Towards the design of a data layer for the management of the smart buildings?

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Designing and operating complex systems

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Increasing computer networked system complexity

e.g., geographical distribution, number and type of devices, demand

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Network management to deal with the complexity of network infrastructures

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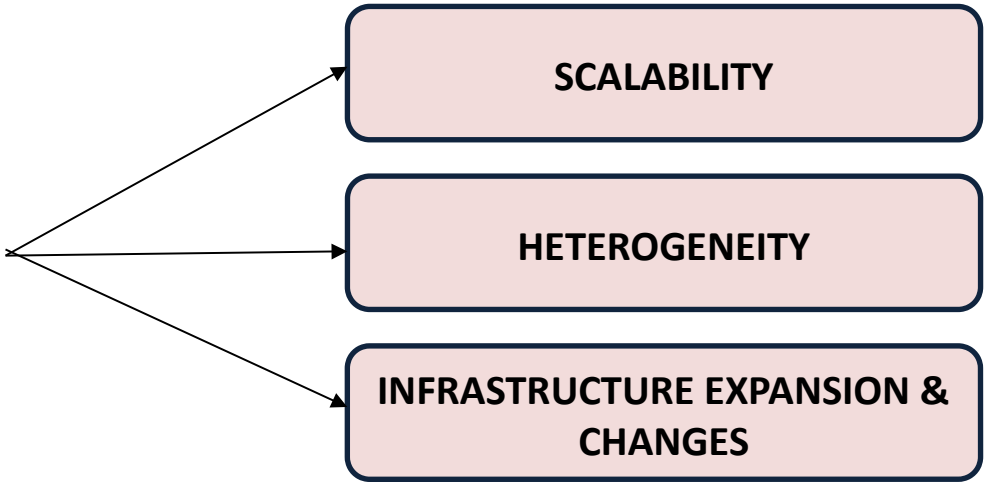
Network management to deal with the complexity of network infrastructures

Need to manage



Towards self-managed networked systems

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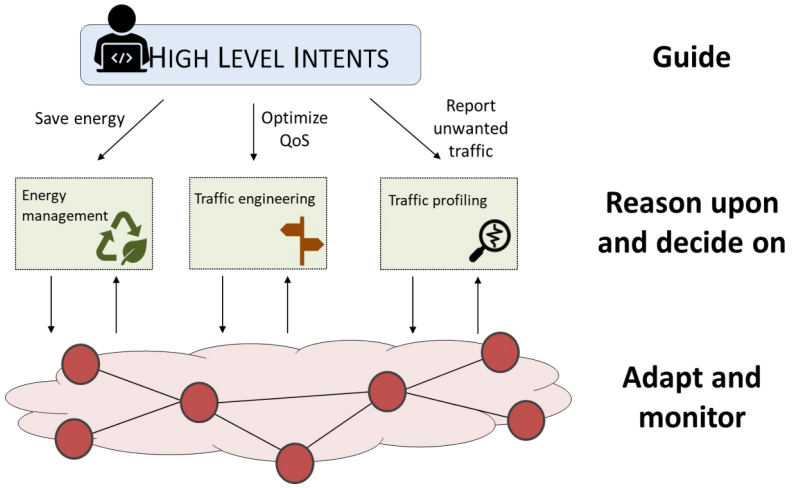
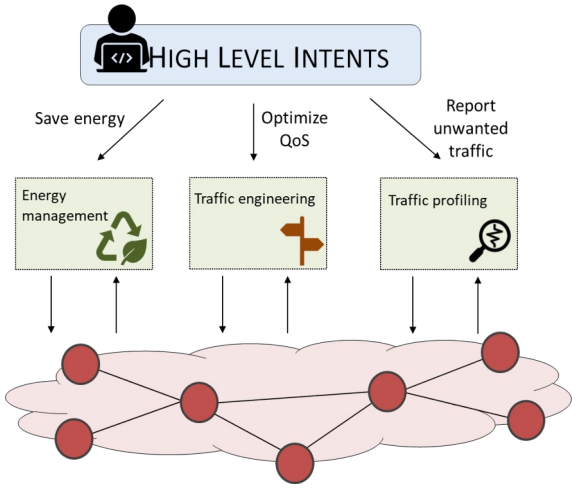


Envisioned ultimate goal…

Towards self-managed networked systems



Guide

Reason upon and decide on

Adapt and monitor

Envisioned ultimate goal…

… through supporting, evolving technologies

Active networks

Policy-based

Self-management / Knowledge plane

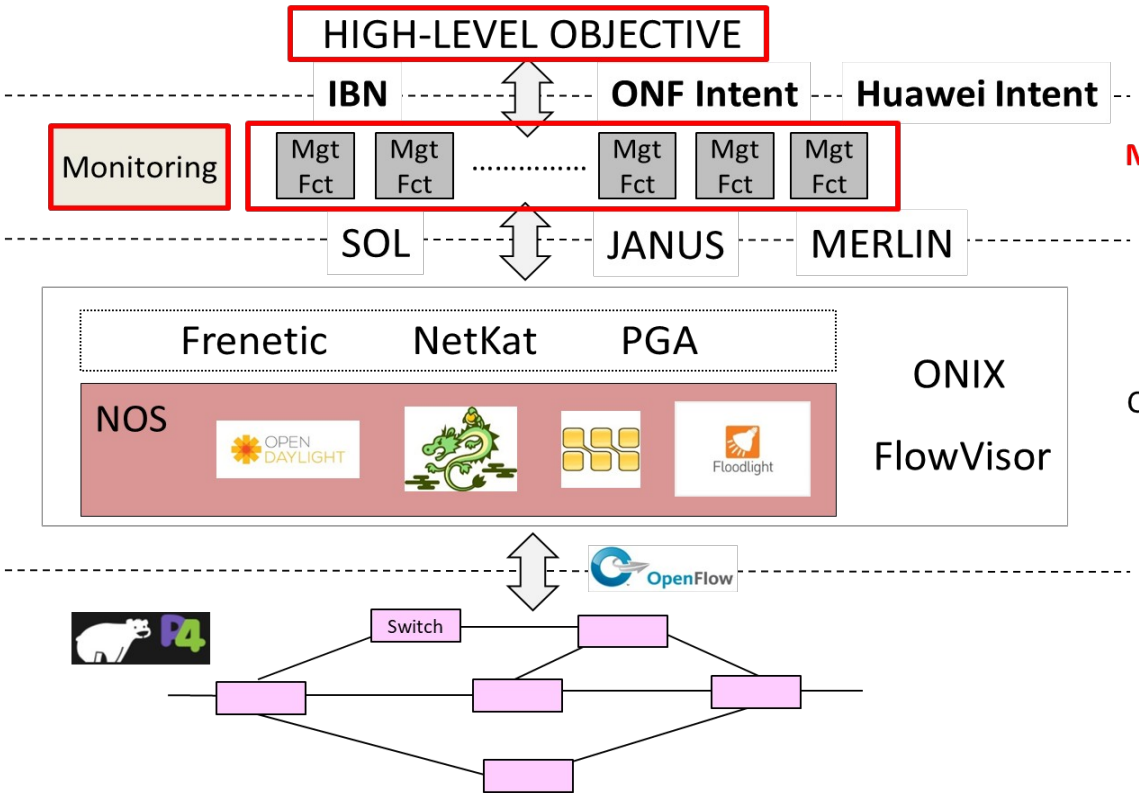
Software-defined networking

Virtualisation Programmability

Data-driven

Automation and networking planes

Automation and networking planes

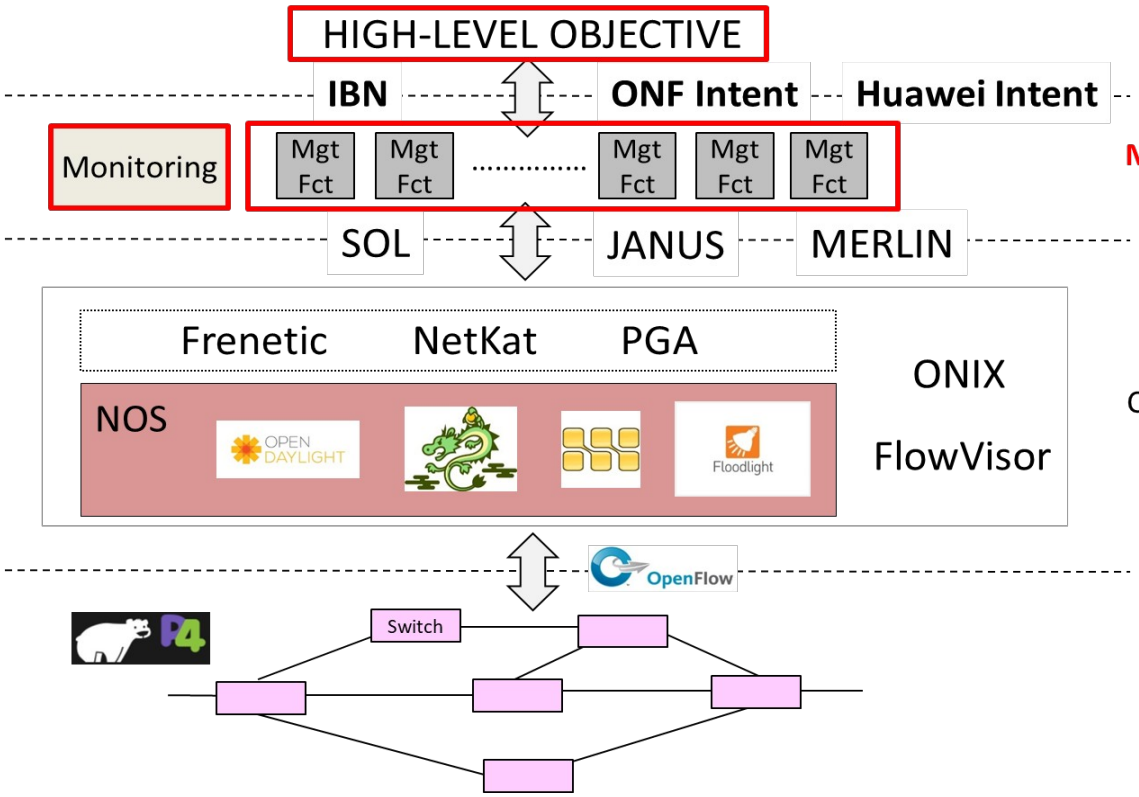


Monitor and configure the network

Define the policies driving how to handle data packets

Process and deliver data packets

Automation and networking planes



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How to automate network resource management tasks?

Cyberphysical system management

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e.g., PV on a smart building as a source for electric vehicle charging through smart charge management

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Need for a joint resource management approach that involves heterogeneous stakeholders and infrastructures

Investigate the **use of intents** (*i.e.,* what to do rather than how to do) **coupled to a data layer** in the context of **cyberphysical system infrastructures**

Use case: smart building

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Data production

Resource forecast

Predictive maintenance

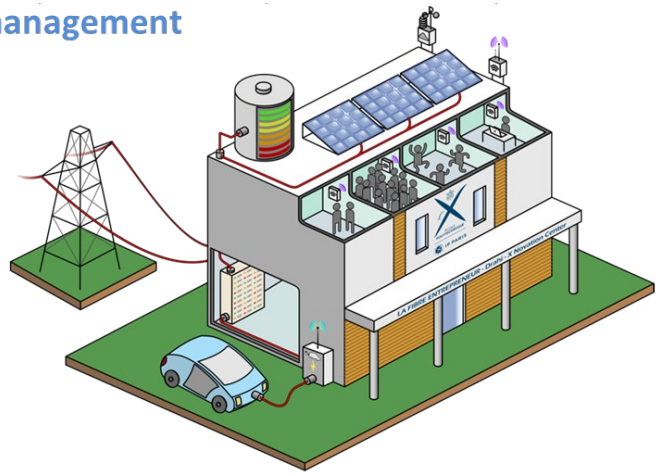
Energy management

Fire detection

Smart charging

Real-time occupancy monitoring

Data analysis



Source: J. Badosa, *Presentation platforms and demonstrators, E4C*

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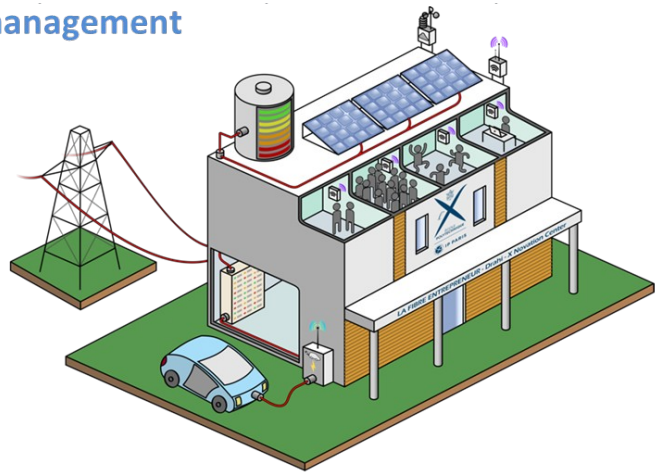

Real-time occupancy monitoring

Data analysis

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Step 1: implementing a data model

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Data represents different aspects of a *thing*

- Convention to depict the things and their attributes (*i.e.,* information about these things) using high-level constructs
- Typically includes entities (*i.e.,* the things and their attributes) and relationships between them

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Example

Entity: `Room (Number, Surface, Purpose, etc.)`

Relationships: `Building in which the Room is located`

Smart building data models

Smart building data models

Name	Date	Focus	RDF Ontology	Extensibility
Haystack	2011	Building automation and control systems	No	Yes
Brick	**2016**	**Describing smart building data**	**Yes**	**Yes**
RealEstateCore	2017	Representing real estate data, including information about properties, listings, and agents.	Yes	Yes
LBD	Early 2000's	Representing and integrating building-related data	Yes	Yes
SAREF4BLDG	2017	Describing smart appliances and devices	Yes	Yes
SSN/SOSA	2008/2017	Representing sensor data	Yes	Yes
NGSI-LD	**2019**	**Providing a standardized way of representing and exchanging data in the context of the Internet of Things**	**No**	**Yes**

Focus on BRICK

Focus on BRICK

Developed at Standford University

Very active community of developers

Model focused on smart buildings

Technologies: RDF triples, SPARQL, highly integrated with web semantic technologies

Open source license

BRICK specifics

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Brick Schema: data and metadata organisation

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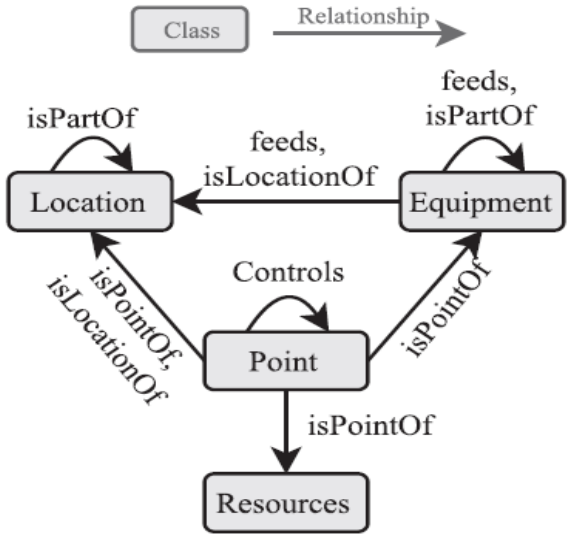
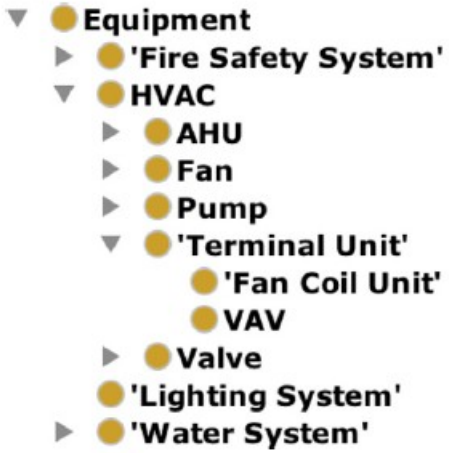
Brick Schema: data and metadata organisation

Brick Ontology: description of building-related objects and relationships





B. Balaji, *et al.*, ''Brick: Metadata schema for portable smart building applications,'' *Applied Energy*, vol. 226, pp. 1273-1292, 2018

Feasibility study applied to IPP building 103

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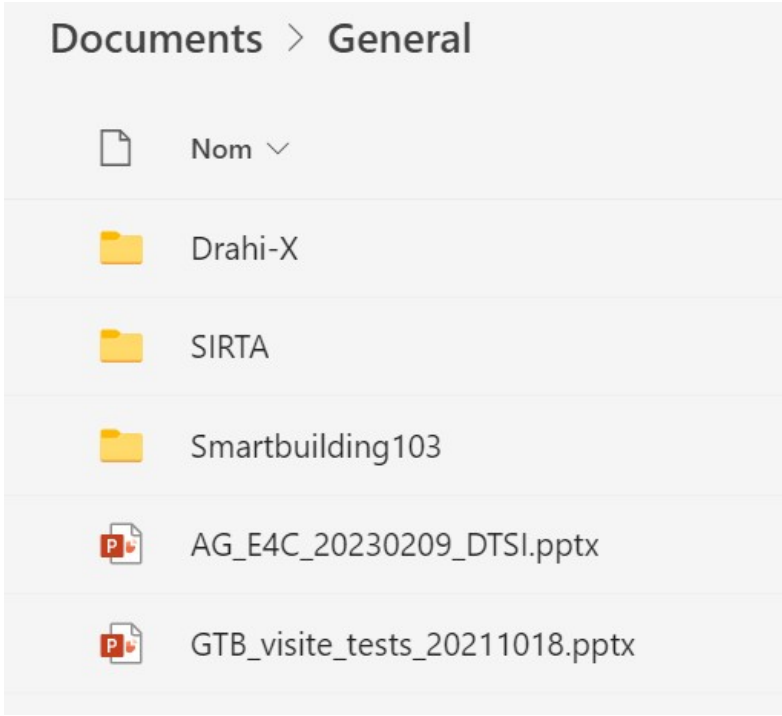
Drawing an exhaustive inventory of building components

Mapping to BRICK classes and objects

Instantiation of the model for building 103

Preliminary performance analysis on different use case scenarios

(type of queries supported, read/write delays, *etc.*)



Use cases and associated data query

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Investigated use cases

- Surge Detection in Electricity Comsumption
- Real-time Monitoring of Electricity Usage
- Comparison with Baselines for a Set Period
- Peak Thermal Power Consumption
- Variation Analysis of Daily Consumption
- Water Leak Detection

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```
PREFIX brick: <https://brickschema.org/schema/Brick#>
PREFIX E4CL: <http://E4C.com/Location#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>

SELECT ?timestamp ?readingValue
WHERE {
  ?meter a E4CL:Electrical_Meter_General ;
         brick:isLocatedIn E4CL:Logement-3-1-3 ;
         brick:hasPoint ?reading .
  ?reading E4CL:timestamp ?timestamp ;
           brick:value ?readingValue .
}
ORDER BY DESC(?timestamp)
LIMIT 1
```

Query to monitor an electric meter sensor in a room

```
PREFIX brick: <https://brickschema.org/schema/Brick#>
PREFIX E4CL: <http://E4C.com/Location#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>

SELECT ?meter ?timestamp ?previousReading ?currentReading ?consumptionDifference
WHERE {
  ?meter a E4CL:Heat_Meter ;
         brick:hasPoint ?reading ;
         brick:isLocatedIn ?area .
  ?reading E4CL:timestamp ?timestamp ;
           brick:value ?currentReading .

  # Subquery to get the previous reading for each meter
  {
    SELECT ?meter (MAX(?t) AS ?previousTimestamp)
    WHERE {
      ?meter a E4CL:Heat_Meter ;
             brick:hasPoint ?r .
      ?r E4CL:timestamp ?t ;
         brick:value ?previousValue .
      FILTER(?t < "2023-08-07T00:00:00"^^xsd:dateTime)
    }
    GROUP BY ?meter
  }
  ?meter brick:hasPoint ?previousReading .
  ?previousReading E4CL:timestamp ?previousTimestamp ;
                   brick:value ?previousValue .

  # Calculate the consumption difference between consecutive readings
  BIND(?currentReading - ?previousValue AS ?consumptionDifference)

  # Filter for sudden spikes based on a threshold value
  FILTER(?consumptionDifference > threshold // to be determined )
}
```

Query to detect abnormal values

Beyond data model implementation

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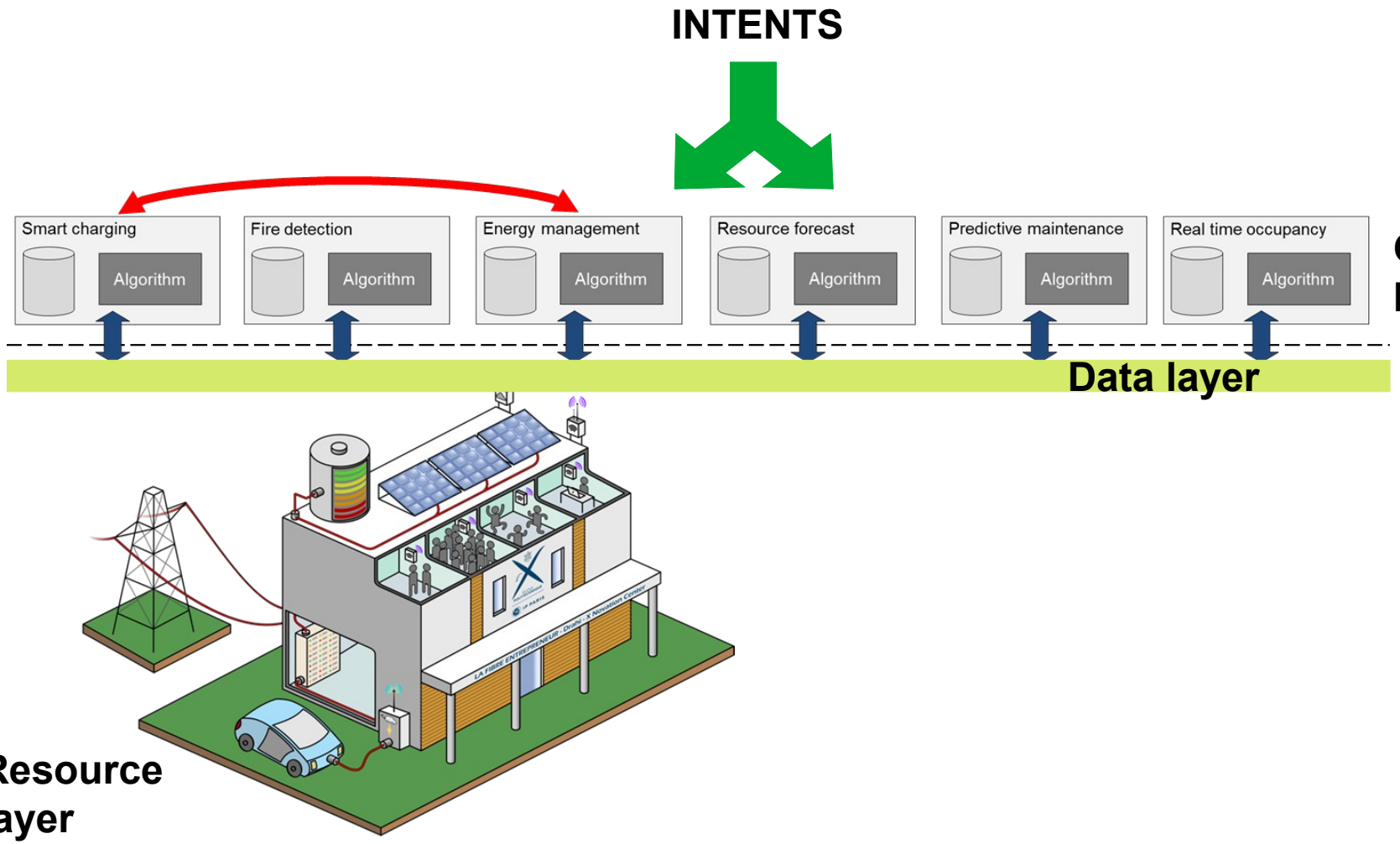

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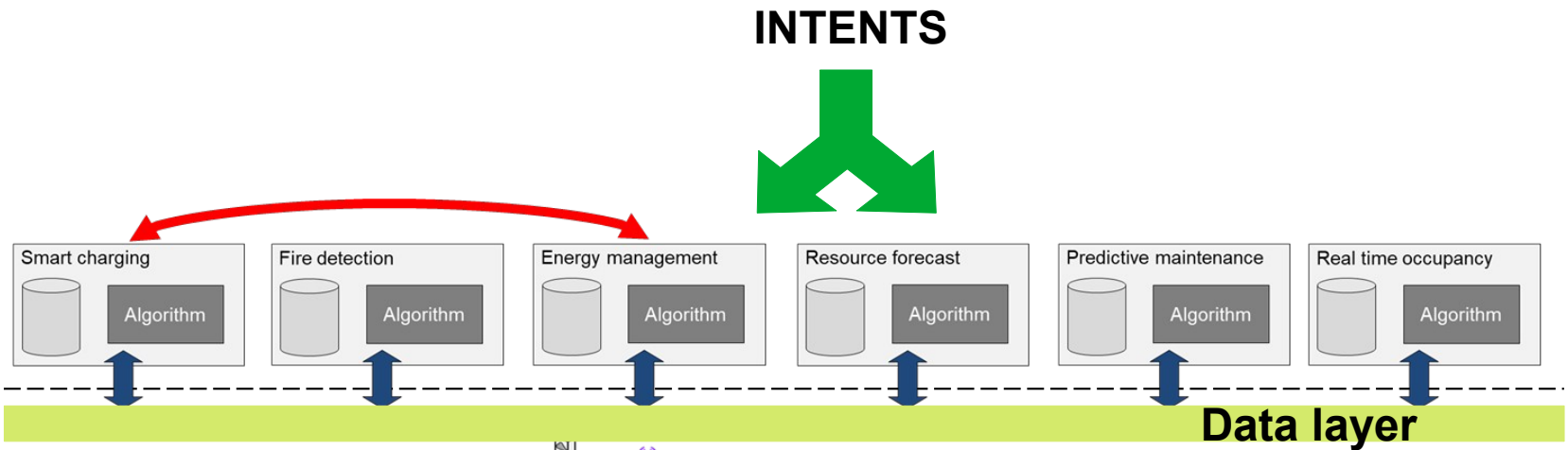
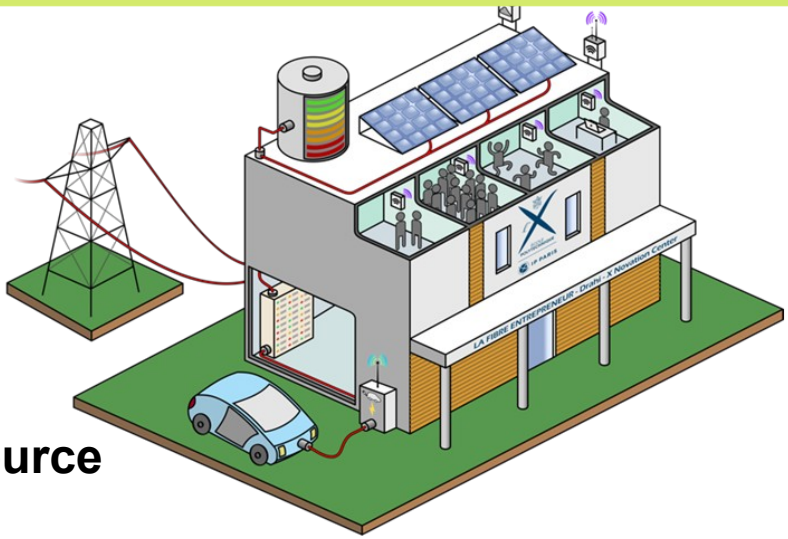
Beyond data model implementation





Resource layer

Interoperability ?

Function abstraction ?

Feedback loop to the operator ?

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Thank you

Any question?

If interested in the work, please get in touch
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