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Semantic Web for Information Modelling in Energy Efficient Buildings

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Executive Summary

This report summarizes the main aspects of the 5th SWIMing workshop, held on Wednesday 07th of September, 2016, at the European Conference on Product and Process Modelling (ECPMM) Conference in Limassol, Cyprus. The event was organized in cooperation with a number of EU projects, the W3C LBD Community Group and the buildingSMART Linked Data working group. The focus of this workshop was to discuss exchange requirements for a selected set of use cases, with particular focus on product modelling towards enabling building energy simulation.

The report also covers two related workshops. The first, which was co-organized by the SWIMing and University Polytechnic Madrid (UPM), is the Linked Data in Architecture and Construction (LDAC) event held on the 21st and 22nd of June in University Polytechnic Madrid, Spain. SWIMing chaired a session on use case exploration on the second day.

The final workshop, organized by SWIMing and the Linked Building Data community, was an event held on the 19th September, 2016 at the W3C TPAC 2016 in Lisbon, Portugal. This explored the creation of a W3C Working Group around developing a standard for publishing BIM data on the web.

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List of Abbreviations

BIM	Building Information Modelling
BIM-LD	Building Information Modelling – Linked Data
BIM-LOD	Building Information Modelling – Linked Open Data
BLC	Building Life Cycle
BLCEM	Building Life Cycle Energy Management
BMS	Building Management System
CSVW	CSV on the Web Working Group
EC	European Commission
EEB	Energy Efficient Building
ICT	Information and Communication Technology
IFC	Industry Foundation Classes
IDM	Information Delivery Manual
ISO	International Organization for Standardization
LBD	Linked Building Data
LD	Linked Data
LOD	Linked Open Data
LDWG	Linked Data Working Group
MDV	Model View Definitions
RDF	Resource Description Framework
W3C	World Wide Web Consortium

Introduction

This report summarizes the main aspects of the 5th SWIMing workshop, held on Wednesday 07th of September, 2016, at the European Conference on Product and Process Modelling (ECPPM) Conference in Limassol, Cyprus¹. The event was organized in cooperation with a number of EU projects, the W3C LBD Community Group and the buildingSMART Linked Data working group. The focus of this workshop was to discuss exchange requirements for a selected set of use cases, with particular focus on exchange requirements related to product modelling to enable building energy simulation. The 5th SWIMing Clustering workshop was to be held on July 2016 but after taking into account the low expected participation due to the summer period and the suggestions from the Project Officer, the workshop was postponed for a later date (07/09/2016) and thus, the report is being delivered with a delay from 30/07/2016 to 19/10/2016.

The report also covers two related workshops. The first, which was co-organized by SWIMing alongside UPM, is the LDAC event on the 21st and 22nd of June, held in University Polytechnic Madrid, Spain². SWIMing chaired a session on use case exploration on the second day.

The final workshop, organized by SWIMing and the Linked Building Data community, was an event held on the 19th September, 2016 at the W3C TPAC 2016 in Lisbon, Portugal³. This explored the development of a W3C working group around developing a standard for publishing BIM data on the web.

ECPPM Workshop

Overview

As the 5th Clustering Workshop of the SWIMing project, the ECPPM workshop, continued the cluster building activities focused on BIM and LOD across the BLC of EeB domains, expanding the findings from the previous four workshops as well as the results from the SWIMing consortium effort in between. There were 23 participants at the event, with 5 projects represented through presentations (SWIMing, EeEmbedded, OptEEmAL, NewTrend, DAREED) and participants representing 5 other EU projects (RESILIENT, STREAMER, Mas2tering, Wisdom, KnoHoLEM).

The purpose of this workshop was to discuss issues related to product modelling to enable energy simulation targeting the design and operational stage of the BLC, with the main objective being to identify whether a reference data schema exists to meet project requirements and make recommendations for which existing standards can meet these requirements. A secondary objective was to discuss current challenges and barriers to the uptake of existing standards.

¹http://www.cyprusconferences.org/ecppm2016/files/ECPPM_2016_Handbook&BookofAbstracts_26.08.2016.pdf, pp37-40

² <http://smartcity.linkeddata.es/LDAC2016/>

³ <https://www.w3.org/2016/09/TPAC/>

There were a total of six presentations followed by an active discussion session. The first presentation was a short introduction to the SWIMing methodology and the following four were use cases related to energy simulation which have used the SWIMing methodology and have been working with the BIM*Q tool to capture high level use case data requirements. Finally, a presentation was given on a new model for managing product data, which is based on IFC, called *SimpleBIM*.



Figure 1 Presentation of ifcOWL @ ECPPM SWIMing Workshop

The four use case presentations were structured as follows:

- introduction to project (1 page)
- overview of use cases (s) (1 - 2 pages) (name, life cycle stage, stakeholders, high level domains of interest)
- overview of data requirements (break down of concepts for data domains, focus on 'Product domain, i.e. description of building, building elements, relationship to location, representation etc. (2-3 pages)
- overview of existing standards and ontologies being considered/applied to the use case for Product modelling (1-2 pages)
- findings, conclusions and lessons learned (1 page)

The objectives of the workshop were to:

1. identify shared concepts for describing building elements (products)
2. discuss current barriers to publication of BIM product data

Presentations

SWIMing - Guidelines for Publishing Building Data as Linked Data **(Kris McGlinn, ADAPT Centre, Trinity College Dublin, Ireland)**

This talk presented the guidelines developed within the SWIMing project for supporting projects in the process of capturing use cases, identifying data requirements, aligning these with existing standards and ontologies and publishing data as Linked Data to support semantic querying over open, interlinked data.

OptEEmAL Project Use Case: A comprehensive ontologies-based framework to support retrofitting design **(Gonçal Costa, La Salle BES, Spain)**



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The OptEEmAL project is based on the development of a platform aimed at delivering an optimized, integrated and systematic design for building and district retrofitting projects. Based on given initial district conditions, the platform provides the necessary information to simulation tools according to multiple candidate energy conservation measures (ECM). This information includes buildings, urban areas, weather, sensors, etc., and project conditions (costs, barriers, targets, etc.). It therefore requires careful consideration on how to best represent the different data requirements. This presentation will highlight the project Product data requirements with reference to the SWIMing guidelines.

DAREED Project Use Case: *Semantic Data Integration for Smart Cities using Linked Data*

(Kiril Tonev, Institute for Information Management in Engineering, Karlsruhe Institute of Technology, Germany)

The smart city initiatives aim to contribute to more sustainable cities characterized by integrated technologies and services related to energy efficiency. The energy efficiency technologies and services require active and synergical roles from multiple stakeholders, for instance citizens, energy providers, and policy makers. Those technologies and services generate and consume data from multiple, originally unrelated domains. The presentation will introduce linked data approach to interlink the generated and existing open data to facilitate the data integration. The linked data is developed by following the guideline of SWIMing project. The presentation will also demonstrate the mechanism to query the linked data.

EeEmbedded Project Use Case: *Collaborative design and simulation platform for designing energy-efficient buildings and their optimal energetic embedding in the neighbourhood*

(Nikolaos Kaklanis, CERTH, Thessaloniki, Greece - Matthias Weise (presenter), AEC3, Munich, Germany)

Through the eeEmbedded project presentation an open BIM-based holistic collaborative design and simulation platform was presented, followed by a related holistic design methodology, an energy system information model and an integrated information management framework for designing energy-efficient buildings and their optimal energetic embedding in the neighbourhood of surrounding buildings and energy systems. The development work has been soundly based on 2 business models – the business model of the owners and hence the equipment providers and the business model of construction and design companies, and on a set of ISO and industry standard data structures and specifications such as IFC, STEP, CityGML and OWL. A new ontology-based Link Model (ESIM) is expected to provide the bridge between the multiple physical and mathematical models involved in the eeBuilding domain warranting the desired data and services interoperability.

NewTrend Project Use Case: *Capturing building data requirements in the NewTREND project*

(Matthias Weise, AEC3, Munich, Germany)

The NewTREND project is developing an integrated design methodology for energy retrofit of buildings addressing all phases of the refurbishment process. This requires consideration of a large set of different data sources, ranging from architectural drawings,

structural data, energy models, operational data and district data. This presentation will cover the first steps of the SWIMing guidelines as applied to the modelling of project use cases which require product data along with the initial mappings of these to existing standards.

ifcOWL and SimpleBIM for Managing Product Data

Pieter Pauwels, Ghent University, Belgium

Managing product data across the Building Life Cycle remains a challenge due to the heterogeneous and fragmented nature of the data. IfcOWL provides a standard approach for describing building data, like product data, in RDF. This supports the publication of Product data on the web, making it accessible over HTTP. In this presentation some of the different properties of Building Products in IFC will be explored and how these may be applicable to the requirements of a diverse set of use cases, in domains such as energy modelling, retrofitting and intelligent control.

Discussion Session (Q and A)

At the end of the presentations the floor was opened up to discussion. The main topics of discussion were around current barriers to the adoption of standards for publishing product data on the web and the adoption of SimpleBIM to support this process.

Main points raised:

- What are the current challenges for converting IFC for Energy Modelling?

Challenges	Solution
Access to required data	Standards for describing relevant data sets as open data
Conversion of geometric models into boundary surface topology	Converting of complex facades which include multiple building elements into one surface remains a challenge

- Other relevant domains for energy simulation– district data, weather, behavior (schedules), energy tariffs, building topologies, simulation parameters
- What are the important IFC concepts for energy simulation?
 - Elements: IfcWall, IfcSlab, IfcRoof, IfcColumn, IfcBeam, IfcDoor, and IfcWindow (the latter two may be replaced with IfcOpening)
 - Materials: U-value, solar transmission co-efficient
 - Behavior (operational characteristics of devices, occupants):
 - Topology: IfcSpace, IfcZone,
- Data completeness to enable simulation (at a minimum the following data is required):
 - Boundary conditions, conditioned space(s), material properties and space boundaries.
- What are the requirements of the SimpleBIM models?
 - Reduce the complexity of the current IFC schema
 - Removal of all instances that were part of the Presentation Resource, the Presentation Definition Resource, the Presentation Appearance Resource, the Profile Resource, the Representation Resource, the Topology Resource, the Geometry Resource, the

Geometric Model Resource, and the Geometric Constraint Resource.

- 'unwrapping' of wrapped data types. Wrapping of data types is performed to allow a safe and uniform conversion of EXPRESS and IFC-SPF constructs into OWL and RDF respectively
 - replacement of the relational instances, which are all subclasses of IfcRelationship
- How do we encourage industry to adopt standards for publishing product data on the web using the discussed standards?

Barriers	Solution
Protection of IP	Strong business case needed for publishing data must be made, e.g. greater access to new facades for retrofitting
Lack of awareness of standards	Greater promotion of standards, e.g. IFC
Complexity of standards	Promotion of simplified views of standards (e.g. SimpleBIM)

Outcomes

The two main challenges currently identified for generating energy simulations are related to lack of knowledge about existing standards, and also the complexity of converting geometric models into energy simulation models. The workshop helped identify several core IFC concepts which are required for energy simulation, which are related to elements, materials, behavior and topology. Other issues are related to data completeness.

One of the main discussion points of the workshop was the need to support the publication of BIM data. One issue for developers relates to the complexity of the IFC schema, which is born out of its requirements to satisfy complex use cases in the Design and Construction stages of the building. A recommendation therefore is the development of a SimpleBIM model which supports publication of building data, like product data, in a structured and standardized manner. Unfortunately, barriers still exist for this which must be overcome, for example the desire of industry to protect IP and also lack of awareness of standards and the complexity of existing standards. The workshop discussed potential solutions to these problems

LDAC Workshop

Overview

This workshop is a continuation of the LDAC workshop series and was co-organized by SWIMing, which hosted and chaired a session on use case development. The event was held on the 21st and 22nd of June, in University Polytechnic Madrid, Spain. There were 25 participants on day one and 22 on day two, which is when the use case session took place. These had backgrounds and experience in semantic web technologies, BIM and Linked Data, with experts in ontologies such as ifcOWL, SAREF, COINS, COBieOWL, IFCWoD,

simpleBIM, SIMModel etc. and projects such as DIMMER, IDEAS, DAREED, V-Con, etc. The main report generated by UPM can be found here⁴.

The LDAC provides a focused overview on technical and applied research on the usage of semantic web, linked data and web of data technologies for architecture and construction (design, engineering, construction, operation, etc.). It brought together researchers, industry stakeholders, and standardization bodies of the Linked Building Data (LBD) community together. The aim of the workshop was to present current developments, coordinate efforts, gather stakeholders, use cases and plan future activities for building information modelling standardization.

The topic of the 2016 event was on the use of semantic web technologies for building information management in diverse practical use cases. These use cases deployed a number of concepts and approaches around the use of semantics in Building Information Modelling. SWIMing chaired a dedicated session on use case exploration, in particular around the exploration of methods for representing BIM data for visualization and simulation. The outcomes of which were used to structure the ECPPM event.



Figure 2 Presentation of DAREED Project Use Case @ LDAC Workshop

Use Case Session

The use case session explored methods for representing buildings and building geometry.

The main discussion focused on the Concept Modelling Ontology (CMO) developed within the context of the proficient project.

- CMO Model - stores quadratic equations using semantic web technologies
 - Gives flexibility with geometric data
 - drag, squash, stretch shapes
 - Architect export Revit model as IFC, imported into CMO tool
 - Add CMO libraries
 - Export as IFC or COLLADA models for geometry visualisation
 - (web app for visualisation uses WebGL)
 - Semantic data is attached to objects using RDF
 - Supports dynamic changing of parameters through interface

⁴ https://docs.google.com/document/d/1O_lvMnj6z3tch9XFQikLgr4WBCc1A-szMtvHAr_zWGU

- When converted into IFC/RDF, file size increases greatly
- Open Question: Should representation data be stored as RDF?
 - Recommendation – Representation data is better stored as none RDF and described and referenced through RDF.
- Related question - Should sensor data be included as RDF?
 - Recommendation – sensor data should be stored in non RDF format, which reference to the id of the measurement. The measurement is described as part of the sensor model, using RDF.
- Open question – how to link sensors and other product data to a BIM model?
 - Use of Space as a container for building elements, like devices, and behaviours, like occupancy patterns combined with instance of concept ID.
 - Use of location is not recommended as several elements can theoretically occupy the same location – therefore better to use space and property ‘contains’ and its inverse.

Outcomes

The main points of discussion of the Use Case session were related to the limits of Linked Data for meeting certain data modelling requirements. It was concluded that Linked Data may not be appropriate for managing data related to visual representation models. BIM objects that require visual representation should have some form of linking to external formats which store complex geometric properties for representation, such as polygons. Potential standards for managing representation data are Collada⁵. Similarly, large amounts of sensor data are better stored in non-RDF formats, in traditional data bases (SQL) or in tabular formats, like CSV. Once again, these can be referenced by more semantically meaningful models which describe the data in more detail, for example, by linking a data store to an SSN model which describes the capabilities of the sensor which generated the data.

The discussion also opened up questions regarding data requirements for energy simulation, in particular, what data is required for enabling energy simulation. Here the open question was how to link product libraries to BIM standards such as IFC, and how to standardize that product data. This was left as an open question and led to the topic addressed in ECPPM.

⁵ <https://www.khronos.org/collada/>

W3C TPAC Linked Building Data community Workshop

The W3C TPAC Linked Building Data community Workshop organized by SWIMing and the Linked Building Data community, was an event held on the 19th September, 2016 at the W3C TPAC 2016 in Lisbon, Portugal. This explored the development of a W3C working group around developing a standard for publishing BIM data on the web. The workshop looked at the development of the Linked Building Data on the Web Charter, a precursor to the setting up of a W3C working group for BIM. In the next section we present the charter, which was developed during the course of the workshop, interaction with TPAC members and previous Linked Building Data teleconferences.



Figure 3 Discussion of SimpleBIM @ TPAC

Building Data on the Web Charter Development

Mission Statement: The mission of the Building Data on the Web Working Group is to develop a set of technical best practices and associated materials in support of representing and using data across a buildings life cycle on the web.

Scope: The main objective of the Buildings on the Web Working Group is to enable all stakeholders in the BLC to access and query required data to support their business use cases using web technologies.

The Buildings on the Web WG is closely related to existing standardisation bodies and initiatives. The Buildings on the Web WG will be part of the Data Activity and is explicitly chartered to work in collaboration with BuildingSMART International, in particular, the Linked Data Working Group (LDWG). Formally, each standards body has established its own group with its own charter and operates under the respective organization's rules of membership, however, the 'two groups' will work together very closely and make sure that outputs are not common, but do align with each other.

Deliverables: The deliverables of this WG reflect the deliverables used for the Spatial Data on the Web Working Group, mainly applying it to buildings.

- Use Cases & Requirements
- Buildings on the Web Best Practices
- SimpleBIM ontology (or similar), e.g. Schema.org
- Reference dictionary (examples)

- Devices and Control
 - SAREF - smart appliances reference ontology
 - SSN - Sensor data: <https://www.w3.org/TR/vocab-ssn/>
 - DogONT - Domotics Ontology (building control for homes)
- District
 - CityGML - GIS data
- Units and Measurements
 - QUDT – Units
 - OM Ontology
 - Data Cube (representation of data sets according to different dimensions) - derived from sdfx in owl
- Energy
 - Ero (energy resource)
 - SimModel
 - Eplus (derived from Energy Plus Data Dictionary)
- Geolocation
 - Geonames
 - Basic Geo (WGS84)
- Others
 - OWL Time ontology

Timeline (Depending on levels of support):

- 1st April start date
- 1st task: define and publish simpleBIM ontology (FPWD: 1 July 2017)
- 2nd task: list relevant other ontologies so that they can be found (FPWD: 1 July 2017)
- 3rd task: document best practices regarding the publication of links between datasets in these ontologies (FPWD: 1 October 2017)
- 4th task: supply full working examples that illustrate best practices (FPWD: 1 January 2018)

Coordination:

Coordination is done by the WG chairs through the appropriate channels (mailing list etc.).

Participation:

>30 W3C community members need to support this initiative. Existing community group members should become paying W3C members and support the WG. Furthermore, potential members need to be sought in industry and academia. As a source of reference, we can ask Spatial Data on the Web WG member to support our group as well. Supporting members can also be found in BuildingSMART Int'l.

Industrial interest is key to the success of any proposed working group. Therefore, we should be targeting industrial partners. Potential candidates are IBM, IES, Siemens, Rijkswaterstaat.

Overall Conclusion and Future Work

The SWIMing project continues to bring together projects in the EeB domain with experts in data modelling standards for enabling publication of open BIM data. Through the organization and hosting of the ECCPM and related workshops, the process of building greater awareness among EeB projects about the developments of an open BIM approach for building lifecycle (BLC) energy management processes and more generally, on standards and interoperability, continues.

The ECPPM workshop set out to identify issues related to product modelling to enable energy simulation, targeting the **design and operational stage** of the BLC, with the main objective being to identify whether a reference data schema exists to meet project requirements and make recommendations for which existing standards can meet these requirements. A secondary objective was to discuss current challenges and barriers to the uptake of existing standards.

In this regard, a set of core EeB projects (5) were given an opportunity to share their models and successes with the wider community. The workshop resulted in the following main outcomes:

- Identification of several core IFC concepts which are required for energy simulation, which are related to elements, materials, behavior and topology.
- A recommendation for a SimpleBIM model which supports publication of building data, like product data, in a structured and standardized manner.

Other outcomes of ECPPM relate to:

- Increase awareness of the advantages of open BIM and the use of standards
- Exploration and validation of the SWIMing methodology

The SimpleBIM concept was further explored during the W3C TPAC event, held in Lisbon, Portugal. This event examined the creation of a W3C Working Group, in particular the development of a charter and identification of requirements to conduct this research.

The next steps for the SWIMing project will be to continue exploring data requirements in order to identify which data models best meet the requirements for different use cases, and whether a reference model such as IFC, or SimpleBIM can be used to help link BIM data. It will also continue to encourage and support projects to publish their data models and support the dissemination of their developments among the wider open BIM community.