Ontology-based IoT and Building data Integration for Demand Response

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00 Motivation

01 The RESPOND Project

02 Building and IoT Data Integration

03 Pilot House Example

04 Conclusions
Peak Energy Demands are Undesirable
Grid operators deploy generation plants to satisfy demand peaks.
Demand Response (DR) as a Solution
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as a Solution

• Change user consumption habits
• Balance energy supply and demand
• Via incentives
DR tries to shift energy use to balance supply and demand.
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DR tries to shift energy use to balance supply and demand.
Demand Response is promising for the Residential Sector
Renewable Energy’s Exploitation Difficulties
Renewable Energy’s Exploitation Difficulties

- Intermittent
- Dependent on the weather
Renewable Energy does not match the distribution of energy demand in time
Renewable Energy does not match the distribution of energy demand in time
RESPOND
DEMAND RESPONSE FOR ALL

Co-funded by the Horizon 2020 programme
of the European Union
RESPOND Pilot Sites

ARAN ISLANDS, Ireland

AARHUS, Denmark

MADRID, Spain
RESPOND Mobile App

Towards the user-engagement:

• Multilingual
• Cross-platform
• Functionalities including display and actuation
Data Analytic Services

- Energy Demand Forecasting
- Energy Production Forecasting
- Suggest Optimal DR opportunities
Integrating heterogeneous IoT data

• Monitoring & Actuation Devices
• Appliances
• Energy Prices
• Weather Forecast
00 Motivation

01 The RESPOND Project

02 Building and IoT Data Integration

03 Pilot House Example

04 Conclusions
Building and IoT Data Storage

**Building Topological Data**

**Time Series Database**

<table>
<thead>
<tr>
<th>Timestamp</th>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
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Building and IoT Data Storage

Building Topological Data

IoT Data

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</table>
RESPOND Ontology: Reusing Existing Ontologies

BOT

SEAS Ontology

SAREF
RESPOND Ontology: Defining New Concepts

- Extending existing ontologies
  - New Appliances (e.g. Tumble Dryer)
  - New Spaces (e.g. Common Area)
  - New Qualities (e.g. Gas Consumption)
  - New Units (e.g. ppm)

- Creating new concepts
  - Building-related properties (e.g. Volume)
  - Linking Measurements with DB Queries
  - Linking Devices to Gateways
RESPOND Ontology

https://w3id.org/respond

02 Building and IoT Data
RESPOND Ontology
https://w3id.org/respond

- Available online
- CC-BY 4.0 License
- Documentation Page
- Recommended Metadata
## Pilot Site Characterization

- Filled by each Pilot Site Coordinator
- Excel sheets with installed devices’ information:
  - Device Type
  - Location
  - Connected Appliance
  - …

<table>
<thead>
<tr>
<th>Location in the apartment</th>
<th>Device_type</th>
<th>Appliance</th>
<th>Location</th>
<th>Device_type</th>
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RESPOND Ontology Instantiation
Linking devices with their measurements stored in another Database

https://147.91.50.171:8086/query?q=SELECT integral("value",1h) AS "energy" vicedID="ENE-01000180" GROUP BY time(1d) ...

respond:hasDBQuery

seas:isPropertyOf

seas:isPropertyOf
Mobile App Data Display: Dishwasher Energy Consumption
LDAP Directory:
Data Access via hierarchical directory service

OpenLDAP Server v1.2.5
phpLDAPadmin Server V0.8.0
Semantic Repository: Information Retrieval via SPARQL Query

Openlink Virtuoso Server
v07.20.3217

Virtuoso SPARQL Query Editor

```
PREFIX respond: <https://w3id.org/def/respond#>
PREFIX seas: <https://w3id.org/seas#>
PREFIX dc: <http://purl.org/dc/terms/>
PREFIX saref: <https://w3id.org/saref#>

SELECT ?dbQuery
WHERE{
    ?device saref:measuresProperty ?property;
    dc:identifier ?deviceID.
    ?property rdf:type respond:ElectricConsumption;
    seas:isPropertyOf ?foi;
    respond:hasDBQuery ?dbQuery.
    ?foi dc:identifier "Aarhus03_kitchen_dishwasher".
}
```
Time Series Database:
Information Retrieval via InfluxQL Query

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InfluxDB
v1.6.2
Mobile App Data Display: Dishwasher Energy Consumption

- Web Service
- Enables data-access control
- Decoupling from Repositories
- Enables Distributed Data Store
- Scalability is eased
Conclusions

- Linking Semantic Technologies with IoT Technologies
- Leveraging existing ontologies such as SAREF, SEAS, BOT instead of developing new ontologies
- Not exclusive for Energy Domain
Thank you for your attention

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