IBPSA Project 1

International Building Performance Simulation Association

Work Package 2.2 - Building Information Modeling (BIM)

Web Meeting, 06 May 2020

Introduction

Goal

- Tool chain from IFC to building performance simulation e.g. in EnergyPlus with semantical and geometrical data enrichment

Work Package Leader

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Contributor to this presentation

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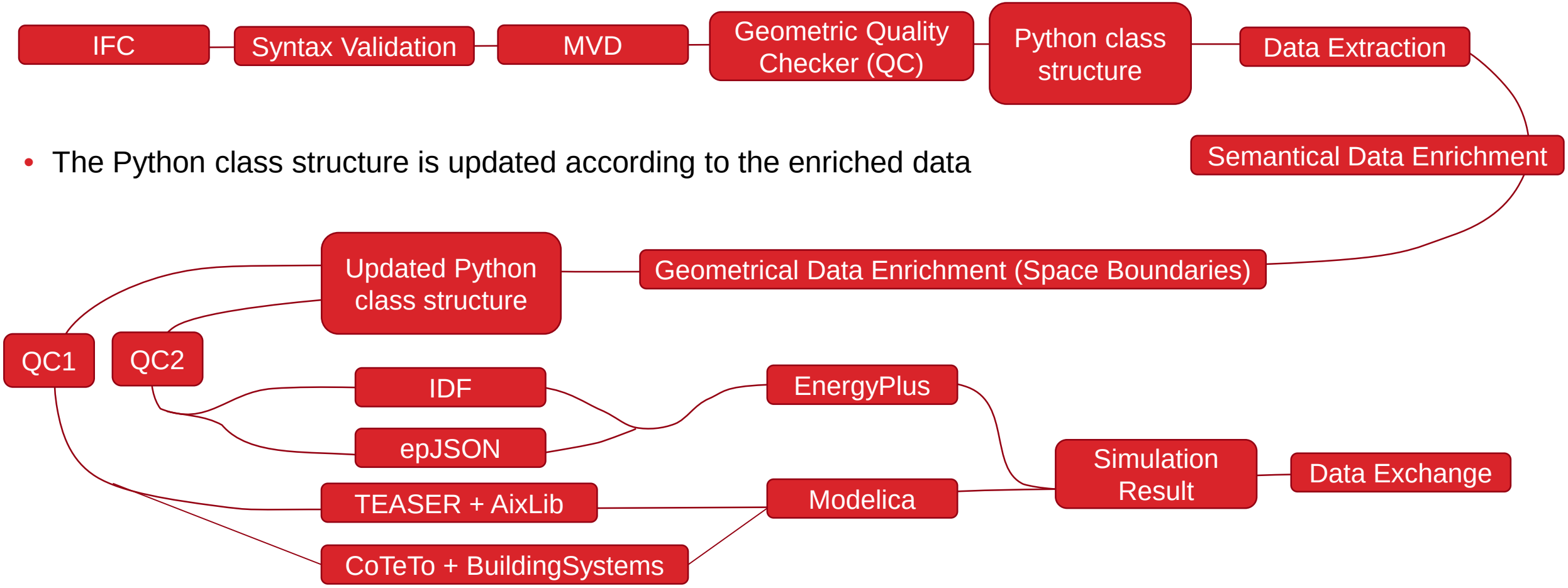
- Nytsch-Geusen, Christoph (UDK Berlin)
- Richter, Veronika (RWTH Aachen University)
- Waluga, Christian (LiNear)

Workflow

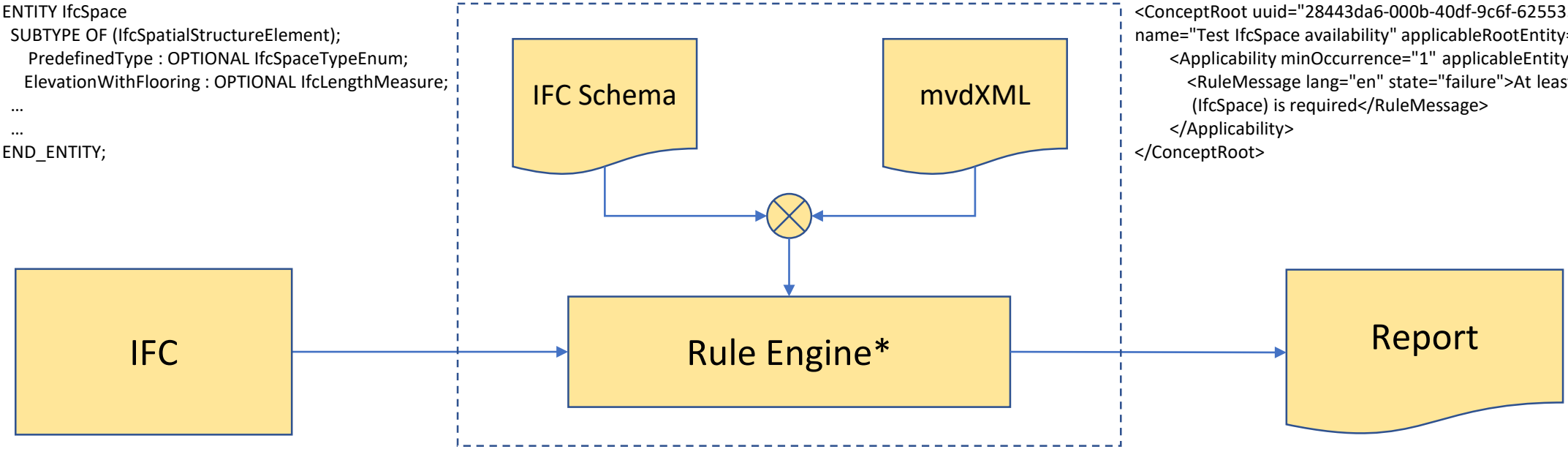
- Subprocesses for simulation model preparation with focus on data enrichment



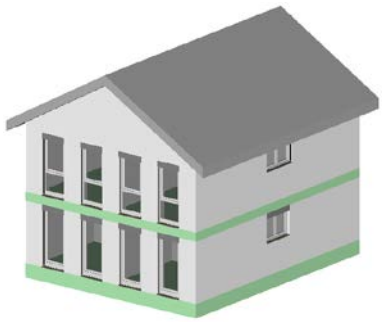
- The Python class structure is updated according to the enriched data

Model View Definition Check

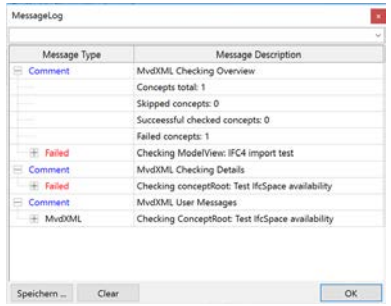
```
ENTITY IfcSpace
  SUBTYPE OF (IfcSpatialStructureElement);
     PredefinedType : OPTIONAL IfcSpaceTypeEnum;
    ElevationWithFlooring : OPTIONAL IfcLengthMeasure;
  …
  …
END_ENTITY;
```




```
<ConceptRoot uuid="28443da6-000b-40df-9c6f-62553300f55f"
name="Test IfcSpace availability" applicableRootEntity="IfcSpace">
    <Applicability minOccurrence="1" applicableEntity="IfcSpace">
      <RuleMessage lang="en" state="failure">At least one room
       (IfcSpace) is required</RuleMessage>
    </Applicability>
</ConceptRoot>
```



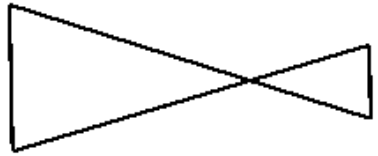
Root Entity	Checking Functionality
IfcProduct	Check name
IfcProduct	Check description
IfcProduct	Check name and description
IfcObjectDefinition	Check name
IfcProject	Check geo reference (IfcMapConversion)
IfcSpace	Check for space boundaries
IfcSpace	Check availability
IfcMaterial	Check material properties



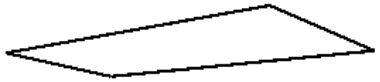
*Download FZKViewer: https://github.com/ibpsa/project1/tree/master/wp_2_2_bim/mvdXML

Building Model Quality Check

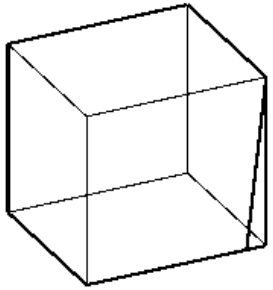
Incorrect Polygons

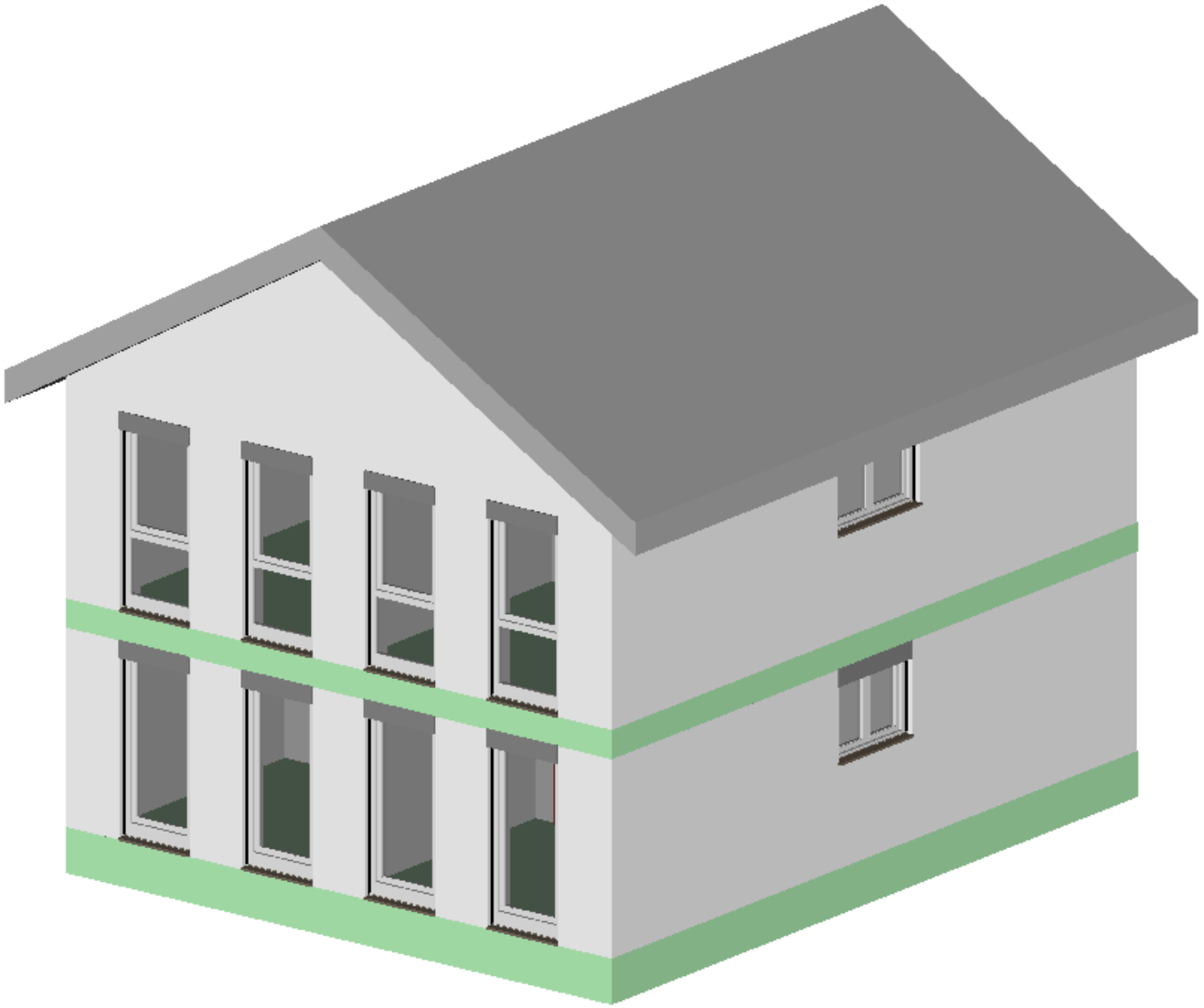


Surface Planarity

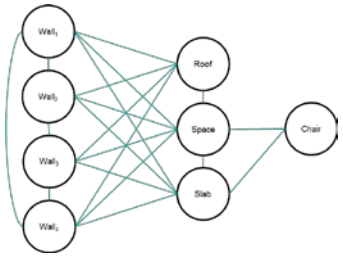


Solid Check

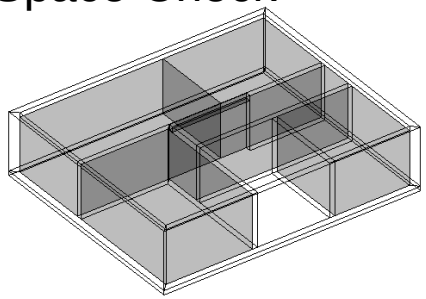




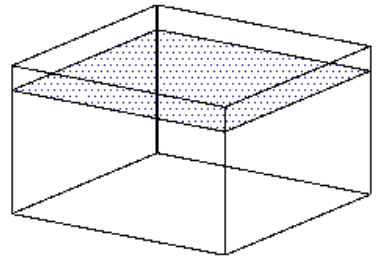
Element Connections



Space Check



Space Boundary Geometry



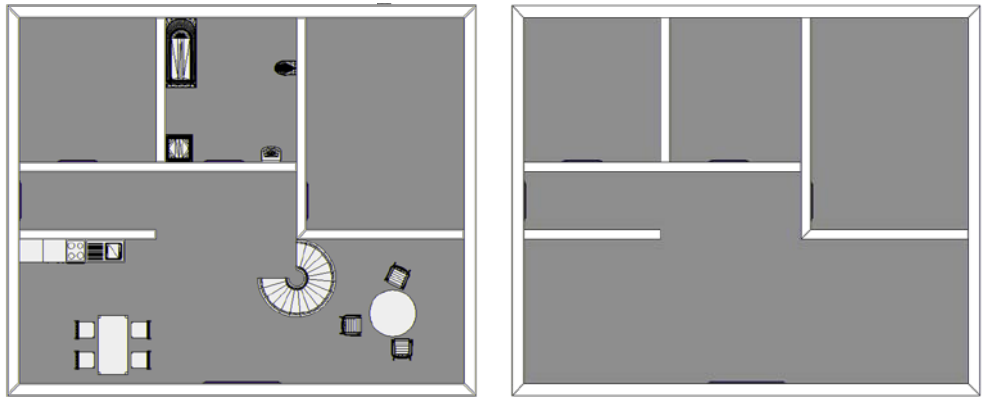
Geometrical Data Enrichment - Space Boundary Generation

IFC

Validation

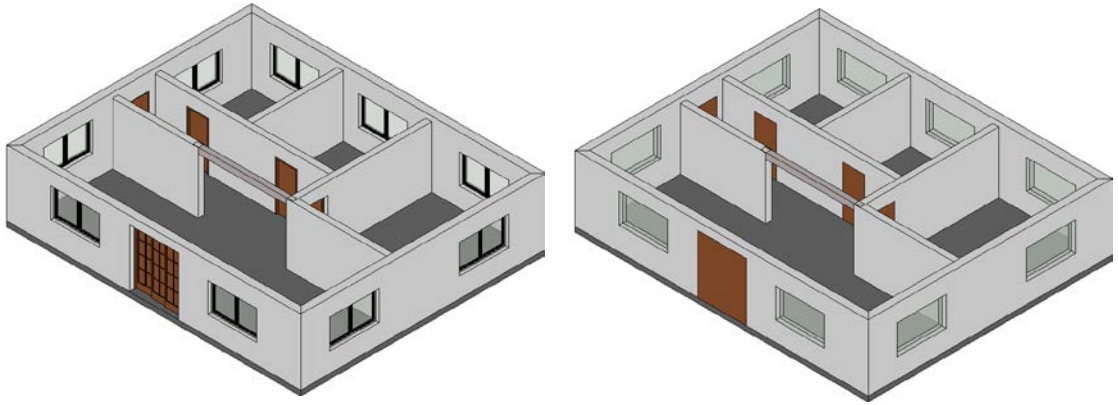
```
In #588657=IfcRelDefinesByProperties('2f7amF3yb3ofhP$vU7oopb',#42,$,$,(),#588639)
() not valid for <attribute RelatedObjects: <set [1:?] of <entity IfcObject>>>
```

Filtering



By IFC class or by user-defined criteria

Simplification



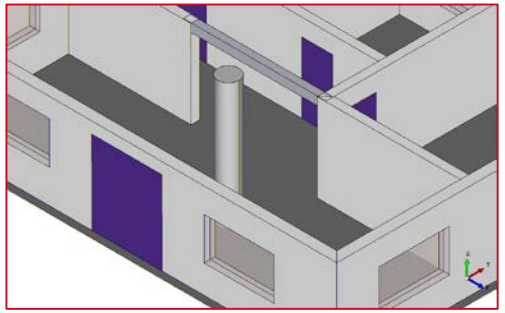
BIM2SIM

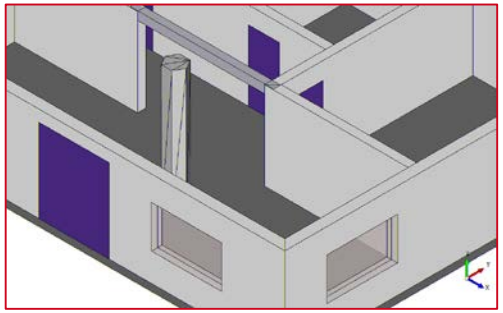
Method development for the generation of simulation models from building information modeling data. Subproject: Development of methodology, process chains and interfaces

RWTH Aachen University
Funding Code: 03ET1562A
Operational time: 2018-05-01 – 2021-04-30
Info: https://www.e3d.rwth-aachen.de/cms/E3D/Forschung/Projekte/~rdrk/Bim2Sim/?lidx=1

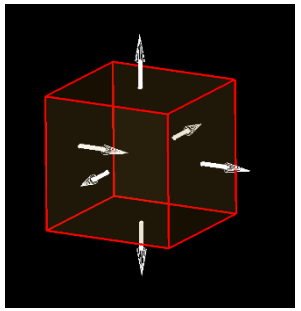
Geometrical Data Enrichment - Space Boundary Generation

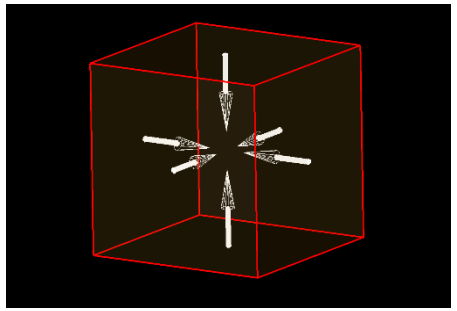
Planar Faces

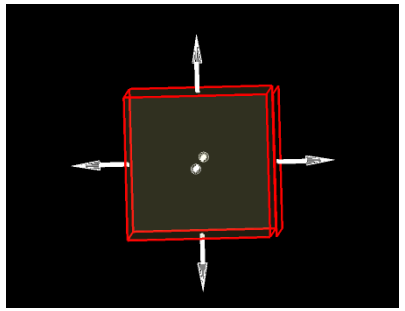




Geom Checker

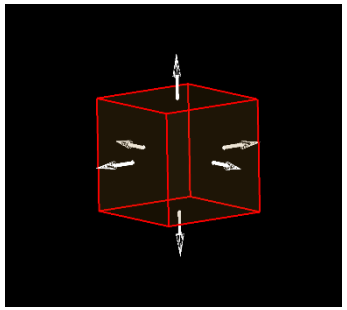




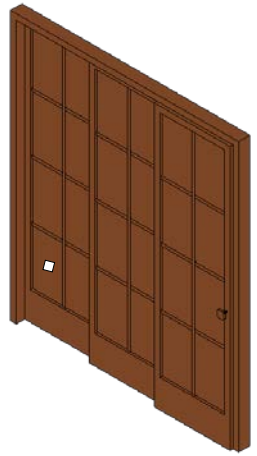


Detects bad orientation or gaps

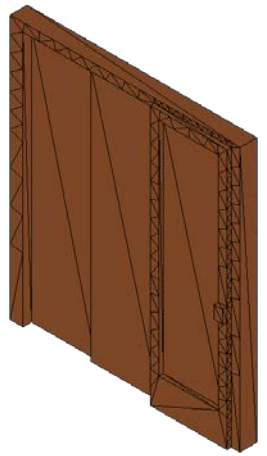
Geom Fixer



Tries to heal geometry. Can only fix to a certain level. Serious cases can‘t be fixed, so „dummy“ geometry is used



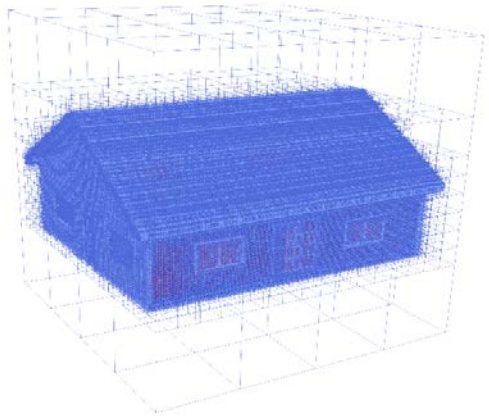
Incurable Geometry

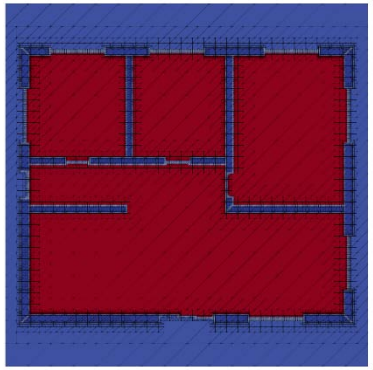


Dummy geometry

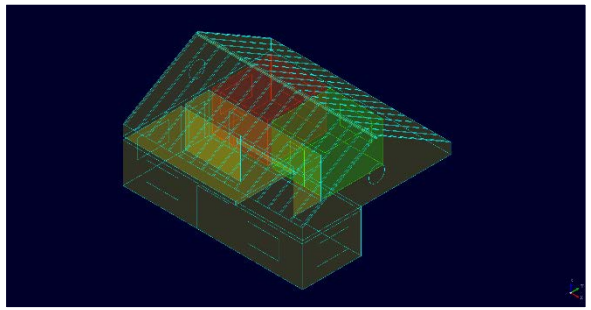
Geometrical Data Enrichment - Space Boundary Generation

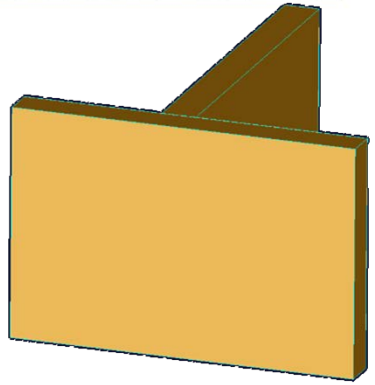
Space Detection

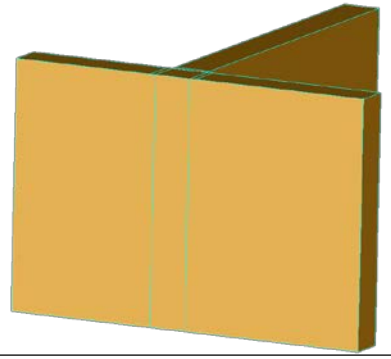




SB Generation



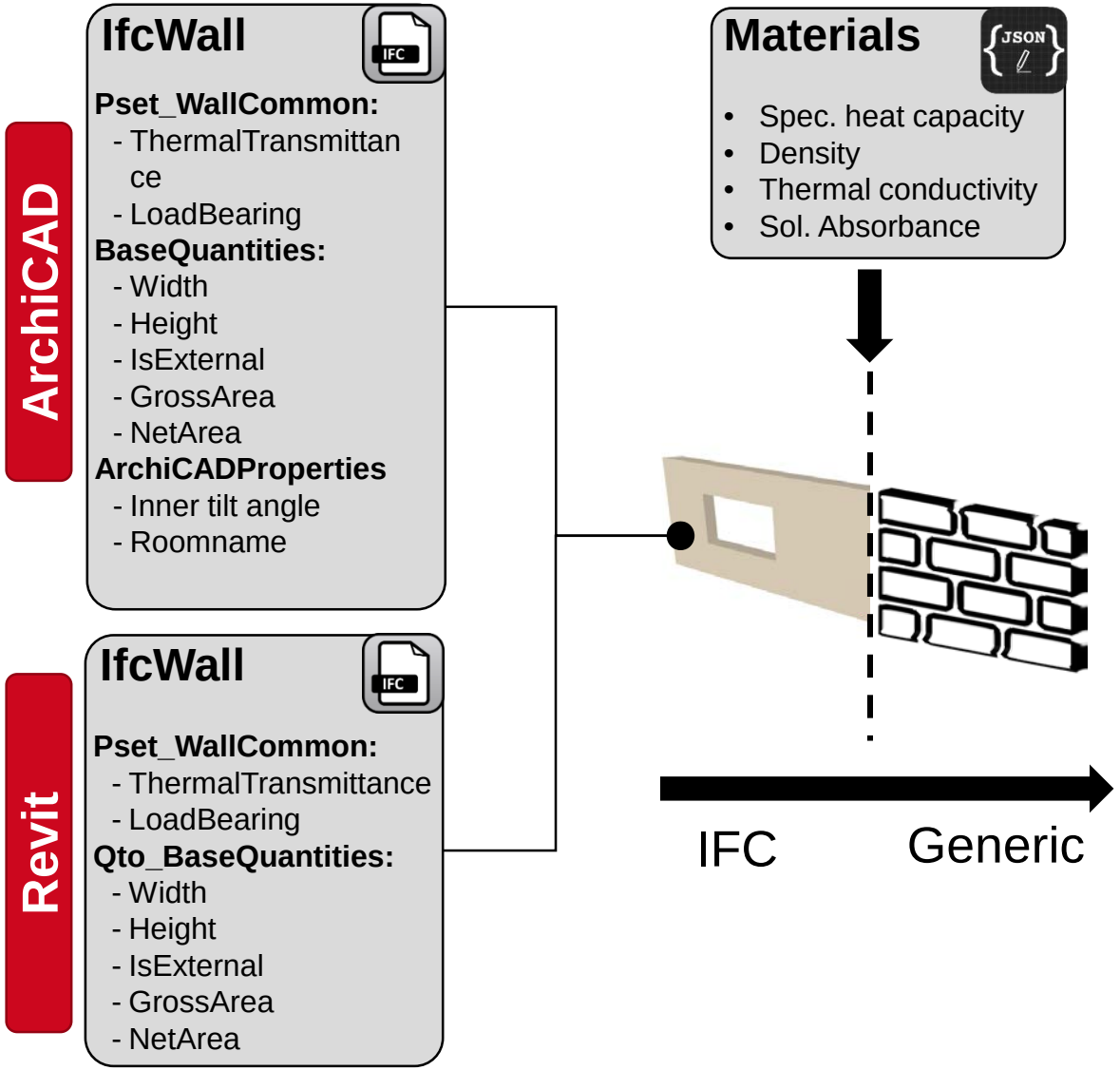




IFC

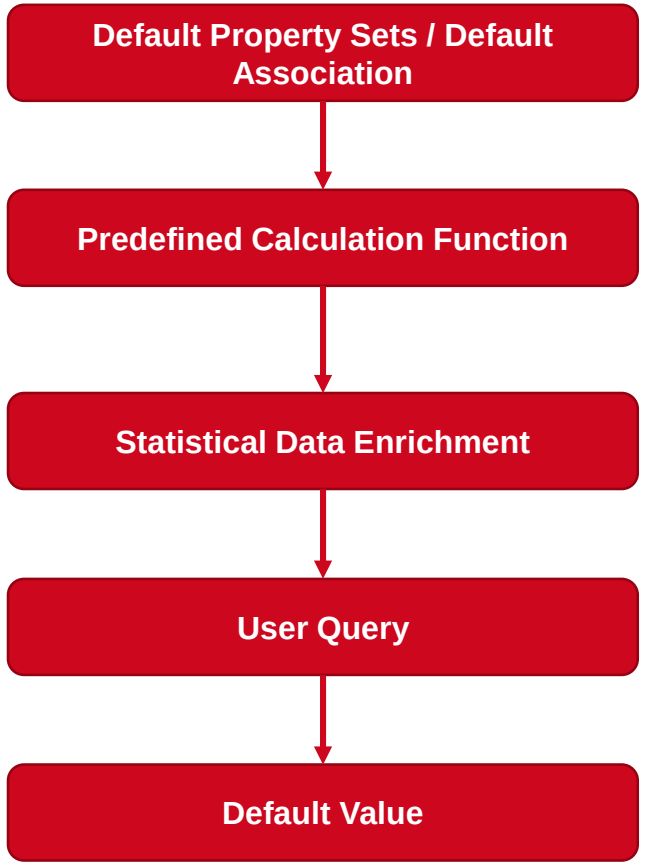
- **Current state**
  - Filtering, Validation and Space detection nearly finished
  - All other modules in development
  - Writing back to IFC not done yet
- **Current and future development**
  - Implementation and testing of all modules

Data Extraction



- Import of IFC to Python using IfcOpenShell
- Creation of generic python instances to stay schema and tool independent
- Using of enrichment methods for not existing values → Multistage hierarchical decision system, e.g. automatical download of TRY data

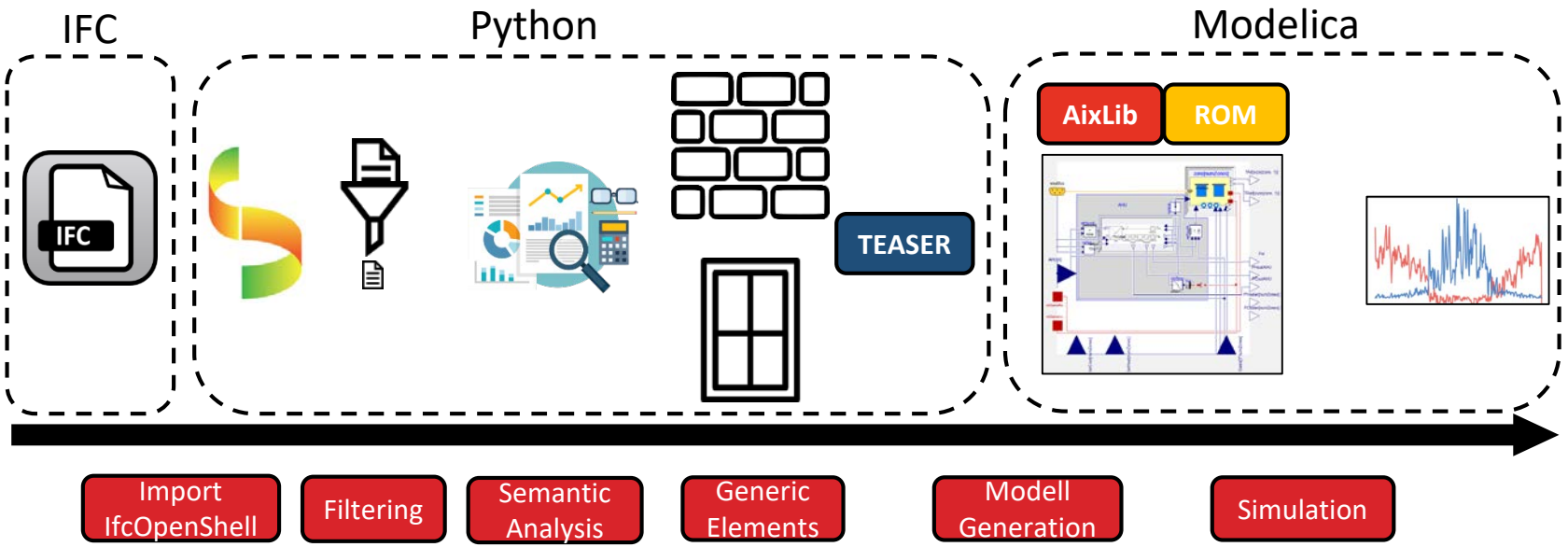
Semantical and Statistical Data Enrichment



Multistage hierarchical decision system

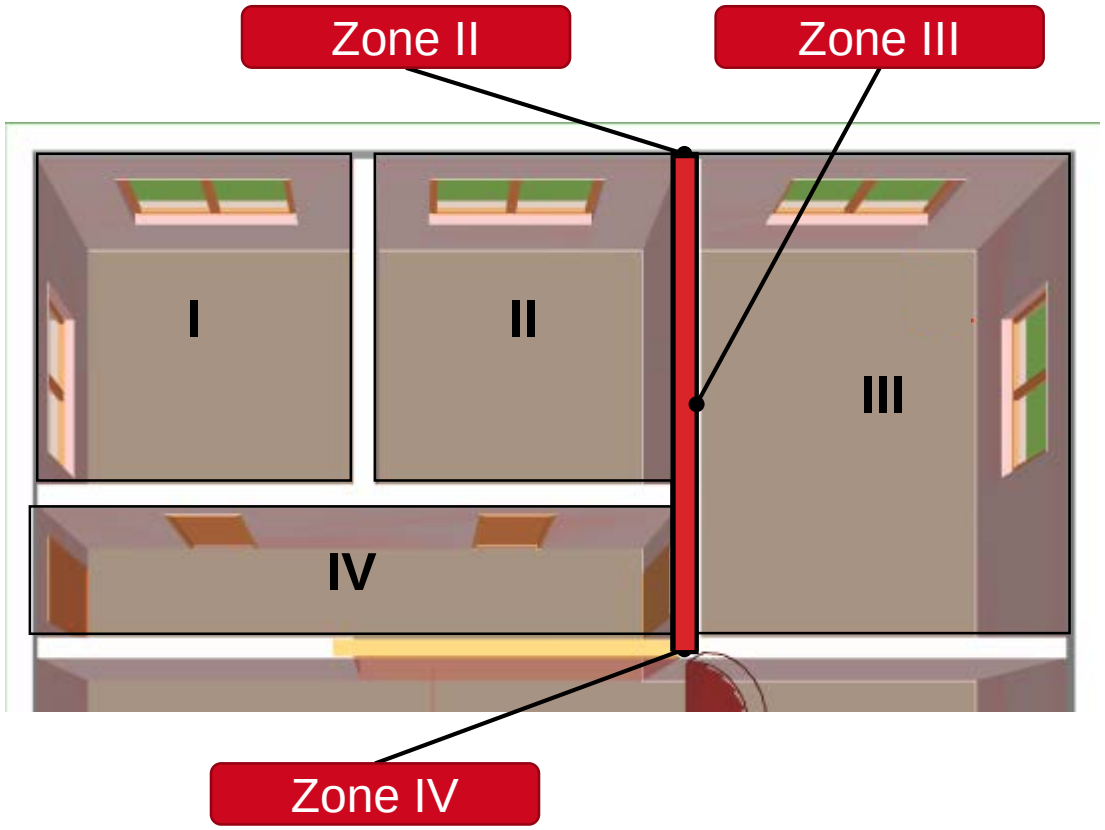
1. Searches for default property sets or association sets (Export Tool dependent)
2. Uses predefined function to calculate searched values from existing values
3. Uses statistical data enrichment by predefined templates (json format)
4. Ask for user input (combined user query in the end of runtime if possible)
5. Uses default value (if useful)

Pre-Processes for Modelica using AixLib and TEASER



- Created generic elements are mapped into TEASER
- Generation of Mulitroom Modelica Model with TEASER mako templates

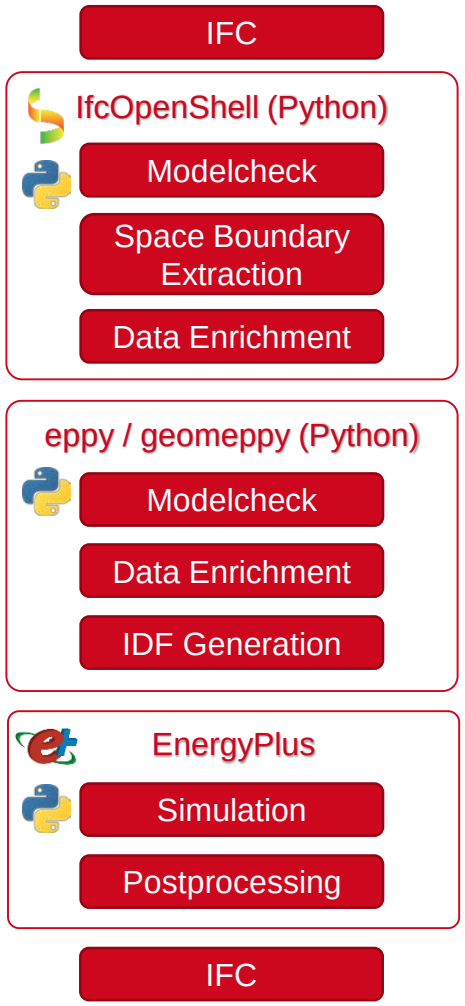
Pre-Processes for Modelica using AixLib and TEASER



- Thermalzones are generated by IfcSpaces
- Building elements are disaggregated to the thermal zones (2nd Level Space Boundaries)

- **Current state**
  - Every space leads to a thermalzone
  - Entire building lead to one zone
- **Current and future development**
  Algorithms for aggregation of zones by
  - Usage conditions
  - Orientation
  - Placement
  - Installed hydraulic systems

Pre-Processes for EnergyPlus

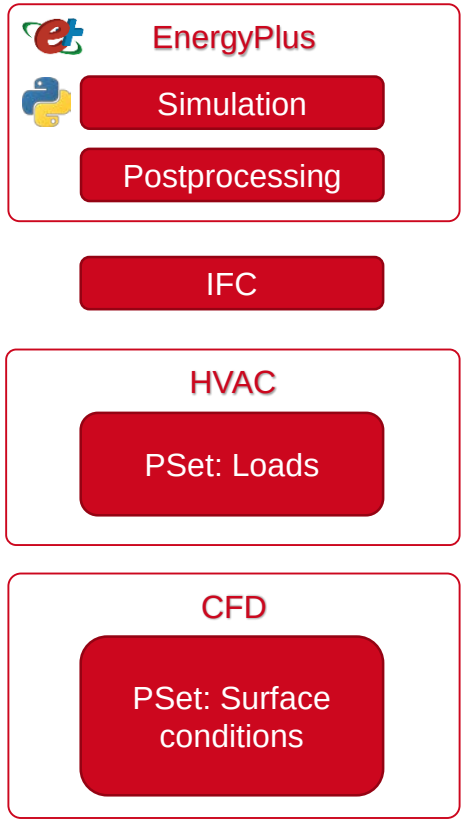


- Modelcheck to ensure applicability of tool chain (e.g. availability of space boundaries)
- Extract space boundary information from IFC and transfer to python class structure
- Enrich space boundary data by related element data (e.g. apply material finder)

- Modelcheck to ensure availability of data required for transformation to EnergyPlus
- Derive missing data from IFC and add missing data in GUI (e.g. simulation settings)
- Generate IDF (Standard used by BIM2SIM‘s industry partner)

- Run EnergyPlus simulation from Python
- Postprocess results for export to IFC

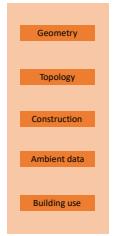
Data Exchange (EnergyPlus)

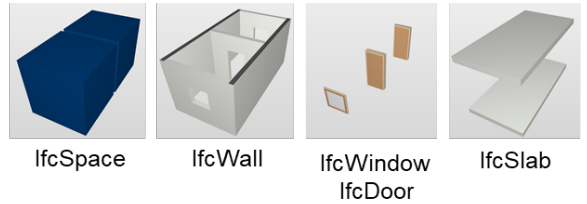


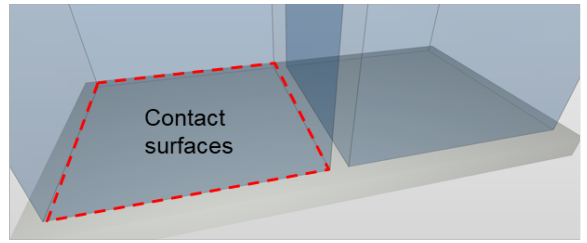
- Export of EnergyPlus simulation results as property sets
  - For individual building components
  - For spaces and zones
  - For the total building
- Data exchange with HVAC simulation
  - Provide thermal loads for heating and cooling
  - Annual / design day / peak load results
- Data exchange with CFD simulation
  - Provide surface temperatures
  - Annual / design day / peak load results

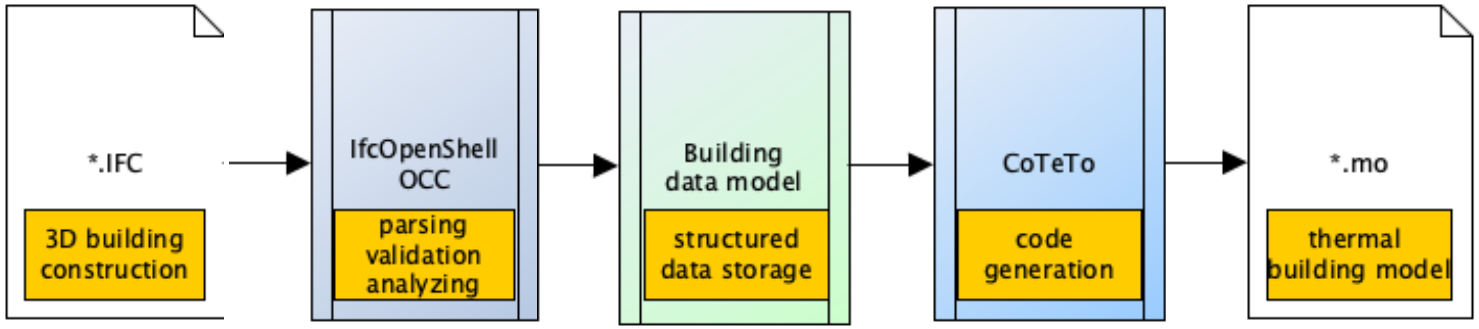
- **Current state**
  - Main modules (focus on semantic geometry) within IFC2IDF workflow implemented in a basic version
  - Manual data enrichment and model checks
  - Single thermal zone per single space approach
- **Current and future development**
  - Automatic model checks
  - Automatic data enrichment from IFC (e.g. Component Materials, …)
  - Export of results as input for HVAC and CFD Simulation

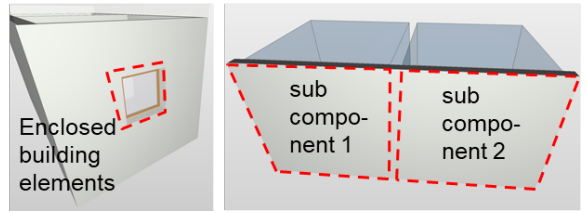
Pre-Processes for Modelica using BuildingSystems and CoTeTo







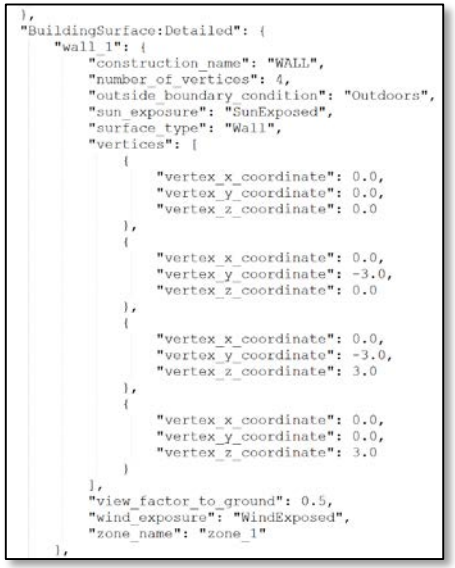




- Tool chain from IFC to Modelica (https://github.com/UdK-VPT/BIM2Modelica.git)
- 1st: Analysis of IFC BIM models with IfcOpenShell and OCC
- 2nd: An Intermediate building data model stores the structered building data
- 3rd: Generation of Modelica multi-zone building models with a generalized CoTeTo template

EnergyPlus and Modelica Simulations based on epJSON File Format

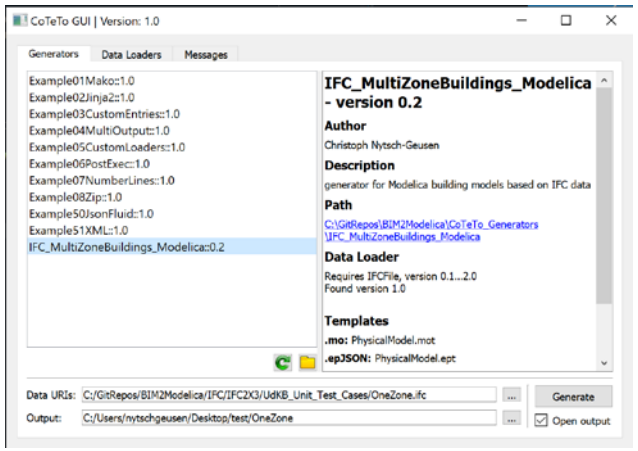
BES with EnergyPlus



OneZone.epJSON

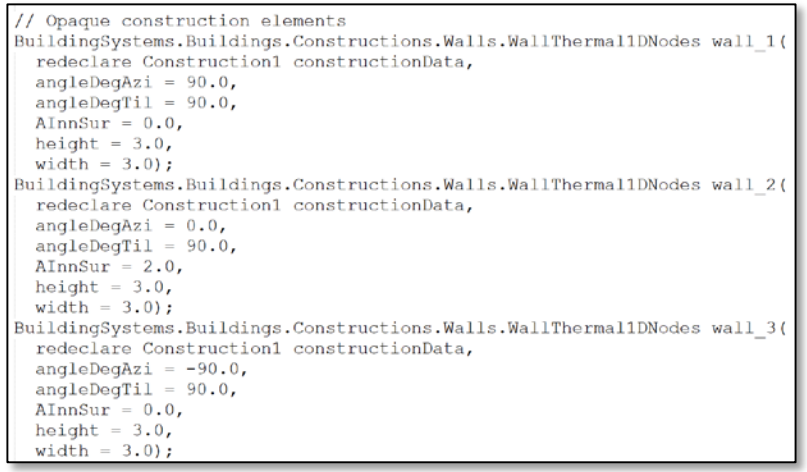
BIM model

OneZone.ifc



CoTeTo templates (epJSON and mo)

BES with Modelica



OneZone.mo

- epJSON is the future input file format for EnergyPlus (JSON is easier to read than IDF)
- **IFC → epJSON: Generation of EnergyPlus input files (epJSON format) and Modelica files from the same IFC file based on two different CoTeTo templates**
- epJSON → Modelica: Mapping EnergyPlus building models to Modelica building models

Conclusion

- **Github repository** https://github.com/ibpsa/project1-wp-2-2-bim
  - Some code examples are online, most of them are not yet, because of restrictions by the funding projects (e.g. BIM2SIM)
  - But: Modular approach. After defining interface, everyone can contribute

- **Contributions welcome!**
  - Adding other aspects/codes to tool chain
  - Missing modules, e.g.
    - Writing data back to IFC using e.g. IfcOpenShell
    - Interoperability approach to read/write simulation results from/to IFC
    - Geometrical extraction of Space Boundary Information from the IFC
    - Geometry Checker
  - Case study test files (IFC4 including Space Boundaries)
- Contacts:
  - Fichter, Eric, fichter@e3d.rwth-aachen.de - Space Boundary Generation
  - Häfele, Karl-Heinz, karl-heinz.haefele@kit.edu - Model View Definition
  - Jansen, David, david.jansen@eonerc.rwth-aachen.de - Modelica/Teaser, Semantical Data Extraction/Enrichment
  - Nytsch-Geusen, Christoph, nytsch@udk-berlin.de - CoTeTo, epJSON
  - Richter, Veronika richter@e3d.rwth-aachen.de - EnergyPlus tool chain