Acceptance of Smart Grid Technologies: User-Centricity in Privacy, Security and Control

Dominik Engel, Günther Eibl, Christian Neureiter, Judith Schwarzer and Armin Veichtlbauer
Salzburg University of Applied Sciences
Josef Ressel Center for User-Centric Smart Grid Privacy, Security and Control

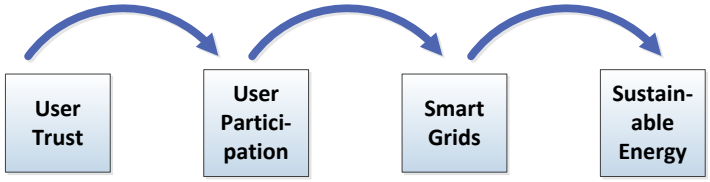
Fachhochschule Salzburg University of Applied Sciences

The Research Center

Spreading Smart Grid technologies will be inherently difficult without **addressing end-user concerns** and actively managing **user acceptance** by providing secure methods and demonstrating safety of user data and privacy. **Privacy, security, and user control** in the smart grid user domain are **critical for establishing user trust** and enabling user participation.

The aim of the Josef Ressel Center for User-Centric Smart Grid Privacy, Security and Control is to **implement a comprehensive trust framework in the smart grid user domain**. In collaboration with our company partners, this framework will be integrated into **real-world test pilots**. Through the methods developed in the proposed Josef Ressel Center **trustful user interaction** in the smart grid user domain will be enabled.

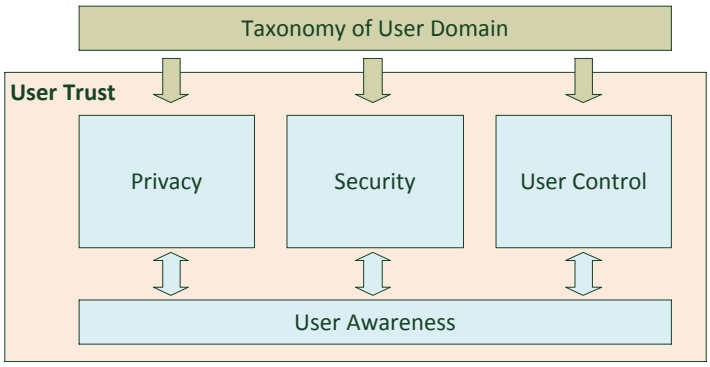
Vision



Central Research Question

Which **technological methods** are suited to enable **end-user trust** in smart grid technology in a **sustained manner**?

Research Domains



Main Use Cases

- Smart Metering and Energy Feedback
- Supply and Demand Response Management
- Health Monitoring

Company Parners

- Salzburg AG für Energie, Verkehr und Telekommunikation
- Salzburg Wohnbau GmbH

References

[1] D. Engel.
Wavelet-based load profile representation for smart meter privacy.
In *Proc. IEEE PES Innovative Smart Grid Technologies (ISGT'13)*, pages 1–6, Washington, D.C., USA, Feb. 2013.
http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6497835.

Acknowledgements

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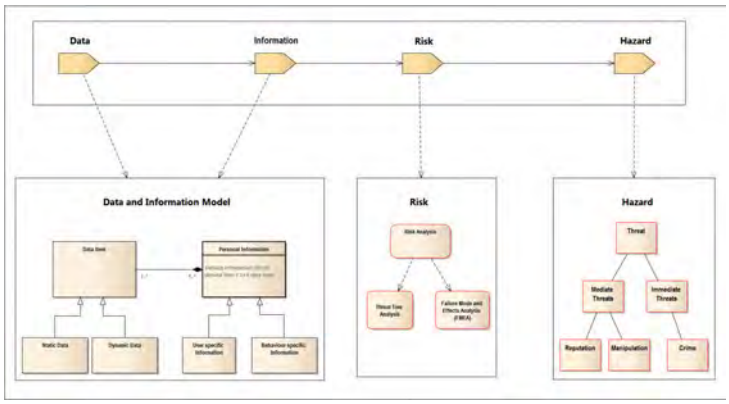
Exemplary Project: Privacy in Smart Metering

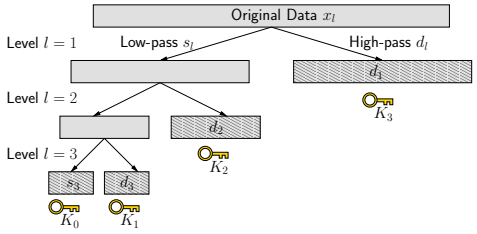
- Smart Metering provides a daily load profile
  - Intervals may differ: 1 second to 30 minutes
- Non-intrusive load monitoring (NILM) techniques allow the analysis of load profiles to infer user behavior, such as sleep-wake cycles
- Accuracy of NILM is directly linked to available load profile resolution
- We investigated and compared the utility the wavelet transform for creating a multi-resolution representation of load profiles
- The proposed approach was evaluated based on the provided level of security, computational demands and economic feasibility
- Multi-resolution representation with conditional access is a suitable tool to **balance privacy and functionality**

Modeling of Privacy Requirements



Conditional Access Based on Multi-resolution Representation [1]

- Create **multiple resolutions of load profiles** for use in different use-cases, e.g.:
  - Low resolution for billing purposes (energy provider)
  - Mid-level resolution for aggregated information contribution (network operator)
  - High-level resolution for energy usage analysis (third party service using non-intrusive load monitoring)
- Different **access levels for different purposes**
- Wavelet Transform is used to create multi-resolution representation



$$s_l^{(0)} = x_{2l}$$
$$d_l^{(0)} = x_{2l+1}$$
$$d_l = d_l^{(0)} - s_l^{(0)}$$
$$s_l = s_l^{(0)} + \frac{1}{2} d_l$$

Results

- Scenarios
  - Wavelet Filter: Haar
  - Encryption Modes: Symmetric (AES, 256bit), Asymmetric (RSA, 2048 bit), Hybrid (AES-256 + RSA-2048)
- ARM-based Execution Environment (≈100 €)
  - Beagleboard (TI DM3730 ARM, 512 MB RAM)
- Non-optimized Implementation
  - Java, OpenJDK 1.6
  - Ubuntu Linux
- Data Set
  - 400 daily load profiles
  - Siemens TD3510 smart meter
  - 15 minute sampling interval
  - Level 5 wavelet decomposition (Lowest resolution: 3 values per day)

	Wavelet	AES-256	RSA-2048	Hybrid
Average Execution Time (ms)	0.3092	2.36	89.27	92.12
Standard Deviation	0.0356	0.42	4.92	6.59

Execution Times on a Beagleboard: Avg. for 400 load profiles (1000 executions each)