Energy-efficient and secure communication network for the Internet of Energy

Presentation of eSafeNet Project to ETIP SNET Working Group 4 (“Digitisation of the electricity system and Customer Participation”)

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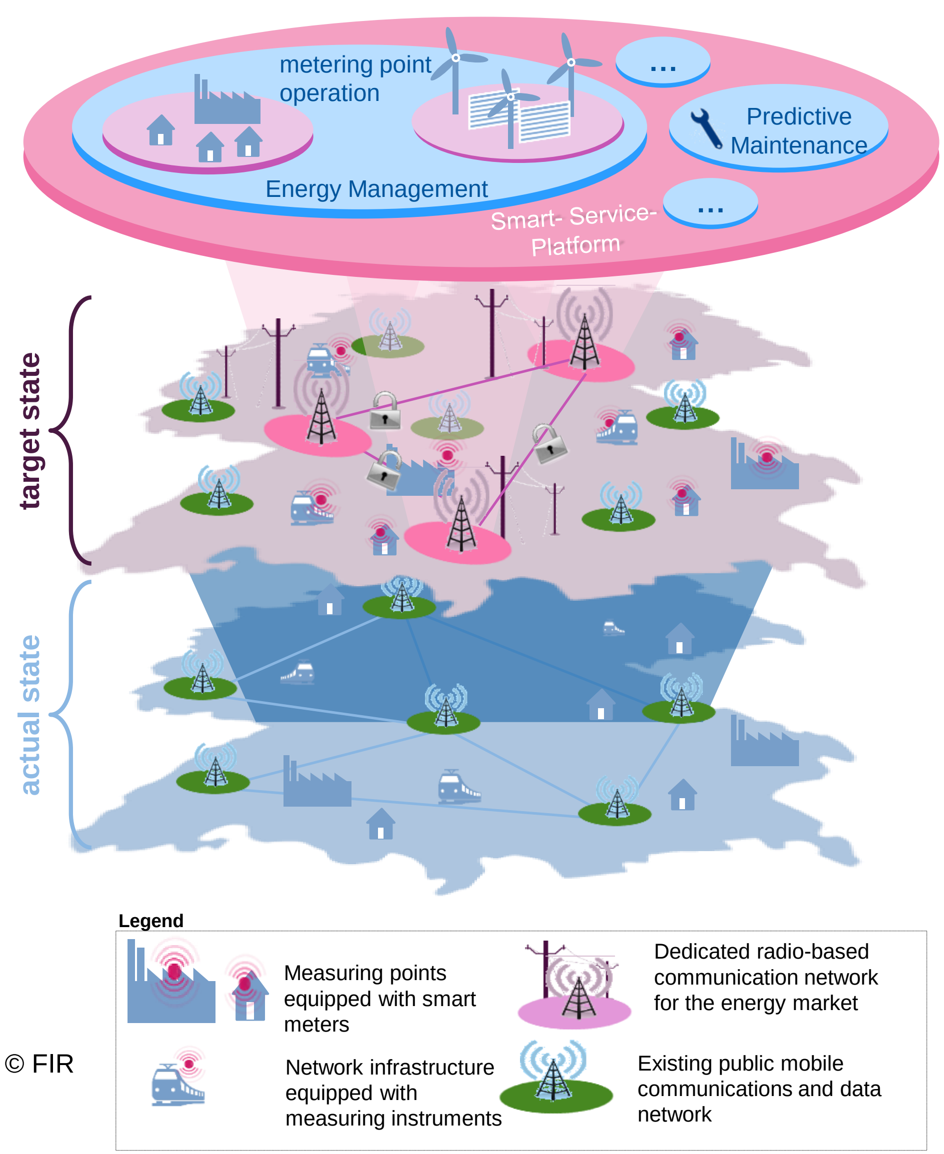
Overview of eSafeNet Project:
Energy-efficient and secure communication network for the Internet of Energy



Research objective 2:
Development of a smart service platform and design of business models to establish profitability and energy efficiency

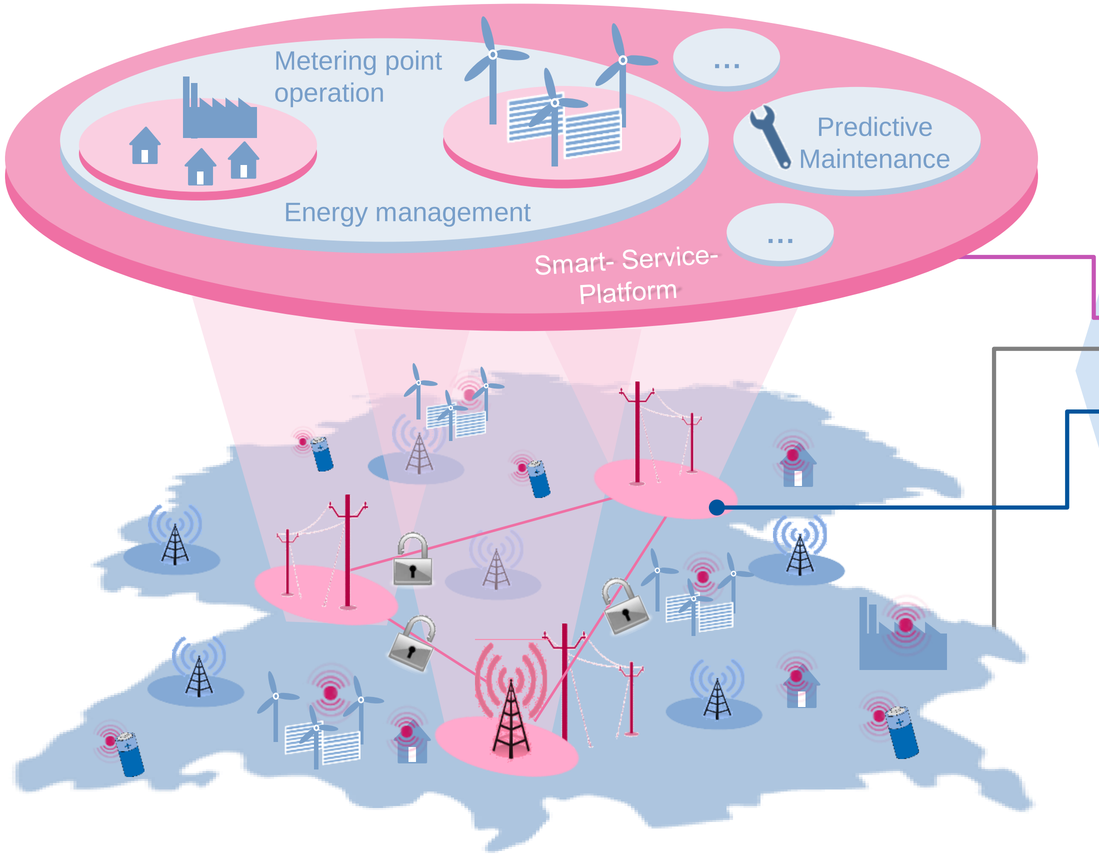
Research objective 1:
Scenario-based selection and test setup of a dedicated secure communication network

Research objective 3:
Definition of requirements and specifications for a holistic data and communication security concept

- **Central project objective**
  - Build secure and energy-efficient communication networks for Internet of Things
- **Approach**
  - Develop prototype of planned network
  - Validation in three field tests
- **Actual situation**
  - Communication and interaction of power generators not ideal on Medium Voltage, Low Voltage grid levels
  - Inefficient use of wind energy generation
- **Target state**
  - Secure and fast communication infrastructure
  - Monitoring of local networks with measurement infrastructure (using Broadband Powerline Communications technology (BPL))
  - Development of a Smart Service platform to make use of centrally collected and analysed data
  - Added value for different market players through more transparency about technical assets and market conditions

The project objective of eSafeNet is the development of a secure communications network for distribution grids and its connection to a service platform for the Internet of energy

eSafeNet Kommunikationsnetze im Internet der Energie



New Communication Network for the Internet of Energy

Metering Points (mobile or stationary)

Existing public mobile communication network

Initial Situation

- The energy networks, and thus the energy supply management, are becoming more complex in the Energiewende, as energy is increasingly generated, fed, stored and consumed decentrally.
- This results in the need for a communication infrastructure which provides a wide range of services through which volatile decentralized generating stations, smart meters and other measuring devices communicate.
- Such an infrastructure needs stringent security, data protection, and technical and vendor-independent characteristics

Goal 1: Infrastructure

- Conception of a communication infrastructure to meet the requirements of the energy industry
- Construction and evaluation in three field tests with different scenarios

Goal 2: Platform

- Evaluation of new business models and data services within the platform
- Development of a smart service platform as well as integration of the use cases

Goal 3: Security

- Defining the specifications for a data and communication security concept
- Verification of the reliability and security of the communications network

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

Partners:

fir an der RWTH Aachen
Stadtwerke Mainz AG
KaCon Kalinowski Consulting GmbH
Ericsson
E.ON Energy Research Center
RWTH Aachen University
QSC AG
software AG
SOLIT SYSTEMS IT – mit Sicherheit!

The field tests are supposed to implement, test and validate different elements of the eSafeNet concept (I/II)

eSafeNet
Kommunikationsnetze im Internet der Energie

1 Generation

Problem:

- Inefficient, untransparent communication between system operators, direct marketers and wind farm operators
- Currently many different (proprietary) connecting systems used

Aspect of eSafeNet:

- Monitoring and controlling wind power plants
- Collecting and analyzing real time data (generation and condition data)
- Data based added value services for participating market players (e.g. predictive maintenance)

Implementation Concepts:

- Connecting wind power plants to the eSafeNet platform
- Implementing analytics on ARIS platform of Software AG
- Training algorithms on test data to deploy forecasting models

2 Metering

Problem:

- Also consumers and small producers have to be connected by ICT in the future
- Especially on local grid level voltage fluctuations appear and pose a risk to the grid stability

Aspect of eSafeNet:

- Monitoring of local grids using metering infrastructure (BPL) within Mainz network
- Better understanding of the grid for the necessary grid expansion in the future
- Better understand usage patterns

Implementation Concepts:

- Installation of metering and communication technology in local grid of Stadtwerke Mainz
- Testing of the used equipment

3 Survivability

Problem:

- Ensuring robustness to blackout scenarios including renewable energies and different communication technologies

Aspect of eSafeNet:

- Testing of blackout scenarios
- Evaluation of different communication technologies

Implementation Concepts:

- Connecting electric network simulation with Multi-agent system communicating with Mobile 5G and Powerline Communications (PLC)

The field tests are supposed to implement, test and validate different elements of the eSafeNet concept (II/II)

4

IT-Security

Problem:

- Energy supply is part of the critical infrastructure
- Threats have to met via a proper safety and IT-security concept
- Different concepts for communication technologies and security scenarios are required

Aspect of eSafeNet:

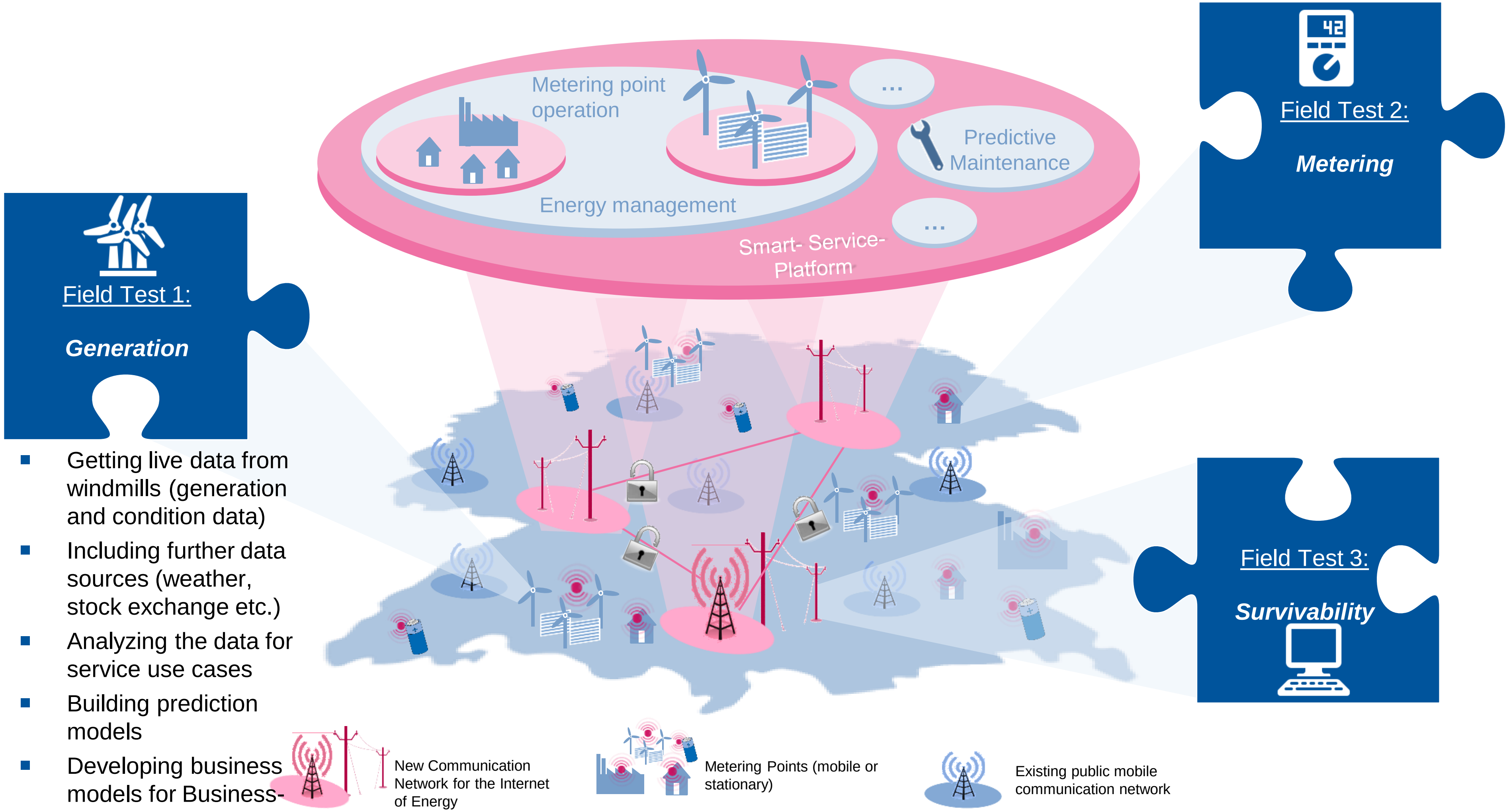
- Providing an overview about relevant security scenarios
- Developing security concepts for each scenario considering 5G, Broadband Powerline Communications etc. as communication technologies

Implementation Concepts:

- SOLIT implemented a server based IT security System
- Building a demonstrator where different security scenarios are presented

The project objective of eSafeNet is the development of a secure communications network and its connection to a service platform for the Internet of energy

eSafeNet
Kommunikationsnetze im Internet der Energie



Field Test 1: Generation

- Getting live data from windmills (generation and condition data)
- Including further data sources (weather, stock exchange etc.)
- Analyzing the data for service use cases
- Building prediction models
- Developing business models for Business-to-business

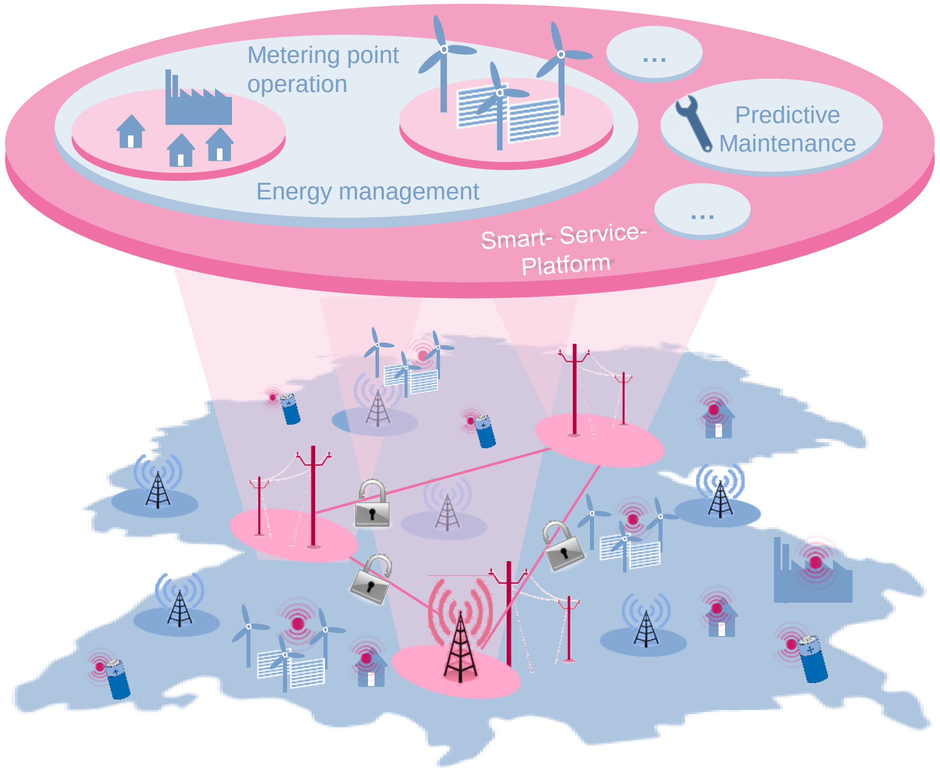
Field Test 2: Metering

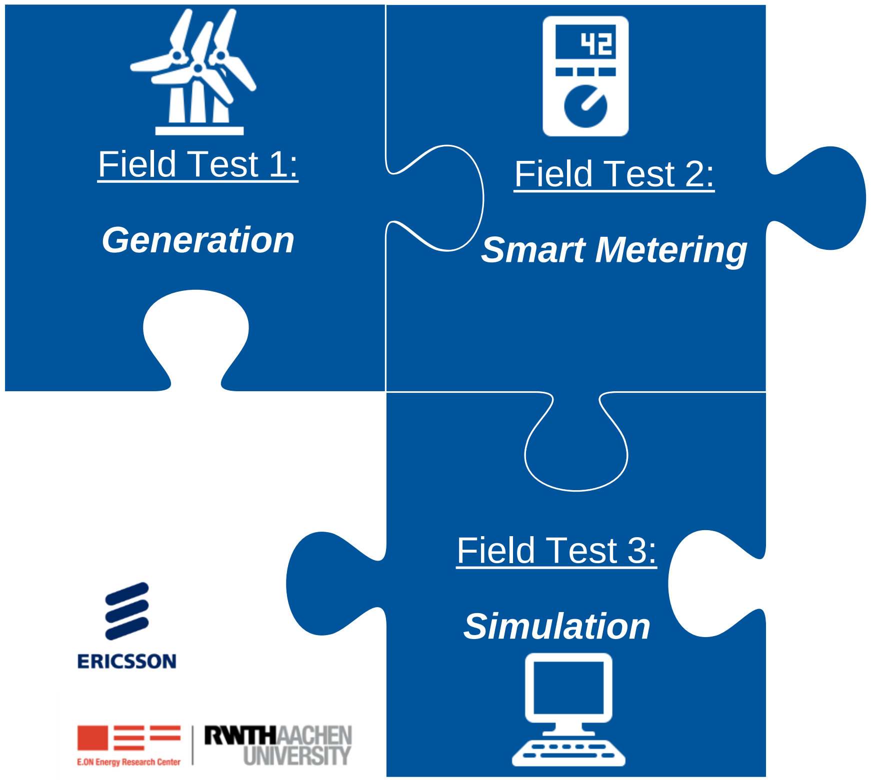
- Adapting Broadband Powerline measurement infrastructure to detect voltage deviations in local grids
- Connection to the service platform
- Analyzing data for decision support
- Providing scenarios for future loads on the grid regarding e-mobility

Field Test 3: Survivability

- Autonomous and independent blackout recovery of islanded microgrid
- Field test in Lab environment using simulated grid, multi-agent system and real Broadband Powerline and mobile communications

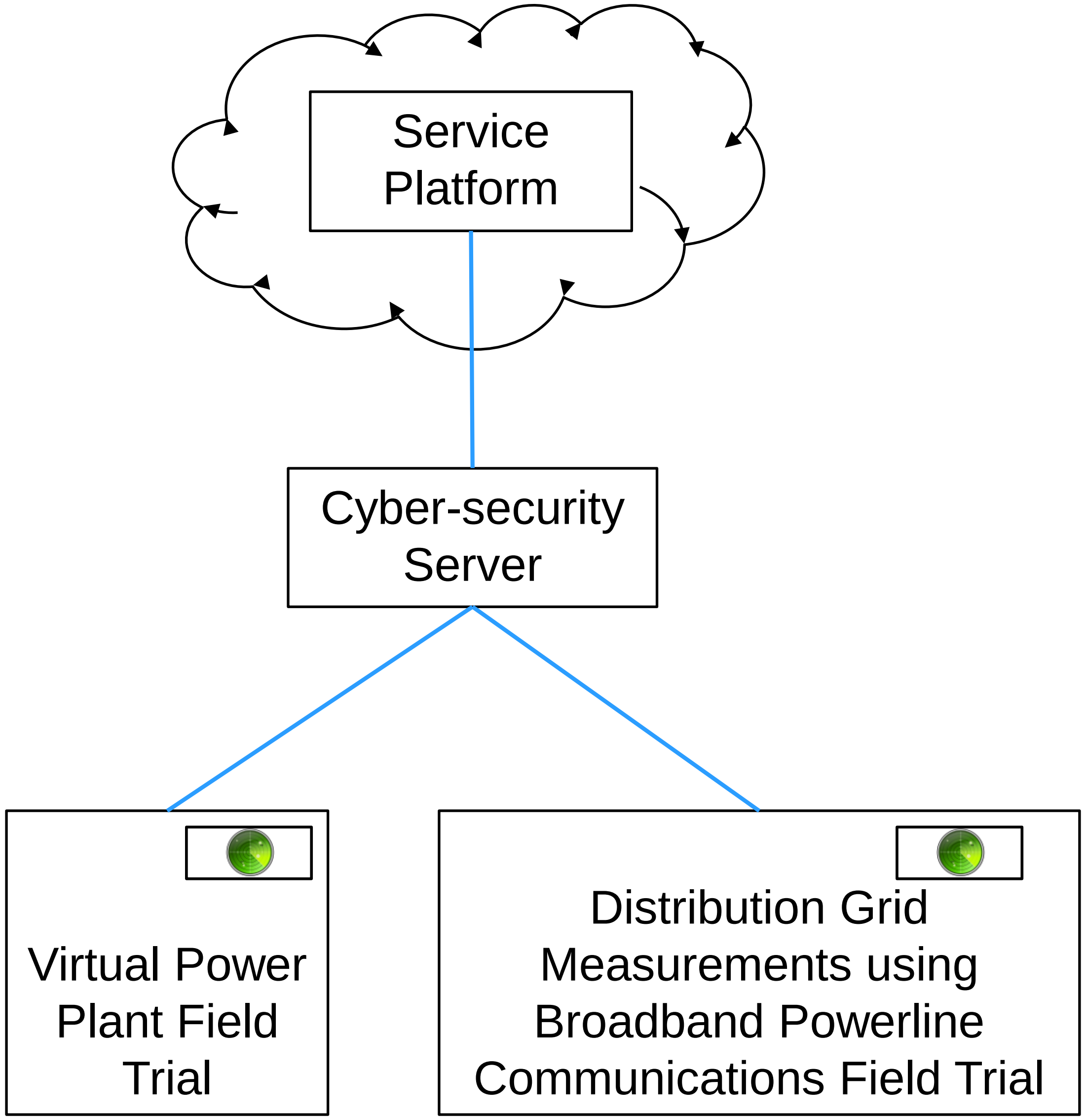
Within the project three different field tests will be executed – each contributing one central element to the eSafeNet





Each field test is led by a consortium partner while all other are supporting in their field of expertise

Overview of Cyber-security Setup in eSafeNet Field Trials



- Trial sites equipped with cyber-security **"sensor"** shown as which performs cyber-security monitoring against APT (Advanced Persistent Threats)
- Communication encrypted
- Communication traffic between the trial sites and the Service Platform routed through a **cyber-security server**
  - because communication is via Internet and dedicated networks
  - cyber-security server performs various security functions such as virus scanning, firewall, APT, Sandbox, Intrusion Detection/Prevention (IDS/IPS), SIEM (security information and event management)
  - run by SNOC (Security Network Operation Centre) personnel

Stadtwerke Mainz Field Trial of Distribution Grid Measurements using Broadband PLC

- Measurement of voltage levels in Low Voltage grid
- 92 locations equipped with measurement devices and Broadband Powerline Communications modems
- Measurement data gathered and analysed locally
- Data sent to service platform for analysis
- Now able to analyse electricity grid in much more detail and also determine whether certain customers are feeding into our grid or drawing excessive amounts of electricity.
- All this can be deduced from the voltage because the voltage goes down when the power consumption in the house increases. Conversely, when the voltage rises, the power consumption in the house decreases.
- Can now read these things very accurately for the equipped outlets, which of course helps network operator to keep the network more stable overall.

Stadtwerke Mainz Field Trial of Distribution Grid Measurements using Broadband PLC

Exploitable results: Added value, benefits	Network stability and efficiency of network operation increased. Benefit not quantifiable, need wide-scale deployment to get real effect. Beneficiary: Electrical Distribution System Operator and society
Lessons learned, barriers?	It can be easily implemented! But it will take some time to pay off the investment.
Deployment prospects?	Stadtwerke Mainz are planning a large-scale rollout in all of Mainz. In eSafeNet, the measurement device and Powerline Communications modems were 2 boxes – in future they should be 1 box and also integrated with Smart Meter Gateway (also offering a distributed service platform).
Need for further testing	Concept can already be deployed on large scale. Further work on standardisation and definition of interfaces could be done.
Use/need of an inter-regional cooperation	Would be very useful to help other Distribution System Operators to do a similar implementation

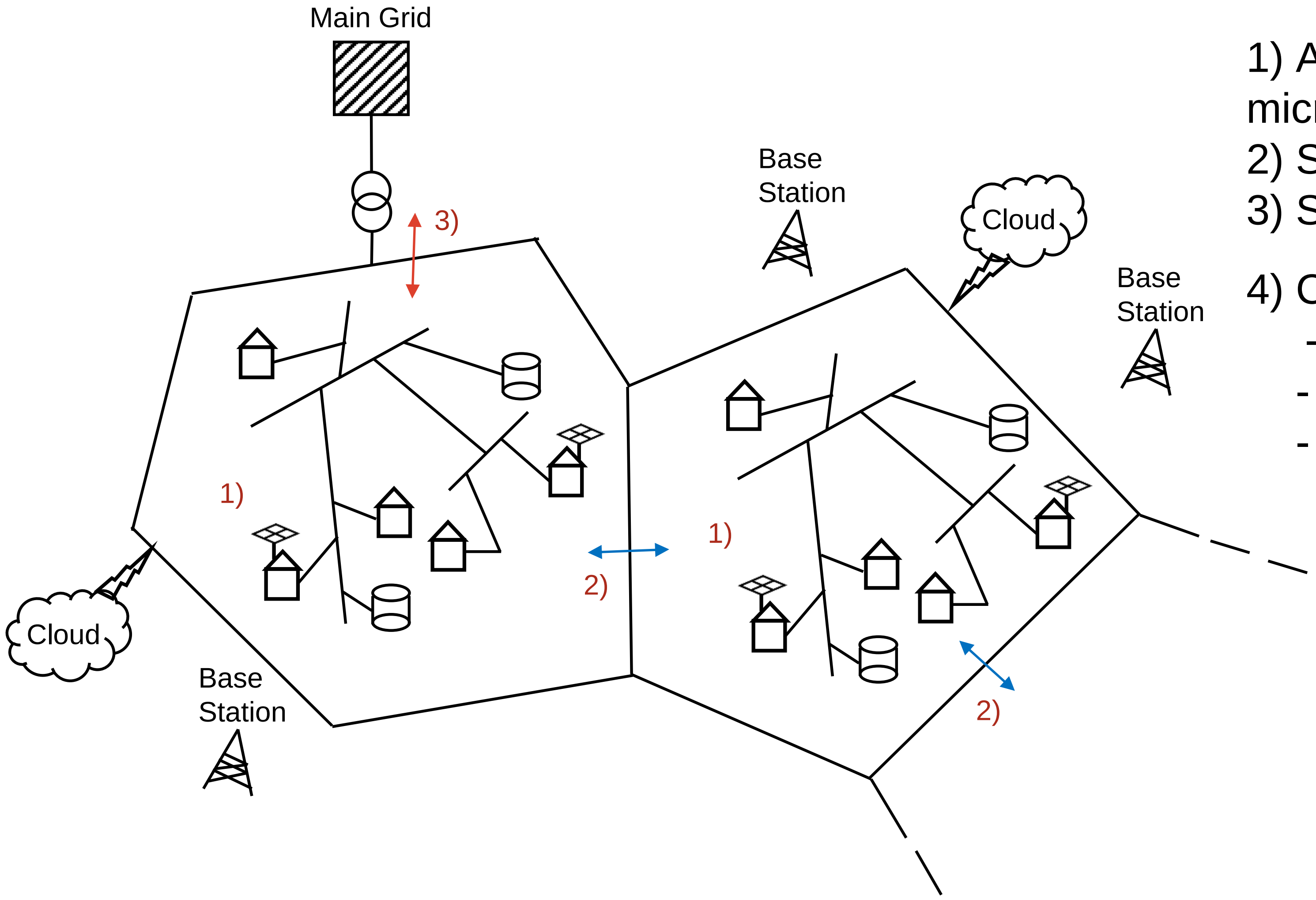
Software AG (Data Analysis Platform based on ARIS system)

Exploitable results: Added value, benefits	Concept and prototype of a smart service platform for consolidating common energy data & providing/ marketing energy services Definition of 2 business models for a smart service platform in the energy sector Concept and prototype of a real-time analytics platform, e.g. for anomaly detection in energy grids, including visual analytics (dashboarding) Domain know how (energy), State-of-the-art analysis
Lessons learned, barriers?	Insight into branch specific requirements for an integrated energy platform Identification of existing and prevalent communication channels and standards Identification of suitable communication protocols for the Internet of Energy Approaches to real-time energy data analytics, esp. time series analysis 2 patent applications in preparation
Deployment prospects?	Approaches for decentralized self-synchronizing edge platforms may be investigated in the future
Need for further testing	For thorough testing of the intended smart service platform, more use case partners providing real-world data and service requirements would be helpful
Use/need of an inter-regional cooperation	Many energy grid approaches on European level => cooperation with other European countries may lead to synergies

SOLIT Systems (Cyber-security)

Exploitable results: Added value, benefits	Holistic security concept, in particular: - Defence mechanisms against APT (Advanced Persistent Threat) For APT defence, the SOLIT network sensor was further developed to include special services for use in the energy industry and special protocols for the energy industry. A functioning protection concept always includes the cooperation of security specialists, for example in a SNOC (Security Network Operation Centre). - Use of suitable sandbox processes - Completed by effective/coordinated cyber security services
Lessons learned, barriers?	Security concept based on need for holistic security solution. E.g. protecting equipment from electricity meter to control system of power plant.
Need for further testing	Results of the project will be tested over the next few months on a heterogeneous demonstrator network. Here it will also be proven that the developed protection mechanisms have the required robustness and effectiveness. A later marketing, especially in the energy sector, is planned.

RWTH Aachen: Microgrid Multi-agent System for Recovery from Blackout



1) Automatic, autonomous restoration of microgrids
2) Synchronise and connect microgrids together
3) Synchronise to Main Grid

4) Communications:
- Power Line
- Mobile (LTE/Narrowband IoT)
- Cloud Support

RTWH Aachen: Microgrid Multi-agent System for Recovery from Blackout

Exploitable results:	- Method for autonomous, independent black start of islanded microgrid (without switching off loads) by means of distributed control of local generation and storages. - Method for management of islanded microgrid to optimise operation during islanding. Includes control of batteries and Photovoltaic generators to perform voltage and frequency control of the microgrid.
Added value, benefits	- Reduces need for large generators with black start capability - Local generation and storage currently sits idle in blackout – wasted investment which must be compensated by larger amount of central generation. - Reduced need for investment in large scale generation and transmission - Mitigates risk of large-scale blackout - Puts focus on ICT solution that survives blackout and can restore power, which is a fundamental requirement which directs towards a distributed, robust architecture.

RTWH Aachen: Microgrid Multi-agent System for Recovery from Blackout

Lessons learned, Barriers?	Distributed Controllers seem to be very interesting for black-start of microgrids. This is due to the reduced communication (only with neighbors) and to the fact that with distributed control, the data are not collected in a central unit but only exchanged among the nodes. Automatic topology identification is vital for operation of grids from black start. Powerline Communication technology can be leveraged to build the topology , in a way that distributed knowledge of the topology could be derived as the first step of blackstart. The distributed knowledge of topology increases the resilience and is adaptive to real time topology changes or changes in topology due to some catastrophes - Less centralized control represents a paradigm change. - Need of batteries to perform black-start restoration. Without them there is no possibility to perform voltage and frequency control in isolated microgrid. - Modification of grid code needed. - Inverters with grid-forming capability needed in real grids (normally they don’t have this capability).

RWTH Aachen: Microgrid Multi-agent System for Recovery from Blackout

Deployment prospects?	Concept at lab prototype level with simulated grid => TRL 3-4
Need for further testing	System developed to level of lab prototype. Communication between agents should not be on application level but on a lower level in the stack (possible follow-up project in Powerline Communication area to develop this). Multi-agent system should be integrated with Smart Meter Gateway and communication modems, as in Mainz field trial.
Use/need of an inter-regional cooperation	Concept can be locally implemented, but a co-ordination with overall grid black start procedures is desirable. Should be part of emergency management infrastructures and procedures Cost of deployment of adequate storage offset by use of storage for normal grid operation.

eSafeNet References

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

- RWTH ACS Website: http://www.acs.eonerc.rwth-aachen.de/cms/E-ON-ERC-ACS/Forschung/Forschungsprojekte/Gruppe-Building-Level-Energy-Management/~ltll/eSafeNet/?lidx=1
- This project is sponsored by BMWi (German Ministry for Industry and Energy), project number 03ET7549A und runs from April 2016 to the end of March 2019
- Publications

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  - E. De Din, G. Lipari, A. Angioni, F. Ponci and A. Monti, "Effect of the reporting rate of synchrophasor measurements for distributed secondary control of AC microgrid," *2017 IEEE International Workshop on Measurement and Networking (M&N)*, Naples, 2017, pp. 1-6. doi: 10.1109/IWMN.2017.8078378
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