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Empa
Materials Science and Technology

Proposed linked data platform for organising data resources for urban energy modelling

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Motivation

- Many heterogeneous datasets used by multiple researchers on many different projects
- Traceability from the results of their studies can be a challenge
- It is a challenge to control who has access to what data and the usage restrictions of using that data
- Attended the Linked Data in Construction and Architecture and there is a lot of work to apply semantic technologies to the data
- Not much work related to urban scale and stock modelling. Mainly associated with BIM. product and GIS data.

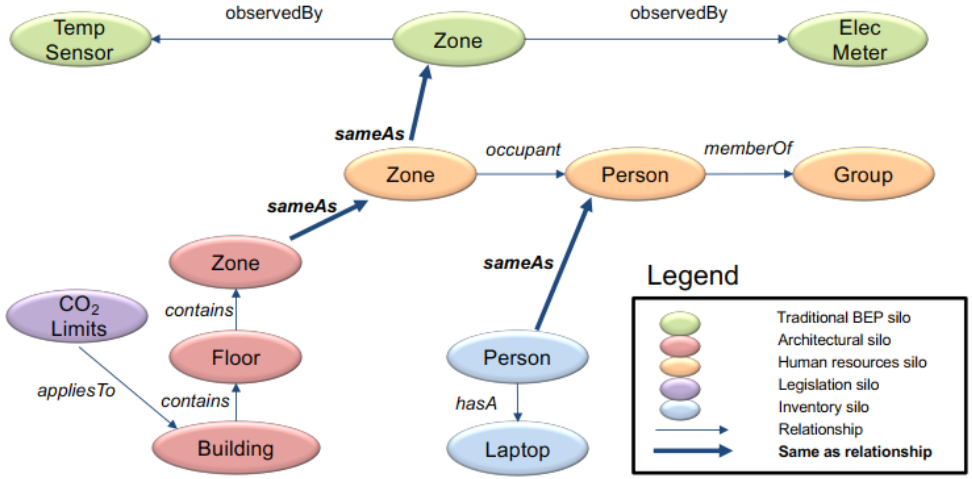
Linked Data Platform - Stages

Generation
Collection
Pre-processing
Storage
Simulation
Analysis

What is linked data?

- Semantic linked data to W3 standards is stored in an RDF triples store

- Each node contains a unique reference identified (URI) that provides additional information about its context



Source: Building performance optimization using cross-domain scenario modeling, linked data, and complex event processing – O'Donnell 2013

Linked Data Technologies

- Neo4j is a labelled property graph that enables more efficient representation of the data by allowing the nodes to have properties

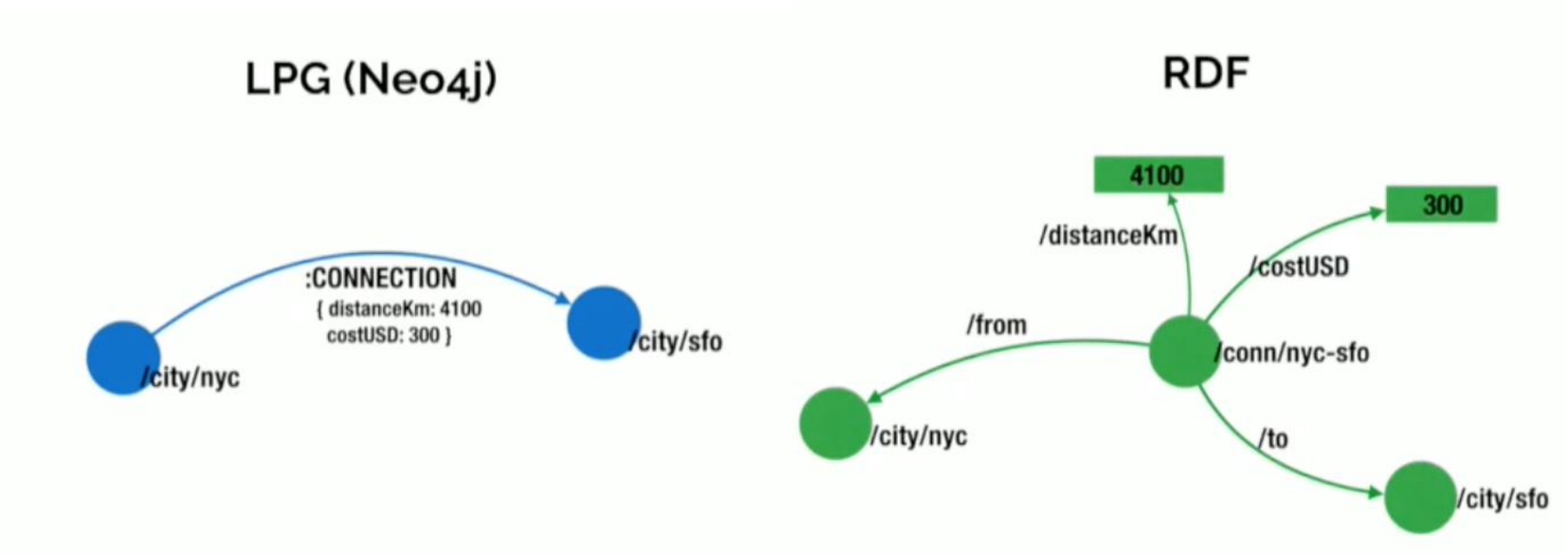


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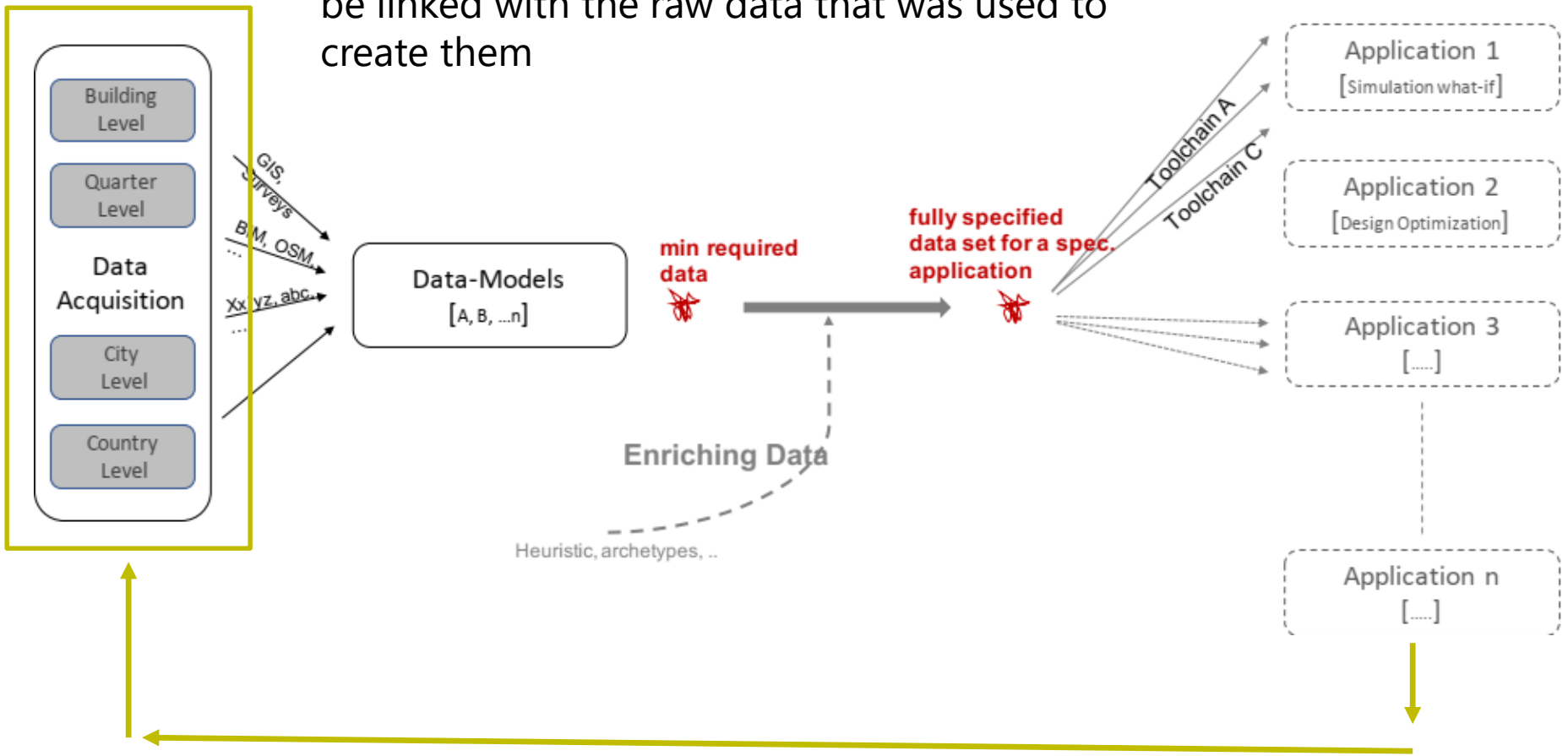
Image source: https://neo4j.com/blog/rdf-triple-store-vs-labeled-property-graph-difference/

Envisaged Usage Scenarios

1. Support development of decision support at district scale where information has various levels of granularity;
2. Provide a standards based, flexible, decoupled architecture;
3. Be cheap to use in terms of hardware, expertise, implementation.

Where does this work fit in

The data that is pulled into the data models/format will be linked. Results can then be linked with the raw data that was used to create them



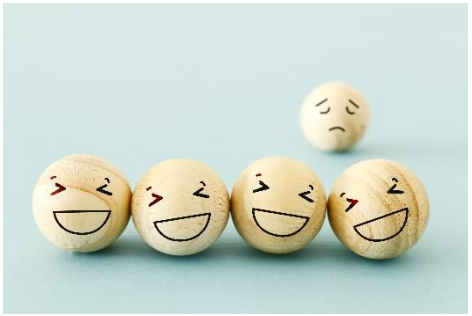
Data Exchange Problem…

And issues from the real world…

Cost and Regulatory



Systems Organisation



Loosely Bound
(data oriented)

Linked Data

Common Data Store

Monolithic Application

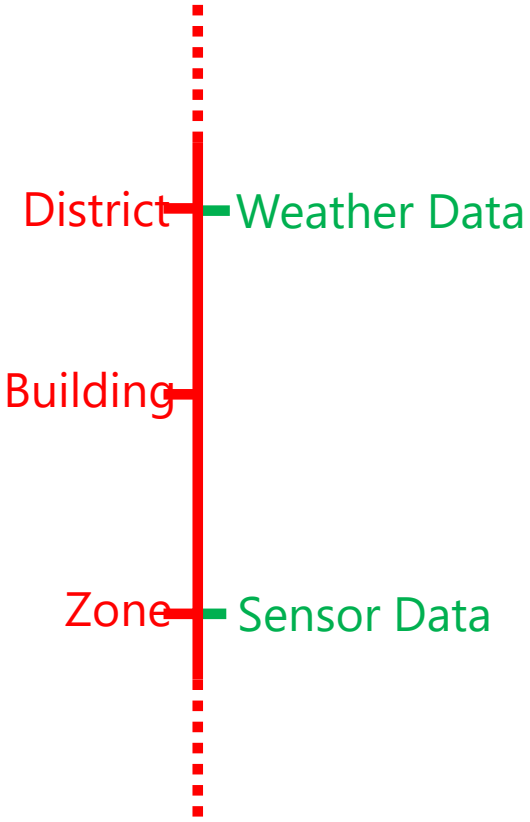
Tightly Bound
(system oriented)

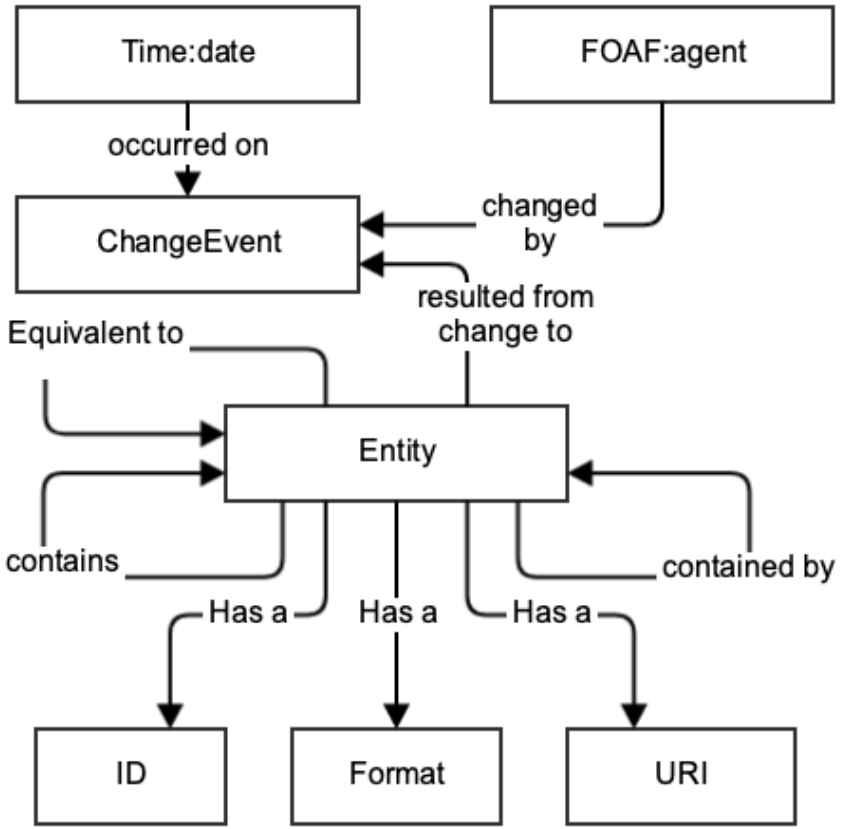
The DDIM Server

- The server acts as a data registry implemented through DCAT and an ontology that provides a common context for entries in the registry;
- Common context associates information with time and place;
- Providers of information must express their contribution in this context.

Hoare, Cathal, Usman Ali, and James O'Donnell. 'Dynamic District Information Server: On the Use of W3C Linked Data Standards to Unify Construction Data'. In *Test Proceedings Title*, 1:265–73. European Conferences on Computing in Construction. Chania, Crete: Publisher EC3, 2019. https://doi.org/10.35490/EC3.2019.185.

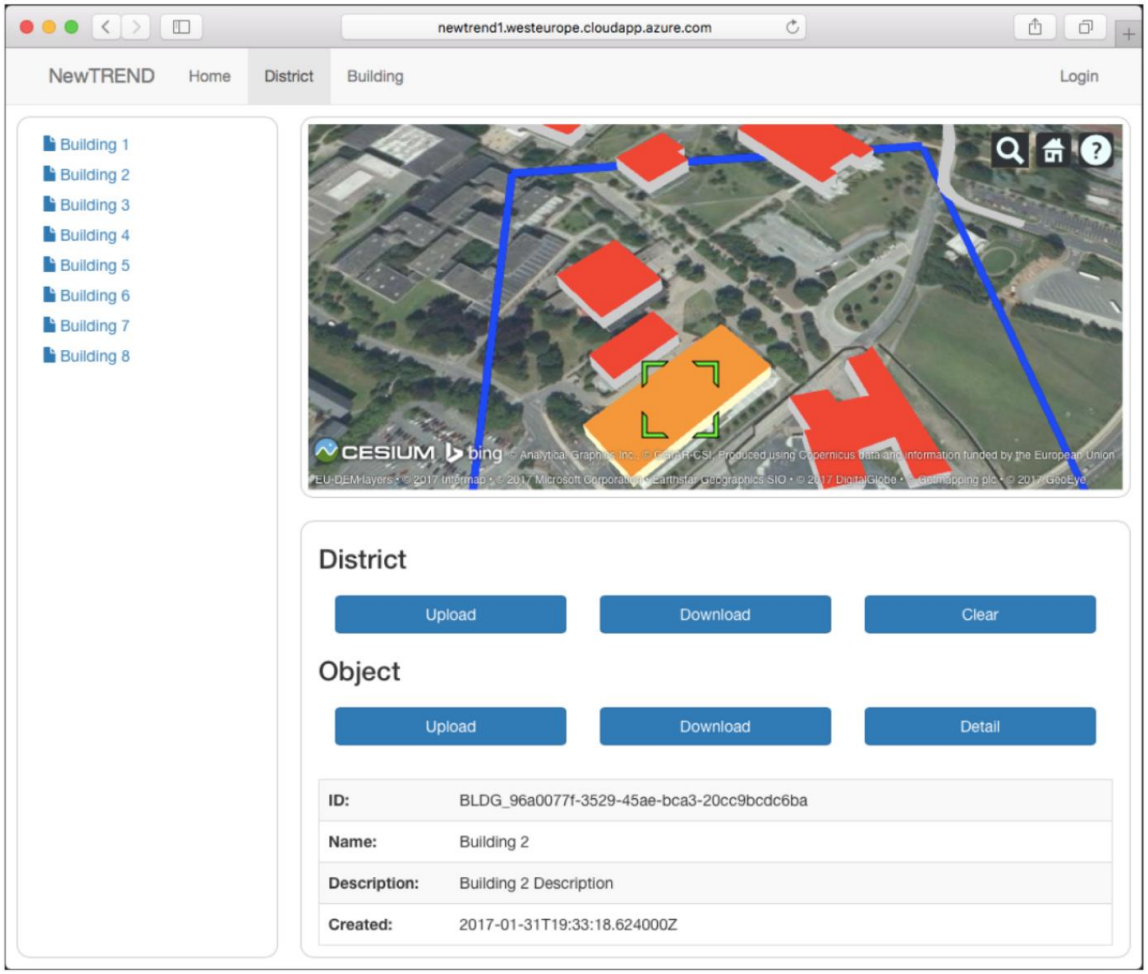
Core Context Ontology





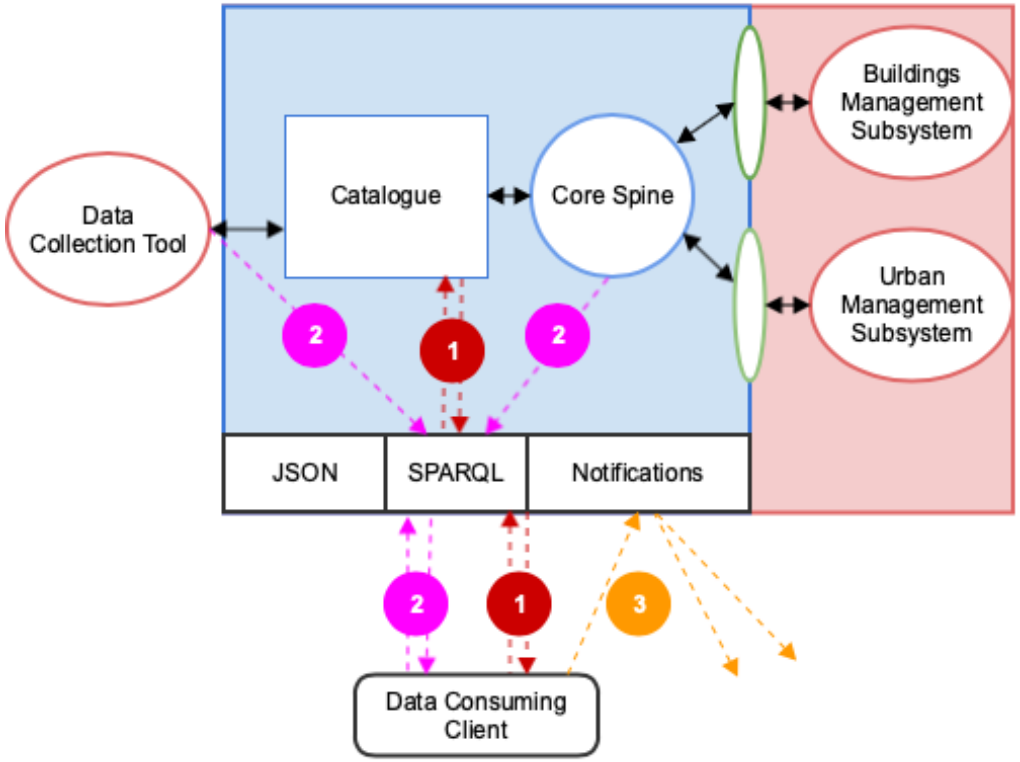
"what were the humidity readings in all zones when the external humidity was at level n:"

Initializing the Project



Server Summary

- Third-parties expose their data repositories as RDF endpoints and register these with the server;

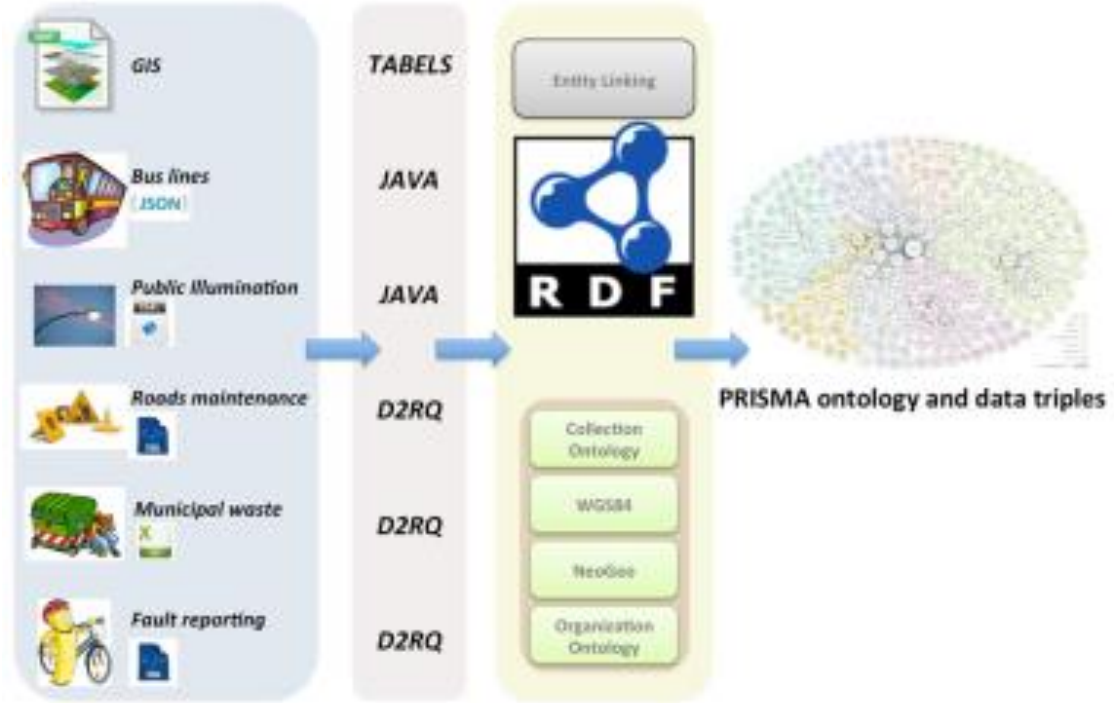


- These endpoints express their information in the common context;
- The Server supports federated queries across these endpoints;

There are reusable resources available

Examples cases of linked urban data

Producing Linked Data for Smart Cities: The Case of Catania - Consoli et al. 2017



- Comprehensive data model for smart cities that integrates:
    - Geo-referenced data, public transport, urban fault reporting, road maintenance and waste.
    - Feed-back from users

Useful Ontologies: BOT

- The Building Topology Ontology (BOT) is a minimal ontology for describing the core topological concepts of a building.

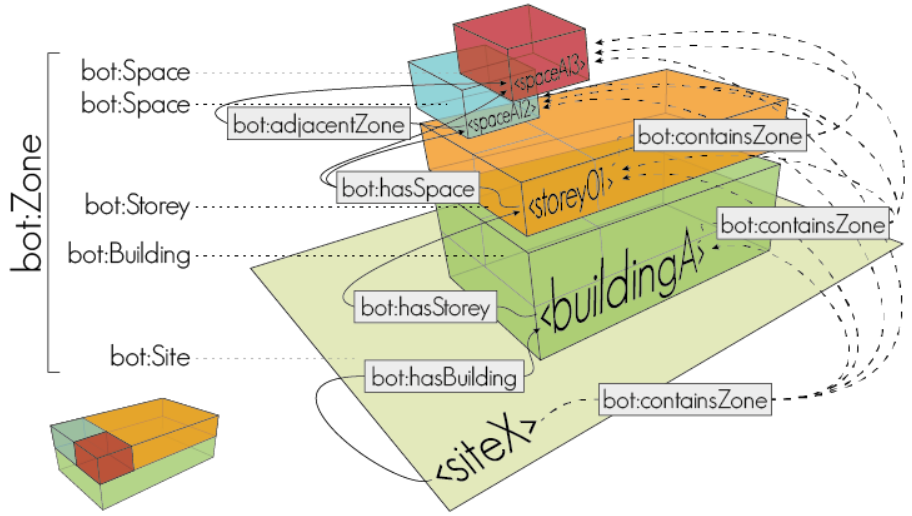
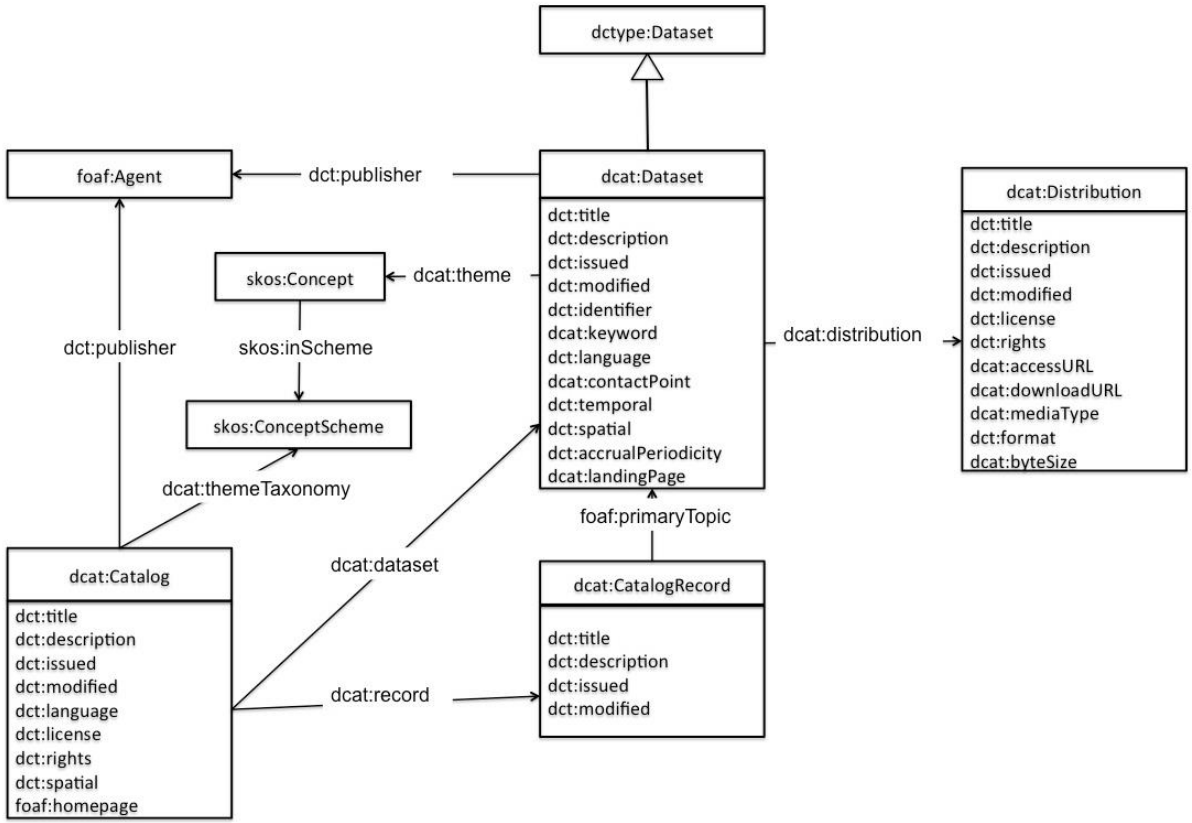


Figure 1 Classes and relationships involved in Zones

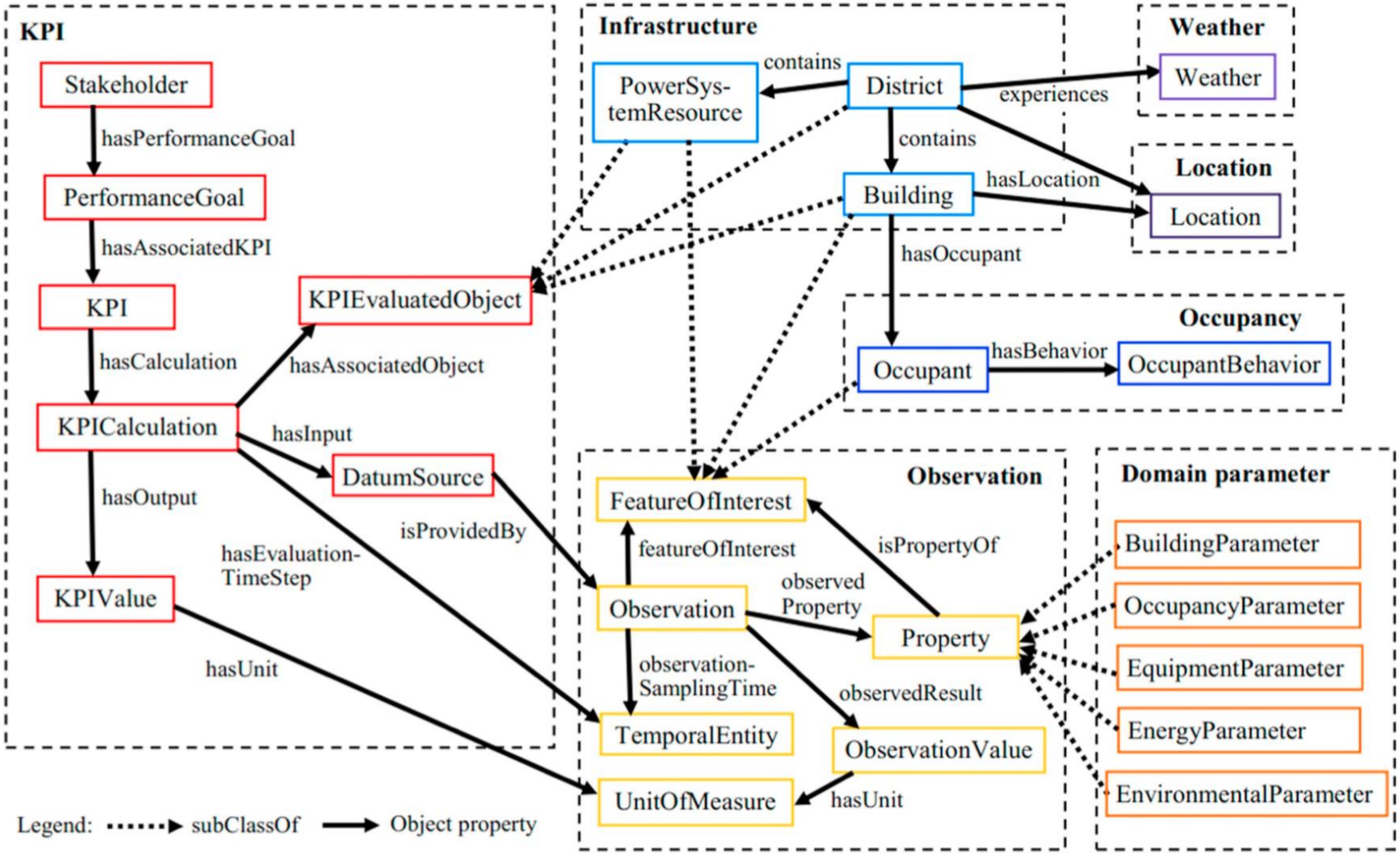
- Useful for general envelope simulation, but there is no property for results

Useful Ontologies: DCAT

DCAT ontology – For managing our datasets within the lab. This could tell us the origin of a given set of results and the usage restrictions of that data. https://www.w3.org/TR/vocab-dcat/. This could then be expanded to international and cross department datasets.



High Level District Energy Management (EM-KPI) Ontology



Reusing existing ontologies in the EM-KPI ontolgy

Table 3
Ontologies selected for the development of the EM-KPI ontology.

Ontology	Namespace	Prefix	Example of term
DUL ontology	http://www.ontologydesignpatterns.org/ont/dul/DUL.owl	dul	*PhysicalObject, hasLocation, isLocationOf*
Dublin core ontology	http://purl.org/dc/terms/	dct	*identifier, title, description, type, Location*
WGS84 geo positioning ontology	http://www.w3.org/2003/01/geo/wgs84_pos#	geo	*Point, lat, long, alt*
schema.org	http://schema.org/	schema	*Event, Postal Address*
gbBuilding information ontology	https://www.auto.tuwien.ac.at/downloads/thinkhome/ontology/building/1_10/gbBuildingOntology.owl	bio	*Building, Building Element, Zone, containsArea, Area, containsVolume, Volume, BuildingStorey, Weather*
Energy resource ontology	https://www.auto.tuwien.ac.at/downloads/thinkhome/ontology/EnergyResourceOntology.owl	ero	*EnergyFacility, Equipment, Appliance, consumesEnergy, producesEnergy, EnergySupply, EnergyDemand, EnergyType*
Weather ontology	https://www.auto.tuwien.ac.at/downloads/thinkhome/ontology/WeatherOntology.owl	wo	*WeatherCondition, WeatherPhenomenon, Humidity, SolarIrradiance*
User behavior and building process information	https://www.auto.tuwien.ac.at/downloads/thinkhome/ontology/ProcessOntology.owl	po	*OccupancyParameter, hasInfluenceOn*
Semantic sensor network ontology (SSN)	http://purl.oclc.org/NET/ssnx/ssn	ssn	*Observation, ObservationValue, observedProperty, Property, observationSamplingTime, observationResult*
Ontology of units of measure (OM)	http://www.wurvoc.org/vocabularies/om-1.8/	om	*Unit_of_measure, Compound_unit, Singular_Unit, Unit_multiplication*
OWL-time ontology	http://www.w3.org/2006/time#	time	*Interval, hasEnd, hasBeginning, Instant*
Mathematical modelling ontology	http://identifiers.org/mamo/	mamo	*Mathematical_model, Variable, Independent_variable, Dependent_variable*

Li, Yehong, Raúl García-Castro, Nandana Mihindukulasooriya, James O'Donnell, and Sergio Vega-Sánchez. 'Enhancing Energy Management at District and Building Levels via an EM-KPI Ontology'. *Automation in Construction* 99 (1 March 2019): 152–67. https://doi.org/10.1016/j.autcon.2018.12.010.

Draft Objectives

1. Develop a procedure to link and extend data for urban modelling across the available datasets for each country*
   - Collect sample datasets from project partners.
   - Convert the data into linked data format (rdf)
   - Store the data onto DDIS platform
2. Query the linked data and generate the file formats (EnergyADE) required for simulation or data enrichment stage
3. Link the results from the simulation back to the building record so that all assumptions can be traced

*If the data cannot be shared/linked then placeholder data with the same variable names/type can be supplied. The objective here is to demonstrate the process

Open Questions

- What is the best graph technology to represent the data used in urban energy modelling?
- How to manage the complexity of the data models? Data models get complicated very quickly but how much information is enough?
- How much maintenance is required for the platform?
- How much work is required to update and link the data?
- Can we convert existing datasets into rdf or is it best to preserve their native format?
- Which ontologies can be used to represent data for urban energy modelling?
- How can the data be linked across the working groups?