

FIWARE
**Global
Summit**

Scalable Monitoring of Building Energy Systems Using Semantics

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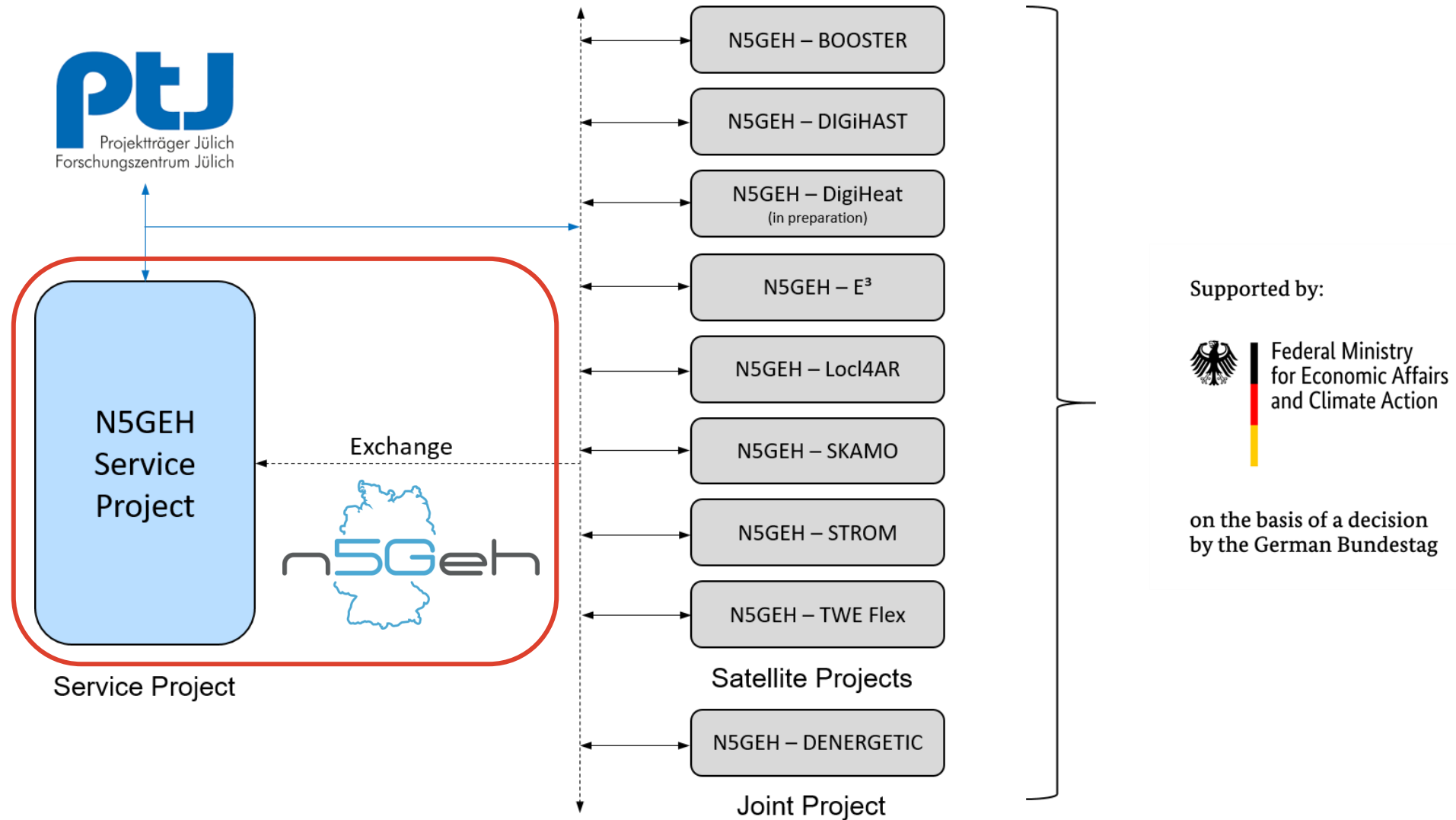
Vienna, Austria
12-13 June, 2023
#FIWARESummit

**From Data
to Value**

OPEN SOURCE
OPEN STANDARDS
OPEN COMMUNITY

 **FIWARE**
Open APIs for Open Minds

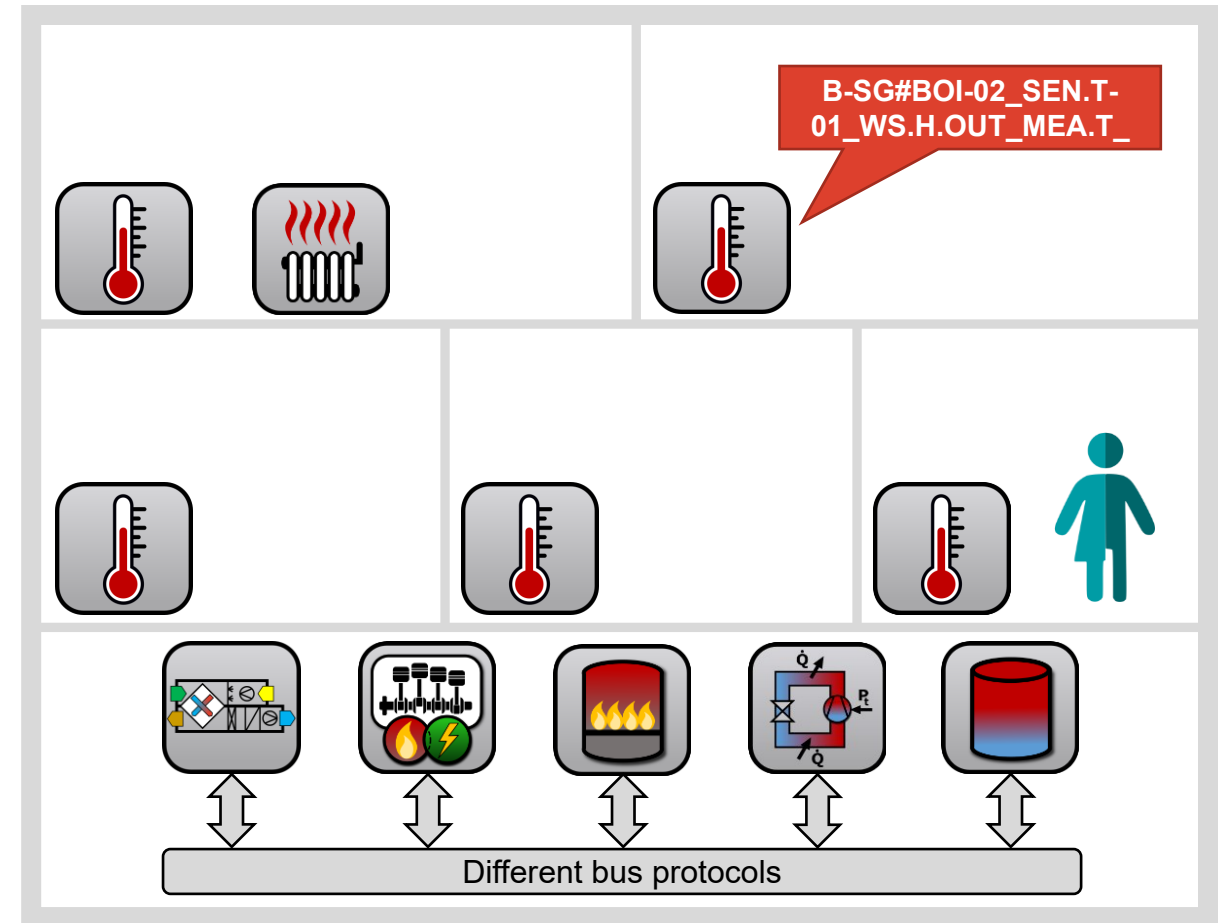
N5GEH - Service Project



Motivation



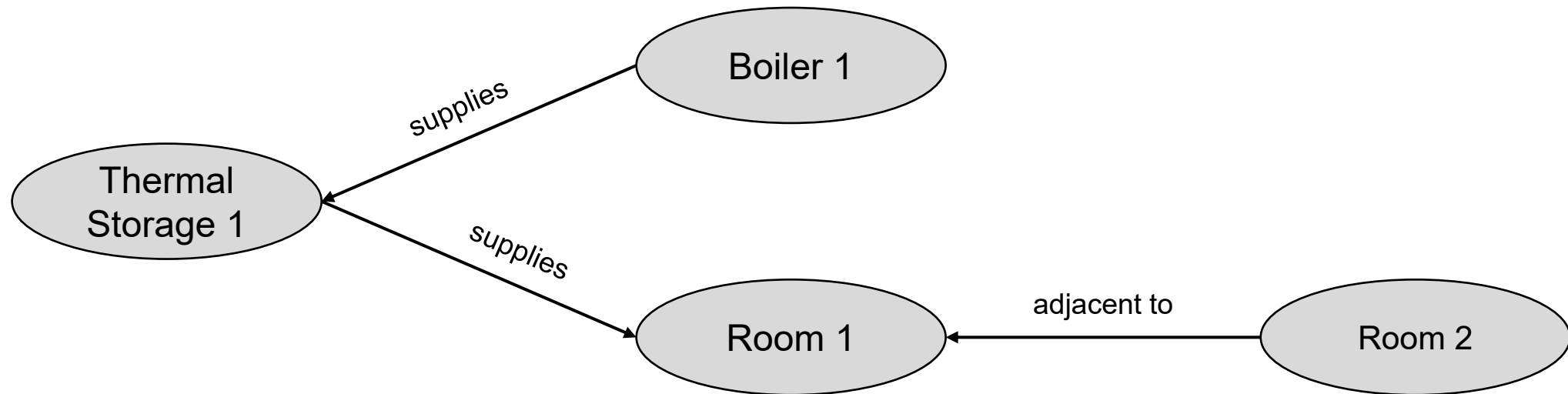
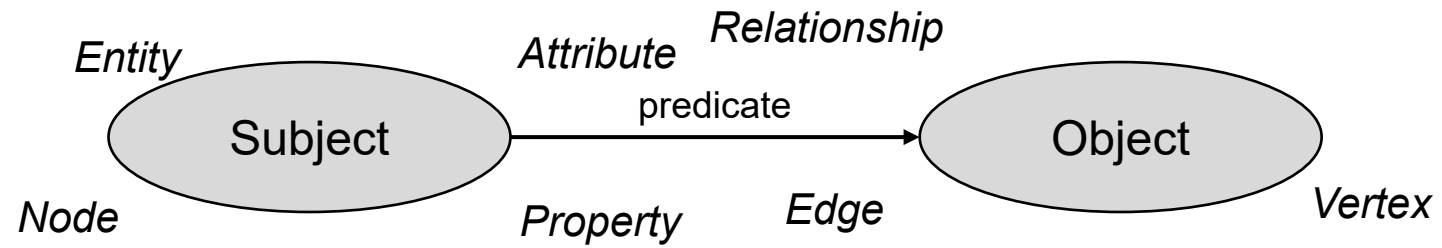
- Modern Building Energy Systems (BES)
 - ≡ Are complex
 - ≡ Bear many sensors from different trades in **data silos** [1,2,3]
 - ≡ Are **unstructured** using **different naming schemes** most of the times [1,2,4]
 - ≡ Search for errors is time **consuming and costly** [1,2,5]



→ Make data **available** and **understandable**

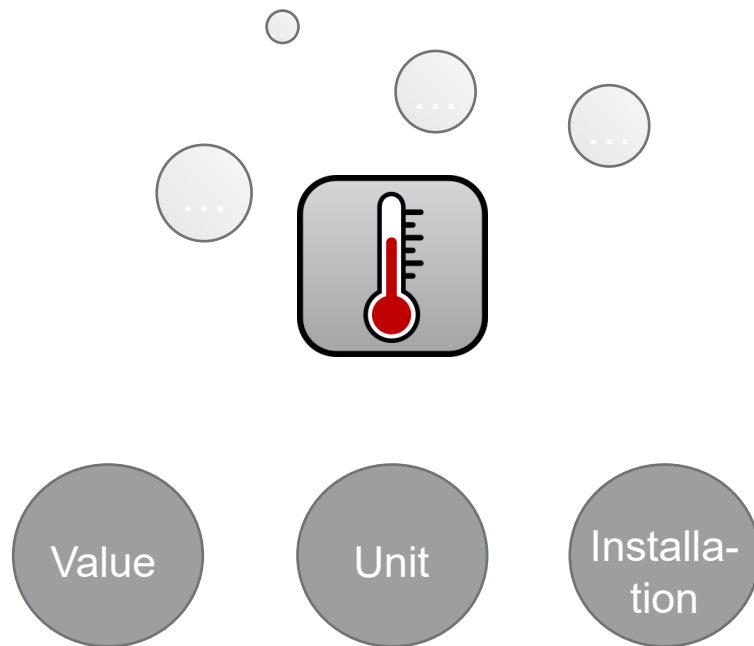
Knowledge Representation

Resource Description Framework (RDF)



Formal Knowledge

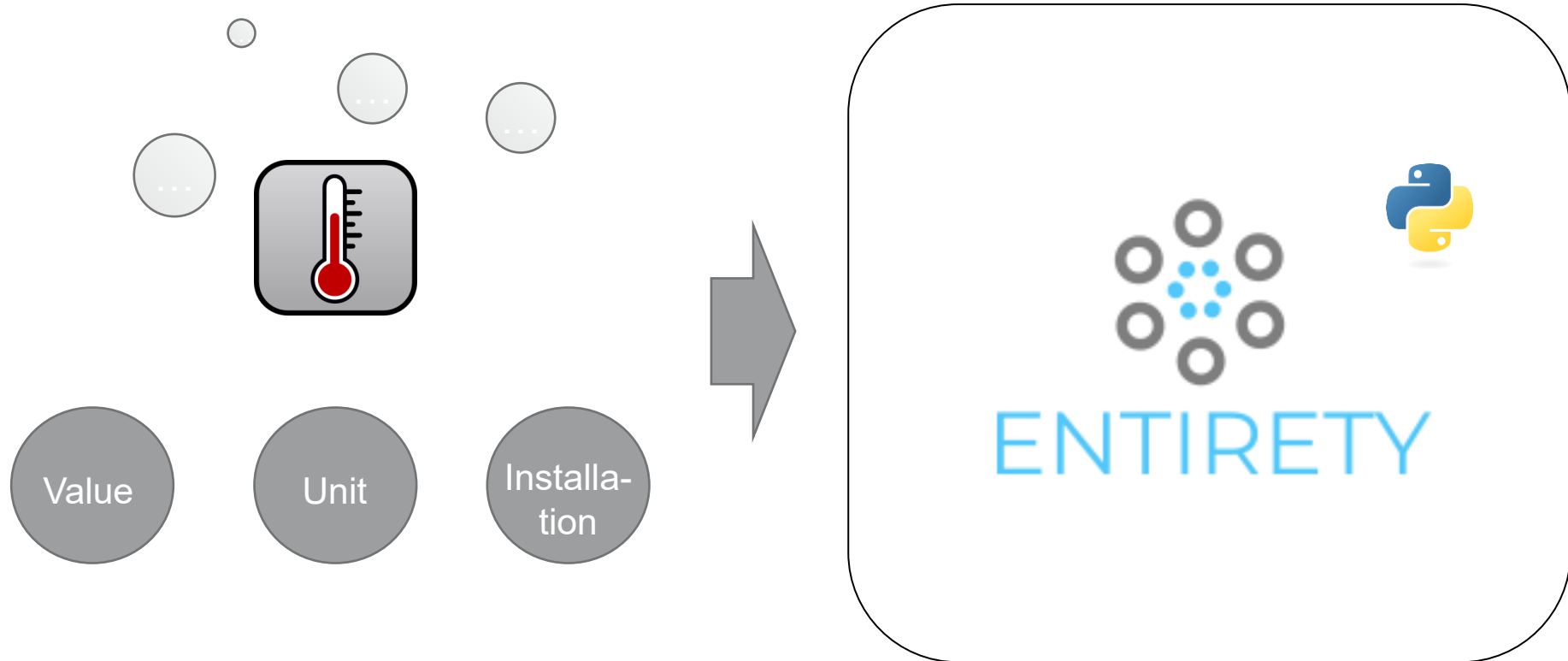
- **Ontologies** are used to represent knowledge in a certain domain and enable data exchange between processes and services
 - ≡ **Formalizing** a common **set of rules for that domain**
- Import of **json.schema** files based on ontologies



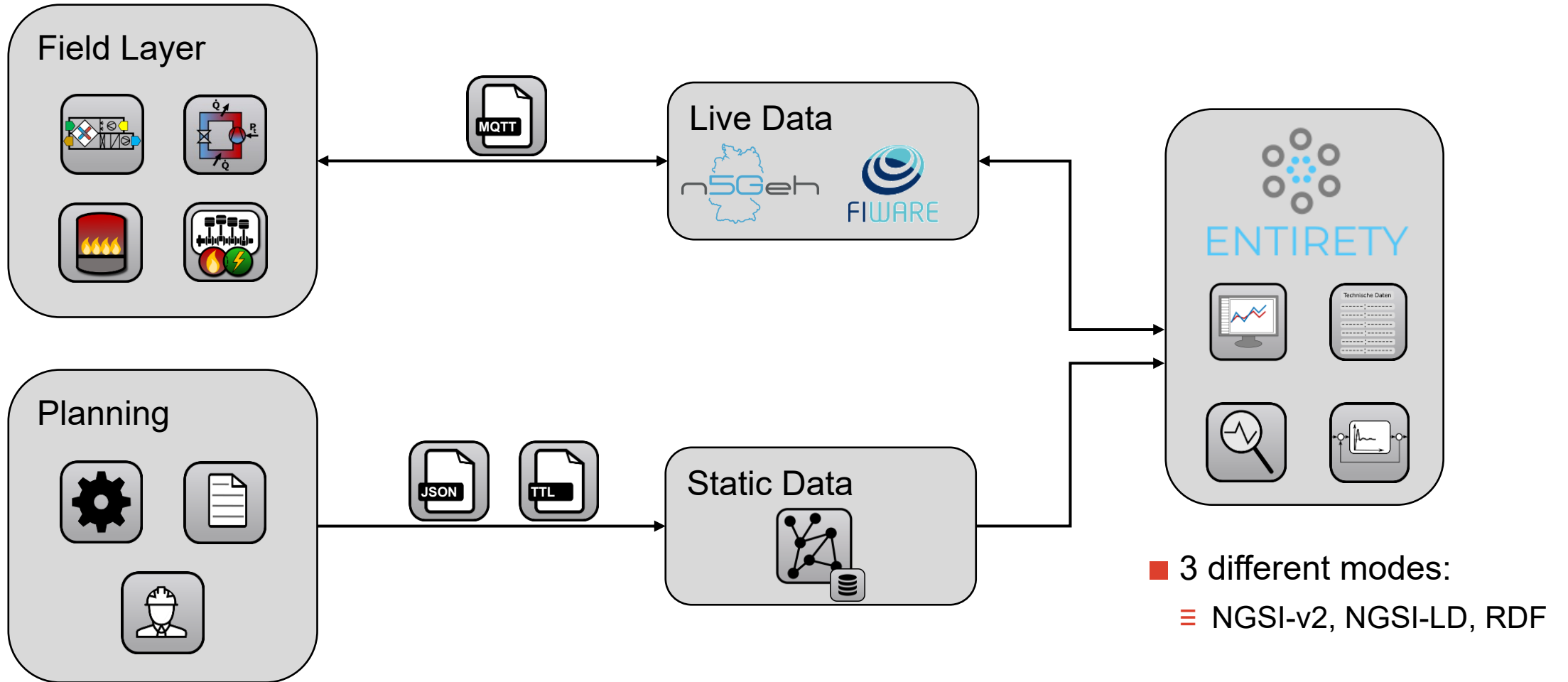
```
1 {
2   "properties": {
3     "temperature": {
4       "type": "number",
5       "description": "The measured value from the sensor."
6     },
7     "unit": {
8       "type": "string",
9       "enum": ["Degrees Fahrenheit", "Degrees Celsius", "Kelvin"],
10      "description": "Unit of the temperature value."
11    },
12    "installedAt": {
13      "type": "string",
14      "description": "Date and time the sensor was installed."
15    },
16    [...]
17  },
18  "required": [
19    "id",
20    "type",
21    "temperature",
22    "unit"
23  ]
24 }
```

Formal Knowledge

- **Ontologies** are used to represent knowledge in a certain domain and enable data exchange between processes and services
 - ≡ **Formalizing** a common **set of rules for that domain**
- Import of **json.schema** files based on ontologies



Semantic-Based Monitoring Using Entirety - Architecture



Entirety: Data Model App

Create New Smart Data Model

Name*
TemperatureSensor

Schema link

Json schema*

```
{  
  "$schema": "http://json-schema.org/schema#",  
  "$schemaVersion": "0.0.3",  
  "$id": "http://test-data-models/dataModel.Device/TemperatureSensor.json",  
  "description": "This entity captures the static properties of a temperature sensor",  
  "type": "object",  
  "properties": {  
    "type": {  
      "type": "string",  
      "enum": [  
        "TemperatureSensor"  
      ]  
    }  
  }  
}
```

Save { } Beautify Json Load Schema from Github link

Entirety: Data Model App

The screenshot displays the Data Model App interface. At the top, there is a dark header bar with the n5GEH and FIWARE logos on the left and a user profile icon on the right. Below the header is a dark sidebar menu with the following items: N5GEH-Demo, Entities, Devices, Notifications, Data Models (highlighted), Orion Broker, Quantum Leap, IOT Agent, and Projects. The main content area features a search bar with the placeholder text "Search models by name" and a magnifying glass icon. Below the search bar, there is a grid of four data model cards. Each card represents a different model: TemperatureSensor, SmartThermostat, HumiditySensor, and WeatherStation. Each card includes a JSON icon, a "Created by:" field, a "Last modified by:" field, "Edit" and "Delete" buttons, and a timestamp. The timestamp for all models is "May 25, 2023, 10:25 p.m." or "May 25, 2023, 10:26 p.m."

Model Name	Created by	Last modified by	Timestamp
TemperatureSensor	[Redacted]	[Redacted]	May 25, 2023, 10:25 p.m.
SmartThermostat	[Redacted]	[Redacted]	May 25, 2023, 10:26 p.m.
HumiditySensor	[Redacted]	[Redacted]	May 25, 2023, 10:26 p.m.
WeatherStation	[Redacted]	[Redacted]	May 25, 2023, 10:26 p.m.

Entirety: Data Model App

The screenshot displays the 'Entirety: Data Model App' interface. The top navigation bar includes the n5GEH and FIWARE logos, a hamburger menu, and a user profile icon. The left sidebar contains navigation options: N5GEH-Demo, Entities (selected), Devices, Notifications, Data Models, Orion Broker, Quantum Leap, IOT Agent, and Projects. The main content area is titled 'Entities' and features two search filters: 'Search entities by id' and 'Search entities by type'. Below the filters are three action buttons: '+', a trash icon, and an edit icon. A table lists five 'TemperatureSensor' entities with columns for 'Select', 'Id', 'Type', and 'Attributes'.

Select	<u>Id</u>	<u>Type</u>	<u>Attributes</u>
<input type="checkbox"/>	TemperatureSensor:2aafbfeb	TemperatureSensor	6
<input type="checkbox"/>	TemperatureSensor:69fe1a73	TemperatureSensor	6
<input type="checkbox"/>	TemperatureSensor:9801f013	TemperatureSensor	6
<input type="checkbox"/>	TemperatureSensor:efa41693	TemperatureSensor	6
<input type="checkbox"/>	TemperatureSensor:c66dfd51	TemperatureSensor	6

Entirety: Data Model App

The screenshot displays the 'Entirety: Data Model App' interface. At the top, there is a header bar with the n5GEH and FIWARE logos on the left and a user profile icon on the right. A dark sidebar on the left contains navigation options: 'N5GEH-Demo', 'Entities', 'Devices', 'Notifications', 'Data Models', 'Orion Broker', 'Quantum Leap', 'IOT Agent', and 'Projects'. The main content area shows a grid of six data model attribute forms, arranged in two columns and three rows. Each form includes an 'Attribute Name*', 'Attribute Type*', and 'Attribute Value' field, along with a red trash icon for deletion. The first row contains 'documentation' (Text) and 'manufacturer' (Text). The second row contains 'measurementRange' (Number) and 'modelName' (Text). The third row contains 'temperature' (Number) and 'TimeInstant' (DateTime). A yellow 'Update' button is located at the bottom left of the main content area.

Attribute Name*	Attribute Type*	Attribute Value
documentation	Text	
manufacturer	Text	
measurementRange	Number	
modelName	Text	
temperature	Number	19.088186843
TimeInstant	DateTime	2023-05-25T20:30:29.130Z

Entirety: Data Model Visualization

nsGeh FIWARE

PostEnt
Entities
Devices
Notifications
Semantics

Orion Broker
Quantum Leap
IOT Agent
Projects

Filter Label Layout

Search Search

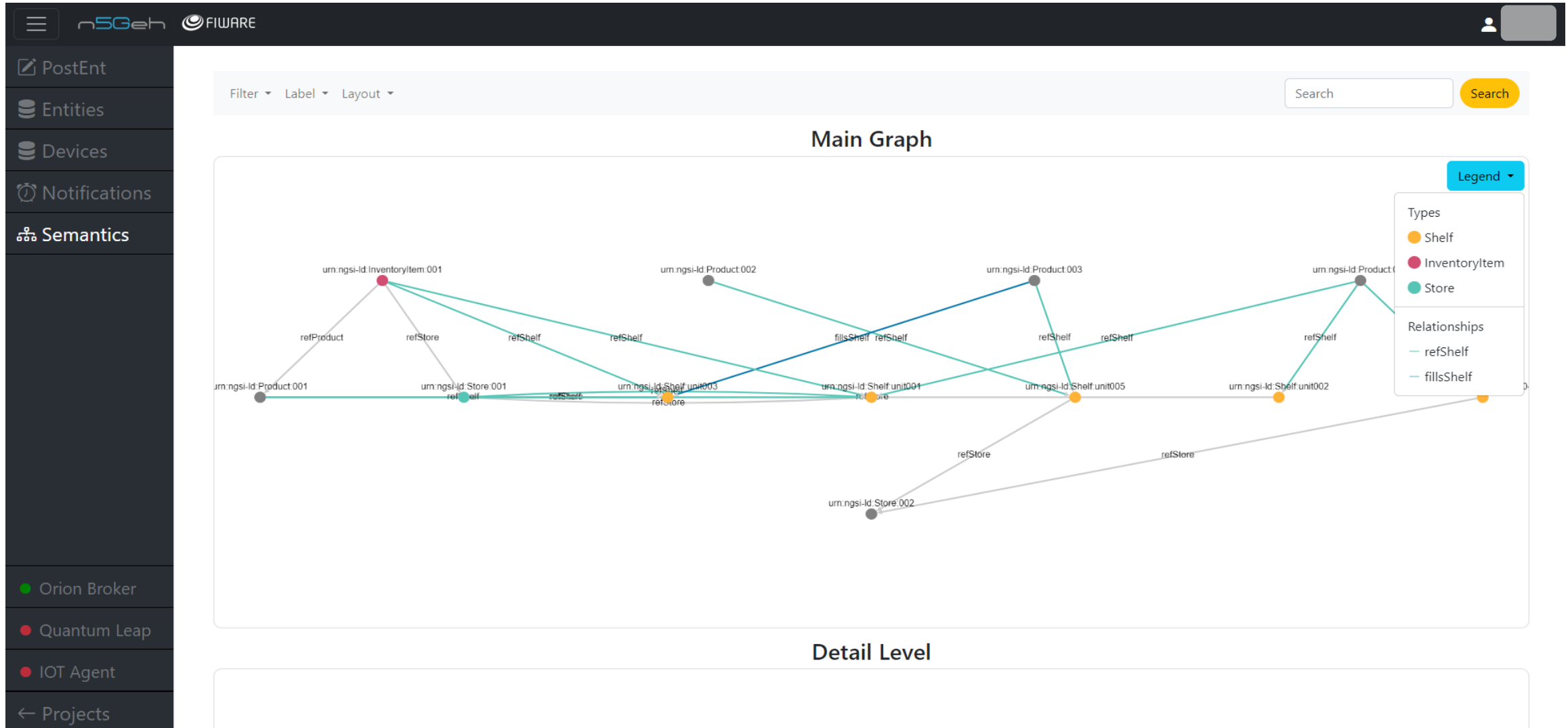
Main Graph

Legend

- Types
 - InventoryItem
 - Product
- Relationships
 - fillsShelf
 - refProduct

Detail Level

Entirety: Data Model Visualization



Entirety: Data Model Visualization

nsGeh FIWARE

PostEnt
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Projects

Filter Label Layout

Search Search

Node ID: urn:ngsi-Id:InventoryItem:001

Name	Value	Type	Metadata
id	urn:ngsi-Id:InventoryItem:001	-	-
type	InventoryItem	-	-
refStore	"urn:ngsi-Id:Store:001"	Relationship	{}
refProduct	"urn:ngsi-Id:Product:001"	Relationship	{}
refShelf	["urn:ngsi-Id:Shelf:unit001", "urn:ngsi-Id:Shelf:unit0...]	Relationship	{}

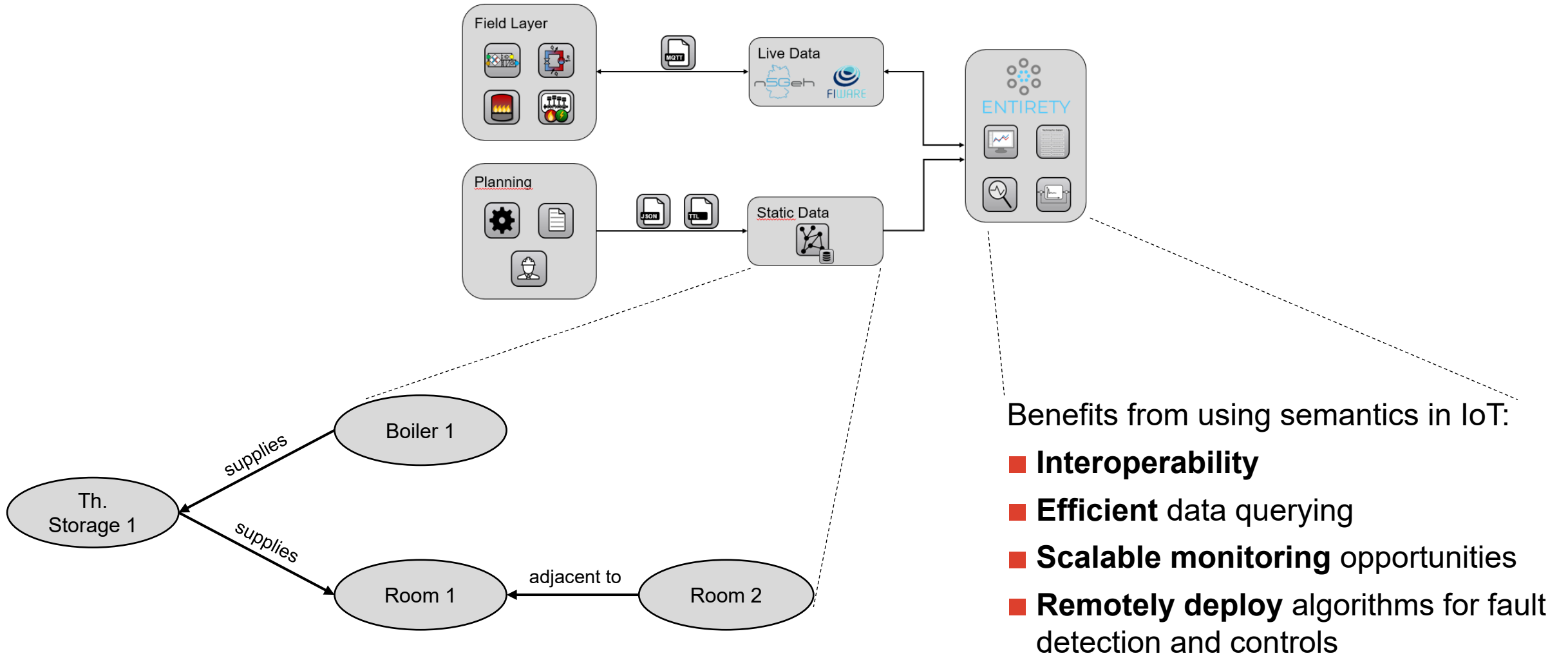
Main Graph

Legend

Entirety: Data Model Visualization

The screenshot displays a web application interface for data model visualization. The top navigation bar includes the n5Geh and FIWARE logos, a hamburger menu, and a user profile icon. A left sidebar contains navigation options: PostEnt, Entities, Devices, Notifications, Semantics, Orion Broker, Quantum Leap, IOT Agent, and Projects. The main content area is divided into two sections. The top section shows a single entity node labeled 'urn:ngsi-Id:Store:002'. The bottom section, titled 'Detail Level', shows a hierarchical structure of three entities: 'urn:ngsi-Id:InventoryItem:001' at the top, 'urn:ngsi-Id:Shelf:unit003' in the middle, and 'urn:ngsi-Id:Store:001' at the bottom. The entities are connected by vertical lines, with the relationship 'refShelf' between the top and middle nodes, and 'refStore' between the middle and bottom nodes.

Summary



Benefits from using semantics in IoT:

- **Interoperability**
- **Efficient** data querying
- **Scalable monitoring** opportunities
- **Remotely deploy** algorithms for fault detection and controls



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FIWARE
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Summit**

Thanks!

Vienna, Austria
12-13 June, 2023
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References

- [1]: Bergmann et al. “Semantic Interoperability to Enable Smart, Grid-Interactive Efficient Buildings Lawrence Berkeley National Laboratory. (November 2020). <https://escholarship.org/uc/item/1325d5j3>
- [2]: Schneider et al. “Ontology-Based Modeling of Control Logic in Building Automation Systems.” *IEEE Transactions on Industrial Informatics* 13, no. 6 (December 2017): 3350–60. <https://doi.org/10.1109/TII.2017.2743221>.
- [3]: Curry et al. “Linking Building Data in the Cloud: Integrating Cross-Domain Building Data Using Linked Data.” *Advanced Engineering Informatics* 27, no. 2 (April, 2013): 206–19. <https://doi.org/10.1016/j.aei.2012.10.003>.
- [4]: Mishra et al. “Unified Architecture for Data-Driven Metadata Tagging of Building Automation Systems”. *Automation in Construction* 120 (December, 2020): 103411. <https://doi.org/10.1016/j.autcon.2020.103411>.
- [5]: Fierro et al. “Application-Driven Creation of Building Metadata Models with Semantic Sufficiency”. (October 2022). <https://home.gtf.fyi/papers/fierro2022application.pdf>