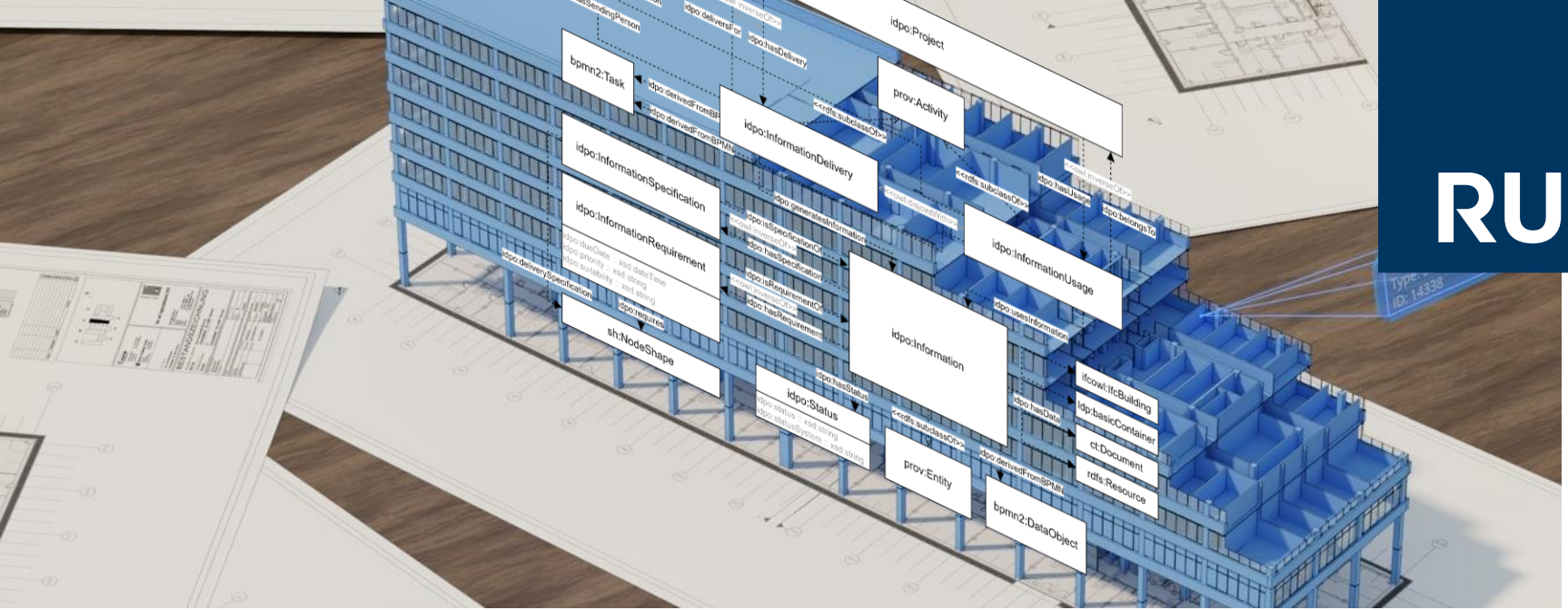

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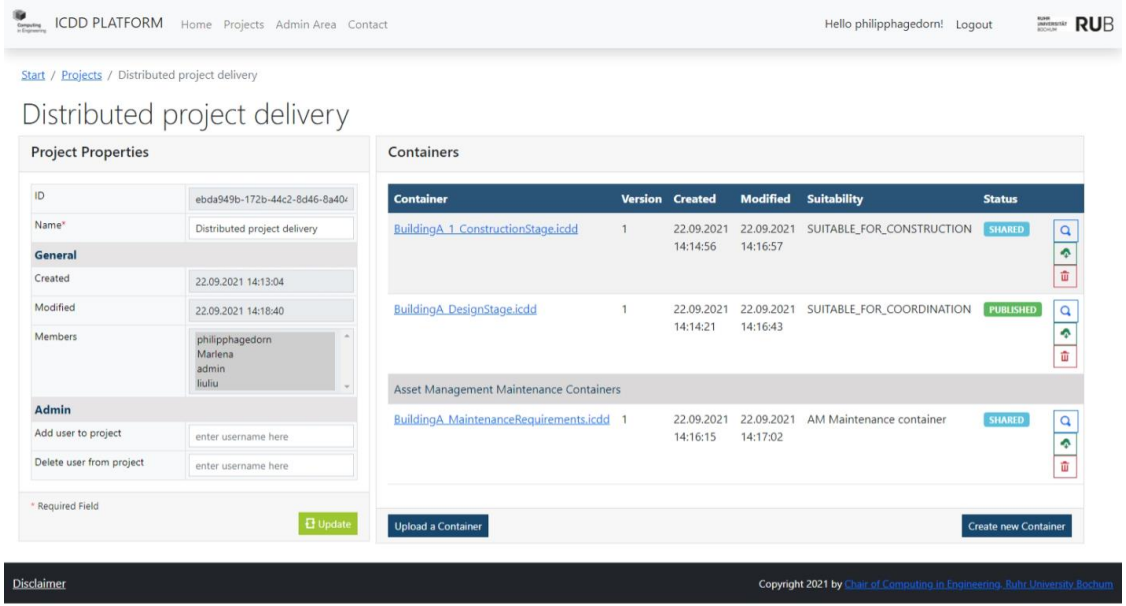
BPMN-related Ontology for Modeling the Construction Information Delivery of Linked Building Data

LDAC 2021 | 12.10.2021 | Philipp Hagedorn and Markus König

Motivation

Why an ontology for information delivery?

- processes are usually documented with well established BPMN diagrams
- IDM consists of BPMN diagrams for information delivery
- distributed CDE evolve using Linked Building Data technologies
- ongoing ICDD platform development at RUB



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Motivation

Why an ontology for information delivery?

- related research[1] introduces delivery specifications for ifcOWL-based data sets
- product-process integration using Linked Building Data[2]
- proposed ontology integrates specifications, activities, requirements, and project information

[1] van Berlo, L., Willems, P., Pauwels, P.: Creating information delivery specifications using linked data. In: Proceedings of the 36th CIB W78 2019 Conference. pp. 647-660 (2019)

[2] Karlapudi, J., et al.: Enhancement of BIM Data Representation in Product-Process Modelling for Building Renovation. In: Product Lifecycle Management Enabling Smart X, 594. (2020).

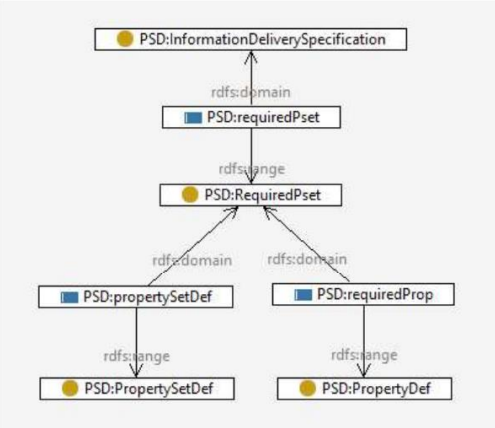


Fig.: The Information delivery specification ontology [1]

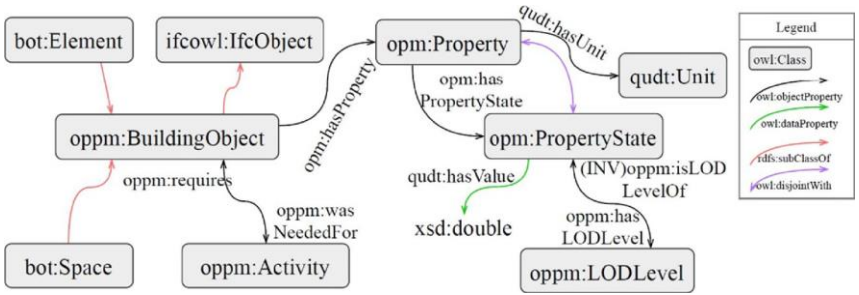
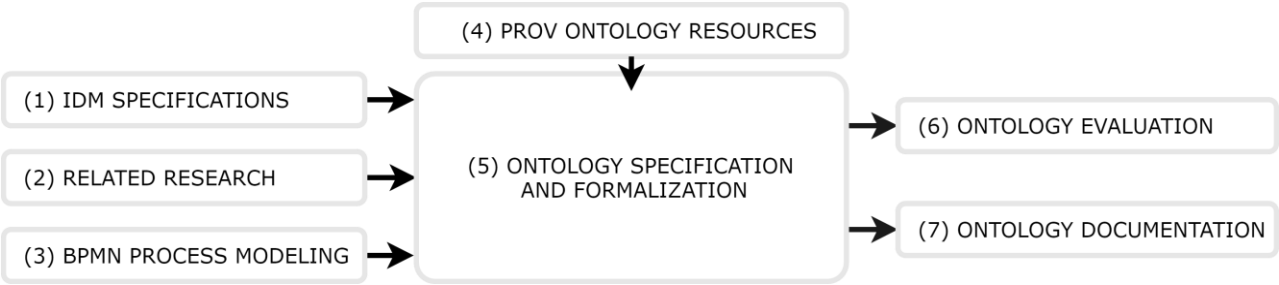


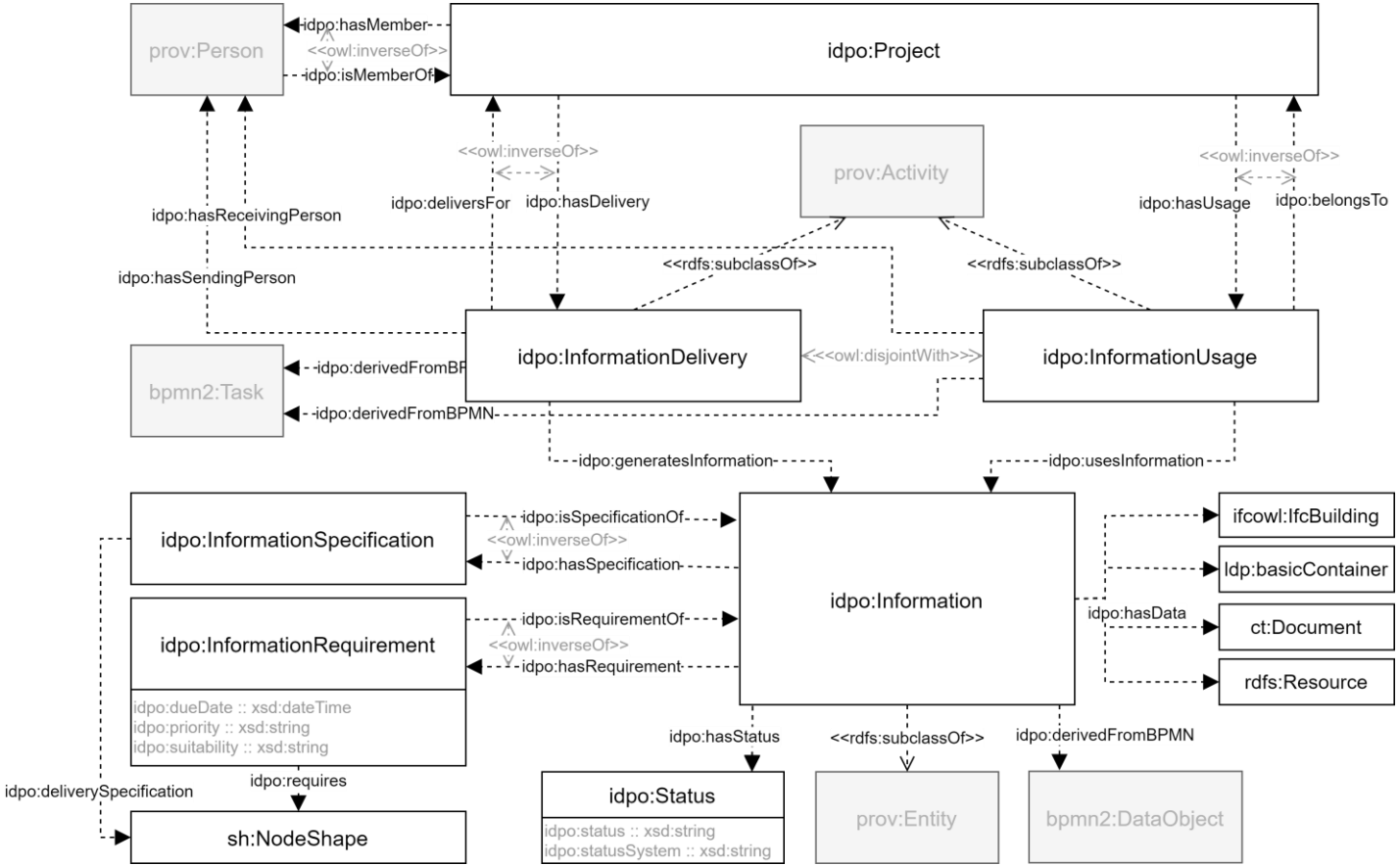
Fig.: The ontology representing the relation between activity, BIM data and LOD [2]

Methodology

- based on NEON Methodology[3] for Ontology development
- acquiring and analyzing knowledge from BIM-specific and general process modeling resources (e.g., IDM, BPMN, PROV) (1-4)
- modeling ontology (5), considering dependencies to existing ontology resources
- evaluating and documenting ontology (6-7), providing ontology information, examples and converter



[3] Gomez-Perez, A., Suarez-Figueroa, M.C.: Neon methodology for building ontology networks: a scenario-based methodology. In: Proceedings of International Conference on Software, Services & Semantic technologies (S3T 2009)



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Information Delivery Processes Ontology (IDPO)

Information

Information [c]

IRI http://w3id.org/idpo#Information

Description

This class is used to represent a set of data summarized as information. Information can be generated and used. Instances of this class can be derived from bpmn2:DataObject individuals. This class is a subClass of prov:Entity which allows to associate additional provenance information.

Super-classes

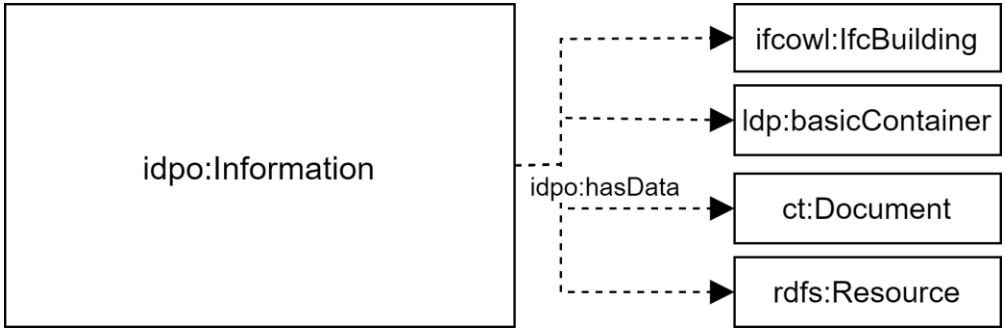
prov:Entity [c]
owl:Thing [c]

In domain of

idpo:hasRequirement [op]
idpo:isGeneratedBy [op]
idpo:hasData [op]
idpo:isUsedBy [op]
idpo:derivedFromBPMN [op]
idpo:hasSpecification [op]
idpo:hasStatus [op]

In range of

idpo:usesInformation [op]
idpo:isStatusOf [op]
idpo:isRequirementOf [op]
idpo:isSpecificationOf [op]
idpo:generatesInformation [op]



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Information Delivery Processes Ontology (IDPO)

Information Delivery

Information Delivery [c]

IRI	http://w3id.org/idpo#InformationDelivery
Description	This class is used to represent the activity of generation information regarding defined information requirements and delivery specifications. Instances of this class can be derived from bpmn2:Task individuals. This class is a subClass of prov:Activity which allows to associate additional provenance information.
Super-classes	owl:Thing [c] prov:Activity [c]
In domain of	idpo:generatesInformation [op] idpo:hasSendingPerson [op] idpo:derivedFromBPMN [op] idpo:deliversFor [op]
In range of	idpo:isGeneratedBy [op] idpo:hasInformationDelivery [op]

derived from BPMN object [op]

IRI	http://w3id.org/idpo#derivedFromBPMN
Description	Associates the BPMN object from which this individual has been derived
Super-properties	owl:topObjectProperty
Domain(s)	idpo:Information [c] idpo:InformationDelivery [c] idpo:InformationUsage [c]
Range(s)	bpmn2:DataObject [c] bpmn2:Task [c]

Information Delivery Processes Ontology (IDPO)

Information Requirement

Information Requirement [c]

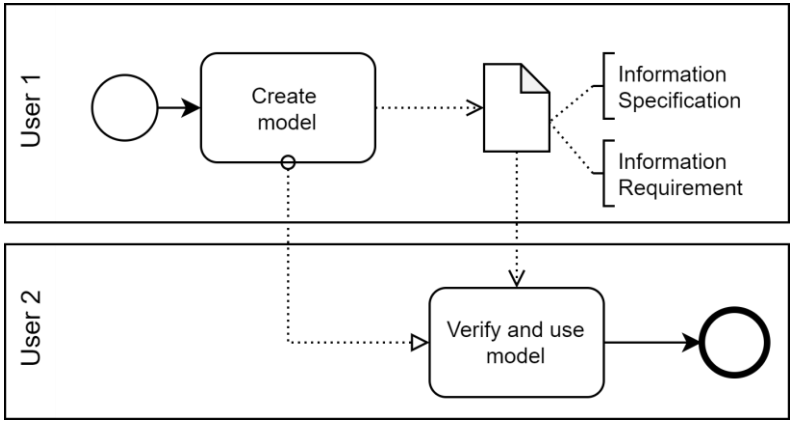
IRI	http://w3id.org/idpo#InformationRequirement
Description	This class contains the information requirements for an associated information individual.
Super-classes	owl:Thing [c]
In domain of	idpo:dueDate [dp] idpo:requires [op] idpo:suitability [dp] idpo:priority [dp] idpo:isRequirementOf [op]
In range of	idpo:hasRequirement [op]

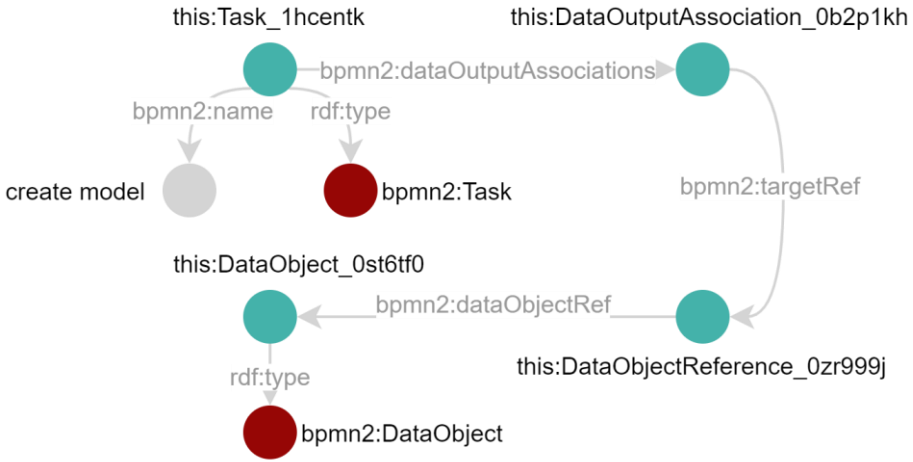
requires [op]

IRI	http://w3id.org/idpo#requires
Description	Represents the concrete requirement of delivered information as a sh:NodeShape oder any other rdfs:Resource on the dataset and/or document level
Super-properties	owl:topObjectProperty
Domain(s)	idpo:InformationRequirement [c]
Range(s)	sh:Shape [c]

Evaluation case 1: From BPMN to IDPO

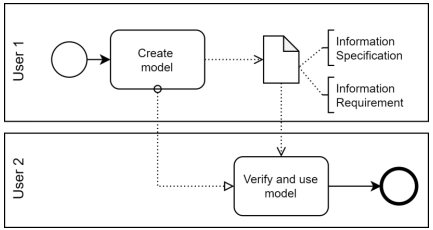
Minimum working sample

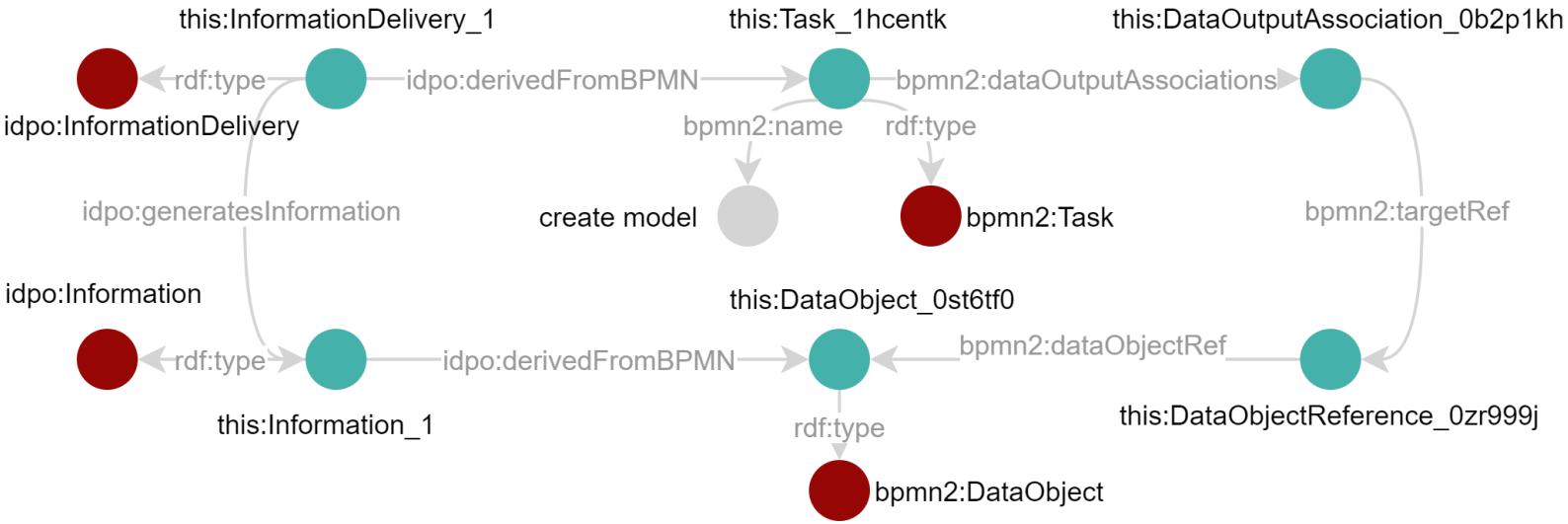




Evaluation case 1: From BPMN to IDPO

Minimum working sample





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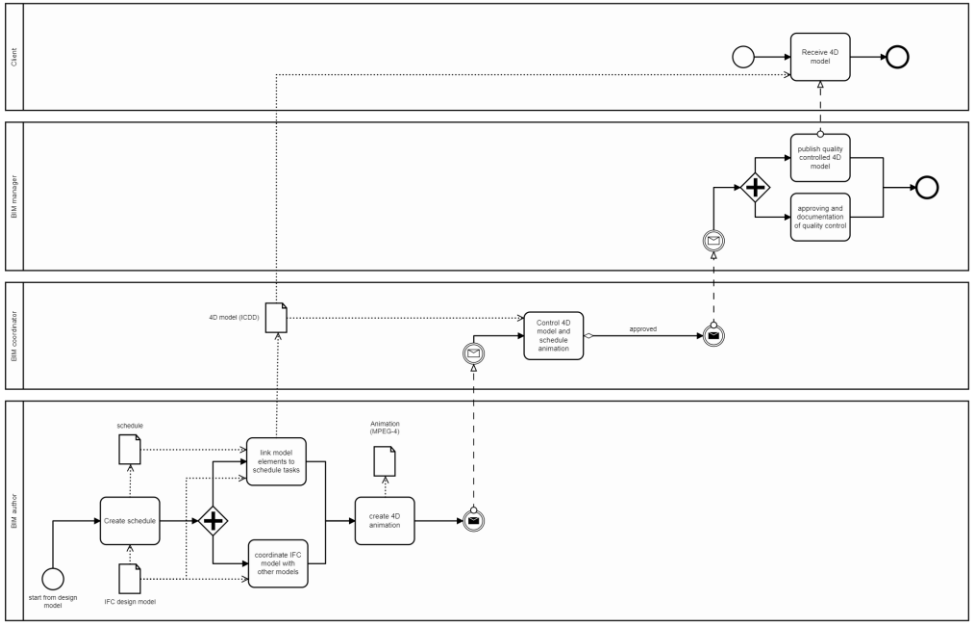
Evaluation case 1: From BPMN to IDPO

More complex sample



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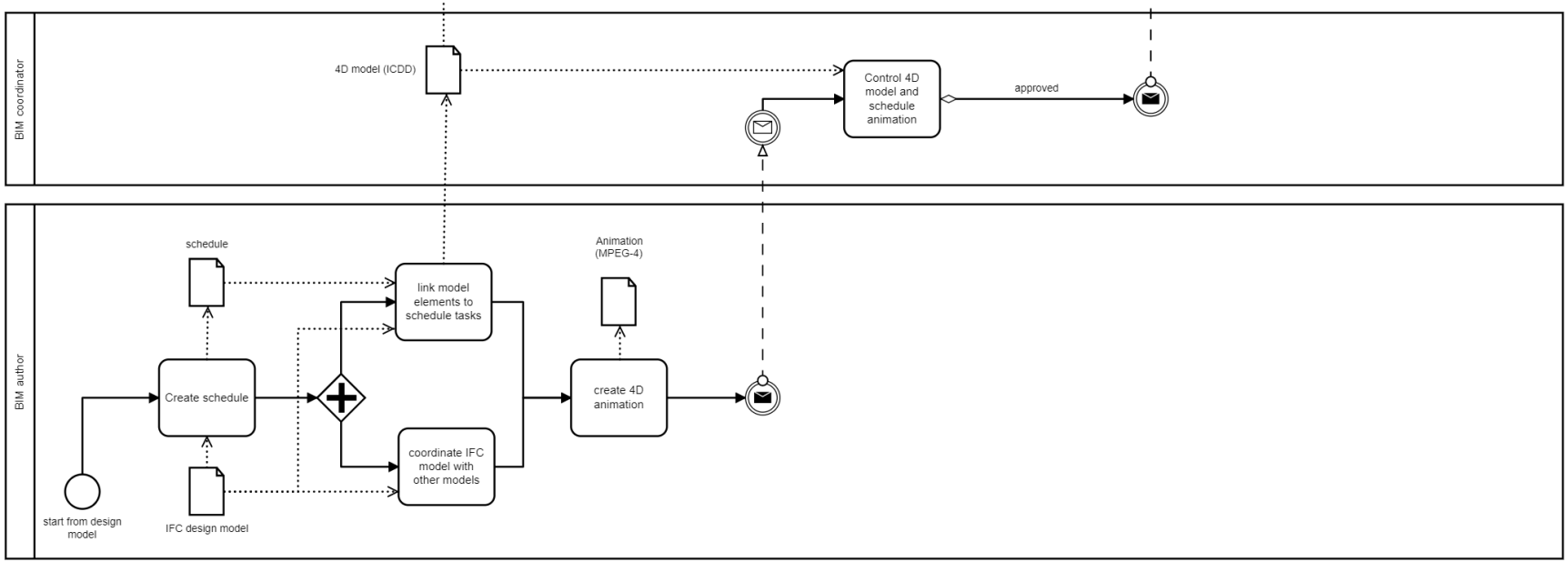
Evaluation case 1: From BPMN to IDPO

More complex sample



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Evaluation case 1: From BPMN to IDPO

Converter

Convert from BPMN

Input file (*.bpmn, *.xml)

Datei auswählen diagram_o...nes.bpmn

Conversion method

Convert to IDPO ontology

Start Conversion

Convert

Input data

```
<?xml version="1.0" encoding="UTF-8"?>
<definitions xmlns="http://www.omg.org/spec/BPMN/20100524/MODEL"
xmlns:bpmndi="http://www.omg.org/spec/BPMN/20100524/DI"
xmlns:dc="http://www.omg.org/spec/DD/20100524/DC"
xmlns:di="http://www.omg.org/spec/DD/20100524/DI"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:modeler="http://camunda.org/schema/modeler/1.0" id="Definitions_06lg7wd"
targetNamespace="http://bpmn.io/schema/bpmn" exporter="bpmn-js (https://demo.bpmn.io)"
exporterVersion="8.7.2" modeler:executionPlatform="Camunda Platform"
modeler:executionPlatformVersion="7.14.0">
  <collaboration id="Collaboration_1y4f0m8">
    <participant id="Participant_011og1s" name="BIM author"
processRef="Process_1dawfg1" />
    <participant id="Participant_1ea5pia" name="Client" processRef="Process_1tsnr5g"
/>
    <participant id="Participant_0opg9ce" name="BIM manager"
processRef="Process_024vb7c" />
    <participant id="Participant_19409ag" name="BIM coordinator"
processRef="Process_16d5euw" />
    <messageFlow id="Flow_1ho3ks6" sourceRef="Activity_05vui5g"
```

Output (TTL)

```
instances:InformationRequirement_1vlyqii
        a                       idpo:InformationRequirement ;
        idpo:dueDate            ""^^xsd:dateTime ;
        idpo:isRequirementOf    instances:Information_1vlyqii ;
        idpo:priority           "Default"@en ;
        idpo:requires           [ a       <http://www.w3.org/ns/shacl#NodeShape> ;
                                  <http://www.w3.org/ns/shacl#property>
                                          [ <http://www.w3.org/ns/shacl#minCount>
                                                  1 ;
                                            <http://www.w3.org/ns/shacl#path>
                                                  idpo:hasData
                                          ] ;
                                  <http://www.w3.org/ns/shacl#targetNode>
                                          instances:Information_1vlyqii
                                ] ;
        idpo:suitability        "Default"@en .

instances:InformationUsage_1lasci2
        a                       idpo:InformationUsage ;
```


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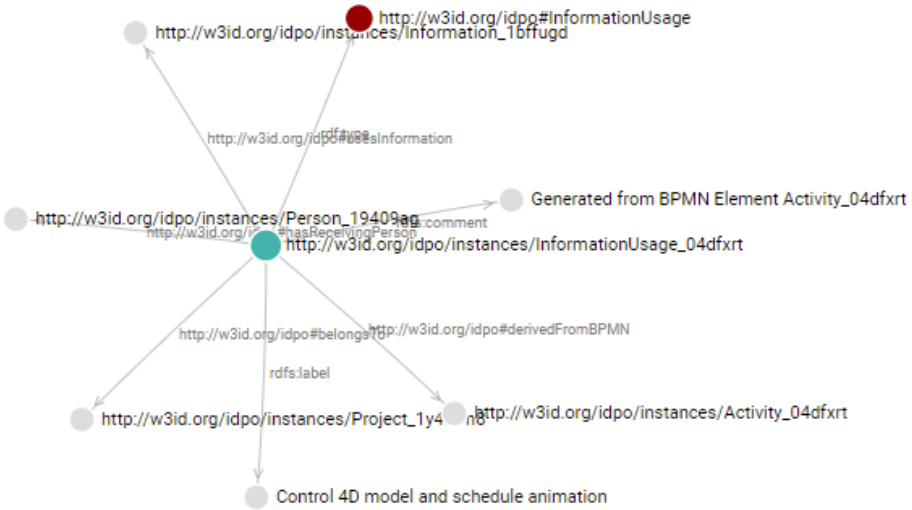
Evaluation case 1: From BPMN to IDPO

More complex sample



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Converter implementation

Converter using SPARQL-Generate[4]

```
PREFIX ite: <http://w3id.org/sparql-generate/iter/>
PREFIX fun: <http://w3id.org/sparql-generate/fn/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX instances: <http://w3id.org/idpo/instances/>
PREFIX idpo: <http://w3id.org/idpo#>
PREFIX prov: <http://www.w3.org/ns/prov#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX bpmn2: <https://www.omg.org/spec/BPMN/2.0#>

GENERATE {
<http://w3id.org/idpo/instances/InformationUsage_{?tID}> a idpo:InformationUsage;
        rdfs:comment "Generated from BPMN Element {?taskId}"@en ;
        idpo:derivedFromBPMN <http://w3id.org/idpo/instances/{?taskId}>;
        rdfs:label ?taskname.

        <http://w3id.org/idpo/instances/{?taskId}>  a bpmn2:Task.

}
SOURCE <http://example.org/document#document0.xml> AS ?source

ITERATOR ite:XPath(?source, "//task", "/task/@id" ) AS ?task ?taskId
WHERE {
     BIND( fun:XPath(?task,"/task/@name"  ) AS ?taskname )
     BIND( fun:XPath(?task,"/task/dataInputAssociation/@id" ) AS ?inputAssoc )
     BIND( strafter(?taskId ,"_") AS ?tID )
    FILTER(bound(?inputAssoc) )
}
```

- SPARQL-Generate[4] with XML input data
- modular XPath queries to iterate over BPMN entities
- implemented using Apache Jena, SPARQL-Generate Maven package and Jakarta REST web service

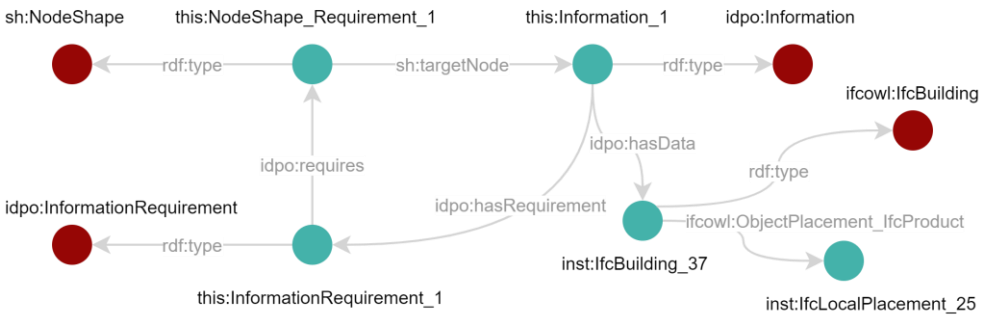
Source code available:
https://github.com/RUB-Informatik-im-Bauwesen/idpo-gen

[4] Maxime Lefrançois et al. A SPARQL extension for generating RDF from heterogeneous formats, In Proc. Extended Semantic Web Conference, ESWC, May 2017, Portoroz, Slovenia

Evaluation case 2

SHACL Validation

- stores the validation requirements directly connected to the information entities
- uses SHACL node shapes with direct referral to the target information objects
- validating ifcOWL data connected to the information entity
- sample data set available: https://icdd.vm.rub.de/ontology/idpo/instances.ttl




```
this:NodeShape_Requirement_1
  rdf:type sh:NodeShape ;
  sh:property [
      rdf:type sh:PropertyShape ;
         sh:path <https://icdd.vm.rub.de/ontology/idpo#hasData> ;
         sh:minCount 1 ;
         sh:qualifiedMinCount 1 ;
         sh:qualifiedValueShape [
              rdf:type sh:NodeShape ;
              sh:property [
                   sh:path ifcowl:objectPlacement_IfcProduct ;
                   sh:qualifiedMinCount 1 ;
                   sh:qualifiedValueShape [
                   sh:property [
                        sh:path rdf:type ;
                        sh:maxCount 1 ;
                        sh:minCount 1 ;
                        sh:value ifc:IfcLocalPlacement ;
                        ] ;
                   ] ;
              ] ;
         ] ;
    ];
  sh:targetNode this:Information_1 ;
.
```

Conclusion

- proposes the IDPO ontology
- covers the interrelation between business processes, exchange requirements, and LBD
- reuses well-established concepts and patterns of PROV
- converter from BPMN XML to IDPO RDF
- feasibility shown in two demo scenarios
- implementation into the ICDD Web platform currently under development

- GitHub: https://github.com/RUB-Informatik-im-Bauwesen/idpo

w3id.org/idpo

GitHub