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Enabling Multi-scale Energy Modelling through a Linked-Data Approach

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ESIPP Project (esipp.ie)

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Energy Systems Integration Partnership Programme (ESIPP), brings together a multidisciplinary, multi-institutional research team in Ireland with expertise in electricity, gas, water and data, with the relevant industry partners to focus on building human capacity and to develop a national coherent research activity in ESI.

Read more here

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Research Motivation

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Question posed by Economic and Social Research Institute of Ireland in conjunction with our grid operator.

ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE

ESB NETWORKS

What impact will new residential renovations, that involve EVs and/or heat pump installations, have on the Irish transmission grid?

Key obstacles

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- Data used to answer such questions is heterogeneous, is from many separate organizations and formats:
  - Some is public, more is commercially and otherwise sensitive;
  - Ability to interpret the data is often silo'd within an organization;
  - Sources are dynamic – new data artifacts may be produced and be offered.

Requirements for an appropriate solution

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1. Support development of decision support at district to national 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.

Development Goals

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- Sought to create a multi-model approach to district information management; several formats representing information from urban to building to space levels.
- Avoid Centralised server - tightly bound schema and API programming interface that was difficult to maintain and inflexible. Also had issues around data privacy and commercial concerns.
- An opportunity to create a distributed multi-model approach that creates relationships between data sources by describing their position in an overall context
    - Be easier to maintain, flexible/extensible and more expressive

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The Generically Deployable Dynamic District Information Model (DDIM) Service: Applied to an Irish Test Case

The DDIM service addresses issues of heterogeneity, privacy and flexibility

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- Issues:
  - Heterogenous data sources that exist at differing levels of granularity;
  - Issues of data privacy and commercially sensitive data leading to reluctance to share information;
  - Need for flexible querying of information across many levels of detail.
- Solution:
  - Distributed multi-model data service with central coordinating server that provides a central context & data register for external information sources;
  - Uses Linked-Data technologies to model, manage and query information.

Our DDIM server is based upon a core context ontology

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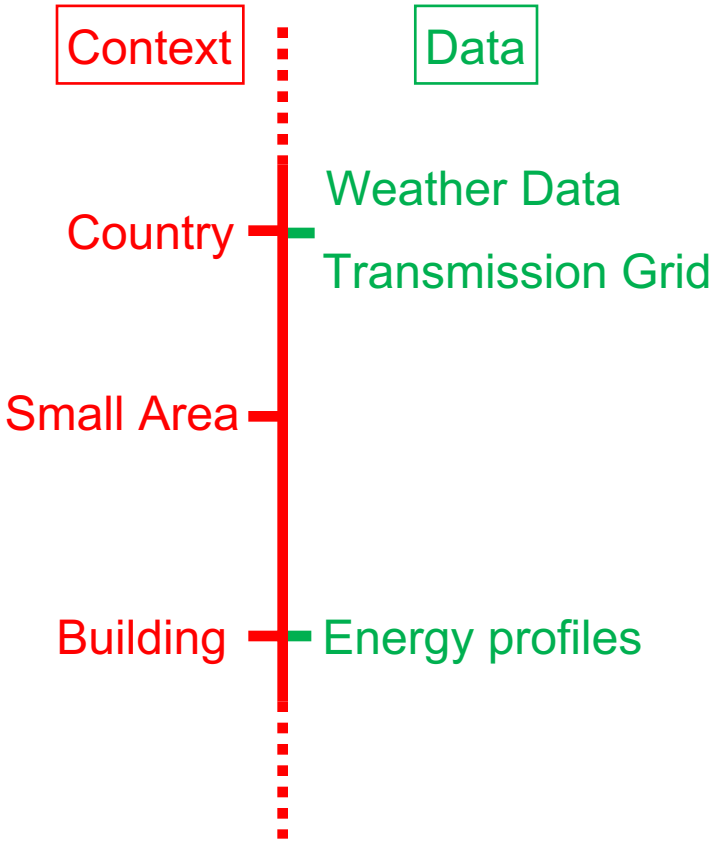

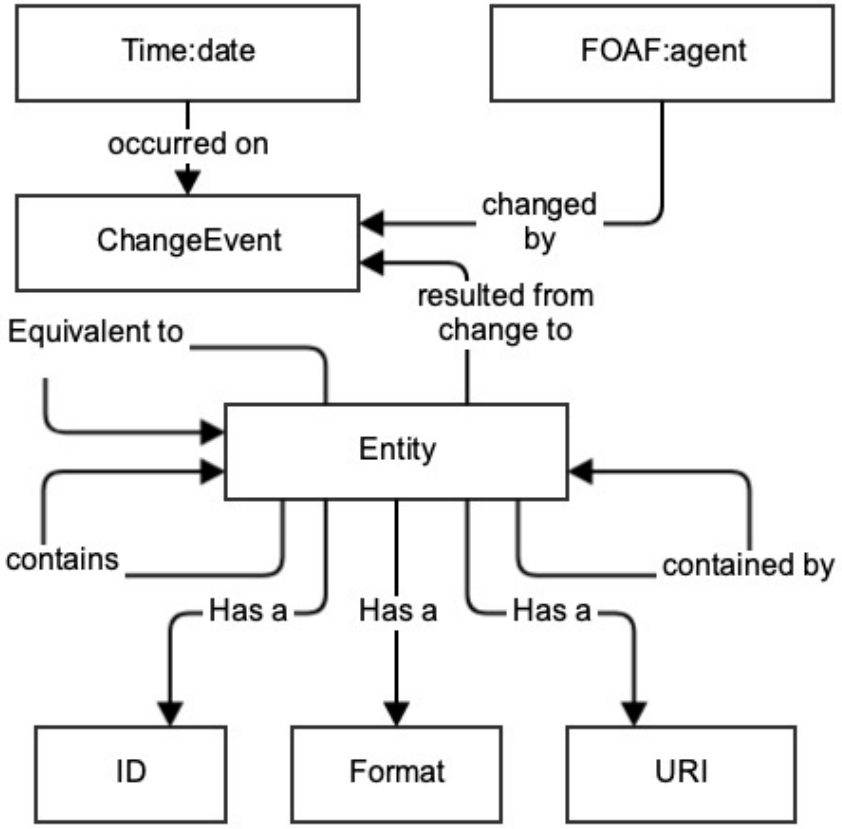

DCAT Schema

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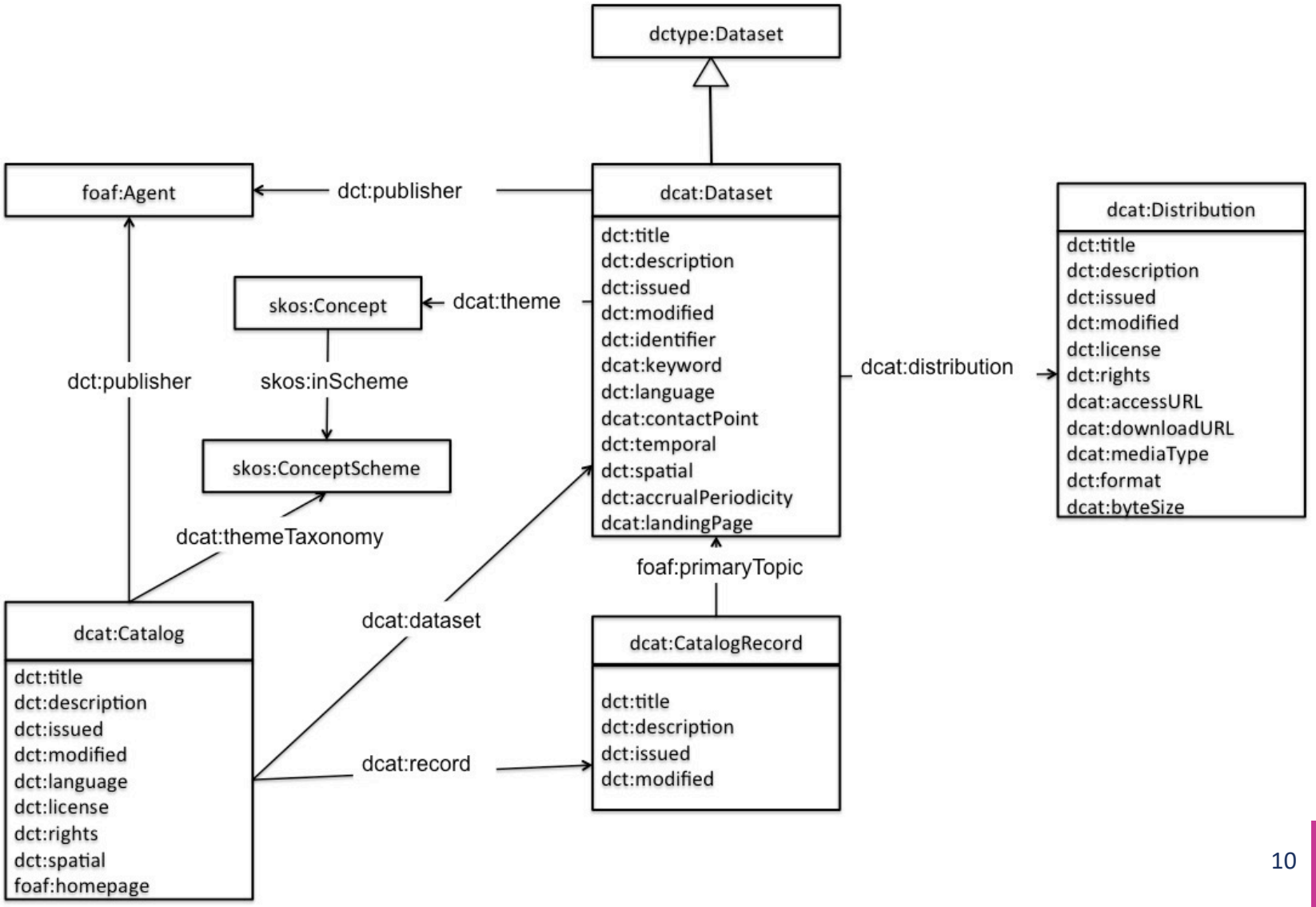
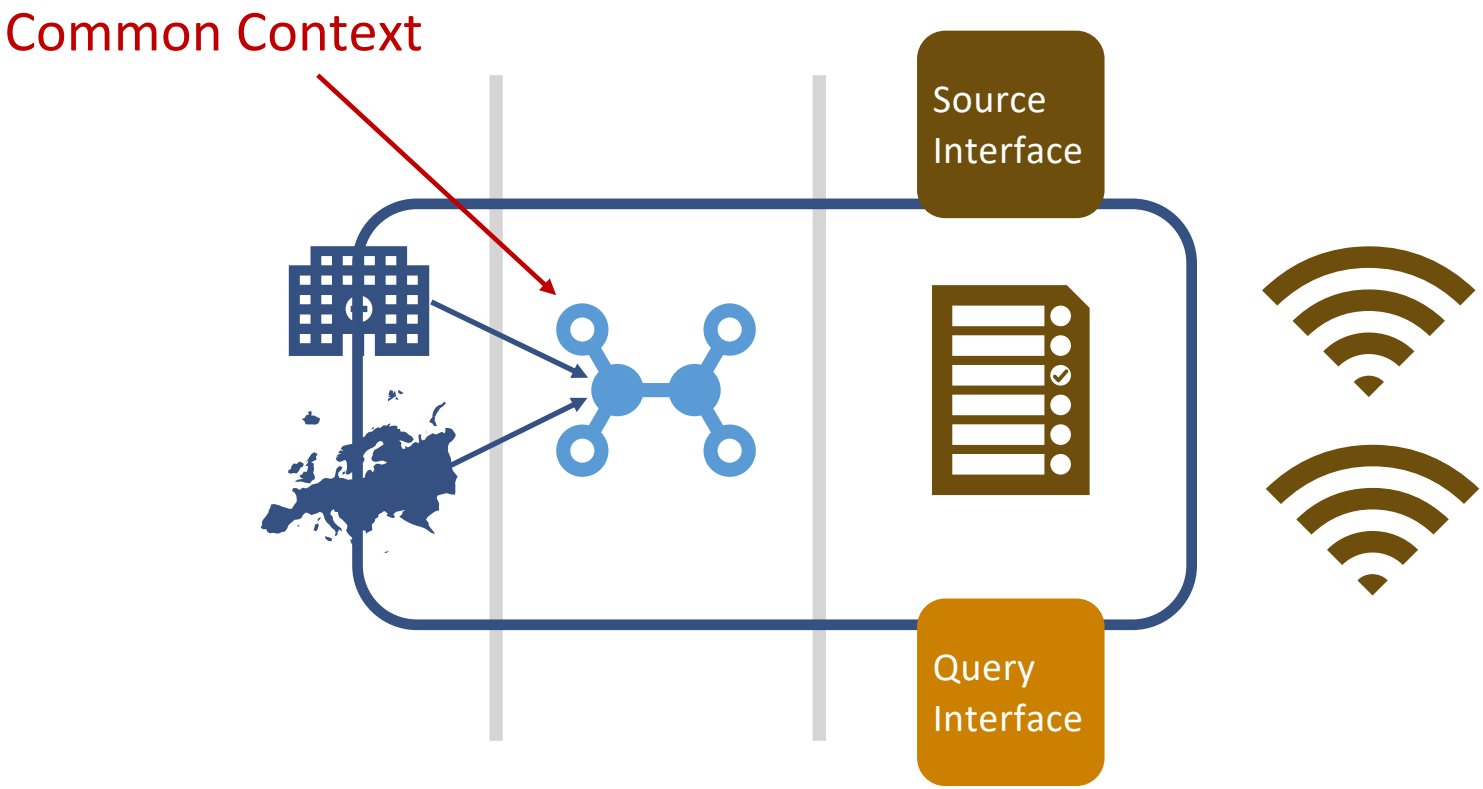


1) DDIM Architecture: Central Context relates information sources to one another



1. Admin is provided with various files that Describe the area of concern for the project. These are used to form the context schema.

Common Context relationships for the Irish test case scenario

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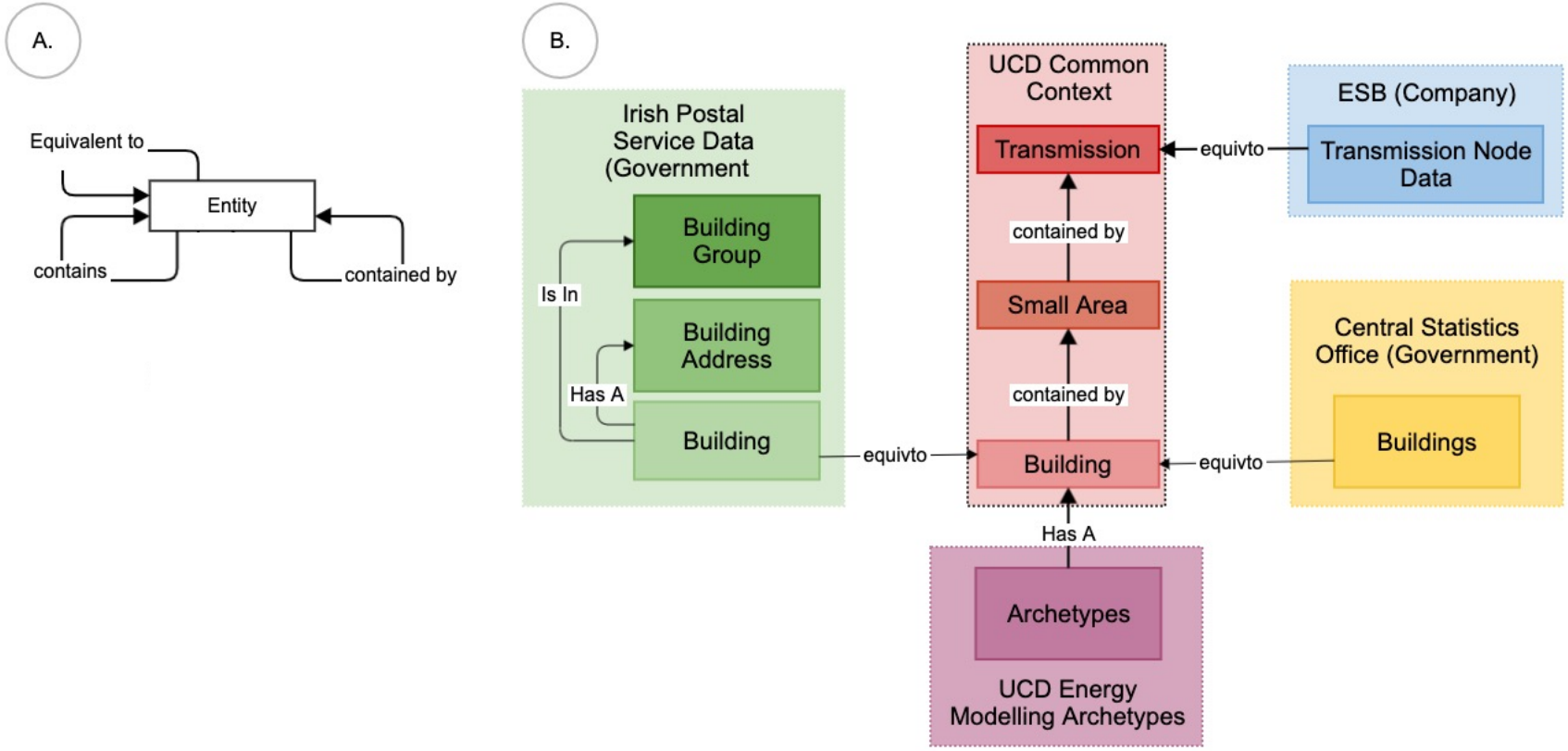

Common Contexts as created in the source interface

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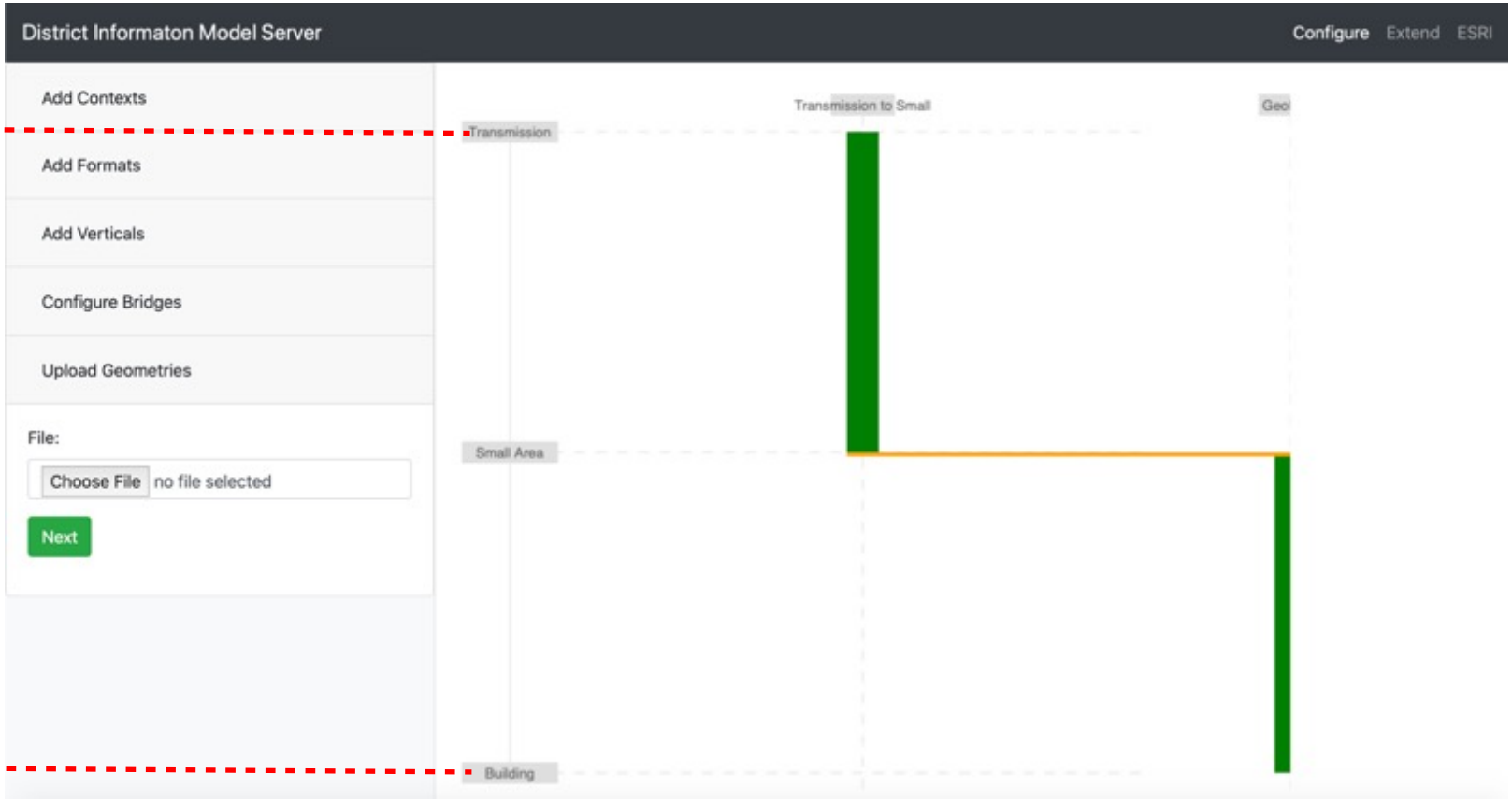
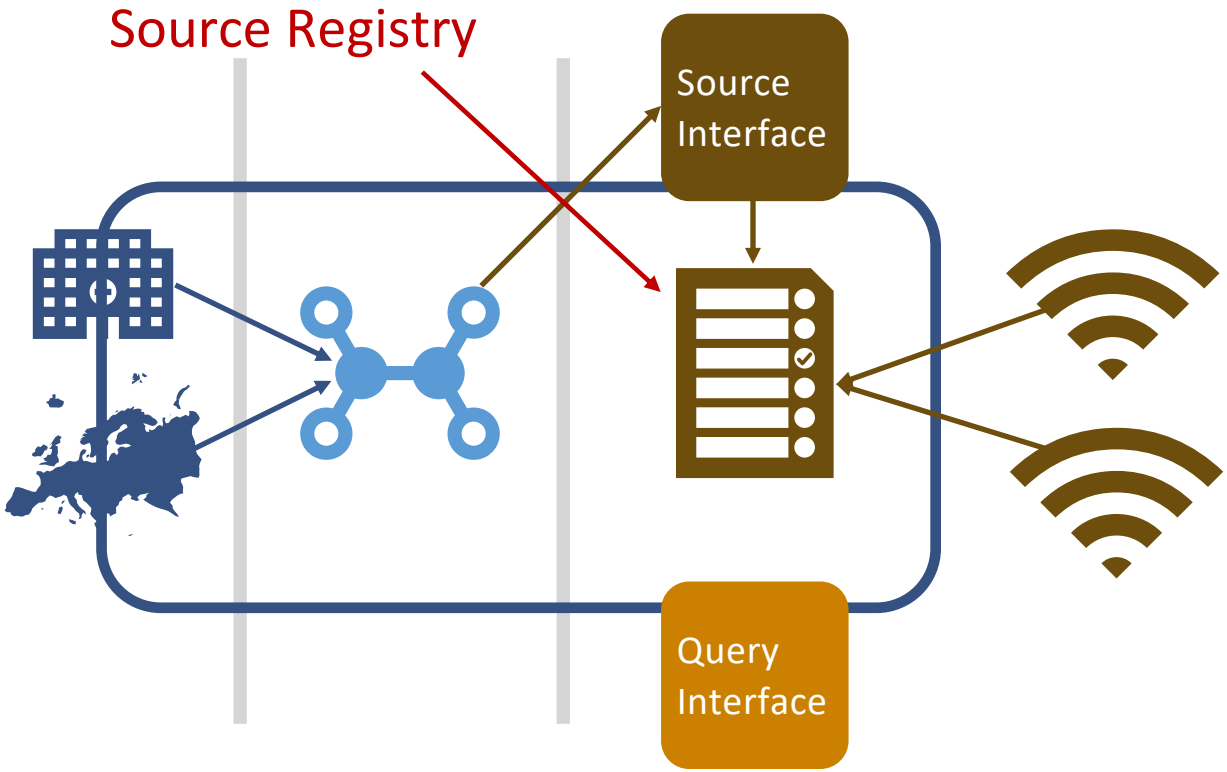


Met Data

Power Usage over time

2) DDIM Architecture:
External information sources are registered centrally to be later queried by federated queries



2. Once the context is defined, other contributors can access the context and use it to place other information in a network of relationships with other available information. Includes the URI for the RDF source and its schema.

Linking Content to Context: Registration of Data sources and content

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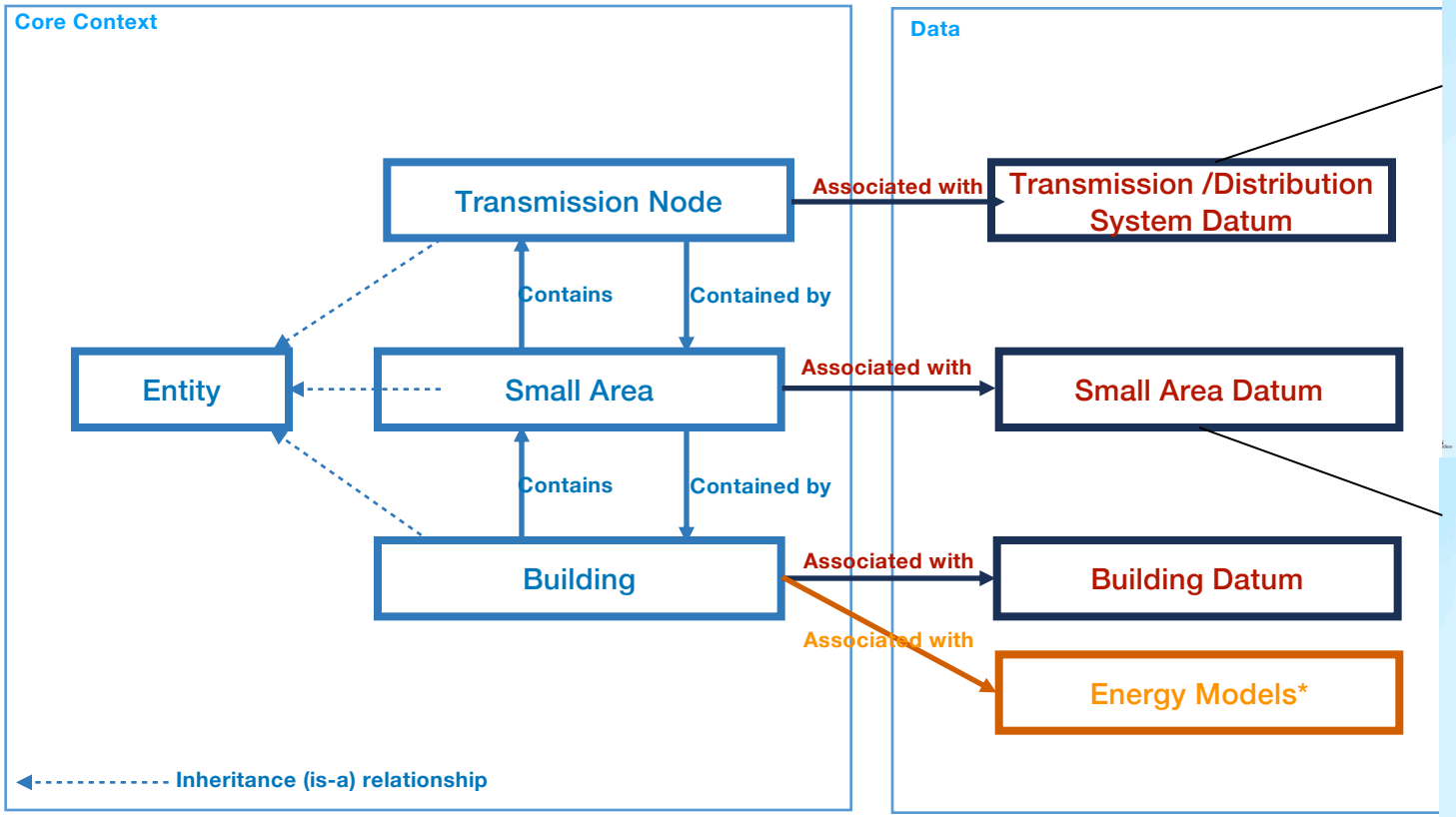
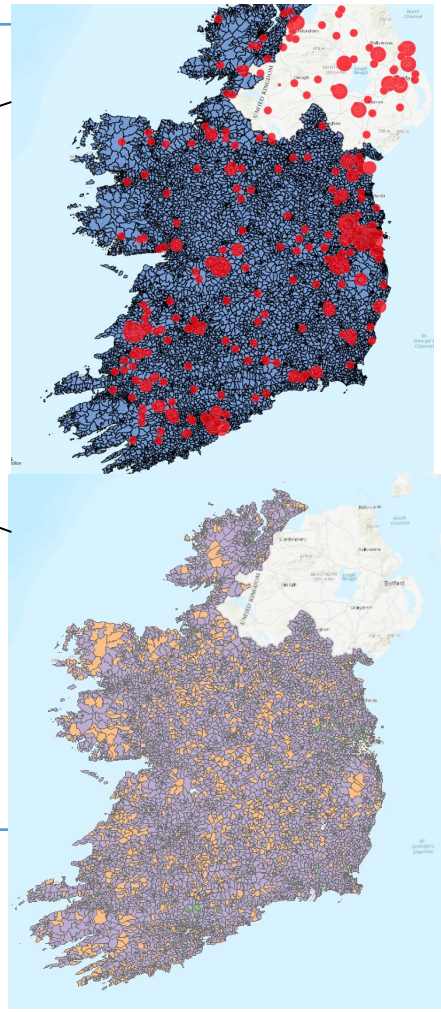




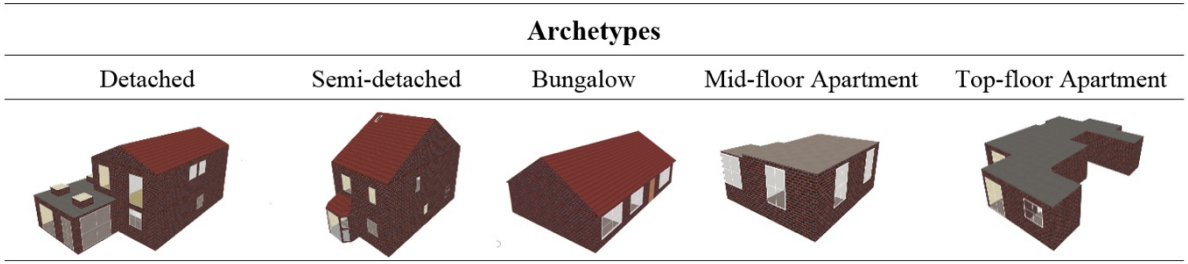
*Handled as class level information (i.e. single instance associated with all instance the Building class

Data sources: Energy Modelling at this scale involves an archetype-centric solution

Heating Systems & Controls

Renovation Packages

Electric Vehicles



Others include

- Terraced House
- Apartment Block

New Technologies

Demand Response

Energy Flexibility

Occupancy Profiles

Egan, James, et al. "Definition of a useful minimal-set of accurately-specified input data for Building Energy Performance Simulation." *Energy and Buildings* 165 (2018): 172-183.

Adding Sources is done as follows

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- Third party data can be included in a project managed by the server.
  - It must be defined in RDF/OWL
  - It must be accessible through a URI
  - It must have a schema defined and published on the server
- Once the data is available at a URI, it is added to the server's DCAT register.
- This distributed arrangement reduces maintenance over the whole project and allows the data controller to maintain control over what data is 'in the wild'.

Registry Lookup Interface

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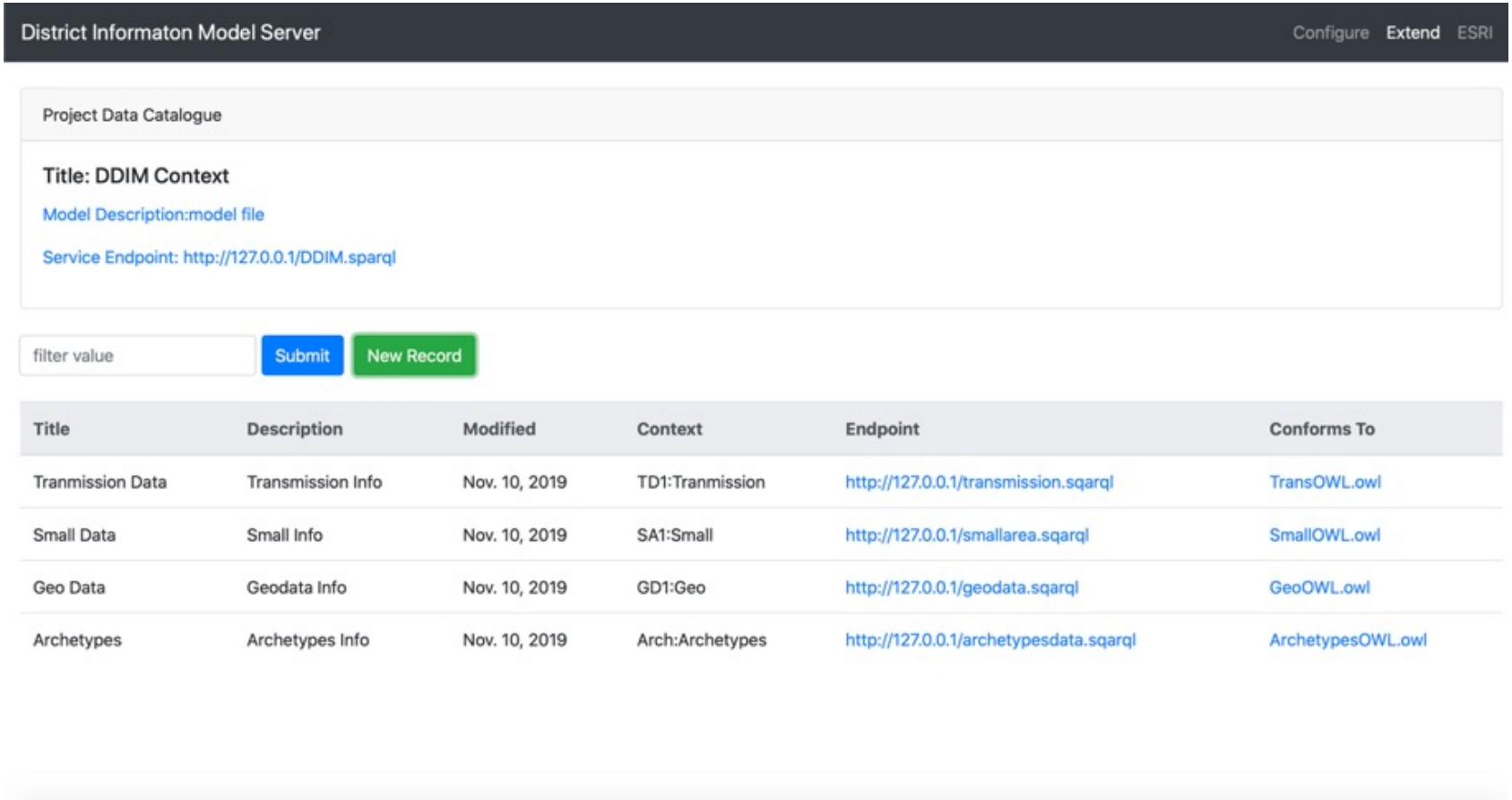

Common Context

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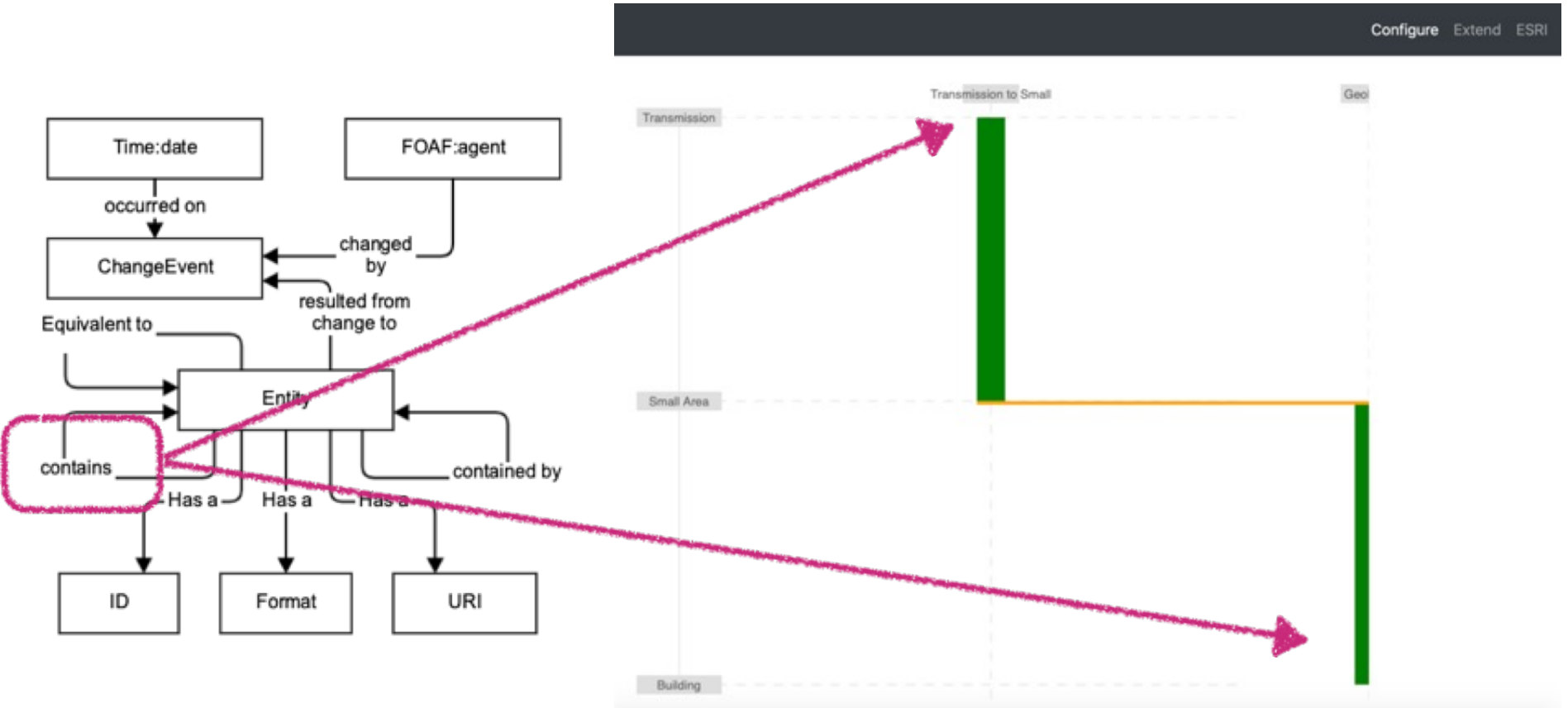

Common Context

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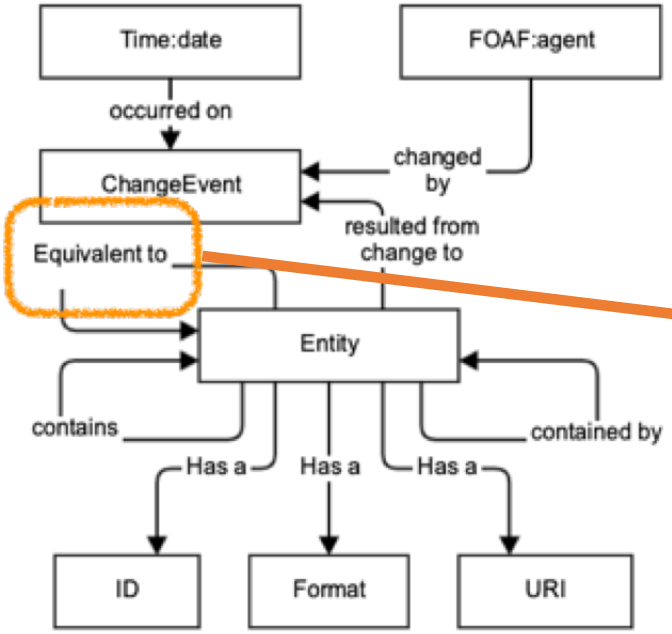

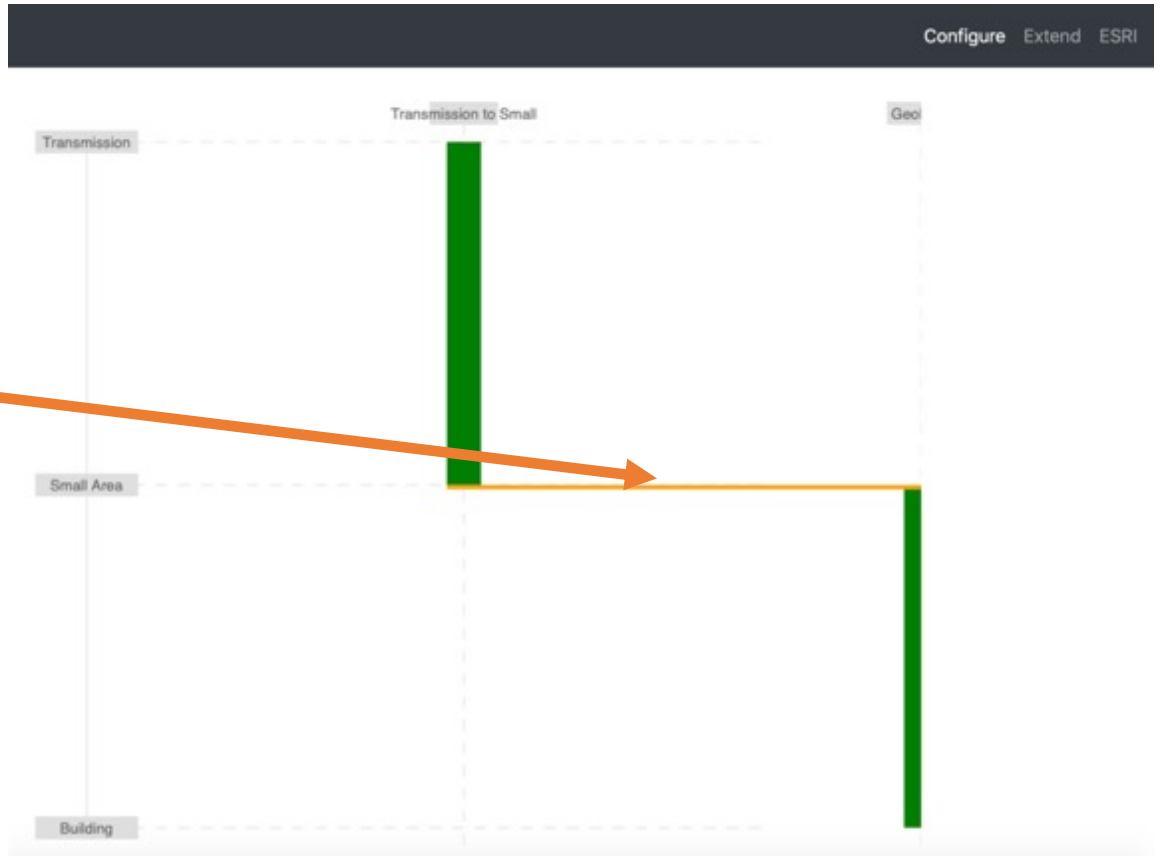

3)DDIM Architecture:
Federated queries visualised for deep insights

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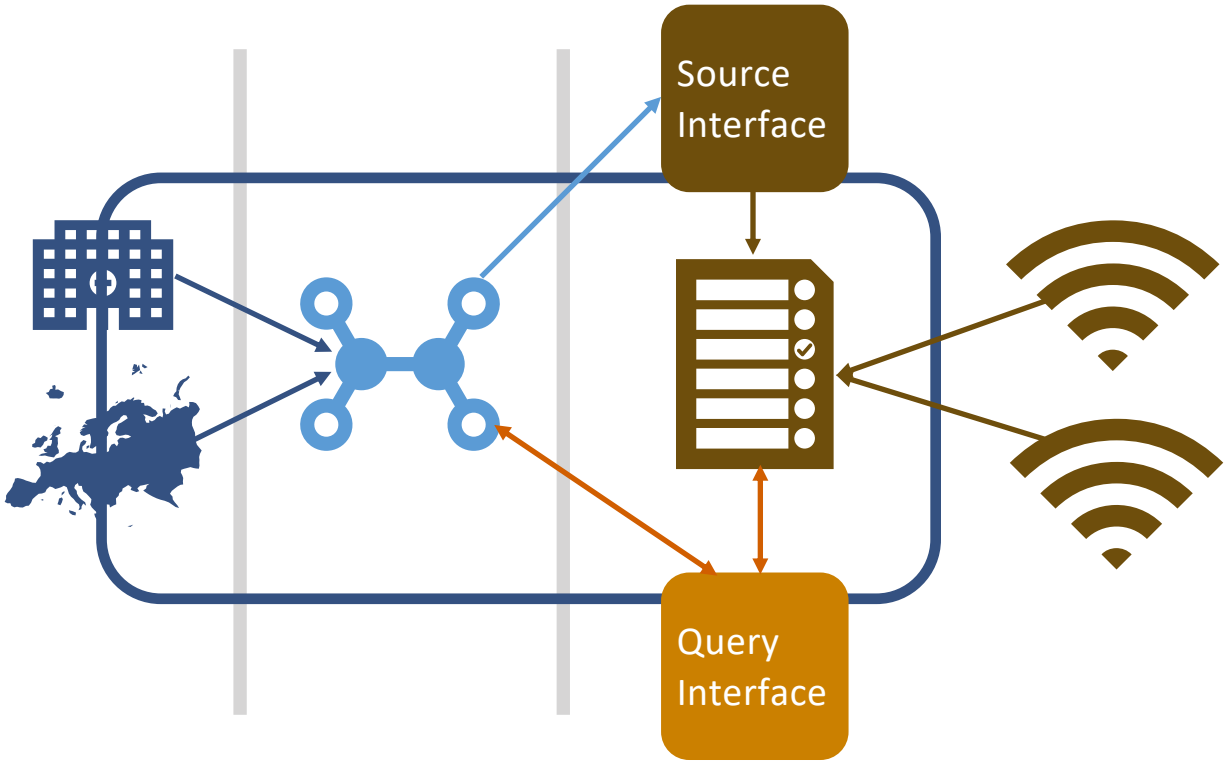

3. Once this association is defined, third parties can access the schema associated with the external source and use that Information to form SPARQL queries that are federated through DIS.

Federated Queries

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- Federated Queries are part of the SPARQL standard.
  - Accepting SPARQL queries through the server will automatically include federated queries.
  - It will be the responsibility of those querying to formulate these correctly.
  - Our federated queries originate from within our server. It has important implications for access and security. Rather than ad hoc connections to federated sources.
  - IP address of our server is whitelisted.
  - Queries have to be part of our infrastructure

https://www.w3.org/TR/sparql11-federated-query/

An example SPARQL federated query: Retrieves calculate buildings archetype count for a particular transmission node.

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```
PREFIX esipparchetypes: <http://192.168.1.24/esipp/archetypes#>
PREFIX esippenergy: <http://192.168.1.32/esipp/MallowExample#>

select ?buildingarchetype (COUNT(?buildingarchetype) as
   ?counttype) where {

    #Get transmission node
    ?t esippenergy:context "Transmission" .
    ?t esippenergy:id 220 .

    #Aggregate buildings under transmission node
    ?t esippenergy:contains* ?childinstance .
    ?childinstance esippenergy:type ?childtype
        filter(?childtype = "SmallArea") .

    #Get buildings at per small area
    ?childinstance esippenergy:contains* ?buildinginstance .
    ?buildinginstance esippenergy:type ?buildtype
        filter(?buildtype = "Building") .
    ?buildinginstance esippenergy:id ?buildingid .

    #Access external data source for aditional building level
       data
    SERVICE <repository:archetypes> {
       ?archetypeinstance esipparchetypes:aid ?buildingid .
       ?archetypeinstance esipparchetypes:oftype
          ?buildingarchetype .
    }
}
group by ?buildingarchetype
```

Using a wild card instead of a transmission node would retrieve a count of all archetypes in Ireland

Preliminary results from case study for one small town

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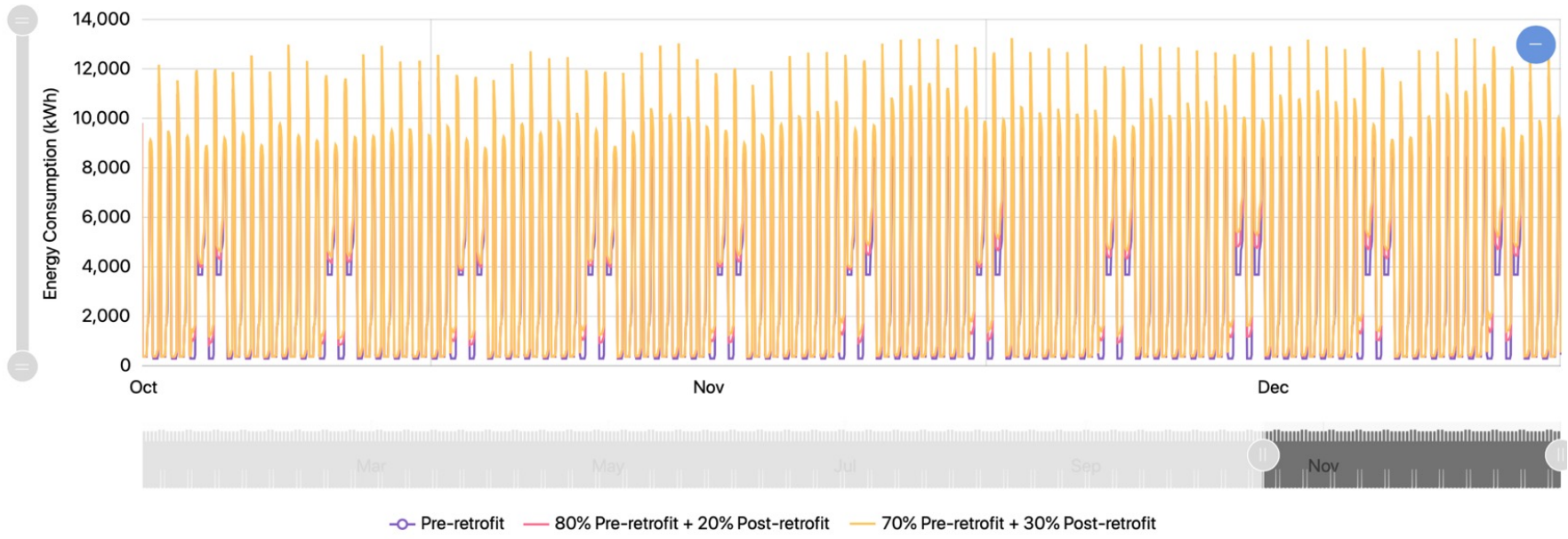
Scenarios +

No Scenarios have been set

Download Dataset | Download Selected | View all data as table



Future work in this area has significant potential

- Additional Scenarios:
  - Renovation types (shallow/deep)
  - Occupancy profiling (time of use occupancy surveys)
  - EV uptake
  - Distribution Grid typologies
  - Demographic influences

- Reasoner for working with such systems
- ML techniques for exploring the decision space

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Thank you

Any Questions?

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