Reuse of Semantic Models for Emerging Smart Grids Applications

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Motivation

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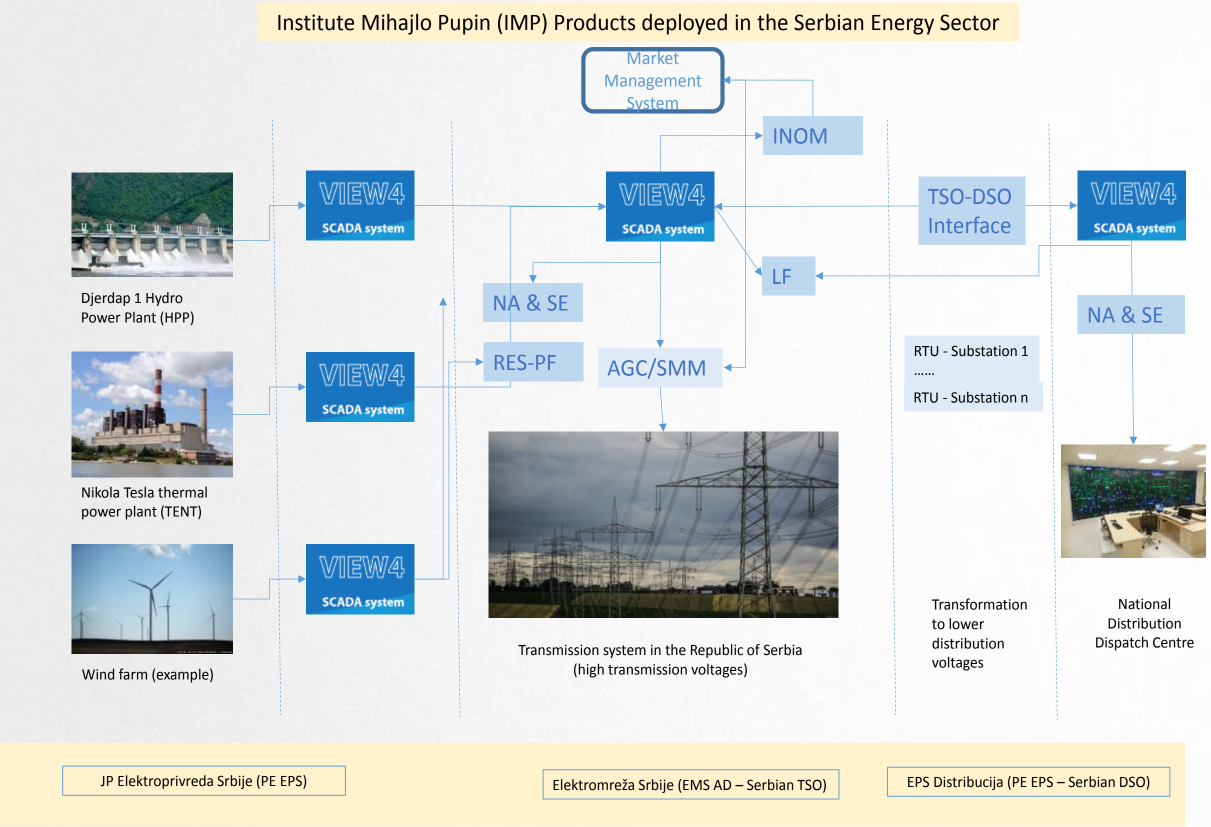


- **Energy management deals with monitoring and controlling the energy production, distribution and usage with different objectives including improvement of energy efficiency, increasing the flexibility and renewable generation share, and reducing the energy cost, e.g.** the Serbian Energy Value Chain
- Challenges
  - **Digitalization of the energy sector** Energy Management Applications are fragmented, developed against energy data silos, and data exchange is limited to few applications
  - **Big Data in the energy domain**
  - **Integration of renewable energy sources (RES)**

Acknowledgement

ARTEMIS - ARTificial Intelligence in Energy Management Innovative Services
PLATOON - Digital PLAtform and analytical TOOls for eNergy
TRINITY – **TR**ansmission system enhancement of reg**I**o**N**al borders by means of **I**ntelligen**T** market technolog**Y**

Challenges

- Data analytics tools
  - Real-time integration and Big Data analysis needed upon the high-volume data streams from metering devices and power grid elements (e.g. switches, transformers, etc.)
  - Decentralised Data Processing Architectures needed for processing multi-stream datasets of different velocity
  - Variability and degree of uncertainty of power output from renewable sources increases with penetration of distributed generation (Wind / PV / Solar Power Plants) and data analytics toolbox (e.g. Accuracy of forecasting, production) and edge computing solutions are needed for optimised real-time energy system management

- RQ1 - Which ontologies cover the needs for modelling the electricity value chain and modelling forecasting services in particular?
- RQ2 - How semantic models support building explainable AI services?

Challenges

- Interoperability
  - Data sources may have different data models, follow various data representation schemes, and contain complementary information
  - New smart grids services needed for effective and scalable semantic interoperability and creation of data spaces (also supported with EU Data Strategy)
  - message-based infrastructure needed to enable the communication of the different nodes and components in the energy value chain and integration in the European Energy Data Space

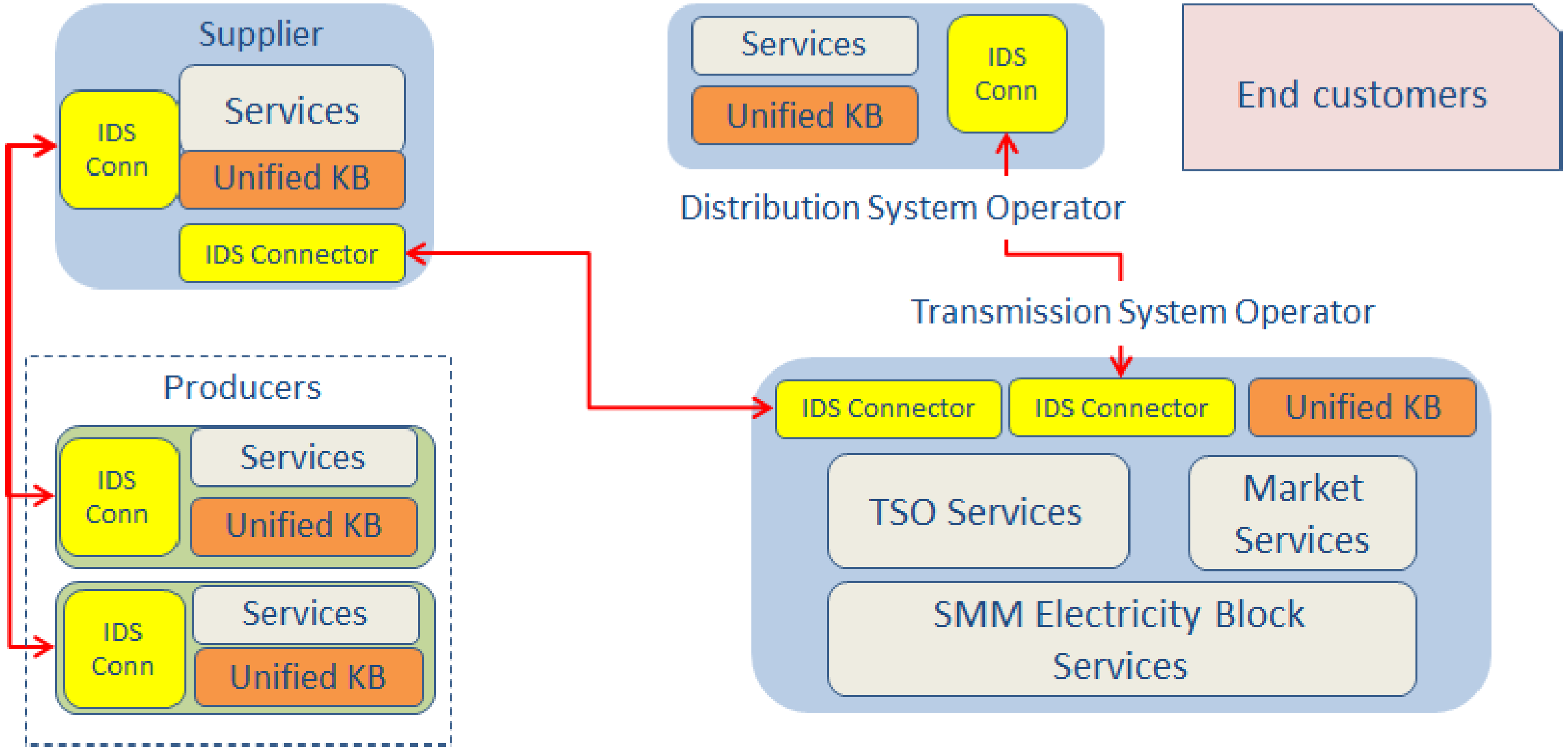
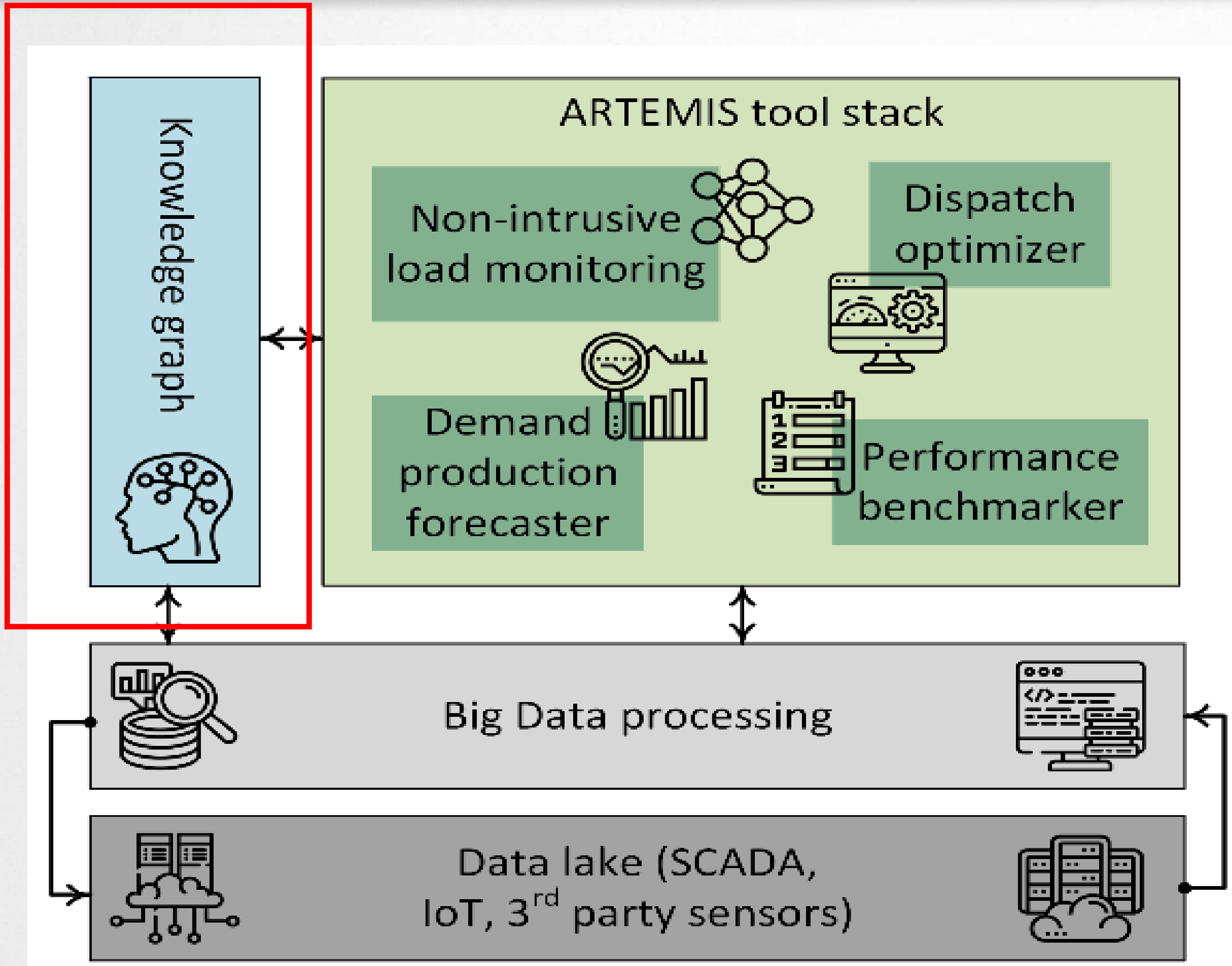


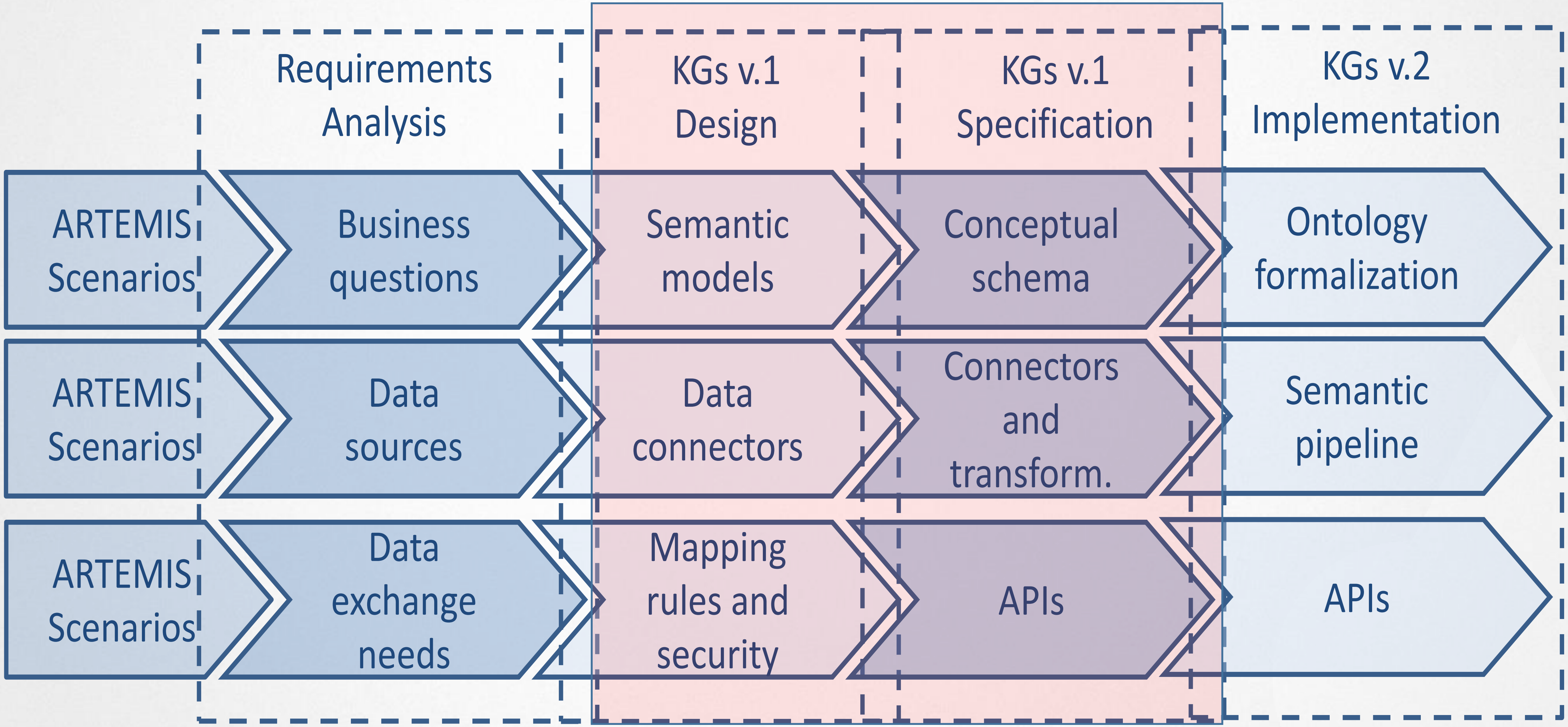
Figure 3: Multi-party data exchange based on IDS concept

Solution

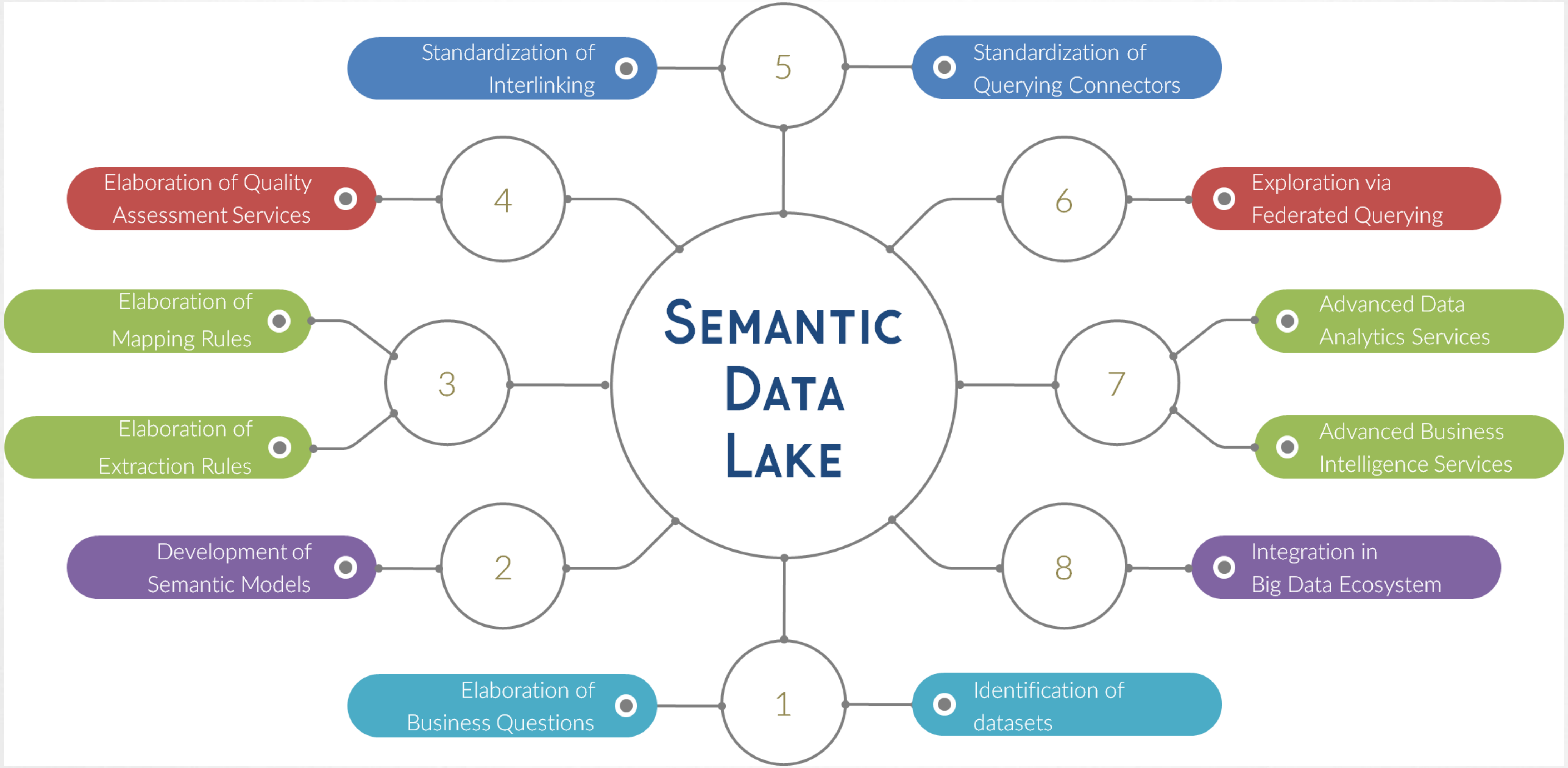


ARTificial Intelligence in Energy Management Innovative Services

Methodology –
Interoperability and Integration Framework



Building a Semantic Data Lake for Energy Management



Survey of Reusable Models

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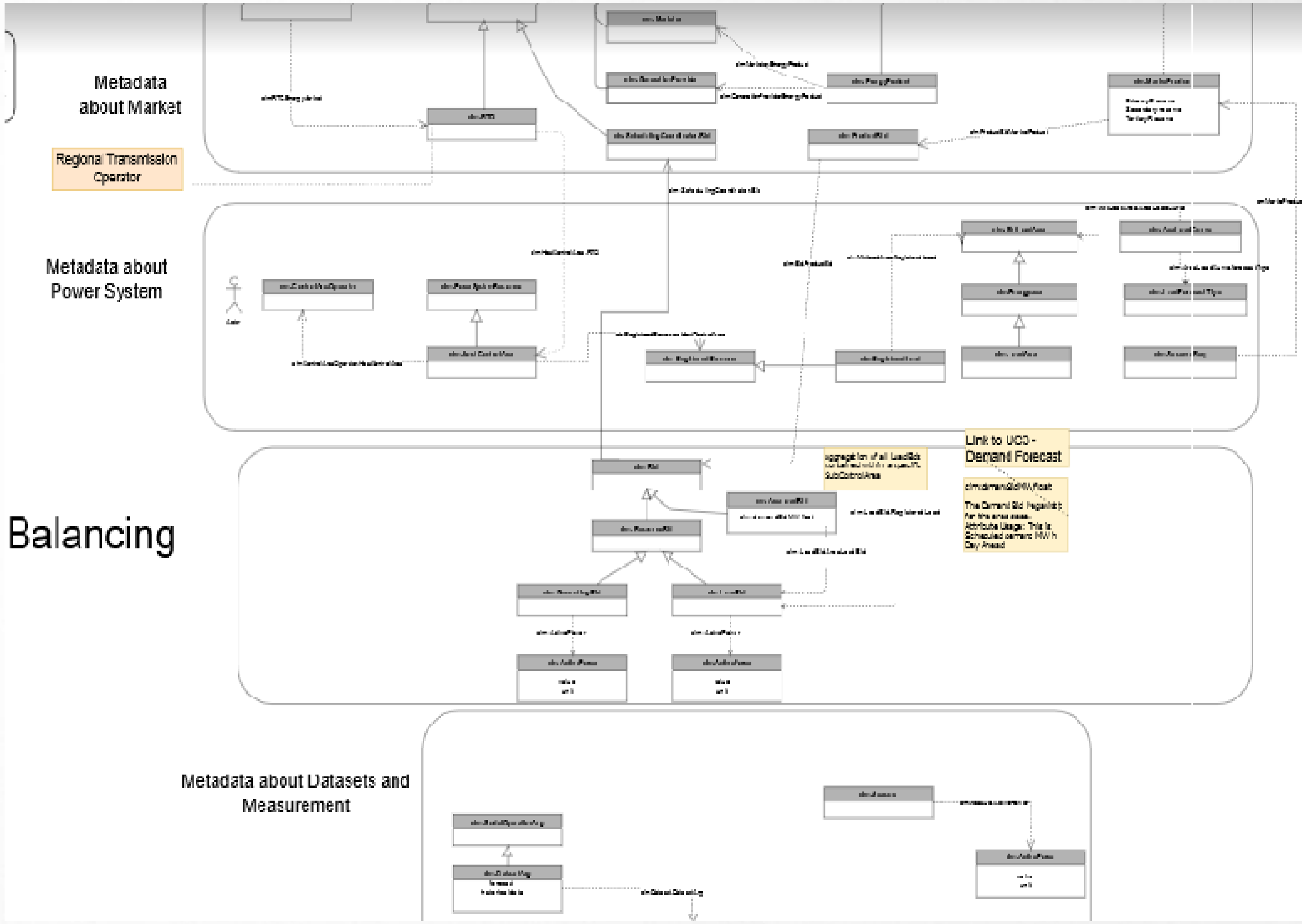
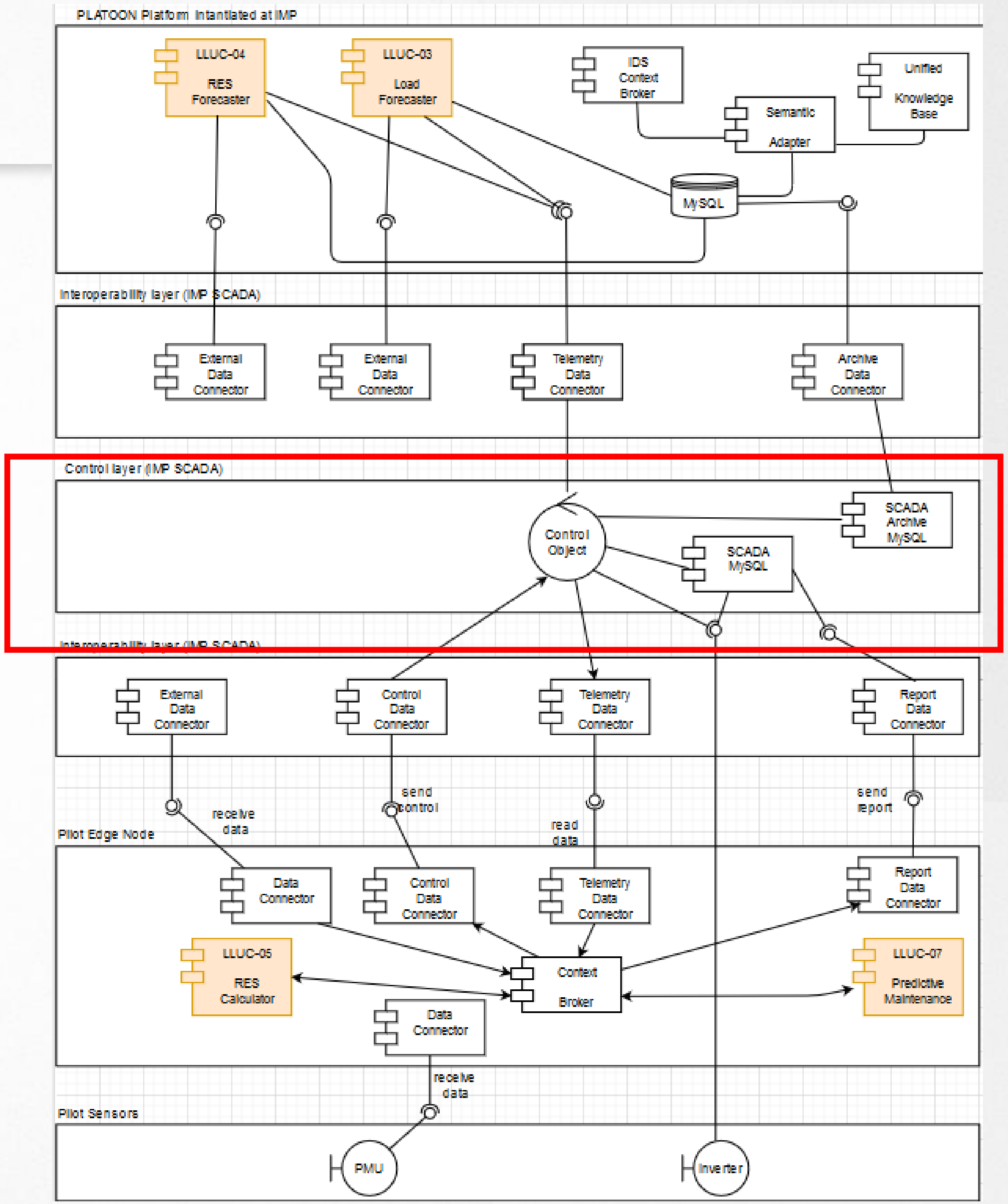
CIM	**Common Information Model, https://ontology.tno.nl/IEC_CIM/**
DCMI	Dublin Core Metadata Initiative, https://dublincore.org/
SAREF	Smart Appliances REFerence ontology https://w3id.org/def/saref4city https://w3id.org/def/saref4bldg https://w3id.org/def/saref4ener/ https://w3id.org/def/saref4agri/ https://w3id.org/def/saref4envi/
IDS	Industrial Data Space (IDS) Information Model



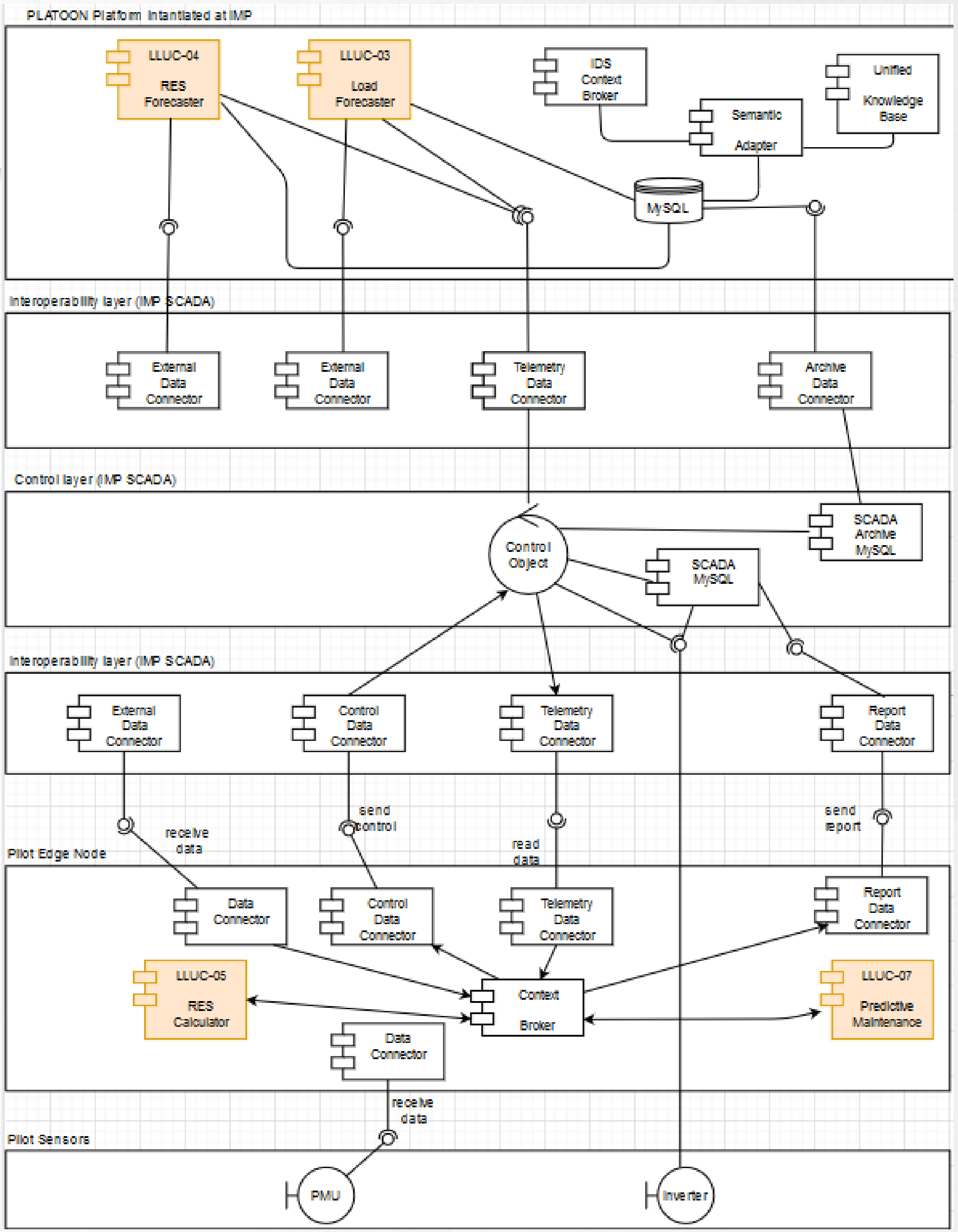
SGAM and IDS Based Architecture

- **Smart Grid Architecture Model (SGAM)** that is a product of the standardization process in the EU Mandate M/490, the work of the CEN-CENELEC-ETSI Smart Grid Coordination Group
- **THE INTERNATIONAL DATA SPACE (IDS) Information Model** Virtual data space leveraging existing standard and technologies, as well as governance models well accepted in the data economy, to facilitate secure and standardized data exchange and data linkage in a **trusted business ecosystem**



Architecture & Components

- Multi-paradigm AI tool-stack encompassing data-driven (deep learning) and model-driven (black/grey box) technologies
- Unified Knowledge Base
- Semantic Adapters and Federated Querying
- IDS-based connectors
- Edge services



Explainable AI Services (under development)

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- **DANN-based non-intrusive "behind the meter" (BTM) analytics** offering appliance-level load disaggregation from smart meter measurements, i.e. featuring appliance status recognition (classification problem) and power consumption estimation (regression problem)
- **Hybrid data and model driven local production forecasting** offering energy generation prediction based on physical models and measured data (black/grey box modelling)
- **Data-driven energy demand forecasting** providing short and long-term forecast of different load types (i.e. electricity, heating and cooling)
- **Hybrid ML-enabled energy performance assessment** delivering a measure of consumer energy efficiency by normalizing energy consumption against context-related (e.g. climate, construction type, number of inhabitants etc.) and behavior-related aspects (e.g. deviations from expected consumption), which will be used for consumer benchmarking

- Evaluation of Machine Learning Interpretability of the Output of Predictive Models
- Enhance Reasoning by Integrate rules (SPARQL queries and SCHACL constraints)
- Identifying new properties for building more accurate predictive models

Conclusion

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- Standardized data models (CIM, SAREF, BOT) relevant for energy management are available in different formats (UML, XML, RDF)
- Development of the Semantic layer extends the reused common vocabularies and ontologies and the selection of models have to be done based on the target scenarios (e.g. for forecasting, see SEAS ontology)
- The meta-data layer in Digital Ecosystems (e.g. Energy Data Ecosystem for Serbia) can (1) facilitate the integration of services in future integrated energy systems and (2) improve the explainability of machine learning services / analytical applications (still under evaluation in PLATOON and ARTEMIS projects)

Questions?

Thank you for your attention!

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Doctoral Workshop 2021