Dynamizer ADE - CityGML 3.0

Kanishk Chaturvedi, Thomas H. Kolbe

Chair of Geoinformatics
Technische Universität München

kanishk.chaturvedi@tum.de

Agenda

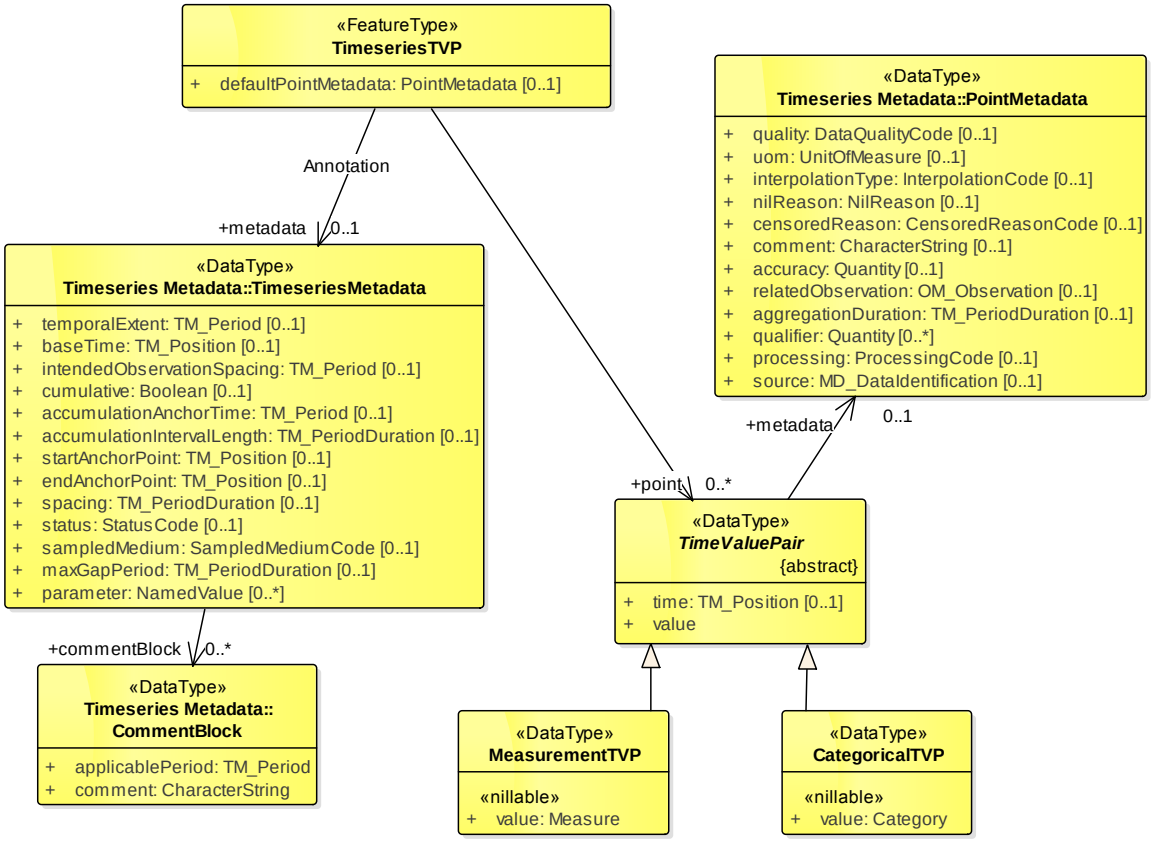
- Update on TimeseriesML 1.0
- CityGML 3.0 – Dynamizers
- Development of XML Schema
  - ShapeChange
- Instance XML Documents

TimeseriesML 1.0

- TimeseriesML 1.0 vote has been concluded and OGC TC has voted yes to adopt the standard – February 3rd, 2016
- Extension of the work initially undertaken within OGC WaterML 2.0:Part 1- Timseries
  - Aim at developing domain-neutral model for the representation and exchange of timeseries data
- Developments
  - OGC 15-043r3: Timeseries Profile of Observations and Measurements
  - OGC 15-042r3: XML encoding that implements the OGC Timeseries Profile of Observations and Measurements
- Next teleconference for TimeseriesML1.0
  - February 16, 2016

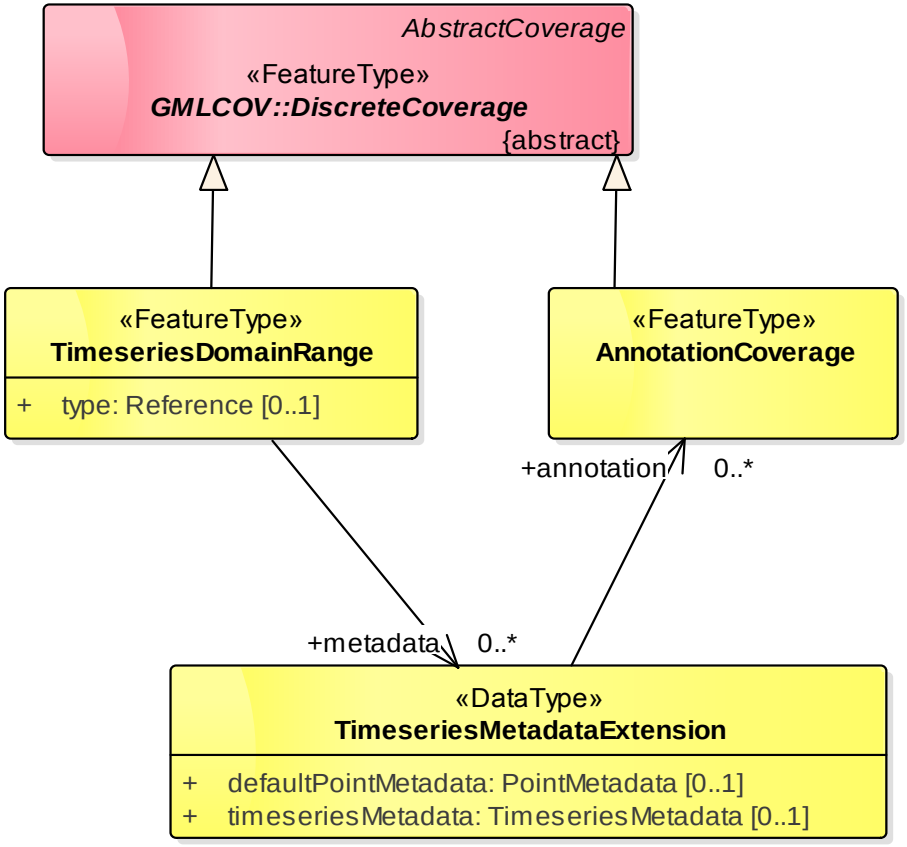
TimeseriesML1.0 – Time-Value Pair Encoding

- Representation of a special case of the CV_DiscreteCoverage class from OGC Abstract Specification Topic 6

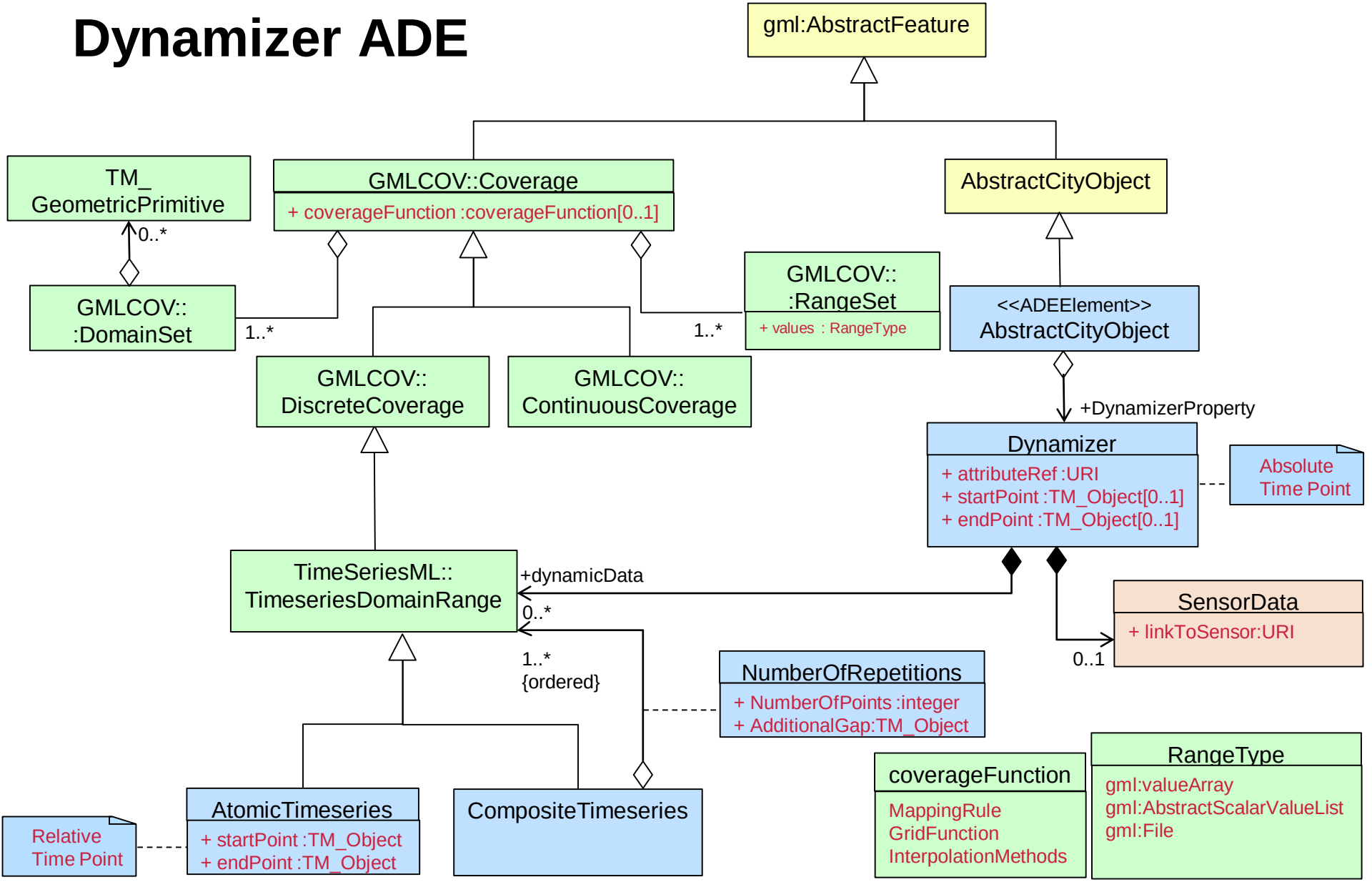


TimeseriesML 1.0 – Domain-Range Encoding

- Extension of OGC Implementation Schema for Coverages (09-146r2)



Dynamizer ADE



Key benefits of the modified Dynamizer ADE

- Supports multiple dynamic representations
  - Timeseries encoded in Time-value Pair
  - Timeseries encoded in Domain-Range
  - External links to Sensor Observation Services
    - The observation results in SOS are encoded in OGC O&M standard and are in time-value pair
    - It is possible to model results from SOS according to Timeseries Time-Value pair specification
- Mappings of missing or multiple attribute values utilizing interpolation and aggregation methods
- Supporting complex patterns based on statistics and general rules
  - It is also possible to define multiple patterns within same time period for the same CityGML feature attribute

UML Model to XML Schema

- The XML Schema can be derived automatically from the UML Model using ShapeChange (http://shapechange.net/)

- ShapeChange requires a configuration file which defines relevant arguments concerning the UML Model

- More details:
  - Kutzner, T., Kolbe, T.H. (Eds.). 2014. OGC CityGML EA UML Model Engineering Report, OGC document (Currently in Draft format)
  - van den Brink, L., Stoter, J., Zlatanova S. (Eds.). 2012. Modeling an application domain extension of CityGML in UML, OGC document 12-066.

Header of the Dynamizer ADE Schema definition file

```
<?xml version="1.0" encoding="UTF-8"?>
<schema xmlns:dyn="http://www.citygml.org/ade/dynamizer_ade/1.0"
  xmlns:core="http://www.opengis.net/citygml/2.0"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:tsml="http://www.opengis.net/timeseriesml/1.0"
  xmlns="http://www.w3.org/2001/XMLSchema"
targetNamespace="http://www.citygml.org/ade/dynamizer_ade/1.0"
version="1.0" elementFormDefault="qualified">
  <import namespace="http://www.opengis.net/citygml/2.0"
schemaLocation="http://schemas.opengis.net/citygml/2.0/cityGMLBase.xsd"/>
  <import namespace="http://www.opengis.net/gml"
schemaLocation="http://schemas.opengis.net/gml/3.1.1/base/gml.xsd"/>
  <import namespace="http://www.opengis.net/timeseriesml/1.0"/>
```

DynamizerPropertyType, DynamizerProperty

```
 <element name="DynamizerProperty"
substitutionGroup="core:_GenericApplicationPropertyOfCityObject"
type="dynamizer:DynamizerPropertyType"/>
  <complexType name="DynamizerPropertyType">
    <sequence minOccurs="0">
      <element ref="dynamizer:Dynamizer"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </complexType>
  <element name="Dynamizer" substitutionGroup="gml:_CityObject"
type="dynamizer:DynamizerType"/>
  <complexType name="DynamizerType">
    <complexContent>
      <extension base="gml:AbstractFeatureType">
        <sequence>
          <element name="attributeRef"/>
          <element minOccurs="0" name="startPoint">
            <complexType>
              <sequence minOccurs="0">
                <element ref="gml:_TimePosition"/>
              </sequence>
              <attributeGroup ref="gml:AssociationAttributeGroup"/>
            </complexType>
          </element>
          <element minOccurs="0" name="endPoint">
            <complexType>
              <sequence minOccurs="0">
                <element ref="gml:_TimePosition"/>
              </sequence>
              <attributeGroup ref="gml:AssociationAttributeGroup"/>
            </complexType>
          </element>
          <element maxOccurs="unbounded" minOccurs="0" name="dynamicData"
type="tsml:TimeseriesDomainRangePropertyType"/>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
```

Reference to CityGML attributes

Absolute Time Points

Link to Timeseries

AtomicTimeSeries

```
 <element name="AtomicTimeseries" substitutionGroup="tsml:TimeseriesDomainRange"
type="dynamizer:AtomicTimeseriesType"/>
  <complexType name="AtomicTimeseriesPropertyType">
    <sequence minOccurs="0">
      <element ref="dynamizer:AtomicTimeseries"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </complexType>
  <complexType name="AtomicTimeseriesType">
    <complexContent>
      <extension base="tsml:TimeseriesDomainRangeType">
        <sequence>
          <element name="startPoint">
            <complexType>
              <sequence minOccurs="0">
                <element ref="gml:_TimePosition"/>
              </sequence>
              <attributeGroup ref="gml:AssociationAttributeGroup"/>
            </complexType>
          </element>
          <element name="endPoint">
            <complexType>
              <sequence minOccurs="0">
                <element ref="gml:_TimePosition"/>
              </sequence>
              <attributeGroup ref="gml:AssociationAttributeGroup"/>
            </complexType>
          </element>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
```

Relative Time Points

CompositeTimeseries

```
<element name="CompositeTimeseries" substitutionGroup="tsml:TimeseriesDomainRange"
type="dynamizer:CompositeTimeseriesType"/>
  <complexType name="CompositeTimeseriesType">
    <complexContent>
      <extension base="tsml:TimeseriesDomainRangeType">
        <sequence/>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="CompositeTimeseriesPropertyType">
    <sequence minOccurs="0">
      <element ref="dynamizer:CompositeTimeseries"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </complexType>
  <complexType name="NumberOfRepetitionsPropertyType">
    <sequence minOccurs="0">
      <element ref="dynamizer:NumberOfRepetitions"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </complexType>
  <element name="NumberOfRepetitions" substitutionGroup="gml:_GML" type="dynamizer:NumberOfRepetitionsType"/>
  <complexType name="NumberOfRepetitionsType">
    <complexContent>
      <extension base="gml:AbstractGMLType">
        <sequence>
          <element name="NumberOfRepetitions" type="positiveInteger"/>
          <element name="AdditionalGap">
            <complexType>
              <sequence minOccurs="0">
                <element ref="gml:_TimeDuration"/>
              </sequence>
              <attributeGroup ref="gml:AssociationAttributeGroup"/>
            </complexType>
          </element>
        </sequence>
      </extension>
    </complexContent>
```

Repetition of Atomic Timeseries

Data Types and Enumerations

```
<simpleType name="CoverageFunctionAttributeTypeType">
   <restriction base="string">
     <enumeration value="MappingRule"/>
     <enumeration value="GridFunction"/>
     <enumeration value="InterpolationMethods"/>
   </restriction>
 </simpleType>
 <element name="RangeType" substitutionGroup="gml:_GML" type="dynamizer:RangeTypeType"/>
 <complexType name="RangeTypePropertyType">
   <sequence minOccurs="0">
     <element ref="dynamizer:RangeType"/>
   </sequence>
   <attributeGroup ref="gml:AssociationAttributeGroup"/>
 </complexType>
 <complexType name="RangeTypeType">
   <complexContent>
     <extension base="gml:AbstractGMLType">
       <sequence>
         <element name="valueArray"/>
         <element name="abstractScalarValueList"/>
         <element name="file"/>
       </sequence>
     </extension>
   </complexContent>
 </complexType>
```

Coverage Functions Types

Range Types

LinkToSensor

```
<element name="SensorData" substitutionGroup="gml:_GML" type="dynamizer:SensorDataType"/>
  <complexType name="SensorDataPropertyType">
    <sequence minOccurs="0">
      <element ref="dynamizer:SensorData"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </complexType>
  <complexType name="SensorDataType">
    <complexContent>
      <extension base="gml:AbstractGMLType">
        <sequence>
          <element name="linkToSensor"/>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
```

Example XML Structure - Header

```
<?xml version="1.0" encoding="UTF-8"?>
<CityModel xmlns="http://www.opengis.net/citygml/2.0"
    xmlns:bldg="http://www.opengis.net/citygml/building/2.0"
    xmlns:dyn="http://www.citygml.org/ade/dynamizer_ade/1.0"
    xmlns:gml="http://www.opengis.net/gml"
    xmlns:gmlcov="http://www.opengis.net/gmlcov/1.0"
    xmlns:tsml="http://www.opengis.net/timeseriesml/1.0"
    xmlns:xlink="http://www.w3.org/1999/xlink"
    xmlns:xAL="urn:oasis:names:tc:ciq:xsdschema:xAL:2.0"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.citygml.org/ade/dynamizer_ade DynamizerADE/CityGML-DynamizerADE.xsd">
    <cityObjectMember>
    ......
    ......
    ......
    </cityObjectMember>
 </CityModel>
```

XML Structure – Domain-Range Encoding

```
<cityObjectMember>
  <Building gml:id = "building1">
    <gen:doubleAttribute name = "HeatDemand">
      <gen:value = 61578 />
    </gen:doubleAttribute>
  </Building>
</cityObjectMember>
<cityObjectMember>
  <Dynamizer gml:id = "HeatDemandTimeseries" >
    <startPoint>2016-01-01T00:00:00Z</startPoint>
    <endPoint>2016-12-01T00:00:00Z</endPoint>
    <dynamicDataTDR>
      <tsml:TimeseriesDomainRange gml:id="timeseries">
        <gml:domainSet>
          <tsml:TimePositionList gml:id="temporal_domain">
            <tsml:timePositionList>2016-01-01T00:00:00Z 2016-02-01T00:00:00Z
            2016-03-01T00:00:00Z 2016-04-01T00:00:00Z 2016-05-01T00:00:00Z
            2016-06-01T00:00:00Z 2016-07-01T00:00:00Z 2016-08-01T00:00:00Z
            2016-09-01T00:00:00Z 2016-10-01T00:00:00Z 2016-11-01T00:00:00Z
            2016-12-01T00:00:00Z</tsml:timePositionList>
          </tsml:TimePositionList>
        </gml:domainSet>
        <gml:rangeSet>
          <gml:QuantityList uom="kwh"> 61578 52148 41011 missing 41199 48789 56767
                    66554 76777 67665 missing 66552 </gml:QuantityList>
        </gml:rangeSet>
      </tsml:TimeseriesDomainRange>
    </dynamicDataTDR>
    <attributeRef xlink:href = "//building [@gml:id = 'building1']/[@name = 'HeatDemand']"
          position = 'attributes'>
       <attribute name = 'value'> {@rangeSet} </attribute>
          </attributeRef>
   </dynamizer>
<cityObjectMember>
```

CityGML Building

Absolute Time Points

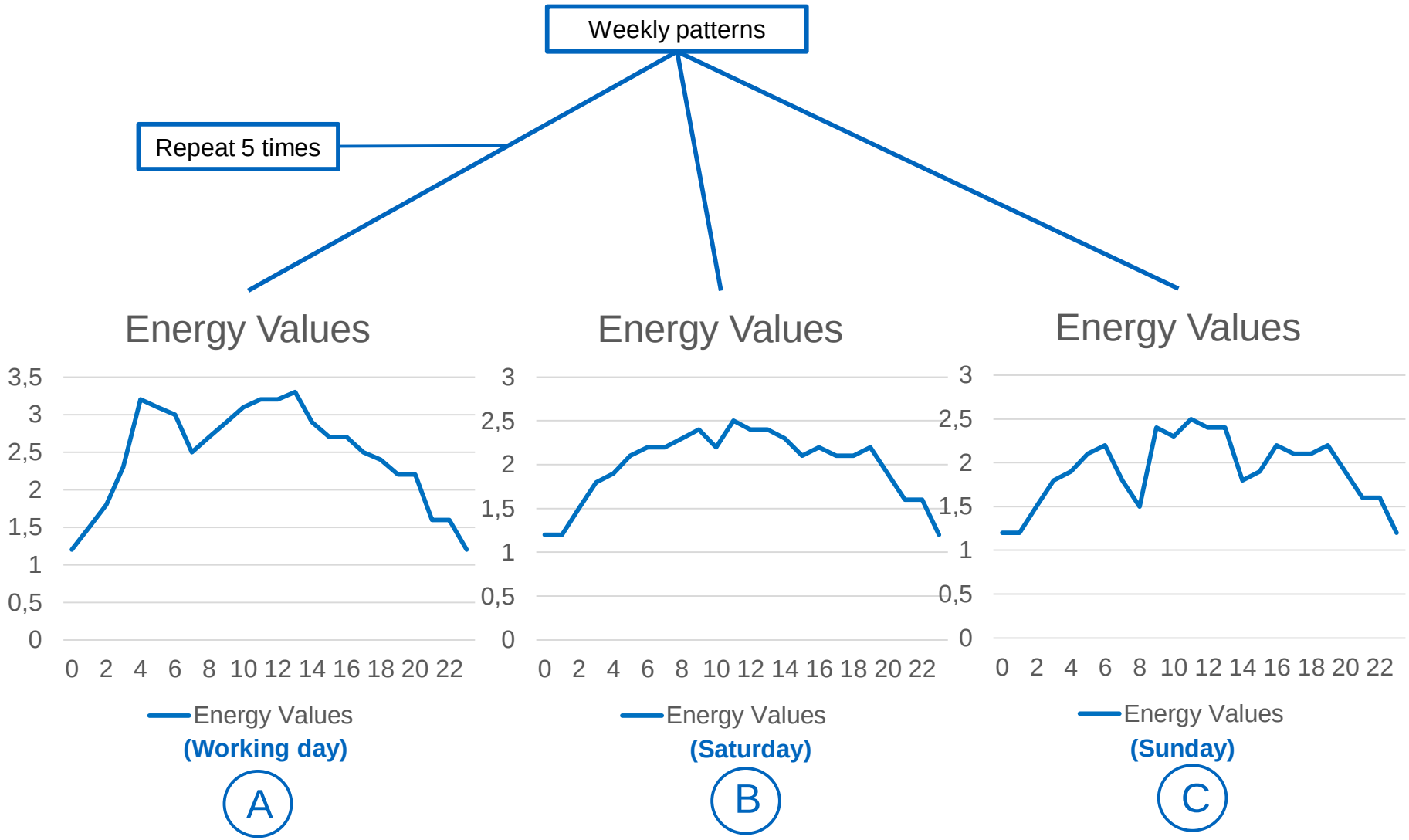
Domain-Range Encoding

Overriding using XPath

XML Structure – Defining Metadata

```
<cityObjectMember>
  <Dynamizer gml:id = "HeatDemandTimeseries" >
    <startPoint>2016-01-01T00:00:00Z</startPoint>
    <endPoint>2016-12-01T00:00:00Z</endPoint>
    <dynamicDataTDR>
     <tsml:TimeseriesDomainRange gml:id="timeseries">
      <gml:domainSet>
        <tsml:TimePositionList gml:id="temporal_domain">
          <tsml:timePositionList>2016-01-01T00:00:00Z 2016-02-01T00:00:00Z 2016-03-
            01T00:00:00Z 2016-04-01T00:00:00Z 2016-05-01T00:00:00Z 2016-06-01T00:00:00Z
            2016-07-01T00:00:00Z 2016-08-01T00:00:00Z 2016-09-01T00:00:00Z 2016-10-
            01T00:00:00Z 2016-11-01T00:00:00Z 2016-12-01T00:00:00Z</tsml:timePositionList>
        </tsml:TimePositionList>
      </gml:domainSet>
      <gml:rangeSet>
        <gml:QuantityList uom="kwh"> 61578 52148 41011 missing 41199 48789 56767 66554 76777 67665
                    missing 66552 </gml:QuantityList>
      </gml:rangeSet>
    </tsml:TimeseriesDomainRange>
    <gmlcov:metadata>
      <gmlcov:Extension>
        <tsml:TimeseriesMetadataExtension>
          <tsml:defaultPointMetadata>
            <tsml:PointMetadata>
              <tsml:uom code="%"/>
              <tsml:interpolationType
                        xlink:href="http://www.opengis.net/def/timeseriesml/1.0/interpolationType/AveragePrec"
                        xlink:title="Average in Preceding Interval"/>
              <tsml:aggregationDuration>PT30M</tsml:aggregationDuration>
            </tsml:PointMetadata>
          </tsml:defaultPointMetadata>
        </tsml:TimeseriesMetadataExtension>
      </gmlcov:Extension>
     </gmlcov:metadata>
    <dynamicDataTDR>
    <attributeRef xlink:href = "//building [@gml:id = 'building1']/[@name = 'HeatDemand']" position =
            'attributes'>
       <attribute name = 'value'> {@rangeSet} </attribute>
    </attributeRef>
  </Dynamizer>
<cityObjectMember>
```

Supporting patterns



Supporting Patterns

```
<cityObjectMember>
  <Dynamizer gml:id = "HeatDemandTimeseries" >
    <startPoint>2016-01-01T00:00:00Z</startPoint>
    <endPoint>2016-12-01T00:00:00Z</endPoint>
    <dynamicDataTDR>
     <dymzr:compositeTimeseries gml:id="Week_Patterns">
      <dymzer:NumberOfRepititions gml:id="Weekdays">
            <dymzr:NumberOfRepititions>5</dymzr:NumberOfRepetitions>
      </dymzer:NumberOfRepititions>
      <dymzr:atomicTimeseries gml:id="Weekdays_Timeseries">
        <dymzer:startPoint>2016-02-15T00:00:00Z</dymzer:startPoint>
        <tsml:TimeseriesDomainRange>
          <gml:domainSet>
            <tsml:TimePositionList gml:id="temporal_domain_weekdays">
              <tsml:timePositionList>2016-02-15T00:00:00Z 2016-02-15T01:00:00Z 2016-
                        02-15T02:00:00Z ..... 2016-02-15T22:00:00Z 2016-02-
                        15T23:00:00Z</tsml:timePositionList>
            </tsml:TimePositionList>
          </gml:domainSet>
          <gml:rangeSet>
            <gml:QuantityList uom="kwh"> 61578 52148 41011 ..... 67665 66552
            </gml:QuantityList>
          </gml:rangeSet>
        </tsml:TimeseriesDomainRange>
       </dymzr:atomicTimeseries>
       <dymzr:atomicTimeseries gml:id="Saturdays_Timeseries">
                . . . .
                . . . .
       </dymzr:atomicTimeseries>
      </dymzr:compositeTimeseries>
     <dynamicDataTDR>
  </Dynamizer>
</cityObjectMember>
```

Repetitions of Atomic Timeseries

Atomic Timeseries for weekdays

Atomic Timeseries for weekends

Alternative Representation Time-Value Pair Encoding

```
<cityObjectMember>
  <Dynamizer gml:id = "HeatDemandTimeseries" >
    <startPoint>2016-01-01T00:00:00Z</startPoint>
    <endPoint>2016-12-01T00:00:00Z</endPoint>
    <dynamicDataTVP>
     <tsml:TimeseriesTVP gml:id="tsml.measurementimeseries.heatdemand">
      <tsml:metadata>
        <tsml:TimeseriesMetadata>
          <tsml:temporalExtent xlink:href="#om.phenomenontime.heatdemand"/>
          <tsml:baseTime>2016-01-01T00:30:00.000+12:00</tsml:baseTime>
          <tsml:spacing>PT30M</tsml:spacing>
          <tsml:startAnchorPoint>2016-01-01T00:00:00.000+12:00</tsml:startAnchorPoint>
        </tsml:TimeseriesMetadata>
      </tsml:metadata>
      <tsml:defaultPointMetadata>
        <tsml:PointMetadata>
          <tsml:uom code="%"/>
          <tsml:interpolationType       xlink:href="http://www.opengis.net/def/timeseriesml/1.0/interpolationType/AveragePrec
             xlink:title="Average in Preceding Interval"/>
          <tsml:aggregationDuration>PT30M</tsml:aggregationDuration>
        </tsml:PointMetadata>
      </tsml:defaultPointMetadata>
      <tsml:point>
        <tsml:MeasurementTVP>
          <tsml:value>39.97</tsml:value>
        </tsml:MeasurementTVP>
      </tsml:point>
      <tsml:point>
        <tsml:MeasurementTVP>
          <tsml:value>40.12</tsml:value>
        </tsml:MeasurementTVP>
      </tsml:point>
      <tsml:point>
        <tsml:MeasurementTVP>
          <tsml:value>40.02</tsml:value>
        </tsml:MeasurementTVP>
      </tsml:point>
          ............
     </tsml:TimeseriesTVP>
    <dynamicDataTVP>
    <attributeRef xlink:href = "//building [@gml:id = 'building1']/[@name = 'HeatDemand']" position = 'attributes'>
                                        <attribute name = 'value'> {@rangeSet} </attribute>
    </attributeRef>
  </Dynamizer>
</cityObjectMember>
```

Link to Sensor Observation Services

- Query: Get Observation for a sensor for a specific property (temperature in this example) between a given time period http://129.187.38.201:8080/52n-sos-webapp/service?service=SOS&version=2.0.0&request=GetObservation&featureOfInterest=DHT_Sensor_Munich&procedure=DHT22_Sensor&observedProperty=Temperature_DHT22&temporalFilter=om:phenomenonTime,2015-11-10T09:00:00Z/2015-11-10T12:00:00Z

- Structure of the request is
  - http://129.187.38.201:8080/52n-sos-webapp/service(SOS instance)
  - REQUEST=GetObservation (SOS Request parameter)
  - SERVICE=SOS&VERSION=2.0.0 (Service of the request)
  - PROCEDURE=DHT22_Sensor (Procedure of the sensor)
  - temporalFiler= 2015-11-10T09:00:00Z/2015-11-10T12:00:00Z

Link to Sensor Observation Services

```
<cityObjectMember>
  <dynamizer gml:id = "HeatDemandTimeseries" >
    <startPoint>2015-01-01T00:00:00Z</startPoint>
    <endPoint>2015-12-01T00:00:00Z</endPoint>
    <linkToSensor xlink:href = "http://129.187.38.201:8080/52n-sos-
webapp/service?service=SOS&version=2.0.0&request=GetObservation&featureOfInterest=DHT_Sensor_Munich&procedure=DH
T22_Sensor&observedProperty=Temperature_DHT22&temporalFilter=om:phenomenonTime,2015-11-10T09:00:00Z/2015-11-
10T12:00:00Z"/>
    <attributeRef xlink:href = "//building [@gml:id = 'building1']/[@name = 'HeatDemand']" position =
          'attributes'>
        <attribute name = 'value'> {@result} </attribute>
    </attributeRef>
  </dynamizer>
</cityObjectMember>
```

Future Work

- Test implementation with FME
- Modeling of SOS results within Dynamizers
  - The results of GetObservation of SOS are encoded in OGC O&M standards and in time-value pair
  - Dynamizers should be able to read the results in the same structure
- Modeling of data redundantly
  - Should we allow overlapping representations expressing multiple values from different sources?
- Modeling metadata of Dynamizers