



Energy Information Integration Platform (EIIP)



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TNO | *Innovation for Life*



ict for sustainable homes

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Workshop on data models for ICT4EE (Room : Galerie)

Overview

- Project Goal, Strategy & Results aimed at
 - Energy Information Integration Platform (EIIP)
 - Technologies Evaluated
 - The Total picture
 - BIM, SIM & PIM ontologies
 - Semantic Approach
 - Example: Sensor data
 - IntUBE pilot demo scenario
 - Beyond IntUBE
- Feedback/Questions?

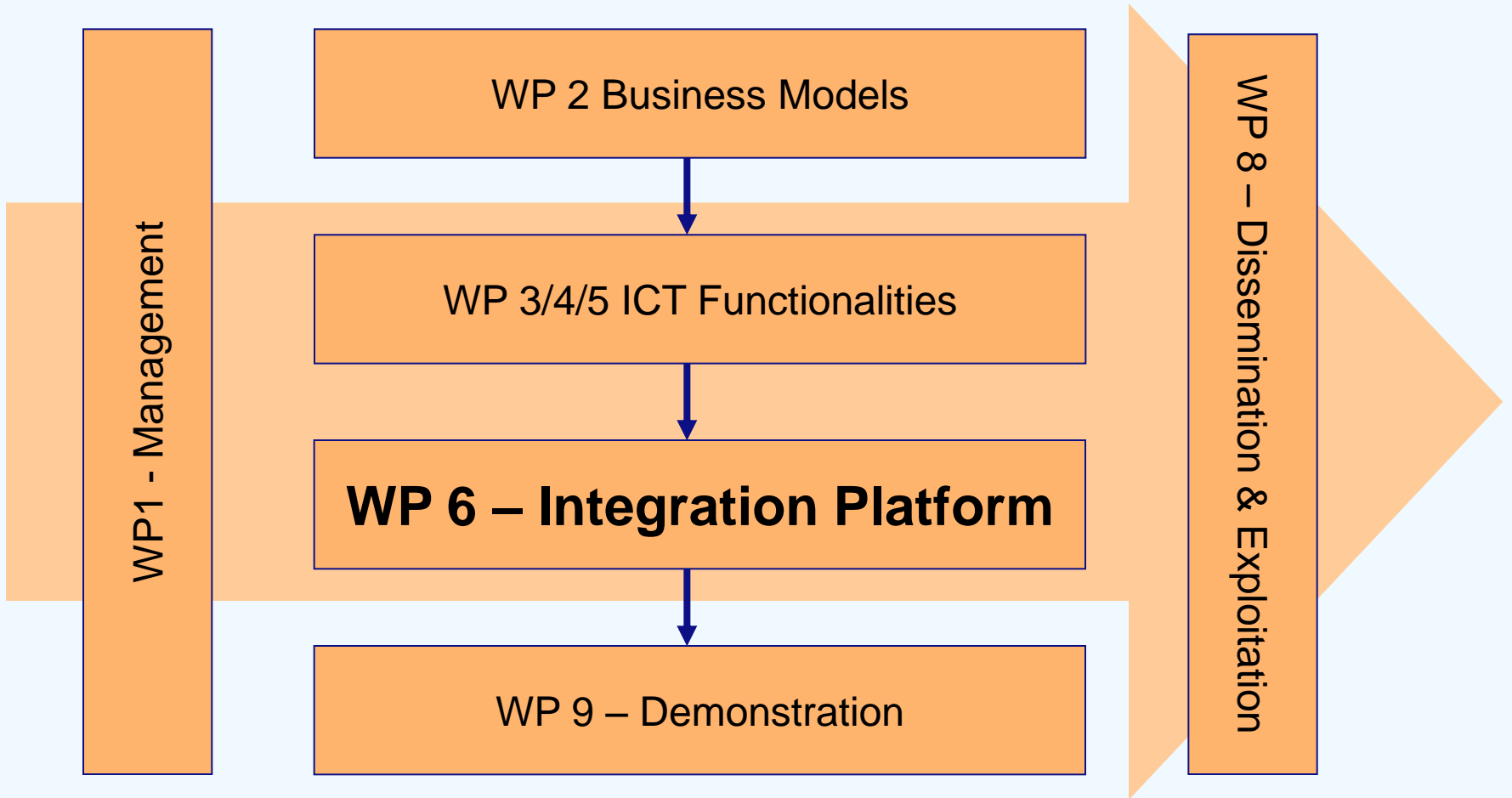
Project Goal

- Background
 - Buildings represent 40% of total energy use
 - In 2020 building stock is 80% as existing today
- Goal
 - Decrease energy use by existing building in Europe with 20%
- By
 - Better decision support to end-users by improved ICT application/integration (incl. building automation systems) in the operational phase of a building

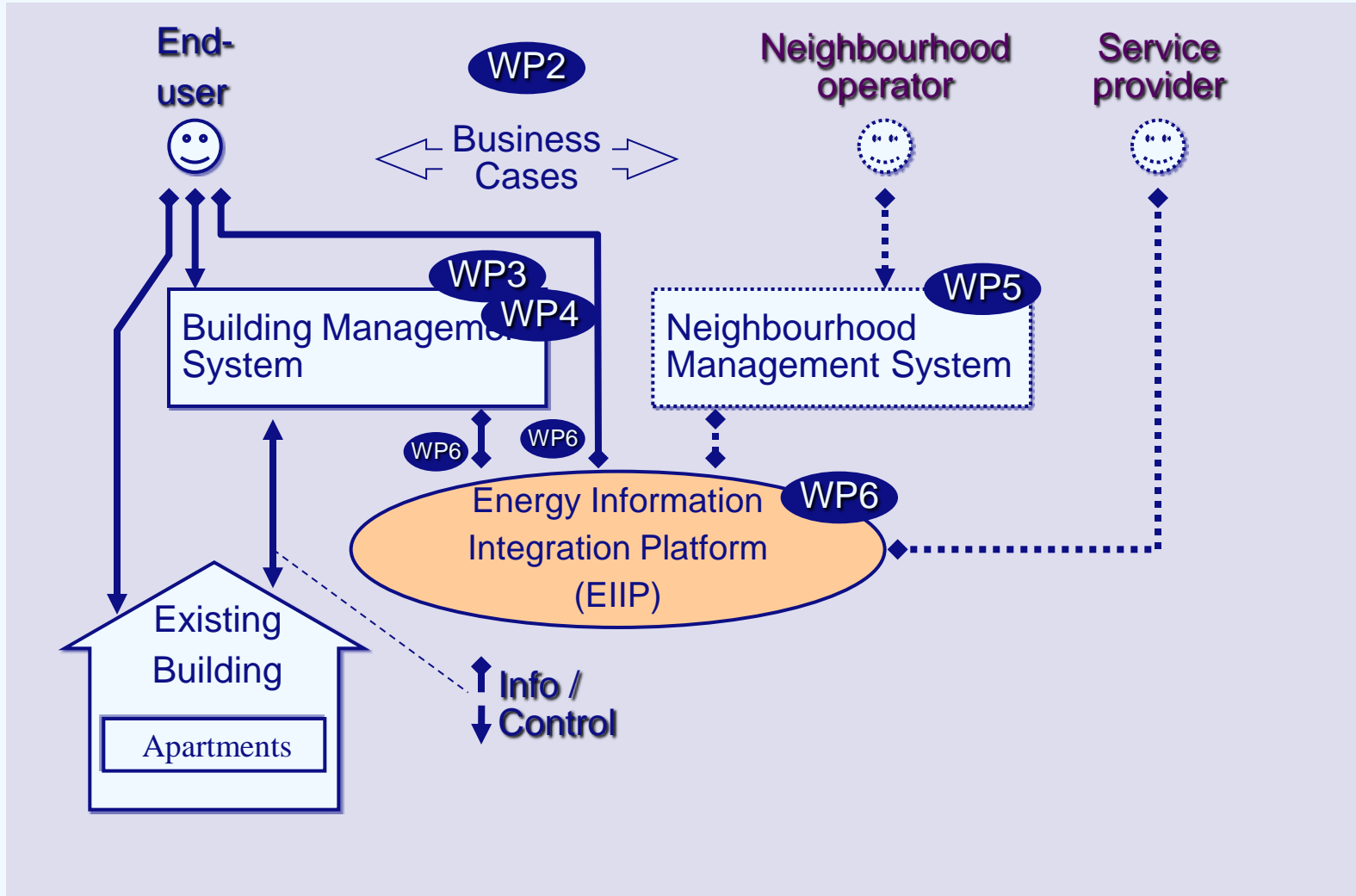
- Period: 1 May 2008 – 30 April 2011
- Budget: 3.8 MEURO
- CSTB, VTT, Fraunhofer, URL



Strategy



Results aimed at



Energy Information Integration Platform (EIIP)

- Integrating various Design & BMS software applications in an open and smart way
- Involved application examples
 - Autodesk Revit Architecture 2010 for design
 - VABI Elements for building energy simulation, and
 - Sensor applications (via OPC server)
- Key component: “Energy Model”:
 - BIM + SIM + PIM



Technologies Evaluated in energy modelling scope



	IFC/IFD	gbXML SW/PMO	CityGML
Open	y	limited	y (technology)
Semantic	limited	limited	flexible
Web-based	n	y	y
International	y	y	y
Generic	n	n	y
Flexible	limited	n	y
Support	y	y	limited

- Choice: “New school” Semantic Web (SW) technology underneath

The Total Picture

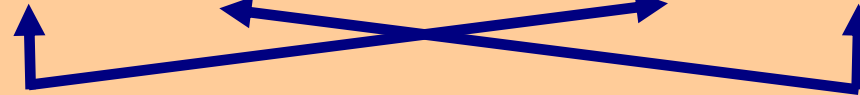
Societal and Commercial Issues & Trends:
Climate Change & Scarce Resources

Goals:
Reduce (Non-renewable) Energy Consumption & CO2 emissions

Processes:
Operational



Products:
Existing Residential Buildings



ICT Functionalities:
CAD, Simulation, Sensor apps & IntUBE EIIP



Information:
BIM/SIM/PIM ontologies & content

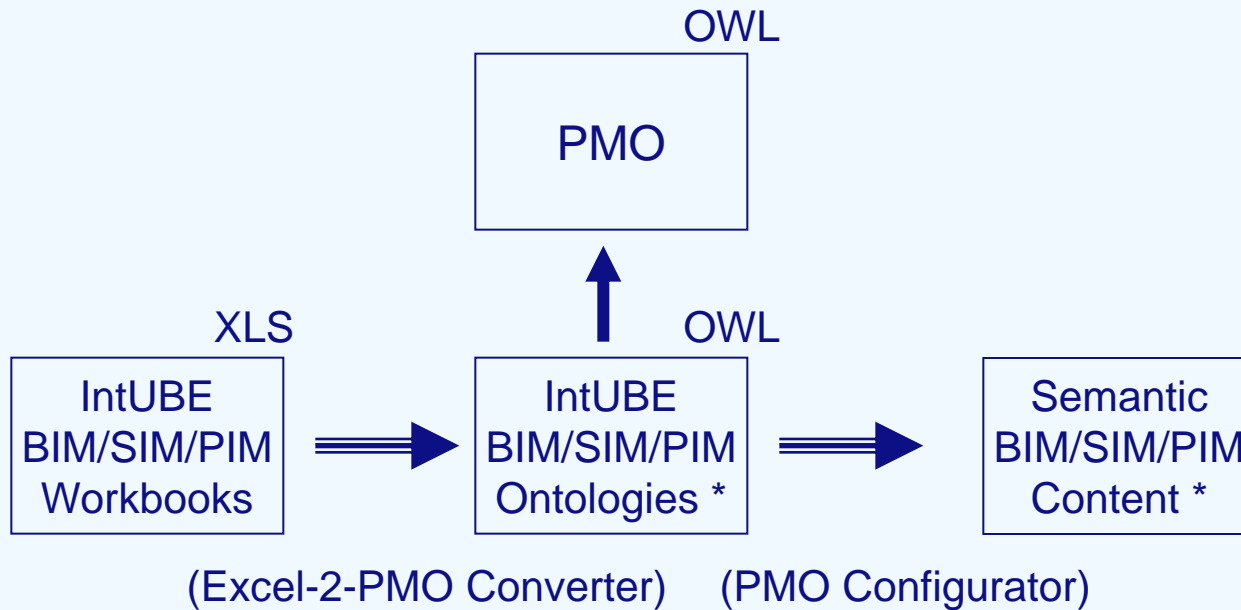
Technology:
**Semantic Web open standards & open source implementations
(RDF / RDFS / OWL / SPARQL & Joseki/TDB)**

Medium:
Internet/WWW

BIM, SIM & PIM ontologies

- BIM
 - Planned static Building Information
 - Coming from Design/CAD
- SIM
 - Planned dynamic Building Usage Information
 - Planned/Estimated Energy Performance (simulation results)
- PIM:
 - (Actual static Building Information)
 - Actual/measured/monitored dynamic Building Usage Information
 - Actual Energy Performance

Semantic Approach



* WWW file and/or Joseki RDF Server/TDB

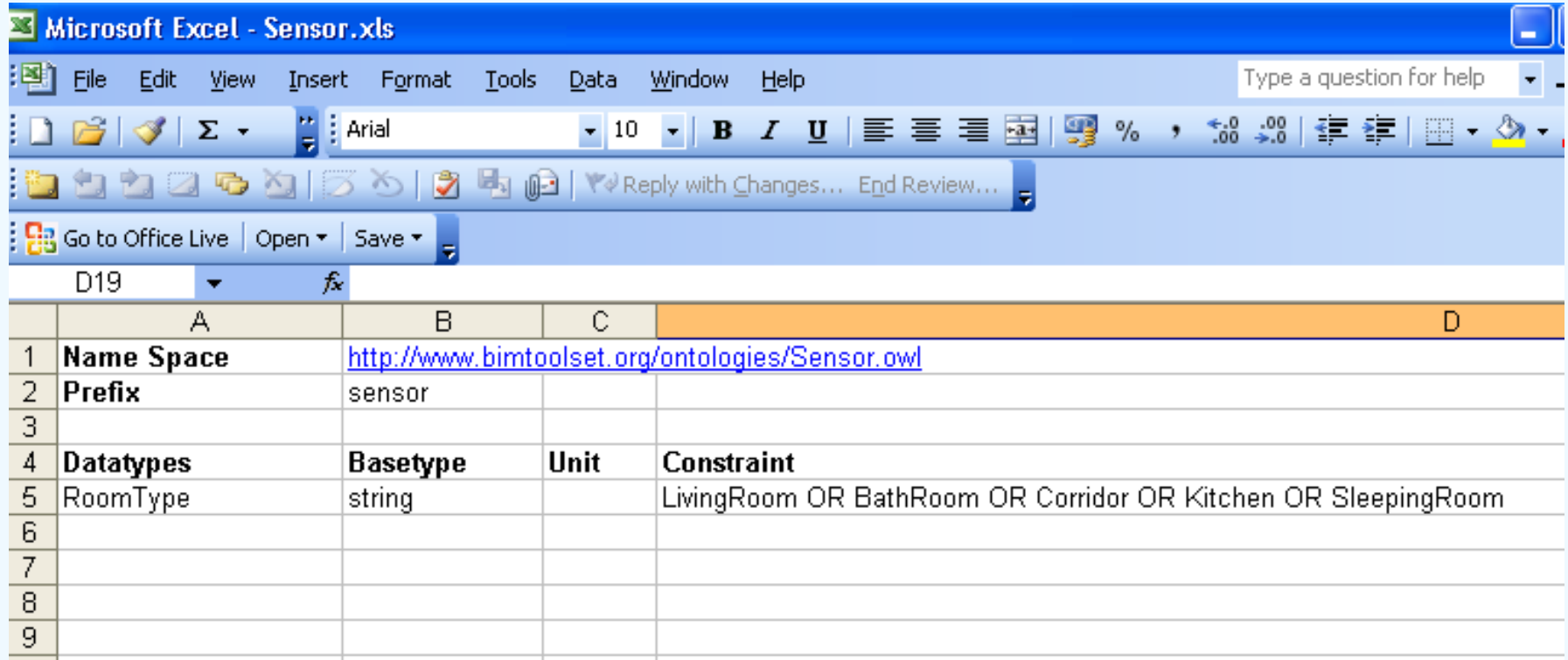
Example: Sensor data

Textual specification

- A Building has one or more Room(s).
- Each Room has always exactly one TemperatureSensor and exactly one roomType (being a LivingRoom OR a BathRoom OR a Corridor OR a Kitchen OR a SleepingRoom).
- Each TemperatureSensor has 1 or more TemperatureMeasurement(s) where each one always has two properties: exactly one temperature being a float measured in unit Celsius and exactly one dateTime 'stamp' like “15-07-2010T11:24:36”



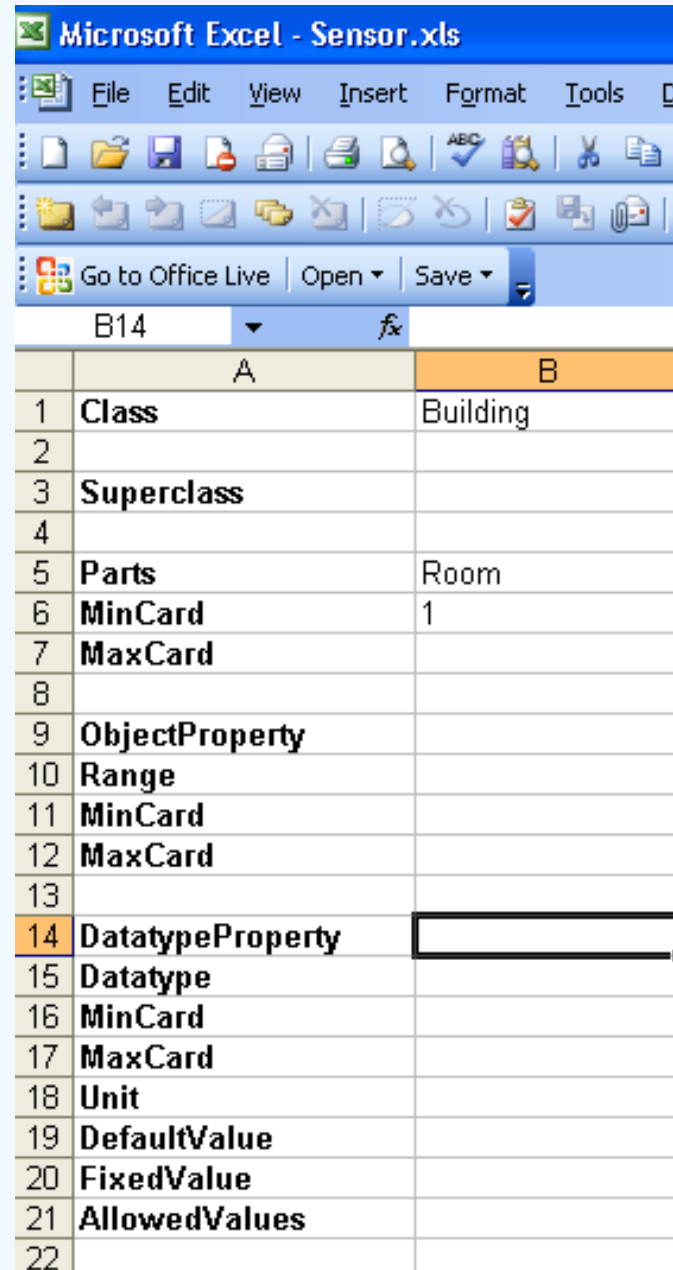
Example: Sensor data Excel workbook /1



The screenshot shows the Microsoft Excel interface with the following data in the worksheet:

	A	B	C	D
1	Name Space	http://www.bimtoolset.org/ontologies/Sensor.owl		
2	Prefix	sensor		
3				
4	Datatypes	Basetype	Unit	Constraint
5	RoomType	string		LivingRoom OR Bathroom OR Corridor OR Kitchen OR SleepingRoom
6				
7				
8				
9				

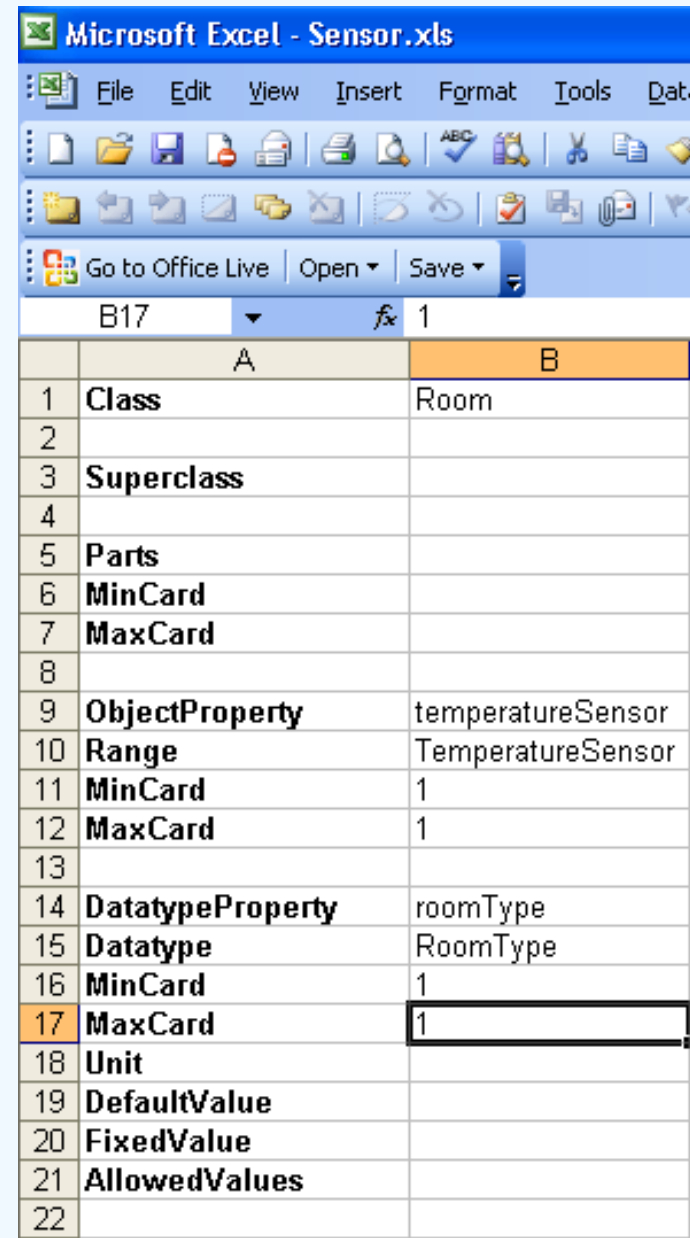
Example: Sensor data Excel workbook /2



The screenshot shows a Microsoft Excel window titled "Microsoft Excel - Sensor.xls". The interface includes a menu bar (File, Edit, View, Insert, Format, Tools) and a toolbar with various icons. The active cell is B14. The spreadsheet contains the following data:

	A	B
1	Class	Building
2		
3	Superclass	
4		
5	Parts	Room
6	MinCard	1
7	MaxCard	
8		
9	ObjectProperty	
10	Range	
11	MinCard	
12	MaxCard	
13		
14	DatatypeProperty	
15	Datatype	
16	MinCard	
17	MaxCard	
18	Unit	
19	DefaultValue	
20	FixedValue	
21	AllowedValues	
22		

Example: Sensor data Excel workbook /3



Microsoft Excel - Sensor.xls

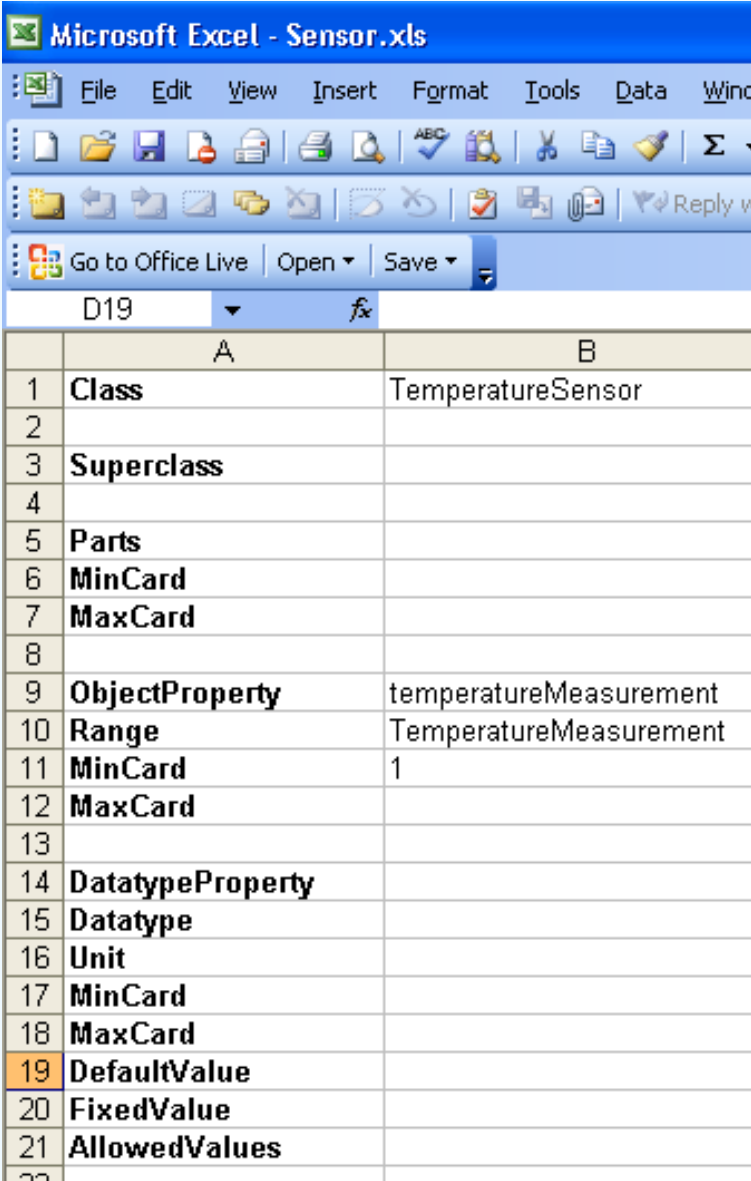
File Edit View Insert Format Tools Data

Go to Office Live | Open | Save

B17 fx 1

	A	B
1	Class	Room
2		
3	Superclass	
4		
5	Parts	
6	MinCard	
7	MaxCard	
8		
9	ObjectProperty	temperatureSensor
10	Range	TemperatureSensor
11	MinCard	1
12	MaxCard	1
13		
14	DatatypeProperty	roomType
15	Datatype	RoomType
16	MinCard	1
17	MaxCard	1
18	Unit	
19	DefaultValue	
20	FixedValue	
21	AllowedValues	
22		

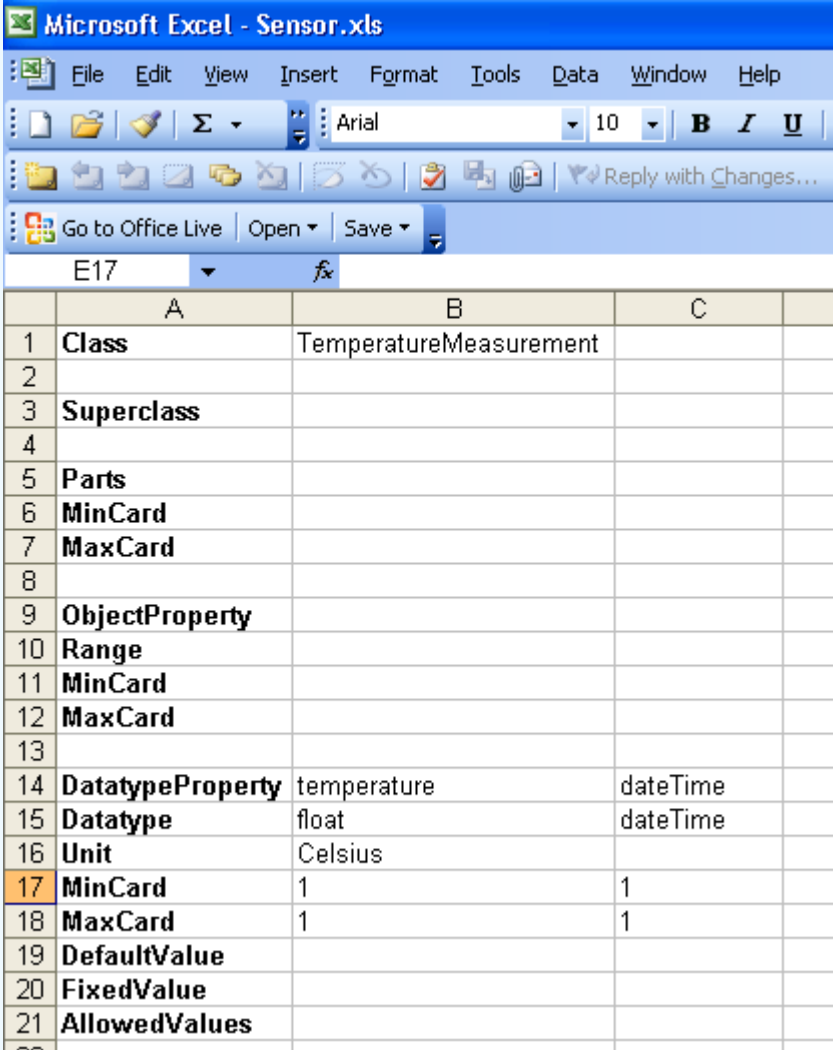
Example: Sensor data Excel workbook /4



The screenshot shows a Microsoft Excel window titled "Microsoft Excel - Sensor.xls". The interface includes a menu bar (File, Edit, View, Insert, Format, Tools, Data, Window) and a toolbar with various icons. The active cell is D19, and the formula bar shows a function symbol (fx). The spreadsheet contains a table with two columns, A and B, and rows numbered 1 to 22. The table lists various sensor-related terms and their corresponding values.

	A	B
1	Class	TemperatureSensor
2		
3	Superclass	
4		
5	Parts	
6	MinCard	
7	MaxCard	
8		
9	ObjectProperty	temperatureMeasurement
10	Range	TemperatureMeasurement
11	MinCard	1
12	MaxCard	
13		
14	DatatypeProperty	
15	Datatype	
16	Unit	
17	MinCard	
18	MaxCard	
19	DefaultValue	
20	FixedValue	
21	AllowedValues	
22		

Example: Sensor data Excel workbook /5



Microsoft Excel - Sensor.xls

File Edit View Insert Format Tools Data Window Help

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E17

	A	B	C
1	Class	TemperatureMeasurement	
2			
3	Superclass		
4			
5	Parts		
6	MinCard		
7	MaxCard		
8			
9	ObjectProperty		
10	Range		
11	MinCard		
12	MaxCard		
13			
14	DatatypeProperty	temperature	dateTime
15	Datatype	float	dateTime
16	Unit	Celsius	
17	MinCard	1	1
18	MaxCard	1	1
19	DefaultValue		
20	FixedValue		
21	AllowedValues		

Example: Sensor data Excel-2-owl mapping

The screenshot shows the 'Excel Controller' application window. At the top, the title bar reads 'Excel Controller'. Below the title bar, there are two text input fields: 'File Name' with the value 'C:\Excel2PMD-Mapper_2010-08-23\excel\Sensor.xls' and 'Export to' with the value 'C:\Excel2PMD-Mapper_2010-08-23\owl\'. To the right of these fields is a 'Create PMO' button.

The main area is divided into two columns: 'Excel Sheets' and 'Found Rows'. The 'Excel Sheets' column contains a list of items with a vertical scrollbar on the right. The items are: NOT SELECTED, SELECTED, SELECTED, SELECTED, SELECTED, MANUAL, NOT SELECTED, Building, SELECTED, path: /, ontology class: Building, Room, and SELECTED. The 'Found Rows' column contains a list of ontology classes: Building, Room, roomType (RoomType), TemperatureSensor, TemperatureMeasurement, temperature (decimal), and dateTime (dateTime).

Below these columns is a 'Found Items' section, which is a large empty rectangular area with a dotted border. At the bottom of this section, the following ontology classes are listed: Building, Room, TemperatureSensor, and TemperatureMeasurement.

Example: Sensor data

Resulting OWL ontology

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:pmo="http://www.bimtoolset.org/ontologies/pmo.owl#"
  xmlns:sensor="http://www.bimtoolset.org/ontologies/Sensor.owl#"
  xml:base="http://www.bimtoolset.org/ontologies/Sensor.owl">
  <owl:Ontology rdf:about="">
    <owl:imports rdf:resource="http://www.bimtoolset.org/ontologies/pmo.owl"/>
  </owl:Ontology>
  <rdfs:Datatype rdf:ID="RoomType">
    <owl:equivalentClass>
      <rdfs:Datatype>
        <owl:onDatatype rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
        <owl:oneOf rdf:parseType="Resource">
          <rdf:rest rdf:parseType="Resource">
            <rdf:rest rdf:parseType="Resource">
              <rdf:rest rdf:parseType="Resource">
                <rdf:rest rdf:parseType="Resource">
                  <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
                  <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
                    >SleepingRoom</rdf:first>
                </rdf:rest>
              </rdf:rest>
            </rdf:rest>
          </rdf:rest>
        </owl:oneOf>
      </rdfs:Datatype>
    </owl:equivalentClass>
  </rdfs:Datatype>

```

.....

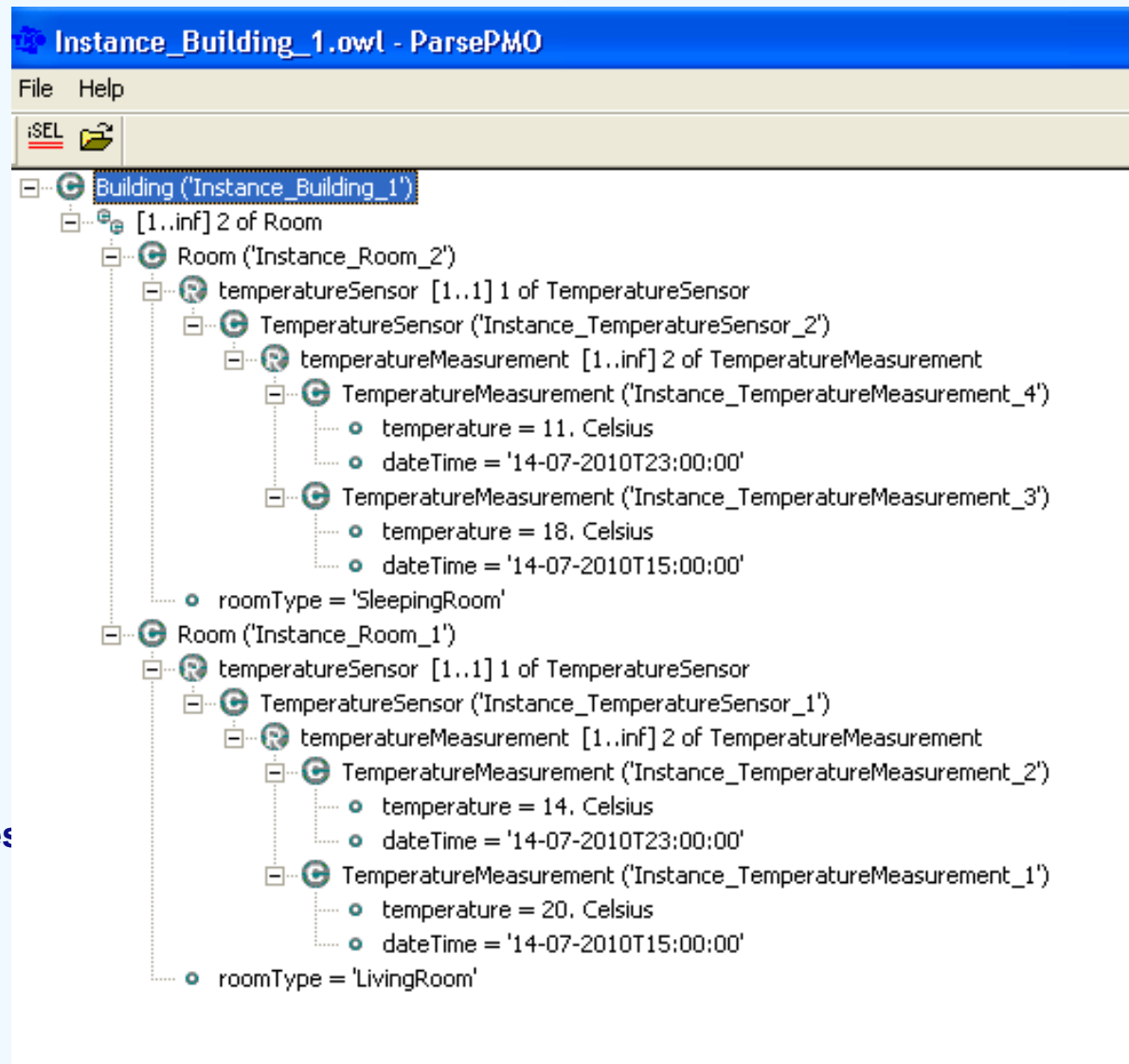


Example: Sensor data Manual Instantiation

with
PMO
Configurator

saved as:
Instance_Building_1.owl

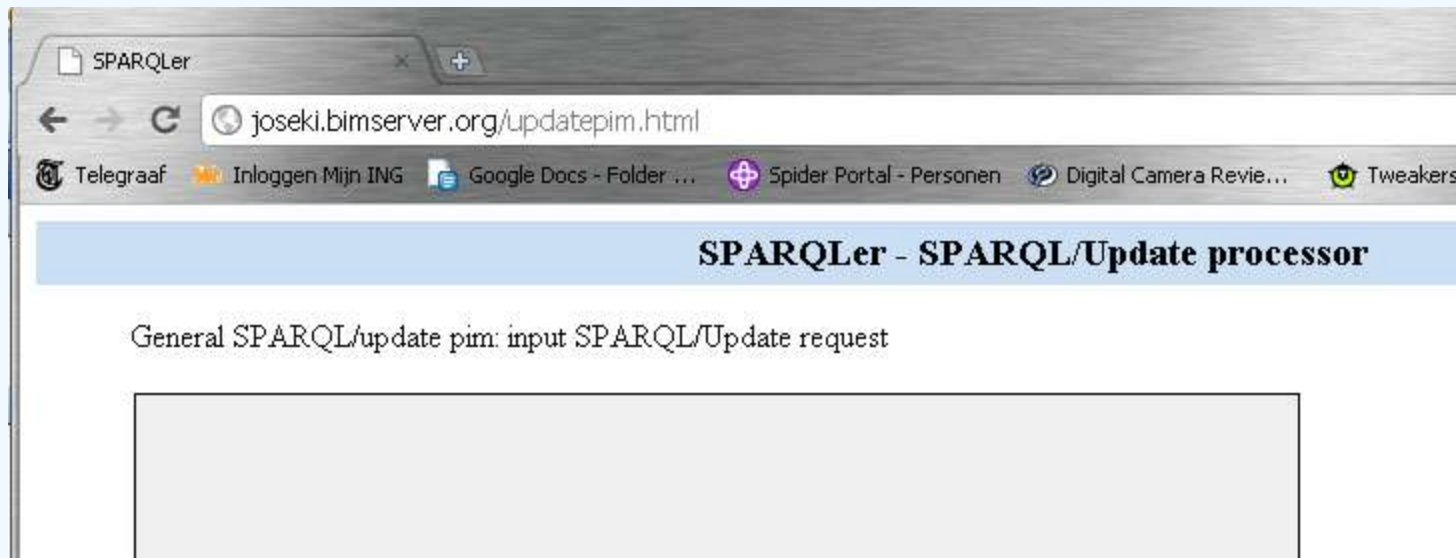
at:
www.bimtoolset.org/ontologies



Example: Sensor data

Put in on the Joseki RDF Server (in TDB data store)

- SPARQL (PIM) Update query:
 - LOAD <http://www.bimtoolset.org/ontologies/Instance_Building_1.owl>



Example: Sensor data

Query the data /1

```
#####  
# Get all triples of the pim_data  
#####
```

```
SELECT *  
{  
GRAPH <http://www.bimtoolset.org/ontologies/IntUBE-EnergyPIM-Data>  
{ ?x ?y ?z }  
}
```



Example: Sensor data

Query the data /3

```
#####  
# Get all rooms in the pim_data  
#####
```

PREFIX rdf: <<http://www.w3.org/1999/02/22-rdf-syntax-ns#>>

PREFIX sensor: <<http://www.bimtoolset.org/ontologies/Sensor.owl#>>

SELECT *

WHERE {

GRAPH <<http://www.bimtoolset.org/ontologies/IntUBE-EnergyPIM-Data>>

{ ?x rdf:type sensor:Room }

}

Example: Sensor data

Query the data /5

```
#####  
# Get the amount of rooms  
#####
```

```
PREFIX sensor: <http://www.bimtoolset.org/ontologies/Sensor.owl#>
```

```
SELECT count (*)
```

```
{
```

```
GRAPH <http://www.bimtoolset.org/ontologies/IntUBE-EnergyPIM-Data>
```

```
{ ?x a sensor:Room}
```

```
}
```

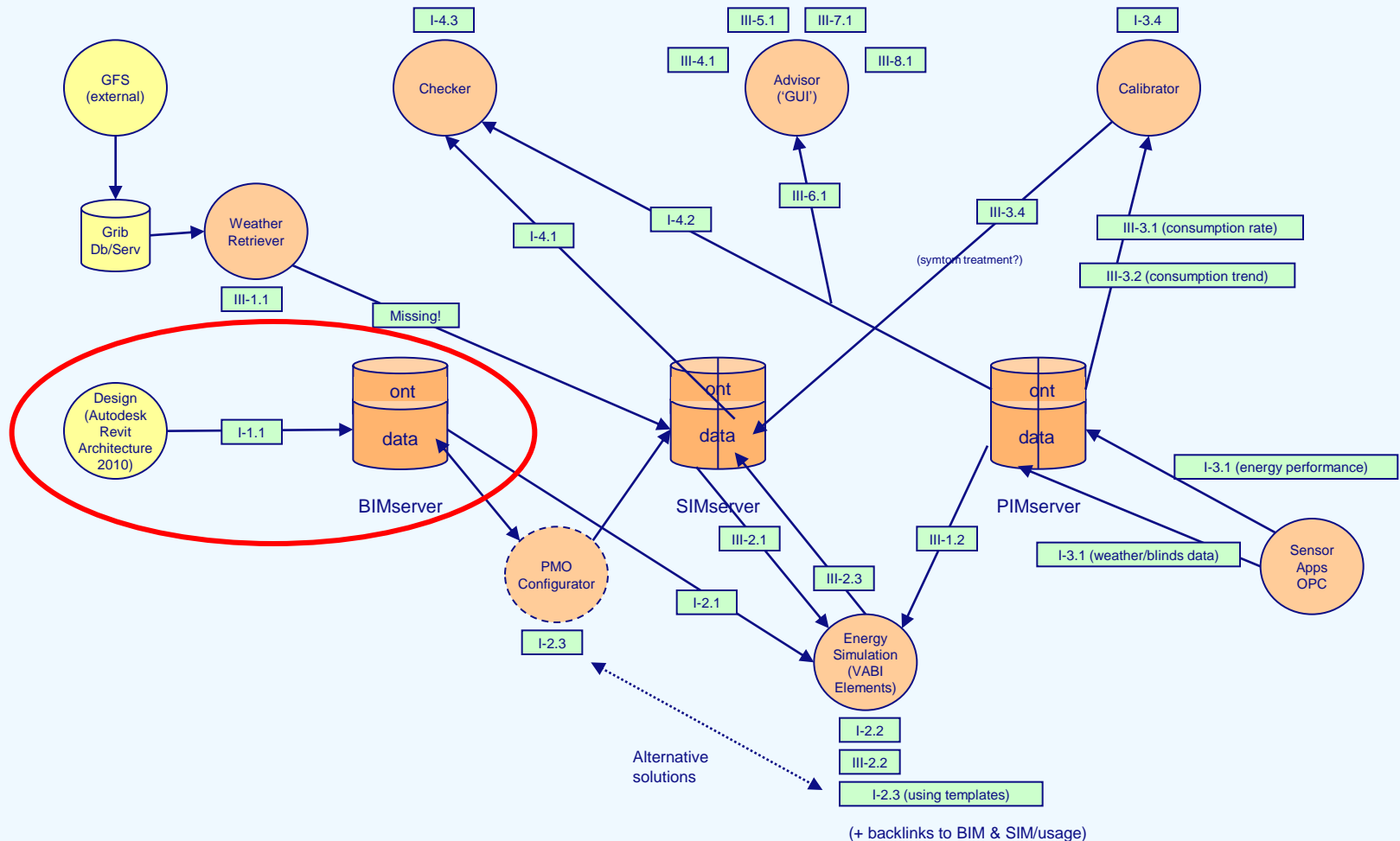

Example: Sensor data

More

- Much more beyond “Sparql Select”:
 - Construct/Describe
 - No “XML Result” results but RDF/XML code
 - Sparql Update (beyond “load”)
 - Insert new triples
 - Jena ARQ beyond standard Sparql
 - LET (), derivations
 - Various functionalities / “magic properties”
 - Like Membership of SET
- Very powerfull ! Especially in combination with SPIN
 - Sparql inferencing notation (www.spinrdf.org)
 - Queries stored as RDFSchema
 - > OO Ontologies



IntUBE pilot demo scenario, overall “ongoing”



BIM

IntUBE-EnergyBIM.owl - ParsePMO

File Help

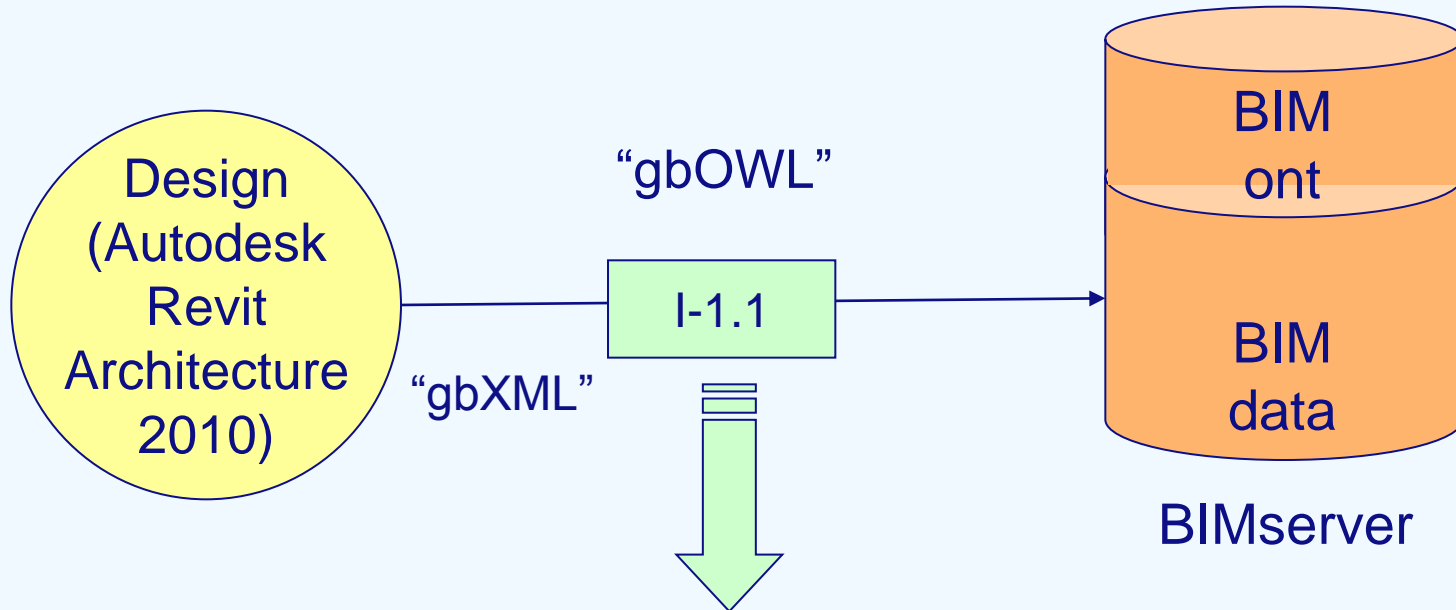
iSEL

- currentProject [0..1] 1 of Project
 - Project ('Instance_Project_1')
 - latestVersion [1..1] 1 of ProjectVersion
 - [1..inf] 1 of ProjectVersion
 - [0..inf] 1 of Project
 - Project ('Instance_Project_2')
 - latestVersion [1..1] 1 of ProjectVersion
 - [1..inf] 1 of ProjectVersion
 - ProjectVersion ('Instance_ProjectVersion_2')
 - nextAlternative [0..1] 0 of ProjectVersion
 - nextStage [0..1] 0 of ProjectVersion
 - [1..inf] 1 of Building
 - Building ('Instance_Building_2')
 - address [0..1] 0 of Address
 - geoLocation [0..1] 0 of GeoLocation
 - [0..inf] 0 of Generation
 - [0..inf] 0 of Distribution
 - [0..inf] 10 of Room
 - Room ('Instance_Room_1')
 - Room ('Instance_Room_2')
 - Room ('Instance_Room_3')
 - Room ('Instance_Room_4')
 - Room ('Instance_Room_5')
 - Room ('Instance_Room_6')
 - Room ('Instance_Room_7')
 - cell [1..1] 1 of Cell

Ready



IntUBE pilot demo scenario, fragment



- Autodesk Revit Architecture 2010, gbXML export
- Top Braid Composer 'semantic XML' import (on the fly gbOWL ontology generation)
- SPARQL mapping of content according to gbXML towards the BIM ontology via construct queries on target BIM ontology

Beyond IntUBE



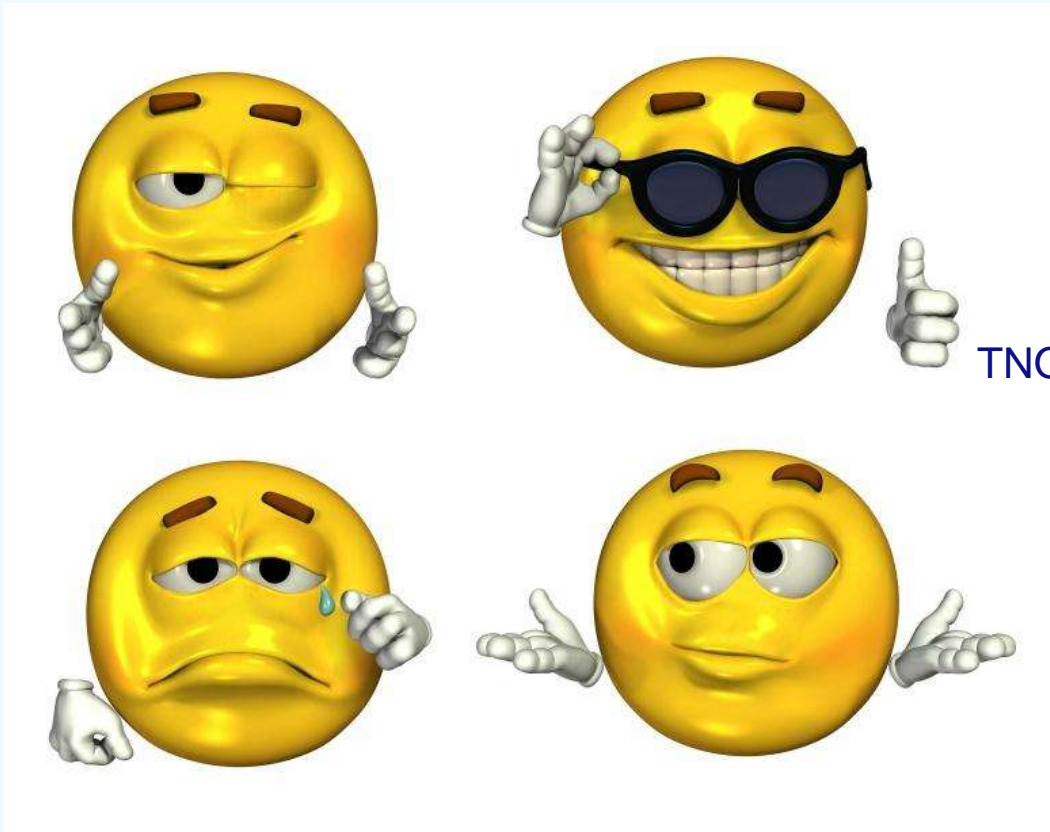
- We will integrate the semantic web server with our current Open Source BiMserver (www.bimserver.org), now “IFC Server”)
- Generating IFC-Geometry from semantic ontologies
 - ifcOWL (first BB next BREP next property sets) conversion by Sparql
 - RDF-XML to SPFF translation (and subsequent viewing by our IFC Viewer)
- Using the ontologies as “PSD/IFD-like” extensions to IFC (controlling new proxies/property sets in IFC)
- Adding also SE & Model/Document Management layer
- Going from “BiMserver” to “BiMstrategy” adding reference functionalities/services
 - Detailed2Global
 - Regulation-based reference applications like energy, material environmental loads, fire analysis, asset management etc.



Standardization of BIM/SIM/PIM ontologies?

- HESMOS
- Link with BuildingSmart
 - BS opened up for other specs but still not valid ...
 - Some properties already in IFC2x4 property sets
- Other ideas for harmonization, common use?
- Where to start? (BIM, SIM or PIM)
- Better framework?
 - Required, Proposed, Realized
 - Proposed = Asserted or Estimated/Simulated
 - Static, Dynamic distinction useful in the end?
 - Better?: Building, BuildingUsage, Performance
 - Environment added?
 - Performance part of Building?
 - Required, Proposed & Realized Building info
 - Required, Proposed & Realized BuildingUsage info
 - Required, Proposed & Realized Performance info

Thank you! Feedback/Questions? Contact



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IntUBE project

www.intube.eu