



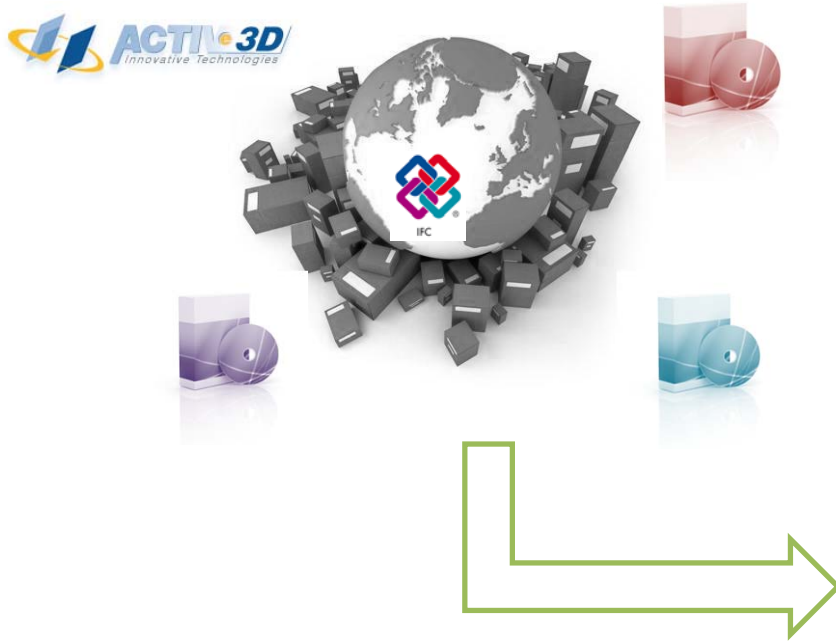
CHECKSEM
SEMANTICINTELLIGENCE RESEARCH

A Rule Based System for Semantical Enrichment of Building Information Exchange

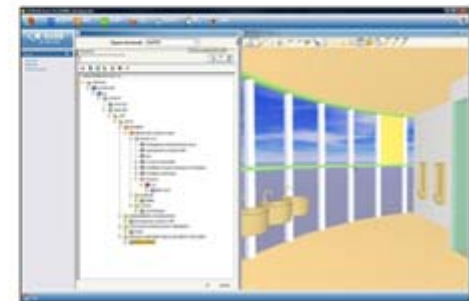
Tarcisio Mendes de Farias, Ana Roxin and Christophe Nicolle



- Standardization of BIM: interoperability through IFC files



Generation of the Facility Management BIM



- Extraction of a subgraph of entities from the IFC file(s) related to a business process.
 - Manuel and fastidious process

[Ifc2DCompositeCurve](#)
[IfcActionRequest](#)
[IfcActor](#)
[IfcActorRole](#)
[IfcActuatorType](#)
[IfcAddress](#)
[IfcAirTerminalBoxType](#)
[IfcAirTerminalType](#)
[IfcBuildingElement](#)
[IfcBuildingElementComponent](#)
[IfcBuildingElementPart](#)
[IfcBuildingElementProxy](#)
[IfcBuildingElementProxyType](#)
[IfcBuildingElementType](#)
[IfcBuildingStorey](#)
[IfcCShapeProfileDef](#)
[IfcCableCarrierFittingType](#)
[IfcCableCarrierSegmentType](#)
[IfcCableSegmentType](#)
[IfcCalendarDate](#)
[IfcCartesianPoint](#)

```

#668 = IFCFLOWFITTING ('36dWzTSVLSUgprRKvvZSsH', #5, 'macro', $, $, #669, 10.
#669 = IFCCARTESIANPOINT ((0., 0., 0.));
#670 = IFCCARTESIANTRANSFORMATIONOPERATOR3DNONUNIFORM ($, $, #669, 10.
#671 = IFCMAPPEDITEM (#304, #670);
#672 = IFCSHAPEREPRESENTATION (#13, $, 'MappedRepresentation', (#671))
#673 = IFCPRODUCTDEFINITIONSHAPE ($, $, (#672));
#674 = IFCDIRECTION ((0., 0., 1.));
#675 = IFCDIRECTION ((0., 1., 0.));
#676 = IFCCARTESIANPOINT ((29375., 26350., 84500.));
#677 = IFCCARTESIANPOINT ((29375., 26350., 84500.));
#678 = IFCLocalPlacement ($, #677);
#679 = IFCFLOWSEGMENT ('2LrYSLvdv4fu6ARczIm08E', #5, 'macro', $, $, #680, 10.
#680 = IFCCARTESIANPOINT ((30., -33.4848, 80.839459000000001));
#681 = IFCCARTESIANPOINT ((30., -33.4848, 80.839459000000001));
#682 = IFCCARTESIANPOINT ((0., -30.423333, 73.448423000000001));
#683 = IFCCARTESIANPOINT ((0., 0., 79.5));
#684 = IFCPOLYLOOP ((#680, #681, #682, #683));
  
```

Plumbing View



Architect View

- More than 800 entities
- Vocabulary and data structure is not easily understandable

- Modification or creation of entities and roles
 - Incompatibility with applications based on an old IFC version;
- An application based on a new version of the IFC standard can be not fully backward compatible.

5.3.3.6 IfcTask

FR Tâche

DE Aufgabe

An IfcTask is an identifiable unit of work to be carried out in a construction project.

A task is typically used to describe an activity for the construction or installation of products, but is not limited to these types. For example it might be used to describe design processes, move operations and other design, construction and operation related activities as well.

Quantities of resources consumed by the task are dealt with by defining the *IfcElementQuantity* for the resource and not at the instance of *IfcTask*.

HISTORY New entity in IFC1.0. Renamed from *IfcWorkTask* in IFC2x.

IFC4 CHANGE Attributes *TaskTime* and *PredefinedType* added. *IfcMove* and *IfcOrderRequest* has been removed in IFC4 and are now represented by *IfcTask*. *IfcRelAssignsTasks* relationship has been removed as well.

- Web of data
 - For humans and machines
 - Based on the standard representations and formal resources

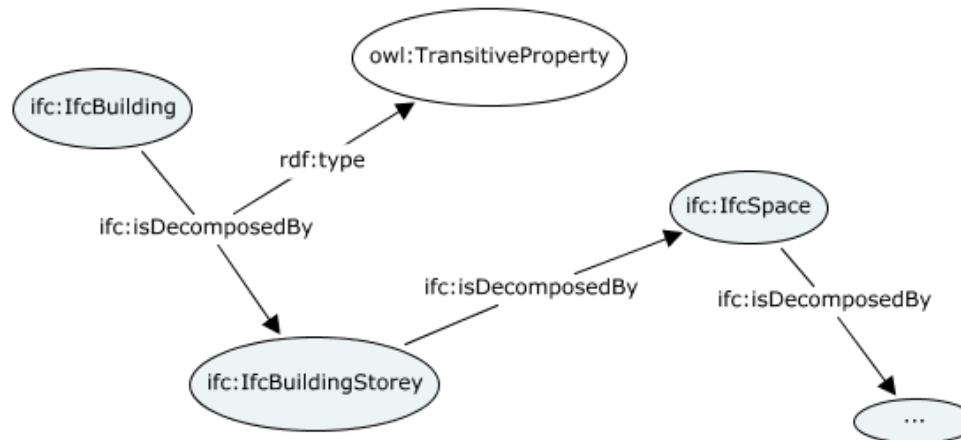
- Definition of an ontology by  :
 - *“Ontology is a term borrowed from philosophy that refers to the science of describing the kinds of entities in the world and how they are related.”*

- An ontology comprises:
 - TBox
 - ABox





- OWL is a language for defining and instantiating Web ontologies (classes, properties and instances)
 - Management of the semantic interoperability
 - Inference capacity (DL-based)



- SWRL is a rule language that complements DL-based languages.
 - Reasoning problems involving data.

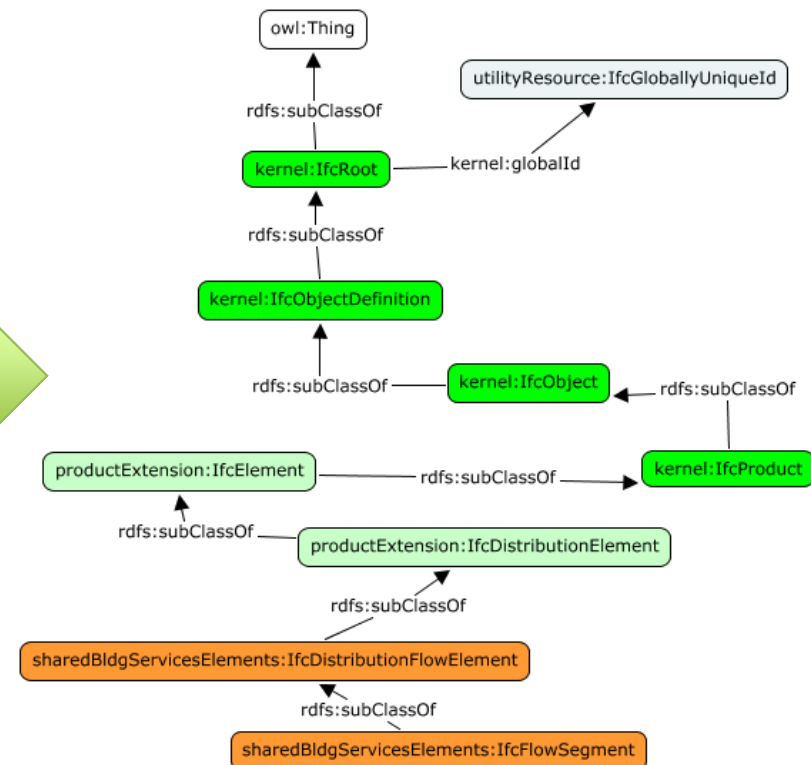


o Beetz et al. propose a semi-automatic conception of an IFC ontology

```

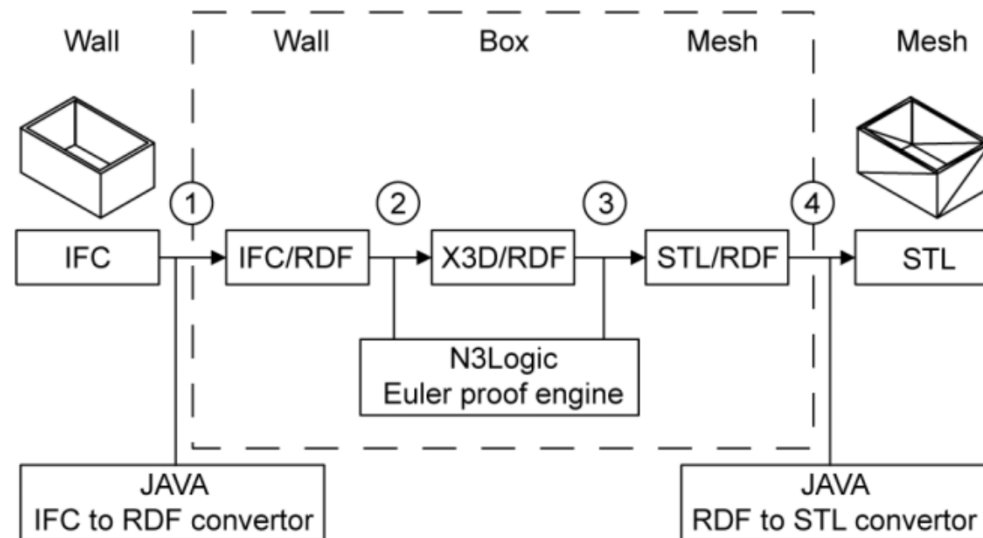
ENTITY IfcFlowSegment;
ENTITY IfcRoot;
  GlobalId
  OwnerHistory
  Name
  Description
  : IfcGloballyUniqueId;
  : IfcOwnerHistory;
  : OPTIONAL IfcLabel;
  : OPTIONAL IfcText;
ENTITY IfcObjectDefinition;
INVERSE
  HasAssignments
  IsDecomposedBy
  Decomposes
  HasAssociations
  : SET OF IfcRelAssigns FOR RelatedObjects;
  : SET OF IfcRelDecomposes FOR RelatingObject;
  : SET [0:1] OF IfcRelDecomposes FOR RelatedObjects;
  : SET OF IfcRelAssociates FOR RelatedObjects;
ENTITY IfcObject;
  ObjectType
  : OPTIONAL IfcLabel;
INVERSE
  IsDefinedBy
  : SET OF IfcRelDefines FOR RelatedObjects;
ENTITY IfcProduct;
  ObjectPlacement
  Representation
  : OPTIONAL IfcObjectPlacement;
  : OPTIONAL IfcProductRepresentation;
INVERSE
  ReferencedBy
  : SET OF IfcRelAssignsToProduct FOR Rel
ENTITY IfcElement;
  Tag
  : OPTIONAL IfcIdentifier;
INVERSE
  HasStructuralMember
  FillsVoids
  ConnectedTo
  HasCoverings
  HasProjections
  ReferencedInStructures
  HasPorts
  HasOpenings
  IsConnectionRealization
  ProvidesBoundaries
  ConnectedFrom
  ContainedInStructure
  : SET OF IfcRelConnectsStructuralElement FOR Relati
  : SET [0:1] OF IfcRelFillsElement FOR RelatedBuildi
  : SET OF IfcRelConnectsElements FOR RelatingBuildi
  : SET OF IfcRelCoversBldgElements FOR RelatingBuild
  : SET OF IfcRelProjectsElement FOR RelatingElement;
  : SET OF IfcRelReferencedInSpatialStructure FOR Rel
  : SET OF IfcRelConnectsPortToElement FOR RelatedEle
  : SET OF IfcRelVoidsElement FOR RelatingBuildingEle
  : SET OF IfcRelConnectsWithRealizingElements FOR Re
  : SET OF IfcRelSpaceBoundary FOR RelatedBuildingEle
  : SET OF IfcRelConnectsElements FOR RelatedElement;
  : SET [0:1] OF IfcRelContainedInSpatialStructure FO
ENTITY IfcDistributionElement;
ENTITY IfcDistributionFlowElement;
INVERSE
  HasControlElements
  : SET [0:1] OF IfcRelFlowControlElements FOR Relati
ENTITY IfcFlowSegment;
END ENTITY;
  
```

IFC to OWL



- Defined types are not well translated on OWL
- Express LIST is translated as OWL List

- Pauwels et al. deal with the interoperability of 3D information from IFC to X3D and SLT
 - N3 Logic rules applied to IfcOWL





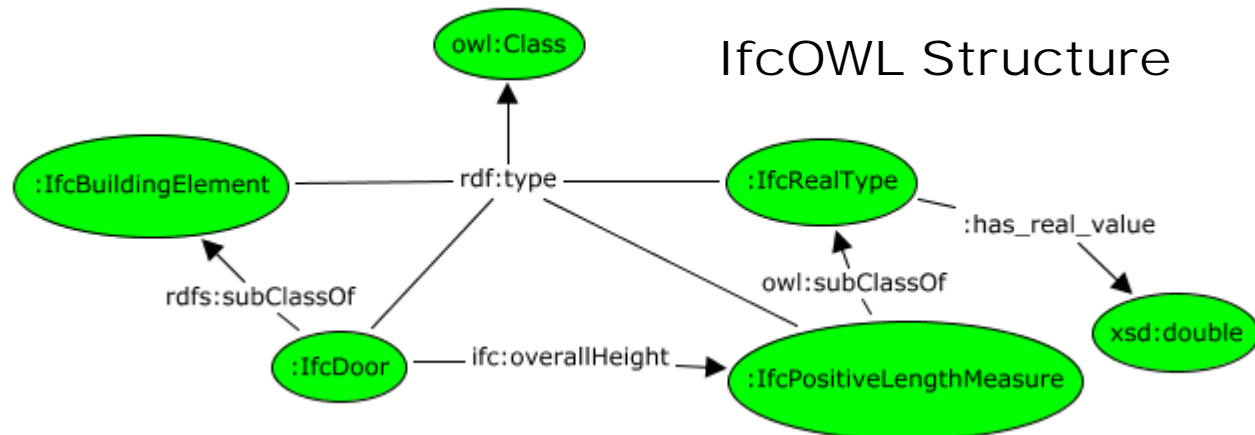
- The enrichment of the IFC model without compromising the system interoperability
- Allowing coexistence of data from different versions of IFC files



- IFC 2x3 EXPRESS specification to OWL
- Translations rules based on IfcOWL
 - IFC Entity => OWL Class
 - IFC Attribute => OWL Property

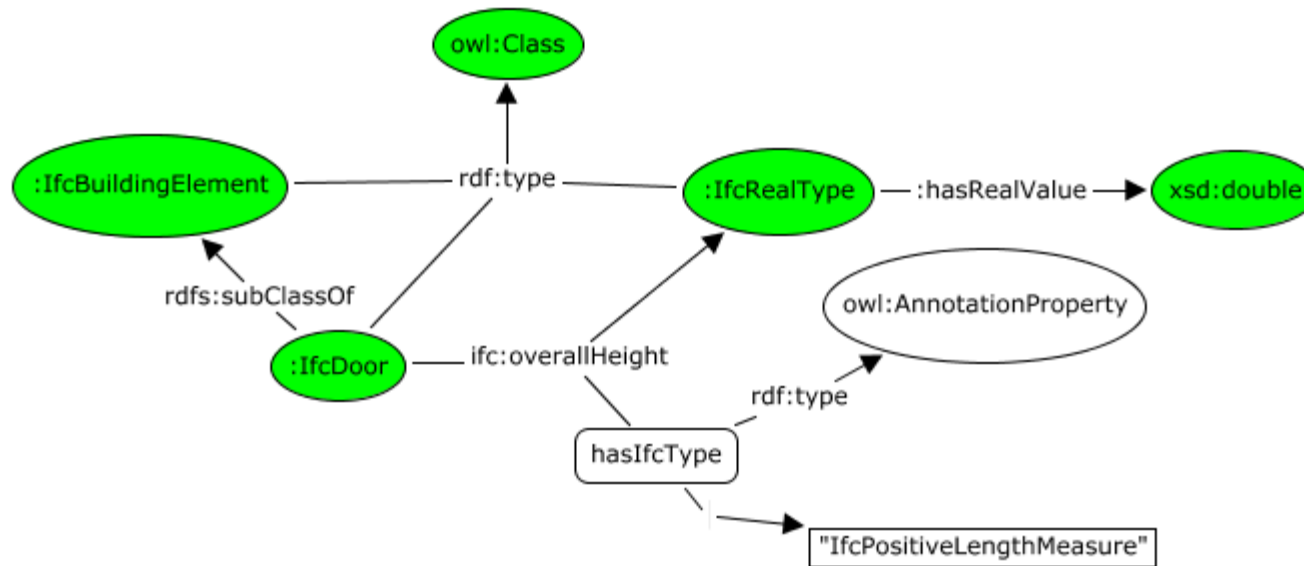
EXPRESS specification:

```
ENTITY IfcDoor
  SUPERTYPE OF (IfcDoorStandardCase)
  SUBTYPE OF (IfcBuildingElement):
    OverallHeight      : OPTIONAL IfcPositiveLengthMeasure;
    OverallWidth       : OPTIONAL IfcPositiveLengthMeasure;
END_ENTITY;
```





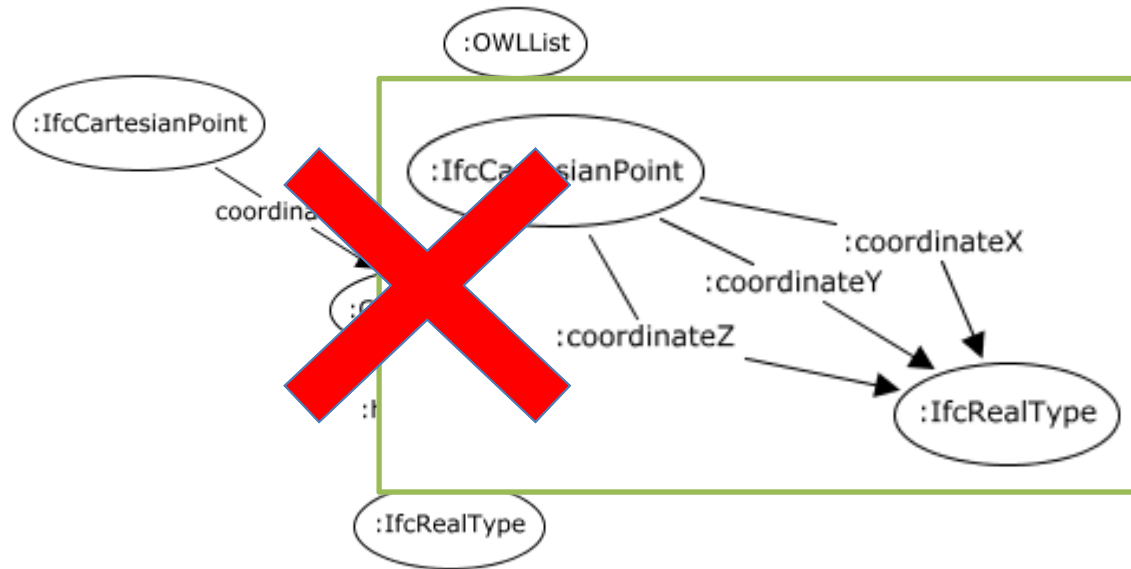
IfcOWL Modified: Defined types (117)



- Merge Defined Types that have the same data type in one class
 - (i.e.: IfcVolumeMeasure, IfcAreaMeasure, IfcPositiveLengthMeasure are real values)
- Some Defined Types are indeed enumerations
 - IfcTextAlignment is mapped as the data property hasTextAlignment rdfs:range {"left", "right", "center", "justify"}.



IfcOWL Modified: Collections

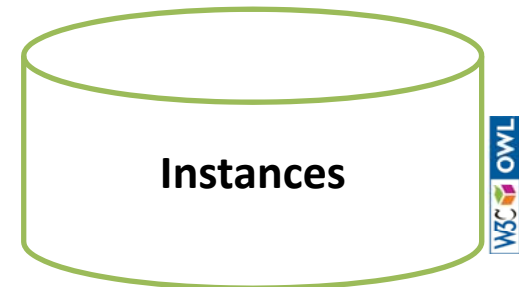


- If the order is not important, a collection (LIST) is mapped as values of a non-functional OWL property
- If the order is important different properties are created



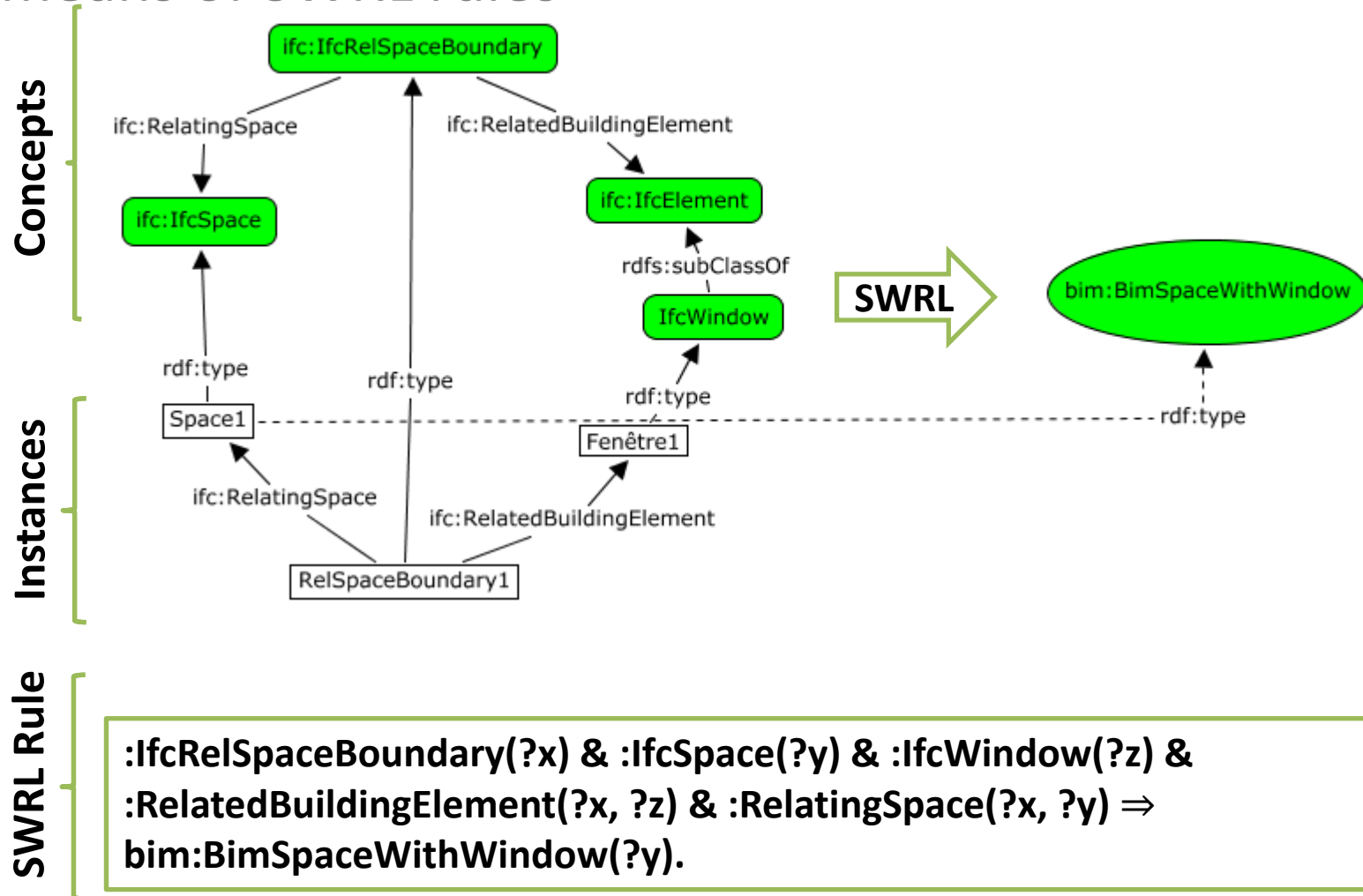
- Populating the so-built **Tbox** with information from IFC files
- One repository per IFC file

```
#3197=IFCAXIS2PLACEMENT3D(#3196,$,$);  
#3198=IFCPOLYGONALBOUNDEDHALFSPACE(#3195,.T.,#3197,#3192);  
#3199=IFCBOOLEANCLIPPINGRESULT(.DIFFERENCE.,#3184,#3198);  
#3200=IFCSHAPEREPRESENTATION(#28,'Body','Clipping',(#3199));  
#3201=IFCPRODUCTDEFINITIONSHAPE($,$,(#3179,#3200));  
#3202=IFCWALLSTANDARDCASE('1iSKq$8HT2UvXyfHrxgRup',#34,  
'Mur de base:G\X\E9n\X\E9rique - 260 mm:193141',$,  
'Mur de base:G\X\E9n\X\E9rique - 260 mm:168419',#3176,#3:  
#3203=IFCQUANTITYLENGTH('Height','',$,2.94);  
#3204=IFCQUANTITYLENGTH('Length','',$,2.015000000000001);  
#3205=IFCQUANTITYLENGTH('Width','',$,0.26);
```





- Defining novel concepts as used by AEC/FM actors by means of SWRL rules

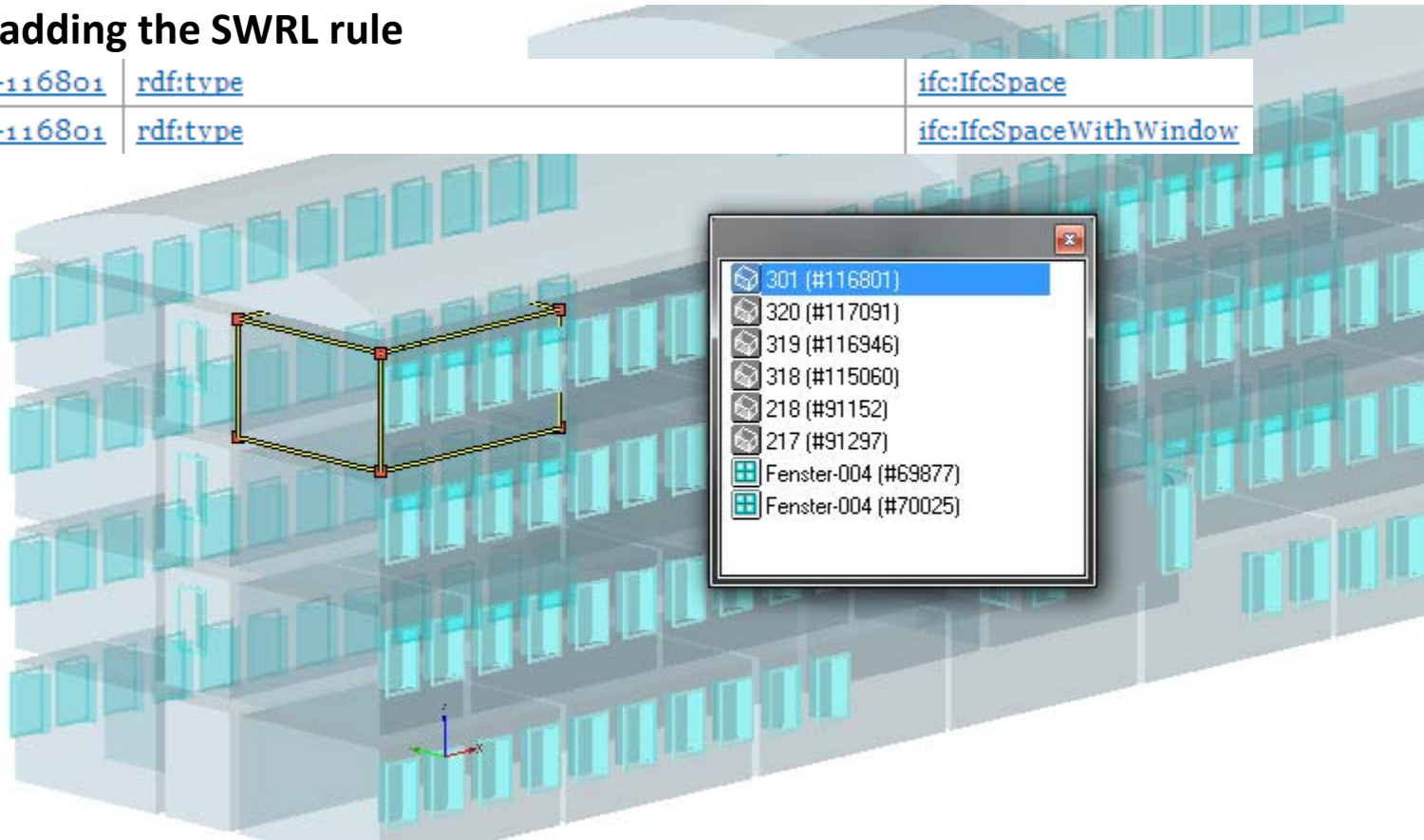


Before adding the SWRL rule

ifc:AC11-116801	rdf:type	ifc:IfcSpace
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After adding the SWRL rule

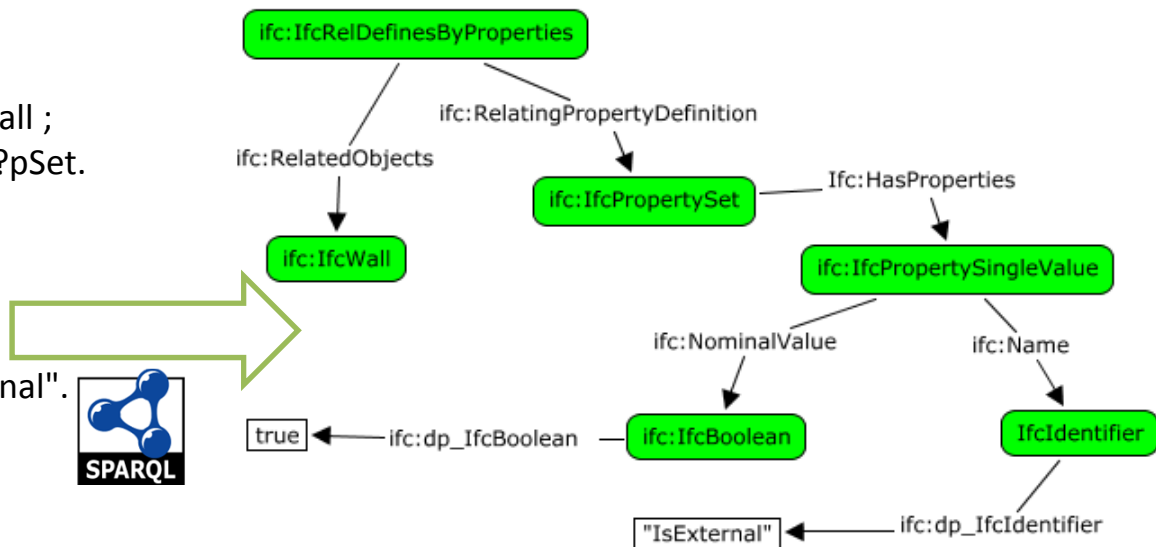
ifc:AC11-116801	rdf:type	ifc:IfcSpace
ifc:AC11-116801	rdf:type	ifc:IfcSpaceWithWindow





- Simplifying the writing of SPARQL queries
- Define a more fine-grained ontology

```
SELECT ?externalWall WHERE {  
  ? externalWall a ifc:IcfWall.  
  ?o a ifc:IcfRelDefinesByProperties;  
    ifc:RelatedObjects ? externalWall ;  
    ifc:RelatingPropertyDefinition ?pSet.  
  ?pSet a ifc:IcfPropertySet;  
    ifc:HasProperties ?p.  
  ?p a ifc:IcfPropertySingleValue;  
    ifc:Name ?name.  
  ?name ifc:dp_IcfIdentifier "IsExternal".  
  ?p ifc:NominalValue ?val.  
  ?val a ifc:IcfBoolean;  
    ifc:dp_IcfBoolean  
    "true"^^xsd:boolean}
```





- With this SWRL rule on top of our TBox:

```
ifc:HasProperties(?a, ?x) & ifc:NominalValue(?x, ?z) & ifc:Name(?x, ?y) &  
ifc:RelPropertyDefinition(?b, ?a) & ifc:RelObjects(?b, ?c) & ifc:IfcWall(?c) &  
ifc:dp_IfcBoolean(?z, true) & ifc:dp_IfcIdentifier(?y, "IsExternal") =>  
:BimExternalWall(?c).
```

- We simplify the previous query as follow:

```
SELECT ?externalWall WHERE { ?externalWall a :BimExternalWall.}
```



- Dynamic handling of the IFC standard's evolution
 - Various versions of IFC standard were deployed
 - Not fully backward and upward compatible
 - The ontology conceived is based on IFC2x3 standard
- Interoperability among different IFC versions



- Backward compatibility:
 - IFC2x4 version has added the entity `IfcPipeSegment` as a subclass of the entity `IfcFlowSegment`
 - “pipe segment” concept is implicit in IFC2x3

```
:IfcFlowSegment(?a) & :IfcDefinesByType(?b) & :RelatedObjects(?b,?a) &  
:RelatingType(?b,?c) & :IfcPipeSegmentType(?c) ⇒ ifc4rc2:IfcPipeSegment(?a).
```

- Upward compatibility
 - IFC2x4 RC2 deletes `IfcAnnotationSymbolOccurrence`
 - Still, its superclass `IfcStyledItem` has been preserved

```
ifc:IfcStyledItem(?x) & ifc:Item(?x, ?y) & ifc:IfcDefinedSymbol(?y) ⇒  
ifc:IfcAnnotationSymbolOccurrence(?x).
```


Rule-based system that aims at easing the processes and the information exchanges related to AEC/FM

Conception of a more suitable IFC ontology based on IfcOWL

Benefits of applying SWRL rules to handle IFC files

- Separate the BIM data structure model (e.g.: IFC) from its semantics
- Increase the data model expressivity without compromising the interoperability made by IFC files
- Increase the interoperability of information exchange among stakeholders.

Comparison of SWRL rules syntax to other ones

- Rule Interchange Format (RIF);
- N3 Logic.

Checking for inconsistencies or ambiguity by introducing new rules