IT-SECURITY FOR E-MOBILITY

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IDC 2019, Scientific School

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St. Petersburg, Russia

Fraunhofer SIT

Member of CRISP Center for Research in Security and Privacy

Fraunhofer Institute for Secure Information Technology SIT

Leading Institution for Applied Cybersecurity Research in Germany

Founded: 1961

Employees: 180

Annual budget: 11 m€

Chair at TU Darmstadt: 1

Additional Professorship at TU Darmstadt: 1

Professorships at h_da: 1

Main Locations: 3 (Darmstadt, Birlinghoven, Mittweida)

Additional locations: 2 (Jerusalem, Singapore)

Fields of Expertise

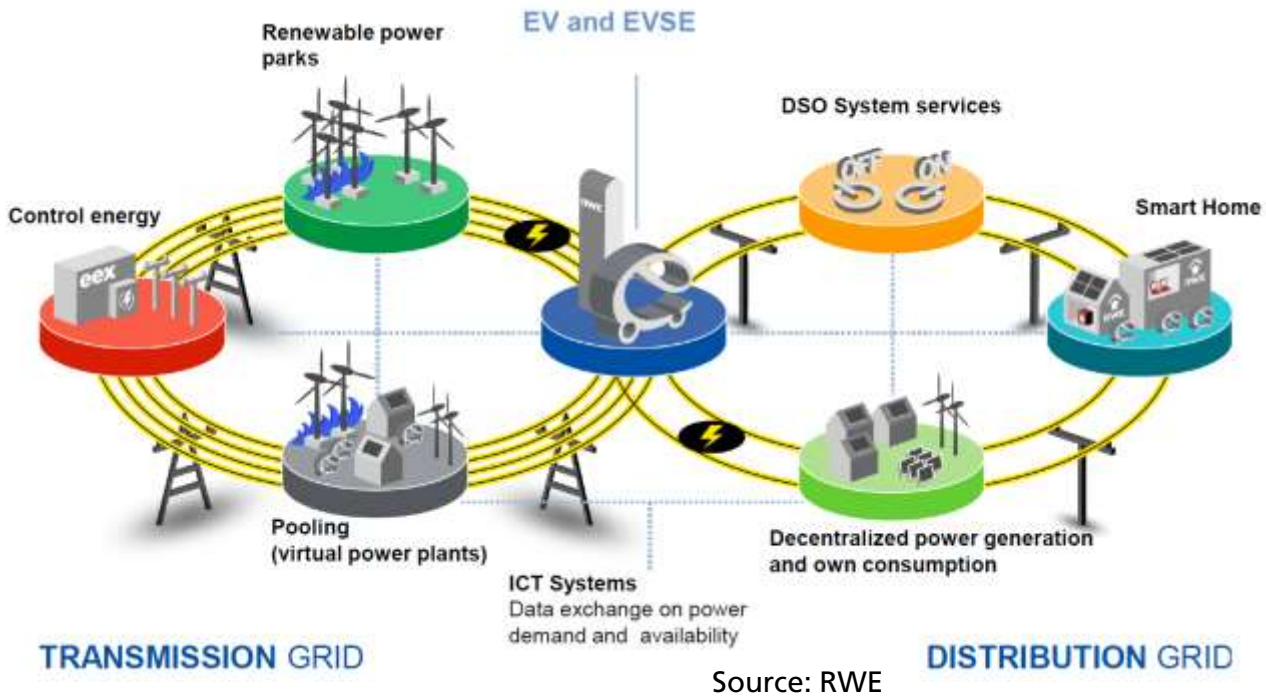
- Automotive Security
- Cloud Computing
- Cyber-Physical Systems
- Identity & Privacy
- Industry 4.0
- Mobile Systems & Networks
- Secure Engineering
- Security Management
- Security Test Lab
- …

Engaged in

- CRISP
- Fraunhofer-Competence Centre “Privacy & Data Protection in the Digital World”
- Learning Laboratory Cybersecurity
- Digital Hub Cybersecurity Darmstadt

Introduction

- Electric mobility is an important technology to reduce emissions in cities
- European Commission developed a roadmap with initiatives towards a competitive and resource efficient transport system
  - By 2030, reduce transport emissions by 20% and only 50% conventionally-fueled cars in cities
  - By 2050, reduce transport emissions by 60% and no conventionally-fueled cars in cities
- Electric mobility will play a major role in the future smart grid



Source: RWE

Introduction

- Smart charging drives the energy revolution forward
  - Satisfy user requirements
  - Demand response and load management
  - Vehicle-to-Grid (V2G)
- Information and communication technology (ICT) required
- However, new security and privacy threats arise
  - Threats to (safety-critical) systems
    - Influence the power grid, inject malware to vehicles etc.
  - Monetary threats
    - Charging for free or on the account of someone else
  - Privacy threats
    - Generation of movement profiles

Source: https://thehackernews.com/2017/06/electric-power-grid-malware.html

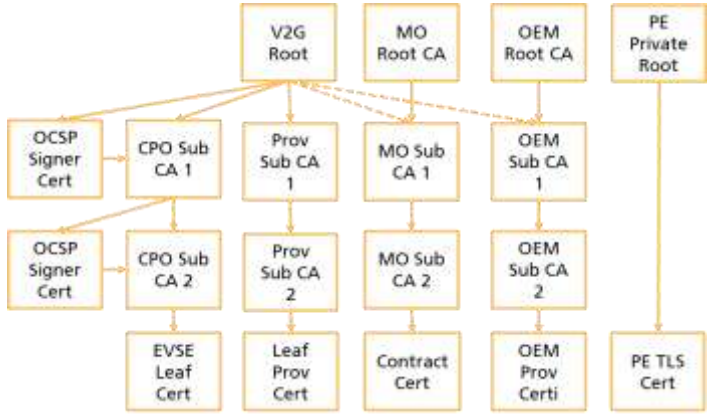
Source: http://ccc.de/en/updates/2017/e-motor

Payment Options

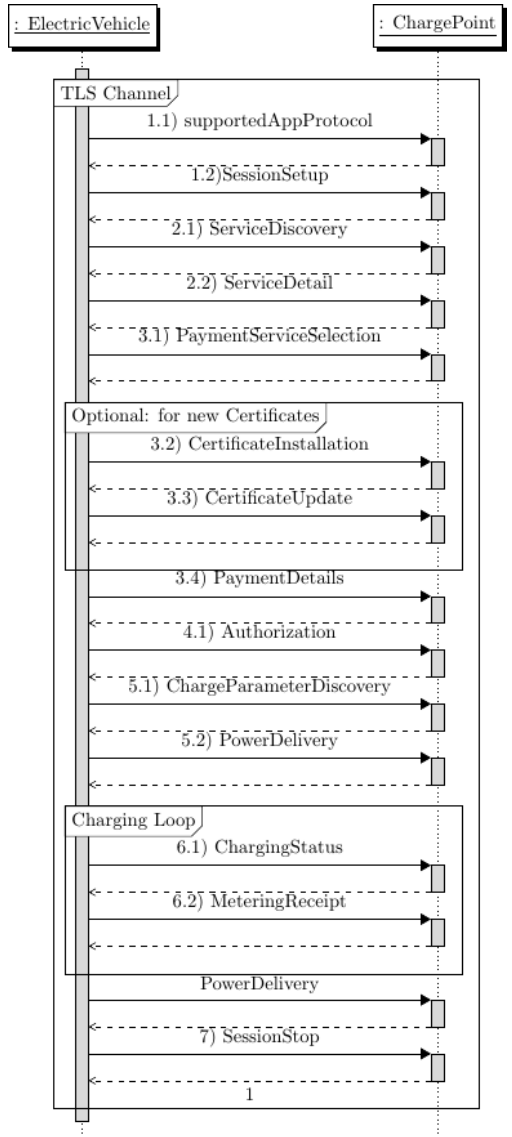
- Charging costs are included in fees for other services
- Cashless payment using EMV reader (not often used)
- External Authentication Means (EIM)
  - (RFID) Charging Card
  - Smartphone App
- Plug and Charge (PnC) using ISO 15118

Charging Card [Entega]

Smartphone App [Fraunhofer SIT]

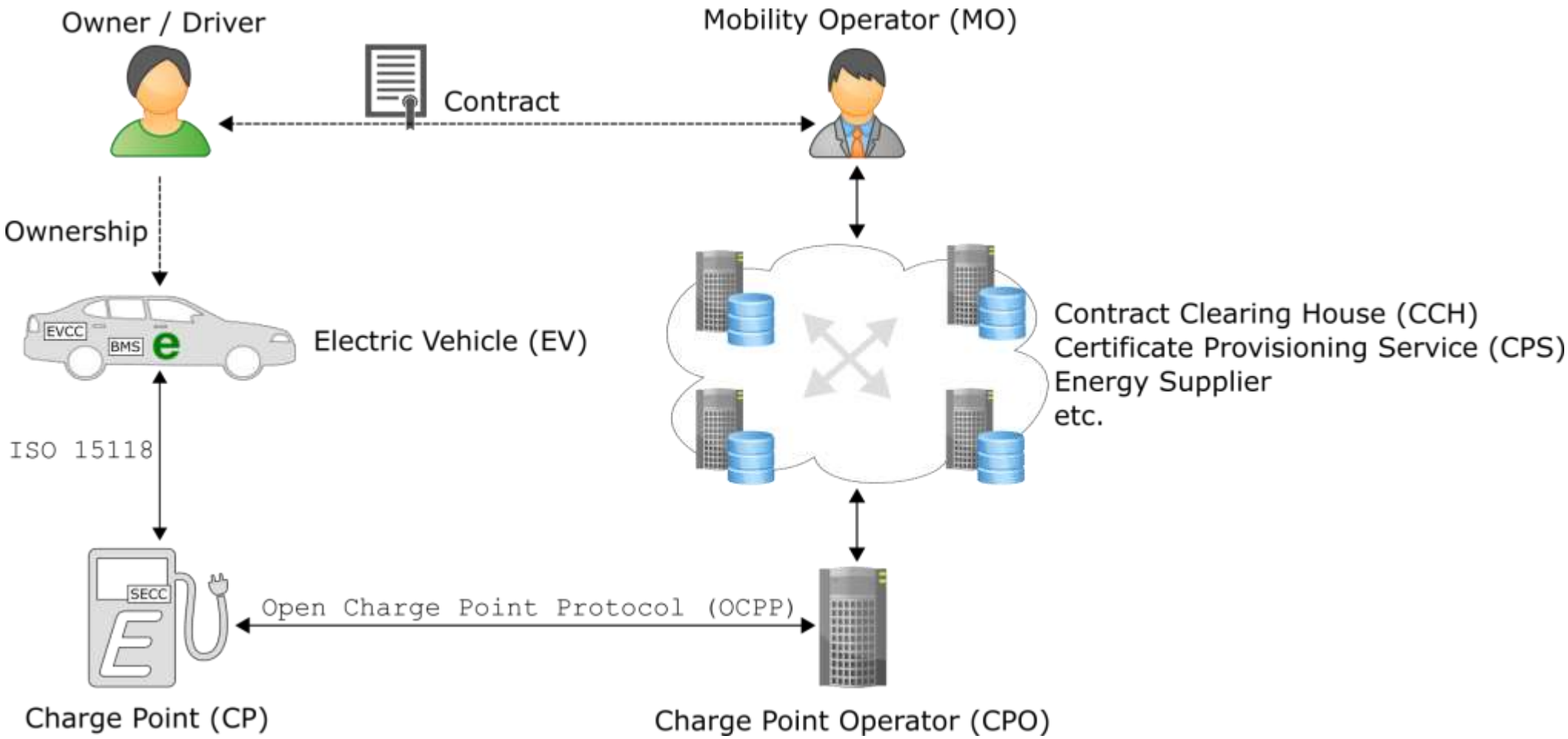


ISO 15118: PKI

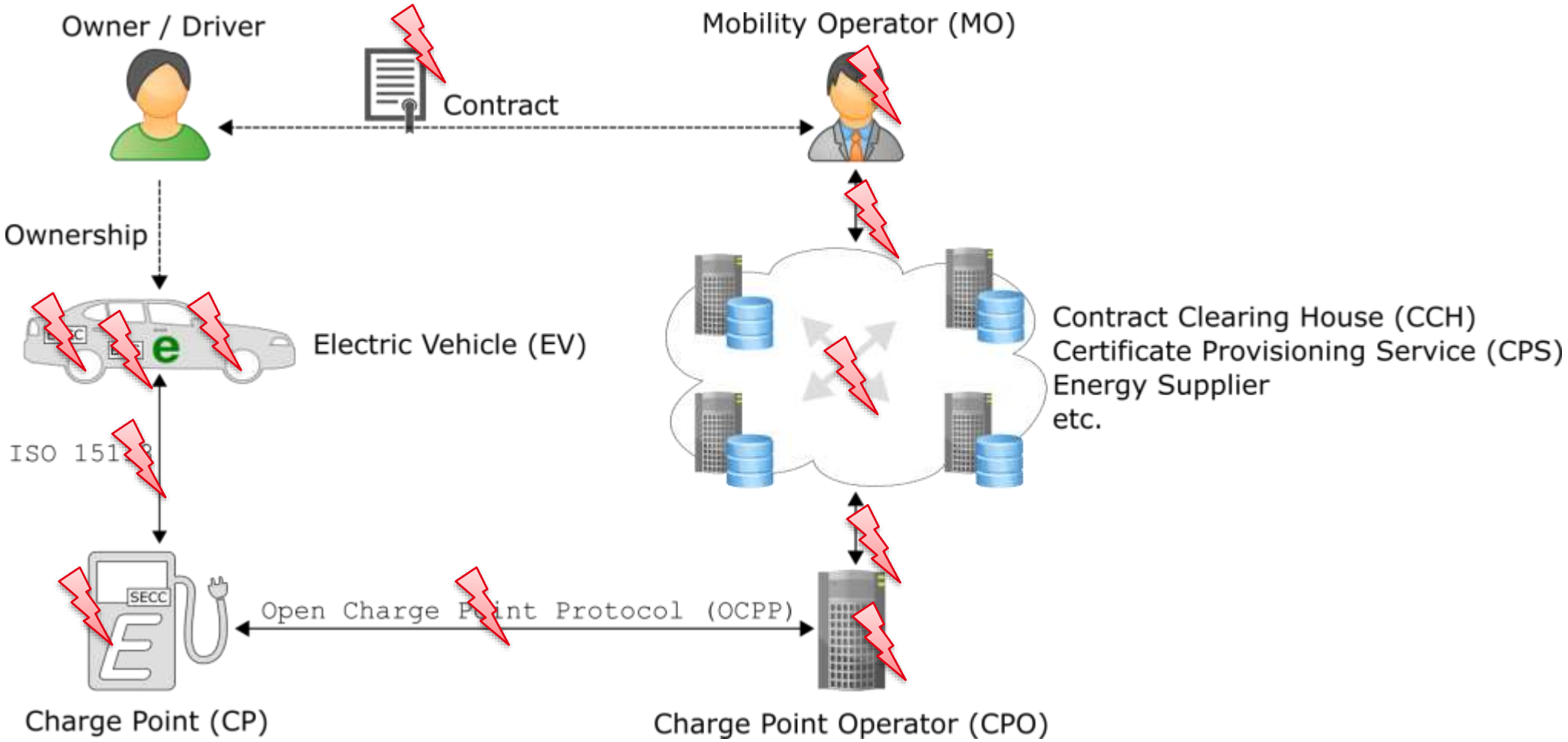


ISO 15118: (TLS) Communication

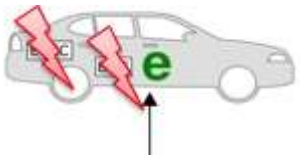
Typical PnC Architecture



IT-Security and Privacy Challenges

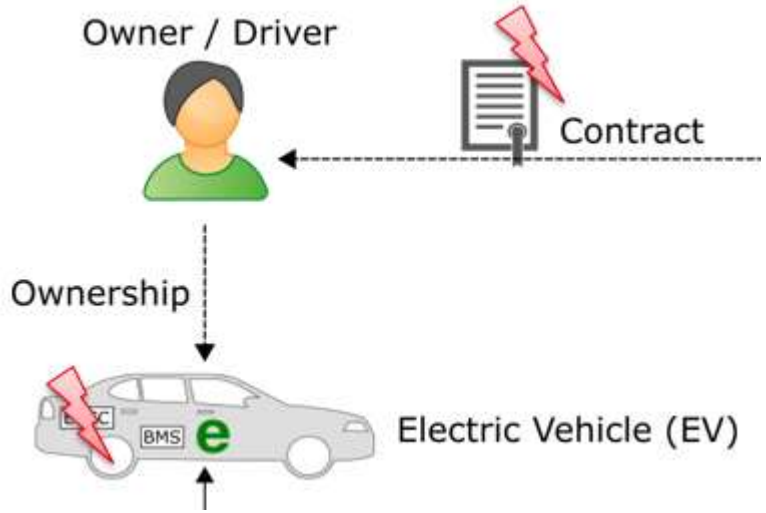


Attacks on Electric Vehicles

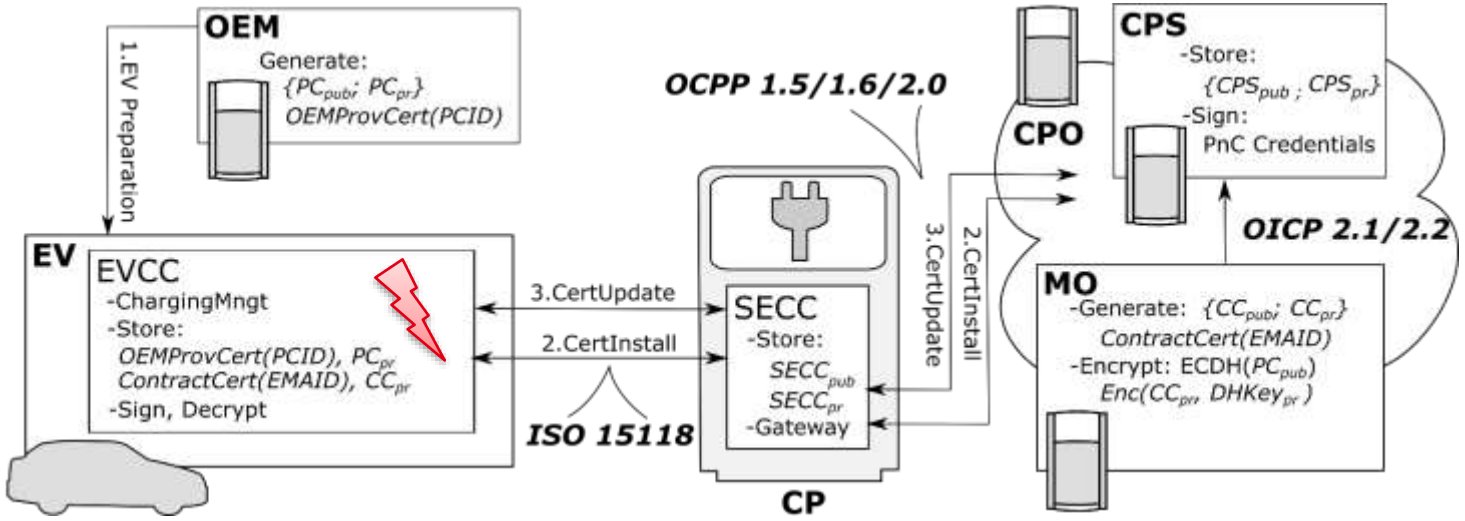


- Electric Vehicles (EVs) could be attacked via communication interfaces or physical access
- Example: Attack of an malicious Charge Point (CP)
  - Data connection between CP and EV could be used for attacks on an EV
    - Data connection examples: PLC in ISO 15118, CAN in CHAdeMo
  - Vulnerabilities in the EV's communication controller could be exploited to
    - Overcharge the batteries
    - Inject messages to the E/E system (if no appropriate separation is deployed)
- By compromising a large number of EVs, attacks on the power grid may be possible, e.g., by influencing the load management

Attacks on ISO 15118 Credentials



- EVs store critical credentials
  - ISO 15118 OEM provisioning certificate and private key
  - ISO 15118 contract certificate and private key
- Currently no requirements for secure key storage and usage



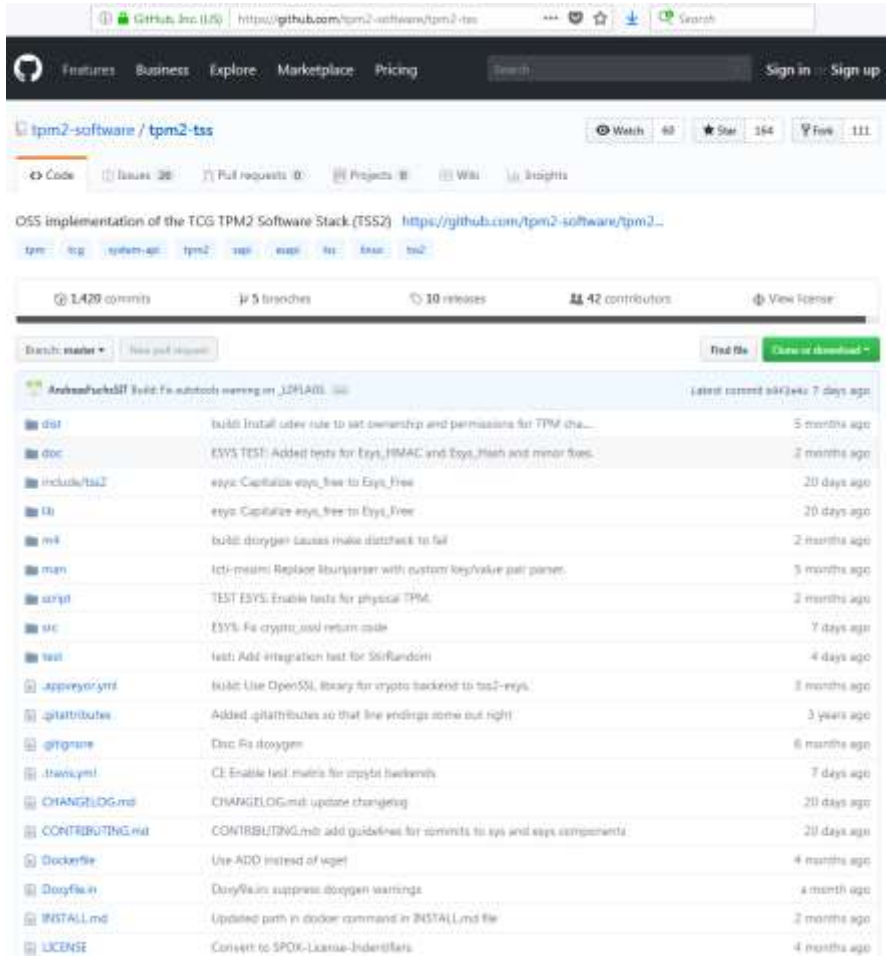
➔ Attacker could easily read out credentials

Trusted Computing – Overview

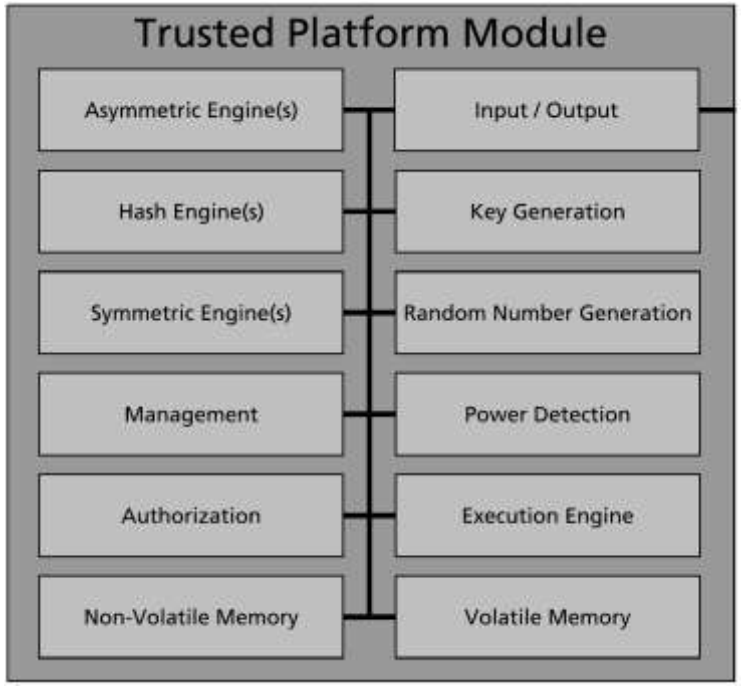
- Hard- and software to enforce that a system behaves consistently and in expected ways
- More than only the Trusted Platform Module (TPM)
  - TPM 2.0 can act as Hardware-Trust-Anchor
  - Hardened against physical attacks
  - Provides secure storage, execution, and more
- Additional Trusted Computing features
  - Measured Boot
  - Attestation
  - Secure device identities …

➔ Trusted Computing as basis for Platform Security

© Infineon

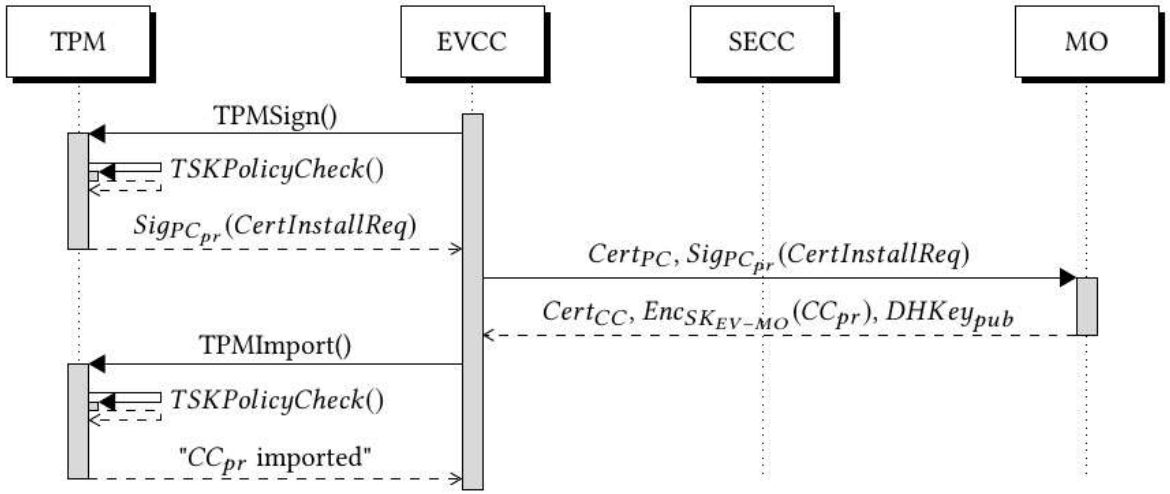


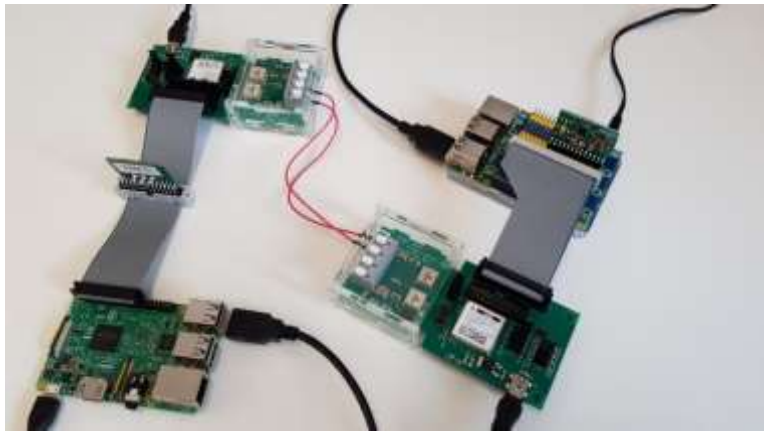
Trusted Platform Module (TPM) – Overview

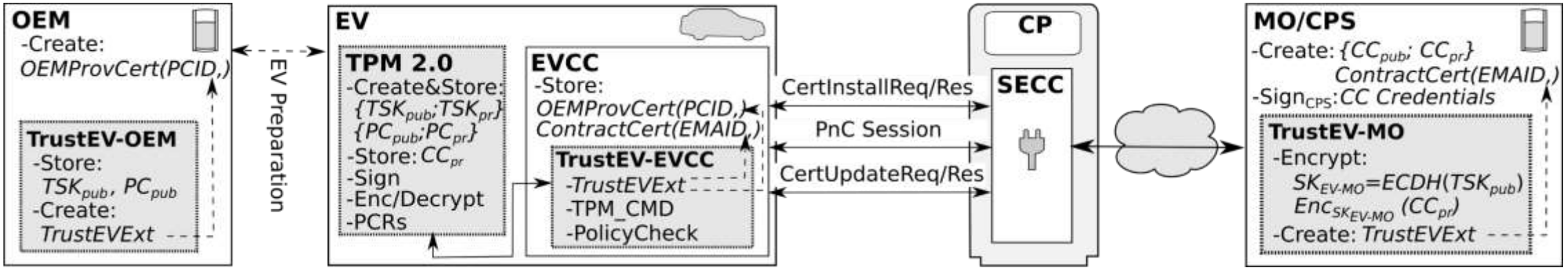


- TPM is a type of Hardware Security Module (HSM)
- Two Specifications: TPM 1.2 and TPM 2.0
  - Specifications are not compatible
  - TPM 2.0 total rewrite and suitable for embedded systems
- Functionalities in Version 2.0
  - Device identification
  - Secure generation, storage, and usage of keys
  - Root of trust for storage, measurement, and reporting
  - Cryptographic agility
  - Enhanced authorization
  - Flexibility (TPM library profiles, dedicated hardware chip vs. firmware TPM …)
  - Encrypted communication between TPM and host or even backend systems
  - Monotonic counters
  - etc.
- Automotive qualified TPMs are available currently from Infineon

Securing ISO15118 Credentials

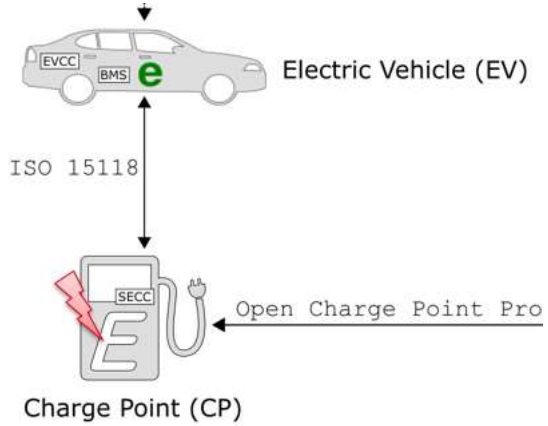




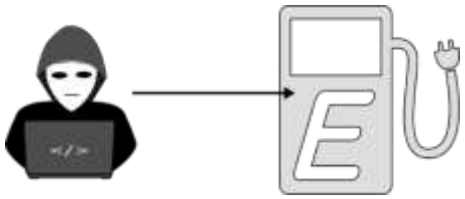


[FKKZ20] A. Fuchs, D. Kern, C. Krauß, M. Zhdanova. TrustEV: Trustworthy Electric Vehicle Charging and Billing, 2020

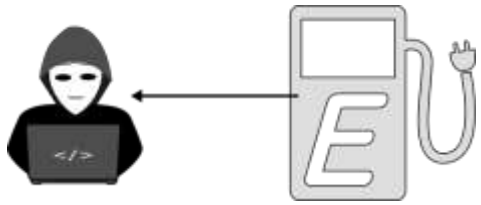
Attacks on Charge Points



- Attacker can attack a CP remotely or via physical access
- CP stores and processes critical data, e.g., (private) keys, billing data, metering data, log data, authorization data, configuration data
- Attacker could …



… manipulate billing data

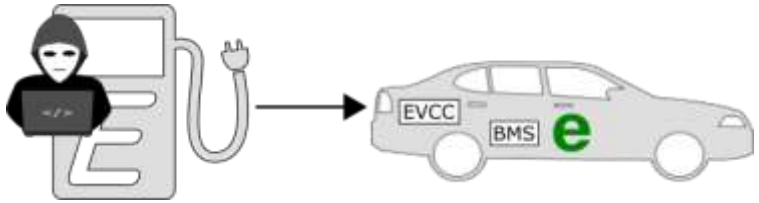


… read out keys and data

… read out personal data

… manipulate firmware

… prevent charging



… attack the vehicle

… and many more, e.g., manipulate the power grid (by compromising a large number of CPs)

Attacks on Charge Points – Examples

- Attacks using insecure maintenance ports
  - Attack on Keba P30 CP [Dal17]
    - Insecure firmware update process via USB enables installation of malicious firmware
- Attack on CP authentication mechanism
  - Fastned / ABB [Dal17]
    - Vehicle MAC address is used for authentication
    - Spoofing of MAC address possible to charge on the account of someone else

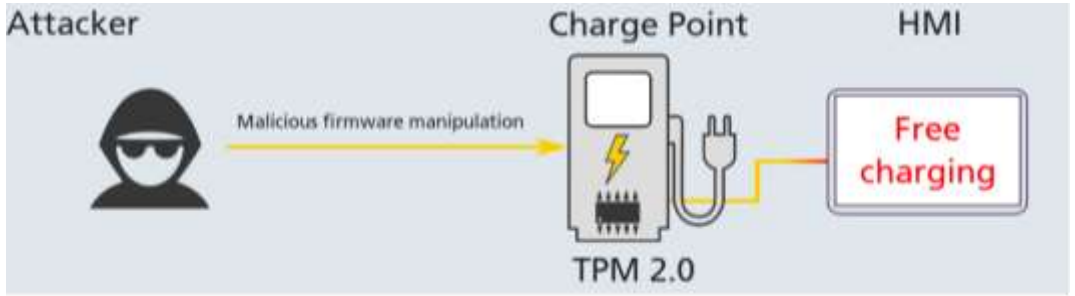
➔ A (large number) of compromised CPs, could attack the power grid or attack electric vehicles

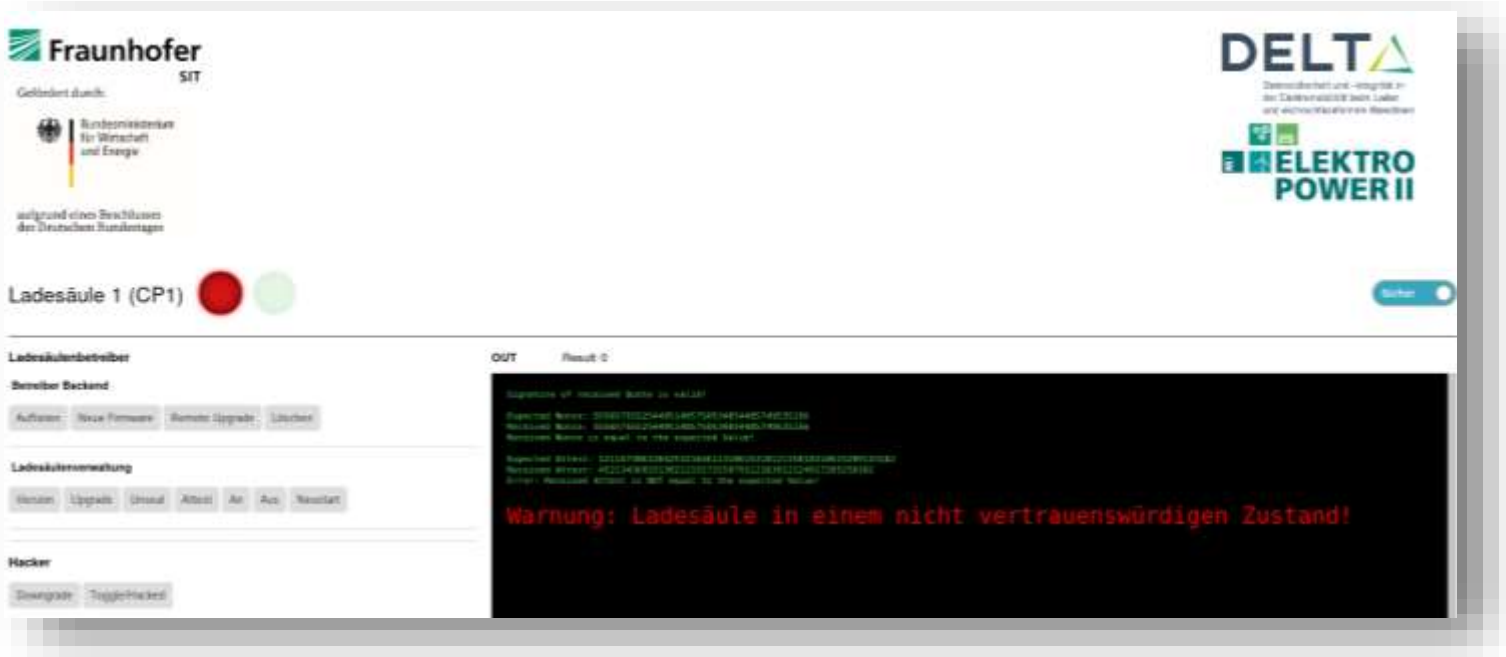
Attack on Keba P30 [Dal17]

[Dal17] M. Dalheimer. Ladeinfrastruktur für Elektroautos: Ausbau statt Sicherheit - Warum das Laden eines Elektroautos unsicher ist, 34C3, 2017

Securing Charge Points – Measured Boot and Remote Attestation

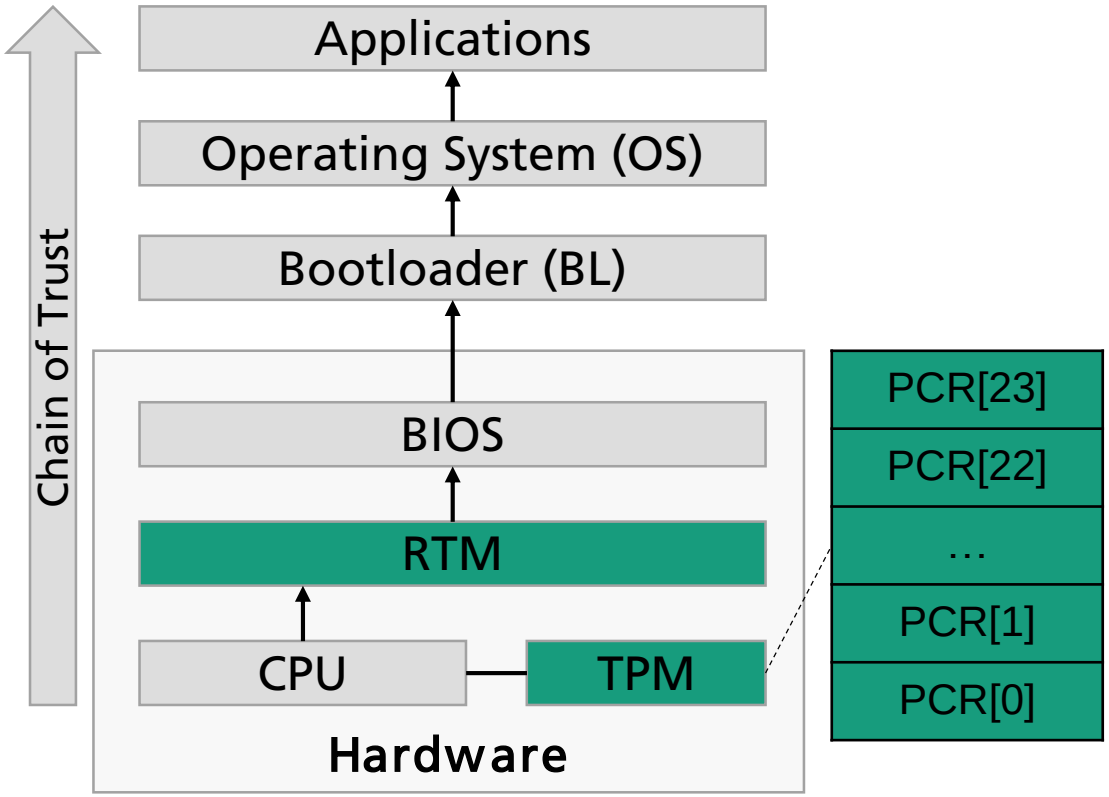
- Local verification of CP state too expensive and slow
  - Would require regularly sending a skilled technician to analyze all CPs
- Remote attestation to detect firmware manipulations using TPM-based measured boot



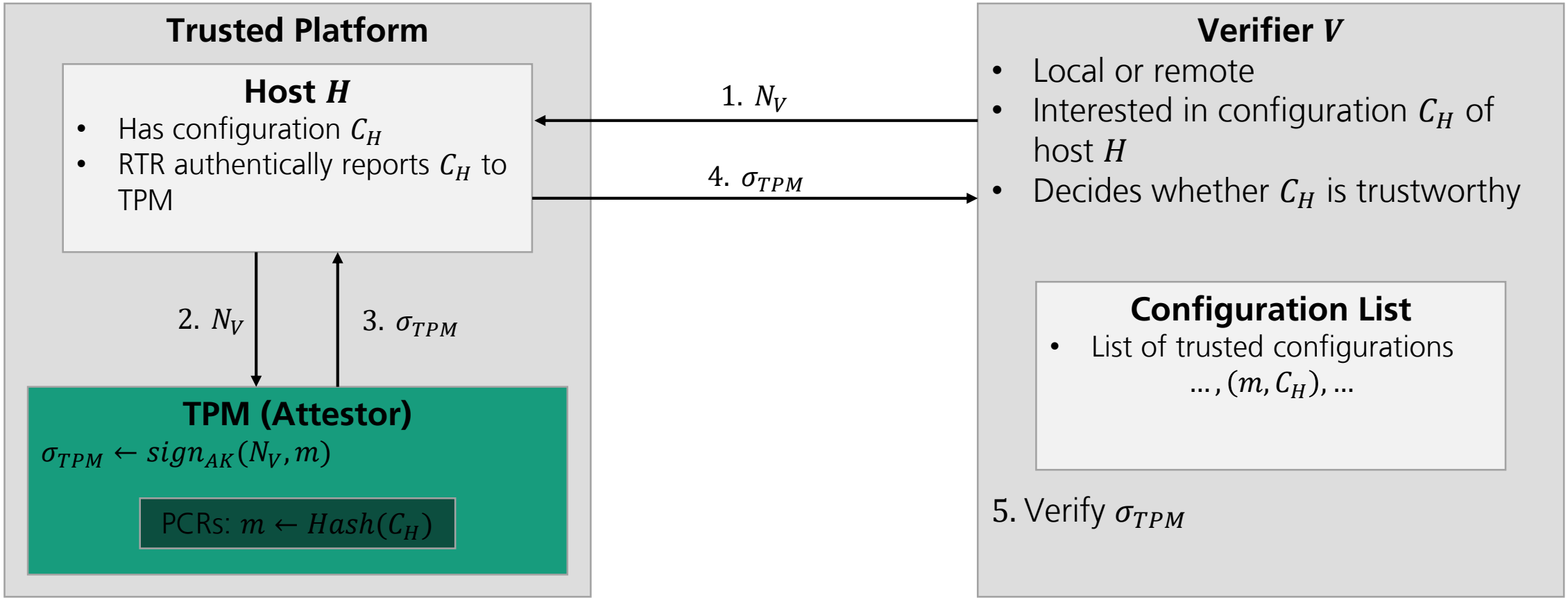


Securing Charge Points – Measured Boot using TPM

- Measurements of software states are stored in Platform Configuration Registers (PCRs)
  - PCRs usually initialized with 0
  - PCRs are extended with software states, i.e., $PCR[n]_{i+1} = Hash(PCR[n]_i || measurement)$
    - RTM measures BIOS
    - BIOS measures BL
    - BL measures OS
    - OS measures Applications
- PCRs for Authorization
  - PCRs must define a specific state to satisfy a policy
  - Use cases, e.g.,
    - Sealing hard disk encryption key
    - Sealing VPN keys
    - Attestation

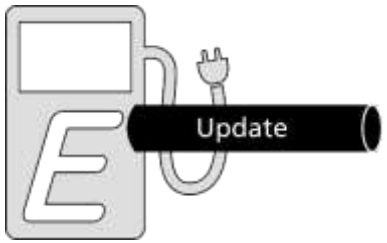


Securing Charge Points – Remote Attestation using TPM (simplified)

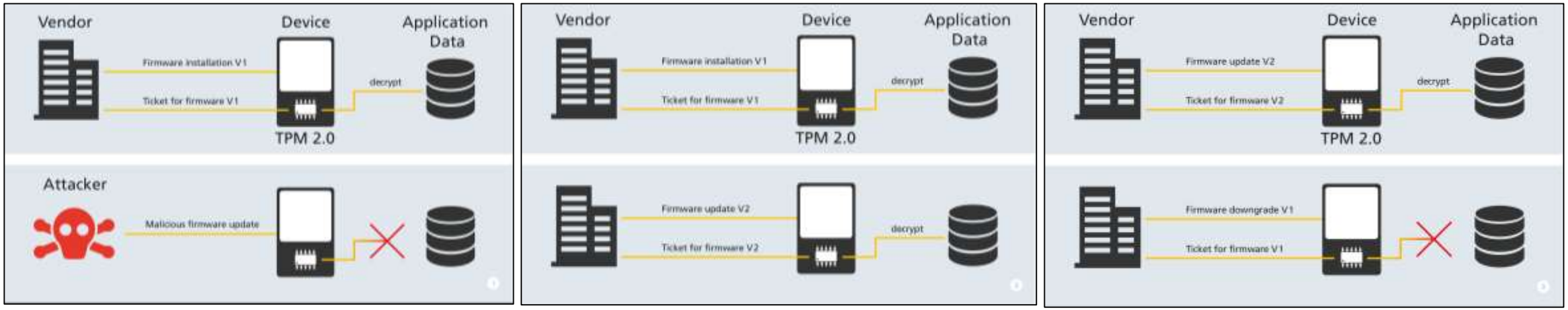


N_V: Nonce chosen by V
C_H: Current configuration of host H
σ_{TPM}: Signature over PCRs and Nonce using AK

Securing Charge Points using Trusted Computing – Secure Update



- Secure Over-the-air (OTA) update required for bug-fixes (functional, security), feature upgrades
- TPM 2.0 based Secure OTA Update Protocol
  - Authenticity, integrity, and confidentiality of update package
  - Downgrade protection, stop system if an older firmware has been installed
  - Allow only the original manufacturer to read / write firmware



[FKR16] A. Fuchs, C. Krauß , J. Repp. Advanced Remote Firmware Upgrades Using TPM 2.0, IFIP SEC, 2016

Attacks on Privacy

- Charging and billing process may lead to privacy problems
- Current (PnC) protocols do not consider privacy protection
  - ISO 15118 User / Contract ID can be read by all entities
  - Tag IDs of charging cards can be read by all entities
- Involved entities gain knowledge of a lot of personal data which is not required for their operation
- Identification of user and used charge points possible
  - Generation of movement or user profiles
  - Possibly deducing driving habits
- Current (PnC) protocols violate the European General Data Protection Regulation (GDPR)

	EV	CP/CPO	CCH	MO
CDR		✓	✓	✓
Charging Parameters	✓	✓		
Contract Certificate	✓	✓		✓
EMAID	✓	✓	✓	✓
EVCCID	✓	✓		
EVSEID	✓	✓	✓	✓
Location	✓	✓	✓	✓
MeterID	✓	✓	✓	✓
Power Consumption	✓	✓	✓	✓
Time	✓	✓	✓	✓

Example: Personal Data in PnC [ZSZK18]

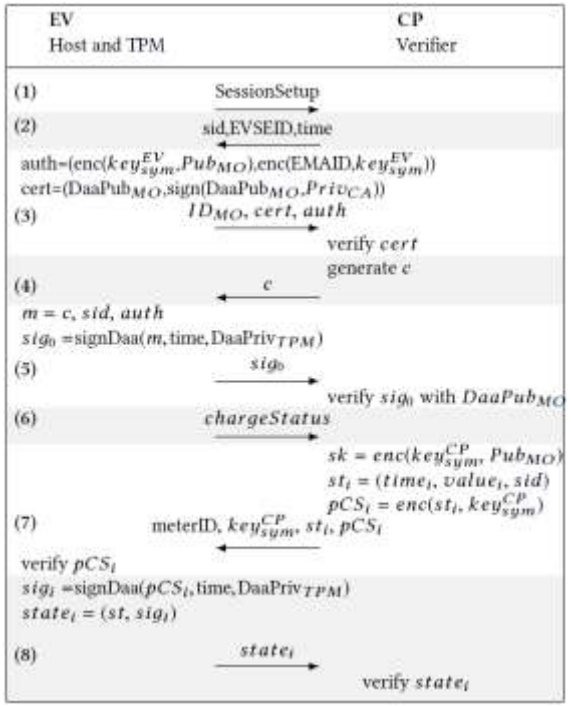
[ZSZK18] D. Zelle, M. Springer, M. Zhdanova and C. Krauß. Anonymous Charging and Billing of Electric Vehicles, ARES, 2018

Protecting Privacy

- Transparency Enhancing Technologies (TETs)
  - Inform user and get consent
  - Enable EV users to make informed and effective decisions on data protection relevant information sharing

TET developed within the SeDaFa project
(HMI design by IAD, TU Darmstadt)

- Privacy Enhancing Technologies (PETs)
  - Example: Privacy- preserving billing process using Direct Anonymous Attestation (DAA)



[ZSZK18] D. Zelle, M. Springer, M. Zhdanova and C. Krauß. Anonymous Charging and Billing of Electric Vehicles, ARES, 2018

Conclusion

- E-mobility will be an important part of our mobility
- Technologies, standards etc. still under development
- Many security and privacy challenges require additional research and development
- Ongoing research at Fraunhofer SIT
  - Development of draft protection profiles for CPs, EVs, and backend connection
  - Development of technical guidelines and prototypical implementations
  - Integration and evaluation of security solutions in test fields, e.g., charging infrastructure of the Fraunhofer LamA (Charging at Work) project

Fraunhofer SIT: Secure Charging Demonstrator

Contact

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