CERTH
CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

Data integration & interoperability:

Data integration & Data modeling with other sources/software

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SmartWins

❖ Data Integration and Interoperability

- ➢ Enabling Seamless Data Exchange
- ➢ Efficient data sharing towards more efficient decision-making
- ➢ Eliminating data silos and promote collaboration
- ➢ Enhancing data accuracy and consistency

❖Data Integration

- **The process of combining data from multiple sources to provide a unified view**
    1. Extraction: Gathering data from different systems and sources
    2. Transformation: Conversion and harmonization of data to a common format
    3. Loading: Storing the integrated data in a central repository
- **Challenges**
    1. Data incompatibility(different formats, schemas, etc.)
    2. Data quality issues(duplication, errors, proper validation)
    3. Security and privacy considerations

❖Data Interoperability

- The ability of systems and applications to communicate and exchange data seamlessly
- Use of standardized data formats and protocols
- Use of Defined Interfaces and APIs
- Enhancement of Compatibility across different platforms and technologies
- Facilitation of integration and collaboration among diverse systems
- Scalability and Extensibility

Data integration & interoperability

❖Data Importance of Software Design Architecture

- Provides a blueprint for organizing and structuring systems and data
- Defines components, modules and interactions
- Enables scalability, flexibility and maintainability

❖Principles of a robust architecture design

- Modular design: Breaking down the system into independent modules
- Minimizing dependencies between components
- Scalability: Handling growing data volumes
- Flexibility: Adapting to changes in requirements and technologies

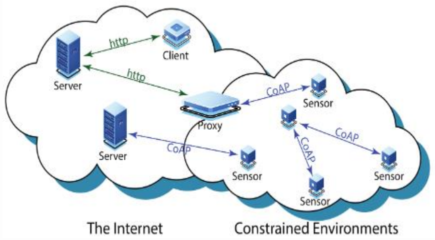
Data integration & interoperability

❖Data Transmission protocols for IoT devices

- A set of rules/standards that govern data exchanging among IoT devices and systems
- Define format, structure and procedures of data transmission
- Facilitate IoT systems optimal functionality, real-time monitoring, control and decision making

❖Most Commonly Used Protocols

- **<u>MQTT:</u>**
  - Lightweight publish-subscribe model efficient for one-to-many communication
  - Low latency, power consumption
  - *QoS – Quality of Service* levels for reliable message delivery
- **<u>CoAP:</u>**
  - Lightweight with built-in resource discovery and caching mechanisms
  - Request-Response support functionality and asynchronous notifications
  - Reliable or Best-Effort message delivery features
- **<u>HTTP:</u>**
  - Well-established, extensive support and compatibility
  - Rich methods for data manipulation(GET, POST, PUT, DELETE)
  - Preferred for web-based services and APIs
- **<u>XMPP:</u>**
  - Designed for instant messaging
  - Extended for IoT communication, device control, sensor data collection, event notifications
  - Can be integrated with other protocols like HTTP and MQTT



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❖ Devices Connections Architecture

- Ways devices are interconnected in a network
- Ways to communicate with each other

❖ Most Commonly Used

- **Star Architecture:**
  - Centralized design with a single hub or gateway for device connection
  - Devices communication directly with hub, not with each other
  - Home automation
- **Mesh Architecture:**
  - Decentralized design, devices communicate directly
  - Data routed through multiple paths, no single point of failure
  - Increased complexity in managing network routing
  - Smart city where devices need to communicate across a large area
- **Tree architecture:**
  - Efficient for hierarchical systems
  - Reduced communication overhead
  - Industrial monitoring systems(factory automation)

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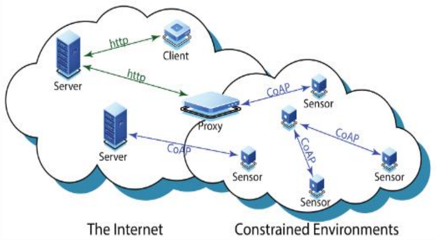
❖Communication with Gateways

- Interaction and data exchange between devices or networks and a gateway device
- Gateway acts as a bridge between different networks, protocols, e.t.c.
- Facilitate communication interoperability

❖Important functionality

- Network interconnection
- Protocol conversion
- Security and Firewall
- Data Aggregation and Processing
- Remote Management and Control
- Interaction with Cloud Services
- Interoperability and Standardization



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❖RE-COGNITION PROJECT

- **Develop a solution aming to:**
  - Maximize utilization of locally produced energy by building level renewable energy technologies
  - Reduce implicitly and explocitly induced costs towards Zero Energy Building’s realization

- **Cross-Functional Renewable Energy Sources Integration Platform**
  - Automated Cognitive Energy Management Engine (ACEME)
  - BuildingEnergy Plant Planning Tool (BE-PLATO)
  - iGateway
  - Visual Analytics Dashboard

- **Techonlogies Used**

❖RE-COGNITION PROJECT – Conceptual architecture

Building Equipment Layer

- BIPV
- VAWT
- mCHP
- EV Charger
- LHTS
- Chiller
- Energy storage system

ICT Backbone Layer

- ACEME
- iGateway
- BE-PLATO
- BEFS Component

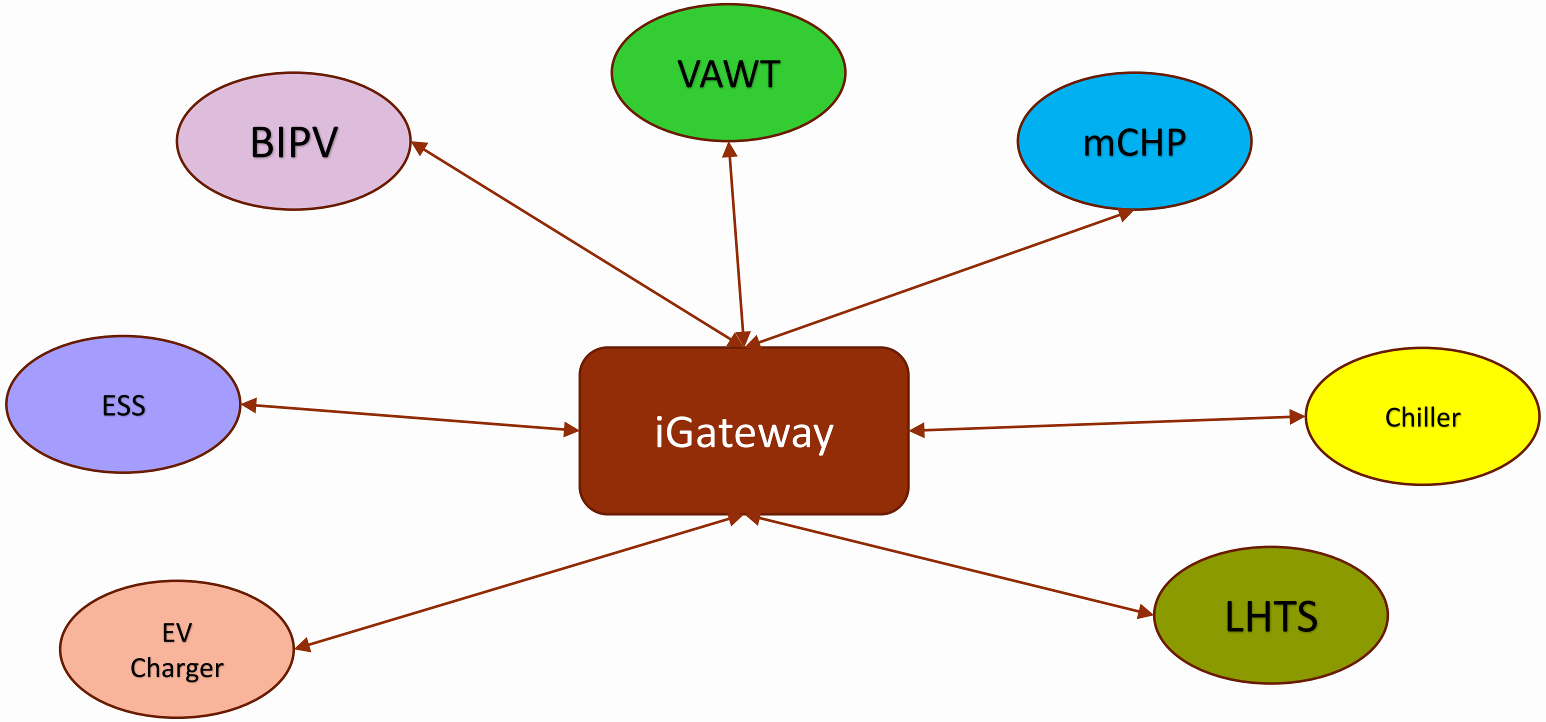
VAD

- Visual Analytics Dashboard

❖RE-COGNITION PROJECT – Devices Connections architecture

➢ Star Architecture

- Centralized Design
- iGateway for connection



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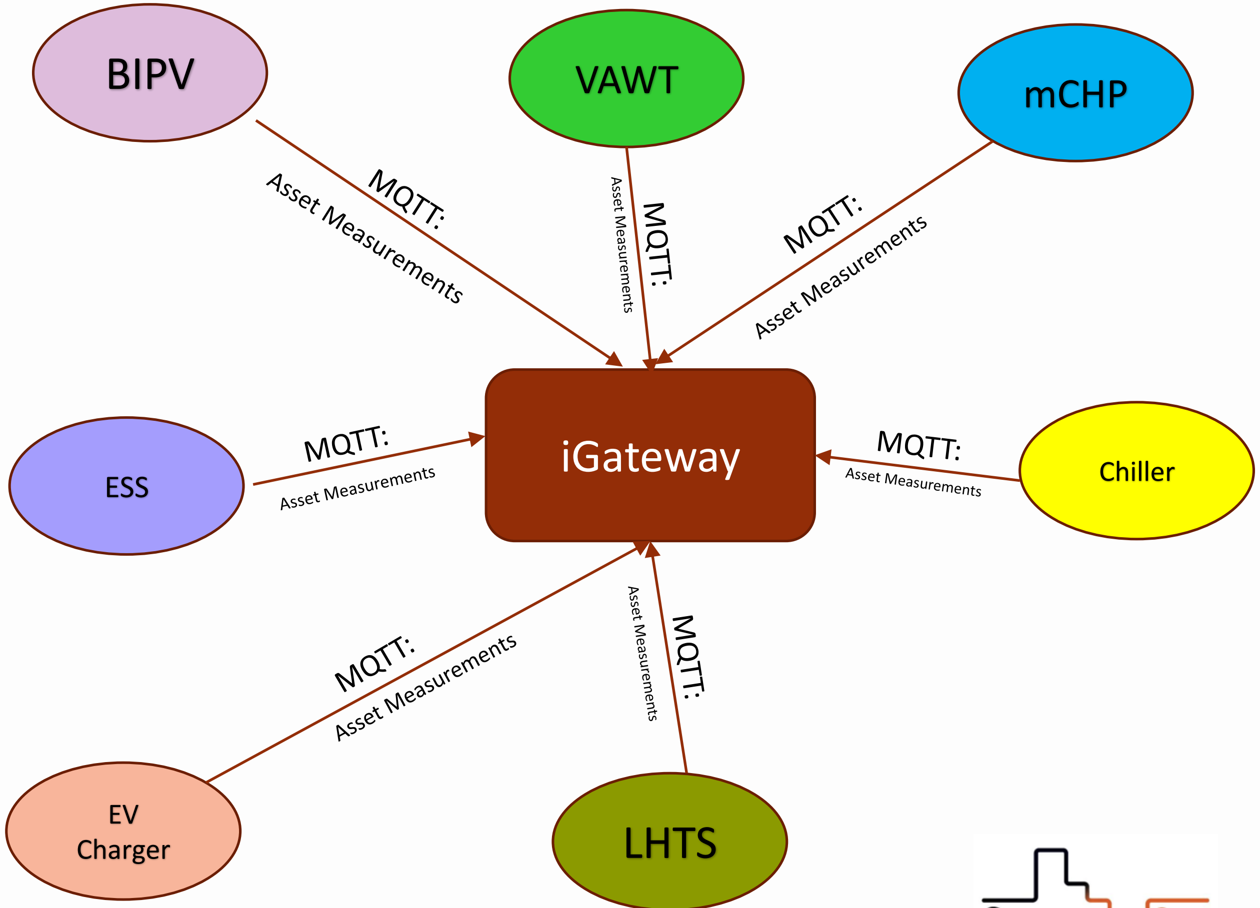
❖RE-COGNITION PROJECT – iGateway(1)

➢ iGateway

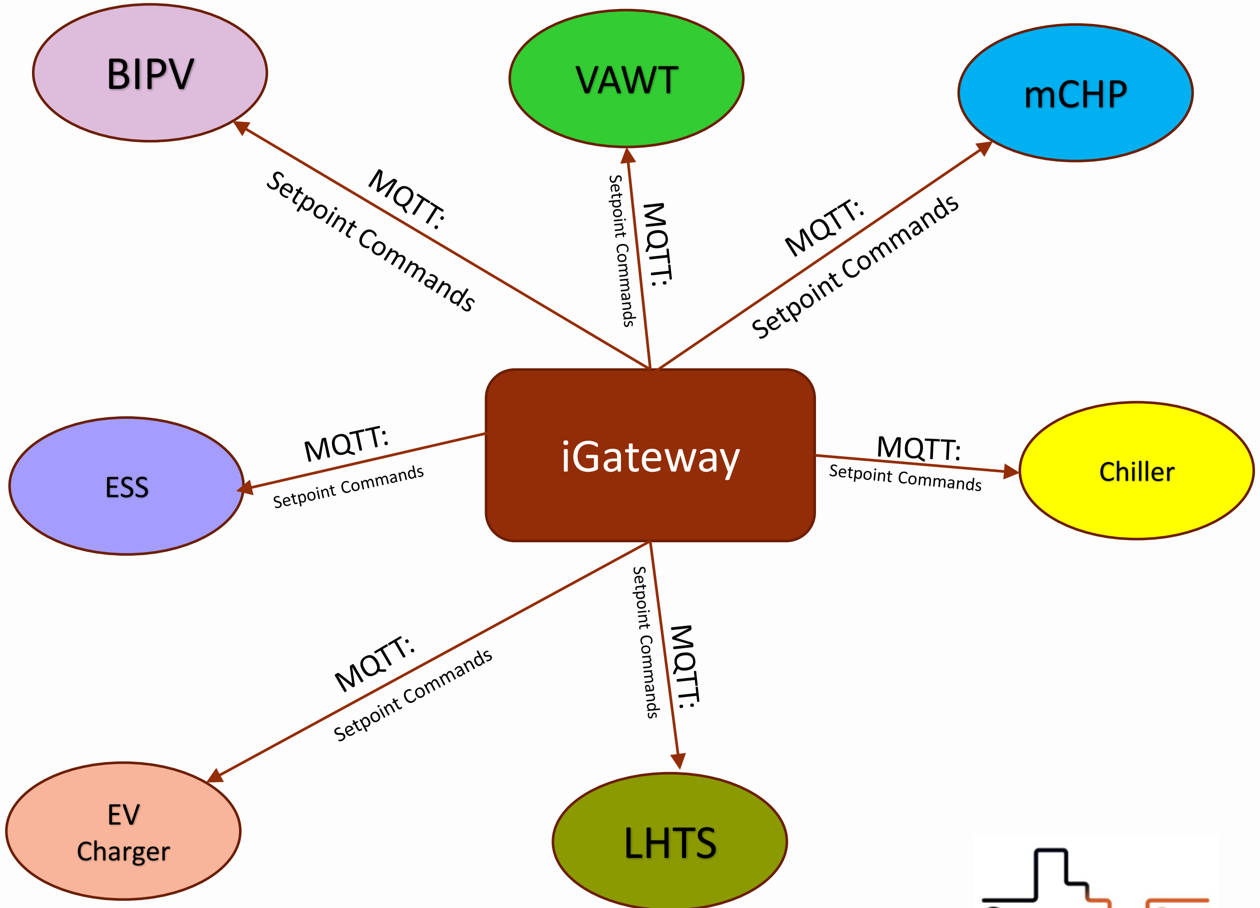
- Based on NODE-RED configuration environment
- Modular, Scalable
- Standardize protocols (wired/wireless)
- Configures and handles data flows
- Communication with ACEME component
- Device discovery in the network
- Data storage capability
- Data Processing Module
- Real-Time Local Engine
- Hardware: Raspberry Pi 4



❖RE-COGNITION PROJECT – iGateway(2)

➢ iGateway

- Based on NODE-RED configuration environment
- Modular, Scalable
- Standardize protocols (wired/wireless)
- Configures and handles data flows
- Communication with ACEME component
- Device discovery in the network
- Data storage capability
- Data Processing Module
- Real-Time Local Engine
- Hardware: Raspberry Pi 4



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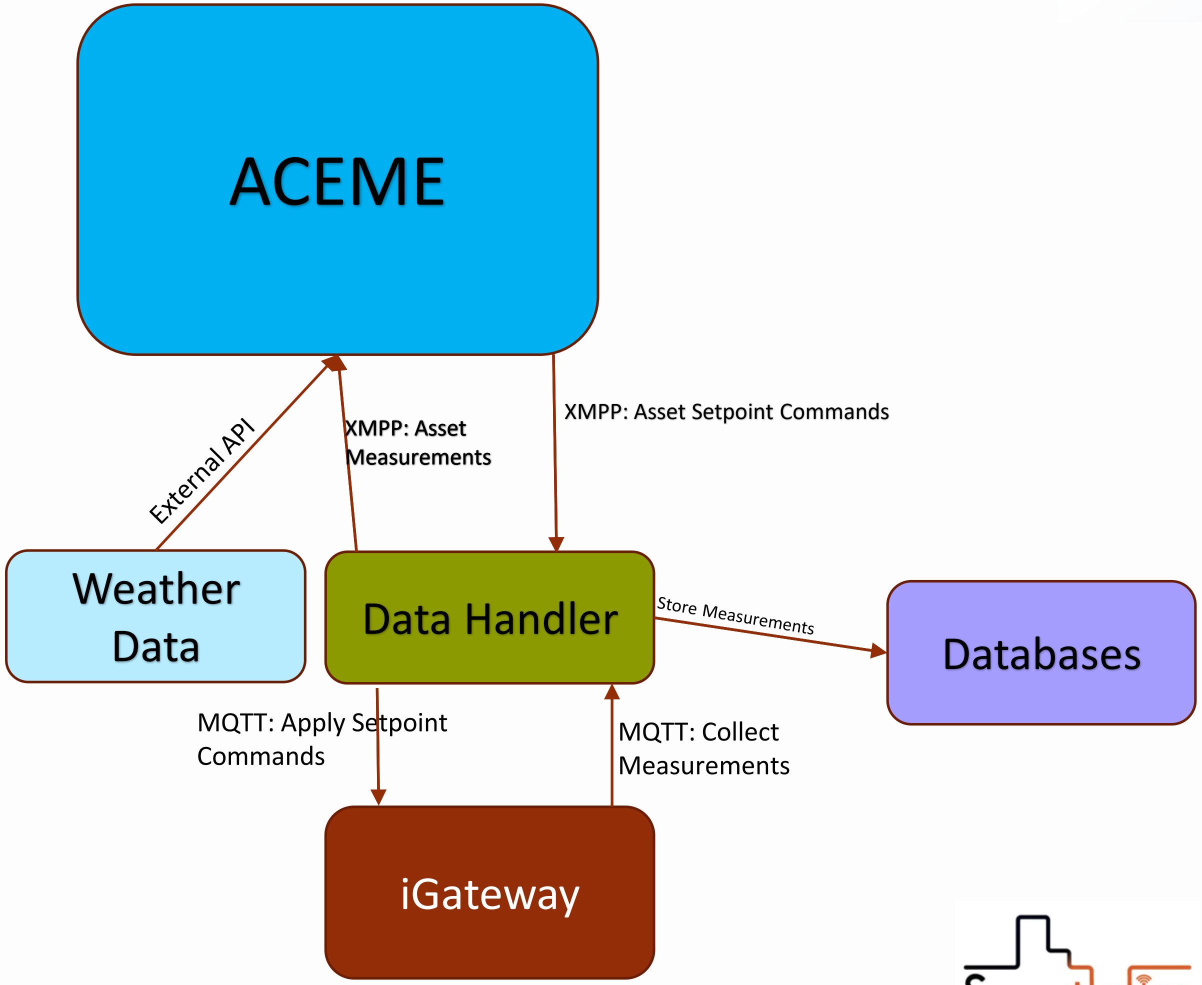
❖RE-COGNITION PROJECT – ICT Backbone layer

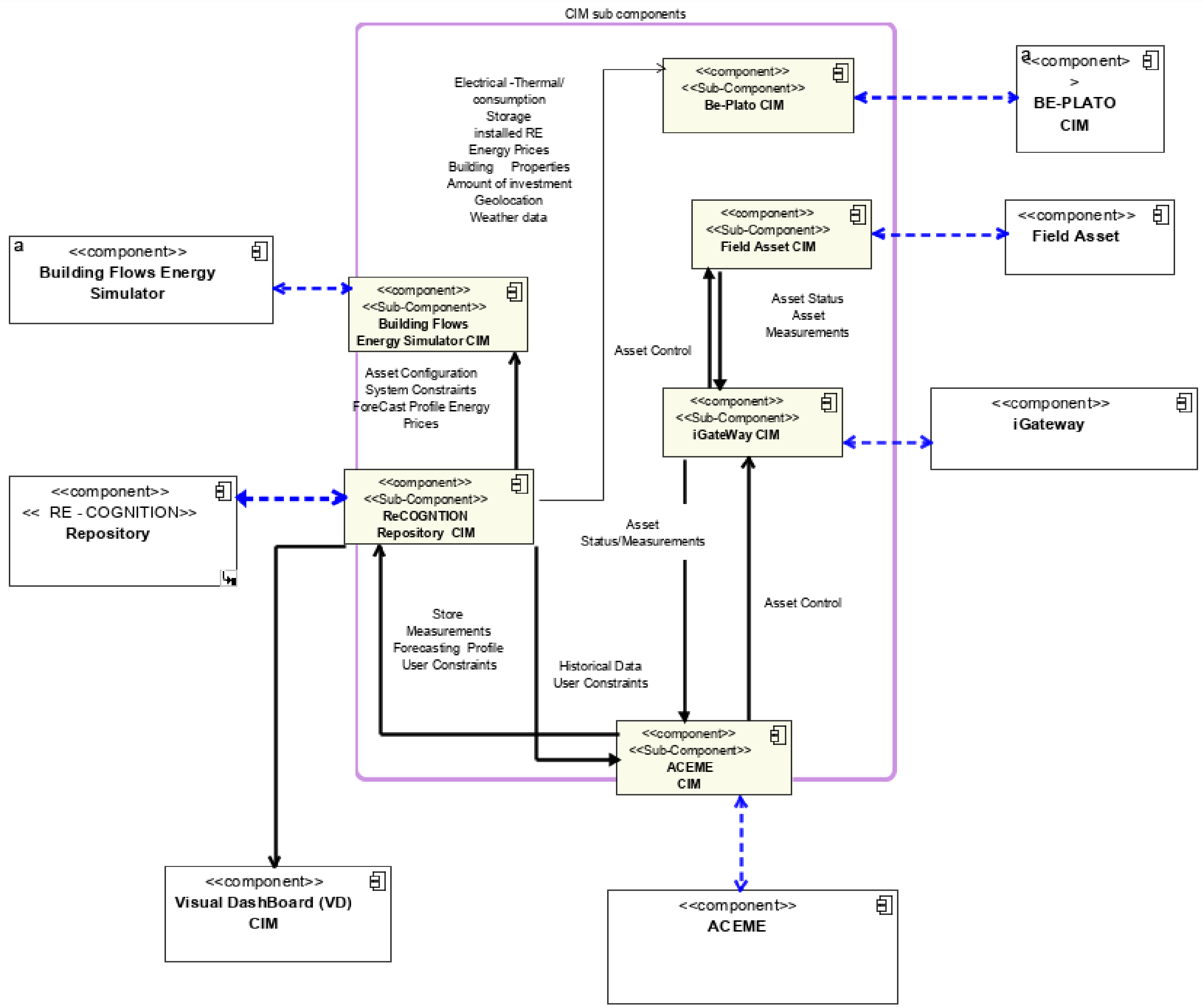
- **ACEME – Automated Cognitive Energy Management Engine**
  - Main Goal: Achieve highest possible level of RES penetration through a decision making system
  - Receives data from on-site energy consuming devices
  - Predicts patterns regarding the aggregated load per building
  - Distributes intelligence via an agent –based representation of each energy Asset



❖RE-COGNITION Common Information Model (CIM)

- Responsible for transparent data exchange among architecture components
- Implements several CIM sub-components to assist deployment of RE-COGNITION main components
- Ensures data interoperability by having an interface for each CIM sub-component
- Depicts different components interrelations

❖RE-COGNITION CIM - high level view



❖ RE-COGNITION CIM designed to:

- Facilitate translation of different formats into a common understandable format
- Describe sources of information in a common terminology to all RE-COGNITION components
- Standardize a format acceptable by all project partners when proceeding "*from specification to implementation*" regarding project tasks

❖ Methodology

1. Analysis of relevant approaches and standards
2. Analysis of RE-COGNITION data requirements based on architecture components and functionalities

❖ RE-COGNITION CIM – Final Version(1)

1. <u>Data Modeling:</u>

a) Use of Ontology concept to:

i. Create entities hierarchy providing important information semantically-wise
ii. Clarify entities linkage and interrelations
iii. Identify best practice for data storing and creating the CIM data repository

b) Data models in JSON_LD format

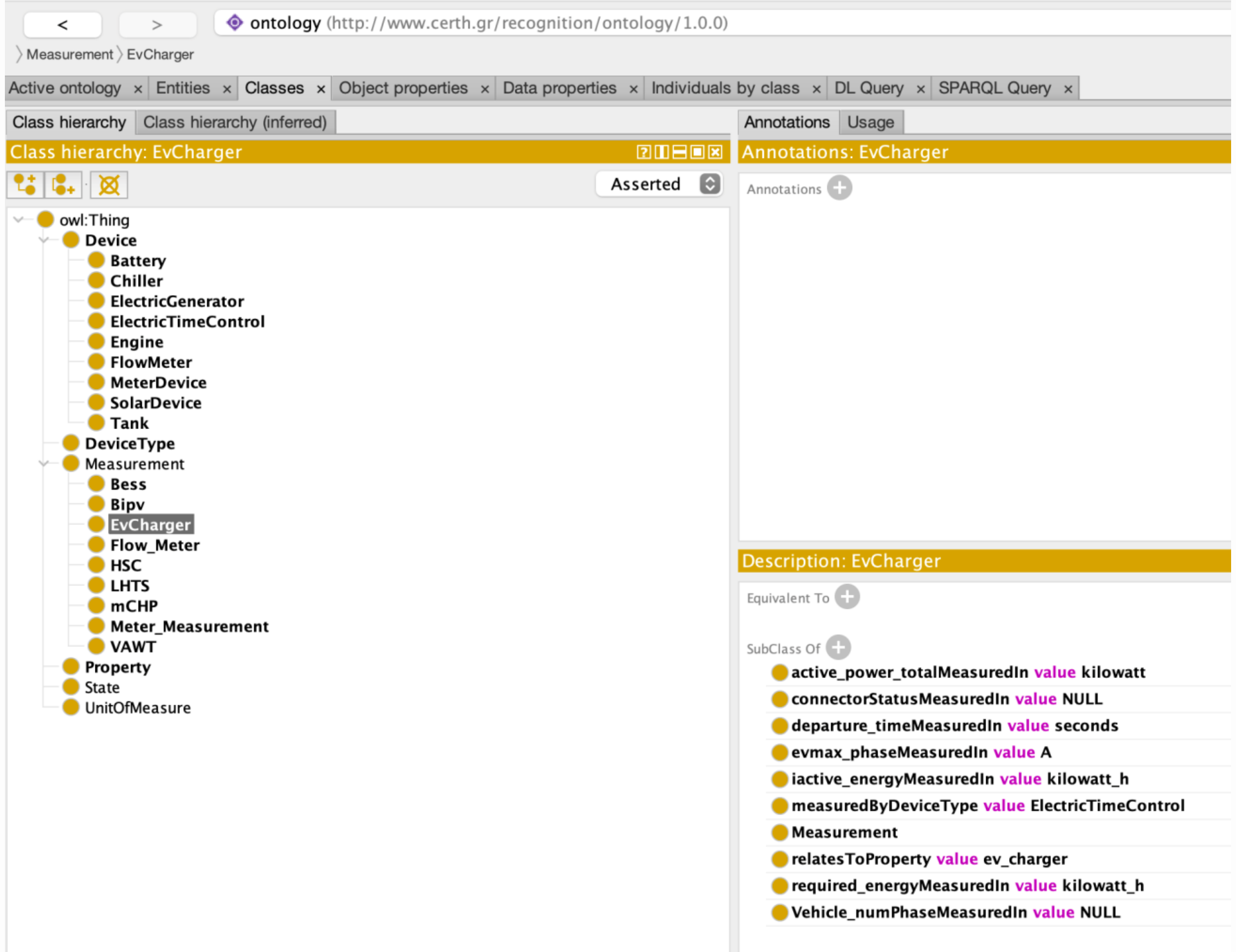
i. Ideal to create well wrapped payloads of linked data and facilitate data exchange
ii. Ensure data communication in common format and validation
iii. Facilitate data storing

❖ RE-COGNITION CIM – Data Modelling(1)

❖ Ontology

- Data modelling concept
- Ideal for RDF data
  - A standard for data interchange on the web
  - Flexible, extendable
- Hierarchical design - Organize data models in classes
- Predefine data linkage and interrelation in class level
- Allow direct linkage for class instances
- Saved in owl format
  - Practically a logic-based language exploitable by computer programs
- Other formats
  - turttle
  - RDF-XML
- Entities defined in the web by URIs as downloadble resources
- Data saved as triples – *RDF Triplestore*
- *SPARQL querries*

❖ RE-COGNITION CIM – Data Modelling(2)



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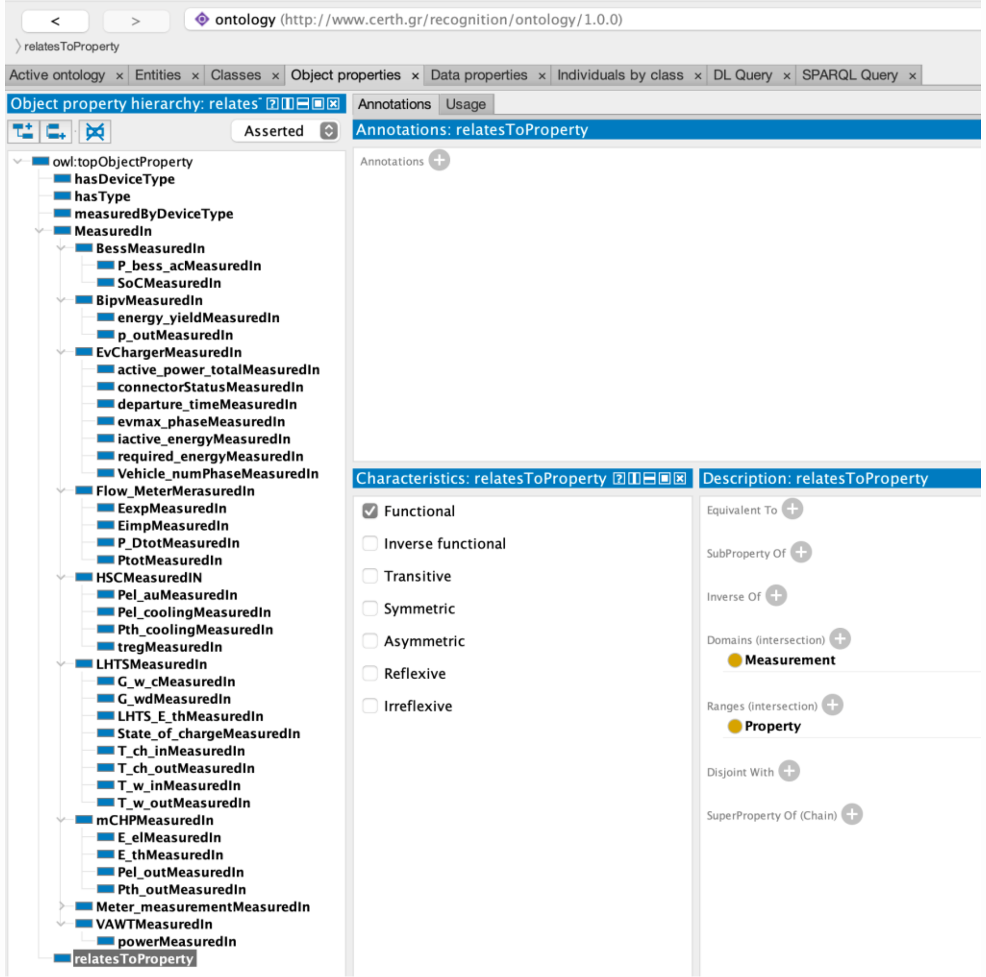
❖ RE-COGNITION CIM – Data Modelling(3)



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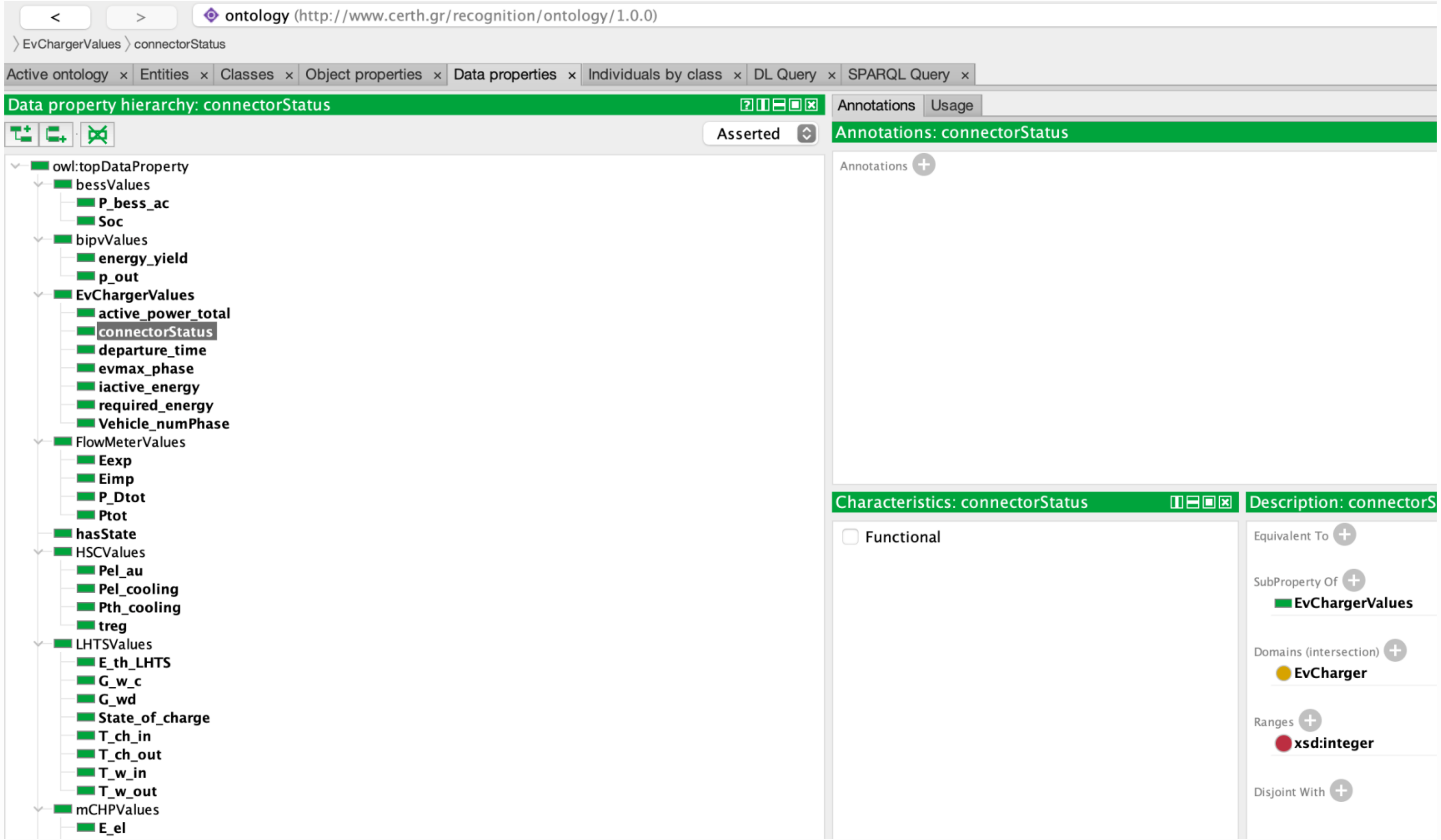
❖ RE-COGNITION CIM – Data Modelling(4)



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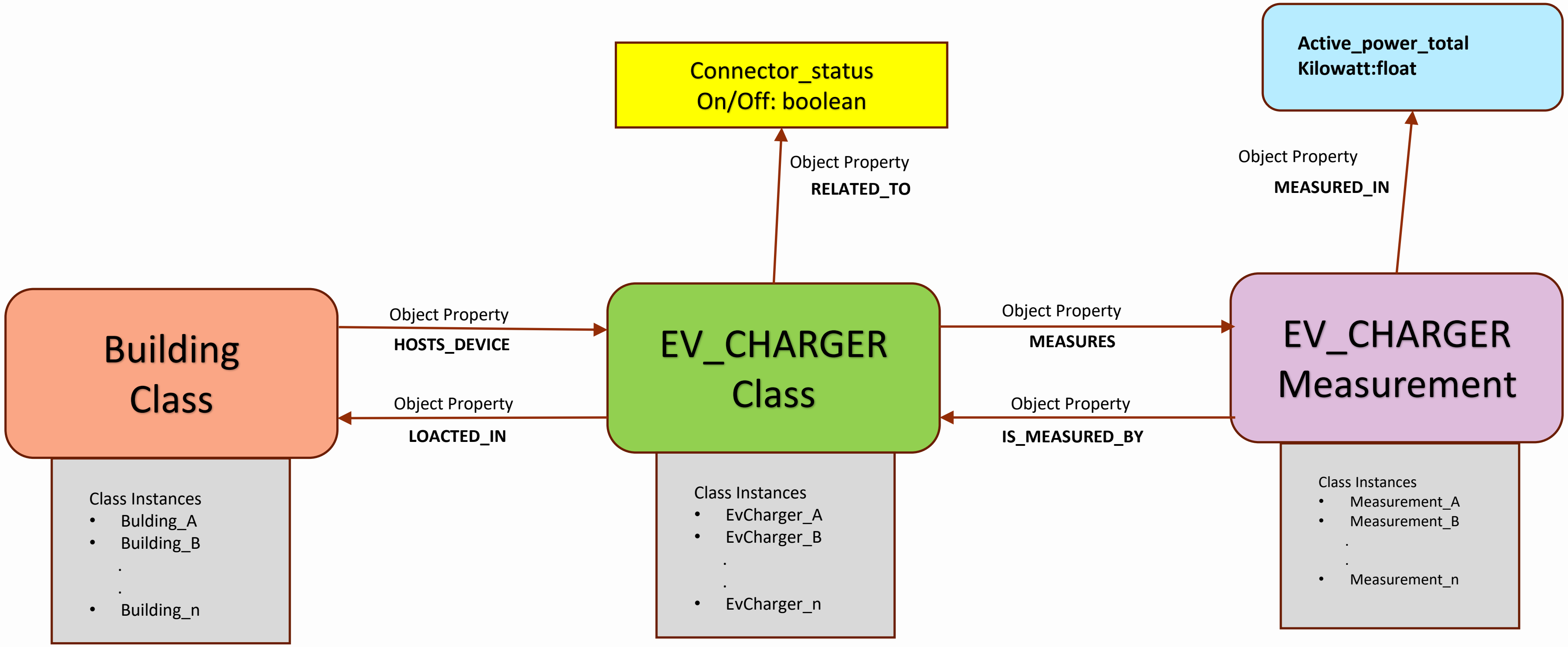
❖ RE-COGNITION CIM – Data Modelling(5)



❖Data models in JSON_LD format

mCHP_command payload


```
{
    "data": {
        "@id": "Pre-Pilot-data",
        "@type": "Command",
        "@context": {
            "core": "http://purl.org/recognition/Cim#"
        },
        "label": "Recognition CIM Example",
        "location": "Certh",
        "operation": "4",
        "hasName": "",
        "hasVersion": "v1",
        "hasTimestamp": "",
        "consists_of": [
            {
                "@type": "Engine",
                "hasState": 0,
                "relatesToProperty": "mchp",
                "consists_of": [
                    {
                        "@type": "Pth_setpoint",
                        "hasValue": {
                            "@type": "xsd:float",
                            "@value": 0
                        },
                        "isMeasuredIn": {
                            "@id": "percent"
                        }
                    }
                ]
            }
        ]
    }
}
```


Bipv_measurement payload


```
{
    "data": {
        "@id": "Pre-Pilot-data",
        "@type": "Measurement",
        "@context": {
            "core": "http://purl.org/recognition/Cim#"
        },
        "label": "Recognition CIM Example",
        "location": "Certh",
        "operation": "4",
        "hasName": "",
        "hasVersion": "v1",
        "hasTimestamp": "",
        "consists_of": [
            {
                "@type": "ElectricGenerator",
                "hasState": 0,
                "relatesToProperty": "vawt",
                "consists_of": [
                    {
                        "@type": "power",
                        "hasValue": {
                            "@type": "xsd:float",
                            "@value": 0
                        },
                        "isMeasuredIn": {
                            "@id": "watt"
                        }
                    }
                ]
            }
        ]
    }
}
```

❖RE-COGNITION CIM – Final Version(2)

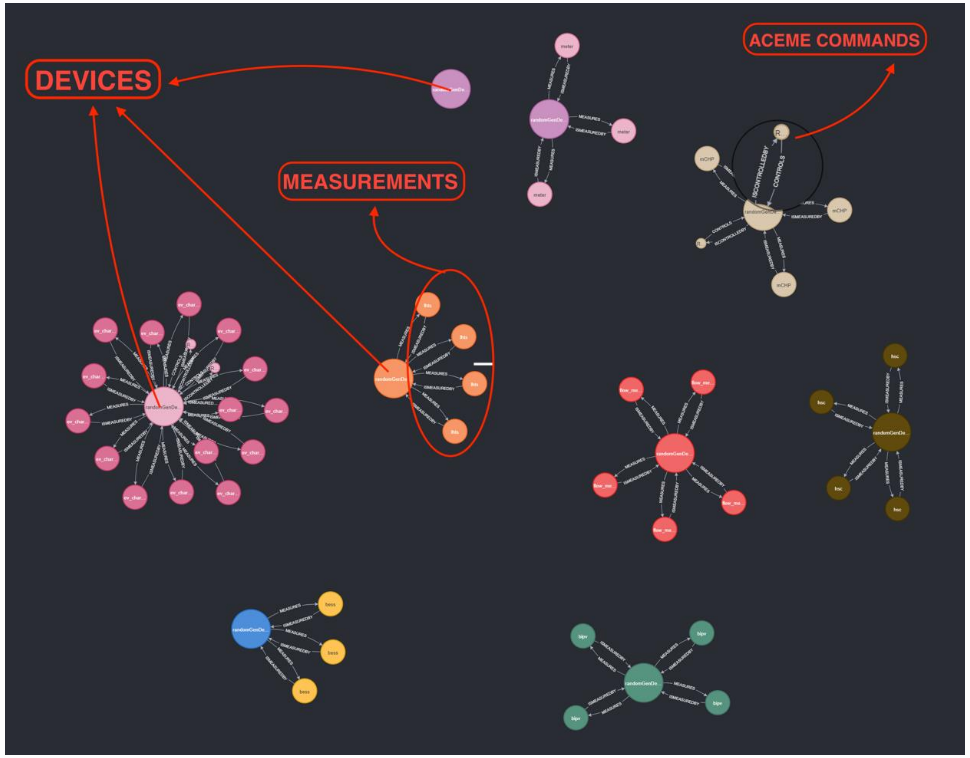
2. CIM Repository:

- Implemented with a graph Database
- Functioning in parallel with RE-COGNITION main SQL-based database
- Both databases get updated simultaneously
- Faster performance than traditional relational databases in retrieving very big amounts of data
- Used for generating energy statistics for buildings under observation
- Neo4J Framework
  - ✓ Python driver availability
  - ✓ Docker friendly
  - ✓ Great Visualization Tool

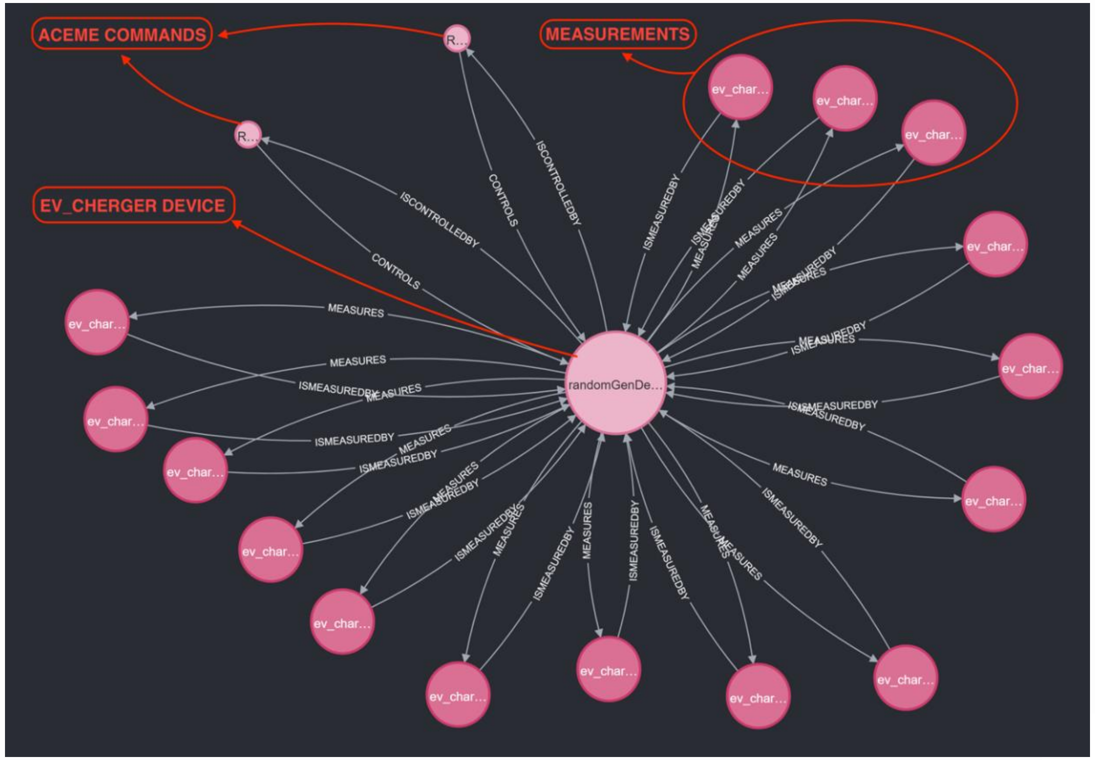
❖RE-COGNITION CIM – Final Version(3)

3. Visualization

- Graph Visualization in testing stages



- Zoomed in a IoT device installed on and Ev Charger



Thank you

Questions?

Project Partners

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