Challenges in Automotive Security

Security for connected, autonomous Road Vehicles

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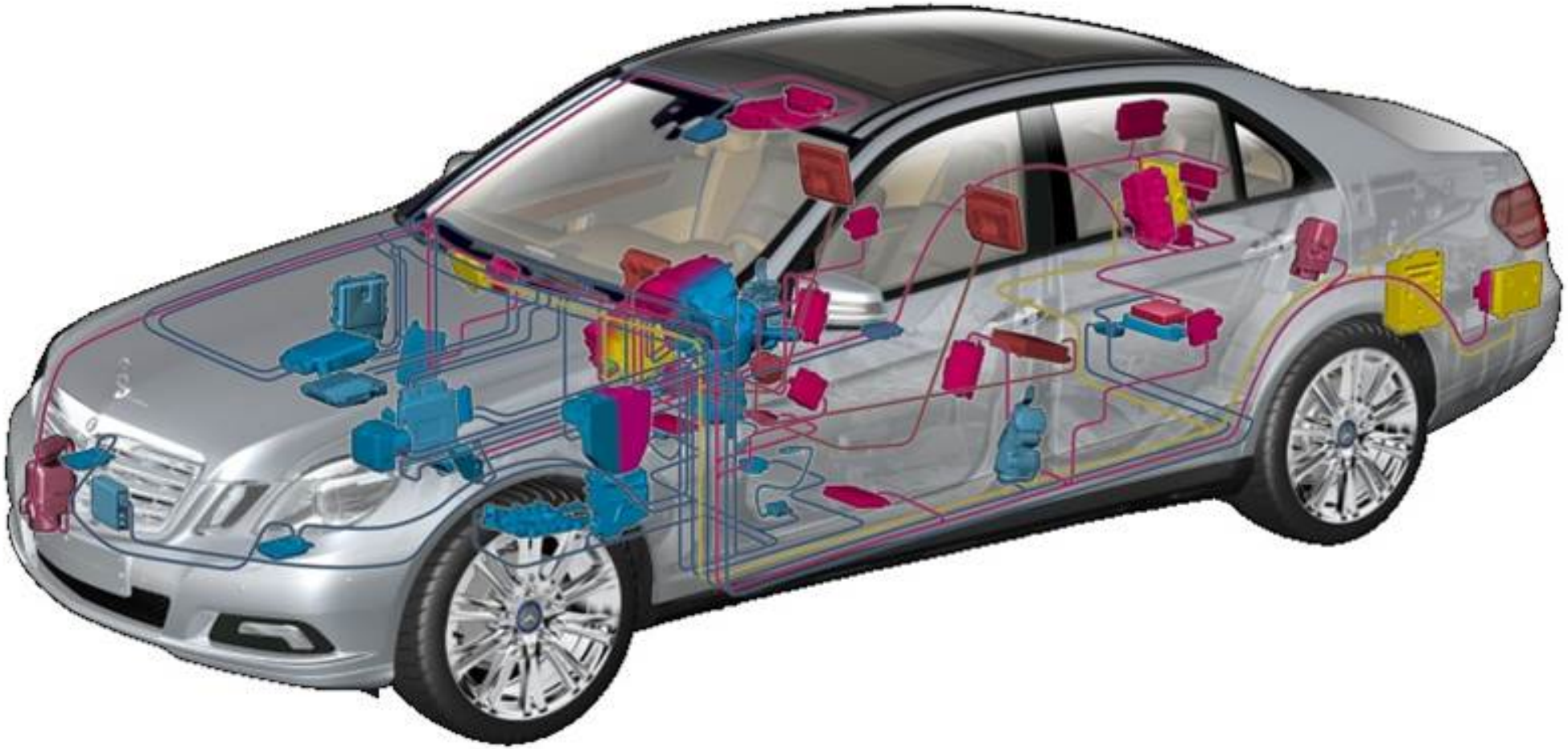
Agenda

1. Attacks on Automotive Systems

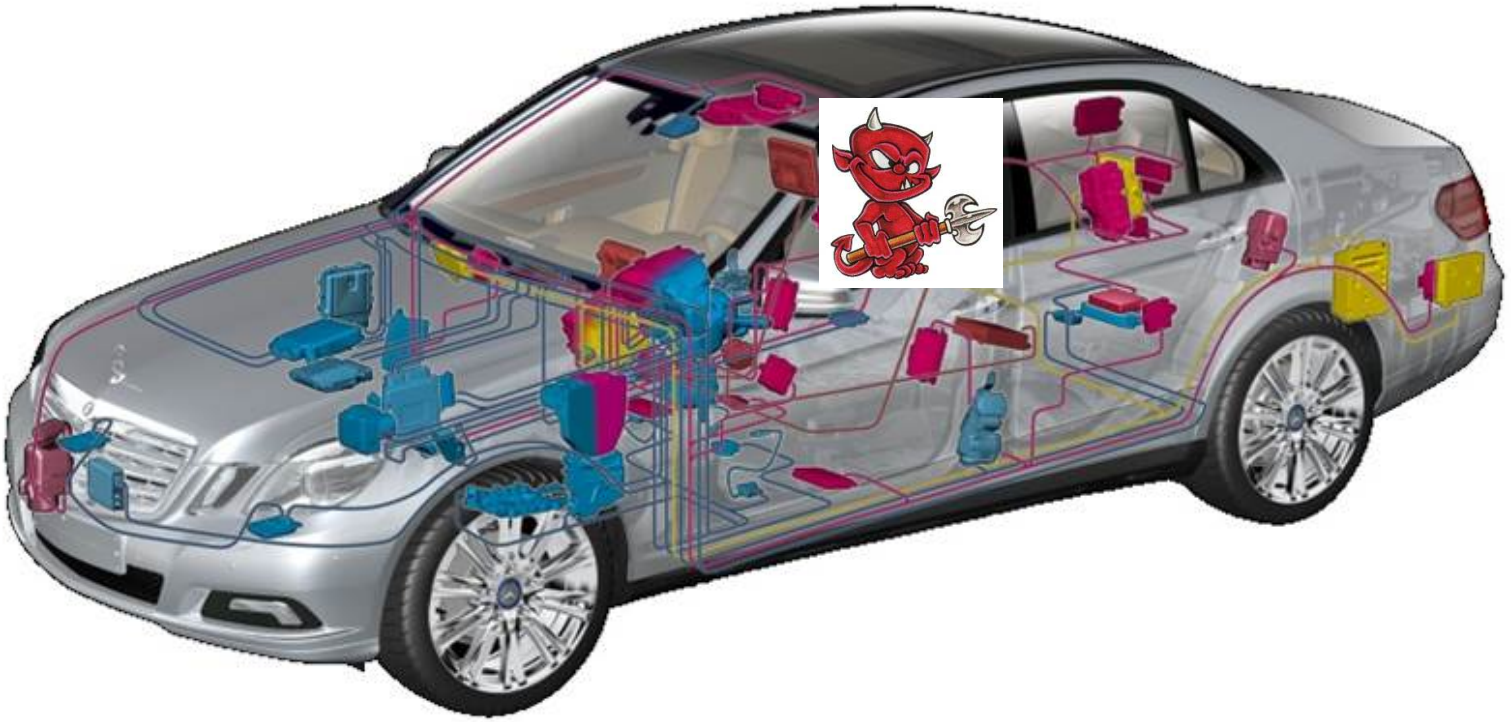
2. Challenges and Solutions

3. Summary

Large number of interconnected components in a vehicle

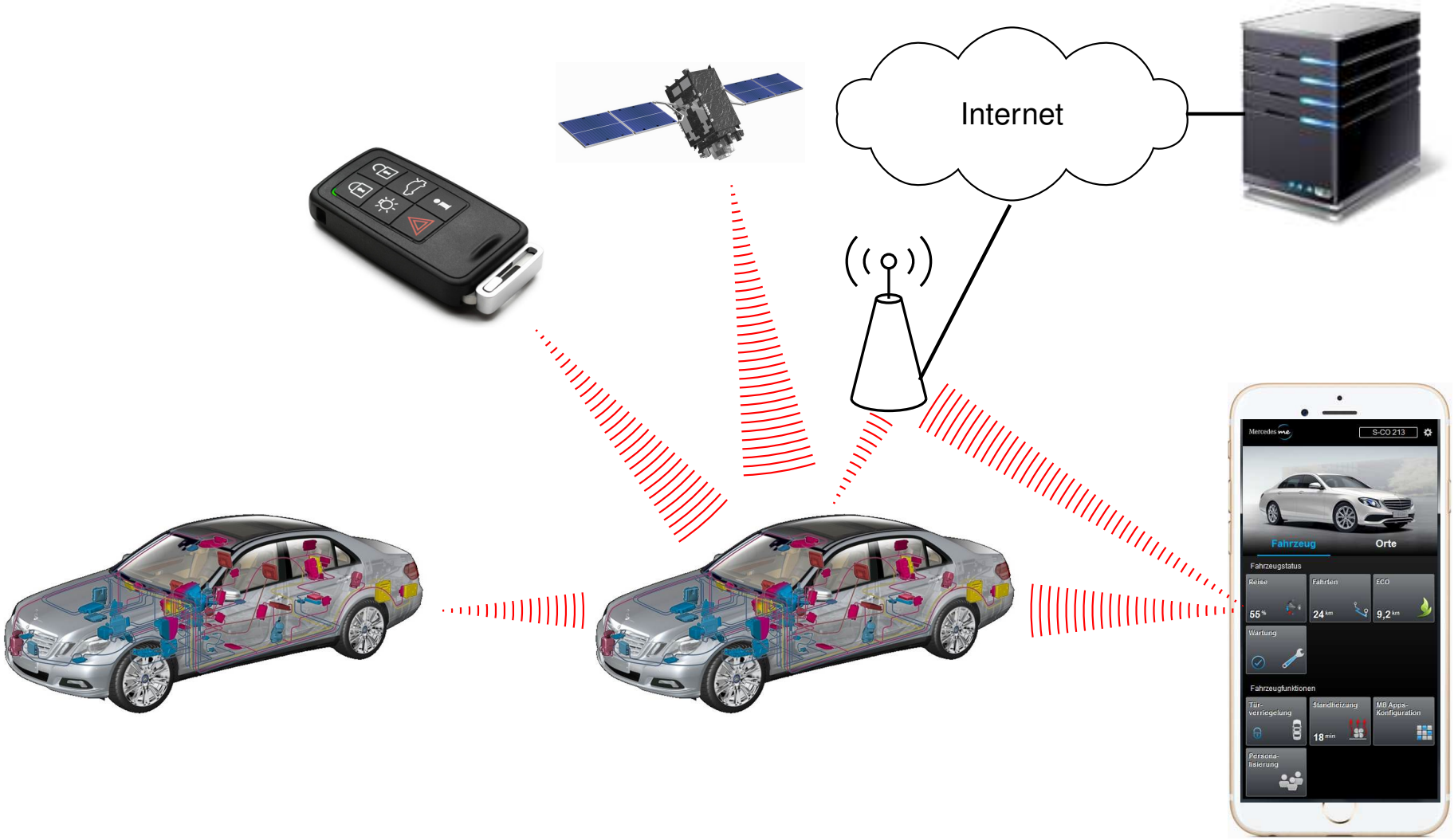


[R. Schmidgall, 2011]

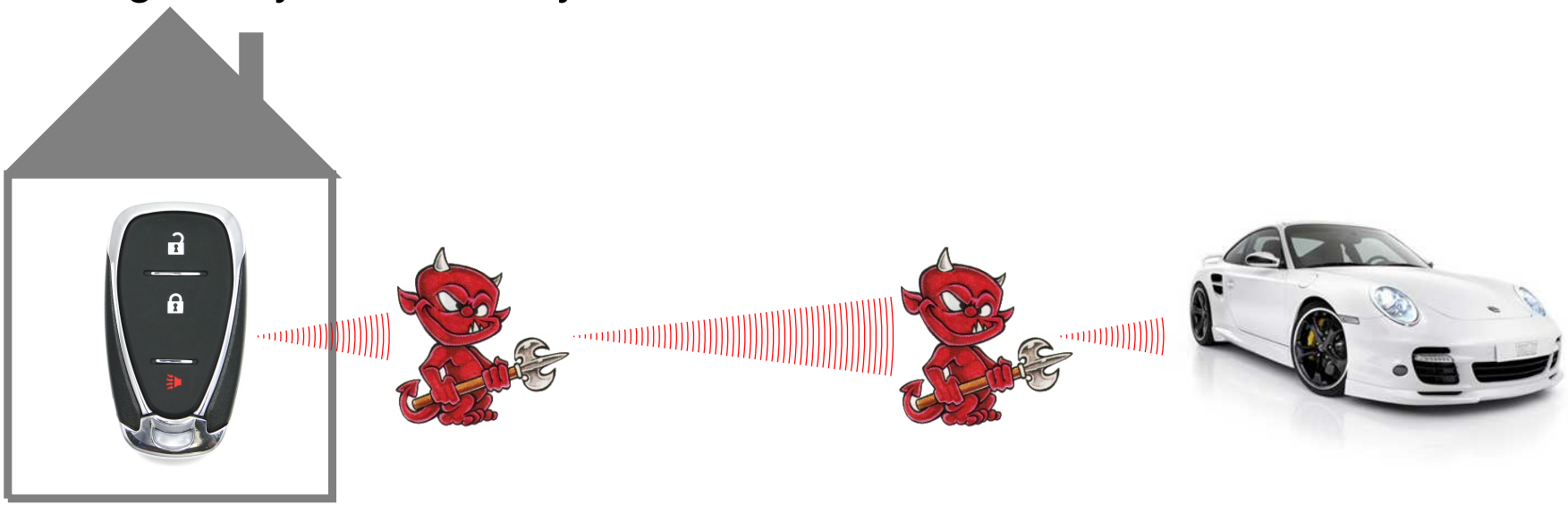


- only limited **authenticity** in automotive bus systems
- system can be manipulated (loss of **integrity**)
- demonstration: Valasek, Miller 2014

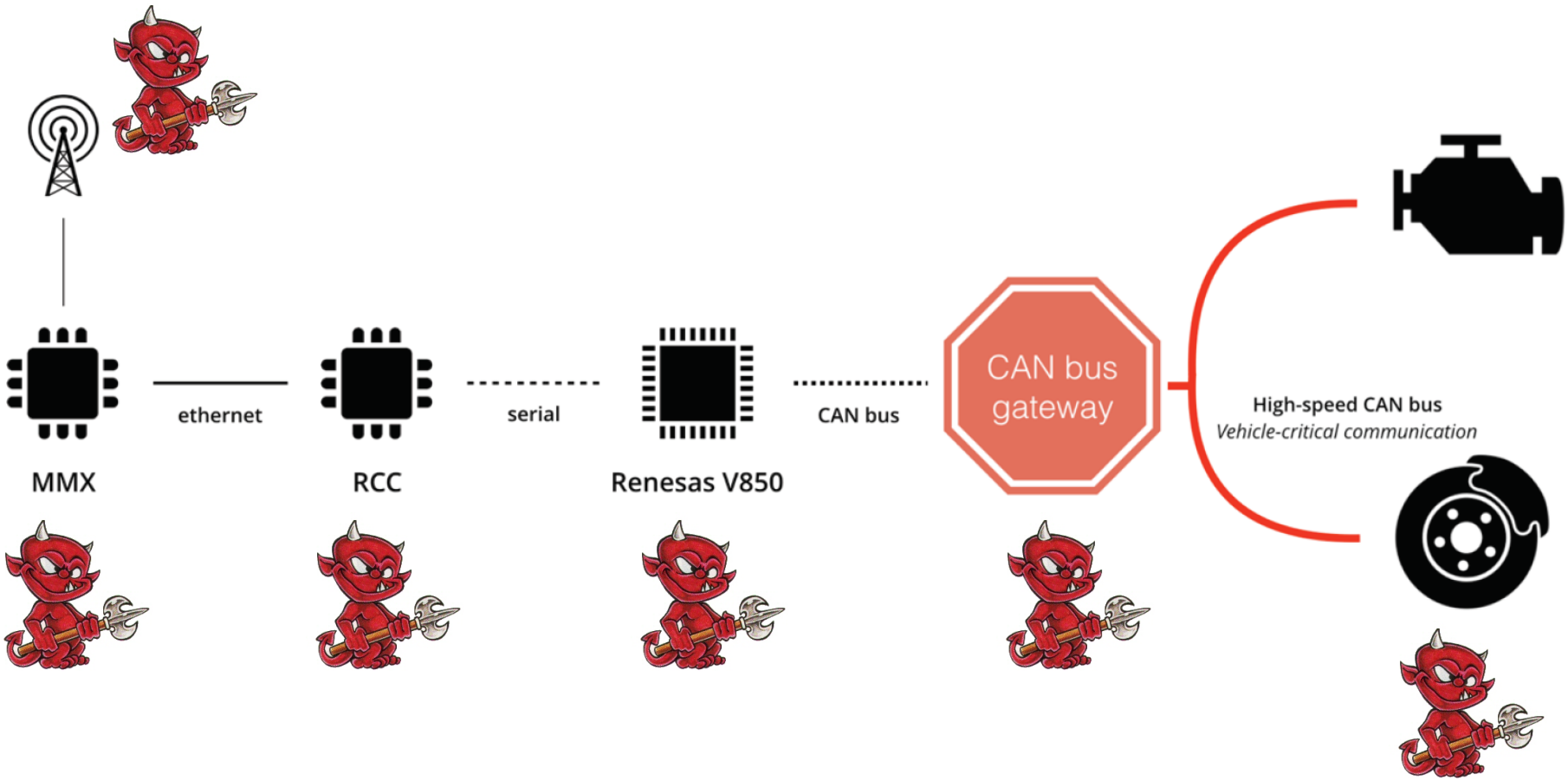
Vehicle as Part of Distributed System



Message relay between key fob and vehicle:



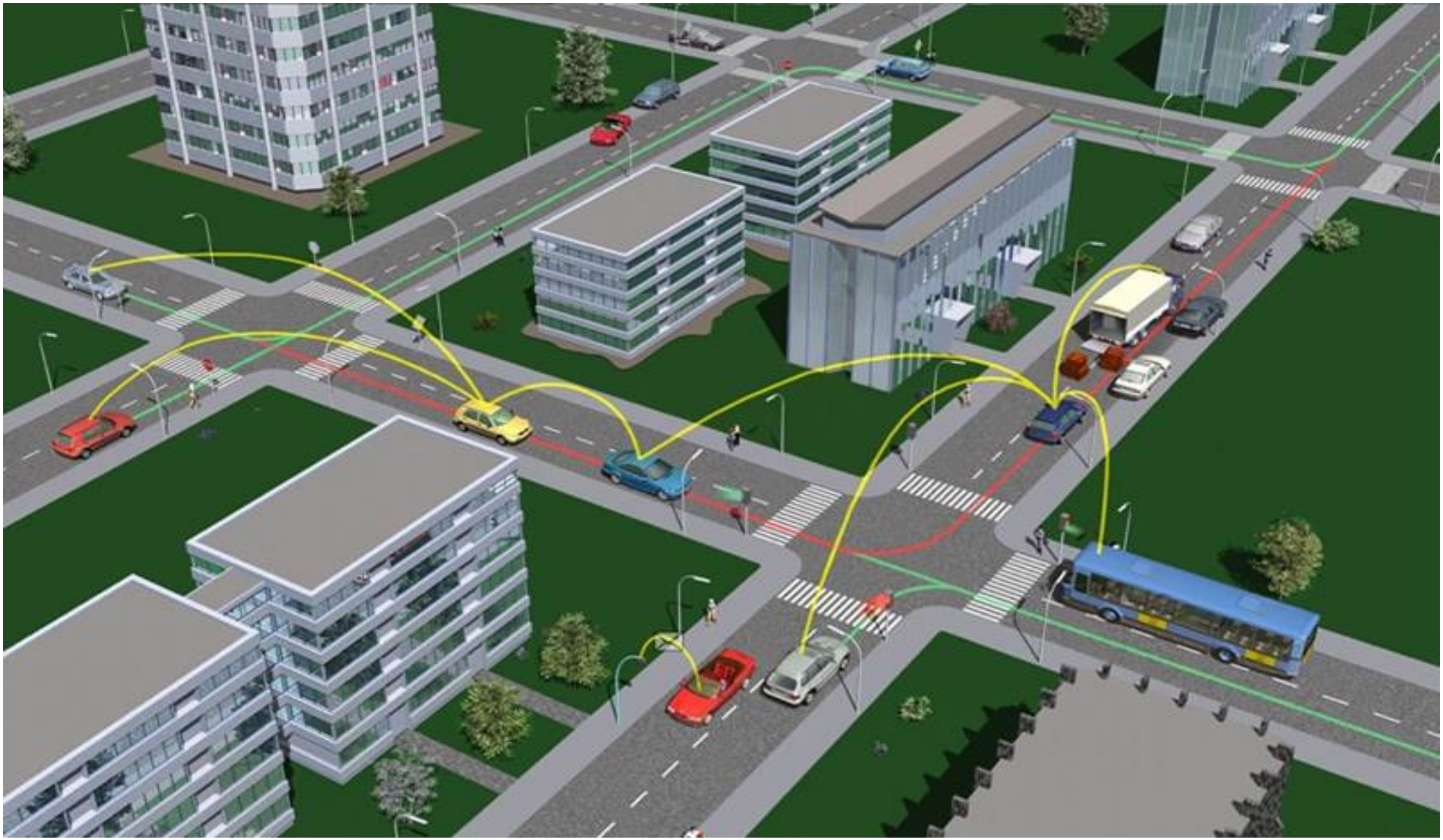
message relay $\rightarrow$ loss of **authenticity of location**



[after The Connected Car, Computest, April 2018]

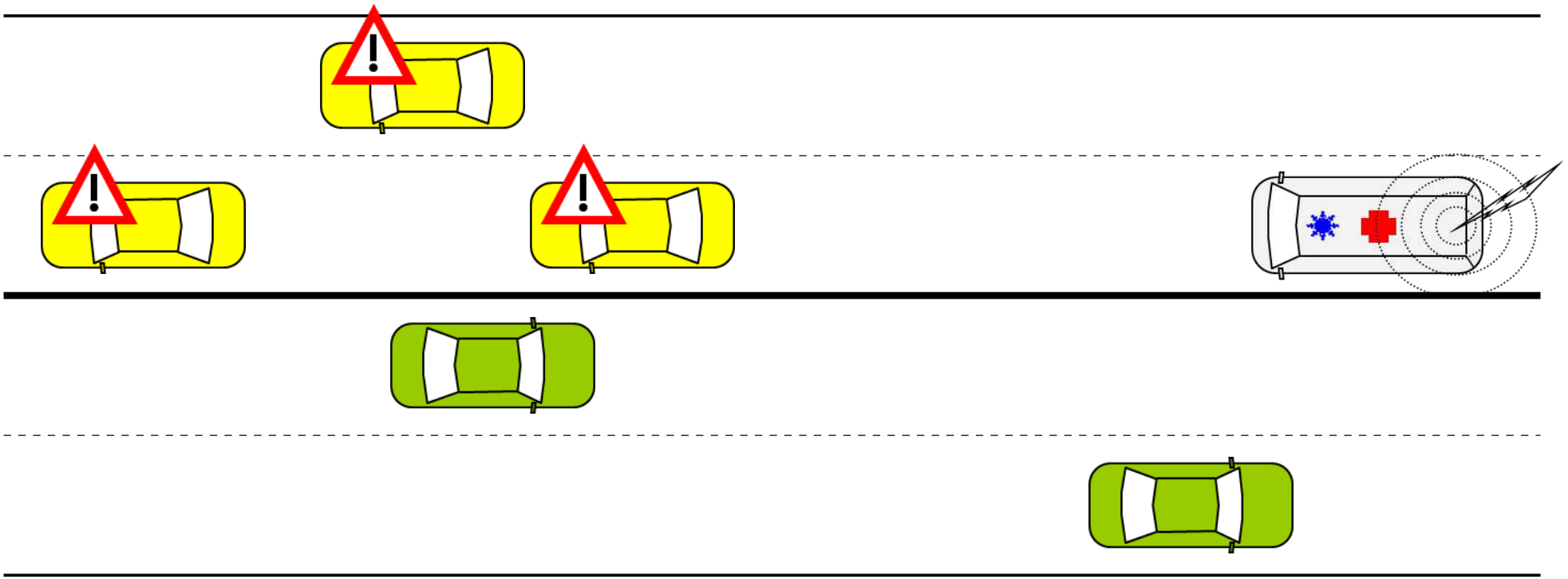
- loss of **authenticity** in communication leads to loss of **integrity**
- demonstrations: Solnik, 2014; Valasek, Miller 2016; Tencent 2019

Communication between vehicle and vehicle or infrastructure (V2X)

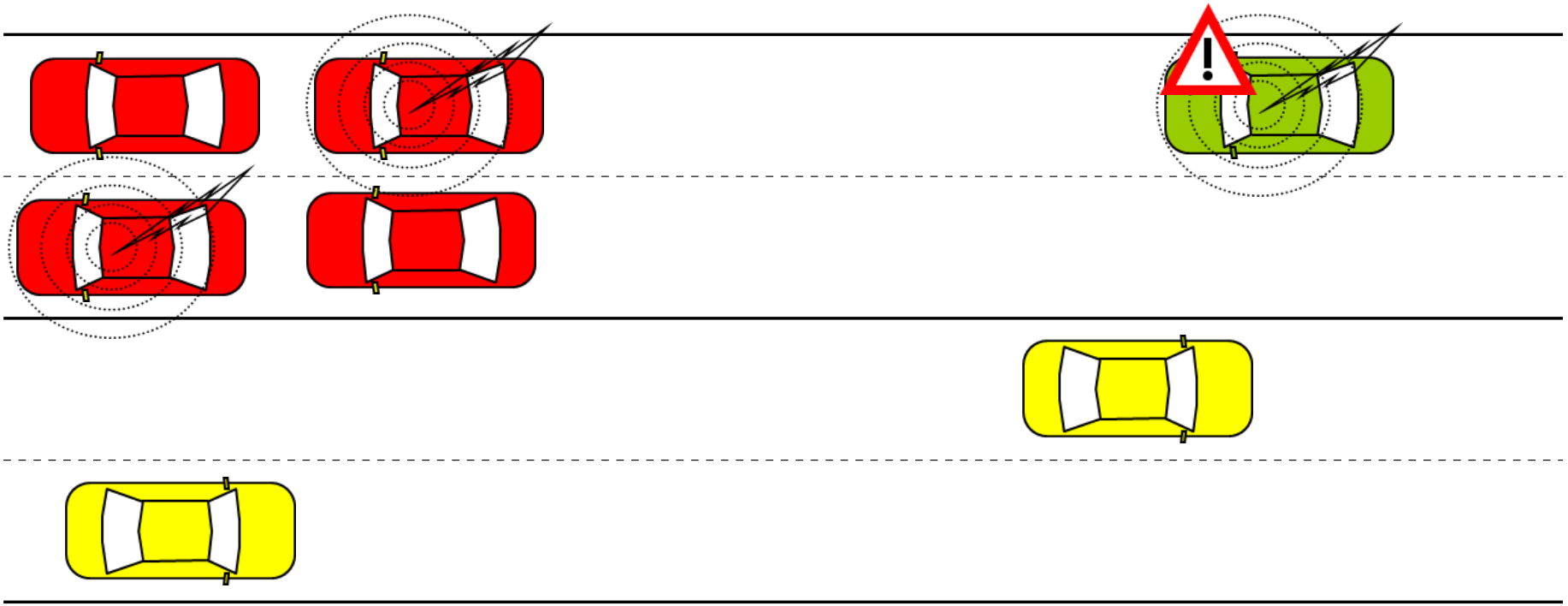


[CAR 2 CAR Communication Consortium, https://www.car-2-car.org/]

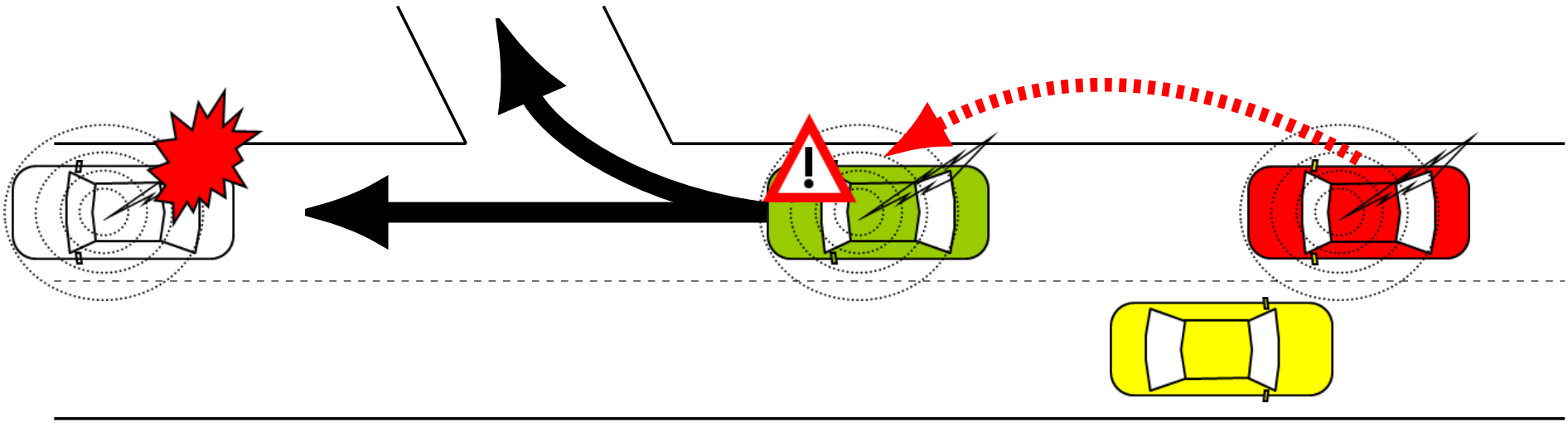
Emergency-vehicle warning



End-of-traffic-jam warning



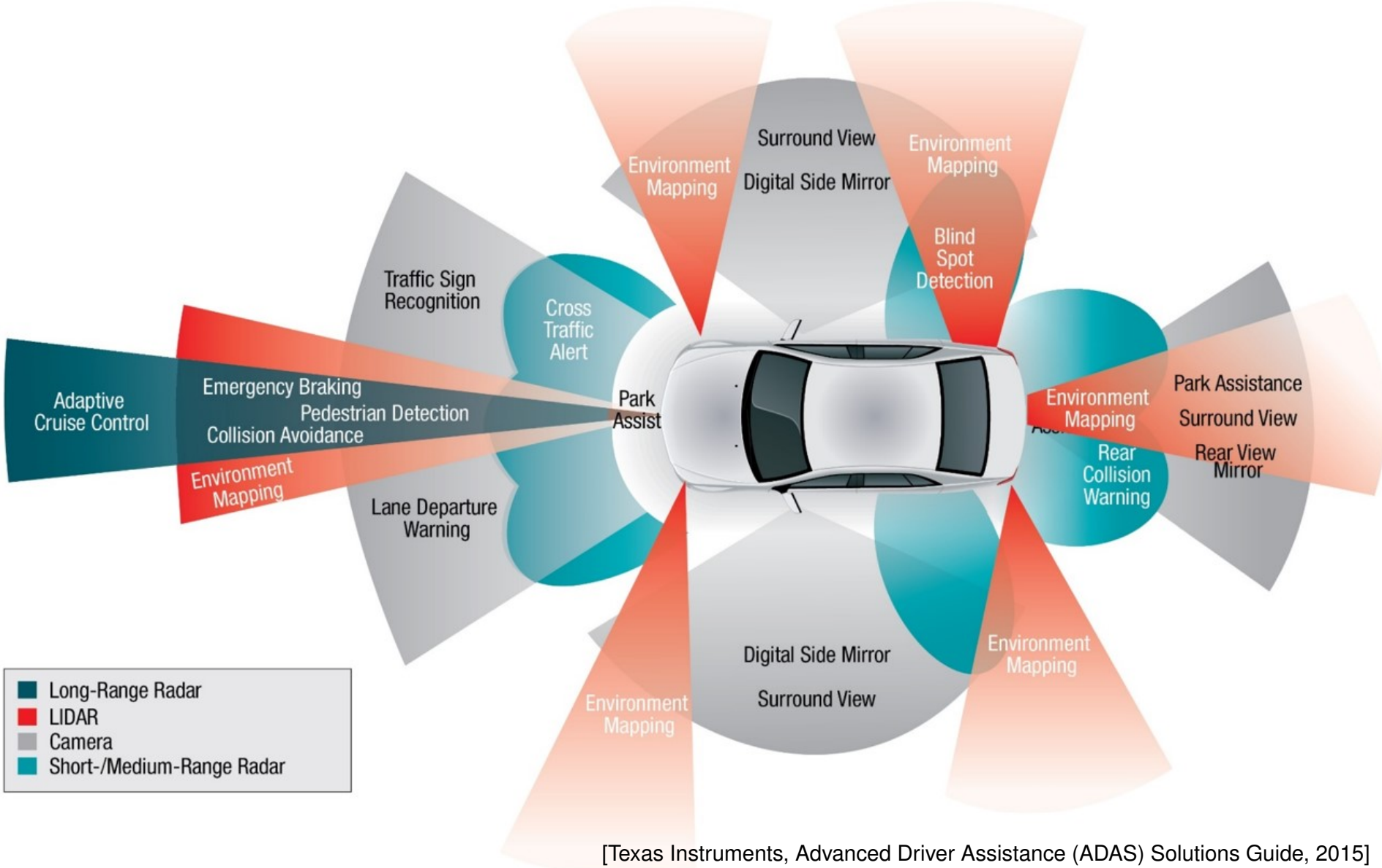
Redirection of vehicles with spoofed messages (missing **authenticity**)



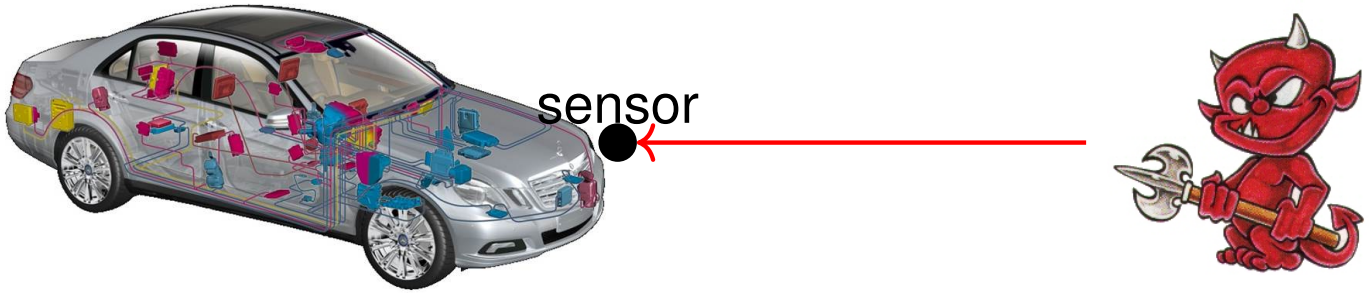
Connected, autonomous Vehicles

Example: Audi A8 Traffic Jam Pilot - SAE Level 3

[Audi AG, AutoBild]



[Texas Instruments, Advanced Driver Assistance (ADAS) Solutions Guide, 2015]



- "Sensor blinding" – render sensor (temporarily) useless by blinding
  Example:
  - laser beam on LIDAR sensor or camera [Petit et al., 2015]
- "Sensor spoofing" – provide faked input for a sensor
  Examples:
  - faked GPS signal [Kexiong et al., 2018]
  - vaseline on rain sensor
  - spoofed LIDAR objects [Petit et al., 2015]
  - spoofed camera images

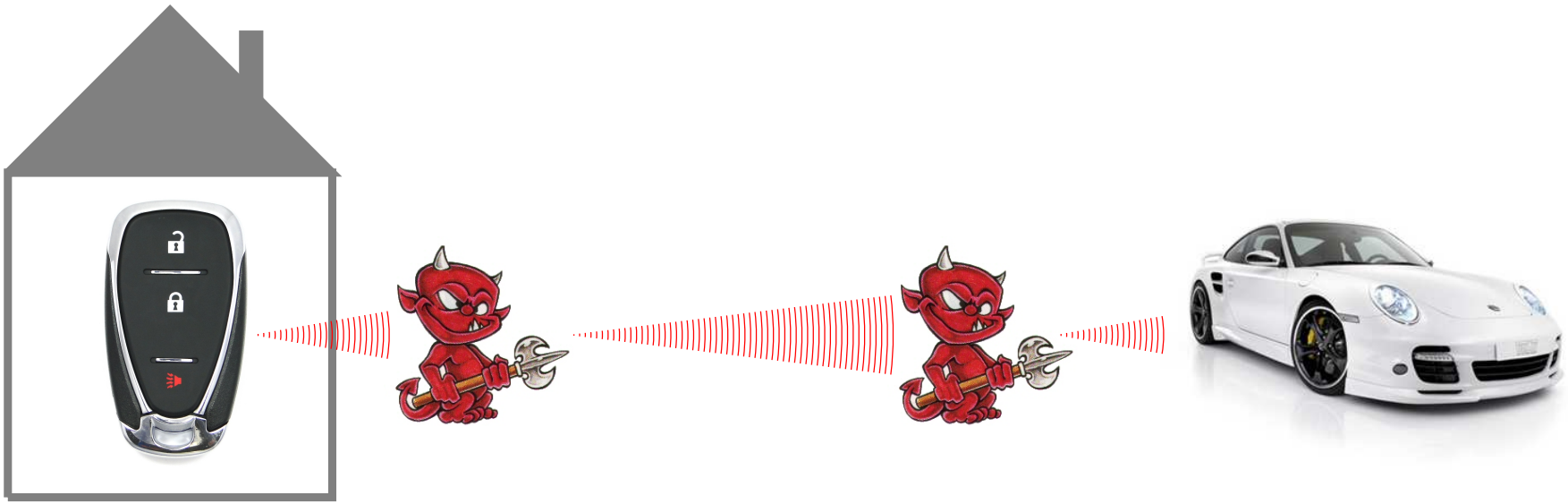
Original sign | Modified sign | Interpretation

[Sitawarin et al., 2018; Eykholt et al., 2018]

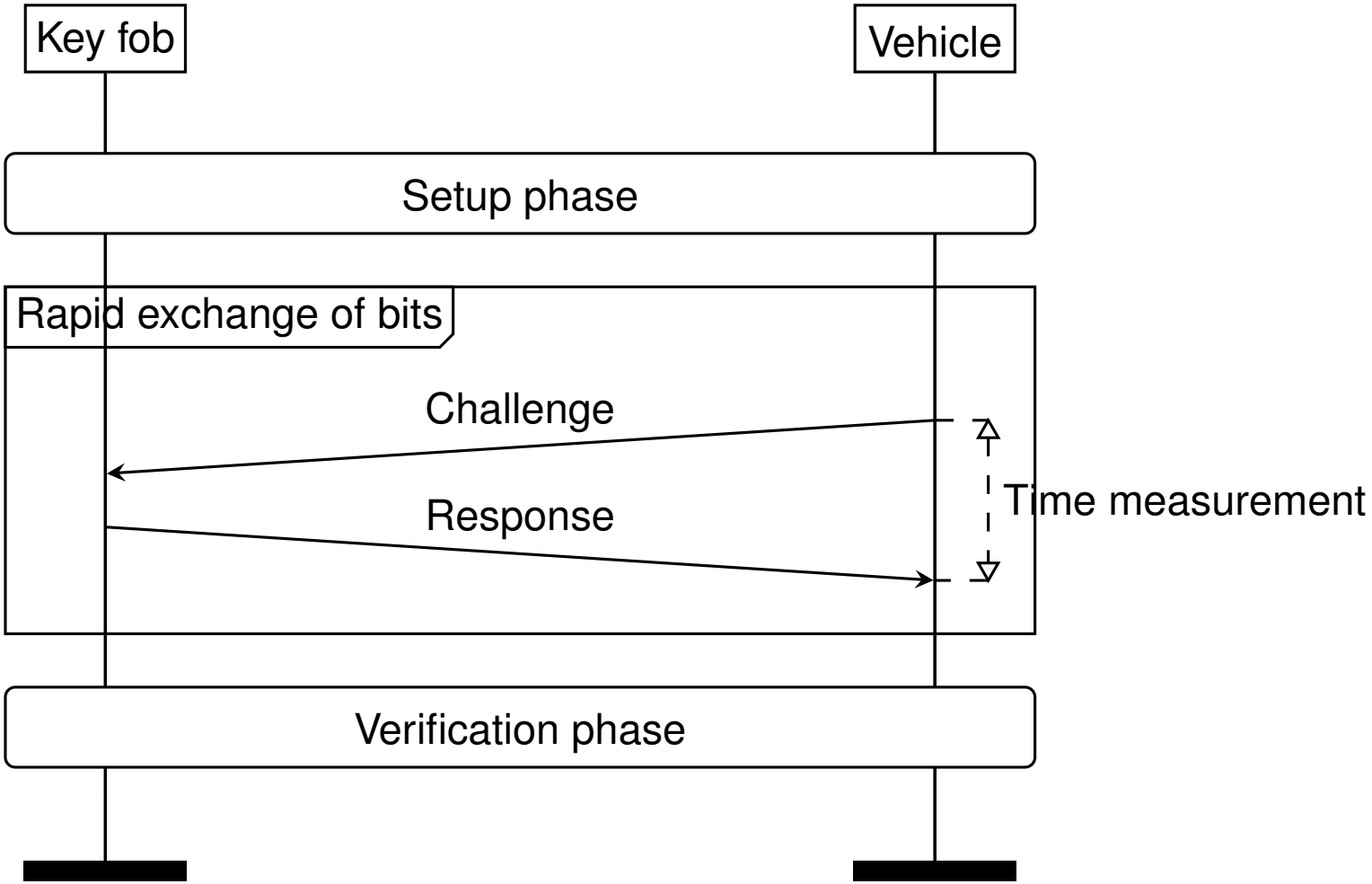
Example: Confusing Tesla Autopilot with dots on the road

[Tencent Keen Security Lab, 2019]

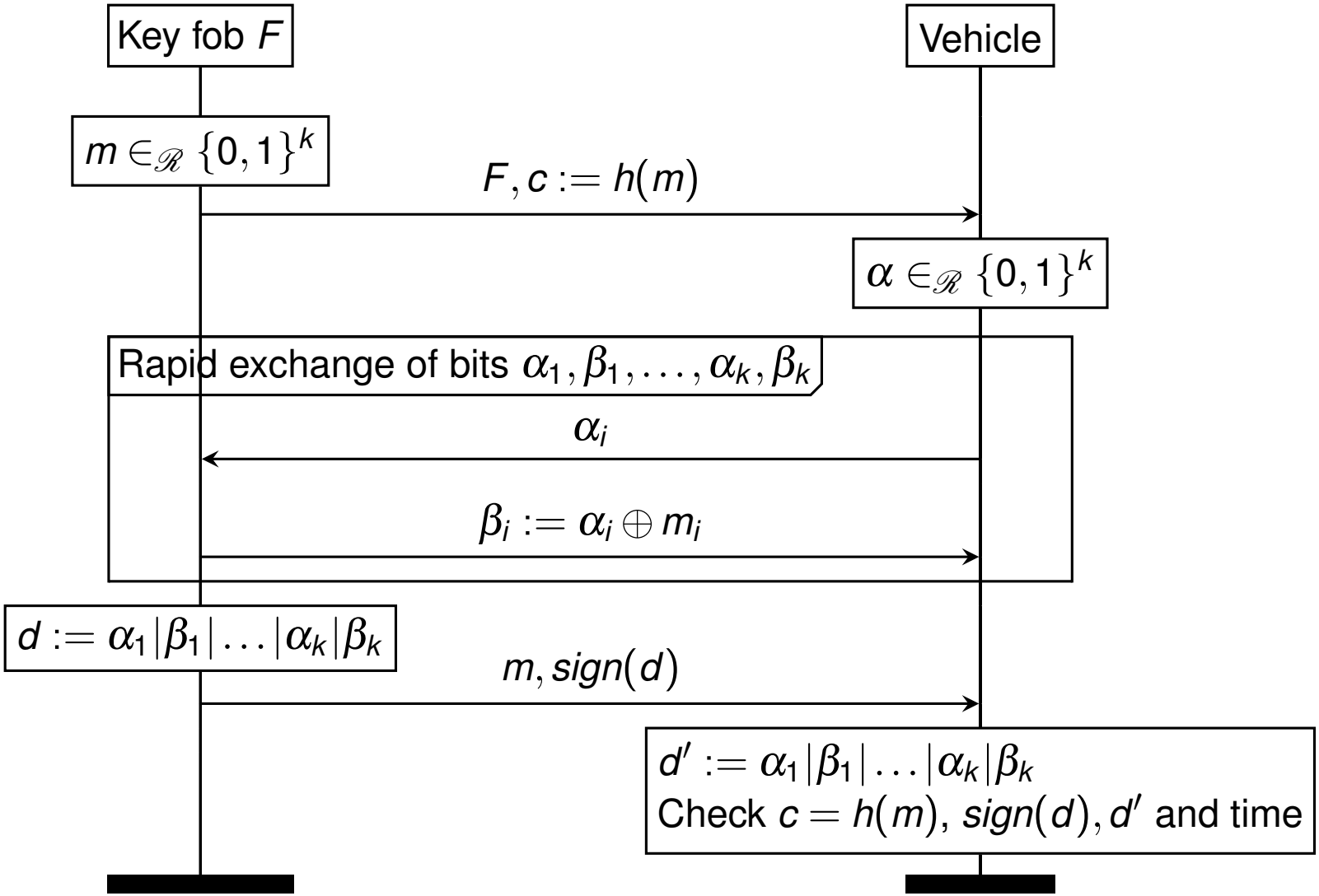
Goal: Vehicle opens if and only if the key fob is close to the vehicle, i.e. messages cannot be relayed (“authenticity of location” of key fob).



Solution: Distance Bounding Protocol



[after Cremers et al., 2011]



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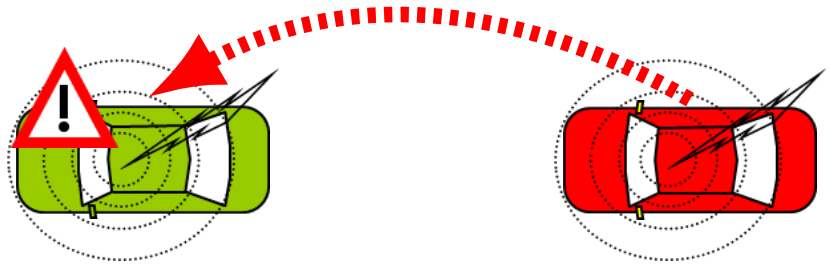


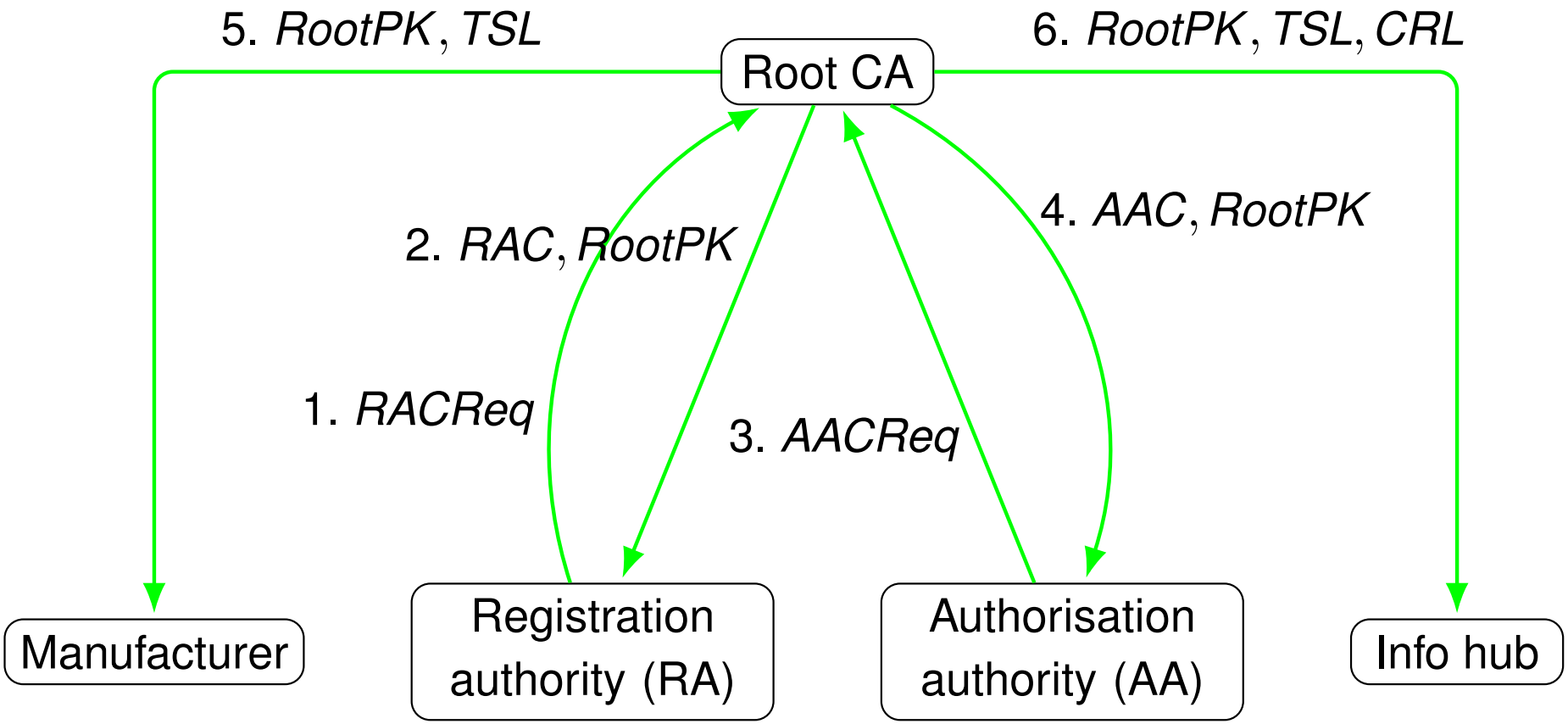
- Authenticity
  - Each message is digitally signed (certificates)
  - Challenge: throughput
- Anonymity
  - Misuse shall be detected
    $\Rightarrow$ no anonymity, only pseudonymity!
- Pseudonymity
  - Pseudonyms are assigned to vehicles by authorities.
  - Pseudonyms have to be changed frequently (unlinkability).
  - Challenge: When to change pseudonyms safely?

authenticity **and** pseudonymity

???

1. Phase: Initialisation of PKI components

$\{m\}_{Sig}$

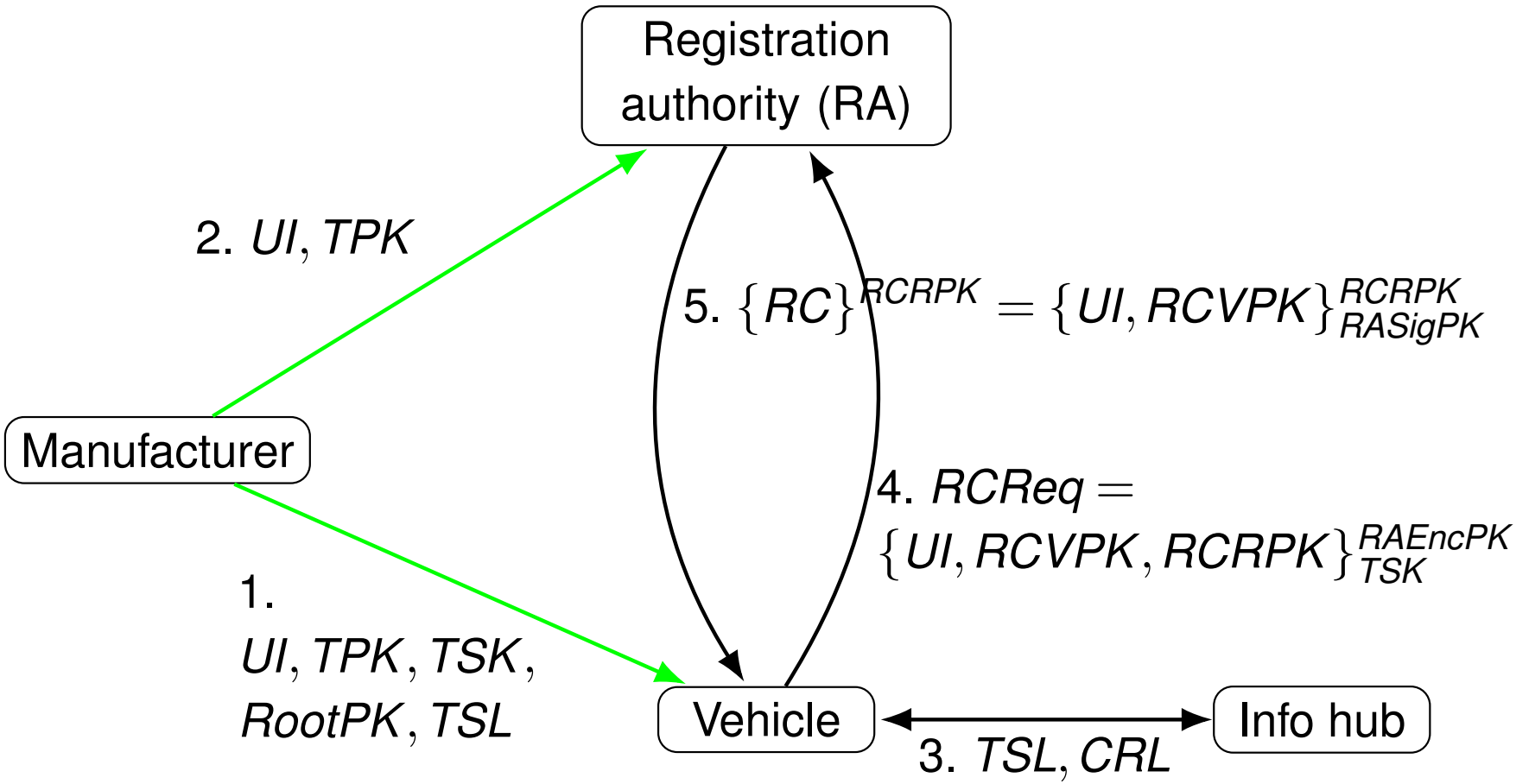


1. $RACReq = \{RA, RASigPK, RAEncPK\}_{RASigPK}$, 2. $RAC = \{RA, RASigPK, RAEncPK\}_{RootSK}$

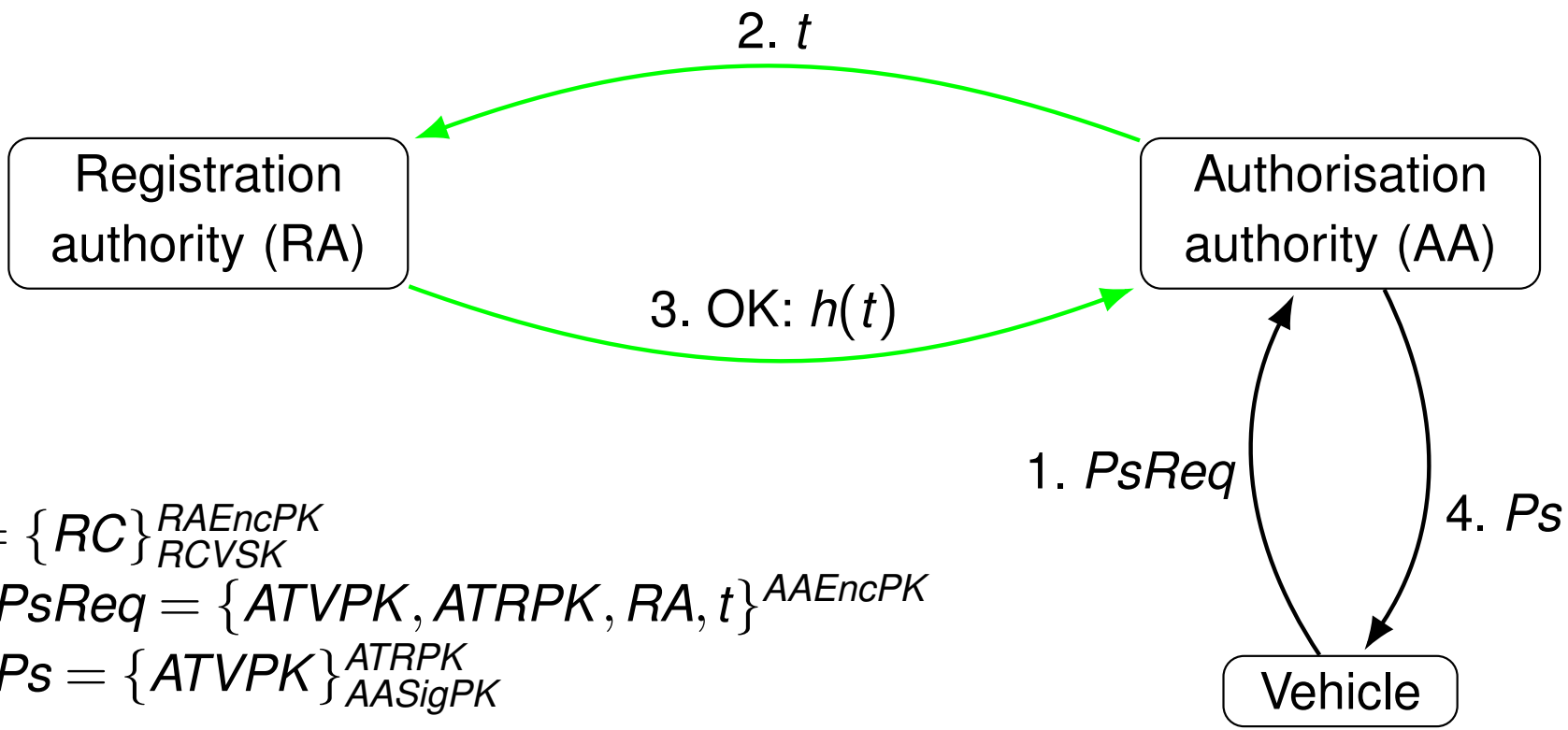
3. $AACReq = \{AA, AASigPK, AAEncPK\}_{AASigPK}$, 4. $AAC = \{AA, AASigPK, AAEncPK\}_{RootSK}$

2. Phase: Registration of vehicle

$\{m\}^{Enc}_{Sig}$



3. Phase: Download of pseudonyms



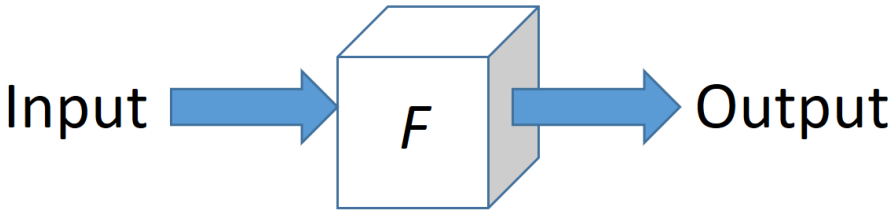
$t = \{RC\}^{RAEncPK}_{RCVSK}$

1. $PsReq = \{ATVPK, ATRPK, RA, t\}^{AAEncPK}$

4. $Ps = \{ATVPK\}^{ATRPK}_{AASigPK}$

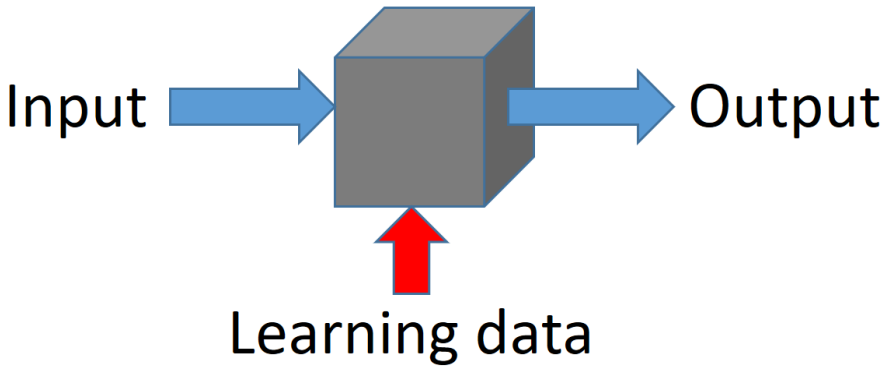
- Common methods to establish **reasonable grounds** for trust in security:
  - security analysis (experts, code analysis, formal methods, verification, ...)
  - security tests (penetration tests, fuzzing tests, ...)

Classic control systems



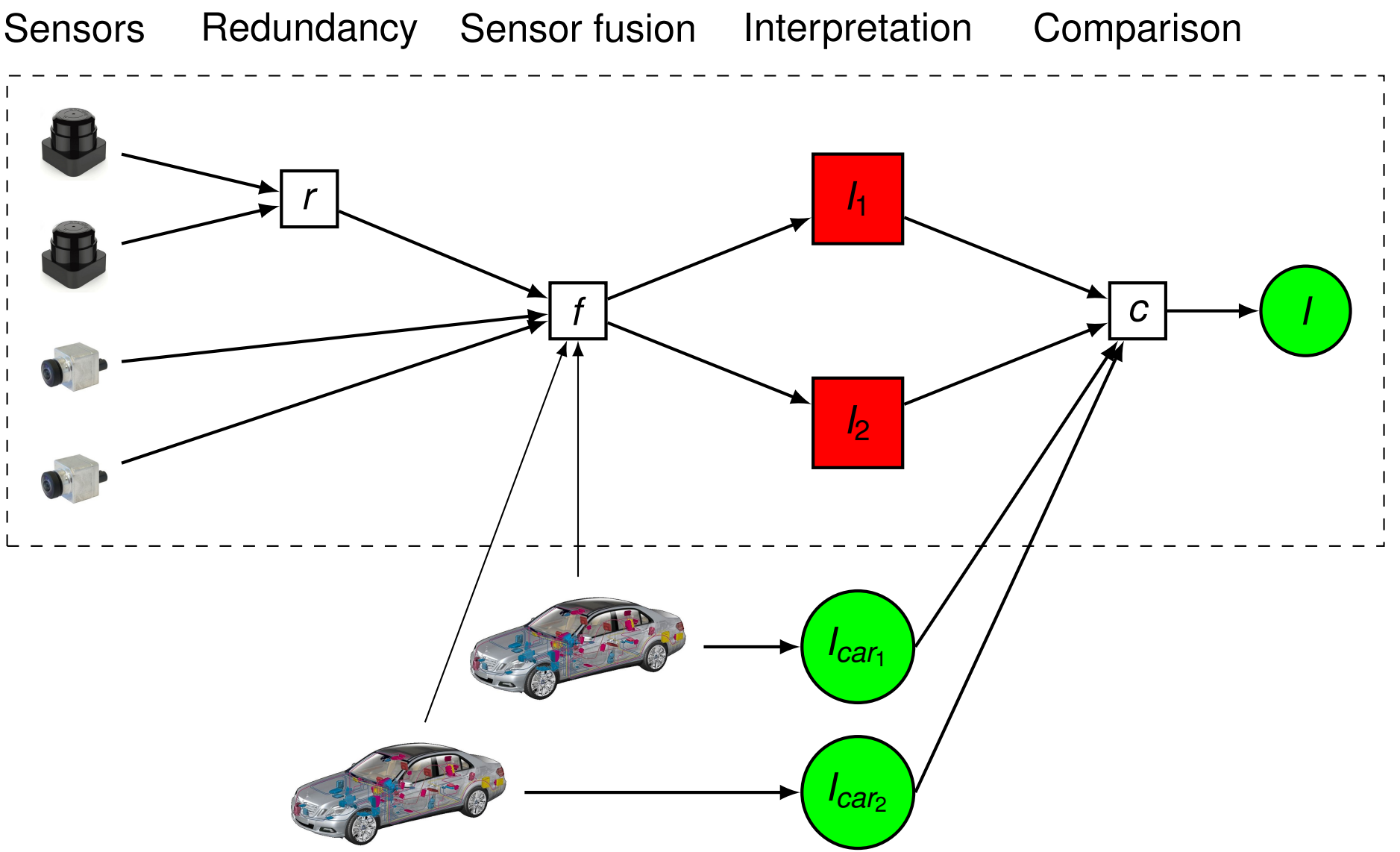
Security analysis of function *F* ✓

Machine learning control systems



Security analysis of function ???

- Suitable methods for security analysis of machine learning systems are necessary.


Sensors
Redundancy
Sensor fusion
Interpretation
Comparison
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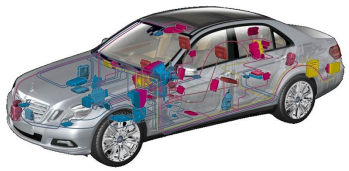
f
I_1
I_2
c
I
I_{car_1}
I_{car_2}

100 MLOC  $\neq$  40 MLOC

- limited resources (hardware, computing power, network)
  $\rightarrow$ limited applicability of classic security mechanisms
- long duration of use of vehicles (e.g. VW: $\varnothing$ 26 years)[1]
  $\rightarrow$ out-dated HW/SW leading to security weaknesses
  $\rightarrow$ vehicles will need patches and updates (SW & HW)

The security of vehicles needs to be better than the security of PCs.

- more modular and more centralised architecture of IT in vehicles
- more standardised interfaces and components
- methods for verification and testing of security of vehicles

[1] WirtschaftsWoche, 28. Juli 2014, Seite 11

Summary

- Connected (autonomous) vehicles are complex, distributed IT systems embedded in distributed IT systems.
- There is the danger of
  - attacks on communication,
  - attacks on components,
  - attacks on sensors,
  - malicious modification of the environment.
- Specific security measures are necessary to protect vehicles and road users.
- New and improved methods for the analysis and test of security for connected, autonomous vehicles are required.