Hierarchical Integrity Checking in Heterogeneous Vehicular Networks

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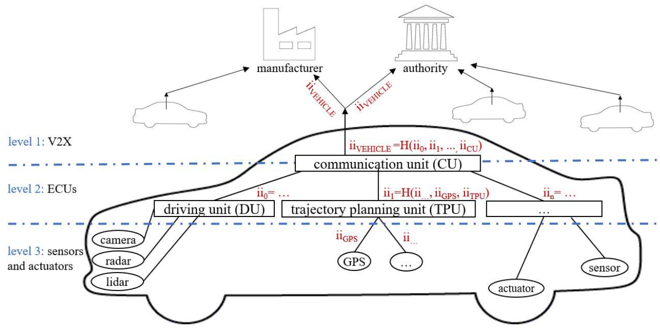
Introduction and Motivation

- Human drivers will be slowly replaced by intelligent machines relying on sensor input and sophisticated algorithms.
  - UNICARagil [1] vehicles
  - SAE level 5 [2] road vehicles
- Safety must be guaranteed to gain acceptance for autonomous vehicles in society.
- The vehicle's integrity state has to be verifiable to ensure a safe driving state:
  - hardware integrity
  - software integrity

Goal: Compute integrity identifiers to represent the vehicle's integrity state

Abstract Vehicular Structure



- Derivation of an integrity identifier $ii_{VEHICLE}$ indicating the overall vehicle's integrity state
- The vehicle is logically divided into three hierarchical levels.

Hierarchical Integrity Checking

An **identity identifier** $ii_{component}$ represents the integrity state of a specific *component*.

An **integrity measurement** of a component is the verification of its valid hardware and software state.

Characteristics of $ii_{VEHICLE}$ **:**

- It should give instant feedback about the vehicle's integrity → usable by third parties
- It should be made available to third parties such as car manufacturers and authorities.
- It should incorporate the integrity measurements of low-end devices (e.g. sensors) and computational powerful units (e.g. environment perception ECU) → creation of a secure key to eventually perform hardware and software attestation

Challenges and Opportunities:

- **Platform Heterogeneity:**
  - low-end devices: Physical Unclonable Functions (PUFs)
    - ➢ inherent key derivation based on hardware characteristics
  - high-end devices: Trusted Platform Modules (TPMs)
    - ➢ vendor-generated secure key stored in tamper-proof chip
- **Hierarchy:**
  - compute identifiers in a distributed way to more reliably distinguish between safety-critical components
- **Identifier Distribution:**
  - V2X communication
  - blockchain

Challenge-Response Game:

Verifier (e.g. authority) | Prover (vehicle)

$\xrightarrow{n}$

On each hierarchy layer:

- integrity measurements of components
- encryption of n with the output of the integrity measurements, resulting in integrity identifiers
- recursive collection, hashing and propagation of integrity identifiers to the upper layer, finally resulting in $ii_{VEHICLE}$

$\xleftarrow{ii_{VEHICLE}}$

- compare the received $ii_{VEHICLE}$ with the value calculated in advance

References

[1] Lutz Eckstein, Stefan Katzenbeisser, Timo Woopen, Dominik Püllen et al. UNICARagil - Disruptive Modular Architectures for Agile, Automated Vehicle Concepts; 1st edition. In 27. Aachener Kolloquium Fahrzeug- und Motorentechnik : October 8th - 10th, 2018 - Eurogress Aachen, Germany = 27. Aachen Colloquium Automobile and Engine Technology. - 1, pages 663–694, Aachen, Oct 2018. 27th Aachen Colloquium Automobile and Engine Technology 2018, Aachen (Germany), 8 Oct 2018 - 10 Oct 2018, Aachener Kolloquium Fahrzeug- und Motorentechnik GbR.

[2] Taxonomy and Definitions for Terms Related to On-Road Motor VehicleAutomated Driving Systems, jan 2014.

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