Mapping the Energy ADE to CityGML 3.0

P5 Presentation

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20.01.2023

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Overview

- Motivation
- Research Question
- Scientific Context
- Methodology
- Implementation
- Results
- Discussion
- Conclusion

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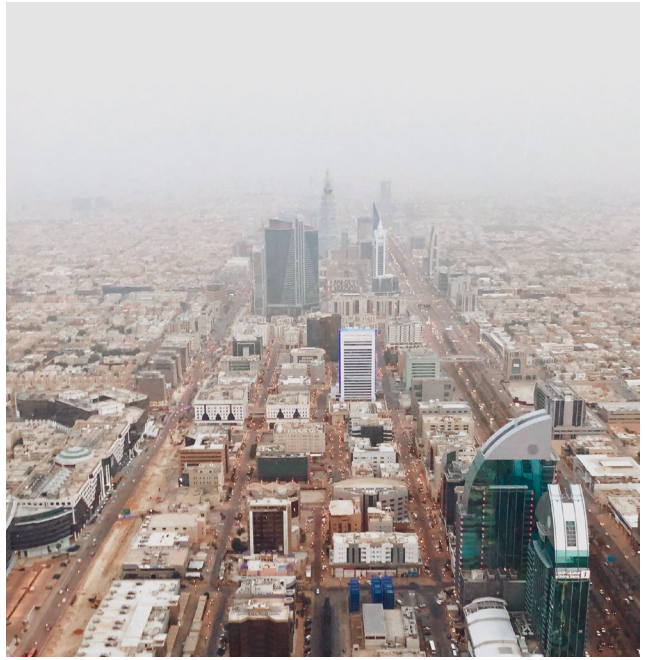
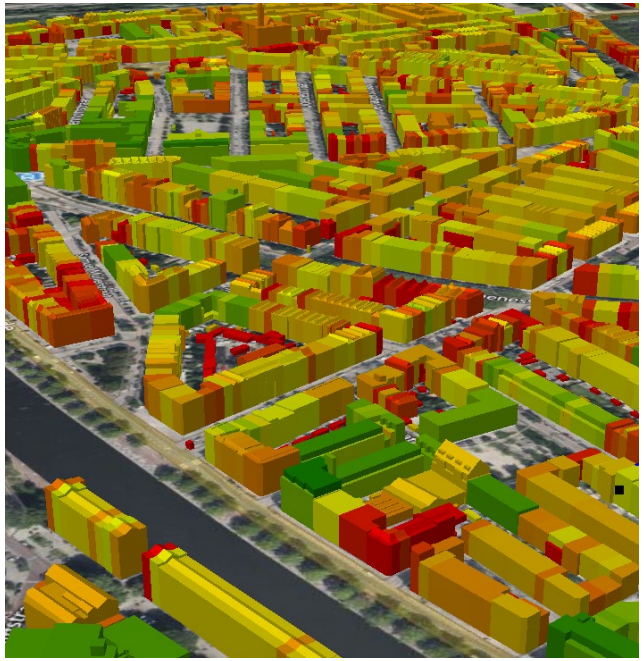
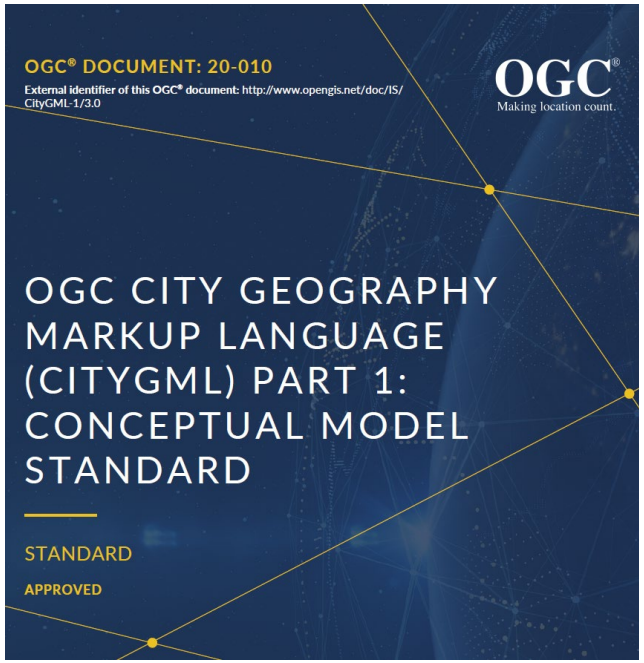
Motivation

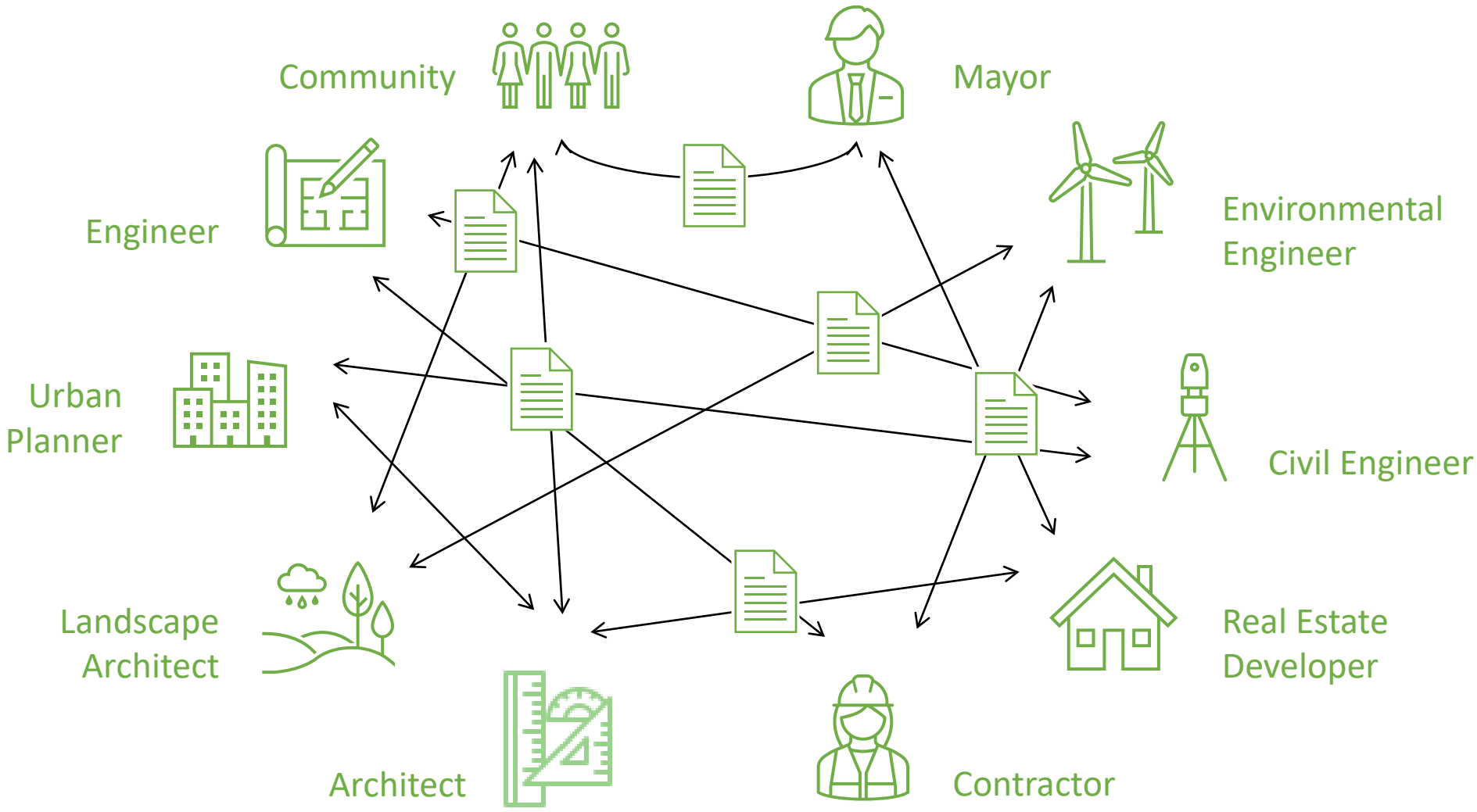






Source: pexels.com (Luftbild einer Stadt), http://steinbeis-3dps.eu/rotterdam/Apps/Rotterdam/Rotterdam_Cesium_Viewer.html, Kolbe et al 2021

Motivation


Community
Mayor
Engineer
Environmental Engineer
Urban Planner
Civil Engineer
Landscape Architect
Real Estate Developer
Architect
Contractor

Motivation


Community
Mayor
Engineer
Environmental Engineer
Urban Planner
CityGML
Civil Engineer
Landscape Architect
Real Estate Developer
Architect
Contractor

Research Question

How and to what extent need the Energy ADE for CityGML 2.0 be adapted to be conformant with the newly released CityGML 3.0 standard?

- Which classes of the Energy ADE 1.0 become obsolete, which ones need to be adapted and which ones can mostly be taken over?
- What will the Energy ADE data model for CityGML 3.0 look like, both in terms of UML encoding and XSD file?
- How can Energy ADE for CityGML 2.0 data be converted to Energy ADE for CityGML 3.0 data?

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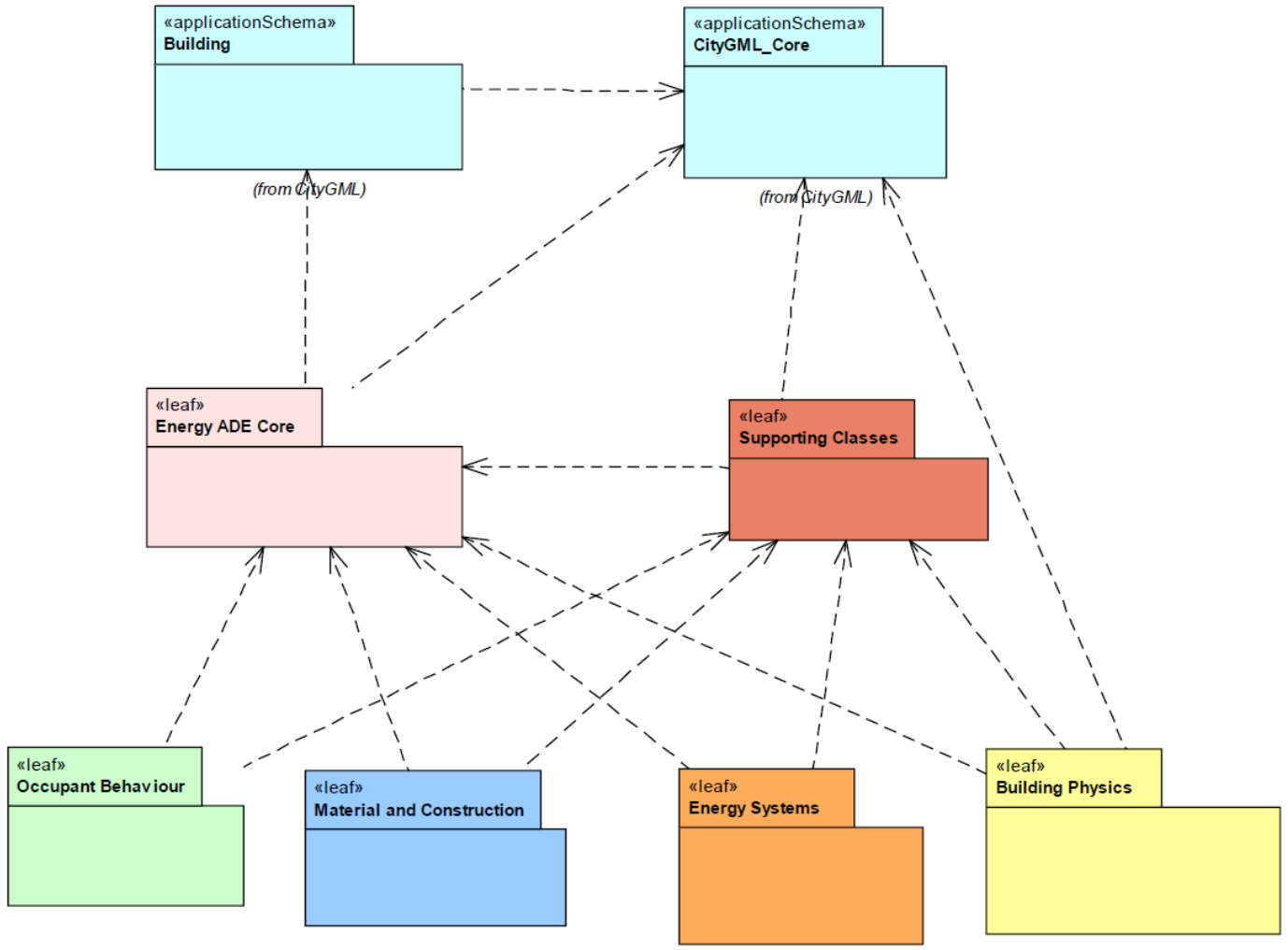
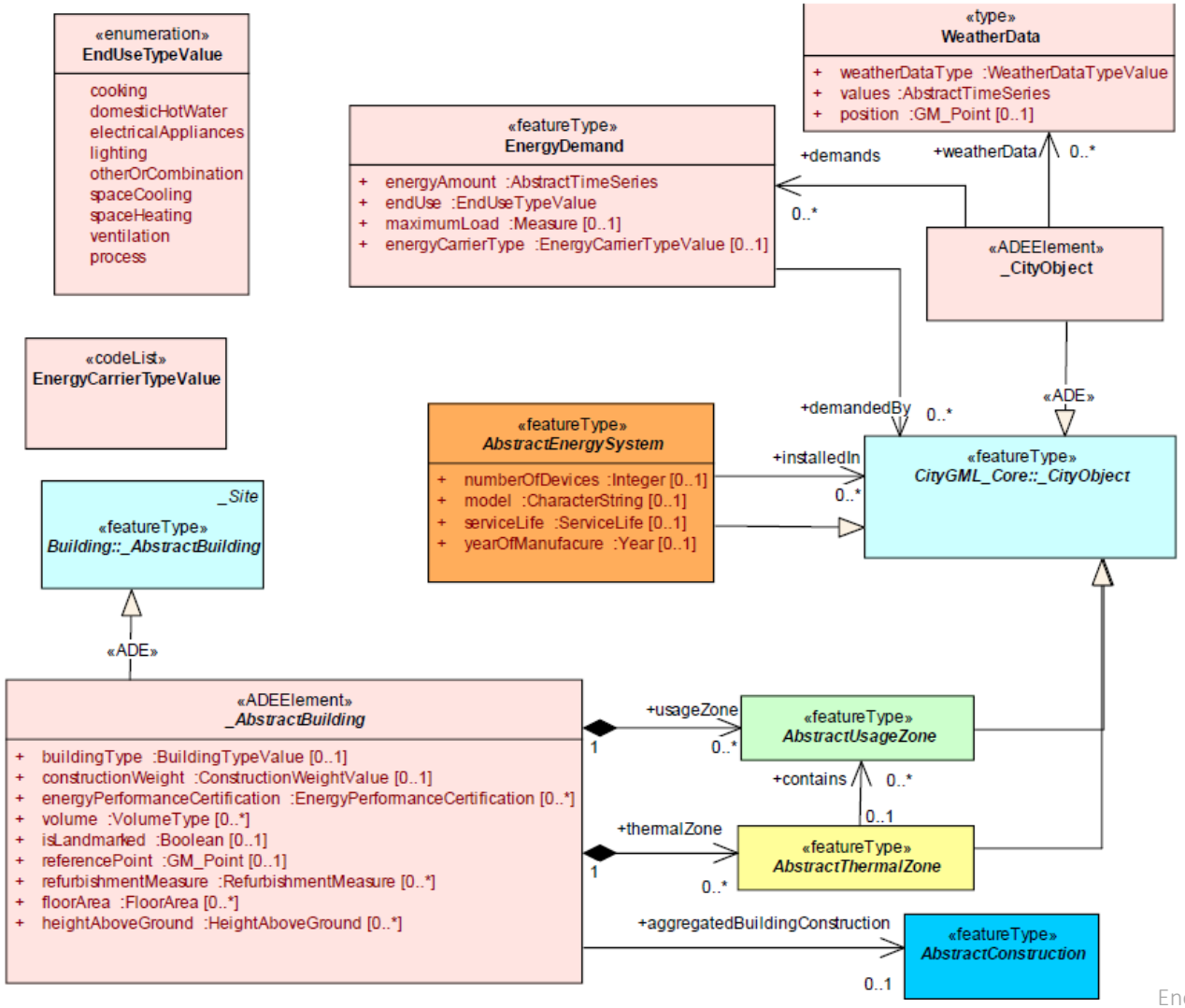
Scientific Context – Energy ADE 1.0



Source: Energy ADE UML Model diagrams

Scientific Context – Energy ADE 1.0

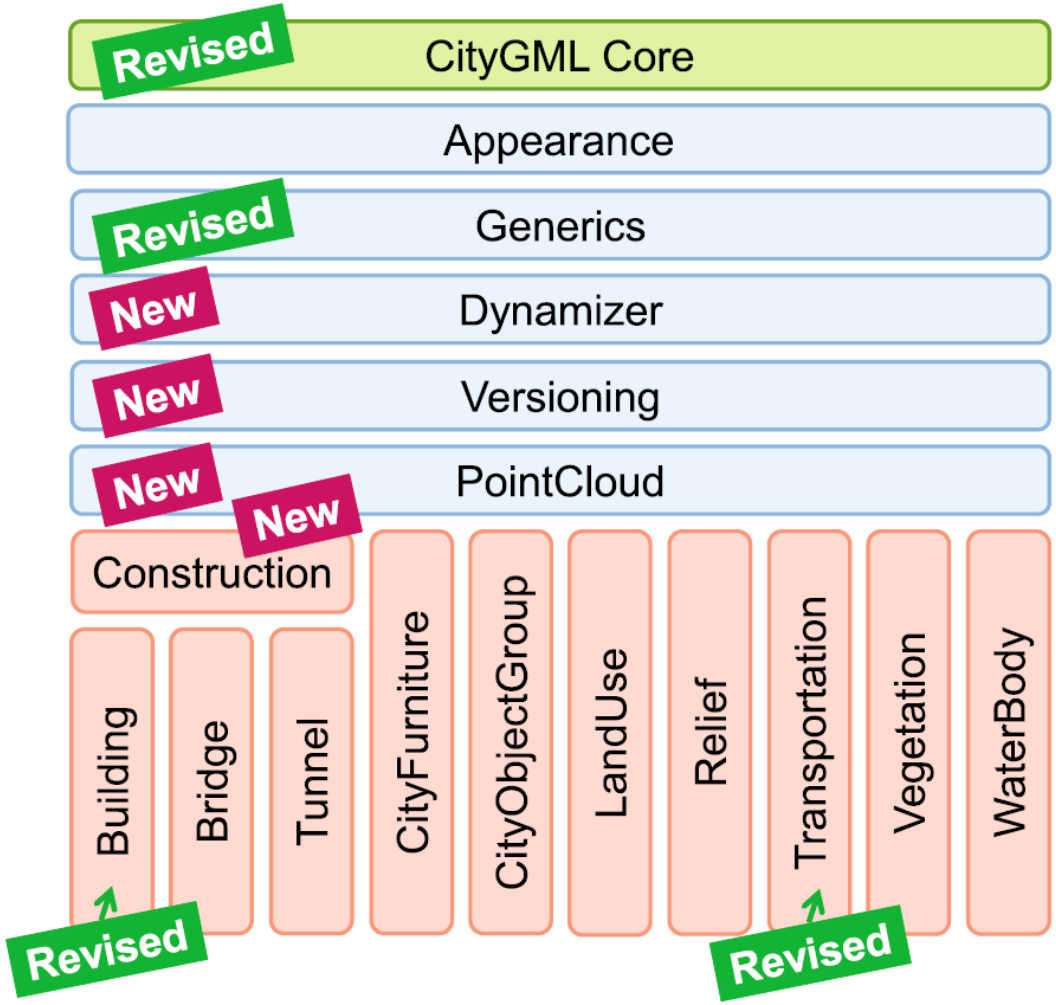


Source:
Energy ADE UML Model diagrams

Scientific Context – CityGML 3.0

Goal: Increase usability for more user groups and use cases

- Defined as Conceptual Model Standard via UML class diagrams
- Major revision of some modules and addition of new ones
- New space and geometry concepts defined in Core
- Refined Application Domain Extension mechanism



Source:Kutzner et al. 2020. CityGML 3.0: New Functions Open Up New Applications

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Scientific Context – CityGML 3.0

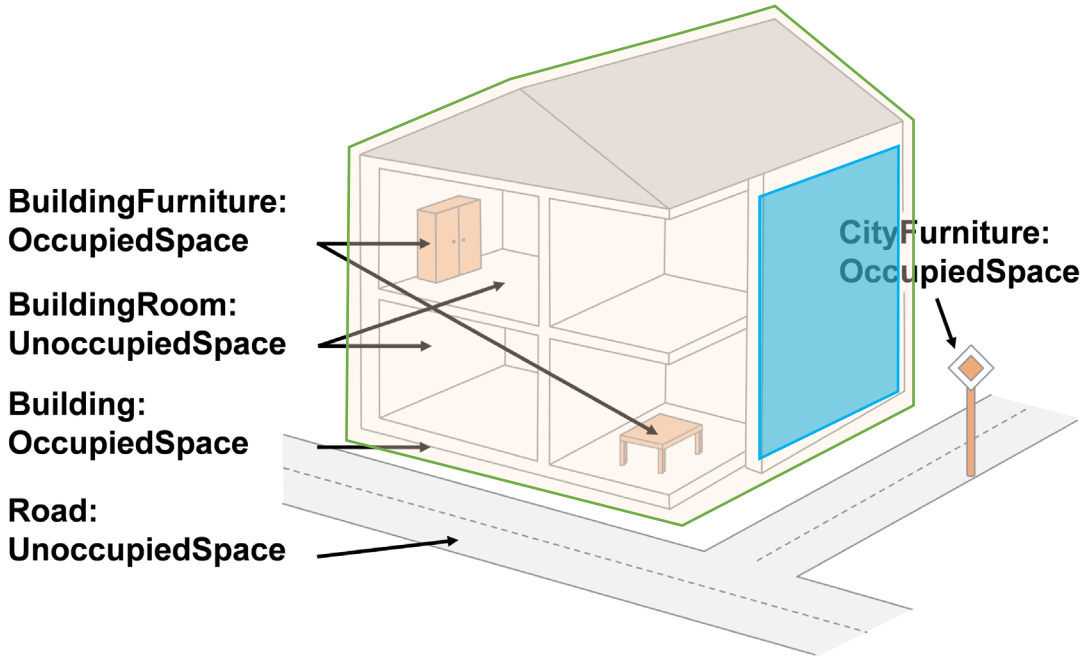
Space Concept

AbstractSpace:

- Volumetric extent
- Buildings, trees, traffic spaces

AbstractSpaceBoundary:

- Areal extent
- Delimits and connects spaces
- Roof surfaces



Source:Kutzner et al. 2020. CityGML 3.0: New Functions Open Up New Applications

Scientific Context – CityGML 3.0

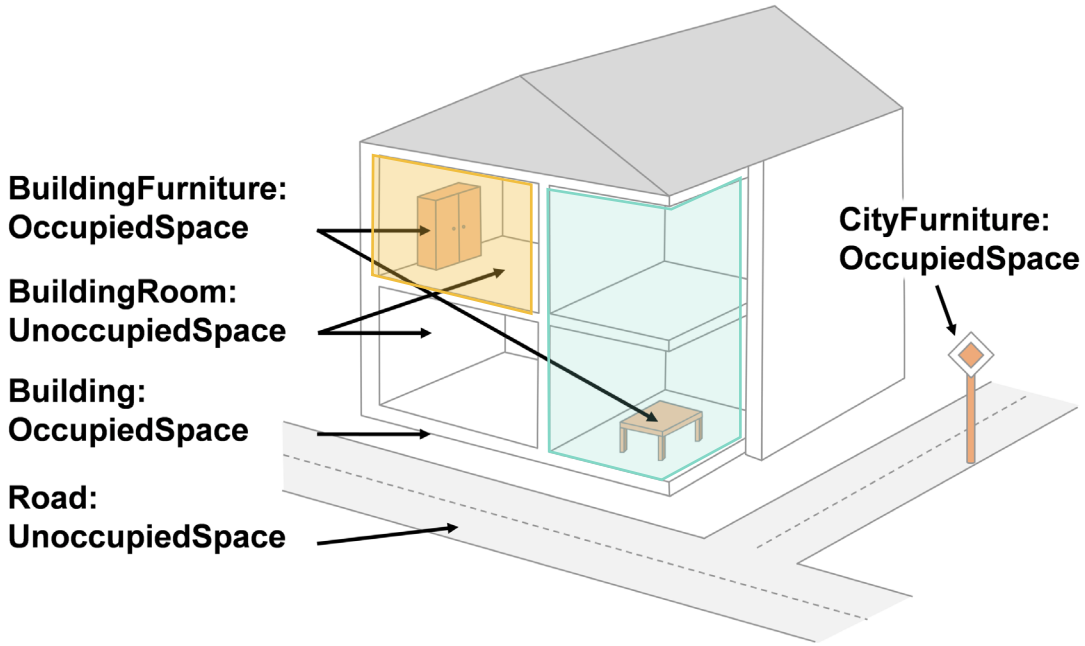
Space Concept

AbstractPhysicalSpace:

- Fully or partially bound by physical objects
- Room, furniture

AbstractLogicalSpace:

- Defined according to thematic considerations
- Aggregation of rooms



Source:Kutzner et al. 2020. CityGML 3.0: New Functions Open Up New Applications

Scientific Context – CityGML 3.0

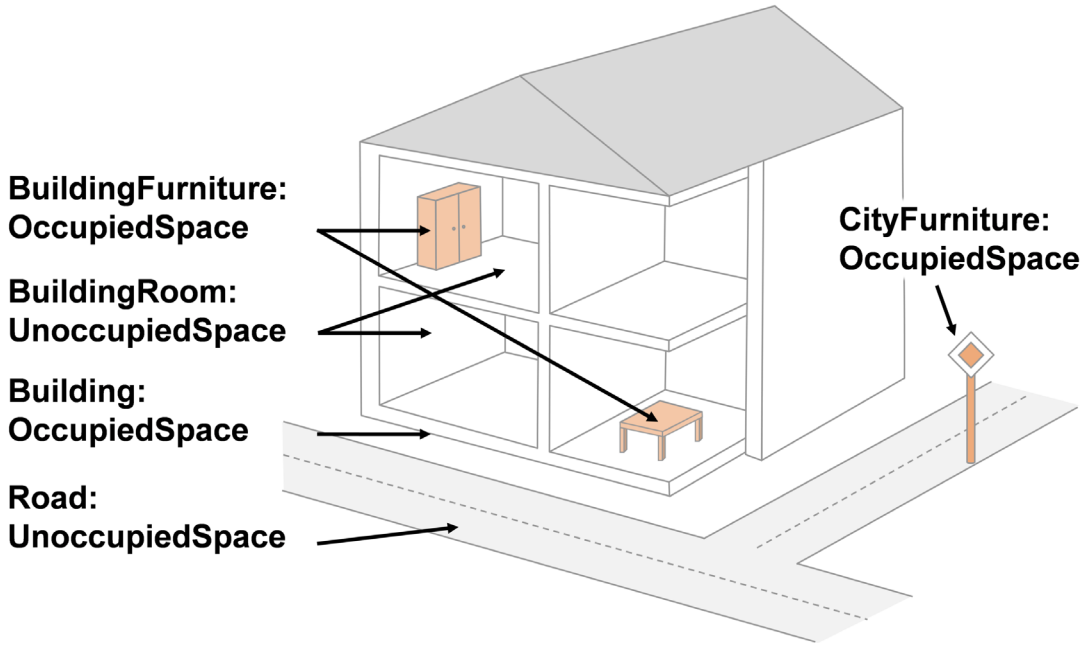
Space Concept

AbstractOccupiedSpace:

- Volumetric physical objects
- Occupy space in its surroundings

AbstractUnoccupiedSpace:

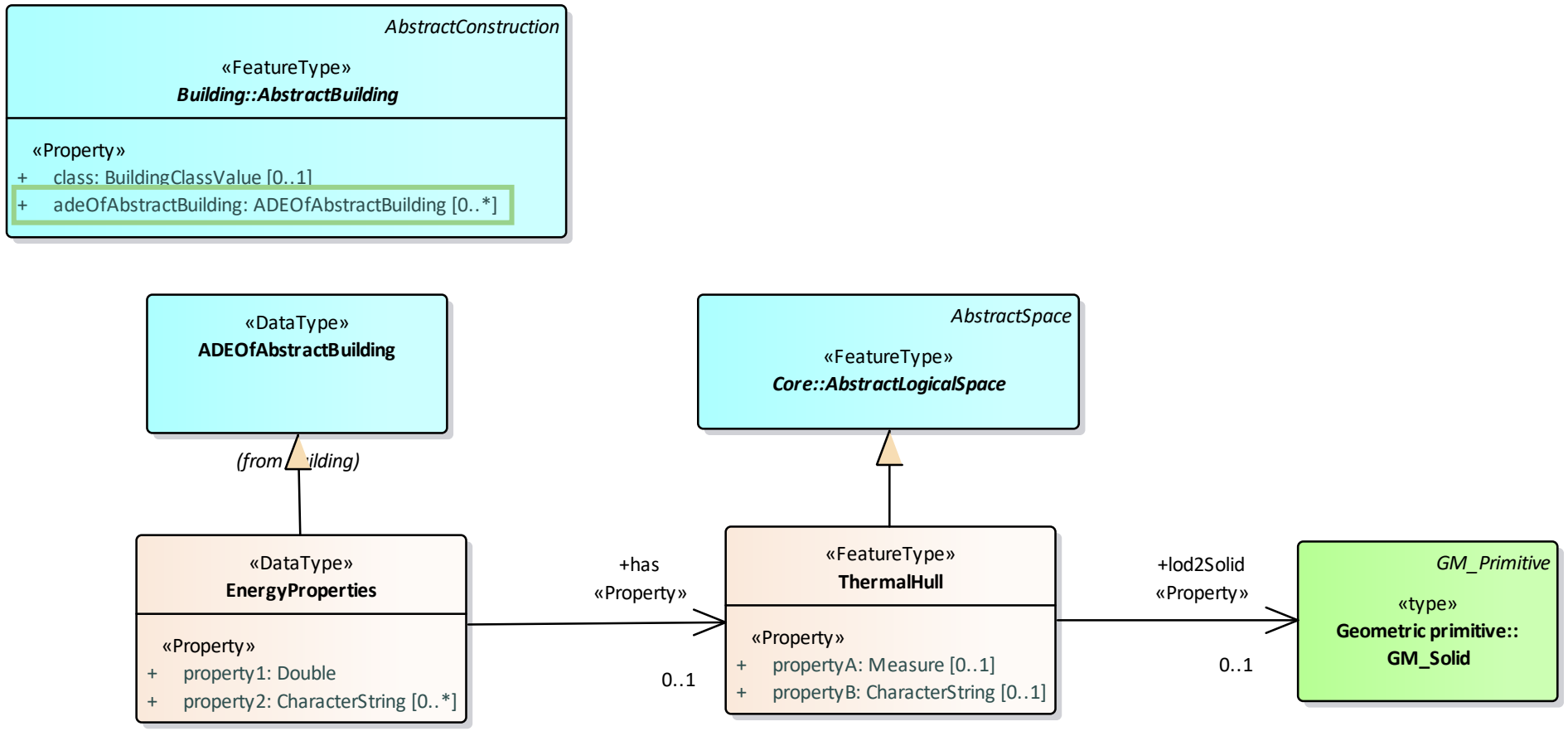
- Volumetric physical objects
- Do not block space for other things



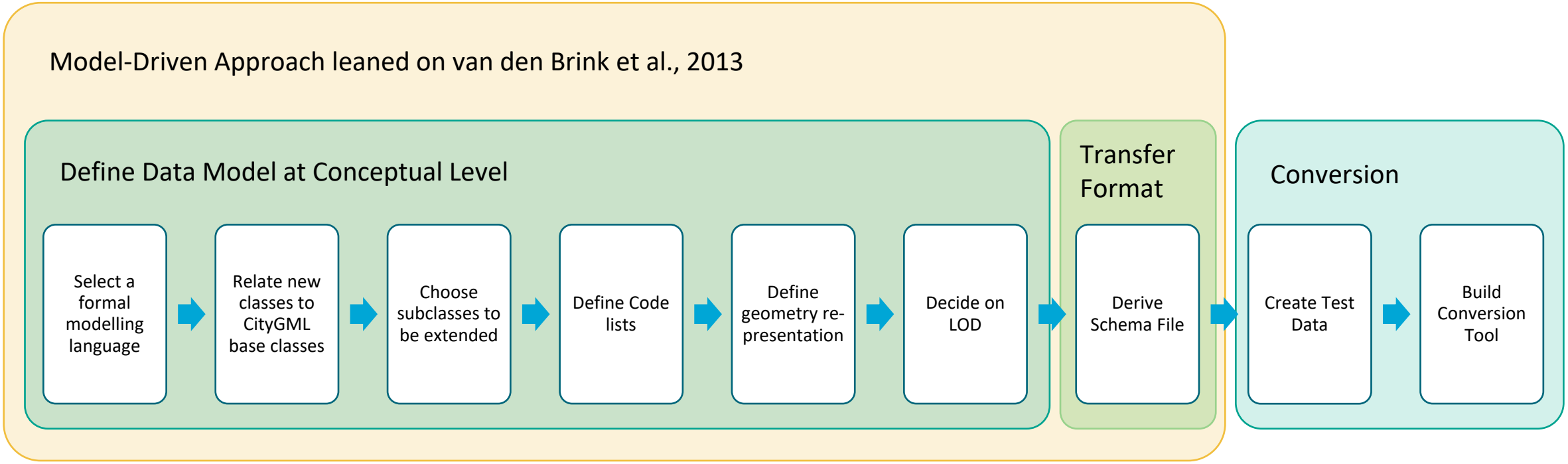
Source:Kutzner et al. 2020. CityGML 3.0: New Functions Open Up New Applications

Scientific Context – CityGML 3.0

ADE mechanism



Methodology



Source: van den Brink et al. 2013. UML-Based Approach to Developing a CityGML Application Domain Extension

Methodology

Model-Driven Approach leaned on van den Brink et al., 2013

Define Data Model

ENTERPRISE ARCHITECT

Transfer Format

ShapeChange

Conversion

Implementation – Mapping

Model-Driven Approach leaned on van den Brink et al., 2013

Define Data Model

Transfer Format

Conversion

Implementation – Mapping

Mapping strategies

- General Mapping Principles
  - Integrate as much as possible
  - Maintain a logical symmetry

- Mapping applied to all modules
  - Use *AbstractFeatureWithLifespan* over *AbstractFeature*
  - Implement abstract base classes (e.g. *AbstractThermalZone*)
  - Properties and relations generally remain as they are
    - Unless they can be replaced by CityGML 3.0

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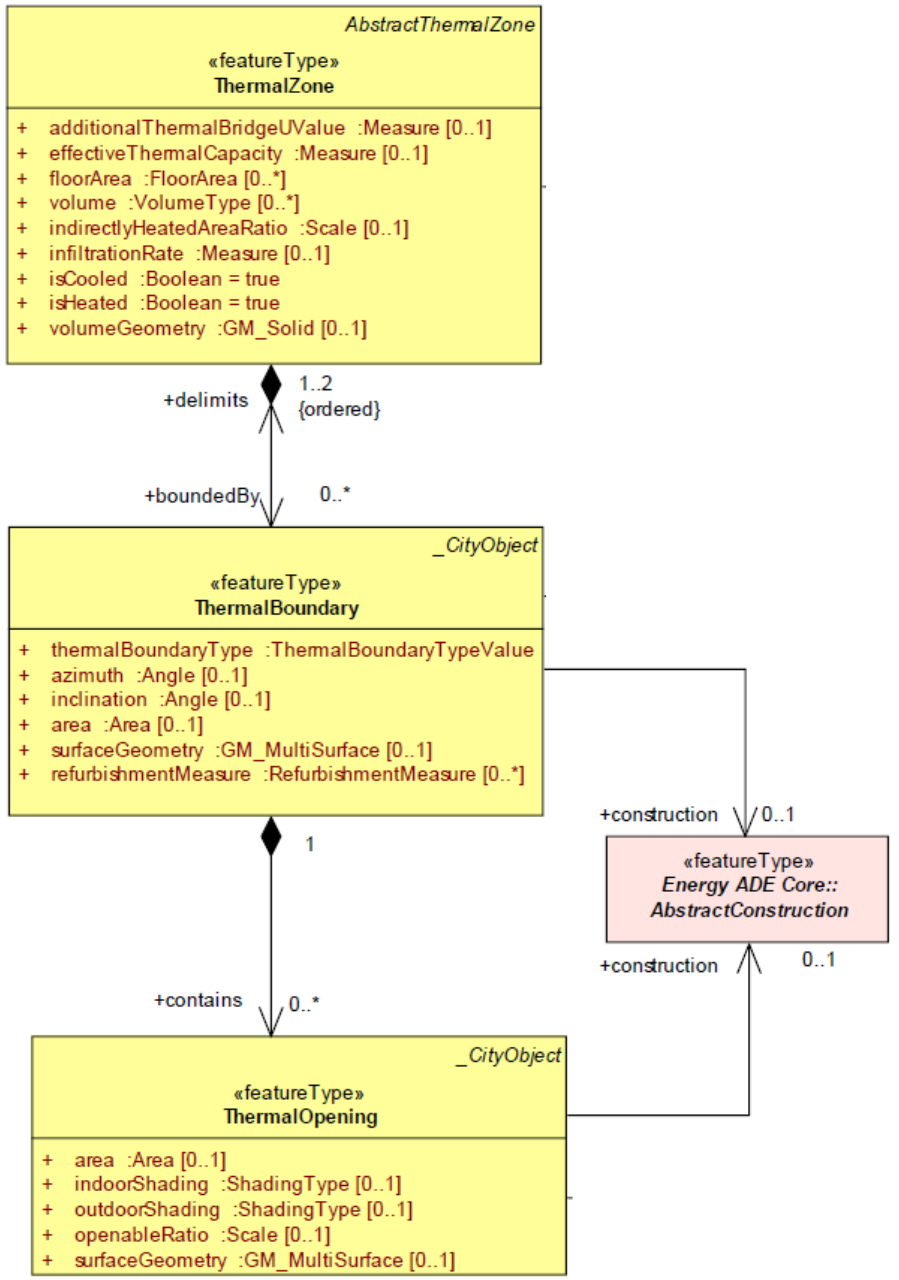
Implementation – Mapping

Example Building Physics Module

Two possibilities:

1. Keep them close together at a higher level
2. Integrate them as much as possible according to their best semantic fit



Source: Energy ADE UML Model diagrams

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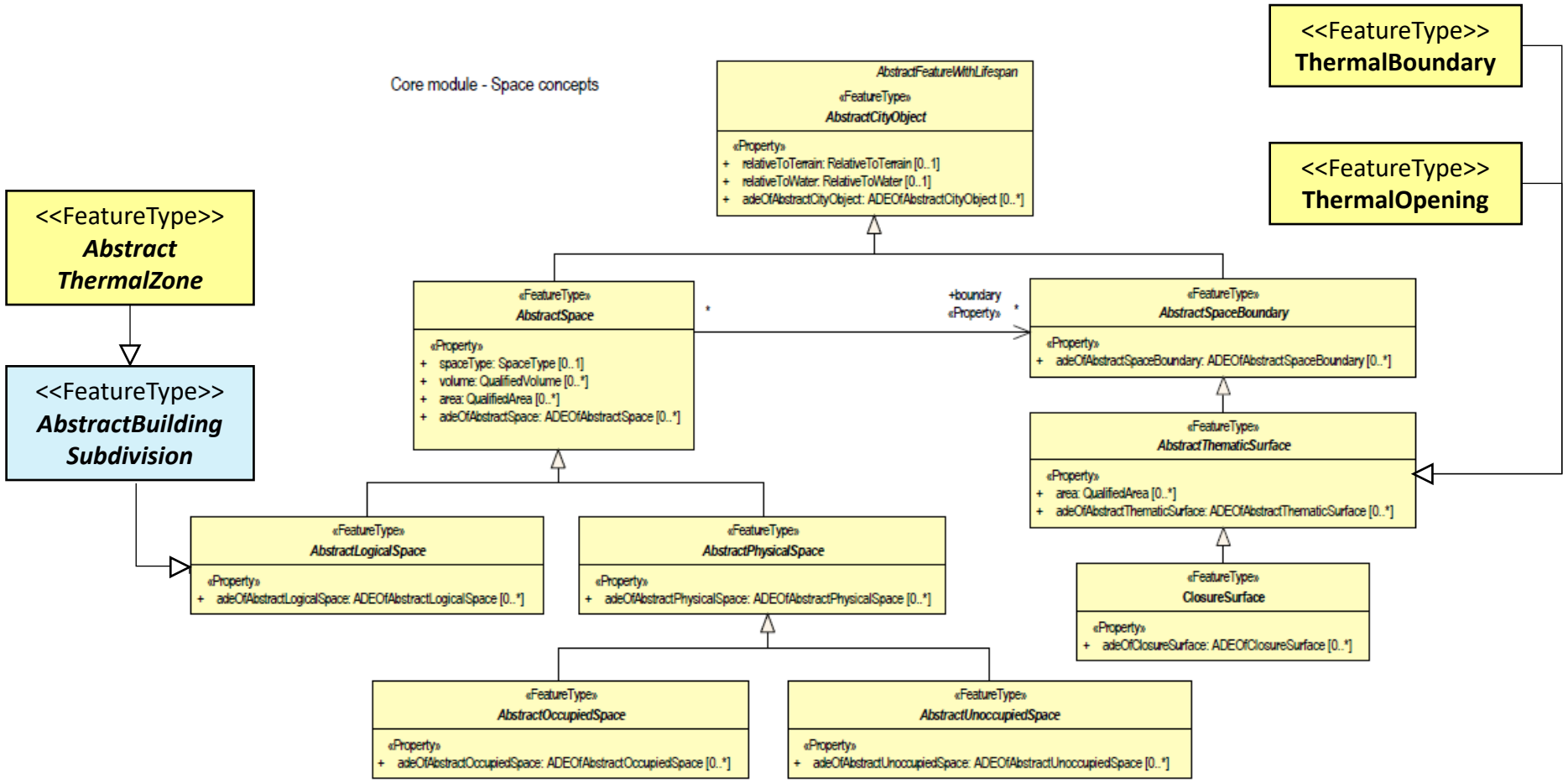
Implementation – Mapping

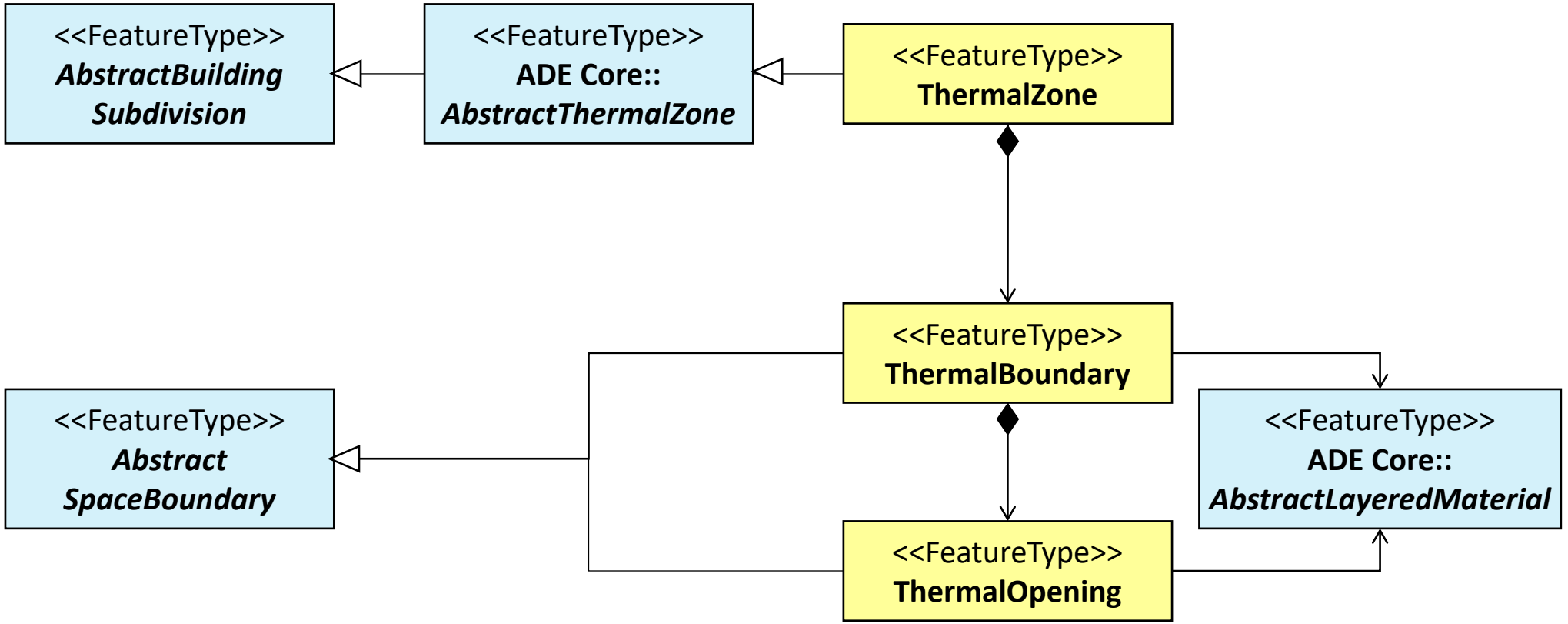
Integration into the space concept



Source: Kolbe et al., 2021. OGC City Geography Markup Language (CityGML) Part 1: Conceptual Model Standard.

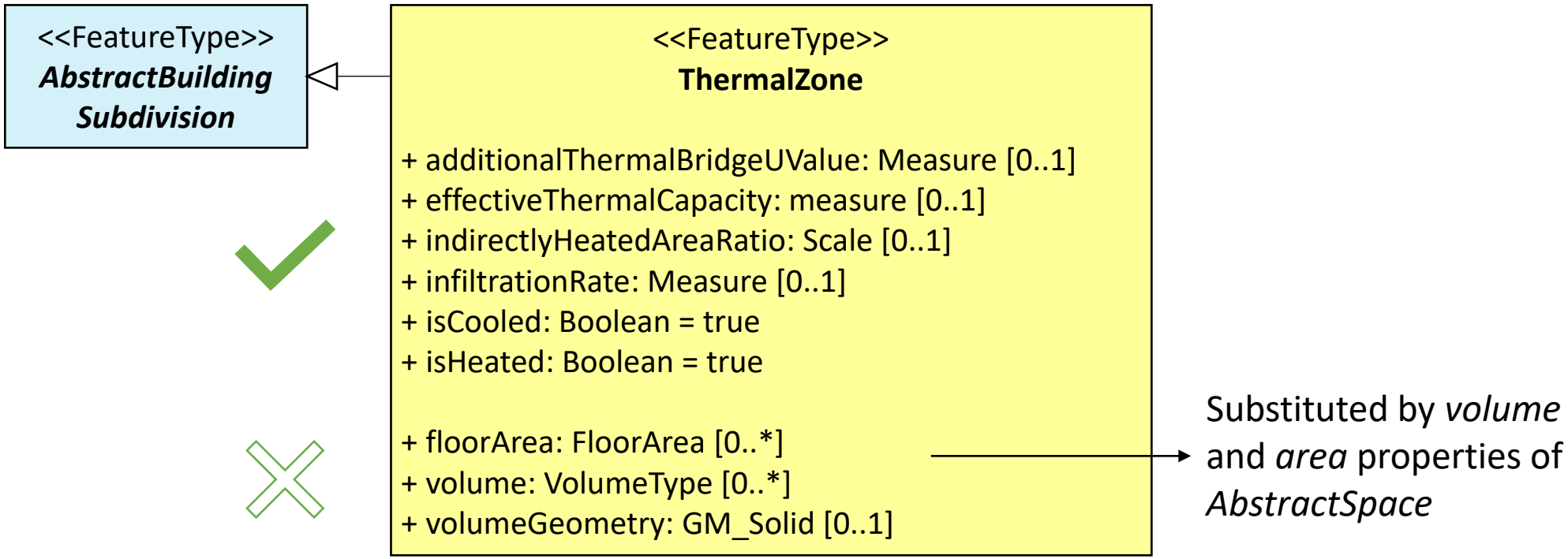
Implementation – Mapping

Mapped result



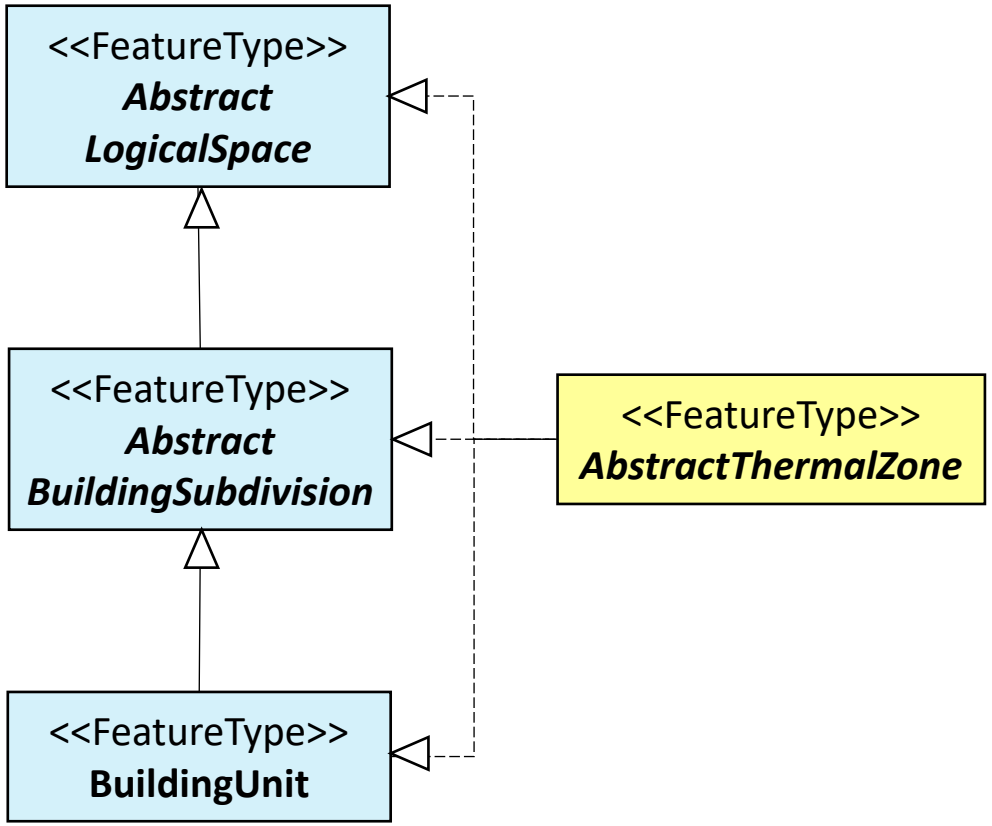
Implementation – Mapping

Properties and geometry



Implementation – Mapping

The “right” superclass



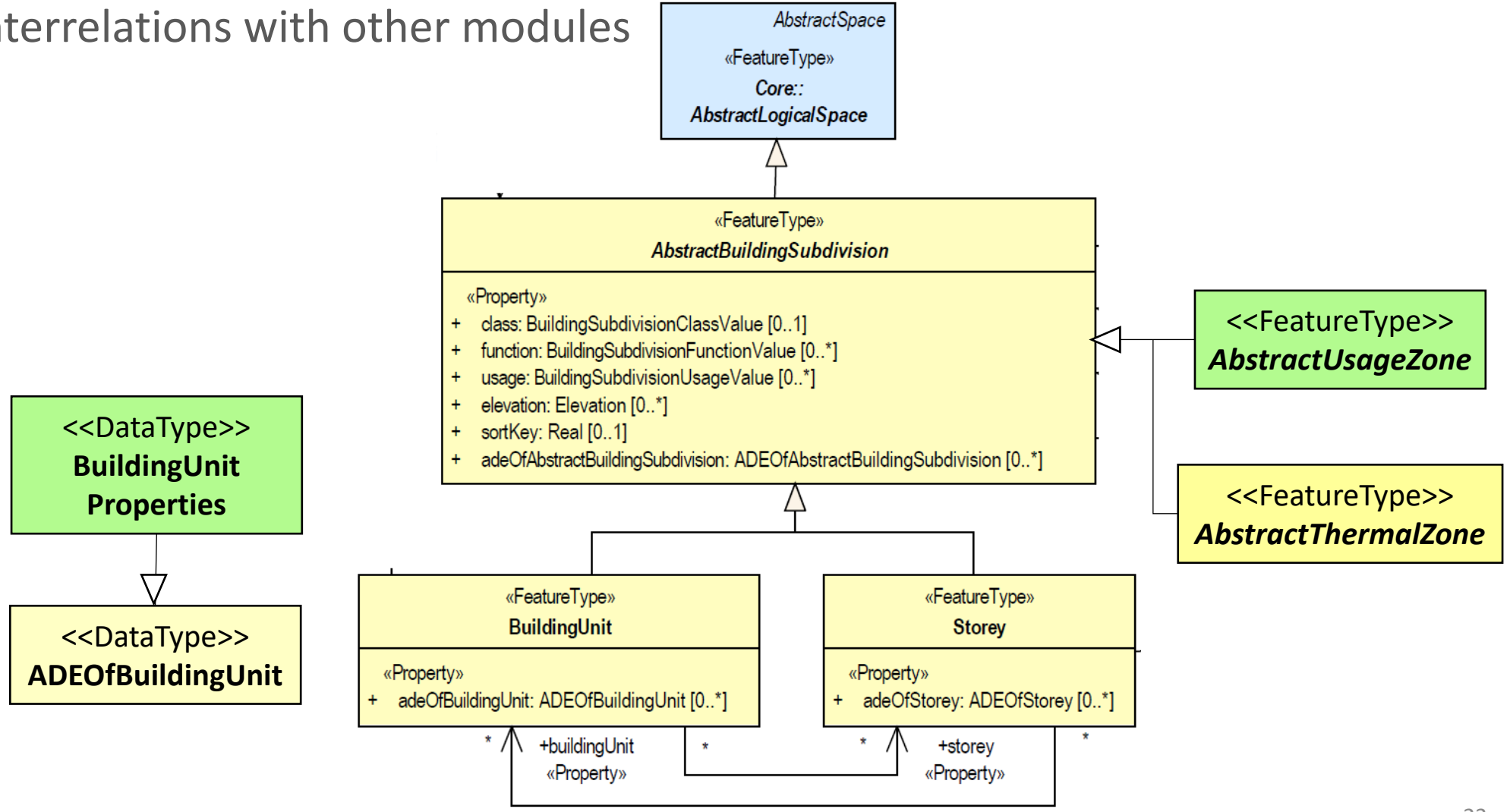
***AbstractLogicalSpace*:** abstract superclass for all types of logical spaces. Logical space refers to spaces that are not bounded by physical surfaces but are defined according to thematic considerations.

AbstractBuildingSubdivision: abstract superclass for different kinds of logical building subdivisions.

BuildingUnit: A BuildingUnit is a logical subdivision of a Building. BuildingUnits are formed according to some homogeneous property like function, ownership, management, or accessibility. They may be separately sold, rented out, inherited, managed, etc.

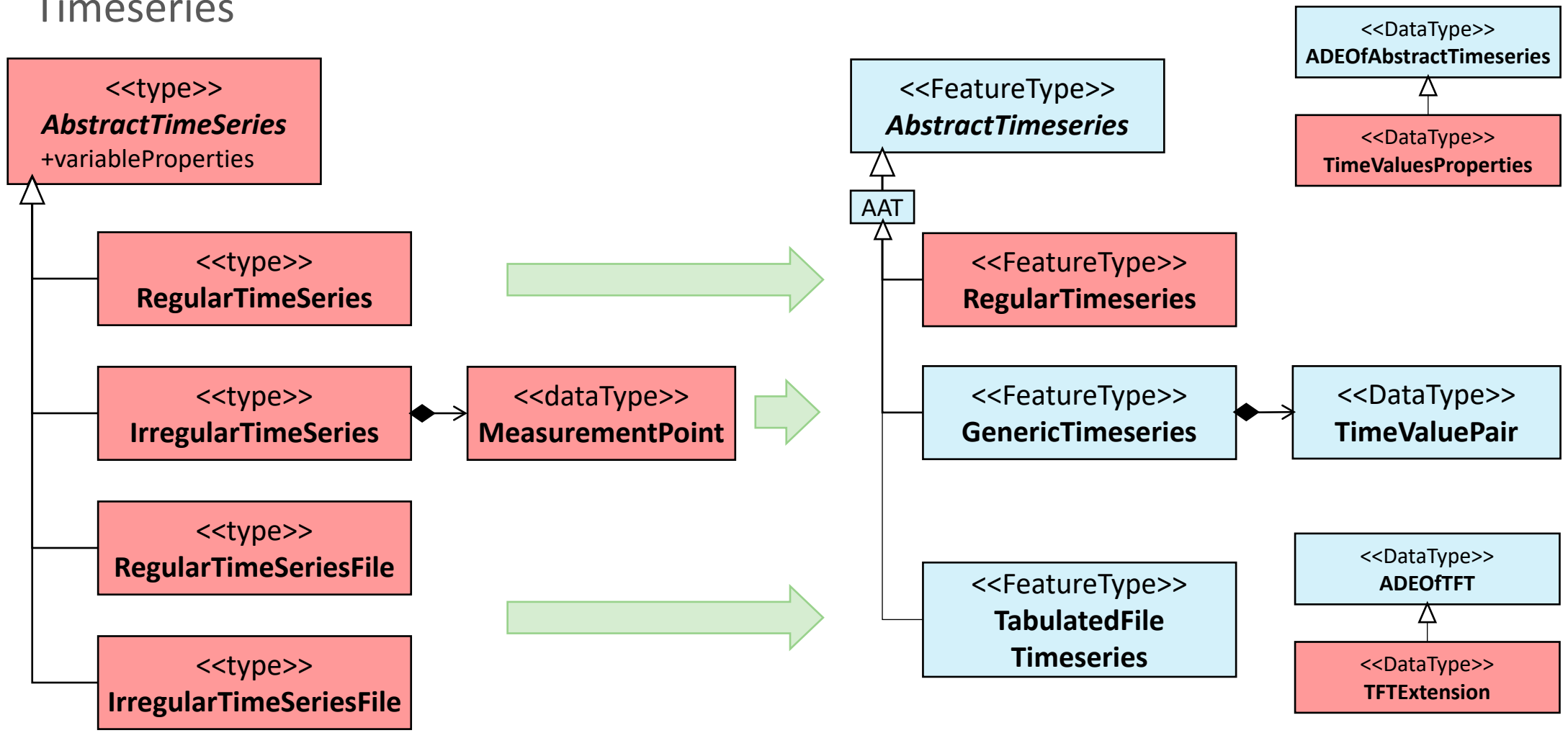
Implementation – Mapping

Interrelations with other modules



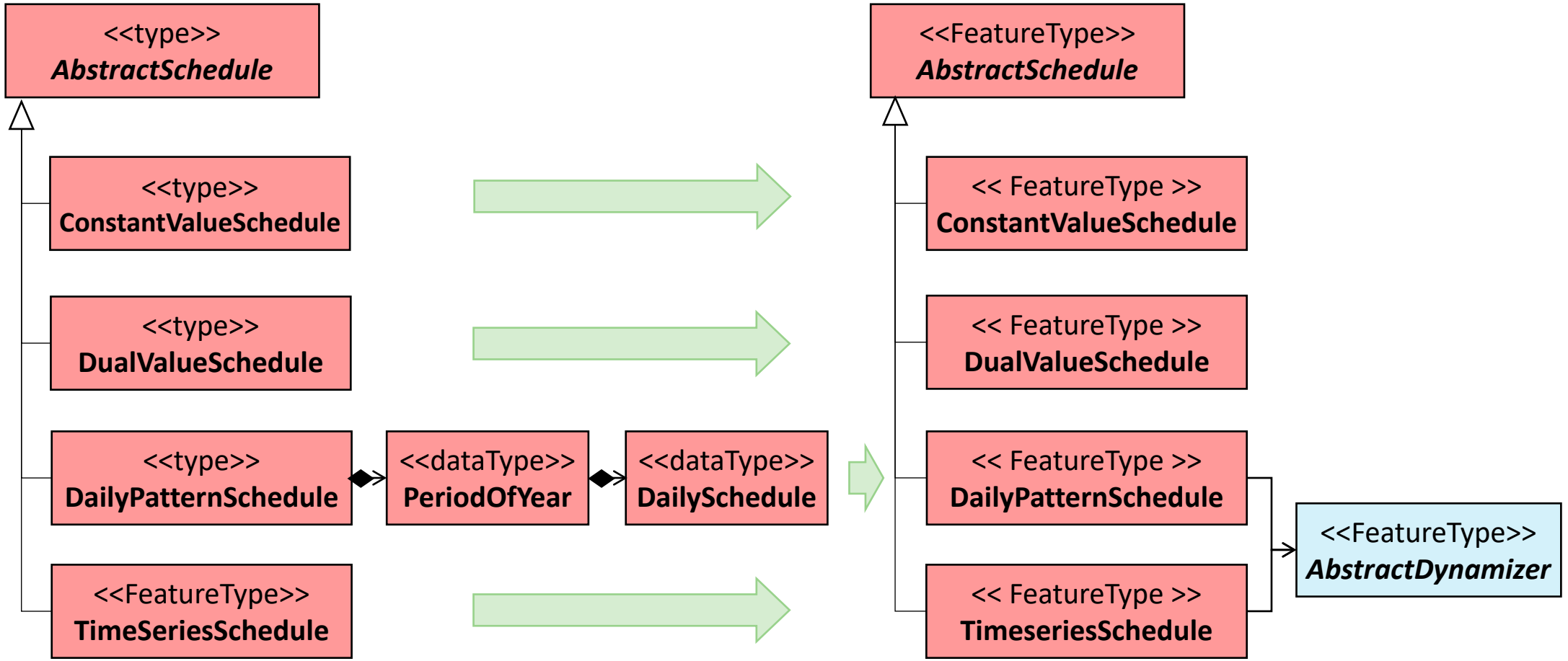
Implementation – Mapping

Timeseries



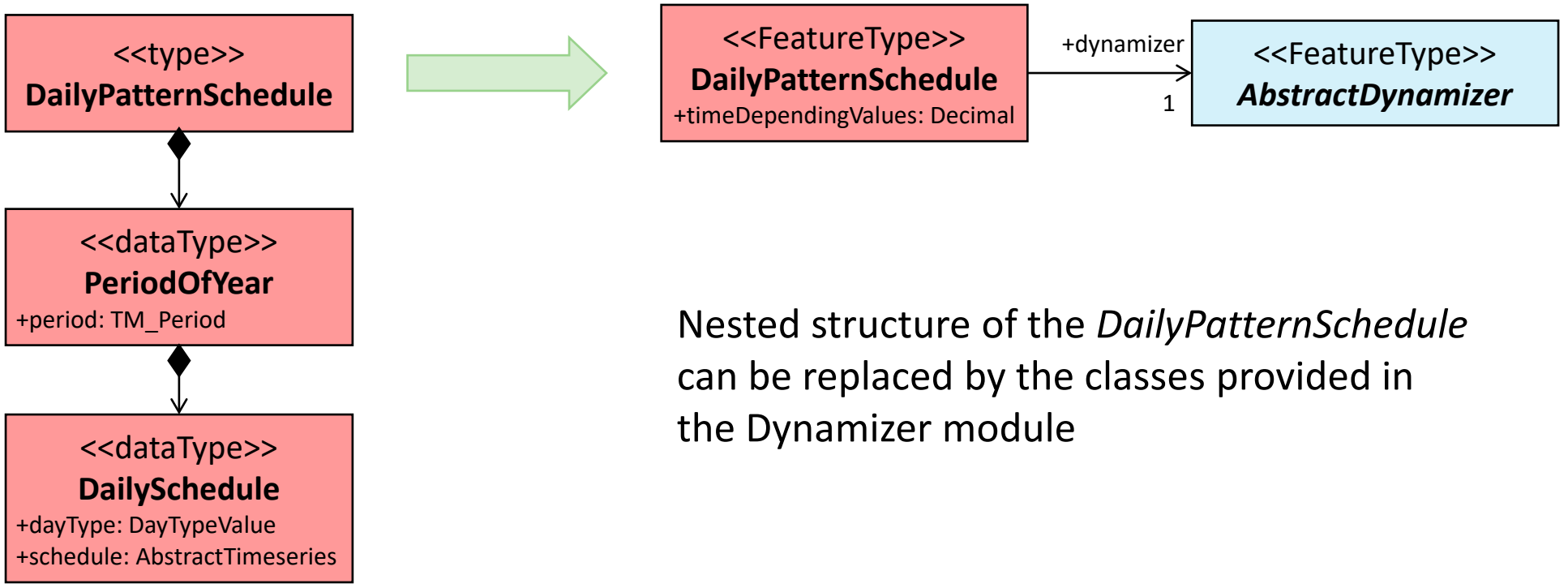
Implementation – Mapping

Schedules



Implementation – Mapping

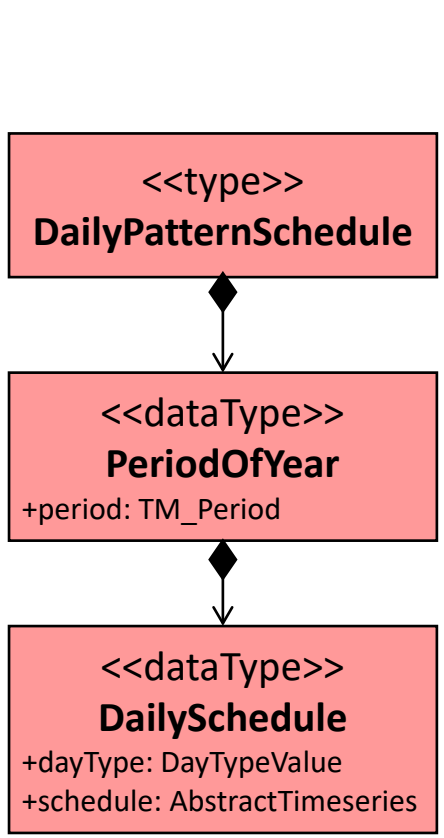
DailyPatternSchedule

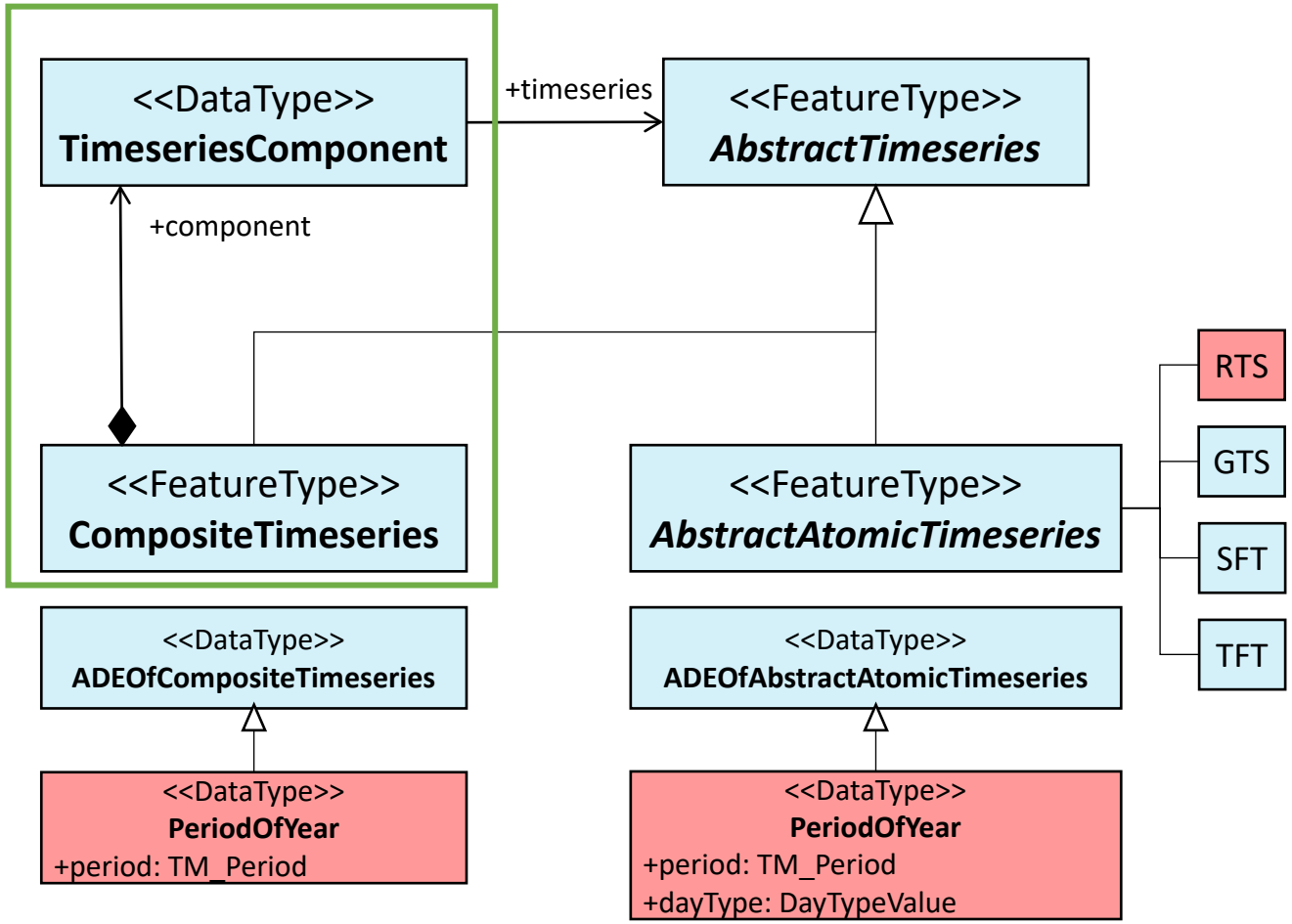


Nested structure of the *DailyPatternSchedule* can be replaced by the classes provided in the Dynamizer module

Implementation – Mapping

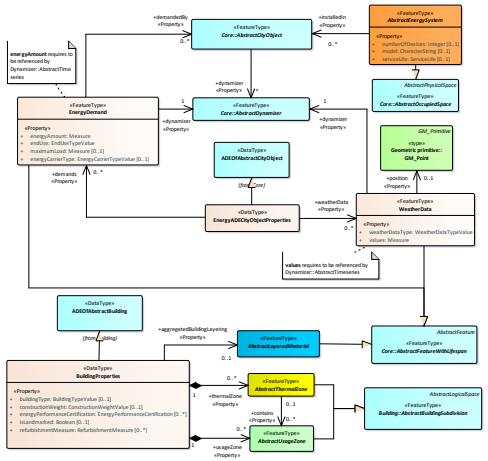
DailyPatternSchedule

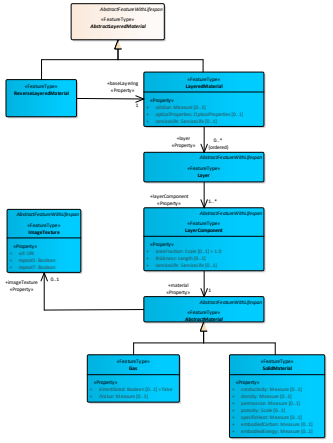


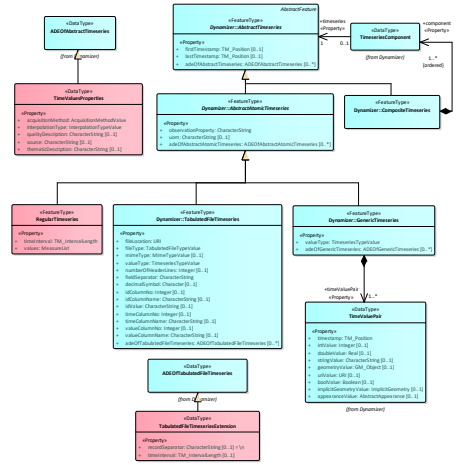


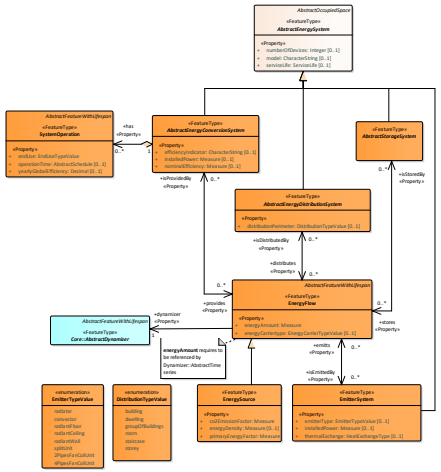
Implementation - Mapping

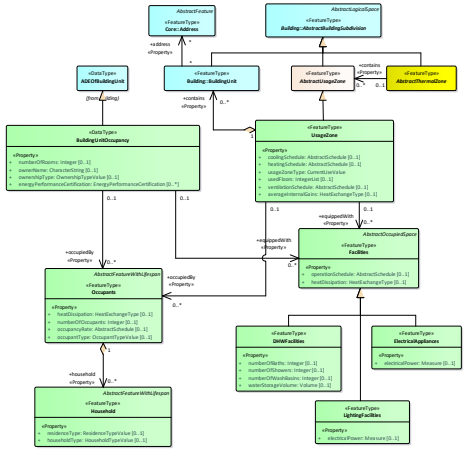
The remaining modules

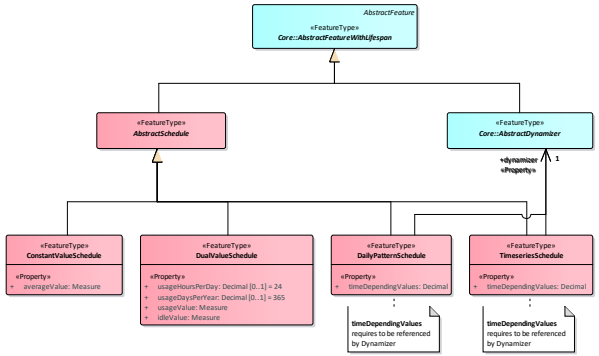












Implementation – XSD Schema derivation

Model-Driven Approach leaned on van den Brink et al., 2013

Define Data Model

Transfer Format

ShapeChange

Conversion

Implementation – XSD Schema derivation

```
<?xml version="1.0" encoding="UTF-8"?>
<ShapeChangeConfiguration xmlns:xi="http://www.w3.org/2001/XInclude"
    xmlns="http://www.interactive-instruments.de/ShapeChange/Configuration/1.1"
    xmlns:sc="http://www.interactive-instruments.de/ShapeChange/Configuration/1.1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.interactive-instruments.de/ShapeChange/Configuration/1.1
    http://shapechange.net/resources/schema/ShapeChangeConfiguration.xsd">

  <!-- defines some input parameters -->
  <input>
    <parameter name="inputModelType" value="EA7"/>
    <!-- the EA file that is read out -->
    <parameter name="inputFile" value="C:/Users/carol/Documents/Geomatics/Thesis/EA/CityGML_3.0_EnergyADE_tryouts.eap"/>
    <!-- the application schema / packages within the EA file which is processed -->
    <parameter name="appSchemaName" value="EnergyADE"/>
    <parameter name="checkingConstraints" value="disabled"/>
    <parameter name="addTaggedValues" value="itemType"/>
    <!-- some custom stereotypes and how they can be translated -->
    <xi:include href="http://shapechange.net/resources/config/StandardAliases.xml"/>
    <stereotypeAliases>
      <StereotypeAlias wellknown="property" alias="Property"/>
      <StereotypeAlias wellknown="version" alias="Version"/>
      <StereotypeAlias wellknown="FeatureType" alias="TopLevelFeatureType"/>
    </stereotypeAliases>
  </input>

  <!-- specifies where the log files are saved -->
  <log>
    <parameter name="reportLevel" value="INFO"/>
    <parameter name="logFile" value="C:/Users/carol/Documents/Geomatics/Thesis/EA/logs/Log_CityGML_3.0_EnergyADE.xml"/>
  </log>
```

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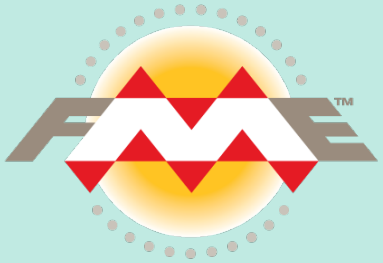
Implementation – Conversion

Model-Driven Approach leaned on van den Brink et al., 2013

Define Data Model

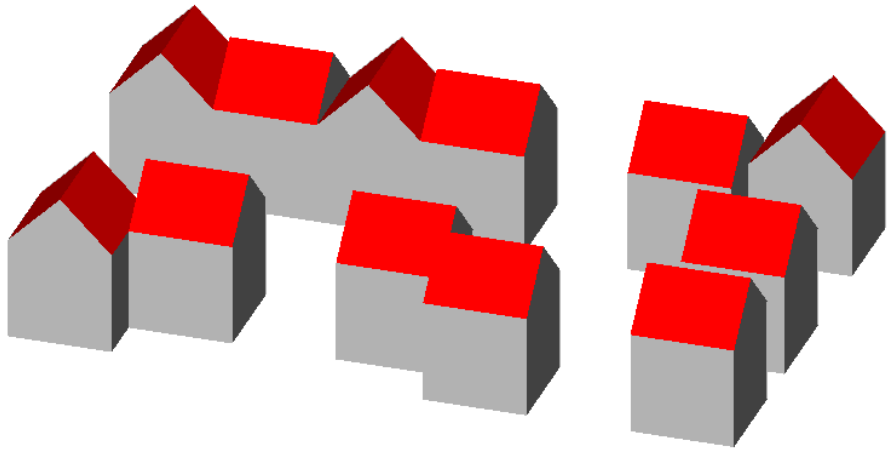
Transfer Format

Conversion



Implementation – Conversion

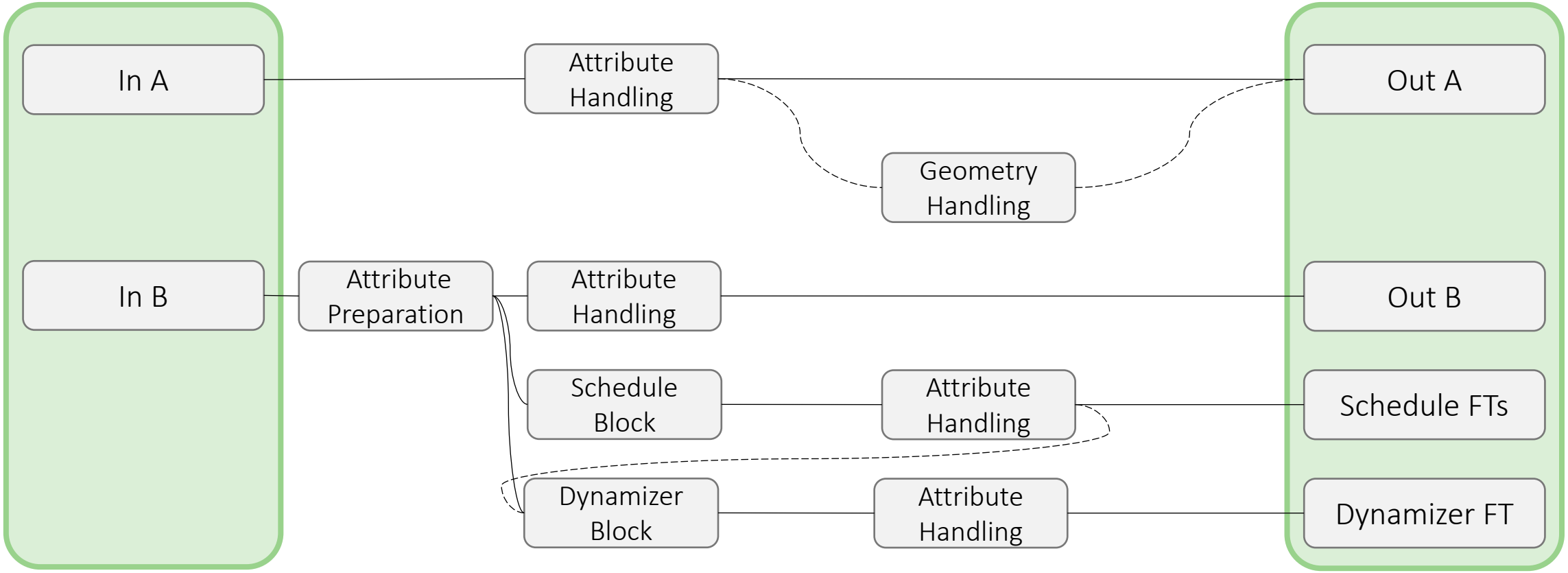
Test Data



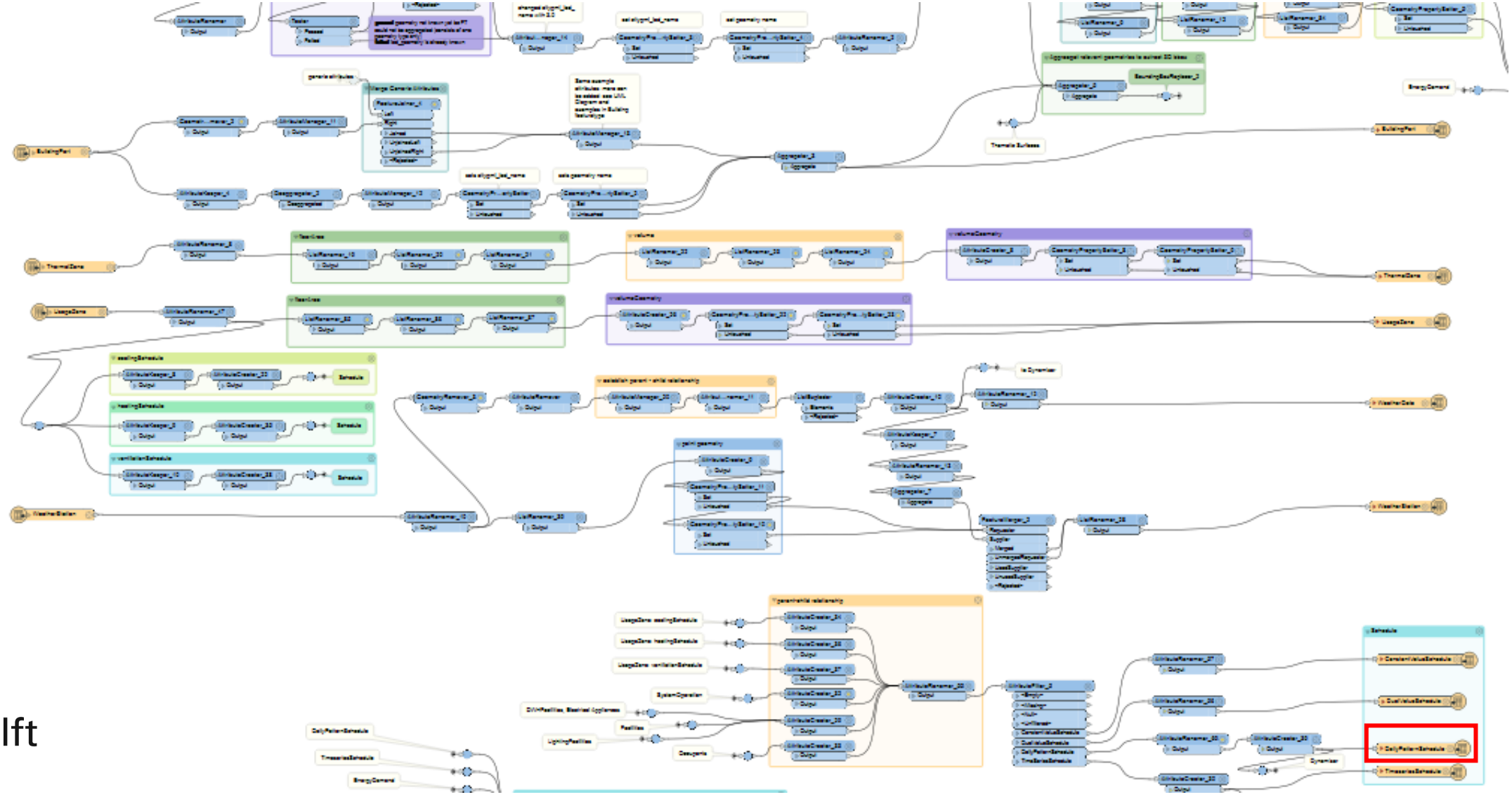
Imaginary City consisting of

- 12 *Buildings*, each containing
  - 1 LOD0 footprint
  - A LOD2 set of thematic surfaces
  - 1 *ThermalZone* comprising the whole building
  - A set of *ThermalBoundaries* (with geometries)
  - A set of *ThermalOpenings* (without geometries)
  - 1 *UsageZone*
  - A set of *Facilities*, *Occupants*, *Households*
  - Time series for HVAC and occupancy
- 1 *WeatherStation*

Implementation - Conversion



Implementation - Conversion



Results

```
<core:cityObjectMember>
    <bldg:Building gml:id="id_building_01">
       <gml:description>This is Building 1</gml:description>
       <gml:name>Snoke's Palace</gml:name>
       <core:creationDate>2019-11-17</core:creationDate>
       <energy:buildingType>Terraced House</energy:buildingType>
       <energy:constructionWeight>medium</energy:constructionWeight>
       <energy:energyPerformanceCertification>
           <energy:EnergyPerformanceCertification>
              <energy:rating>B</energy:rating>
              <energy:name>CasaClima</energy:name>
              <energy:certificationId>CC_12345_AA</energy:certificationId>
           </energy:EnergyPerformanceCertification>
       </energy:energyPerformanceCertification>
       <energy:isLandmarked>false</energy:isLandmarked>
    </bldg:Building>
</core:cityObjectMember>
```

ADE Hook in CityGML 2.0

```
<core:cityObjectMember>
    <bldg:Building gml:id="id_building_01">
       <gml:description>This is Building 1</gml:description>
       <gml:name>Snoke's Palace</gml:name>
       <core:creationDate>2019-11-17T00:00:00</core:creationDate>
       <bldg:adeOfAbstractBuilding>
           <nrg:BuildingProperties>
              <nrg:buildingType>Terraced House</nrg:buildingType>
              <nrg:constructionWeight>medium</nrg:constructionWeight>
              <nrg:energyPerformanceCertification>
                  <nrg:EnergyPerformanceCertification>
                     <nrg:rating>B</nrg:rating>
                     <nrg:name>CasaClima</nrg:name>
                     <nrg:certificationId>CC_12345_AA</nrg:certificationId>
                  </nrg:EnergyPerformanceCertification>
              </nrg:energyPerformanceCertification>
              <nrg:isLandmarked>false</nrg:isLandmarked>
           </nrg:BuildingProperties>
       </bldg:adeOfAbstractBuilding>
    </bldg:Building>
</core:cityObjectMember>
```

ADE Hook in CityGML 3.0

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```
1  <nrg:UsageZone gml:id="id_building_1_usage_zone_1">
2    <gml:name>UsageZone 1 of Building 1</gml:name>
3    <nrg:coolingSchedule>
4        <nrg:DailyPatternSchedule gml:id="id_building_1_cooling_schedule_1">
5          <nrg:timeDependingValues>0.5</nrg:timeDependingValues>
6          <nrg:dynamizer>
7              <dyn:Dynamizer gml:id="id_dynamizer_1">
8                <dyn:attributeRef>//nrg:DailyPatternSchedule[@gml:id='id_ building_1
                  _cooling_schedule_1']/nrg:timeDependingValues</dyn:attributeRef>
9                <dyn:dynamicData>
10                   <dyn:CompositeTimeseries gml:id=
                     "id_CompositeTimeseries_1">
11                     <dyn:component>
12                       <dyn:TimeseriesComponent>
13                         <dyn:repetitions>1</dyn:repetitions>
14                         <dyn:timeseries>
15                           <nrg:RegularTimeseries gml:id=
                             "id_timeseries_01">
…                              ...
40                           </nrg:RegularTimeseries>
41                         </dyn:timeseries>
42                       </dyn:TimeseriesComponent>
43                     </dyn:component>
44                     <dyn:component>
45                       <dyn:TimeseriesComponent>
46                         <dyn:repetitions>1</dyn:repetitions>
47                         <dyn:timeseries>
48                           <nrg:RegularTimeseries
                              gml:id="id_timeseries_02">
…                              ...
73                           </nrg:RegularTimeseries>
74                         </dyn:timeseries>
75                       </dyn:TimeseriesComponent>
76                     </dyn:component>
77                   </dyn:CompositeTimeseries>
78               </dyn:dynamicData>
79             </dyn:Dynamizer>
80         </nrg:dynamizer>
81       </nrg:DailyPatternSchedule>
82   </nrg:coolingSchedule>
83 </nrg:UsageZone>
```

Correct DPS (postprocessing)

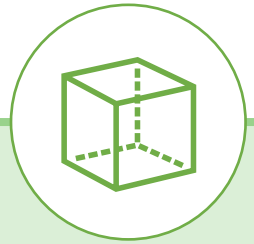
```
1  <nrg:UsageZone gml:id="id_building_1_usage_zone_1">
2    <gml:name>UsageZone 1 of Building 1</gml:name>
3    <nrg:coolingSchedule>
4        <nrg:DailyPatternSchedule gml:id="id_building_1_cooling_schedule_1">
5          <nrg:timeDependingValues>0.5</nrg:timeDependingValues>
6          <nrg:dynamizer>
7              <dyn:Dynamizer gml:id="id_dynamizer_1">
8                <dyn:attributeRef>//nrg:DailyPatternSchedule[@gml:id='id_ building_1
                  _cooling_schedule_1']/nrg:timeDependingValues</dyn:attributeRef>
9                <dyn:dynamicData>
10                   <dyn:CompositeTimeseries gml:id=
                     "id_CompositeTimeseries_1">
11                     <dyn:component>
12                       <dyn:TimeseriesComponent>
13                         <dyn:repetitions>1</dyn:repetitions>
14                         <dyn:timeseries>
15                           <nrg:RegularTimeseries gml:id=
                             "id_timeseries_01">
…                              ...
38                           </nrg:RegularTimeseries>
39                           <nrg:RegularTimeseries gml:id=
                             "id_timeseries_02">
…                              ...
66                           </nrg:RegularTimeseries>
67                         </dyn:timeseries>
68                       </dyn:TimeseriesComponent>
69                     </dyn:component>
70                     <dyn:component>
71                       <dyn:TimeseriesComponent>
72                         <dyn:repetitions>1</dyn:repetitions>
73                       </dyn:TimeseriesComponent>
74                     </dyn:component>
75                   </dyn:CompositeTimeseries>
76               </dyn:dynamicData>
77             </dyn:Dynamizer>
78         </nrg:dynamizer>
79       </nrg:DailyPatternSchedule>
80   </nrg:coolingSchedule>
81 </nrg:UsageZone>
```

Wrong DPS (FME)

Discussion

Mapping Approach

- Not a unique solution
- Mapping strategies to ensure consistent logic
- Still multiple possibilities within this framework



Geometries

- Integration into CityGML 3.0 space and geometry concept
- Multiple geometry representation
- Some features obtain geometries

Conversion

- Converts test data
- Some *DPS* require postprocessing due to FME bug
- Some transformations need to be adapted to the input data

Conclusion

How and to what extent need the Energy ADE for CityGML 2.0 be adapted to be conformant with the newly released CityGML 3.0 standard?

- Which classes of the Energy ADE 1.0 become obsolete, which ones need to be adapted and which ones can mostly be taken over?
- What will the Energy ADE data model for CityGML 3.0 look like, both in terms of UML encoding and XSD file?
- How can Energy ADE for CityGML 2.0 data be converted to Energy ADE for CityGML 3.0 data?

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Conclusion - Future Work

- Define Geometries
- Create a User Guide
- Package Diagrams
- Create a universal conversion for any Energy ADE input data
- Further testing e.g. in real-life applications
- Implement other mapping solutions to test and compare them

Discussion – Overall Contribution

Energy ADE

- Shows how new concepts of CityGML 3.0 can be used by the Energy ADE
- Accounts especially for the handling of timeseries
- Suggestions for future versions beyond a mapping

CityGML 3.0

- Example on how ADEs can be mapped to CityGML 3.0
- Integration of a *RegularTimeseries* in the Dynamizer module
- Integration of a *recordSeparator* property in *TabulatedFileTimeseries*
- All over to the establishment of CityGML 3.0

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Thank you for your attention