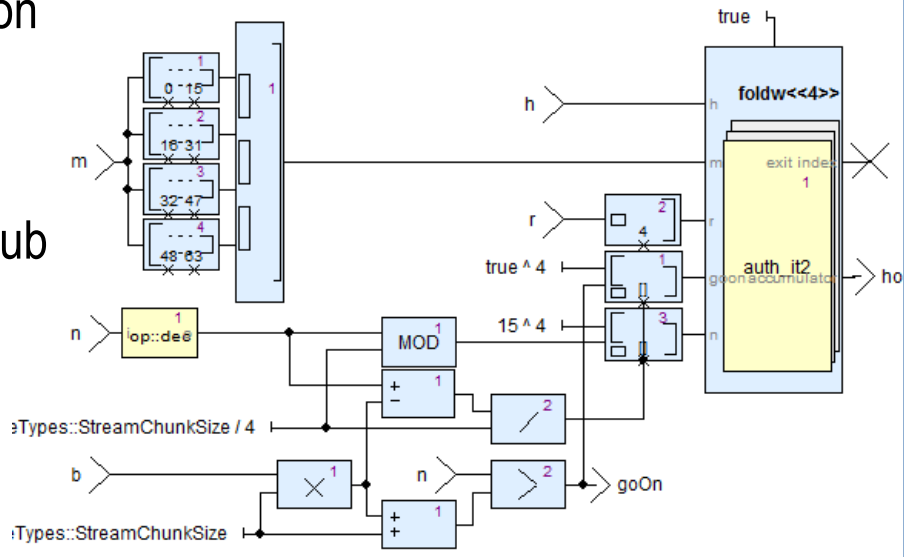
Asymmetric Cryptography of NaCl



Scade Crypto Library "*SLIDE*"

- Asymmetric key generation and exchange
- Authenticated Encryption using Curve25519 algorithms (optimized)
- Signature generation and verification
- SHA2-512

- Availability: pls contact author (github planned), open-source



Exemplary Safety Microcontroller Platform

Texas Instruments Hercules RM57Lx

Features:

- IEC 61508 SIL 3 + ISO 26262 ASIL D certified µC
- LockStep CPUs – 1oo1D safety concept
- ARM-Cortex-R5F @ 330 MHz, 4 MB Flash, 0.5 MB ECC-RAM, Eth, SPI
  …

➢ Automotive + Industrial control

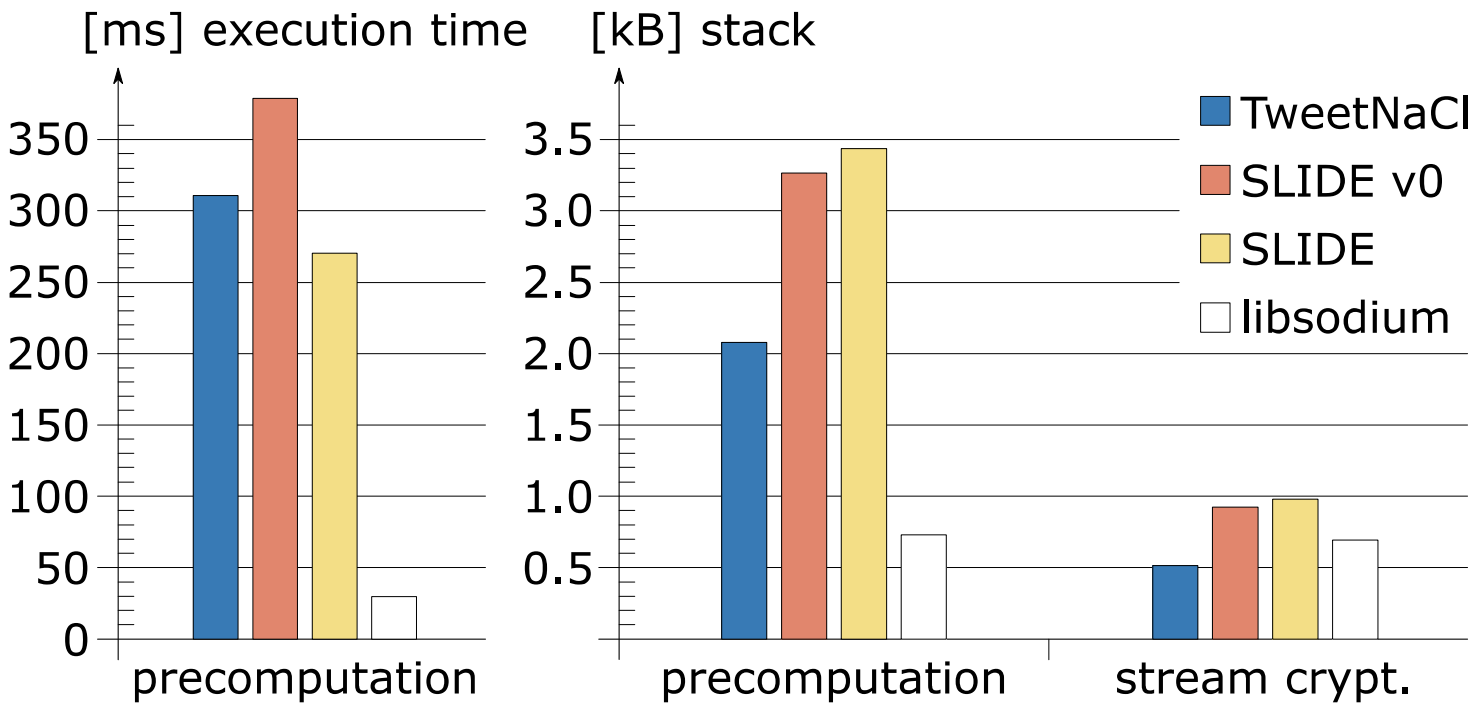
➢ Digital I/O Module

➢ Process automation

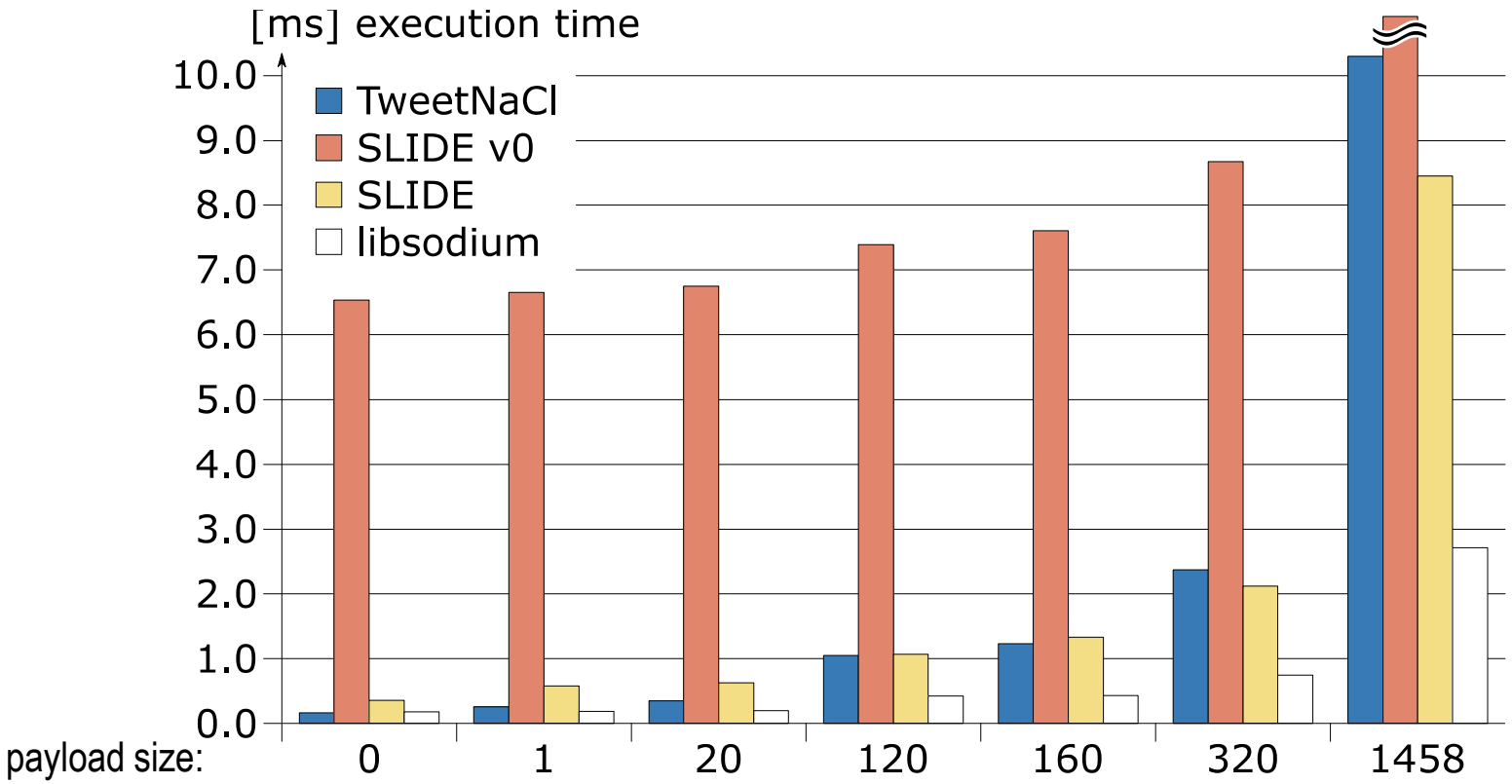
(train == “moving industrial plant”)

Dev-Kit:
LAUNCHXL2-RM57L

Results Key Precomputation (elliptic curve multipl.)

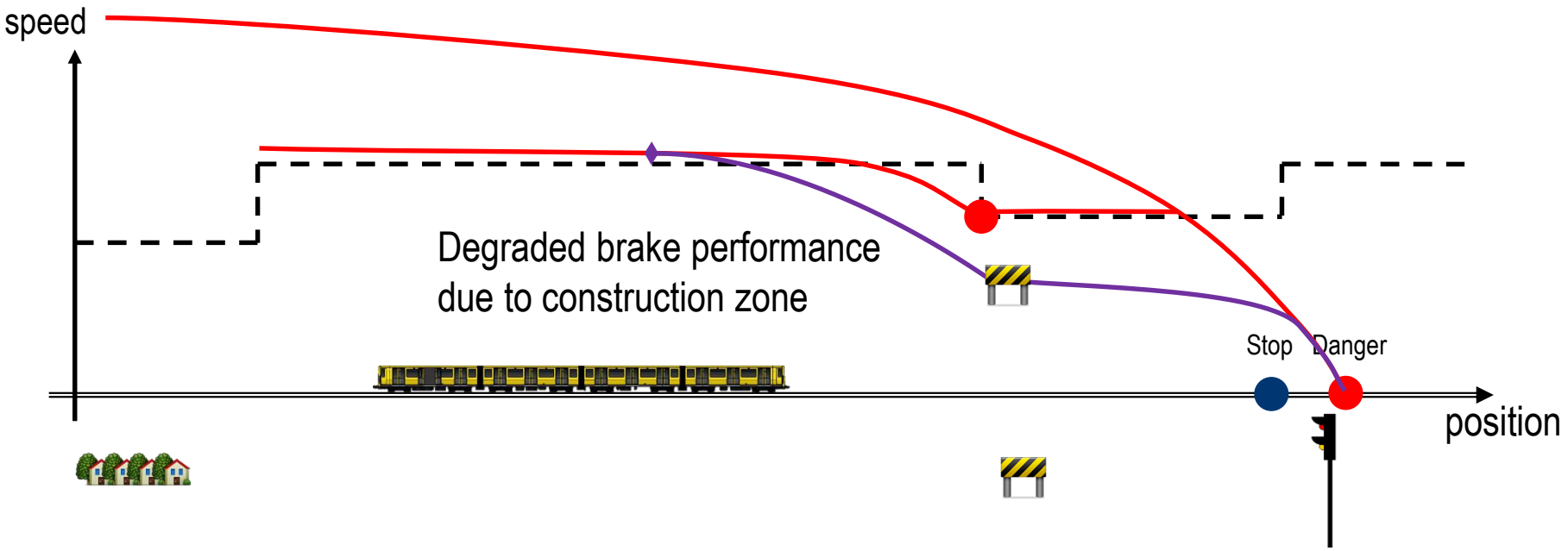


Results Encryption + Authentication

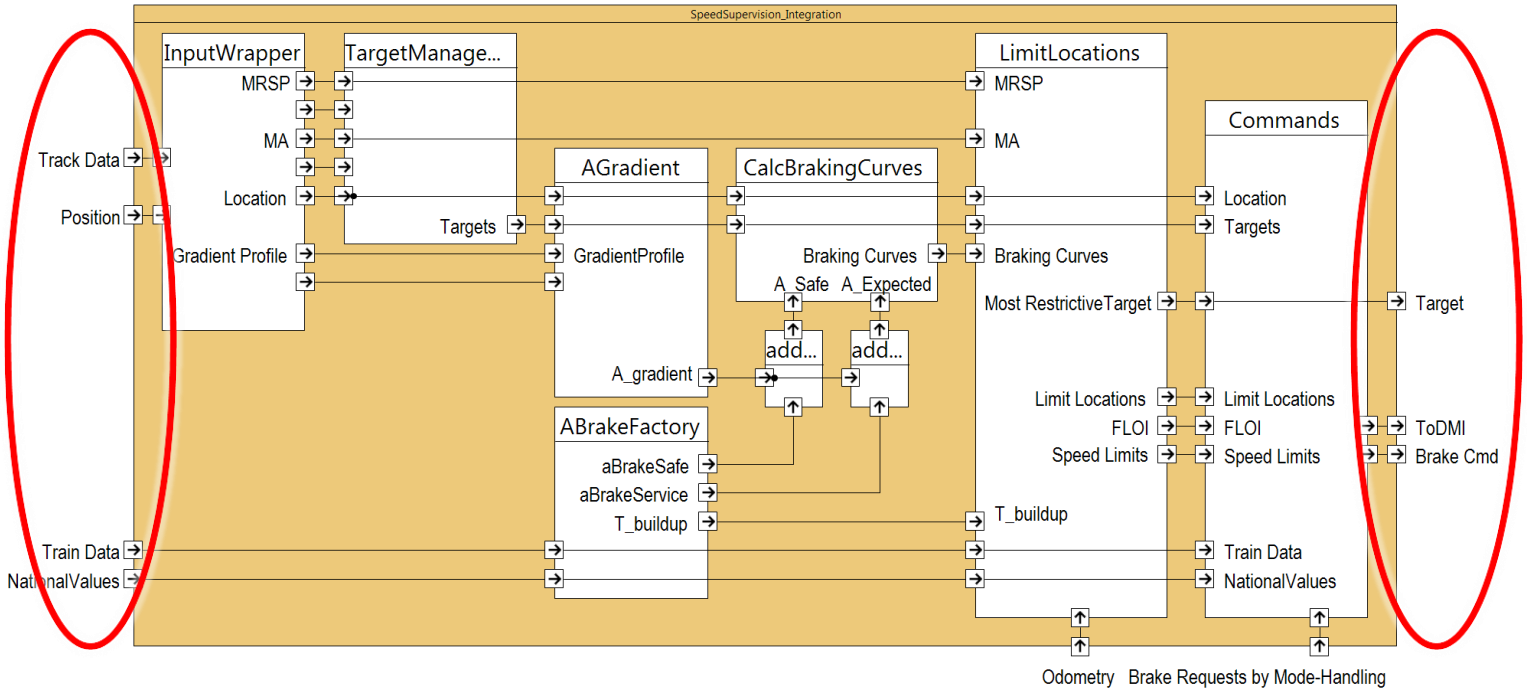


Reference: Model-based Safety Application

Integration with Train Safety Control (ETCS, Intervention Braking)



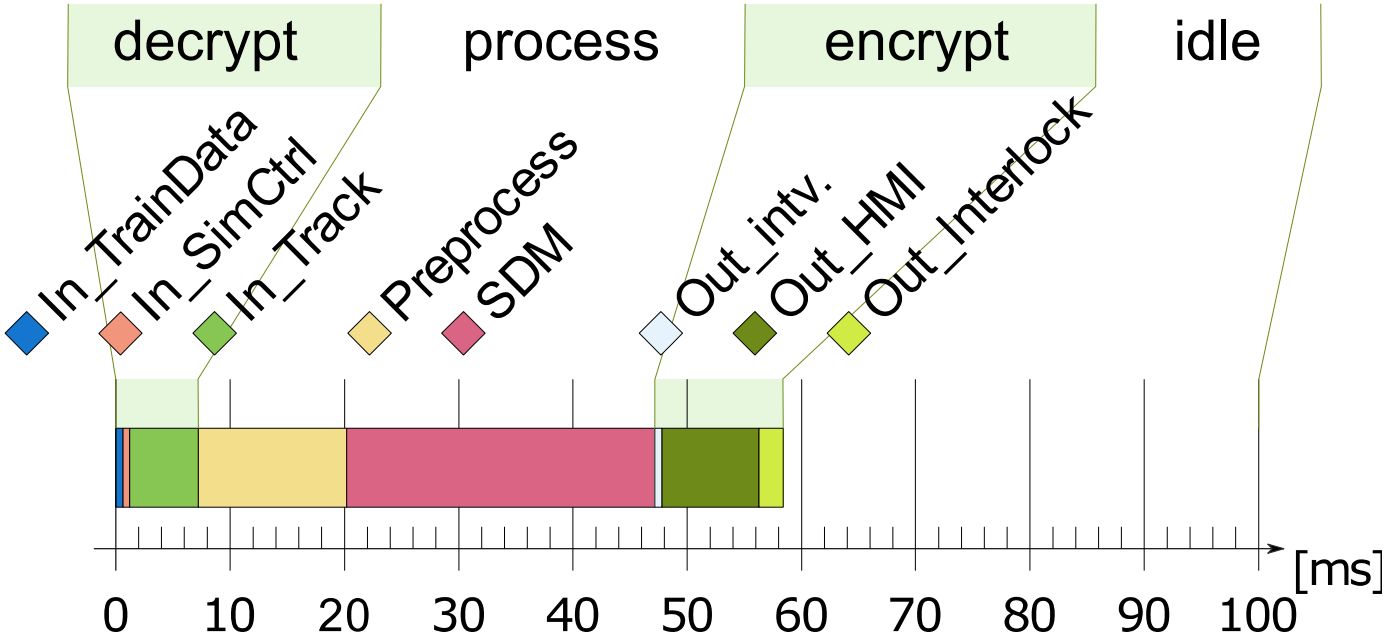
Integration with Model-based Train Safety Control



ANSYS® SCADE System view of SDM (simplified)

Supported by SCADE® ACADEMIC programme

Evaluation of De-/Encrypt to a Process



Results

- ✓ Feasible within 100ms-application-process-cycles
  Compared to optimized C-library (libsodium):
  - ✓ Encrypt+Auth-Execution — same magnitude
  - ✓ Key calculation — slower (simpler algorithm)
- ➢ Actual value of `SLIDE` will be of homogeneous *integration* & *testing*:
  - ➢ Less module-interface glitches
  - ➢ Verifiable application states
    - ➢ But is any *security assured* for certification?

So, if "Crypto wont save you either", what's next?

- Security is much more than cryptography
- Assured security for critical systems needs wider approach:
  - Secure credential storage / boot / update
  - Proof of non-interference of resource sharing, effects of time partitioning …
  - certMILS:
    Compositional security certification for medium to high-assurance COTS-based systems in environments with emerging threats

    http://www.certmils.eu

Conclusion & Take-Home

- ✓ General Proof-of-Concept:
  Crypto within the safety-verified Model-based language Scade
- ➢ Performance results are acceptable on a safety microcontroller
- ➢ Value of `SLIDE` is of homogeneous *integration* & *testing*
- ➢ More Work is required to *assure* Safety is Secure

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Feedback, Questions, Answers

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