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MATHEMATISCH-
NATURWISSENSCHAFTLICHE FAKULTÄT
Kommunikationsnetze

jOSEF – A Java-Based Open-Source Smart Meter Gateway Experimentation Framework

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http://kn.inf.uni-tuebingen.de

Background and Motivation

FP7 Project C-DAX

- Cyber-secure Data And Control Cloud for power grids
- http://www.cdax.eu

- C-DAX middleware
  - Enables smart grid applications to exchange information securely
  - Implements information-centric networking (ICN) and publish/subscribe paradigms

- Project partners

iMinds, alliander, EPFL École Polytechnique Fédérale de Lausanne, UCL, Eberhard Karls Universität Tübingen, University of Surrey, National Instruments, Radboud Universiteit Nijmegen

Motivation

- Targeted use cases of C-DAX
  - Real-time state estimation based on PMU measurements
  - Telecontrol (SCADA)
  - Future retail energy market (REM)
- Integration of smart meter communication as part of REM
- No software available for experiment setups to simulate smart meter communication according to the German regulations

Smart Meters and Smart Meter Gateways

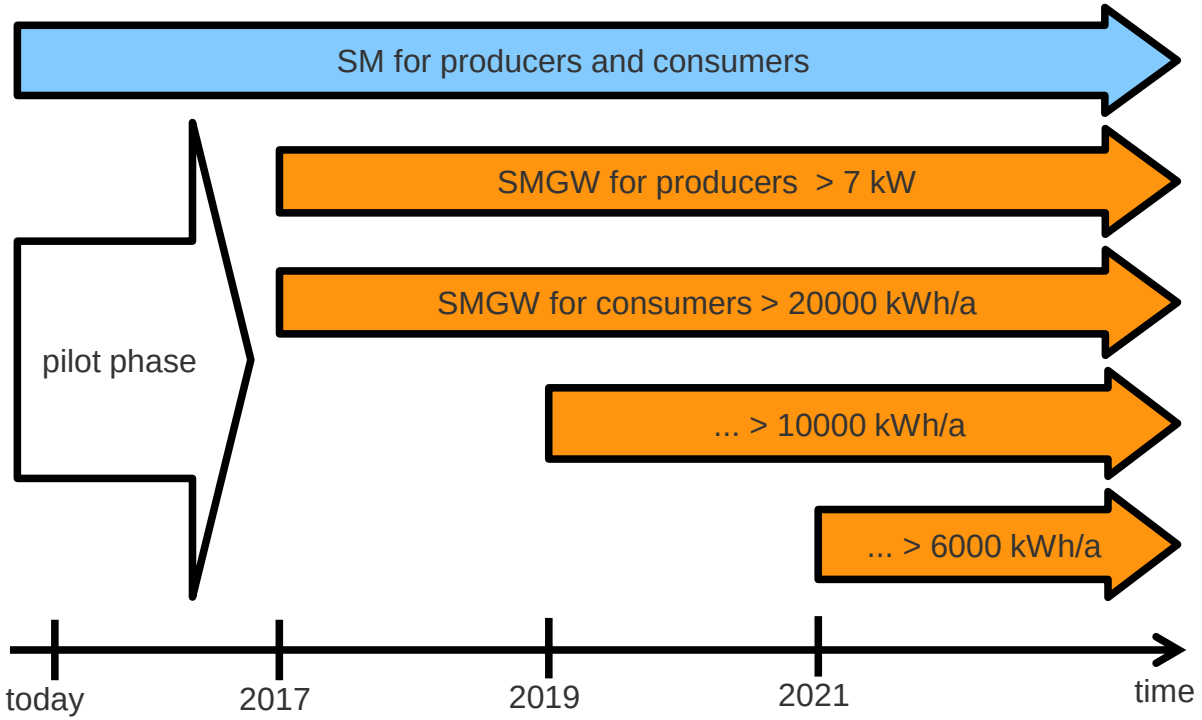
- Smart Meter (SM)
  - Communication interfaces for automated meter reading
  - Additional measurements (e.g. voltage, frequency)
  - New features (e.g. dynamic electricity tariffs)

- Smart Meter Gateway (SMGW)
  - Communication module for SM
  - Core component of German SM architecture
  - Rationale
    - Separate communication and metering
    - Reduce complexity of smart meters

Smart Meter Rollout in Germany

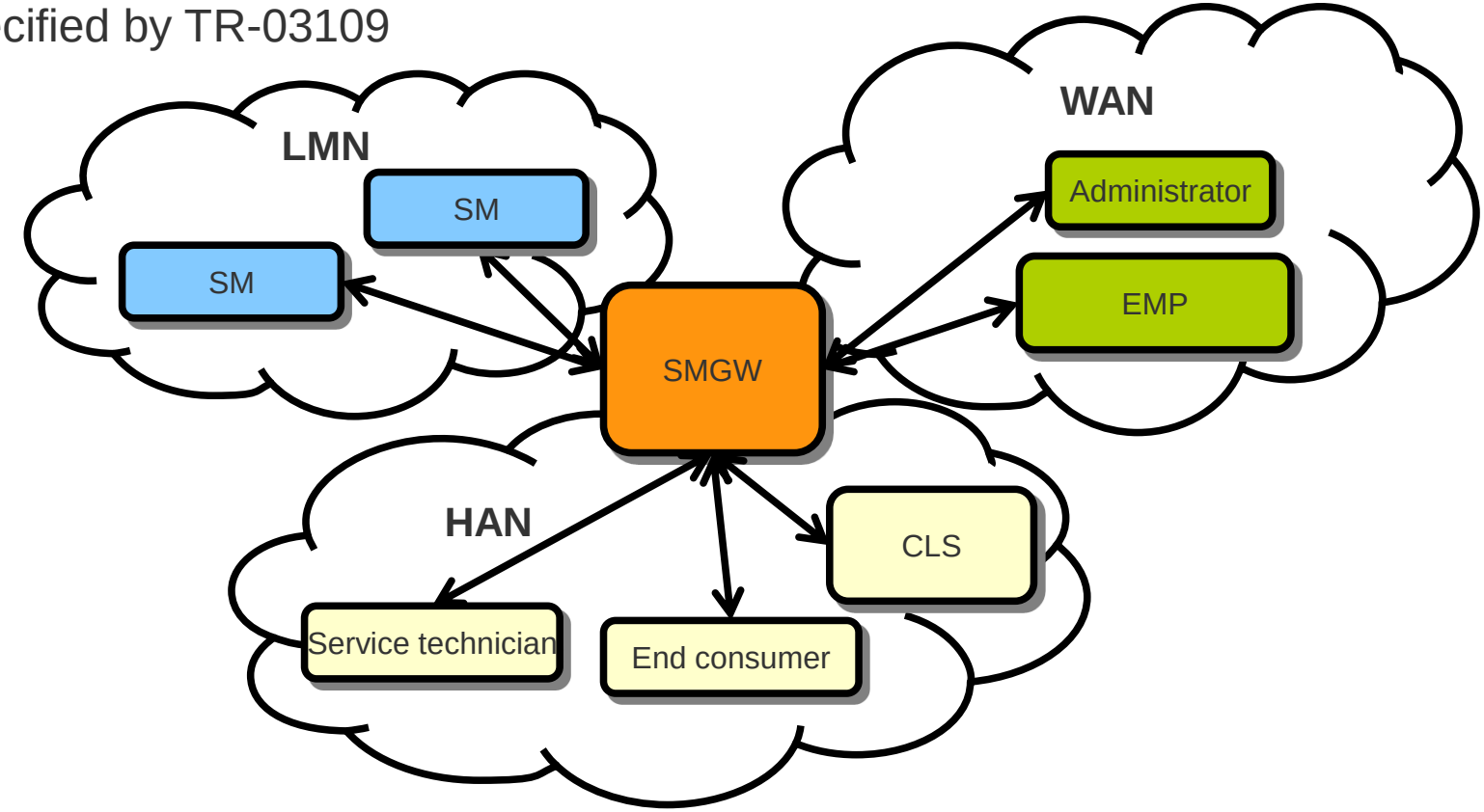
- Legal framework in Germany
  - Energiewirtschaftsgesetz (EnWG §21)
  - Regulation “Intelligente Netze“
  - **Technische Richtlinie (TR-03109)**, published by Federal Office for Information Security (Bundesamt für Sicherheit in der Informationstechnik, BSI)
    - Specifications for SMGW

- Rollout schedule in Germany



SMGW System Boundaries

Specified by TR-03109



- LMN = Local Metrological Network
- HAN = Home Area Network
- WAN = Wide Area Network
- SM = Smart Meter
- SMGW = Smart Meter Gateway
- EMP = External Market Participant
- CLS = Controllable Local System

SMGW: LNM Communication

- Applications
  - Gather metering data from SMs
  - Time-stamping measurements
  - Tariffing
  - Storing data for dissemination to EMPs
- Protocols
  - COSEM
  - M-Bus
  - SML
- Security
  - M-Bus encryption
  - TLS

<table>
<tr><th colspan="4">Protocol stack: LMN SMGW communication</th></tr>
<tr><td colspan="2">wireless</td><td>wired</td><td>open</td></tr>
<tr><td colspan="3">COSEM model with OBIS codes</td><td rowspan="2">other protocols</td></tr>
<tr><td colspan="2">M-Bus application protocol</td><td>SML application and transport protocol</td></tr>
<tr><td>M-Bus AES encryption</td><td>TLS</td><td>TLS</td><td>TLS</td></tr>
<tr><td colspan="2">OMS authentication and fragmentation layer</td><td rowspan="2">HDLC over EIA/RS-485</td><td rowspan="2">other protocols</td></tr>
<tr><td colspan="2">Wireless M-Bus (wM-Bus)</td></tr>
</table>

SMGW: HAN Communication

- Applications
  - (Read-only) access for end consumers
  - Relay control messages between CLS and EMPs
- Protocols
  - Not specified by TR-03109
- Security
  - TLS

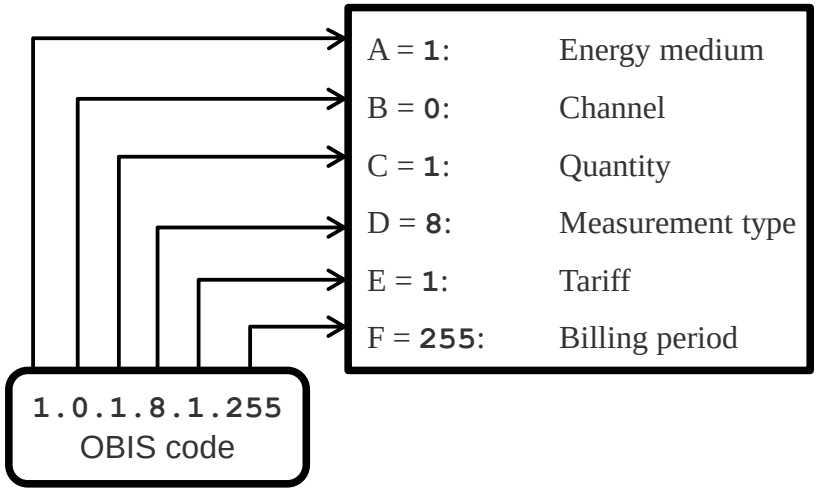
SMGW: WAN Communication

- Applications
  - Forwarding data to legitimate EMPs
  - Remote administration
- Protocols
  - RESTful web service
  - HTTP
  - NTP
- Security
  - CMS
  - TLS

Protocol stack: WAN SMGW communication	
Smart Metering, SMGW Administration	other services
COSEM model with OBIS codes	other protocols
XML	
Cryptographic Message Syntax (CMS)	
RESTful web service	
HTTP	
TLS	
not specified	

Overview: Standards and Protocols

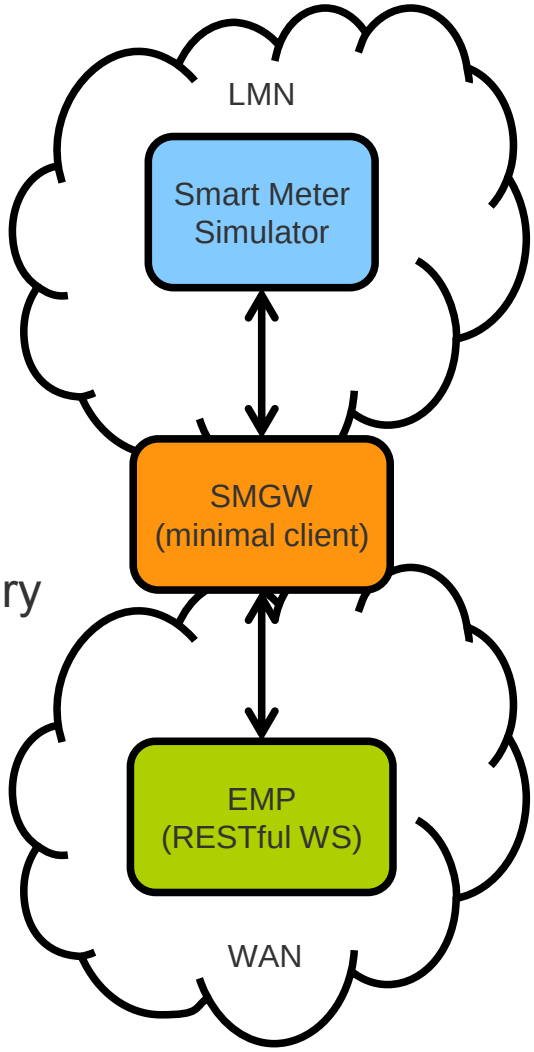
- Companion Specification for Electricity Metering (COSEM)
  - Object oriented modelling system
  - IEC 62056-6-2
- Object Identification System (OBIS)
  - Numeric code system
  - Identification of COSEM objects
  - IEC 62056-6-1



- Smart Message Language (SML)
  - Communication protocol for smart meter access
  - Described in BSI TR-03109-1 appendix IV
  - Inclusion in IEC 62056-5-3-8 planned

jOSEF: Components

- Smart Meter Simulator
  - Data source
  - Server, COSEM model
  - Generates fake metering data based on standard load profiles
  - XML-based configuration
- Minimal SMGW
  - Client for SM simulator → meter reading
  - Client for RESTful web service → meter data delivery
  - Graphical user interface (GUI)
- RESTful web service
  - Data sink
  - Server accepting metering data
  - Role: external market participant

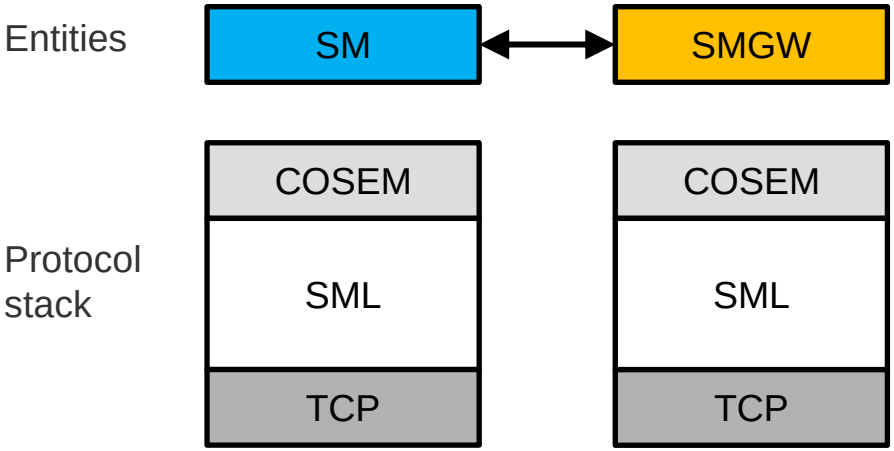


jOSEF: Implementation

- Implemented in Java
- COSEM Object Model
  - Minimal implementation
  - Simplifications: Only required classes and functions implemented
- SML
  - Based on jSML by Fraunhofer ISE (OpenMUC)
  - Modifications for SML v1.04 support
- XML schema based on working draft of BSI TR-03109
- Additional libraries used
  - Jersey: (RESTful web service)
  - jFreeChart (Visualization)

Meter Data Retrieval

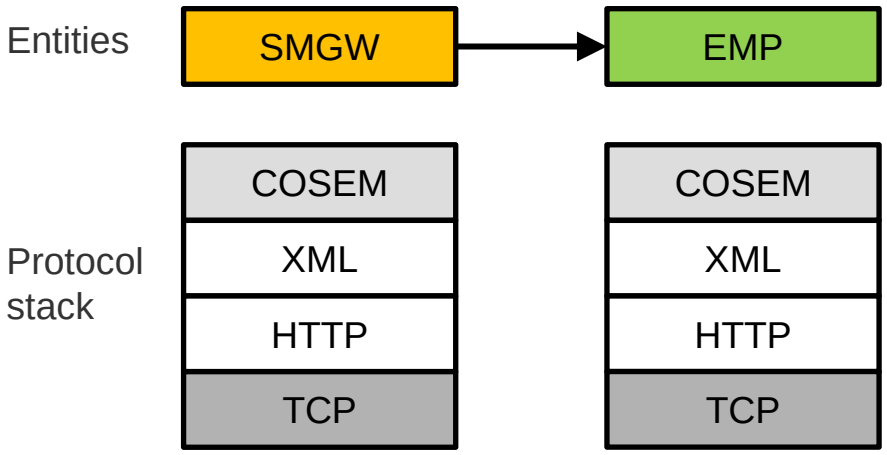
1. SMGW sends SML message to SM
   - Request all COSEM object IDs
   - Discover data model of SM
2. SM sends SML message containing list
3. SMGW sends SML message requesting details about metering objects
4. SM sends SML message containing metering objects



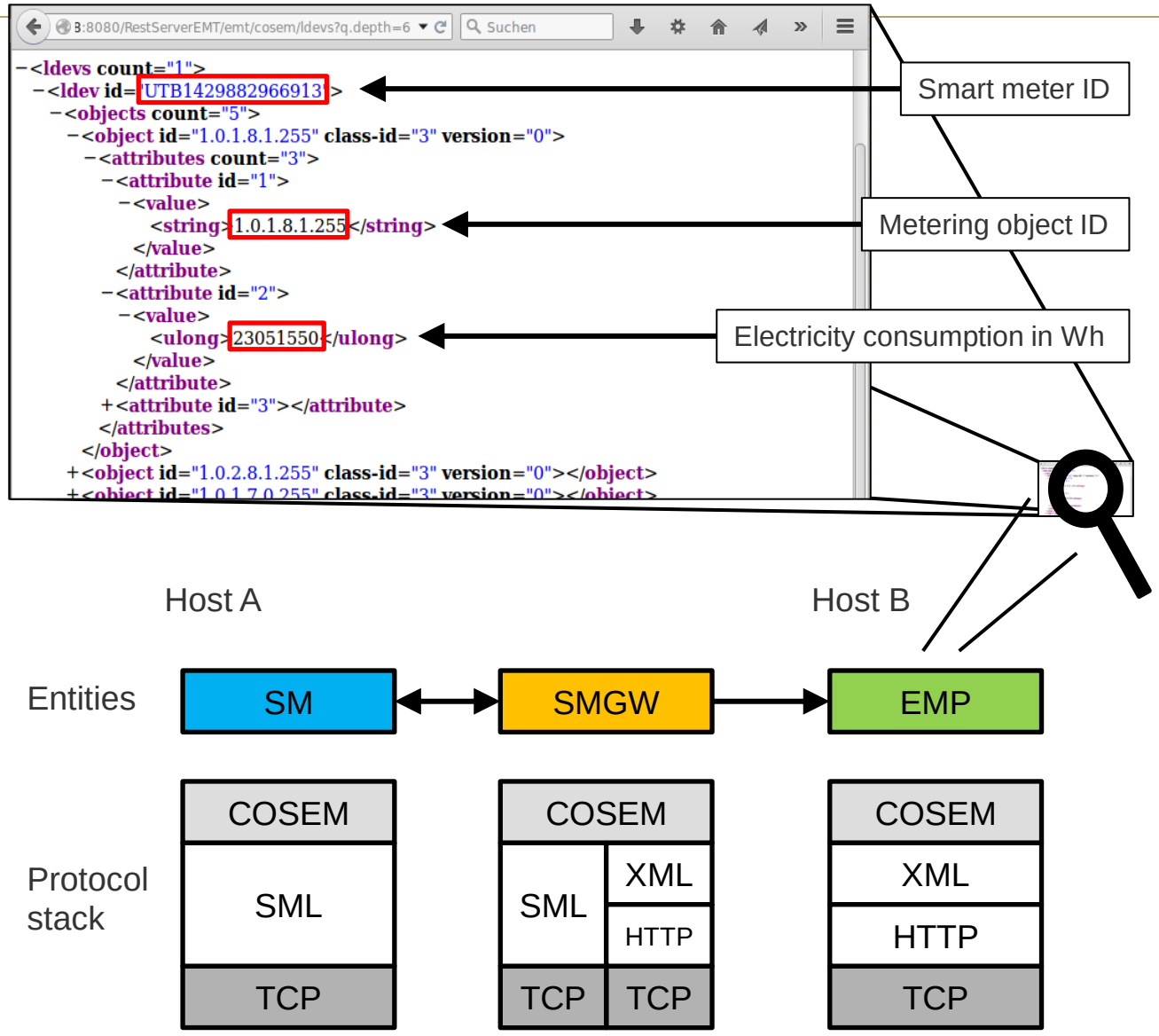
- Steps 1+2 only initially or upon reconfiguration

Meter Data Dissemination

- Meter data received in COSEM over SML is converted to XML representation of COSEM
- SMGW sends COSEM/XML data to RESTful web service end point using HTTP.



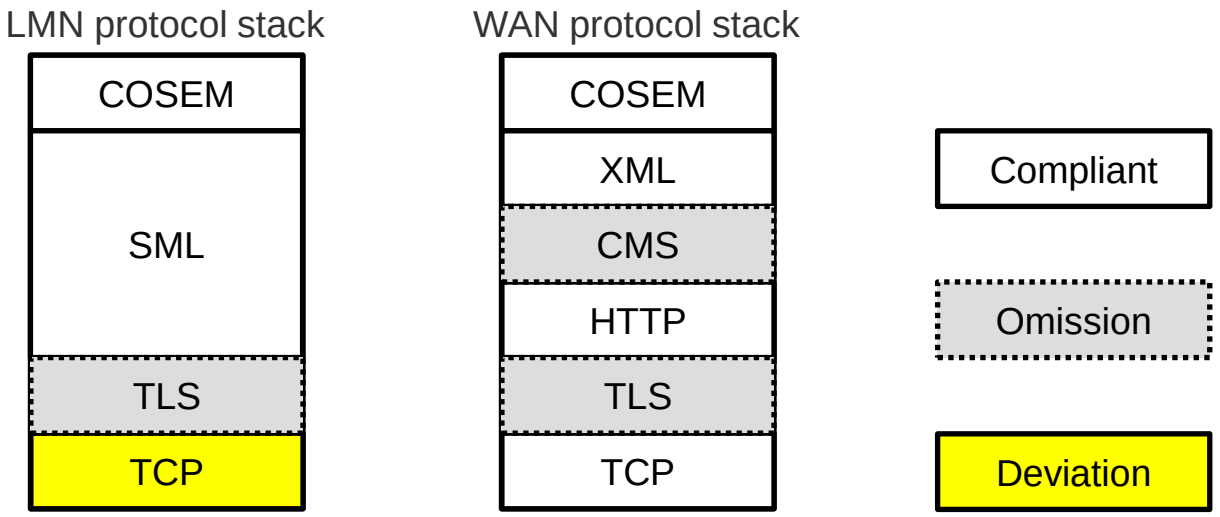
Example Scenario



Limitations

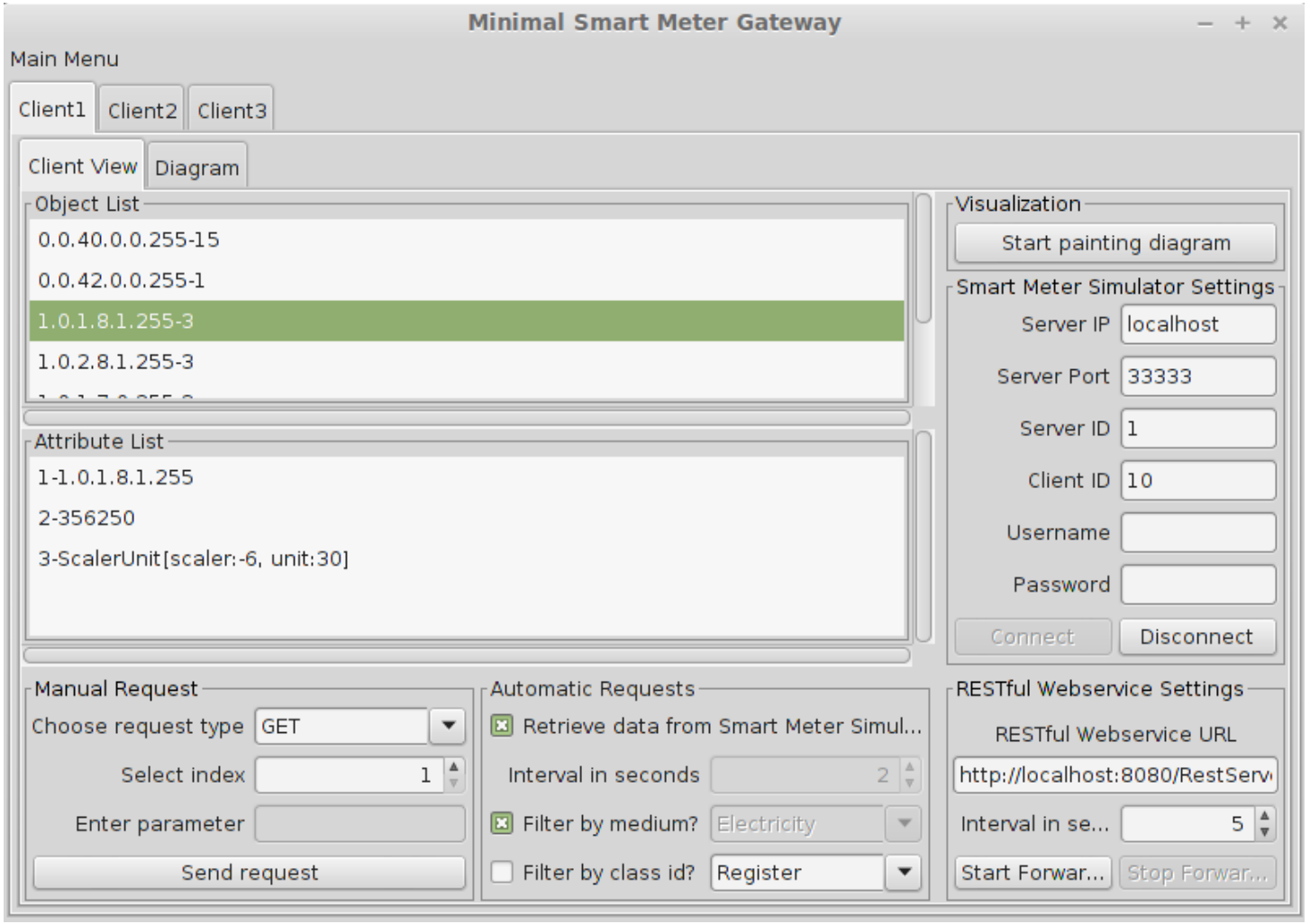
- Missing features
  - HDLC serial link support in LMN
  - Tariffing
  - Remote administration
  - Pseudonymization

- Deviations from TR-03109 specification



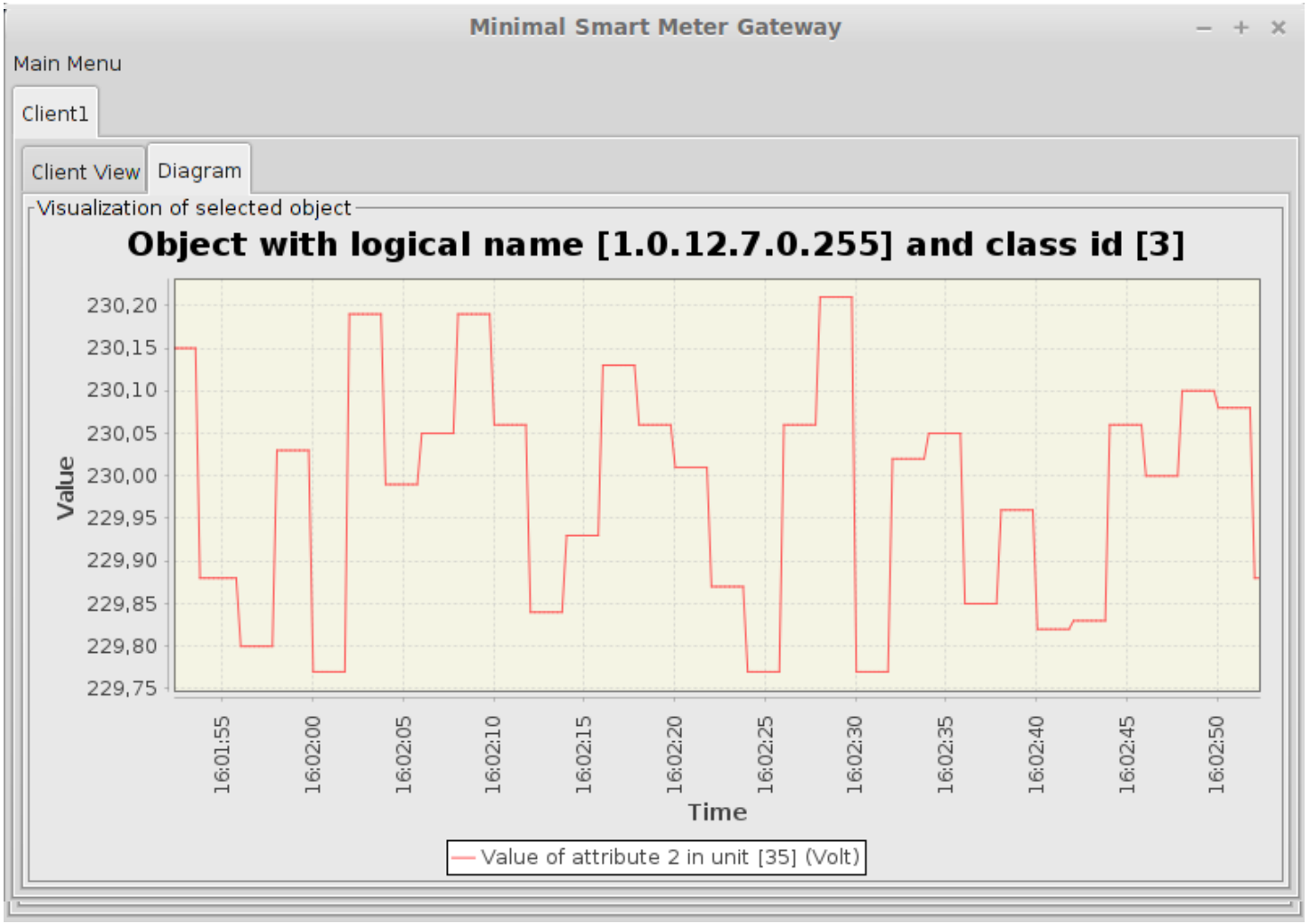
Screenshots

- SMGW GUI



Screenshots

- SMGW GUI (Data Visualization)



Screenshots

- SM-Simulator (Text console UI)

```
Welcome to the Smart Meter Simulator user interface!
Menu:
[1] View server settings.
[2] View simulator settings.
[0] Exit.
1
View server settings:
-> Server is listening on port [33333]
-> Server is not using authentication for clients
Menu:
[1] View server settings.
[2] View simulator settings.
[0] Exit.
2
View simulator settings:
-> Simulated annual power consumption in kWh [1000.0]
-> Simulated annual power infeed in kWh [1000.0]
-> Simulation-time of a 'realtime-quarter-hour' in seconds [4]
-> Simulation resolution in miliseconds [1000]
Menu:
[1] View server settings.
[2] View simulator settings.
[0] Exit.
0
Closing program...
```

Contact

www.cdax.eu

Thank you for your attention!

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