Integrating Building Information Models with Authoritative Irish Geospatial Information

Kris McGlinn[1], Christophe Debruyne[1], Lorraine McNerney[2] and Declan O'Sullivan[1]

[1]ADAPT, Trinity College Dublin, Dublin 2, Ireland
[2]Ordnance Survey Ireland, Dublin 8, Ireland
kris.mcglinn@scss.tcd.ie

Abstract. Building Information Modeling (BIM) is a key enabler to support integration of building data and is an important aspect to support a wide range of use cases, related to building navigation, control, sustainability, etc. Open BIM faces several challenges related to standardization, data interdependency, data access, and security. This means that there is often limited availability of BIM models. In Ireland, the Ordnance Survey Ireland (OSi) has a substantial dataset, called Prime2, which includes not only GIS data (polygon footprint, geodetic coordinate), but also additional building specific data (form and function). In this paper, an extension of an applied and tested methodology for uplifting GIS data into RDF is demonstrated for interlinking to a well-established BIM standard in the Architecture, Engineering and Constructionindustry called Industry Foundation Classes, using geolocation. This builds on initial work interlinking OSi building data with DBpedia. By interlinking building data in this way and making it available to query over, new insights and knowledge about buildings in Ireland can be made. This is an important step towards the iterative integration of ever more complex BIM models into the wider web of data to support the aforementioned use cases.

Keywords: GeoSPARQL, Linked Data, Interlinking, Building Information Modelling, Geographic Information System, Ordnance Survey Ireland

1 Introduction

Access to reliable structured data plays a key role in supporting existing and future services for managing smart and sustainable buildings and cities [1]. Building Information Modeling (BIM) has been identified as a key enabler to support integration of building data not only within the buildings life cycle (BLC), which includes its design, construction, operation and re-design, as well as demolition and recycling [2], but also with other data sources, such as those related to geolocation, people and their behavior, weather, energy, etc. [3]. The potential to link datasets can therefore provide a source of enrichment for the data within a BIM.

The Ordnance Survey Ireland (OSi, Ireland's national mapping agency) developed a spatial data storage model known as Prime2, which is an object-oriented model implemented using the Oracle Spatial and Graph database technology. The system currently holds information of over 45,000,000 spatial objects (road segments, fences, etc.), of which some have more than one representation. The Prime2 data base has 3,532,263 building objects which include a geodetic coordinate as well as a 2D polygon representing the footprint of the building, along with other information such as the buildings form (e.g. Terraced Building) and function (e.g. Residence) and also its current life cycle stage (e.g. In use). This data meets some basic requirements for BIM. For example: how to handle multiple building representations, geometries and how to combine this with authoritative geospatial datasets. Crucially, it provides a sound basis for authoritative building data in Ireland.

The Industry Foundation Classes (IFC), an ISO PAS standard (ISO 2013) developed by buildingSmart [13], is the leading standard for BIM in the Architecture, Engineering and Construction (AEC) community. IFC is also the only BIM currently an ISO PAS standard (ISO 2013), and so remains a primary candidate for BIM. IFC is a non-proprietary data model which addresses several core data domains required for building AEC processes (architecture, structural analysis, control, etc.), enabling information to be passed between different stakeholders across the BLC. In practice, IFC has yet to make the impact expected of it. One major barrier to the use of IFC is its complexity. Often it is difficult for new software developers, unfamiliar with the schema, to access simple things such as a buildings geolocation, without an understanding of the IFC express schema which uses a complex set of relationships to assign longitude and latitude to an IfcSite. For a software developer who just wants to declare a building with a geodetic location, this can be off putting, resulting in the development of ad hoc models with alignments to IFC an afterthought.

This paper demonstrate the use of an applied and tested methodology for uplifting the OSi data into RDF and explore how this data, using Linked Data [23], can be a basis for interlinking to the IFC standard. The paper proposes that this approach to uplifting data can provide new knowledge and insights about buildings in Ireland and the integration of authoritative OSi geospatial data is an important step towards the iterative integration of ever more complex BIM models into the wider web of data.

2 Design and Implementation

The OSi's authoritative geospatial data has been converted into GeoSPARQL[1] and made available through GeoHive (data.geohive.ie). GeoSPARQL is an Open Geospatial Consortium (OGC) standard which not only defines a vocabulary for representing geospatial data on the Semantic Web, but also specifies an extension to the SPARQL query language for processing that geospatial data. In [6][7] the uplifting and linking of the OSi data has been conducted and some initial linking between DBpedia, through geolocation, demonstrated. This paper demonstrates the linking of the OSi data with IFC, specifically ifcOWL[8], which is now an official standard in buildingSMART[9], thereby making it possible to access and query large BIM data sets.

IfcOWL transforms IFC defined in the EXPRESS schema into OWL. Our pro-

[1] HYPERLINK "http://www.opengeospatial.org/standards”

posed linking is supported by a geodetic coordinate defined in IfcSite (lat and lon). IFC maintains a complex set of relations to store data about geometry and placement, leading to large numbers of triples generated when converted to RDF [10]. Creating SPARQL queries to traverse the lists expressed in RDF is therefore not practical for constructing new RDF graphs. The conversion process of IFC from an express STEP file into OWL makes use of Jena libraries, the source code of which has been made freely available[2]. The approach taken here is to therefore introduce an additional step during conversion from STEP to OWL, which takes as an input the ifcOWL model and injects a new relationship geo:hasGeometry to IfcSite to represent the lon and lat as a WKT point, building on the analysis and recommendation made by Pauwels et al. [10]. This code is available here: https://github.com/kmcglinn/IfcOwl2IfcOwlGeoloc.

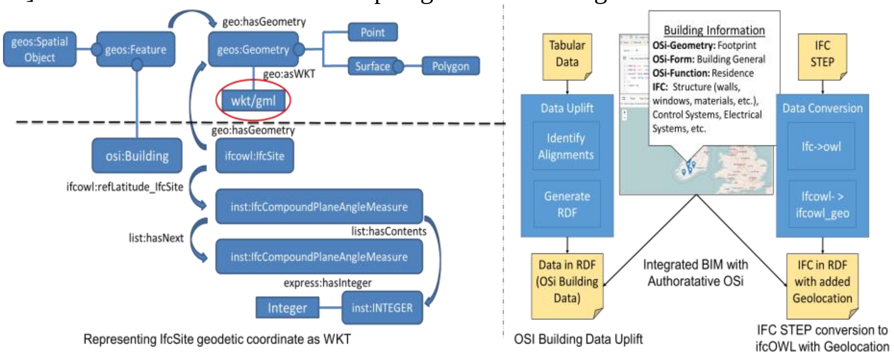

Fig. 1 Linking IfcSite to OSi building using geodetic coordinate

Fig. 1 shows the ifcOWL representation of lat and long, which requires a list of four integer values (deg, mins, secs, fraction) stored as triples each with a hasList and hasContents property, and its equivalent representation in GeoSPARQL, which requires one triple asWKT to represent the same list. **Listing 1** below this figure, demonstrates how this appears in a conversion of the openly available smallhouse.ttl file[2]. **Fig. 1** then demonstrate a GeoSPARQL query (viewed in yasgui.com), using geof:nearby, which will return all geometries near a given point, allowing queires over an IFC model, which includes data on structure (walls, windows, etc.) control systems, electrical systems, etc. and OSi Buildings, combining the two data sets.

3 Conclusion and Future Work

By combining OSi data and IFC, a much richer set of data becomes available for querying BIM. This approach also supports more complex queries over multiple data sets, for example DBpedia[7]. Ultimately, the goal is to develop a method for querying large data sets of BIM and BIM related data, based upon the authoritative geometries which are available through the OSi. Potentially, agreements could be developed between OSi and IFC model owners, whereby queries could return subsets of open

[2] HYPERLINK "http://openbimstandards.org/standards/ifcowl/"

data, along with licensing information for data which is considered to have some commercial value. Future work with IFC will explore the conversion of IFC geometries of floors and spaces into GeoSPARQL, thus enabling the full power of geospatial functions for SPARQL queries, such as nearby, within, touches, etc. which can support queries related to energy efficiency, navigation, building control, etc.

```
PREFIX geo: <http://www.opengis.net/ont/geosparql#> .
PREFIX ifcowl: <http://www.buildingsmart-tech.org/ifcOWL/IFC2X3_TC1#> .
PREFIX inst: <http://linkedbuildingdata.net/ifc/resources20170627_105709/> .
inst:IfcSite_2421 aifcowl:IfcSite ;
ifcowl:compositionType_IfcSpatialStructureElementifcowl:ELEMENT ;
ifcowl:refLatitude_IfcSiteinst:IfcCompoundPlaneAngleMeasure_3211 ;
ifcowl:refLongitude_IfcSiteinst:IfcCompoundPlaneAngleMeasure_3219 ;
geo:hasGeometry<urn:geom:pt:1Y9nGTxX90dwWkO9TbXfao> .
<urn:geom:pt:1Y9nGTxX90dwWkO9TbXfao>
geo:asWKT"POINT (-71.335194702 42.2130344238)"^^geo:wktLiteral .
```

Listing 1: Snippet of Simplehouse.ttl with added GeoSPARQL geodetic placement. A number of properties are not displayed here for IfcSite to reduce size.

Acknowledgements. The ADAPT Centre for Digital Content Technology is funded under the SFI Research Centres Programme (13/RC/2106) and is co-funded under the European Regional Development Fund.

References

1. M. Bilal, L. O. Oyedele, J. Qadir, K. Munir, S. O. Ajayi, O. O. Akinade, H. A. Owolabi, H. A. Alaka, and M. Pasha, "Big Data in the construction industry: A review of present status, opportunities, and future trends," Adv. Eng. Informatics, vol. 30, no. 3, pp. 500–521, 2016.
2. C. Eastman, P. Teicholz, R. Sacks, and K. Liston, BIM Handbook: A guide to Building Information Modeling for owners, managers, designers, engineers and contractors. 2011.
3. P. Pauwels, S. Zhang, and Y.-C. Lee, "Semantic web technologies in AEC industry: A literature overview," Autom. Constr., vol. 73, pp. 145–165, Jan. 2017.
4. K. Afsari, C. E. and D. Shelden, K. Afsari, and C. E. and D. Shelden, "Cloud-based BIM Data Transmission: Current Status and Challenges," ISARC Proc., pp. 1073–1080, 2016.
5. A. Ghaffarianhoseini, J. Tookey, N. Naismith, S. Azhar, O. Efimova, and K. Raahemifar, "Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges," Renew. Sustain. Energy Rev., Dec. 2016.
6. C. Debruyne, A. Meehan, E. Clinton, L. McNerney, A. Nautiyal, P. Lavin, and D. O'Sullivan, "Ireland's Authoritative Geospatial Linked Data," in In Proceedings of The Semantic Web – ISWC 2017 – 16th International Semantic Web Conference, 2017.
7. K. McGlinn, C. Debruyne, L. McNerney, and D. O'Sullivan, "Integrating Ireland's Geospatial Information to Provide Authoritative Building Information Models," in In 13th International Conference on Semantic Systems, 2017.
8. W. Terkaj and A. Šojić, "Ontology-based representation of IFC EXPRESS rules: An enhancement of the ifcOWL ontology," Autom. Constr., vol. 57, pp. 188–201, Sep. 2015.
9. "ifcOWL ontology" [Online]. Available: https://www.w3.org/community/lbd/2014/12/12/ifcowl-ontology-file-added-for-ifc4_add1/. [Accessed: 31-Aug-2015].
10. P. Pauwels, T. Krijnen, W. Terkaj, and J. Beetz, "Enhancing the ifcOWL ontology with an alternative representation for geometric data," Autom. Constr., vol. 80, pp. 77–94, 2017.