White Paper

Sealing the dataflow pipes from knowledge graph to BIM-standards bSDD and IDS.

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Introduction

Building Information Modelling (BIM) requires sharing of information on physical objects in a built environment (cf. ISO 19650). To share the same terminology to capture alphanumeric data on infrastructure assets, several asset owning organisations have developed ontologies that are published as Linked Data. Not all parties in the AEC industry (Architecture, Engineering, Construction) are familiar with this data form, and current BIM software often does not fully align with Linked Data principles for incorporating existing ontological knowledge. To facilitate communication in a BIM context, this research aims to disseminate Linked Data ontologies by automatically transforming them into openBIM standard for sharing object libraries (bSDD) and for information requirements (IDS). The transformation tools developed for this purpose, onto2bsdd and onto2ids, have been made available open source.

USEFUL LINKS

builingSMART website

IFC introduction website from buildingSMART

bSDD web-service to search through all published dictionaries

IFC4x3 publication on bSDD web-service

IDS technical explanations

openBIM
background

BuildingSMART International (bSI) is focusing on improving the exchange of data and information between different software solutions in the construction industry, by the development of open standards for the BIM process (openBIM). This allows information deliveries to be uniform and standardized, improving interoperability and communication between all parties involved.

What is bSDD?

IFC classes and properties can be published as dictionaries in the building-SMART service for Data Dictionaries platform (bSDD), a web-based service for publishing and consolidating of ontologies based on ISO 12006-3. Since 2020, developers have integrated the bSDD platform into their BIM software or plug-ins via its API to access hosted data dictionaries. The bSDD is also accessible through a website.

What is IFC?

The most used openBIM standard is IFC (Industry Foundation Classes), developed by bSI. Representations of buildings or infrastructure projects can be stored and shared as IFC models. These models typically contain the 3D geometry of building elements along with alphanumeric information on those elements.

What is IDS?

To standardize manifestations of BIM requirements, bSI has developed the IDS. This standard enables users to define requirements on a structured and computer interpretable way. Various verification software can automatically check an IFC file on compliance to the requirements.

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USEFUL LINKS

Waternet website to get more information about the organisation

Waternet OTL webviewer of the Object Type Library

Waternet

Waternet is the major water infrastructure organisation in the region of Amsterdam, The Netherlands. The organisation works for the regional public water authority Amstel, Gooi and Vecht and for the municipality of Amsterdam. Their core activities cover the whole water cycle: drinking water, sewage water and water management. The organisation is facing significant challenges ranging from ageing infrastructure to an increase in demand (more inhabitants and in more locations) and stricter requirements concerning aspects such as water quality and protection against current and future sea levels. In order to face challenges such as these, digitization and robust, future-proof information management is essential. Information is often needed to provide clear and better understandings into today's problems and make the best decisions for the future.

Waternet OTL

Moving towards more explicit and standardized ways in capturing and conveying which information is needed, and for what purpose in its asset management processes, the water management organisation aims to improve interoperability and the communication between all parties that carry out information exchanges with them. In recent years, Waternet has opted to develop and employ their own ontology, the Waternet Object Type Library. This W-OTL is developed for expressing terminology on their infrastructure assets in a consistent manner, across all their software databases and, more recently, in communication with other parties (regardless of whether the perspective adopted by these parties are geospatial, BIM, Systems Engineering, or otherwise).

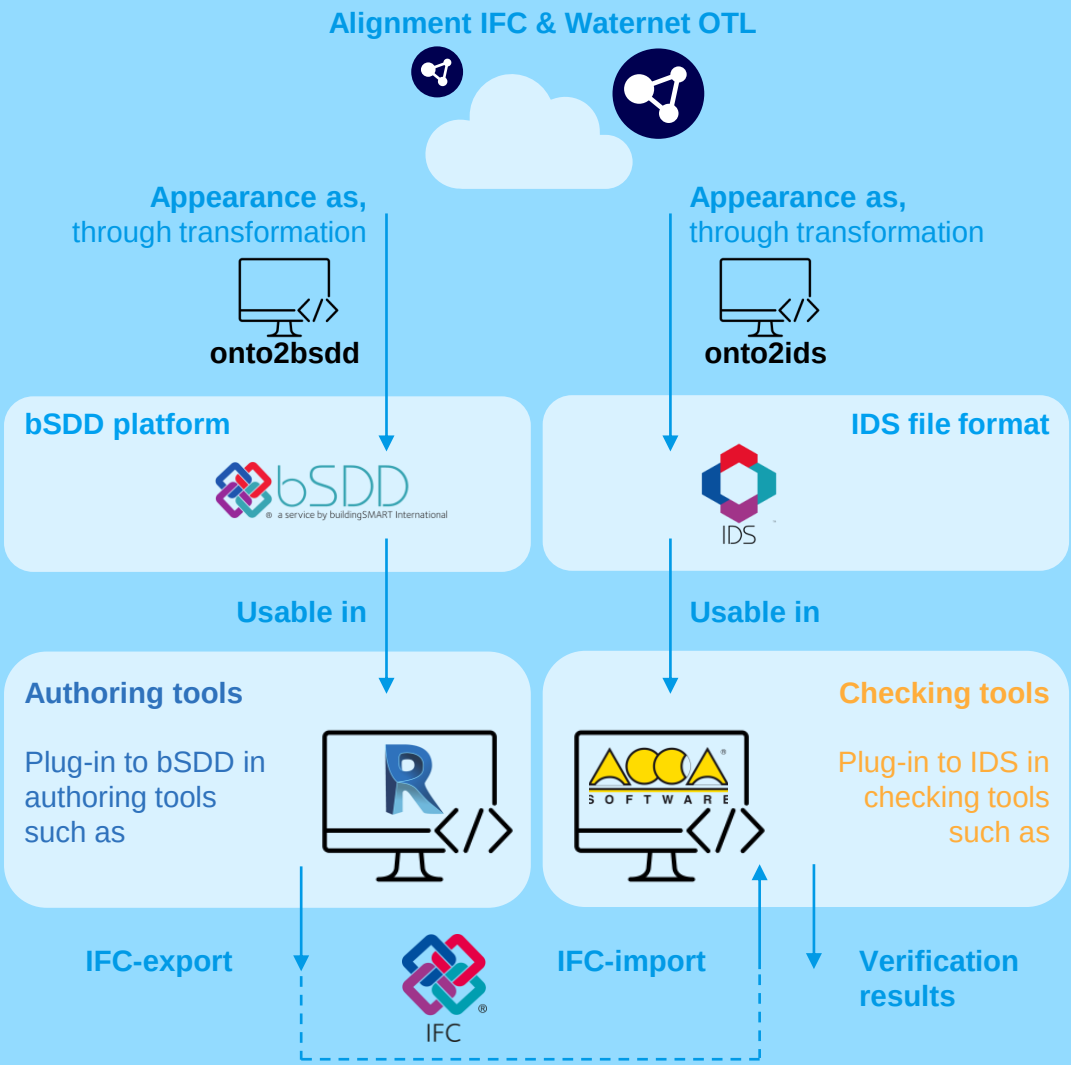
Technical background

The W-OTL is expressed in the open standard Linked Data and contains:

1. a taxonomy of classes (sub-class of structure) expressing physical objects, spatial objects, and documents
2. relations between these classes
3. properties relevant for each class, including possible values

Methodology

In researching the technical viability of a new approach for exchanging asset information between clients and contractors in a BIM context, based on ontological information and the recent openBIM standards bSDD and IDS, we have sketched the architecture and the various components in the figure below. The architecture hinges on the dissemination of knowledge from ontologies (depicted at the top) in formats closer to their application and with which contractors tend to be more familiar, i.e., bSDD and IDS (depicted in the middle). The main challenge is the development of the tools onto2bsdd and onto2ids that facilitate the information to appear as bSDD and IDS. With ontological information available in the bSDD, authoring tools commonly used in the AEC industry (depicted at the bottom left) should be able to access this information for users, who can then apply it to the corresponding geometric elements and verify it using checking tools (depicted at the bottom right).



Alignment IFC

For the purpose of this case study, the W-OTL should be extended to include an alignment with the IFC schema. Thus, a ‘pomp’ according to W-OTL is known to be a pump according to IFC. This alignment, limited in scope to the current case study, has been modelled to ensure classifications between the W-OTL and IFC can be verified for consistency; an object in a BIM model that ought to be classified as a W-OTL pump should not also be classified as an IFC door. The understandings captured in this alignment, published as Linked Data, need to be available to contractors alongside the W-OTL terminology.

We encourage all stakeholders to embrace this system, as it is designed to facilitate better collaboration and foster innovation. Together, we can ensure that our projects benefit from the highest quality information deliveries, driving success and sustainability for our future endeavours. Let's work hand in hand to make this vision a reality!

USEFUL LINKS

bSDD-Revit-plugin
technical explanations

ACCA usBIM.IDS
information website

Alexander Worp
Asset Information Manager
at Waternet

Used BIM tools

In the sketched architecture, there are BIM tools included for authoring and checking IFC-models which were used for testing. By using the open standards bSDD and IDS, other tools could also be used, as these tools embrace the buildingSMART open standards.

bSDD-Revit plugin

Many tools are available for AEC software for modelling in a BIM context. Initiated by Dutch contractors VolkerWessels and Heijmans, their developers recently made an open-source plugin available for modelling tool Revit. The plugin gives Revit users access to terminology from the bSDD platform. In Waternet’s use case, the information from the W-OTL can be accessed by (external) modelers in Revit.

ACCA usBIM.IDS

Software that can verify information models, through the IDS standard, is in full development. One specific piece of software that is well under development is the usBIM.IDS module of the IFC Checker from ACCA software. In Waternet’s use case, the information in the IFC-model (authored by external modelers) can be checked against the W-OTL.

Technical background

We have developed onto2bsdd, a small Web application that generates an input file for the upload of a bSDD dictionary. The logic used in the application is straightforward: header information, which can be adjusted in the onto2bsdd user interface, is combined with the prepared CSV-file. When dropping the CSV-file, the tool runs automatically.

These sources are used together to fill out a JSON object with classes and properties intended to be part of the dictionary in the bSDD. URIs used to identify classes and properties in the source ontology are, in order to retain information on the origins, registered in the bSDD JSON import object alongside their generated counterpart bSDD entities and properties. Links to IFC entities are, whenever present in the query results, included as part of the same JSON object.

...preparations

To use the onto2bsdd application, the data must be extracted from the ontology. This can be done by running a query on the SPARQL endpoint of the ontology in question, resulting in a CSV-file with the structure of 13 variables as shown below. Carrying information about the (1) ontology classification, (2) its relations -for example, its IFC couterpart-, (3) its parent class and (4) associated properties.

	Variable	Description
1	ontoClassPrefLabel	Human readeble
	ontoClassURI	Unique identifier
	ontoClassDefinition	Definition
2	mappedClassRelation	Relation type
	mappedClassURI	Unique identifier
3	ontoParentClassPrefLabel	Human readeble
	ontoParentClassURI	Unique identifier
4	ontoPropertyPrefLabel	Human readeble
	ontoPropertyURI	Unique identifier
	ontoPropertyDefinition	Definition
	ontoPropertyDatatype	Datatype
	ontoPropertyDatatypeLabel	Datatype label
	ontoPropertyEnumValues	Enumeration values

QUICK TIPS

If an Excel, pdf or other data-source is used, instead of a Linked Data ontology, the onto2bsdd tool can be used as well. Preparing a good CSV-file should be done by hand or with a self-created script, resulting in the same CSV-structure.

USEFUL LINKS

onto2bsdd download page, including description & examples

bSDD management page to register your organisation and publish your library to the bSDD

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Technical background

In a similar approach to onto2bsdd, we have developed onto2ids. The user interface of onto2ids requires information of the bSDD dictionary concerned, the IDS that is to be generated, and the prepared CSV-file. When dropping the CSV-file, the tool runs automatically.

The Web application uses JavaScript to parse the content of the CSV and transform that knowledge to an IDS. The premise is that the objects to be checked in the IFC model are classified using the bSDD (or at least its structure). Object properties should be placed in a Propertyset with the same name as the bSDD library.

...preparations

Just like the onto2bsdd application, onto2ids uses extracted data from the ontology by querying the SPARQL endpoint. The CSV file contains fewer variables than the onto2bsdd-CSV, carrying information about the (1) ontology classification, (2) its IFC counterpart and (3) associated properties. Additionally to onto2bsdd, IDS requires information about property cardinality.

	Variable	Description
1	ontoClassPrefLabel	Human readeble
	ontoClassURI	Unique identifier
2	ifcClassLabel	IFC entity
3	ontoPropertyPrefLabel	Human readeble
	ontoPropertyURI	Unique identifier
	ontoPropertyDatatype	Datatype
	ontoPropertyEnumValues	Enumeration values
	*ontoPropertyCardinalityMin	Minimum cardinality
	*ontoPropertyCardinalityMax	Maximum cardinality

* The IDS (v1.0) file format uses a single attribute called "cardinality," which can be "prohibited," "optional," or "required." However, the CSV file uses two attributes for cardinality (min and max), conforming to the W-OTL structure. The tool onto2ids converts the combination of these two CSV variables into the appropriate cardinality value for IDS.

QUICK TIPS

Check the generated IDS-file with the validation script published by buildingSMART. It is built in the IDSeditor from ACCA (free usable in the usBIM cloud) and the auditing webservice of xbim.

USEFUL LINKS

onto2ids download page, including description & examples

usBIM cloud system

Xbim IDS audit for checking the syntax of your newly created IDS

Result

We have used both onto2bsdd and onto2ids in the context of the Waternet case study. With each, their SPARQL query was executed on the two different Linked Data datasets in conjunction: the W-OTL and the alignment between that ontology and IFC.

Currently, the W-OTL lacks information to provide the IDS with cardinalities for properties in information deliveries. As a temporary work-around to test the technical viability, we let the SPARQL query return that each property is required minimally once per element.

RESULT LINKS

bSDD input file made by onto2bsdd

bSDD platform with data from onto2bsdd

IDS file made by onto2ids

Evaluation

The screenshots on the right side are taken from ACCA Software usBIM. In the first, actions are simulated that take place in authoring software. An IFC model was enriched with both classifications to W-OTL classes and with W-OTL properties, both served from the bSDD, on geometric elements selected for the evaluation.

The second screenshot shows that the enriched IFC model has been verified against the IDS generated.

Future work

The advantage of automatically generating bSDD and IDS formats from an ontology is that the same knowledge can be easily adopted in various contexts. We believe the developed applications would benefit from further integration into an automated pipeline, using direct SPARQL instead of the CSV-stage.

With the technical aspect proven feasible, it is now possible to move on to truly adopting these principles in practice and improve collaborations between clients and contractors. Let's seal those pipes!

...on the W-OTL

Work is needed on the W-OTL to determine the information required for a specific project phase or use case to generate an IDS with a specific scope. To be fully IDS-enabled, property cardinality should be included to the W-OTL.