Development of a National Scale Digital Twin for Domestic Building Stock

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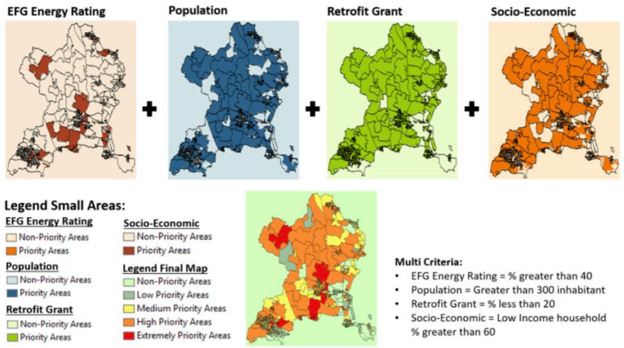

Intelligent Data Harvesting for Multi-Scale Building Stock Classification and Energy Performance Prediction

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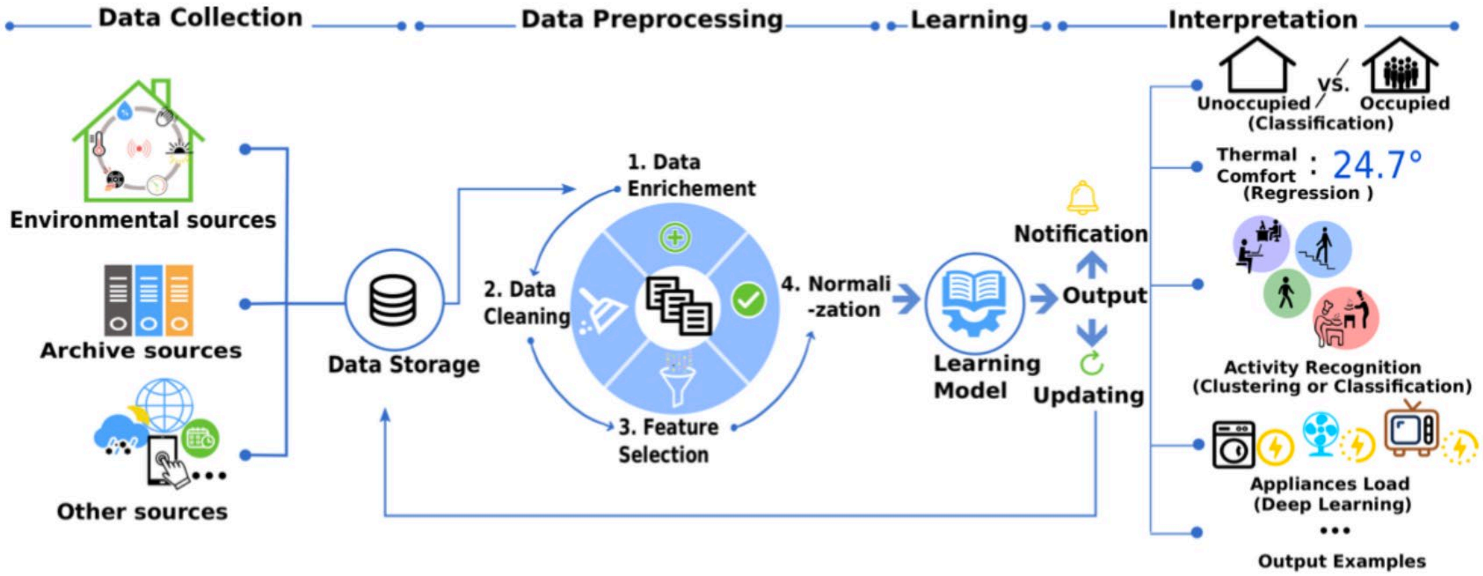

Djenouri, Djamel & Laidi, Roufaida & Djenouri, Youcef & Balasingham, Ilangko. (2019). Machine Learning for Smart Building Applications: Review and Taxonomy. ACM Computing Surveys. 52. 10.1145/3311950.

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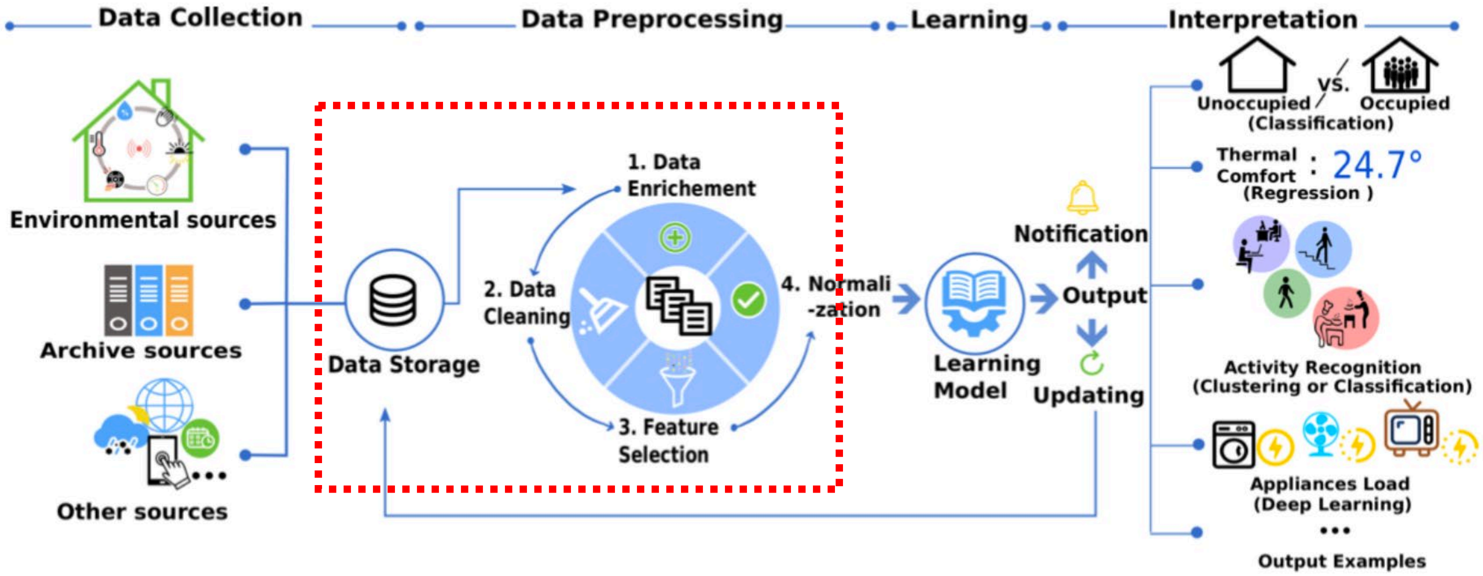

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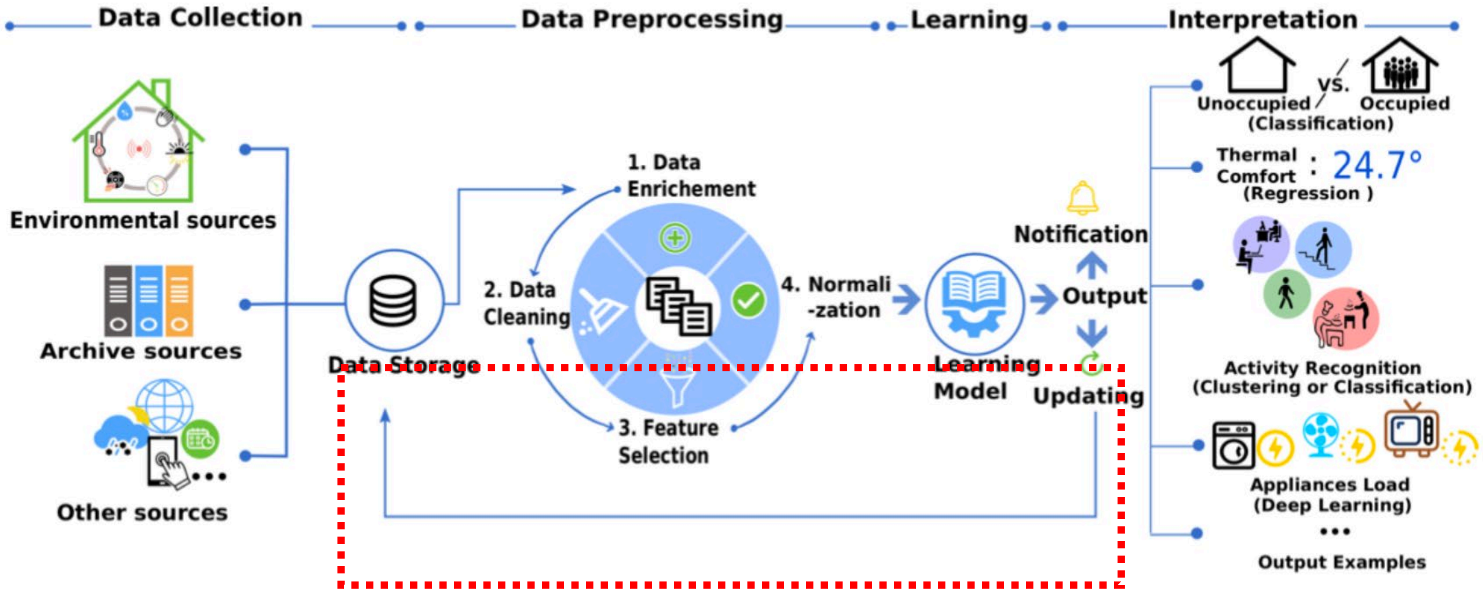

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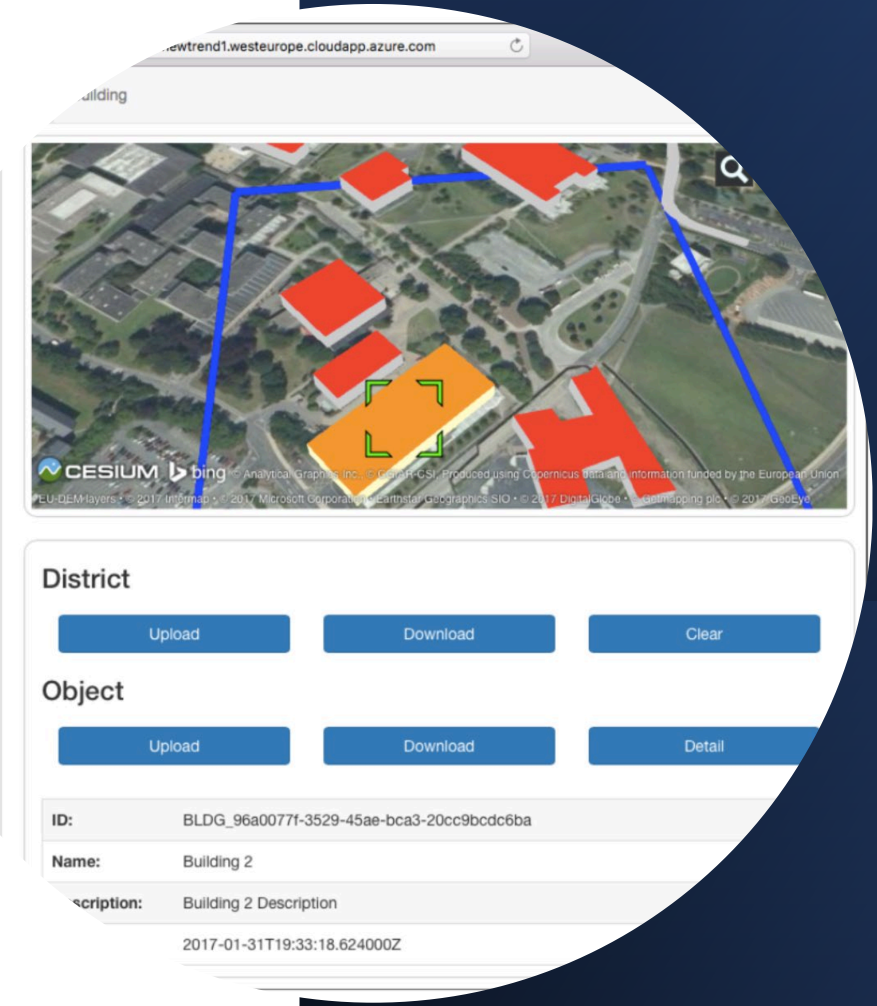
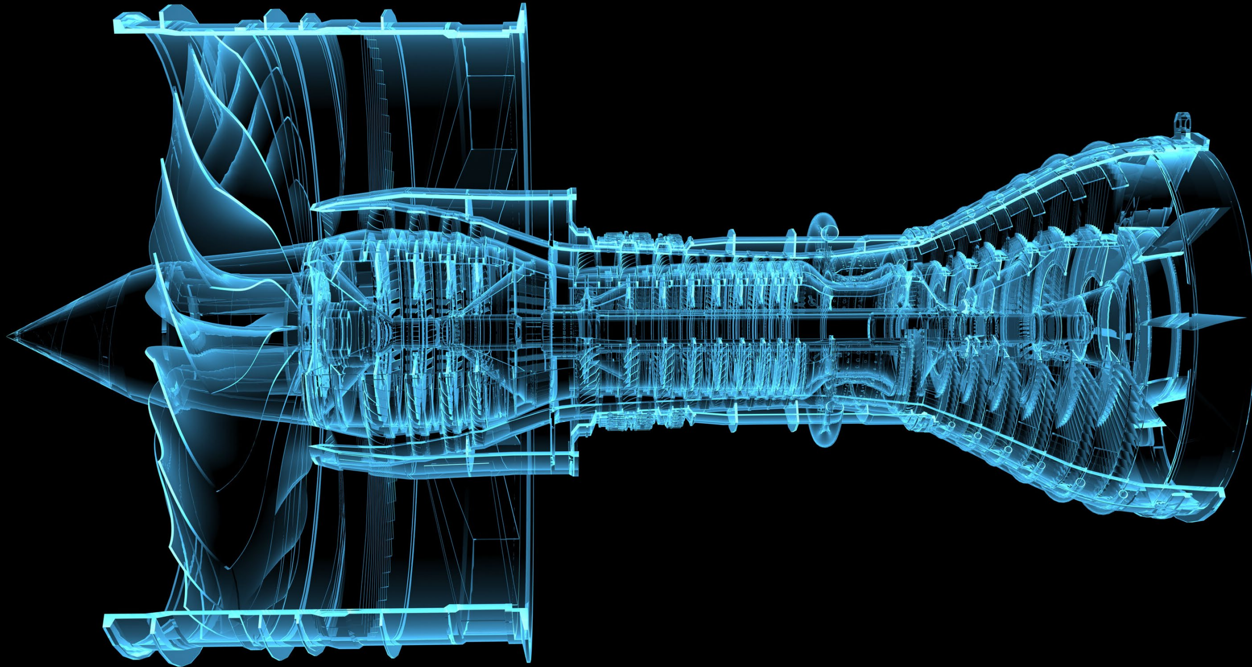
Building Data provides deep insights but is **Large**, **Complex** and **Siloed**

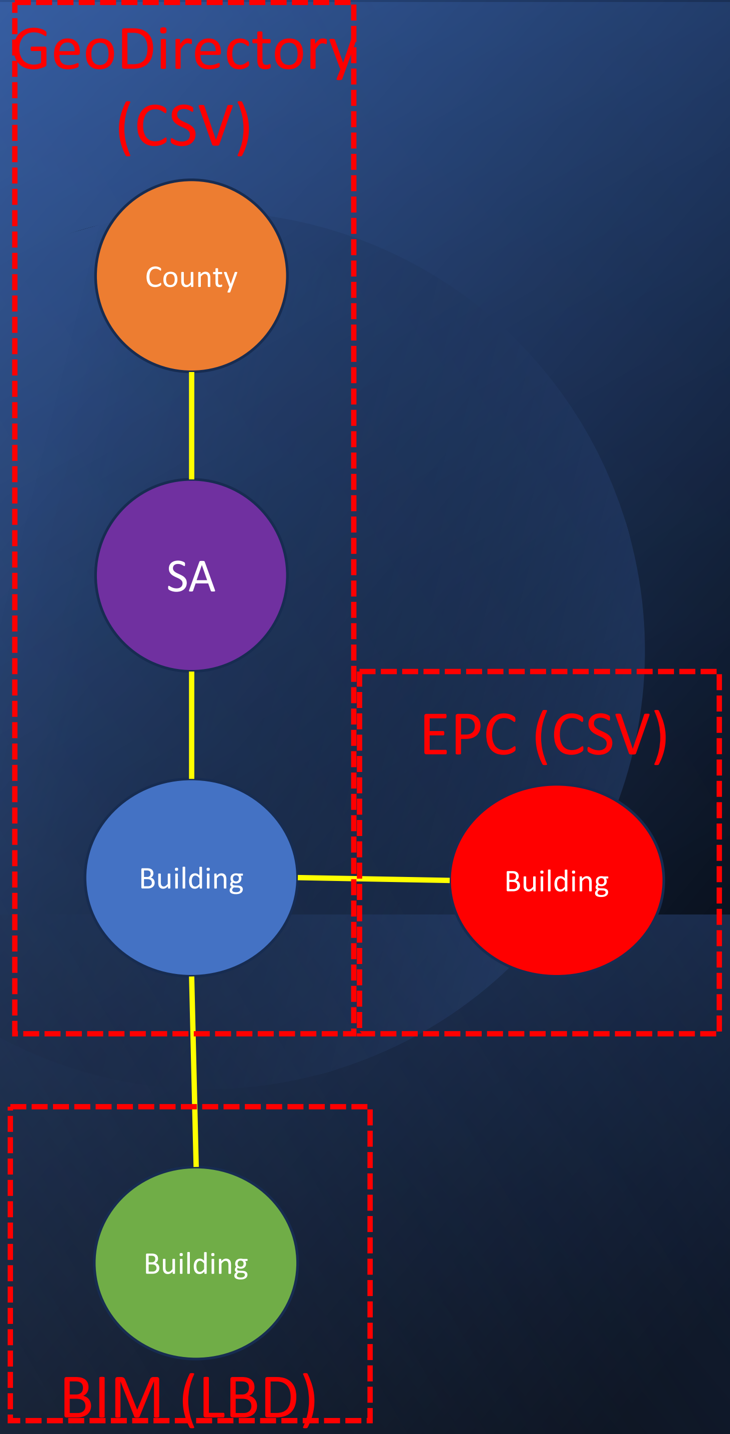


Defining a Digital Twin

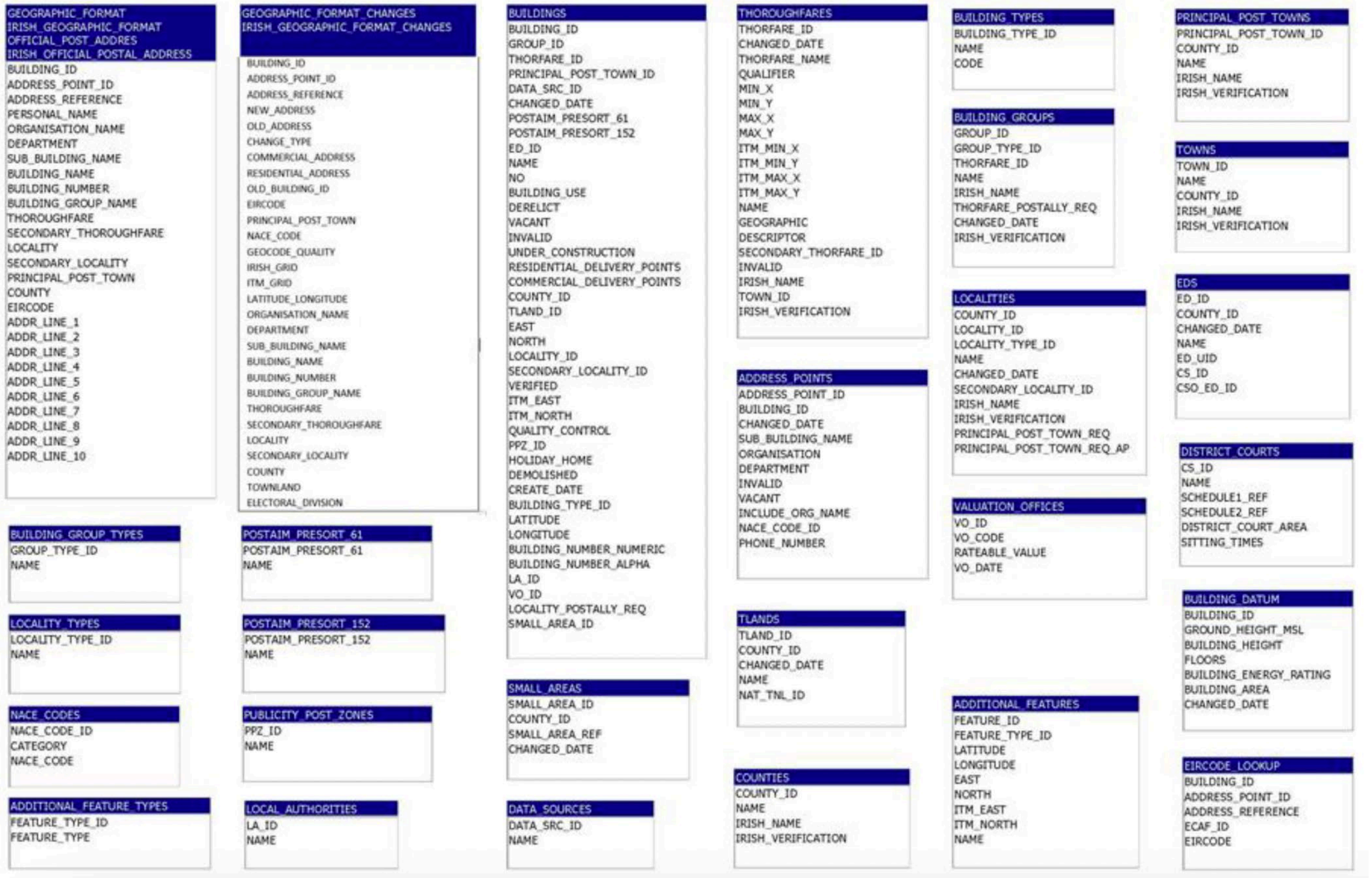


- Digital Twin and Digital Shadow
- Digital Twin is a Two-Way Cyber-Physical Model
- System State Represented by a Rich Data Model
- Learns and enables Learning
- Delivers deep insights
- Feedback

Defining a Knowledge Graph

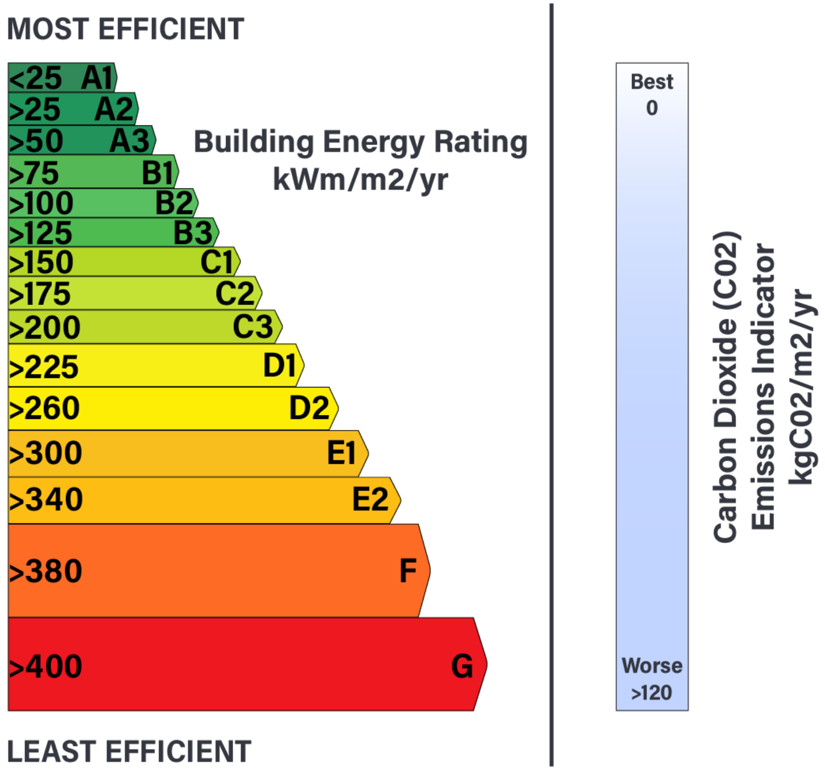

GeoDirectory
(CSV)
County
SA
Building
EPC (CSV)
Building
Building
BIM (LBD)

Diverse Data



GeoDirectory + EPC + web harvested text and imagery + weather

Diverse Data



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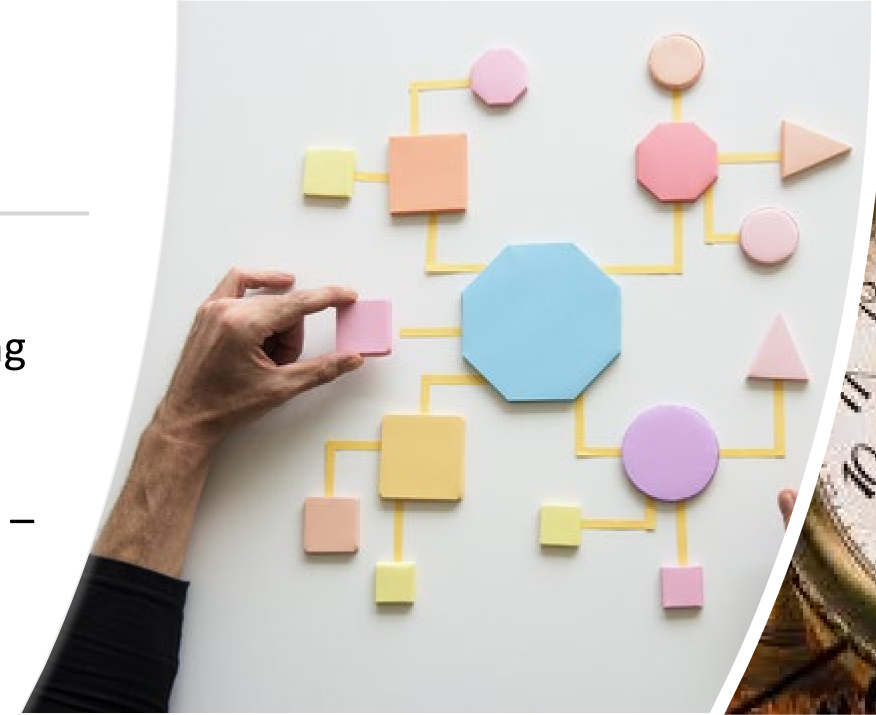
Diverse Data

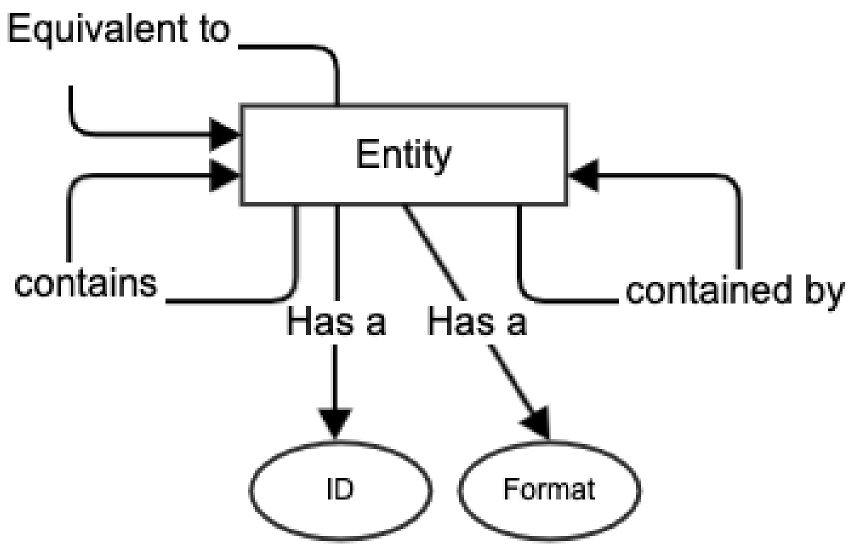
GeoDirectory – whole residential building stock with geographic contexts

Data Integration Framework - DDIM

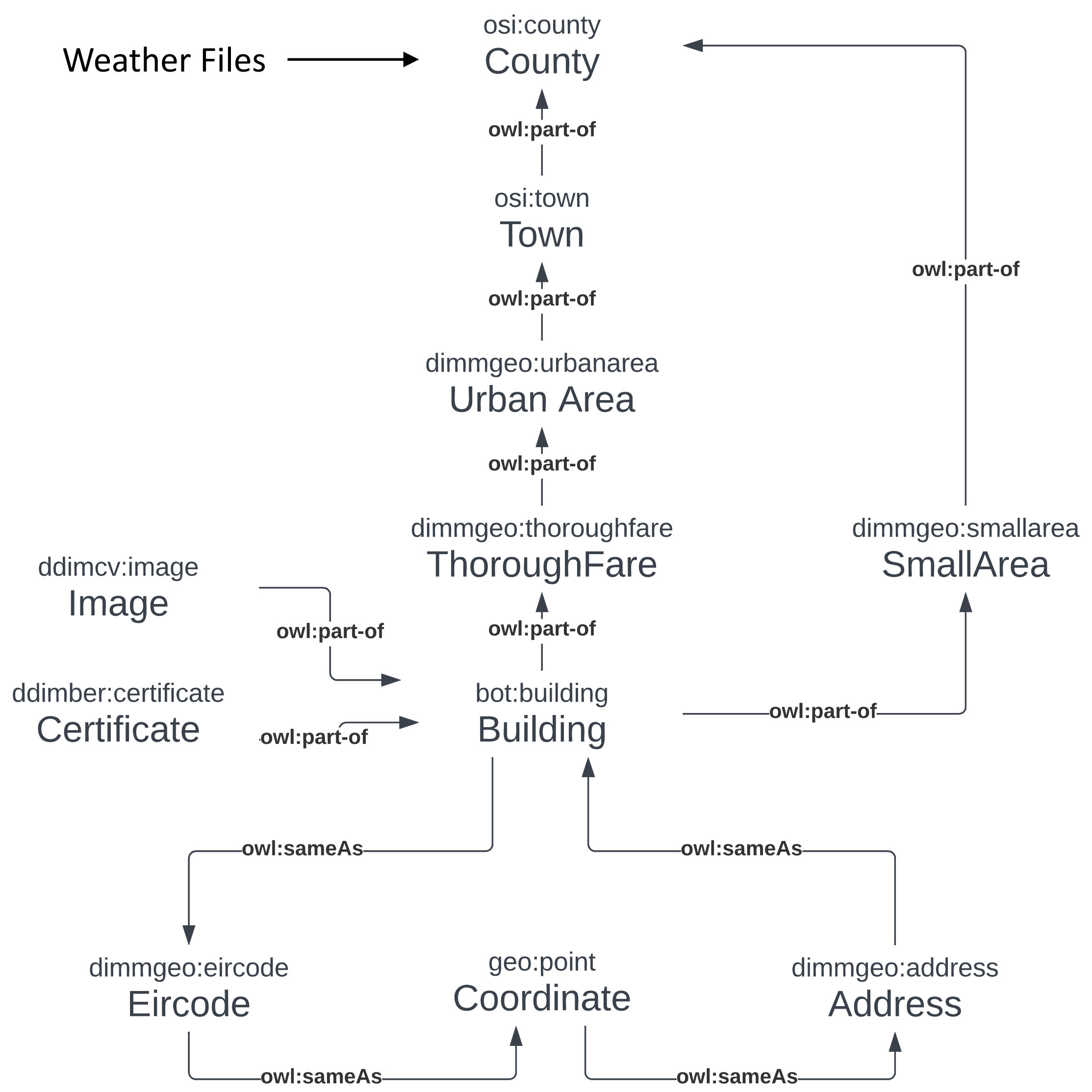
- DDIM is turnkey and form driven
- Serves to integrate information sources among project partners and enable knowledge discovery
- Data is integrated through a common context – this overcomes homogeneity
- Information provenance



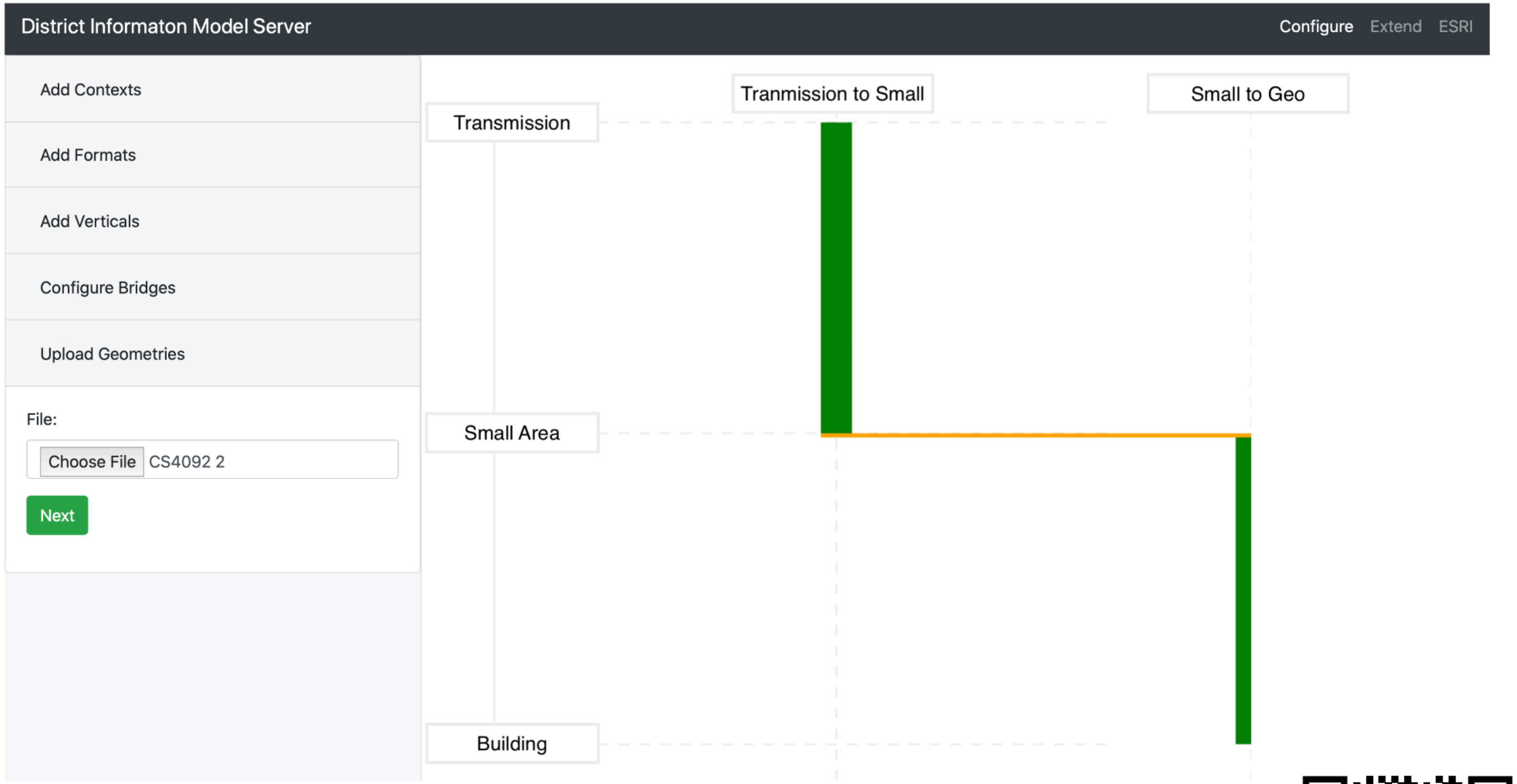
Data Integration Framework – An Ontology to define a **Common Context**



Applying the Common Context



Data Integration Framework - DDIM



- Implemented as a DjangoREST Server, Docker Deployed
- MySQL, Neo4J (with NeoSemantics)/GraphDB
- RESTful interface
- Graph Creation Steps:
  - Upload Information Sources
  - On upload extract source meta-data (for CSV, column headings)
  - Define relationships using forms
  - Script transforms data to set of entities and relationships in turtle format

The Need for Enrichment

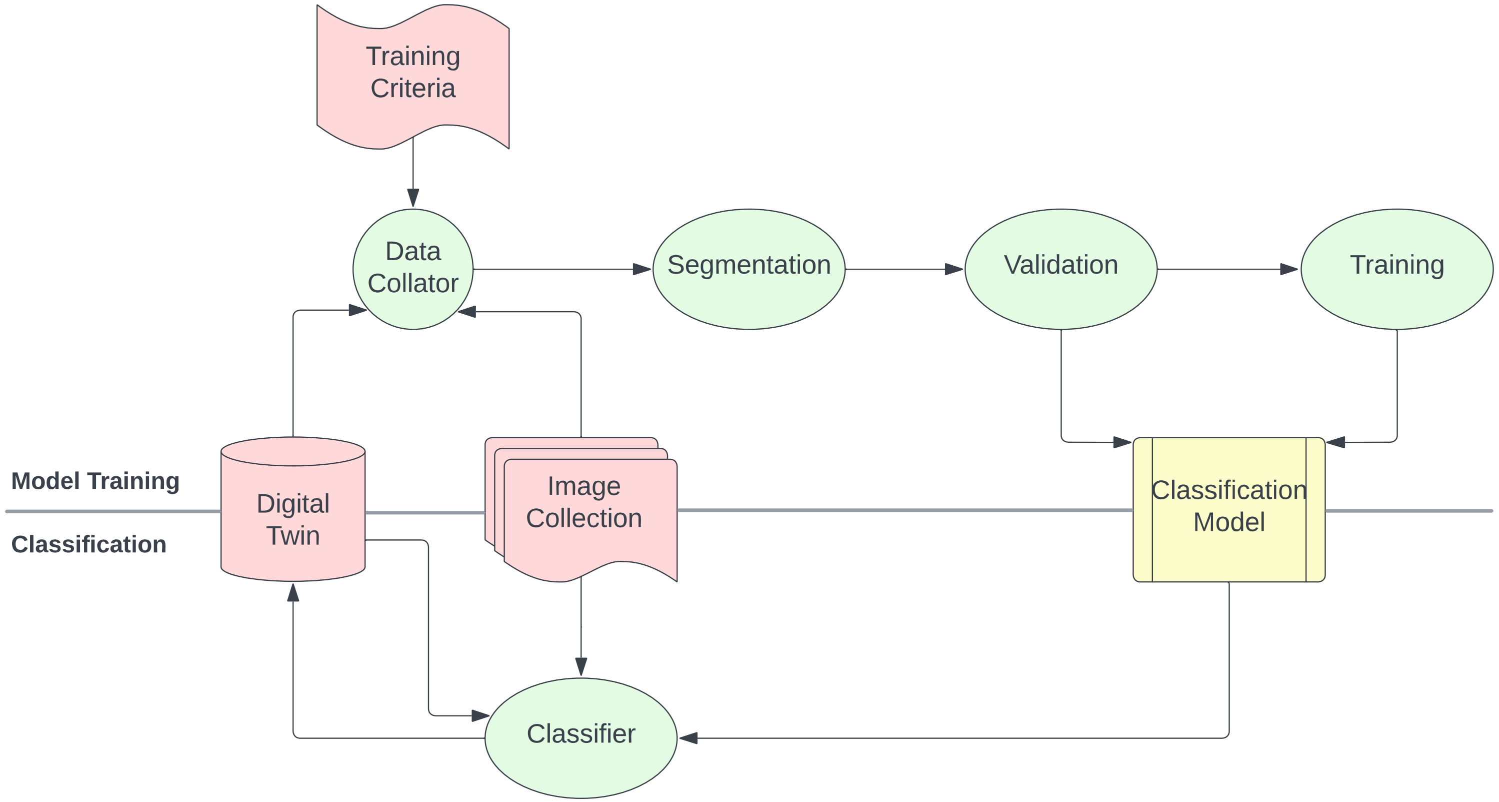
- I Know this building quite well!
- In one database it is described as being built c.2007 and having 2 bedrooms – neither fact is correct
- I could examine data that has been fused from other databases and take an ensemble approach to determine the most accurate value. But the building doesn't have a BER (EPC) Certificate
- A different approach is required

Enrichment Requirements

Number	Parameters	Unit
P1	Wall U-value	W/m^2K
P2	Window U-value	W/m^2K
P3	Floor U-value	W/m^2K
P4	Roof U-value	W/m^2K
P5	Door U-value	W/m^2K
P6	Orientation	North Axis {deg}
P7	Lighting density	W/m^2
P8	Occupancy	Person(s)
P9	Equipment density	W/m^2
P10	Heating setpoint	°C
P11	Heating setback	°C
P12	HVAC efficiency	%
P13	Renewables	boolean
P14	DHW	$l/m^2/day$
P15	ACH	Air changes per hour
P16	Window-to-wall ratio	%
P17	Heating factor	numeric
P18	Electricity factor	numeric

A data-driven approach to optimize urban scale energy retrofit decisions for residential buildings, Usman Ali et al.

An Enrichment Methodology Using Images



An Enrichment Example – Results and Issues

- This building is actually a poor example
  - The least accurate results are for standalone buildings in the countryside where building details are obscured by plants, are variable distances from the image source, have a wide variety of building designs
  - These types of buildings account for X percentage of Irish building stock
- Works best for suburban areas with large numbers of similar designs and site layouts

Thank You

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