Electric Vehicle Authentication and Secure Metering in Smart Grids

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A short resume of the presenter

Yutaka Yamaguchi

- Fourth year student at Kyushu University
- Japanese national

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Topics of research

- Moving Target Defense
- Attacks Tracer

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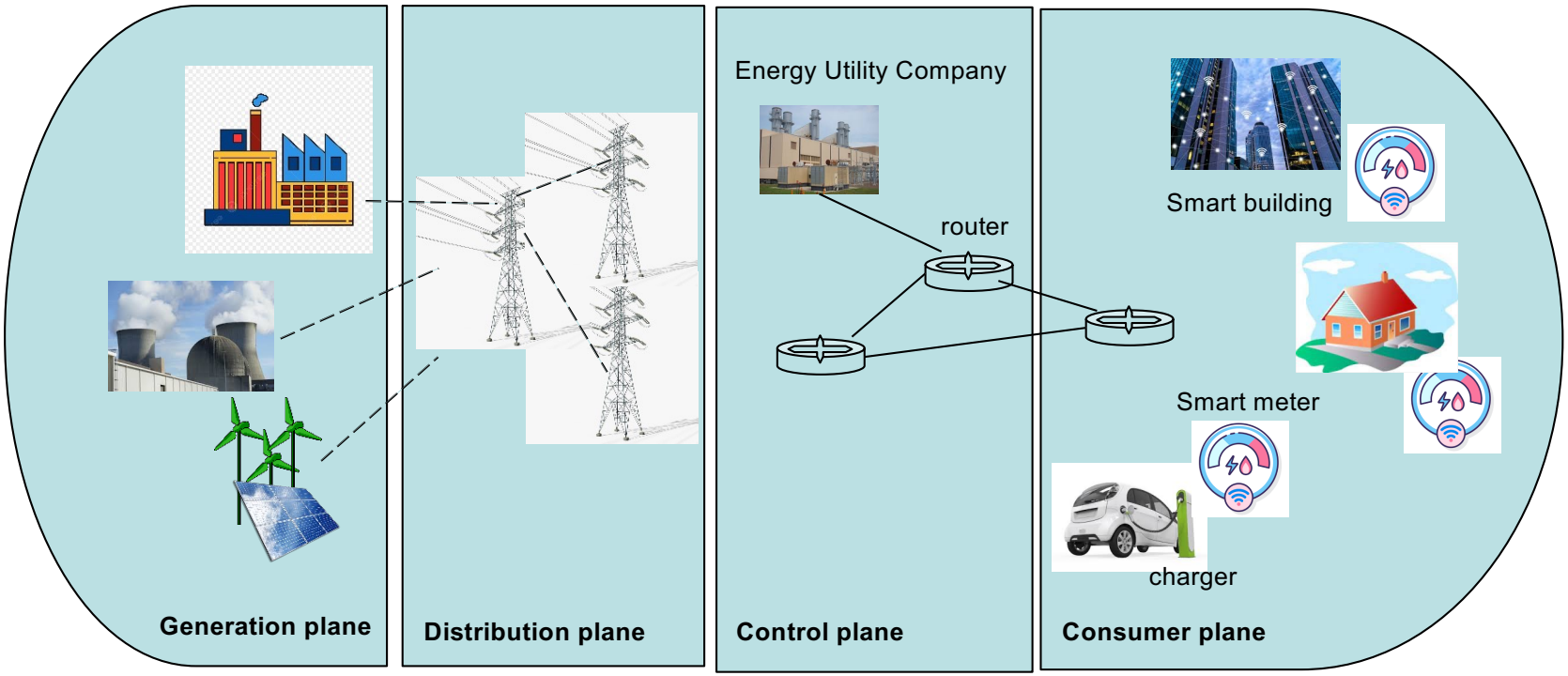
Abstract

Leverage SIM card to electric vehicles.



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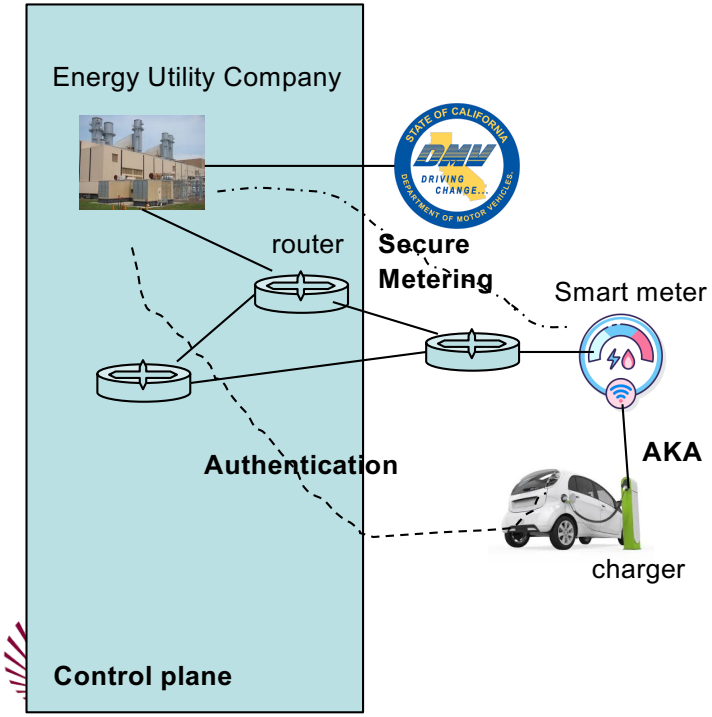
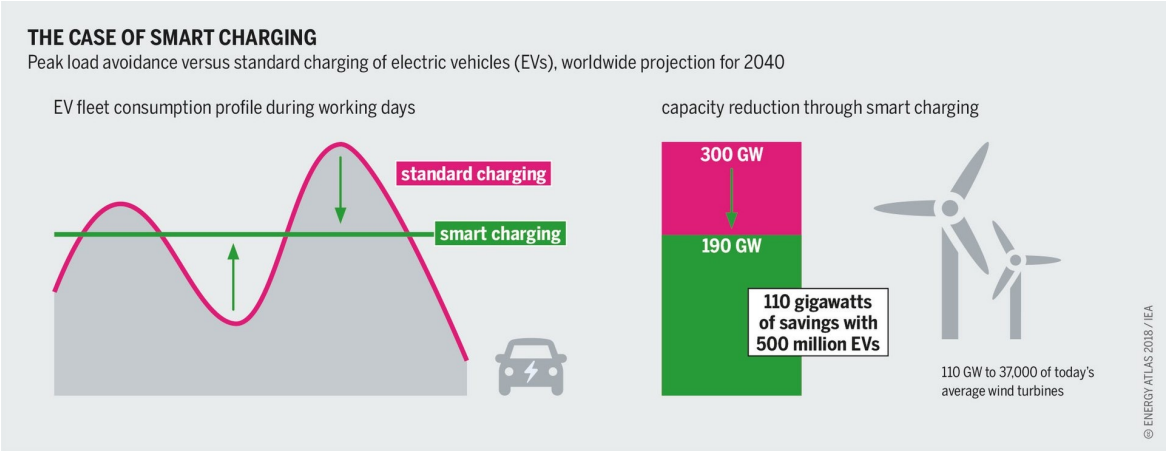
Utility companies and Security

Utility Company Security

- Monitoring/control of regions energy consumption
  - overload/outage monitoring
  - Peak Load EV Charging avoidance(energy aggregators)
- Security:
  - Advanced Metering Infrastructure (AMI) monitors grid resources (e.g. transformers) and energy demand/consumption (smart meters).
  - Consumer subscription reliability/fraud protection
    - EV subscriber authentication protocol (AKA protocol:auth/secure metering)





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Safe EV Charging

EV Charging Requirements

- Mutual authentication of service provider (PUC) and consumer/vehicle

- Secure charging metering:

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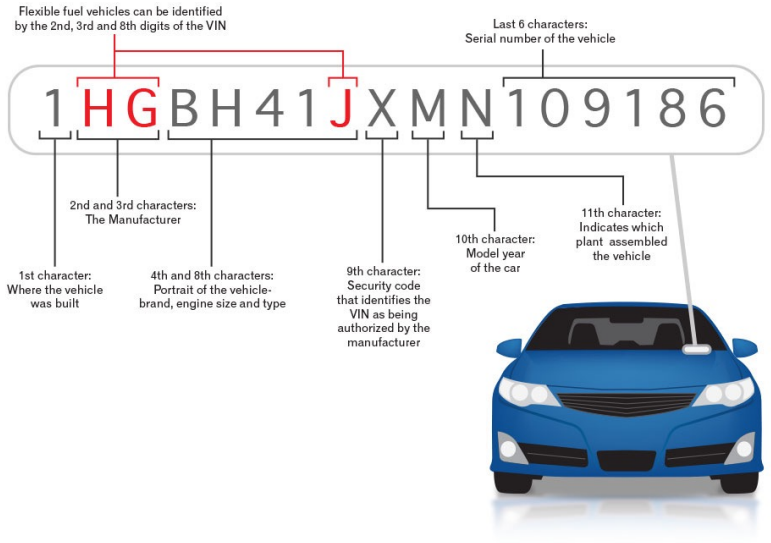
To achieve safe EV charging

・Authentication should be performed using symmetric key authentication.

・Authentication keys should be shared only between users and service providers.



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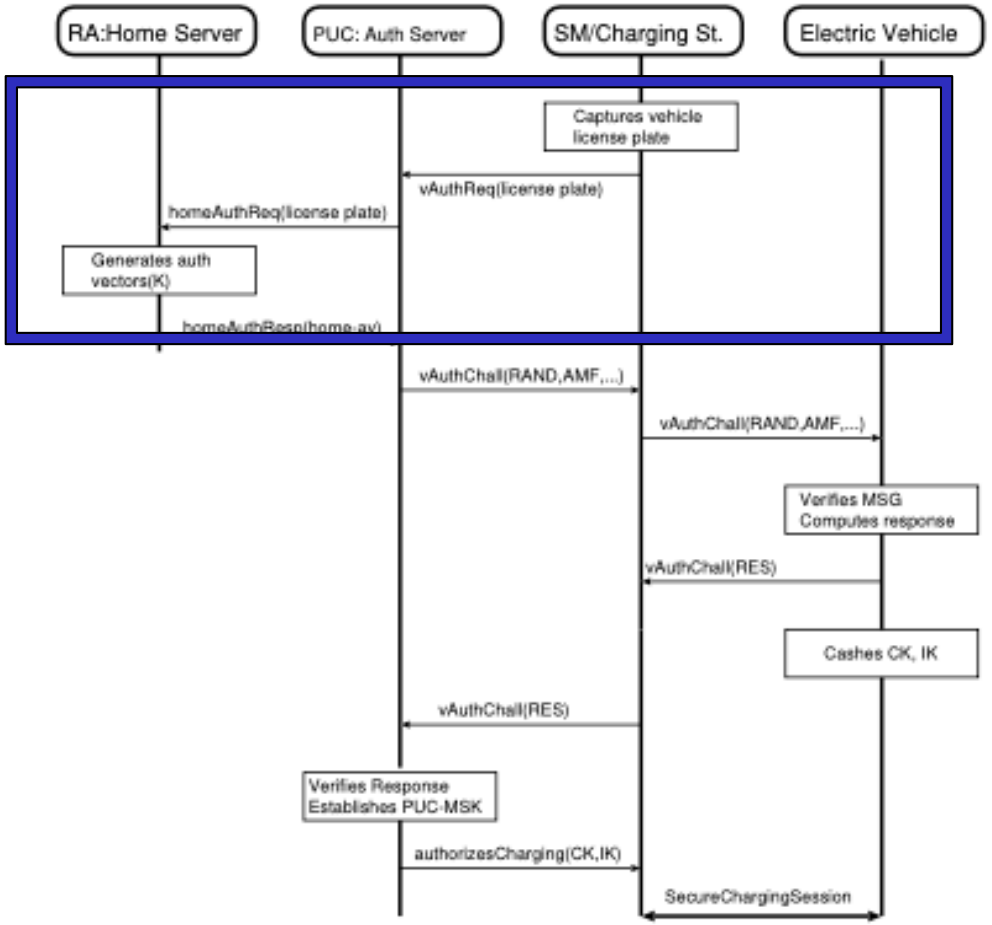
Key Authentication Description

```
SM
home AKA communication initiation

PUC
(Home_AKA)Send_License_Plate

HS
(Home_AKA)Generate_Key
(Home_AKAG)Generate_Authentication_Vector
SQN: 188875110173367
(Home_AKA)Generate_XRES_MAC
XRES: 11665645253085518279
MAC: 10822972401101129059

PUC
(Home_AKA)Extract_RAND_AMF_SN_SQN_XRES_MAC

SM
(Home_AKA)Send_RAND_AMF_SQN_XMAC

EV
(Home_AKA)Generate_RES_AK_CK_IK_MAC
RES: 11665645253085518279
XMAC: 10822972401101129059
AK: 34423461800822
CK: 22491236809316653975152983170713002 81
IK: 22851957903633981703100711352816157 3847
OK! MAC = XMAC
PUC_MSK = 8864995077770743931886362418142198 22

SM
(Home_AKA)Forward_Encrypted_RES

PUC
SQN: 188875110173368
(Home_AKA)Compare_RES_and_XRES
OK! XRES = RES
PUC_MSK: 8864995077770743931886362418142198 22
```



Home Authentication and Key Agreement

Figure 3: Home Authentication and Key Agreement

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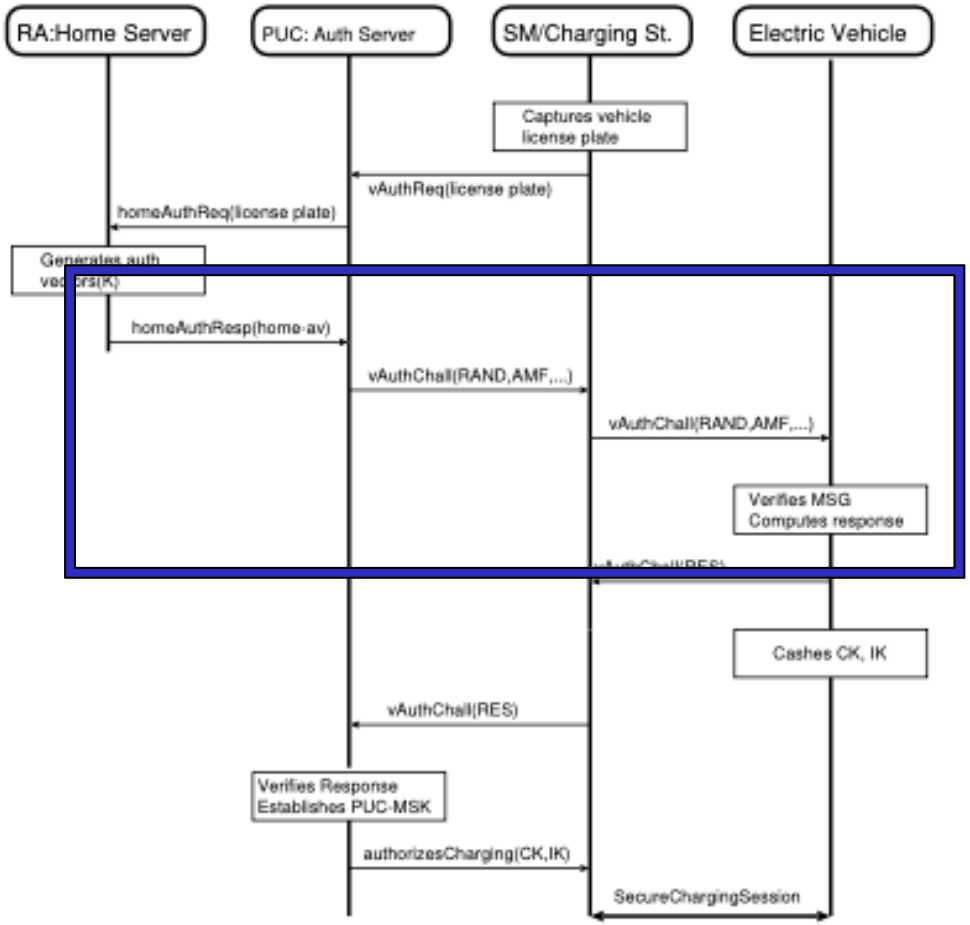

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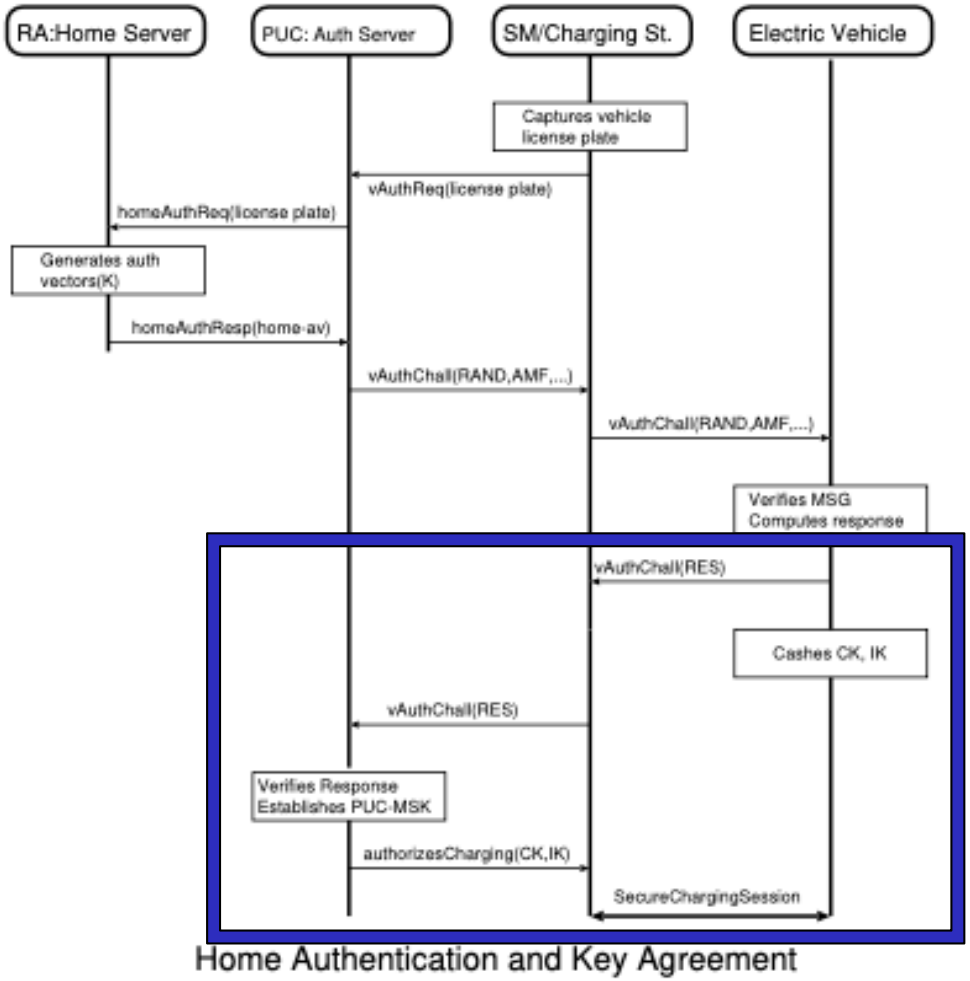

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IMPLEMENTATION PROOF OF CONCEPT

```python
class HomeServer(pykka.ThreadingActor):
    def __init__(self):
        super(HomeServer, self).__init__()

    def link_class(self, instance_name):
        self.PUC_ref = instance_name

    def on_receive(self, message):
        print("")
        print("HS")
        self.message = message
        self.order = message["order"]

        if(self.order == "Send_License_Plate"):
            print("(Home_AKA)Generate_Key")
            self.license_plate = message["license_plate"]
            self.Generate_Authentication_Vector()

    def Generate_XRES_MAC(self):
        print("(Home_AKA)Generate_XRES_MAC")
        self.XRES = Create_RES(self.key, self.RAND, self.OP)
        self.MAC = Create_MAC(self.key, self.RAND, self.AMF, self.OP, self.SQN)
        print(f'XRES: {self.XRES}')
        print(f'MAC: {self.MAC}')
        self.Send_Authentication_Vector()


    def Send_Authentication_Vector(self):
        self.PUC_ref.tell({"order":"Send_Authentication_Vector", "RAND":self.RAND,
```

Library : pykka, Crypto.Cipher.AES

Communication between HS, PUC, SM, and EV was implemented by sending a dictionary type list with the tell function of pykka.

The ciphers were generated using the library Crypto.Cipher.AES

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CONCLUSION AND FUTURE WORK

- A symmetric key based authentication and key agreement protocol.

- There is no need for the smart meter to store authentication information.

- New encryption and integrity keys are used by the smart meter for each charging session.

The framework hence reduces Smart Meter security requirements, as well as its attack surface.

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