A Federated Approach for Interoperating AEC/FM Ontologies

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Abstract. Over the last few years, the benefits of applying ontologies (semantic graph modelling) for Architecture, Engineering, Construction and Facility Management (AEC/FM) industry have been recognized by several researchers and industry stakeholders. One of the main motivations is because it eases AEC data manipulation and representation. However, a research question that still remains open is how to take advantage of semantic web technologies to interoperate the AEC/FM and other ontologies in a flexible and dynamical way in order to solve data structure heterogeneity problem. Because of this, we propose in this paper to apply a rule-based federated architecture to answer this research question.

Keywords: federated architecture, AEC, ifcOWL, Horn-like rules, interoperability, semantic heterogeneity

In the last years, a multitude of knowledge models based on semantic web technologies have been proposed for the AEC/FM industry. Among these models (i.e. ontologies), we can mention ifcOWL [1], COBieOWL [2], IfcWoD [3] and SIMModel [4]. This is because there are various benefits of using semantic graphs (linked data) such as it eases building data access [3]. IfcOWL is an OWL ontology based on the IFC standard. Recently, the BuildingSMART Linked Data Working Group published a common version of an ifcOWL ontology available online in [1]. Concurrently with this effort, we have firstly proposed the COBieOWL ontology for facility managers based on the COBie format [2]. In doing so in the linked data context, facility managers are able to access data that are described by the ifcOWL terms by using the COBie vocabulary instead of ifcOWL. Hence, a facility manager that is used to the COBie structure and vocabulary does not need to know ifcOWL schema to query and retrieve COBie data. Secondly, we proposed the IfcWoD ontology that mainly contributes to better represent the IFC relationships and property sets when using the OWL language (a semantic graph modelling language) rather than an object-oriented modelling language such as EXPRESS. However, a research question that remains open up to today is how to take advantage of semantic web technologies to interoperate these AEC ontologies in a flexible and dynamical way in order to solve data structure heterogeneity problem. For flexible, we mean without establishing explicit links between data models.

We have developed a rule-based data integration architecture in [5] (so-called FOWLA – Federated Architecture for Ontologies) to interoperate ontologies. These ontologies must be defined by using a language based on description logics (DL) that can be combined with Horn-like rules. Therefore, to answer our previous research question, we can implement the FOWLA architecture (see Fig. 1) to seamless and dynamically interoperate those AEC/FM ontologies. To do so, we have to mainly define the following components: a federal controller (FC) and a federal descriptor (FD). The FC contains three modules: a Rule Selector (RS), a rule engine and a DL-based reasoner. As the AEC/FM ontologies are mostly described by using OWL language, we have to choose an OWL-based reasoner that also supports a Horn-like rule processing (a rule engine). The choice of a reasoner is so dictated by the fact that it must support the OWL syntax associated with Horn-like rules. In addition to this, if data materialization avoidance is a constraint to consider, we have to choose a reasoner that implements backward-chaining techniques (i.e. top-down or goal-driven inferences). For instance, we can mention inference engines presented in JENA [6], Stardog [7], ErgoSuite [8], and Prolog-Based reasoners [9]. In this case, the implementation of the RS [10] is strongly recommended to mitigate performance issues in terms of query answer time. On the other hand, if data materialization for inferences is not a constraint, then we can use a forward-chaining reasoner (i.e. bottom-up or data-driven inferences). Examples of bottom-up reasoners are Ontobroker, BigOWLIM and other essentially deductive-based systems [9]. In this case, the implementation of a RS is not necessary. Once we have defined the FC, we should compose the FD. The FD is composed of the following modules: a Federal Logical Schema (FLS) and a Federal Concept Instantiation (FCI). The FLS is an ensemble of logical rules describing the correspondences among AEC/FM ontologies. These mappings are expressed as logical rules, such as SWRL, RIF, SPIN, ObjectLogic and others. The choice of a rule language depends on the definition of the FC component. Thus, for example, if we choose Stardog, it must be defined by using the SWRL language or Stardog Rule Syntax. In addition to this, such logical rules are not capable of creating new concept instances. This is due to undecidability problems when integrating the DL-based languages and Horn-like rules. Therefore, the DL-safe rules (i.e. a subset of Horn-like rules) are implemented to regain decidability. To overcome the drawback of new instances' inference, we propose to include the FCI sub-module in our architecture.

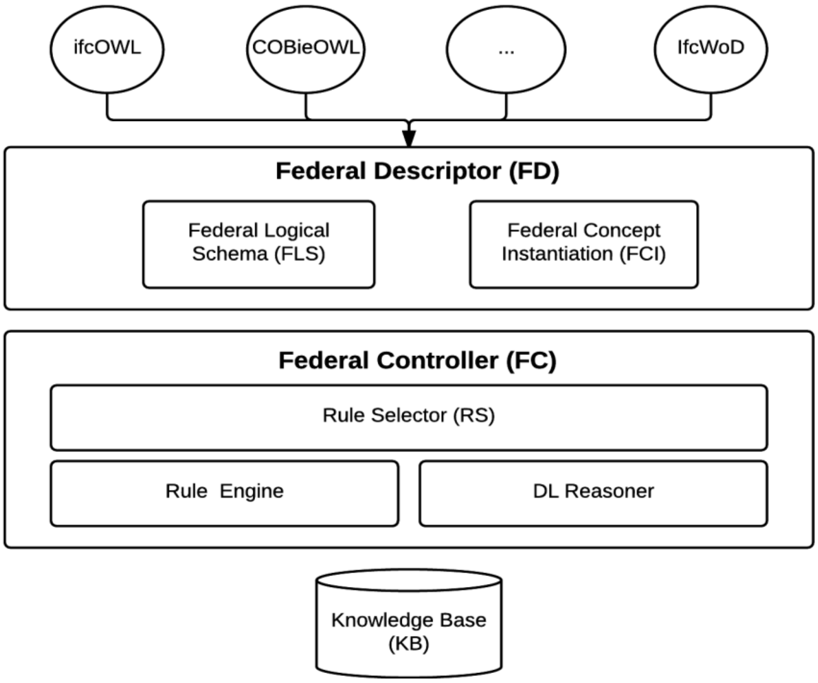

Figure 1. FOWLA architecture applied for AEC ontologies.

Therefore, the FOWLA architecture allows the AEC/FM ontologies (e.g. ifcOWL, COBieOWL and IfcWoD) to interoperate at schema level by solving semantic heterogeneity problems. We mainly identify the following benefits of implementing FOWLA in the context of the AEC/FM ontology interoperability:

- FOWLA allows users to compose queries by mixing terms from ifcOWL, COBieOWL or IfcWoD. Thus, it means that a facility manager that only knows the COBie vocabulary can easier retrieve data originally described by ifcOWL. Moreover, the stakeholders that are only interested in the IFC semantics can use the IfcWoD vocabulary to query building data in a more intuitive way.
- FOWLA takes advantage of a rule engine, then the task of defining the FLS module is mitigate because new alignment rules can be inferred. For example, if COBieOWL is aligned with ifcOWL (that is aligned with ifcWoD), then COBieOWL is also aligned with IfcWoD by transitivity. Therefore, the COBieOWL-ifcWoD alignment is automatically done by the inference engine.

References

[1] BuildingSMART LDWG. Overview page for the linked data working group. Available online : http://www.buildingsmart-tech.org/-future/linked-data/. Last accessed on 26 April 2015.

[2] Farias, M. T., Roxin, A., & Nicolle, C. (2015, October). COBieOWL, an OWL Ontology Based on COBie Standard. In On the Move to Meaningful Internet Systems: OTM 2015 Conferences (pp. 361-377). Springer International Publishing.

[3] de Farias, T. M., Roxin, A., & Nicolle, C. (2015, October). IfcWoD, Semantically Adapting IFC Model Relations into OWL Properties. In Proceedings of the 32nd International Conference of CIB W78, Eindhoven, The Netherlands, 27-29 October, 175-185 http://itc.scix.net/cgi-bin/works/Show?w78-2015-paper-018

[4] P. Pauwels, E. Corry, J. O'Donnell, Representing SimModel in the Web Ontology Language, American Society of Civil Engineers, 2014. 2271–2278

[5] Farias, T. M., Roxin, A., & Nicolle, C. (2015). FOWLA, a federated architecture for ontologies. In Rule Technologies: Foundations, Tools, and Applications (pp. 97-111). Springer International Publishing.

[6] Apache (2015). Apache jena. Available online : https ://jena.apache.org/. Last accessed on 21 January 2015.

[7] Complexible Inc. (2016a). Stardog 4 : The manual – query rewriting. Available online : http://docs.stardog.com/#_query_rewriting. Last accessed on 5 February 2016.

[8] Faber, W., & Paschke, A. (2015). Reasoning Web.

[9] Liang, S., Fodor, P., Wan, H., & Kifer, M. (2009). Openrulebench: Detailed report. Manuscript. http://semwebcentral.org/docman/view.php/158/69/report.pdf

[10] de Farias, T. M., Roxin, A., & Nicolle, C. (2015). SWRL rule-selection methodology for ontology interoperability. Data & Knowledge Engineering.