

SWIMing Methodology

This document provides a description of the application of the SWIMing methodology. The process of defining these use cases is based upon an established methodology called the IDM/MVD methodology [1] and also guidelines¹ set down in the Ready4SmartCities project. We have taken and extended this methodology for the purpose of identifying data requirements (and models) within the EeB projects. Figure 1 gives the BPMN [2] process model we have developed for defining use cases (task 1- 3 in swim lane 1) and which have been employed in the SWIMing project [3],[4],[5],[6]. This document describes the different steps as defined in Figure 1.

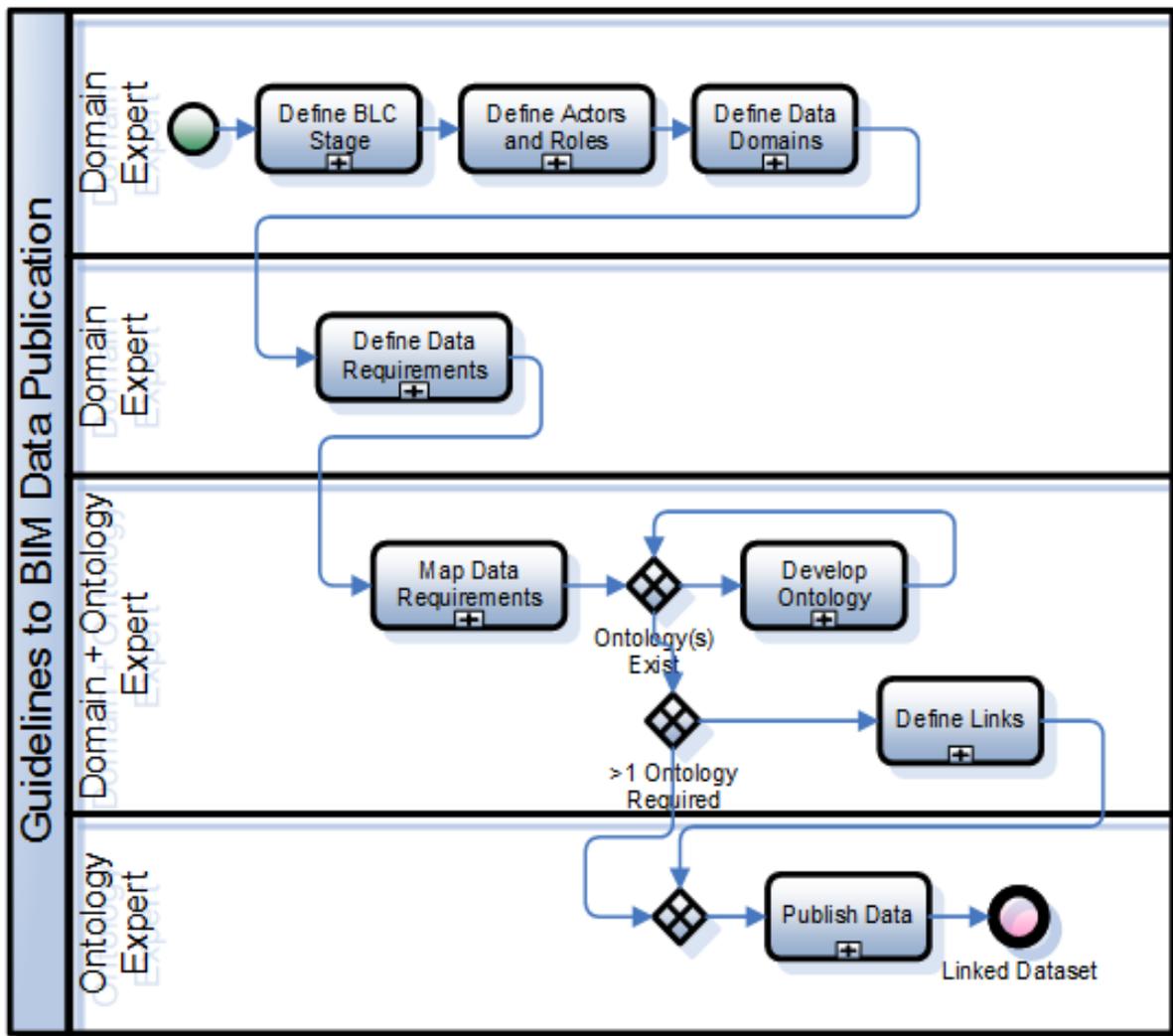


Figure 1: BPMN Model of Guidelines for BIM Data Publication

Step one (1) is to identify the BLC stages which have been defined within the context of the Linked Building Data community and consist of:

- Design,
- Construction,

¹ <http://www.ready4smartcities.eu/guidelines>

- Commissioning,
- Operation,
- Retrofitting/ Refurbishment/ Reconfiguration,
- Demolition/Recycling.²

Use Case Category Template [\[edit\]](#)

In order to keep this web page insightful and digestible, please:

1. Create a link to the use case through the title, in the following format - [[title_of_use_case|Title of Use Case]] and add use case to the new link
2. Keep description short and to the point, also for the title (Suggestion: include the category name or just extend it with a particularity of the use case)
3. Use the categories displayed at the bottom of this web page
4. Use the following template to describe use cases:
 - **Title:** The title of the use case
 - **Description:** A short description of the use case
 - **Data Domain(s):** Please use the categories in 'Data Domains'.
 - **Objectives:** A short description of the objectives of the use case
 - **Stakeholders:**
 - **LD Benefits:**
 1. benefit 1
 - **Challenges**
 1. challenge 1
 - **Data is Processed During BLC Stage:** Planning and Design, Construction, Commissioning, Operation, Retrofitting/Refurbishment/Reconfiguration, Demolition/Recycling
 - **Uses Data Generated During BLC Stage:** Planning and Design, Construction, Commissioning, Operation, Retrofitting/Refurbishment/Reconfiguration, Demolition/Recycling
 - **Data Standards Used:** e.g. IFC
 - **External sources:**
 - **Use Case Description in BIM²Q Tool:** A link to description in the BIM²Q tool
 - **Wiki contributors:**

Figure 2: High Level Use Case Template

Step two (2) is to identify the different actors involved in the different processes required to complete the use case.

The purpose of this process is to enable the quick identification of responsible stakeholders for generating and processing data exchanges. For each process identified in the use case at least one actor must be defined who is responsible for generating that data.

Step three (3) is to identify at a high level the data domains that the use case requires and consist of [11], [3]:

- Product
- Device
- Control
- Behaviour
- Communications
- Data Measures
- Energy
- Weather
- Geolocation

The purpose of this process is to provide a quick reference to data structures best suited for a particular domain. Again this data is added to the wiki, resulting in a description of the use

² This data is first recorded using an open shared wiki [11], described in D1.1 [3]. The shared wiki provides a template (Figure 2) which allows BLC stages to be added to a description of the use case.

case, for example the use case ‘Decision support tool for district renovation planning’³ is shown in Figure 3. The high level use cases are used to automatically generate the use case overview [12]

Decision support tool for district renovation planning

- **Title:** Decision support tool for district renovation planning
- **Description:** Developing decision support tools to assist district renovation planning, integrating the needs of different stakeholders: inhabitants, local authorities and business investors. These tools will give the opportunity to select stakeholders' highest priorities and report building renovation scenarios. The tools will specifically assess related costs & benefits, as well as environmental & social impacts at a district level.
- **Data Domain(s):** Building Devices, Building Control, Energy
- **Objectives:**
 1. To integrate stakeholders' needs in a single software environment
 2. To enable analysis of different scales and different time frames
 3. To create a versatile tool with an open structure
 4. To facilitate day to day work of future users
- **Stakeholders:** Building/Facility Owner, Operations Manager, Financial/Cost Manager, Occupant, Urban planners, Housing corporations, Engineering companies
- **Requirements:** Building owner requirements, Quality, Energy
- **LD benefits:** Structured common vocabularies for building aspects (size, materials, use and occupancy patterns, etc.) allowing data integration
- **Challenges:** Handle different types of information
- **Data is Processed during BLC Stage:** Retrofitting/Refurbishment/Reconfiguration
- **Uses Data Generated During BLC Stage:** Category:Planning and Design, Operation, Retrofitting/Refurbishment/Reconfiguration
- **Data Standards Used:** IFC, SIMModel, CityGML
- **Associated Projects:** ECODISTR-ICT project [↗](#), OptEEemAL [↗](#)
- **External source(s):**
- **Use Case Description in BIM*Q Tool:** BIM*Q Use Case [↗](#)
- **Wiki contributors:** Nick Kaklanis (CERTH) [↗](#)

Figure 3 High Level Use Case Wiki Example

*After the high level use cases is described, the steps 4-5 require more functionality, and so we recommend the use of the BIM*Q tool.*

The first steps are to align the data from the wiki with the BIM*Q tool. To achieve this one must currently take the wiki use case title and description and add these to a new use case templates created in the BIM*Q tool (Figure 4). Once this has been completed, the user must continue to copy and paste data across to the BIM*Q tool. Step 1 and 2 are shown in the BIM*Q in Figure 5 and Figure 6 respectively. In Step 3, particular ontologies are added for each domain as can be seen in Figure 7. Once these steps have been completed, it is possible to begin Steps 4-5.

³ https://www.w3.org/community/lbd/wiki/Decision_support_tool_for_district_renovation_planning




Template Use Cases
Signed in as: mw@aec3.de

List of W3C Template Use Cases

New Template

Search:

Guide	Release	Status	Description	
Sustainable Energy Management System for Underground Stations		Draft	In this Use Case, sustainable energy management is achieved through the development of an advanced energy management system for metro stations, involving model based control of forced ventilation, lighting and passenger transfer systems.	Copy
BEMS Retrofit		Draft	This use case focuses on retrofitting of the building and the HVAC equipment and the parametrization of the BEMS. Link in LBD Wiki: https://www.w3.org/community/lbd/wiki/BEMS_Retrofit	Copy
BIM-GIS Integration		Draft	Define requirements to publish main BIM data in a GIS environment.	Copy
BIM-GIS Integration Version 2		Draft		Copy
Bridge Cloud		Draft	This is a template in order to define a MVD and data exchanges requirements for bridges and especially for CFD analysis.	Copy
Building Energy Simulation Using Minimal Data Requirements		Draft	This use case is concerned with identifying the minimal set of data requirements to provide accurate building energy simulation.	Copy
Collaborative design and simulation platform for designing energy-efficient buildings and their optimal energetic embedding in the neighbourhood		Draft	This use case is developed by the project eeEmbedded. The aim is to develop an open BIM-based holistic collaborative design and simulation platform, 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. Similar use cases are described in the HOLISTEEC project.	Copy
Decision support and energy awareness in a district		Draft	This use case deals with the support the planning activities of energy providers(e.g. definition of new tariffs, planning advertising campaigns).	Copy
Decision support tool for district renovation planning		Draft	This use case is concerned with developing decision support tools to assist district renovation planning and integrating the needs of different stakeholders: inhabitants, local authorities and business investors. These tools will give the opportunity to select stakeholders' highest priorities and report building renovation scenarios. The tools will specifically assess related costs & benefits, as well as environmental & social impacts at a district level.	Copy
Design4Energy Use Case		Draft		Copy
District Key Performance Indicators and forecasting		Draft	This use case allows the user to view a set of key performance indicators (KPI) related to energy consumption and environment, for example total consumed kWh, consumption per m2, emission per inhabitant, etc., during a user defined time interval. Key performance indicators for district energy consumption are provided to be used by other services or consulted by platform users. This is a use case of DAREED project.	Copy

*Figure 4 Overview of Use Cases in BIM*Q*

Template: Intelligent and Integrated Control Based on Building Behaviour (of devices) to Optimize Building Energy Management

New BLC Stage or Process

Search:

Code ^a	Name	Description	BLC Stage
P1	Minimise energy cost	Measurement is the first step in understanding the energy consumption of the technical systems, devices, and appliances within a building. This allows the building operator to know the usage of the technical systems, devices, and appliances within the building and forecast their usage depending on building schedules, day of the week/month/year, or weather. If the loads within a building are smart, then those loads can be controlled to match the needs of the building occupants in order to minimize energy consumption when they are not being utilized. Thus, control is the second step in minimizing energy costs. The use of local renewable energy production and stored energy is the third step. When these three steps are available to the building operator and exercised, then it is possible to minimize energy costs.	Operation & Maintenance
P2	Optimize Building for Occupant Comfort	One of the primary missions of a building operator is to ensure that its occupants are comfortable in the building. This includes the management of the lighting and HVAC systems of the building to suit the needs of the occupants. The thermal envelope of the building and the efficiency of its technical systems will impact the buildings ability to change its performance over a period of time. Understanding the flexibility of the buildings technical systems and forecasting of the buildings usage will allow the building to be maximized for the comfort of its occupants.	Operation & Maintenance
P3	Identify priorities during periods of limited energy availability	During periods where energy capacity is limited / constrained, customers will want to shed loads in order to reduce peak energy charges. By understanding the building loads and identifying their priorities, customers will be able to shed the least critical loads in order to minimize their energy consumption.	Operation & Maintenance
P4	Implement Thermal Energy Management	Knowledge of a buildings thermal envelope and its ability to change due to weather, temperature, and/or climate condition will allow a building operator to manage the energy consumption under varying thermal conditions and in anticipation of forecast events.	Operation & Maintenance
P5	Get prepared to participate in district level management	As district priorities and energy costs change, the building should be prepared to participate and change its performance in response. The building operator should have knowledge of the flexibility of the building performance as well as a forecast of the buildings energy consumption, production, and storage capacity in order to prepare for a change in district energy strategies and pricing policies in order to minimize its energy costs. See Ambassador WP1 D1.1	Operation & Maintenance

Figure 5 Defining Processes in BIM*Q

READY4SMARTCITIES

SWIMing

Template Use Cases Overview Reports Components Setup Requirements Signed in as: kris.mcglinn@scss.tcd.ie

Template: Intelligent and Integrated Control Based on Building Behaviour (of devices) to Optimize Building Energy Management

New Stakeholder

Search:

Code ^a	Stakeholder	Description
N/A	Building Operation Manager	In the operation of a building, the Building Operation Manager may have a number of priorities that they wish to implement. Some of these priorities may be mutually exclusive while others are not.
N/A	Automation Engineer	
N/A	BEMS Engineer	
N/A	HVAC Engineer	
N/A	Architect	

Showing 1 to 5 of 5 entries

Figure 6 Defining Stakeholders/Actors in BIM*Q

READY4SMARTCITIES

SWIMing

Template Use Cases Overview Reports Components Setup Requirements Signed in as: kris.mcglinn@scss.tcd.ie

Template: Intelligent and Integrated Control Based on Building Behaviour (of devices) to Optimize Building Energy Management

New Classification

Name	Edition	Description	Link
New Ontology			
Name	Release	Description	Link
Adapt4EE			http://www.adapt4ee.eu/adapt4ee/results/ontologies.html
IFC4	Ad61	Industry Foundation Classes (IFC) are the buildingSMART data model standard. IFC is the only truly open standard for BIM - it makes the difference between BIM and open BIM.	http://www.buildingsmart-tech.org/ifc/IFC4/Ad61/html/
#ICW:4	Ad61		http://www.buildingsmart-tech.org/future/linked-data/#icw/20150925_labels/IFC4_A6D1.owl
Observation_and_Measurement	V2		Observation_and_Measurement
SARFF			
Semantic Sensor Network Ontology			http://purl.odc.org/NET/ssnx/ssn
Time Ontology in OWL	http://www.w3.org/TR/owl-time/		http://www.w3.org/TR/owl-time/
Weather Ontology			https://www.aalto.fi/en/aalto-downloads/thinkhome/ontology/WeatherOntology.owl

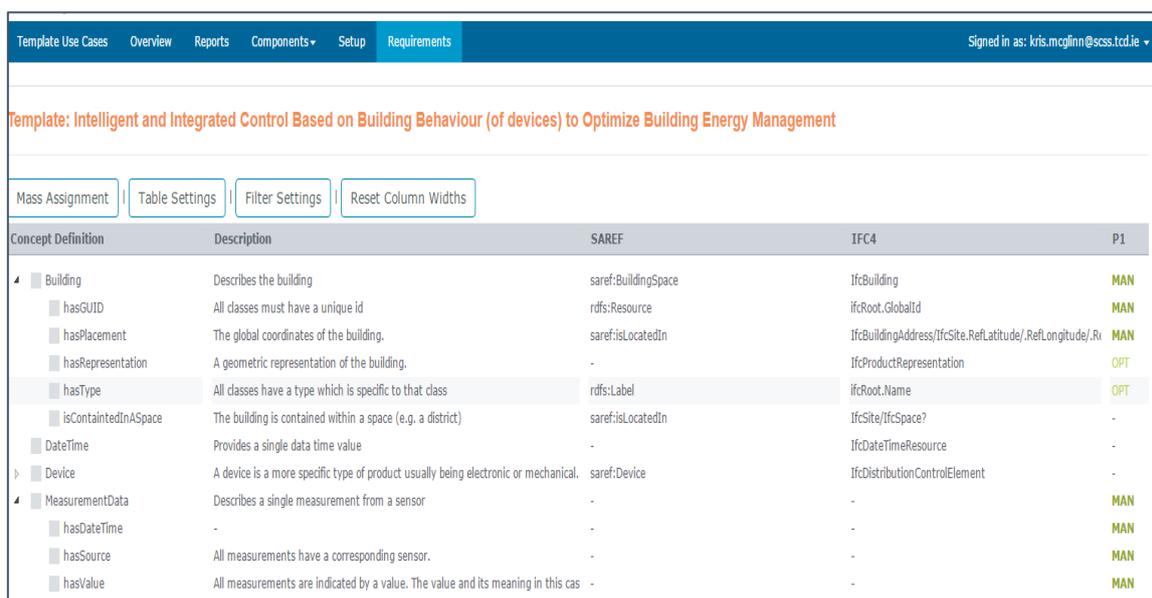
Figure 7 Defining Available Ontologies in BIM*Q

Step four (4) is to identify in greater detail the specific data requirements for each process in the use case.

The purpose of this step is to understand the exact structure of the data required to meet the use case. Each data value that is required must be captured and described. This involves structuring the data as concepts and properties. These classes are then aligned with the processes and actors.

Step five (5) is where the conceptual model is aligned with existing ontologies and standards (Figure 8).

The purpose of this step is to provide a quick reference point for the identification of alignments within existing domain models, thus supporting those who wish to enable similar use cases. The alignment process is based upon expert knowledge of the existing domain models and therefore may need to undergo several review steps to ensure that the data alignments are correct (see Step/Task 8 in D2.2).



Concept Definition	Description	SAREF	IFC4	P1
Building	Describes the building	saref:BuildingSpace	IfcBuilding	MAN
hasGUID	All classes must have a unique id	rdfs:Resource	IfcRoot.GlobalId	MAN
hasPlacement	The global coordinates of the building.	saref:isLocatedIn	IfcBuildingAddress/IfcSite.RefLatitude/RefLongitude/Rx	MAN
hasRepresentation	A geometric representation of the building.	-	IfcProductRepresentation	OPT
hasType	All classes have a type which is specific to that class	rdfs:Label	IfcRoot.Name	OPT
isContainedInASpace	The building is contained within a space (e.g. a district)	saref:isLocatedIn	IfcSite/IfcSpace?	-
DateTime	Provides a single data time value	-	IfcDateTimeResource	-
Device	A device is a more specific type of product usually being electronic or mechanical.	saref:Device	IfcDistributionControlElement	-
MeasurementData	Describes a single measurement from a sensor	-	-	MAN
hasDateTime	-	-	-	MAN
hasSource	All measurements have a corresponding sensor.	-	-	MAN
hasValue	All measurements are indicated by a value. The value and its meaning in this cas	-	-	MAN

Figure 8 Concept Definition and Alignment with Processes and Ontologies in BIM*Q



Figure 9 A Specific Data Exchange Defined in BIM*Q Tool

Step six (6) is to develop models that will meet the data requirements of use cases which are not currently supported by any existing ontology or standard.

The purpose of this step is to develop new or extend existing ontologies were no existing ontology meets the requirements of the use case. The BIM*Q tool provides a basis for capturing concepts and therefore provides a good bridge toward ontology development, but

currently does not provide the kind of complex relations that are required for new ontological definitions. Therefore, it is recommended that OWL based ontology development be conducted with existing tools, such as Protégé [13], or to support more collaborative work the web based WebProtege [14].

There is already plenty of information readily available on ontology development [15] and methodologies for developing ontologies [16], and these can be applied in different scenarios. For example, there are approaches which make use of UML to derive ontologies (e.g. UPON [17]), fact oriented approaches like those GOSPL referred to in [16] and DOGMA [18], structured English approaches (e.g. ACE [19]), and OWL based approaches, which the aforementioned Protégé tool supports, and more collaboratively with WebProtege. NeOn, developed within the context of an EU project of the same name [20], also provides a methodology and workbench which supports choosing between these different approaches based on scenarios [21].

Step seven (7) is to define links between ontologies and data models, where multiple are required to meet the use case Define Links.

The links between ontologies can be created in the T-Box part (classes) and A-Box part (individuals). The linking of T-Box elements results in linked vocabularies. The methods to link the T-Box elements are for example as follows [22]:

1. Creating sub-classes of classes defined in other ontologies using `rdfs:subClassOf`
2. Creating sub-properties of properties defined in other ontologies using `rdfs:subPropertyOf`
3. Defining domain and/or range of properties from imported resources using `rdfs:domain` and `rdfs:range`
4. Linking equivalent classes and properties coming from different ontologies using `owl:equivalentClass` and `owl:equivalentProperties`

The linking of A-Box elements can be done through the use of `owl:sameAs` to define two individuals, that are already declared in different ontologies, refer to the same thing. An individual can be linked to a defined in another ontology by defining class membership using `rdf:type`.

Step eight (8) is the publication of data so as to make it accessible both within the scope of a particular use case, but also to make it available to external use cases.

The linked data can be published by using tools like LOD-Viewer⁴ where the data user can navigate over both classes and individuals. Furthermore, linked open data platform, such as Linked Open Data cloud⁵ initiated by Linking Open Data community, allows the linked data publication on the web and linking to other open data. The data have to be registered in datahub⁶ and follow the linked data principles, i.e. having resolvable http URIs, having RDFa, RDF/XML, Turtle, or N-Triple format, containing at least 1000 triples, having at list 50 links to the registered data sets, and allowing access via RDF crawling, via an RDF dump, or via a SPARQL endpoint. We suggest all data publication follow existing W3C Best Practices⁷, which is also referenced in D2.1 [23].

⁴ <http://lodview.it/>

⁵ <http://lod-cloud.net/>

⁶ <https://datahub.io/>

⁷ <https://www.w3.org/TR/dwbp/>

References

- [1] W. Jeffrey and J. Karlshoej, "Information delivery manual: Guide to components and development methods," *BuildingSMART International*, 2010. [Online]. Available: <http://iug.buildingsmart.org/idms>.
- [2] Object Management Group, "Business Process Model and Notation (BPMN), V1.2," 2012.
- [3] H. Wicaksono and K. McGlenn, "SWIMING : D1.1 Business Use Cases for the Use of BIM-LOD in BLCEM Phase I," 2015.
- [4] H. Wicaksono and K. McGlenn, "SWIMing: D1.2 Business Use Cases for the use of BIM-LOD in BLCEM – Phase II."
- [5] M. Weise and K. McGlenn, "SWIMing: D2.2 Guidelines and best practices for BLCEM process and data management - Phase I," 2015.
- [6] M. Weise and K. McGlenn, "Guidelines and best practices for BLCEM process and data management - Phase II."
- [7] J.-R. Noemi, "EEEMBEDDED Papers," *eeEmbedded Project*, 2013. [Online]. Available: <http://eeembedded.eu/>.
- [8] D. S.p.A., "HOLISTEEC," 2013. [Online]. Available: <http://www.holisteecproject.eu>.
- [9] Solintel, "DESIGN4ENERGY," 2013. [Online]. Available: <http://www.design4energy.eu/>.
- [10] "ISES." [Online]. Available: <http://ises.eu-project.info/>.
- [11] "SWIMing Wiki- Seed Use Cases." [Online]. Available: https://www.w3.org/community/lbd/wiki/Seed_Use_Cases.
- [12] Kris McGlenn and Hendro Wicaksono, "Use Case Classification Table." [Online]. Available: http://phaedrus.scss.tcd.ie/buildviz/SWIMing/u_c_overview/. [Accessed: 18-Dec-2016].
- [13] "The Protégé Ontology Editor and Knowledge Acquisition System." [Online]. Available: <http://protege.stanford.edu/>. [Accessed: 01-Mar-2013].
- [14] "WebProtege." [Online]. Available: <https://webprotege.stanford.edu/#List:coll=Home;> [Accessed: 20-Dec-2016].
- [15] S. Staab and R. Studer, *Handbook on ontologies*. 2013.
- [16] C. Debruyne, T.-K. Tran, and R. Meersman, "Grounding Ontologies with Social Processes and Natural Language," *J. Data Semant.*, vol. 2, no. 2–3, pp. 89–118, Jun. 2013.
- [17] A. De Nicola, M. Missikoff, and R. Navigli, "A proposal for a unified process for ontology building: UPON," *Int. Conf.*, 2005.
- [18] M. Jarrar and R. Meersman, "Ontology Engineering – The DOGMA Approach," in *Advances in Web Semantics I*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2008, pp. 7–34.
- [19] K. Kaljurand, "ACE View---an Ontology and Rule Editor based on Attempto Controlled English.," *OWLED*, 2008.
- [20] "NeOn Project." [Online]. Available: http://www.neon-project.org/nw/Welcome_to_the_NeOn_Project. [Accessed: 21-Dec-2016].
- [21] M. Suárez-Figueroa and A. Gomez-Perez, "The NeOn methodology for ontology engineering," *Ontol. Eng.*, 2012.
- [22] H. Wicaksono, K. Tonev, and P. Dobreva, "Linked Data for Data Integration based on SWIMing Guideline: Use Cases in DAREED Project," in *4th International Workshop on Linked Data in Architecture and Construction (LDAC)*, 2016.
- [23] M. Weise and K. McGlenn, "SWIMING : D2.1 Data Management Plan," 2015.