Atlas Living Lab

- Building operations rely on a combination of systems.
  - Building Management System (BMS)
  - Energy Management System (EMS)
  - Lighting Management System (LMS)
  - BIM models
- Two categories of data
  - Time series data
  - Semantically rich data

Fig.01: Data sources in Atlas Living Lab
Metered data from sensors

- **BMS sensors**
  - Room temperature, CO2, occupancy level
- **Energy meters**
- **IoT devices**

Tab.01: Sample sensor data export from BMS

<table>
<thead>
<tr>
<th>Timestamp</th>
<th>11NR00STE-001TRL</th>
<th>11NR00STE-002TRL</th>
<th>11NR00STE-003TRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-04-2021 00:02:00</td>
<td>21.6</td>
<td>21.1</td>
<td>19.9</td>
</tr>
<tr>
<td>30-04-2021 01:02:00</td>
<td>22.3</td>
<td>21.1</td>
<td>20.0</td>
</tr>
<tr>
<td>30-04-2021 02:02:00</td>
<td>21.9</td>
<td>21.2</td>
<td>20.1</td>
</tr>
<tr>
<td>30-04-2021 03:02:00</td>
<td>22.1</td>
<td>21.1</td>
<td>20.1</td>
</tr>
<tr>
<td>30-04-2021 04:02:00</td>
<td>22.0</td>
<td>21.2</td>
<td>20.1</td>
</tr>
<tr>
<td>30-04-2021 05:02:00</td>
<td>22.0</td>
<td>21.1</td>
<td>20.0</td>
</tr>
<tr>
<td>30-04-2021 06:02:00</td>
<td>22.2</td>
<td>21.2</td>
<td>20.0</td>
</tr>
<tr>
<td>30-04-2021 07:02:00</td>
<td>21.7</td>
<td>21.2</td>
<td>20.0</td>
</tr>
<tr>
<td>30-04-2021 08:02:00</td>
<td>22.3</td>
<td>21.6</td>
<td>20.1</td>
</tr>
</tbody>
</table>
## Metadata about BMS sensors

**Tab. 02: Sensor descriptions extracted from BMS**

<table>
<thead>
<tr>
<th>Sensor Name</th>
<th>Sensor Description (Dutch)</th>
<th>Sensor Description (English)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11NR010TE-028TRL</td>
<td>RUIMTETEMPERATUUR 10_221</td>
<td>ROOM TEMPERATURE 10_221</td>
</tr>
<tr>
<td>11NR010LT-028PIRTM</td>
<td>AANWEZIGHEID 10_221</td>
<td>PRESENCE 10_221</td>
</tr>
<tr>
<td>11NR010CV-028RKWRS</td>
<td>REGELSIGAAL KOELING 10_221</td>
<td>CONTROL SIGNAL COOLING 10_221</td>
</tr>
<tr>
<td>11NR010TE-028MAXBP</td>
<td>KOELINGSETPOINT 10_221</td>
<td>COOLING SETPOINT 10_221</td>
</tr>
<tr>
<td>11IB010PIR028INBAL</td>
<td>52018 ATLAS LICHT RUIMTE 10_221</td>
<td>52018 ATLAS LIGHT SPACE 10_221</td>
</tr>
</tbody>
</table>
Semantically rich data

• BIM Model

Fig.02: Atlas building 8th and 9th floor BIM model
Data integration approach

- Use semantically rich data to contextualize sensor data
- Integrate isolated BIM model and sensor data
Data integration approach

- BIM Model
  - RVTr
    - IFC
      - IFCtoXKT
        - XKT
      - IFCtoLBD
        - RDF
  - BMS Sensor Data
    - Metadata
    - Time-series
      - Brick Builder
      - XLSX to JSON
        - JSON

Semantically rich data

- Triple store

Time series data

- Timeseries database
Adding Brick and Haystack descriptions

sensor_id,sensor_description,room_number,space_name,room_name,brick_tag,HaystackSensor,HaystackTag1,HaystackTag2,Haystacktag3

11NR008QT-301CO2,*CO2 MEASUREMENT 8_140,8.140,space_1266,test 1 area, CO2_Sensor, sensor, co2,air, his

11NR008LT-301PIRTM,PRESENCE 8_140,8.140,space_1266,test 1 area, Occupancy_Sensor, sensor, occupancy, his

11NR008TE-301TRL,ROOM TEMPERATURE 8_140,8.140, space_1266,test 1 area, Temperature_Sensor, sensor,temp,air, his
Semantic graph with sensors and building topology
Querying for sensor data

```
PREFIX brick: <https://brickschema.org/schema/Brick#>
PREFIX inst: <http://linkedbuildingdata.net/ifc/resources20201208_005325/>
PREFIX props: <https://w3id.org/props#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

select * where {
  ?space props:hasCompressedGuid '0KLkXPBfvES9D1y7EjijkE' .
  ?sensors brick:hasLocation ?space .
}
```

<table>
<thead>
<tr>
<th>space</th>
<th>sensors</th>
<th>sensor_type</th>
</tr>
</thead>
<tbody>
<tr>
<td>inst:space_1266</td>
<td>inst:11NR008LT-301PIRTM</td>
<td>brick:Occupancy_Sensor</td>
</tr>
<tr>
<td>inst:space_1266</td>
<td>inst:11NR008QT-301CO2</td>
<td>brick:CO2_Sensor</td>
</tr>
<tr>
<td>inst:space_1266</td>
<td>inst:11NR008TE-301TRL</td>
<td>brick:Temperature_Sensor</td>
</tr>
</tbody>
</table>
Results

Importance:

• Time series data is now contextualized
• Previously isolated BIM and sensor data are now integrated
• Data streams can be stored in databases which are optimum for the data type
• Applications can be decoupled from direct mapping to naming conventions
Future directions

- Integrating IoT devices and real time data
- Integrating Machine Learning model based applications with the contextualized data
Thank you

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