A Domain-Specific MBSE Approach for the Smart Grid

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Hi, I’m Christian...

Christian Neureiter

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Background

- **Energy Turnaround: Integration of renewable energies**
  - Distributed Energy Resources (DER) with volatile injection behavior
    - Bidirectional energy flows influence grid stability
  - Smart Grid
    - Management of bidirectional energy flows
    - Paradigm shift: „Load follows generation“
    - Integration of massive ICT infrastructure

- **Challenge: Develope of a robust and dependable system architecture**
  - Critical infrastructure → extreme dependability requirements
  - System-of-Systems (SoS) → high complexity
  - Numerous stakeholders → different disciplines and domains involved
Hi, I'm Christian. I have great models to develop your Smart Grid!

So, how can we handle all this ICT related complexity?

No, this is Software stuff. THIS is, how a model should look like!
How to develop complex, interdisciplinary systems together?
How to build a house?

Architecture Description
- Basic Views
- Architecture Models
- Stakeholder Concerns

Architecture Development
- Reference Architecture
- Architectural Solution

Building
- Common Understanding
- CAD Tools
- Plumber, Electrician, Owner,…

Smart Grid
- Relevant Aspects ?
- Modeling Tool ?
- Concerns ?
- Reference Architecture ?
- Solutions ???

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Smart Grid Architecture Model (SGAM)

- Proposed 2012 by CEN/CENELEC/ETSI
  1. SGAM-Plane: problem decomposition
     - Domains: energy conversion chain
     - Zones: Automation pyramide
Smart Grid Architecture Model (SGAM)

- Proposed 2012 by CEN/CENELEC/ETSI
  1. **SGAM-Plane**: problem decomposition
     - Domains: energy conversion chain
     - Zones: Automation pyramide
  2. **Interoperability on different layers** („SGAM Layers“)

Relevant aspects for description of Smart Grid systems
How to build a house?

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Common Understanding → CAD Tools → Plumber, Electrician, Owner, ...

Smart Grid

Business
Function
Information
Communication
Component

Functional and architectural aspects


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Modeling the Smart Grid

- Modeling the Smart Grid
  1. Development paradigm
  2. Domain Specific Modeling Language (DSL)
Modeling the Smart Grid

- **Modeling the Smart Grid**
  1. **Development paradigm**
  2. Domain Specific Modeling Language (DSL)

- **Model Driven Architecture (MDA)**
  1. **Functionality („What?“)**
     1. Business Layer
     2. Function Layer

- [Image of diagram showing various layers and interdependencies]
Modeling the Smart Grid

- **Modeling the Smart Grid**
  1. Development paradigm
  2. Domain Specific Modeling Language (DSL)

- **Model Driven Architecture (MDA)**
  1. **Functionality („What?“)**
     1. Business Layer
     2. Function Layer
  2. **Technology („How?“)**
     1. Information Layer
     2. Communication Layer
     3. Component Layer

Diagram:
- Interoperability Dimension
- Business Objectives
- Polit./Regulatory Framework
- Outline of Use Case
- Subfunctions
- Data Model
- Protocol
- Protocol
Modeling the Smart Grid

1. Development paradigm
2. **Domain Specific Modeling Language (DSL)**

The „SGAM Toolbox“
- Domain Specific Language (DSL)
- Extension for *Enterprise Architect*
- Layer-by-Layer development
  - „In the stakeholder’s language“
Modeling the Smart Grid

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- Under the hood: UML Profile
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- **Publicly available**
  - [www.en-trust.at](http://www.en-trust.at) → Downloads
  - Video-Tutorials on youtube
Subject of investigation
- Example on „Component Layer“: Security, Network Segments
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- CAD Tools
- Plumber, Electrician, Owner,…
- „Blueprint“
- My individual house

Smart Grid

- Business
- Function
- Information
- Communication
- Component

Functional and architectural aspects
- SGAM-Toolbox
- Concerns & Views
- Reference Architecture?
- Solutions ???
Reference Architecture

- ENTSO-E Role Model
  - Business Layer
Reference Architecture

- ENTSO-E Role Model
  - Business Layer

- NIST IR 7628 Guidelines for Smart Grid Cyber Security
  - Use Case Collection
  - → Logical Reference Model
  - ~ 46 Actors
  - ~ 140 Interfaces
  - → 22 Interface Categories
  - → Security Requirements
    - ~200 High Level RQ
Reference Architecture

- **ENTSO-E Role Model**
  - Business Layer

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- **Integration with SGAM**
  - Same origin!
    - NIST Domain Model
    - Mapping basically possible
    - Still, some issues exist...
Reference Architecture

- Example Model: NIST LRM Scenario „Smart Metering“
  - Click-through model: www.en-trust.at/NISTIR

Interfaces with Security Requirements
Reference Architecture

- Utilization of standards for communication
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Architectural Solution

My individual house

Smart Grid

Functional and architectural aspects
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SGAM-Toolbox
- Concerns & Views
- ENTSO-E Role Model, NIST LRM,…

Solutions ???
Applications and Experiences

- **Project „RASSA“**
  - „Reference Architecture for a Secure Smart Grid in Austria“

- **Elements of the project**
  - Alignment of LRM with Austrian aspects
    - e.g. regulatory aspects)
  - Integration of Austrian „Smart Metering Use Cases“
  - Expansion of NIST LRM:
    - „Flat“ structure → Business Actors, Logical Actors, Physical Components
  - Update of SGAM Toolbox
    - Implementation of (free) Add-In
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- ENTSO-E Role Model, NIST LRM,...
- Solutions
Experiences

● Technical Aspects
  ● *Appear sound so far*
  ● *Interoperability under investigation*
  ● *Flat structure of NIST LRM vs. 3D structure of SGAM*
  ● *Extendability*
    ● New Interfaces
    ● New Actors
  ● *Dependability*
    ● Security concept valuable
    ● Taxonomy for dependability missing

● Applicability & Acceptance
  ● Used in different projects
    ● Not limited to Europe
  ● Indication: Youtube Tutorials
    ● 116 nations
    ● 42k minutes watched so far
  ● Easy for engineers with general modeling experience
  ● Difficult for DSOs
    ● → „Organizational Development“
  ● → Trainings supportive
Present Work: Toolchain Integration

Power System Analysis Tool

GIS Data → Simulation Engine

External Repositories
- Intelligrid Use Case Templates
- Reference Architecture Model Repository

SGAM Toolbox

Detailed functional description

External Tools
- Model Evaluation
- SGAM Visualization Tool

Smart Grid Subsystem
- FredOSAR Application SW
  - Application
- FredOSAR Base SW
  - Protocols
  - Security
  - Privacy
  - ...
Present Work: Portability

- **Industry 4.0**
  - "Reference Architecture Model for Industry 4.0 (RAMI 4.)"
  - RAMI 4.0 Toolbox
- **Automotive**
  - Project started
  - Interoperability "Vehicle 2 Smart City"
- **Smart City**
  - Contribution to IEC SC Smart Cities, WG 3 Reference Architecture
Further Reading

- **Downloads & Publications available at** [www.en-trust.at](http://www.en-trust.at)

- *And many others... ;-)
...do you want to learn more?