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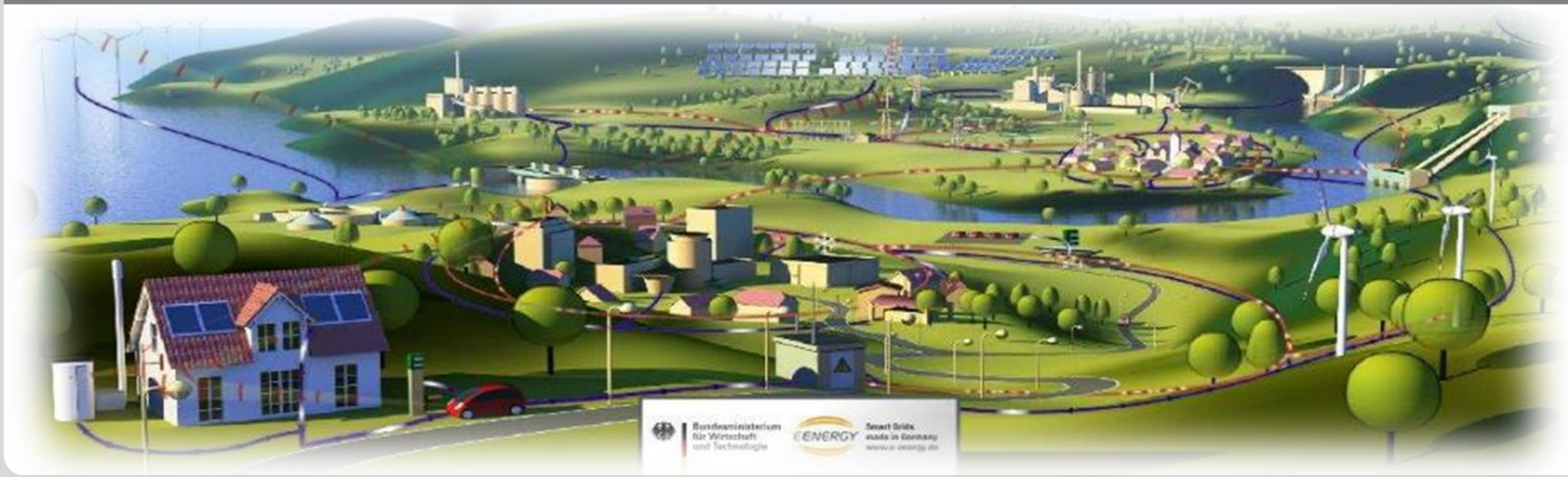
# Concept of a Big Data Infrastructure for Future Power System Control Centers

Eric Braun, Wolfgang Süß, **Karl-Uwe Stucky**, Clemens Düpmeier

INSTITUTE FOR APPLIED COMPUTER SCIENCE (IAI)



# Agenda

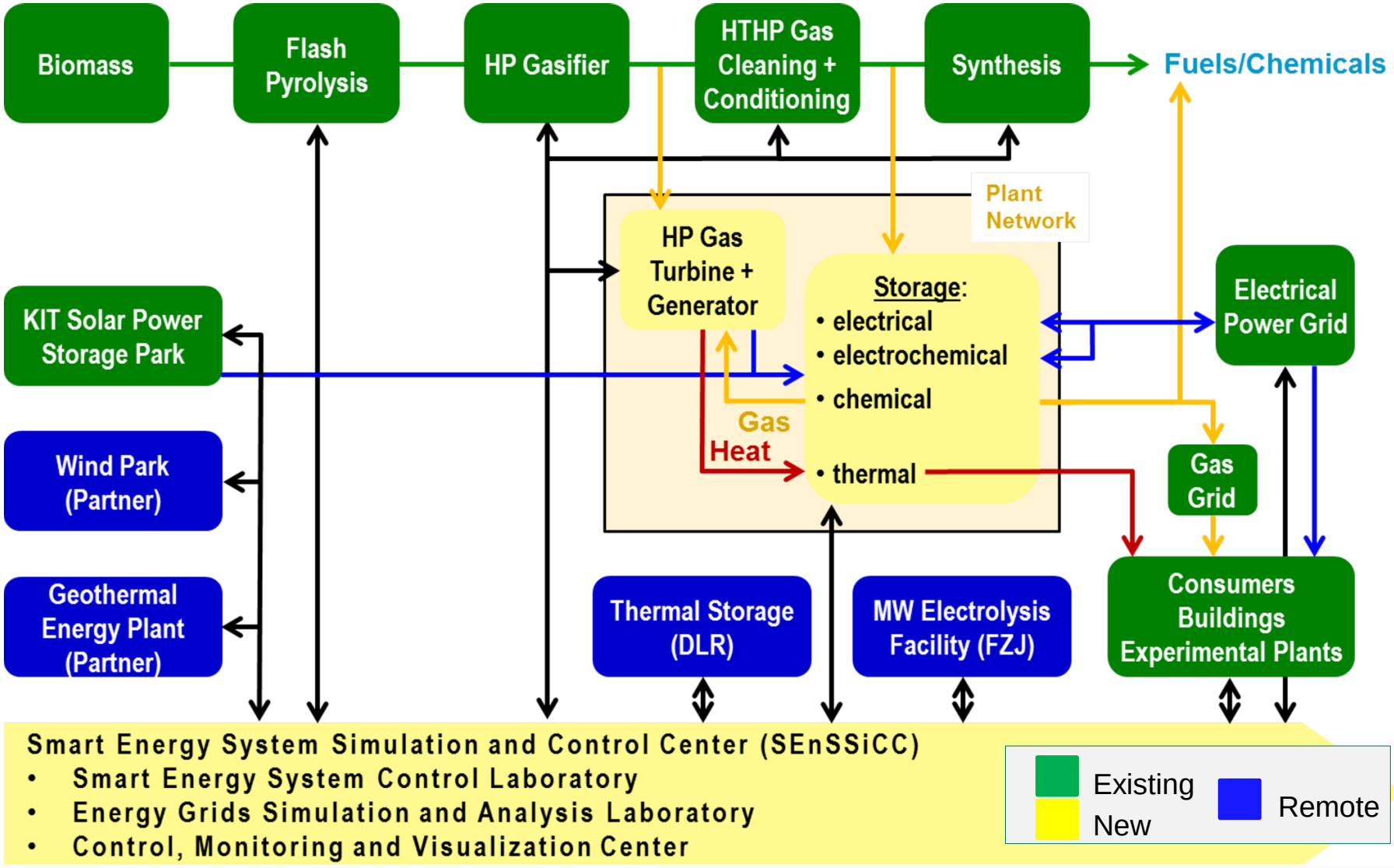
- Goal
- Projects Energy Lab 2.0 and Energy Systems 2050
- Concept Overview
- Details of the Concept

# Goal

- A New Software Architecture for a Distributed, Modular and Scalable IT Infrastructure of Future Power System Control Centers

- Key Challenges:
  - **fast development**
  - distributed cluster-wide **security system** (single sign-on)
  - generic **data management**, **analytics** and **ingestion** (for energy related data)
  - support for **CIM** and **IEC 61850** semantics
  - integration of IEC 61850 **field devices**
  - **high availability**
  - **highly configurable and automated** infrastructure (backend and frontend)

# Energy Lab 2.0 Infrastructure



# Smart Energy System Simulation and Control Center (SEnSSiCC) of Energy Lab 2.0

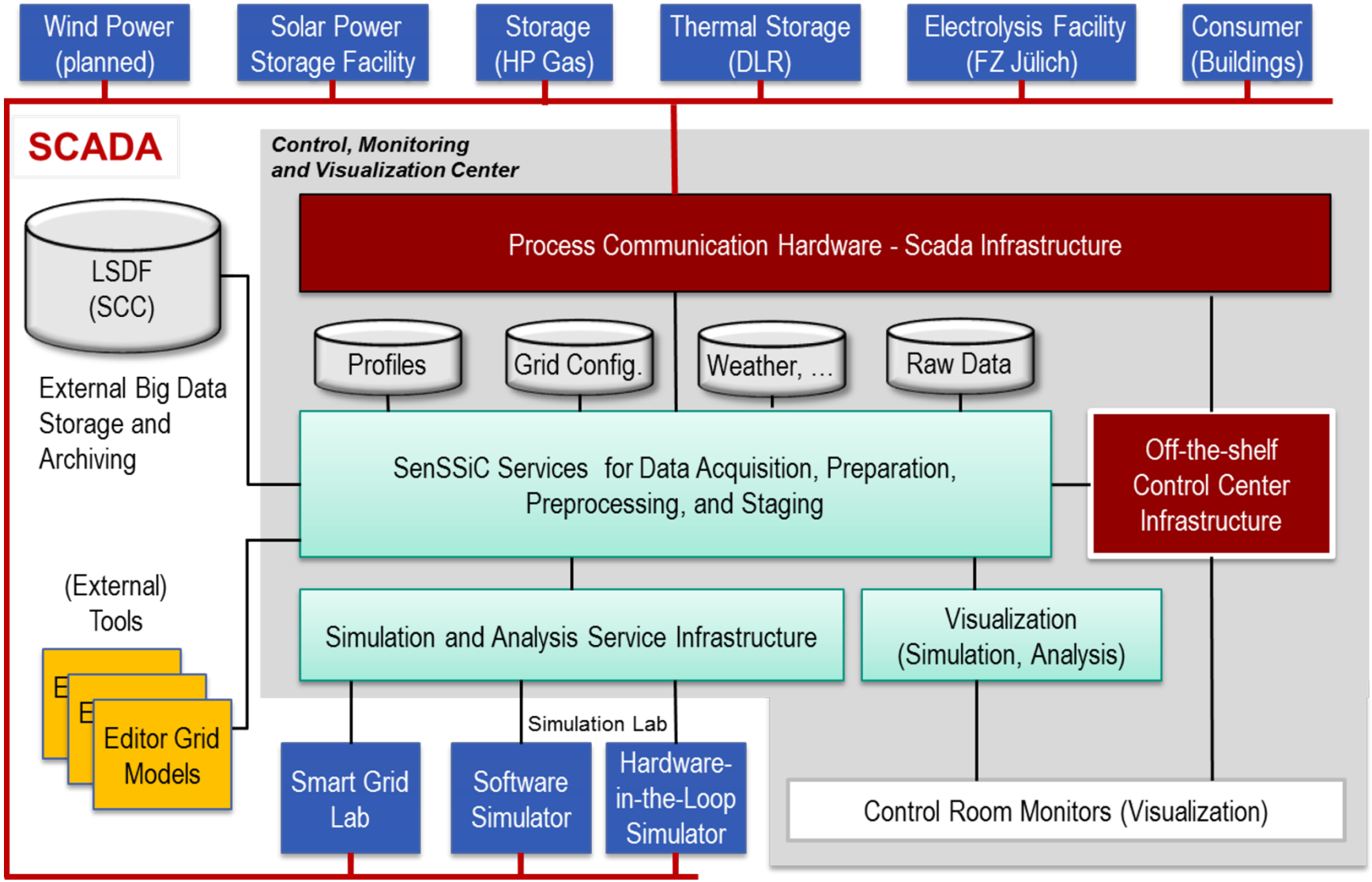
Main parts

- Smart Energy System Control Laboratory with
  - Power hardware in-the-loop test facility
- Energy Grids Simulation and Analysis Laboratory
- Control, Monitoring and Visualization Center (CMVC)

Cross-Cutting Topics

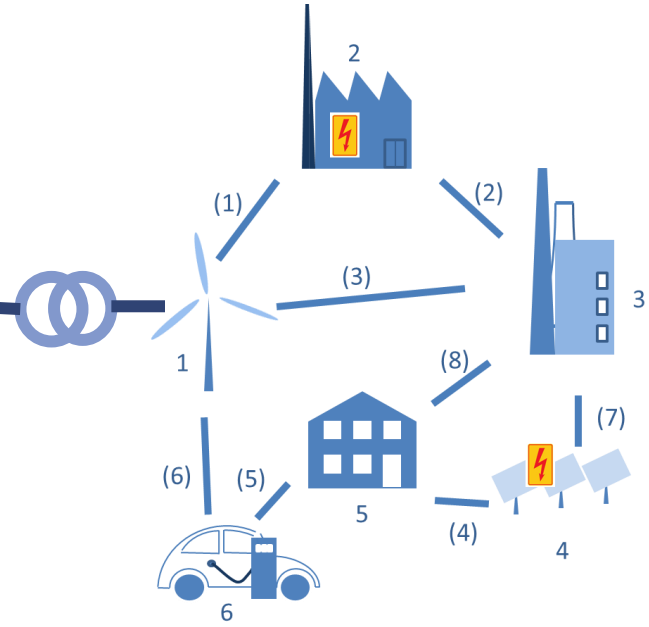
- Big Data
  (Data management
  and analysis)
- Smart control algorithms
- Security, Safety, Controllability

# Control, Monitoring and Visualization Center



# Control, Monitoring and Visualization Center

- Combines own research solutions for monitoring, control and visualization of grid simulations with commercial control center software and a SCADA communication infrastructure
- Integrates grid lab hardware and external Energy Lab plants
- Should look like a real grid control center for operators
- Research on new control center software components and architectures, newer communication technology and risks, tools for demand side management, demand response, grid utility operations



# Energy System 2050

- Running until 2019
- Goals:
  - improving understanding of energy systems
  - developing technological solutions for use by politics and industry.
- Develop toolbox for an „Internet of Energy“ based on Big Data infrastructures
- Use SEnSSiCC infrastructure as test bed

# Energy System 2050

Work in the research topic "Toolbox with Databases" is done under 7 work packages:

- **FT 5.1: Data formats, quality of data and database service**
- **FT 5.2: Building and network models for „Campus Living Labs“**
- **FT 5.3: Simulation platforms, IT architecture and security**
- **FT 5.4: Monitoring and data analysis**
- FT 5.5: Forecasting and automated energy scheduling
- FT 5.6: Optimization and future planning of energy systems
- FT 5.7: Control of future energy systems

# CMVC IT-Infrastructure

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**Applications**

Visualization | Energy Management | Outage Management | Simulation of Power Grids

*Frontend Framework*

*Generic Microservice Backend (GMB)*

**Big Data Services**

*Generic Data Services (GDS)*

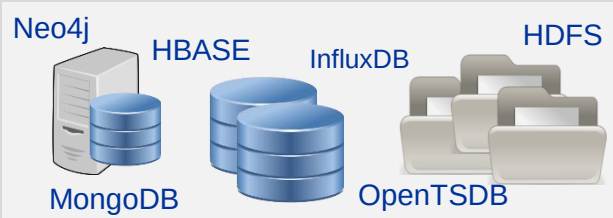
*Process Operation Framework (Proof)*

Data Relation-ship | Schema | Master Data | Time Series Data | Digital Assets

Generic Operations (Data Analysis, Model, Optimization, Simulation)

**Big Data Tools**

***Data Storage Technologies***




***Big Data Analysis Tools***

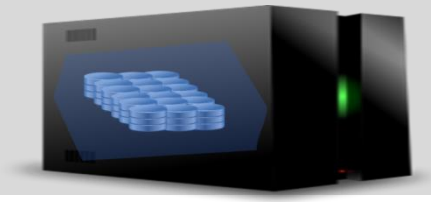
Apache Storm
Apache Spark
Elastic Search
Apache NiFi

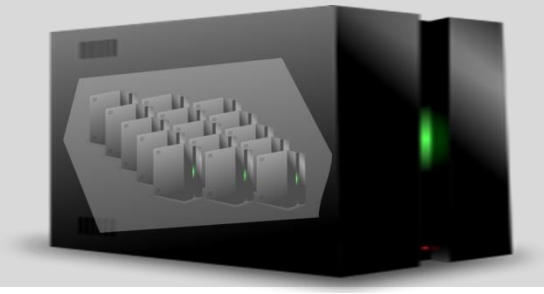
**Cluster Management**

***Distributed Cluster Computing System (DC/OS, MapR, Cloudera, …)***
***Container Virtualization (Kubernetes, Docker, …)***

**Hardware and OS**

***Computing Cluster (Windows and Linux supported)***





# First and Second Layer

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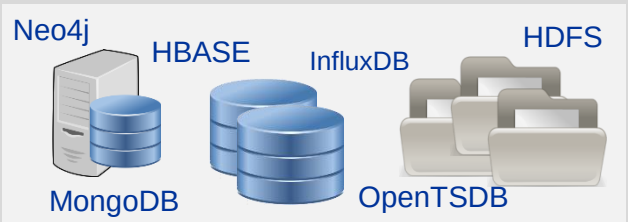


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***Hardware and OS***

# Basic Layers

- First Layer → Hardware and Operating System
  - Computing Cluster
- Second Layer → Cluster Management
  - Big Data Platforms
    - MapR
    - ***Cloudera***
    - DC/OS
  - Includes
    - Virtualization (Docker, Kubernetes)
    - Hadoop File System (HDFS)
    - Apache HBase
    - Yarn
    - Zookeeper

# Third Layer

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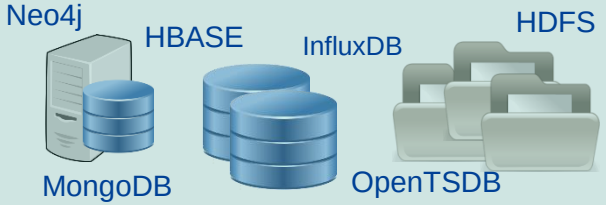


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# Third Layer → Big Data Tools

- Data Storage
  - Filesystems (HDFS)
  - NoSQL Databases
    - Neo4j
    - MongoDB
    - OpenTSDB, InfluxDB
    - Elasticsearch (*data storage and analysis*)
- Data Analysis
  - Apache Spark
  - Apache Storm
  - Apache NiFi

# Fourth Layer

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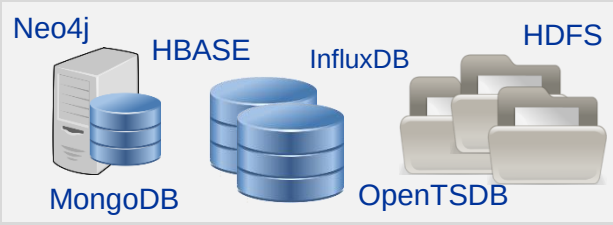


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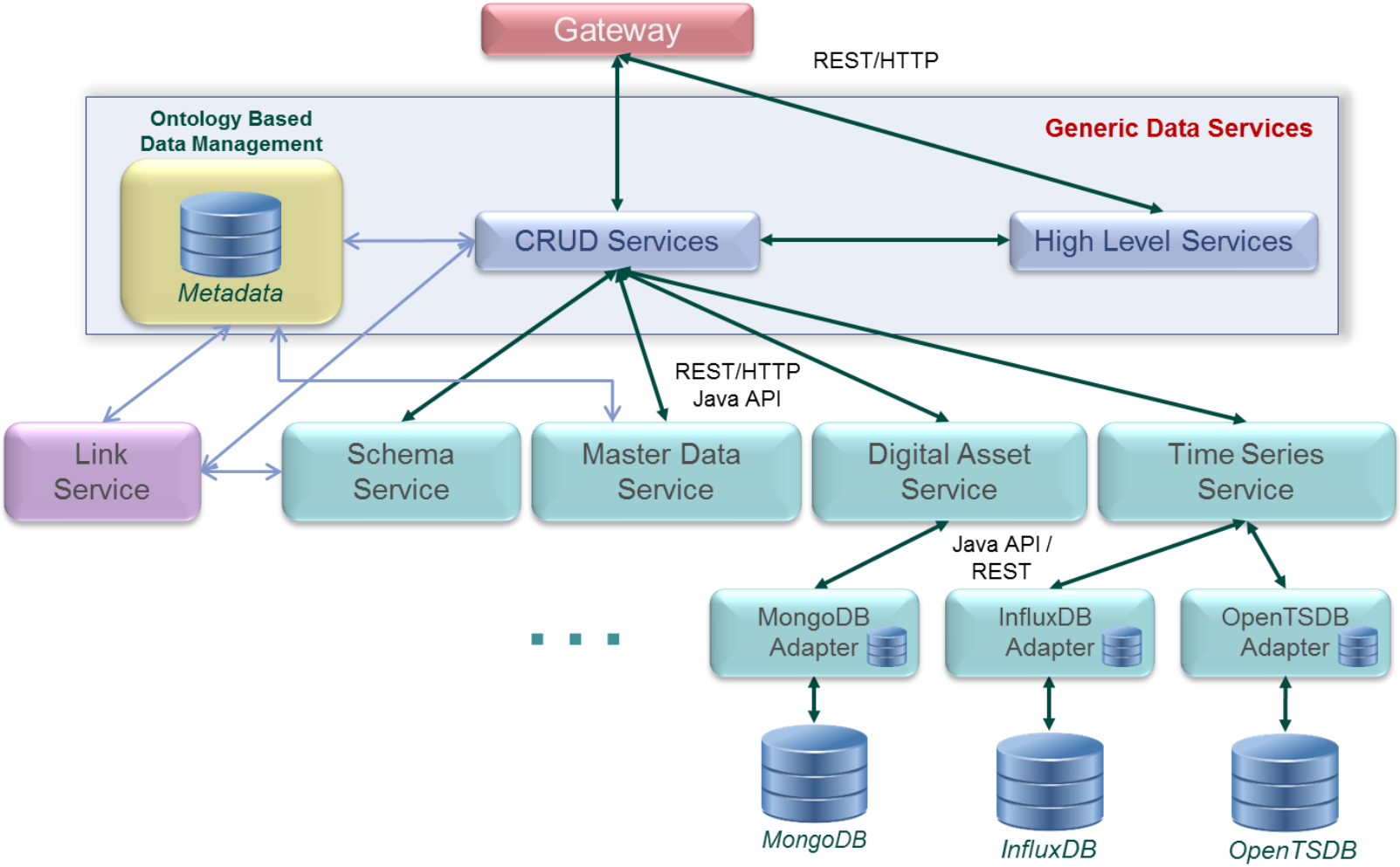
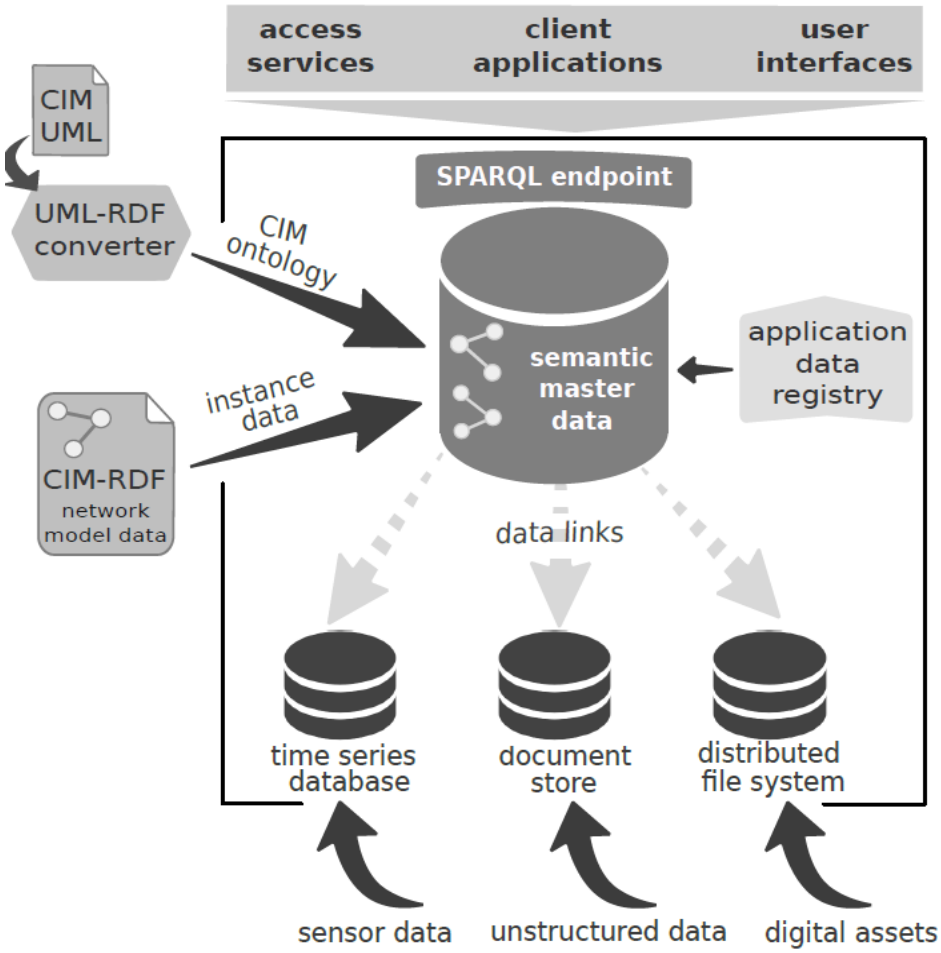
# Fourth Layer → Big Data Services

- Features
  - Service gateway
  - Microservice architecture
- Generic Microservice Backend
  - Security system (single sign-on)
  - Load balancing
  - Service Discovery → Zookeeper
- Components
  - Generic Data Services (GDS) → Data Management
  - Process Operation Framework (Proof) → Data Analysis

# GDS (Generic Data Services)

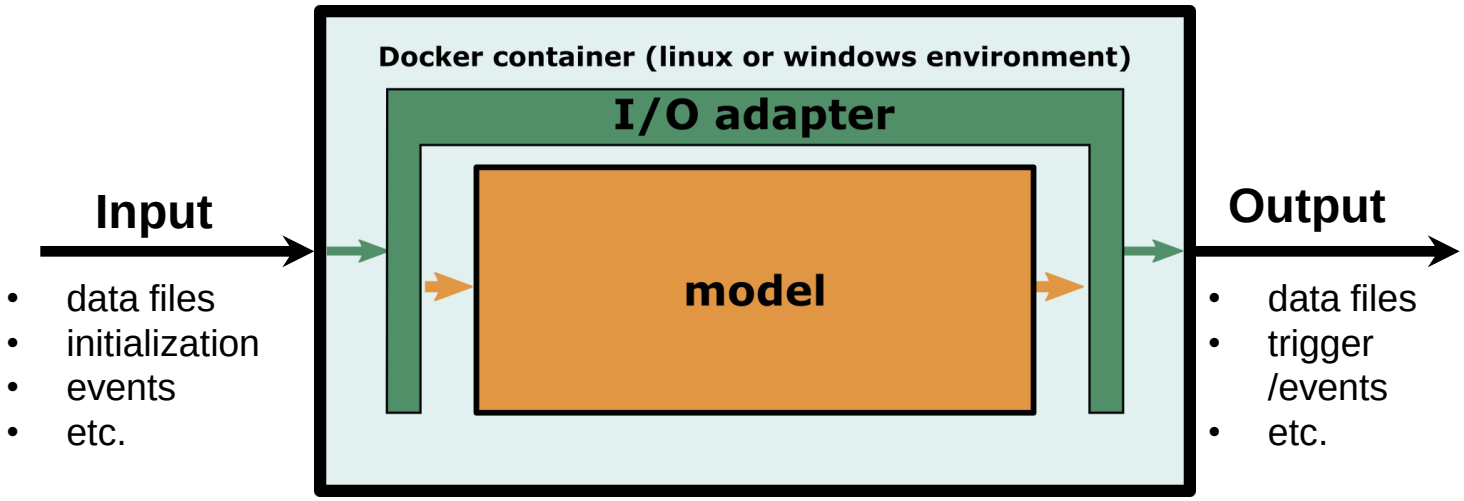


# Common Information Model (CIM)

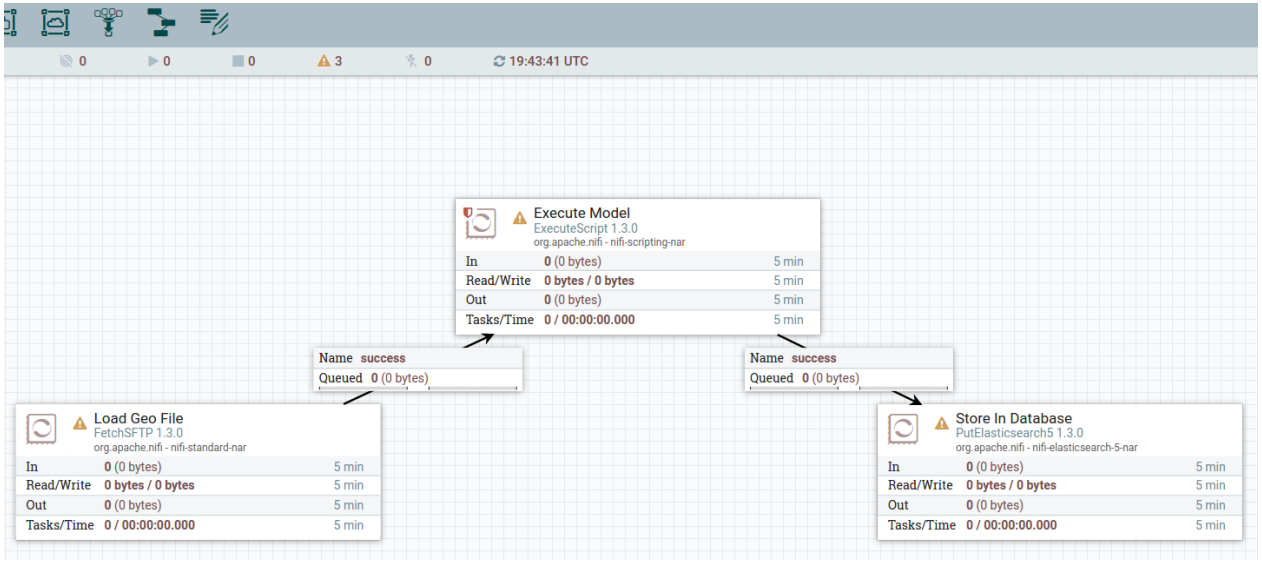



- **Semantic power grid model CIM**
- Data exchange format
- **Ontology-based Data Management (OBDM)**
- Metadata layer

# PROOF (Process Operation Framework)



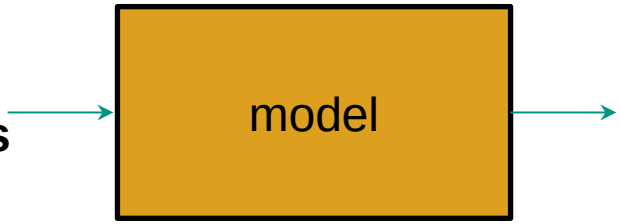

User Interface with Apache NiFi



# PROOF: Example

**Turbines**

**Geo Data**
**Wind Potential Areas**

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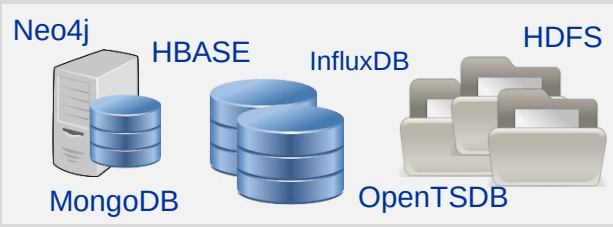


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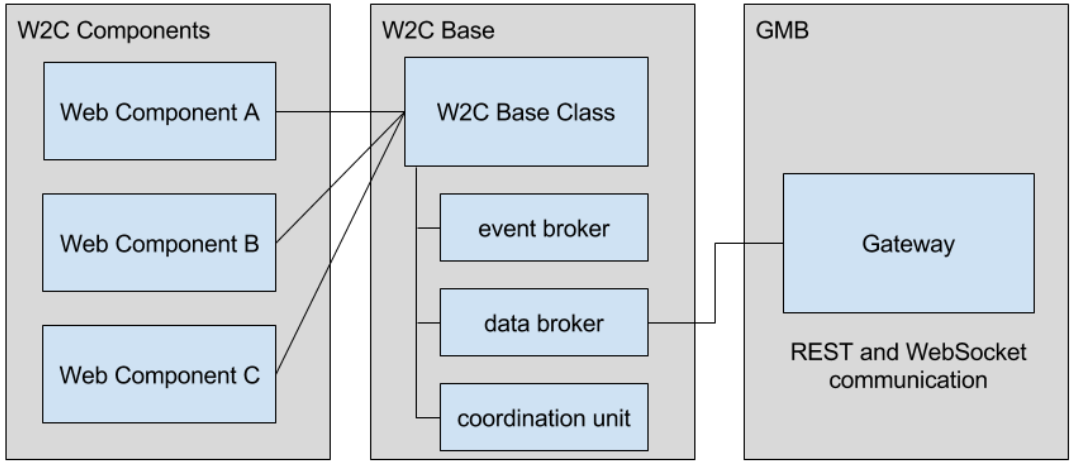
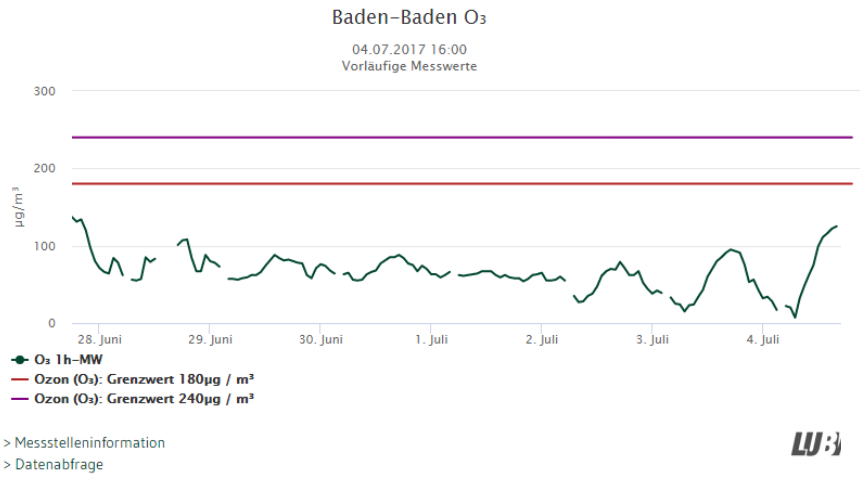
# Lightweight Web Component Framework

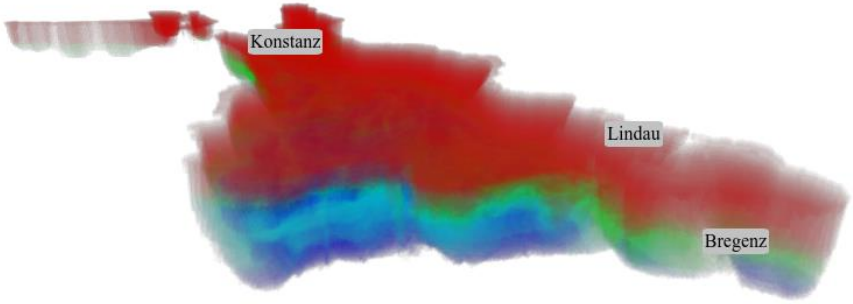
- based on web components technology
  - HTML 5
  - Polymer

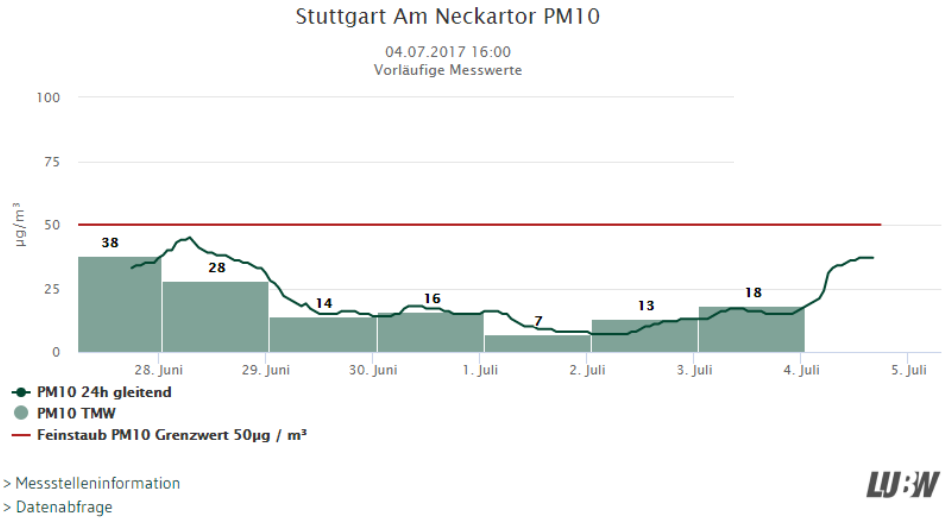

- concept
  - base classes for event and data communication



# Example: Visualization



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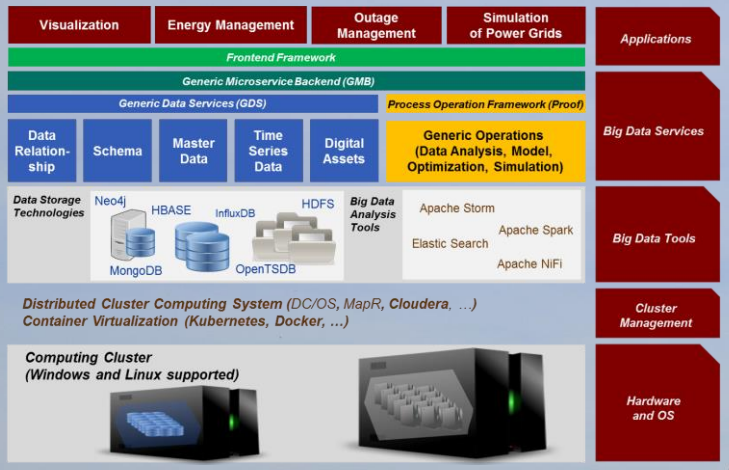
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