Approach for Dynamic Data Schema CityGML 3.0

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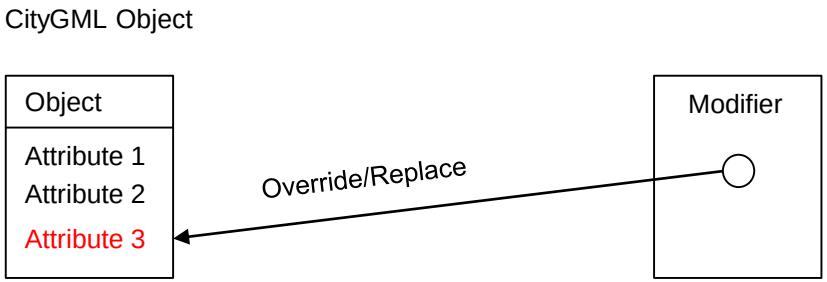
Modifier features

- Modifier features can refer to a specific property of a CityGML feature which value can be then overridden or replaced by the dynamic value specified in the modifier feature



Example Scenario

```
<cityObjectMember>
  <Building gml:id = "building1">
        <gen:stringAttribute name = "HeatDemands">
              <gen:value = 135 />
        </gen:stringAttribute>
  </Building>
</cityObjectMember>

<cityObjectMember>
  <Building gml:id = "building1">
        <gen:stringAttribute name = "HeatDemands">
              <gen:value = 148 />
        </gen:stringAttribute>
  </Building>
</cityObjectMember>

<cityObjectMember>
  <Building gml:id = "building1">
        <gen:stringAttribute name = "HeatDemands">
              <gen:value = 165 />
        </gen:stringAttribute>
  </Building>
</cityObjectMember>
```

Month	Heat Energy Demand
January	135
February	148
March	165
.	.
.	.
.	.
December	201

Overriding using XPath

- XPath is a W3C recommendation used to navigate through elements and attributes in a XML document.
- XPath allows to determine the postion of the contex item and replace the attributes

```
<cityObjectMember>
  <Building gml:id = "building1">
        <gen:stringAttribute name = "HeatDemands">
              <gen:value = 135 />
        </gen:stringAttribute>
  </Building>
</cityObjectMember>
```

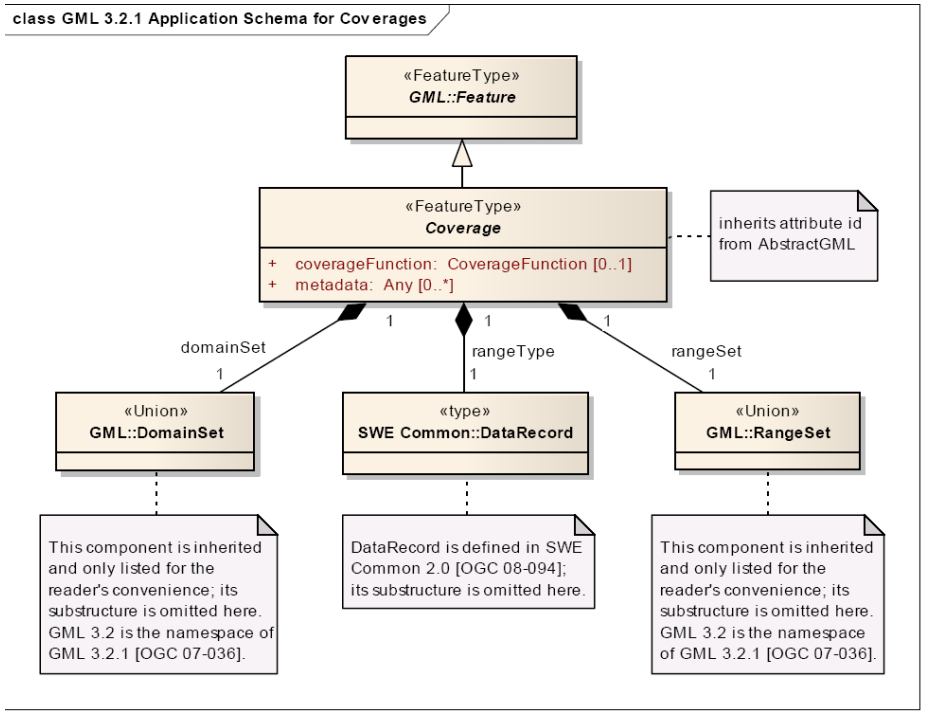
City Object generic attribute

```
<modifier xlink:href = "//building [@gml:id = 'building1']/[@name = 'HeatDemands']" position = 'attributes'>
              <attribute name = 'value'> 148 </attribute>
</modifier>
```

Modifying using XPath

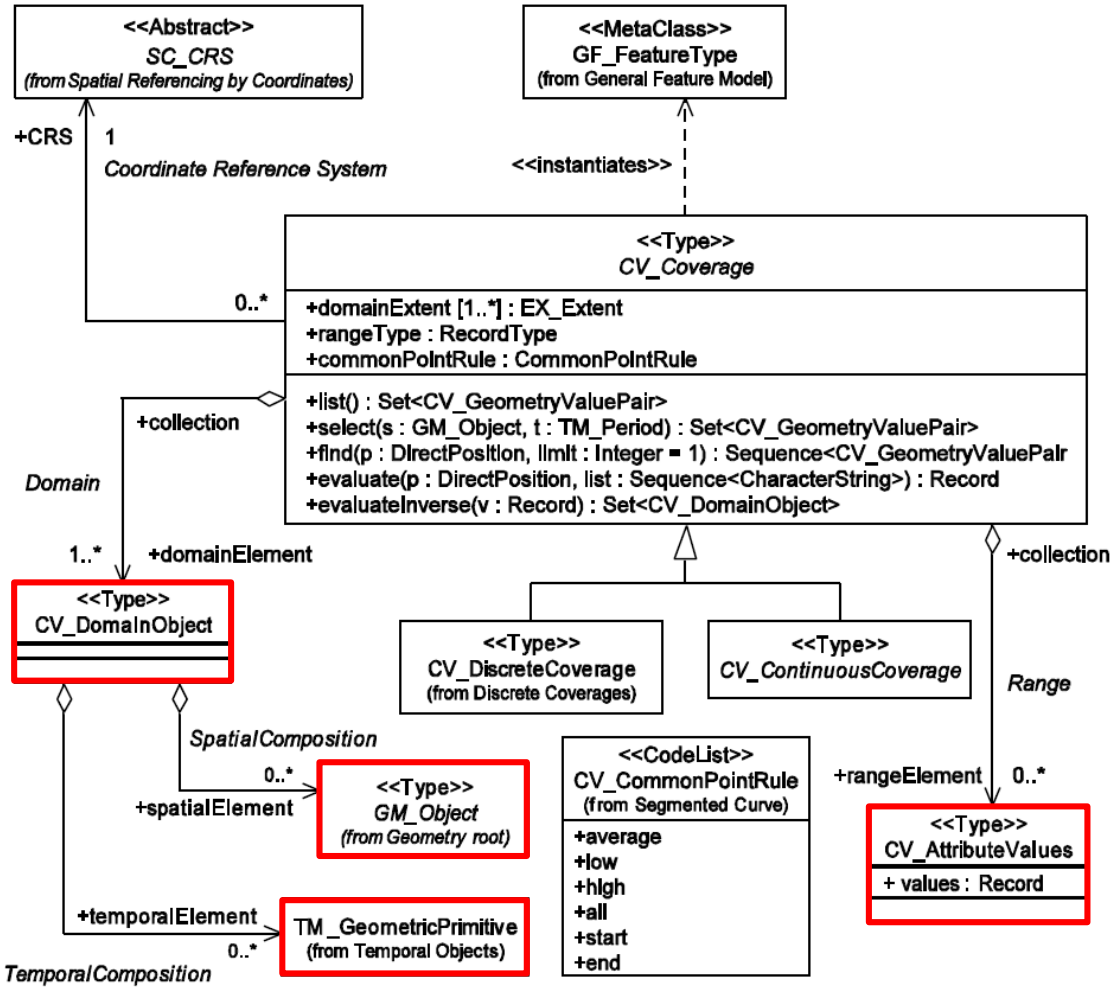
GML Coverage

- The proposed modifier approach has close relation with GML Coverage, where spatial coordinates are mapped to a specific value according to a mapping function

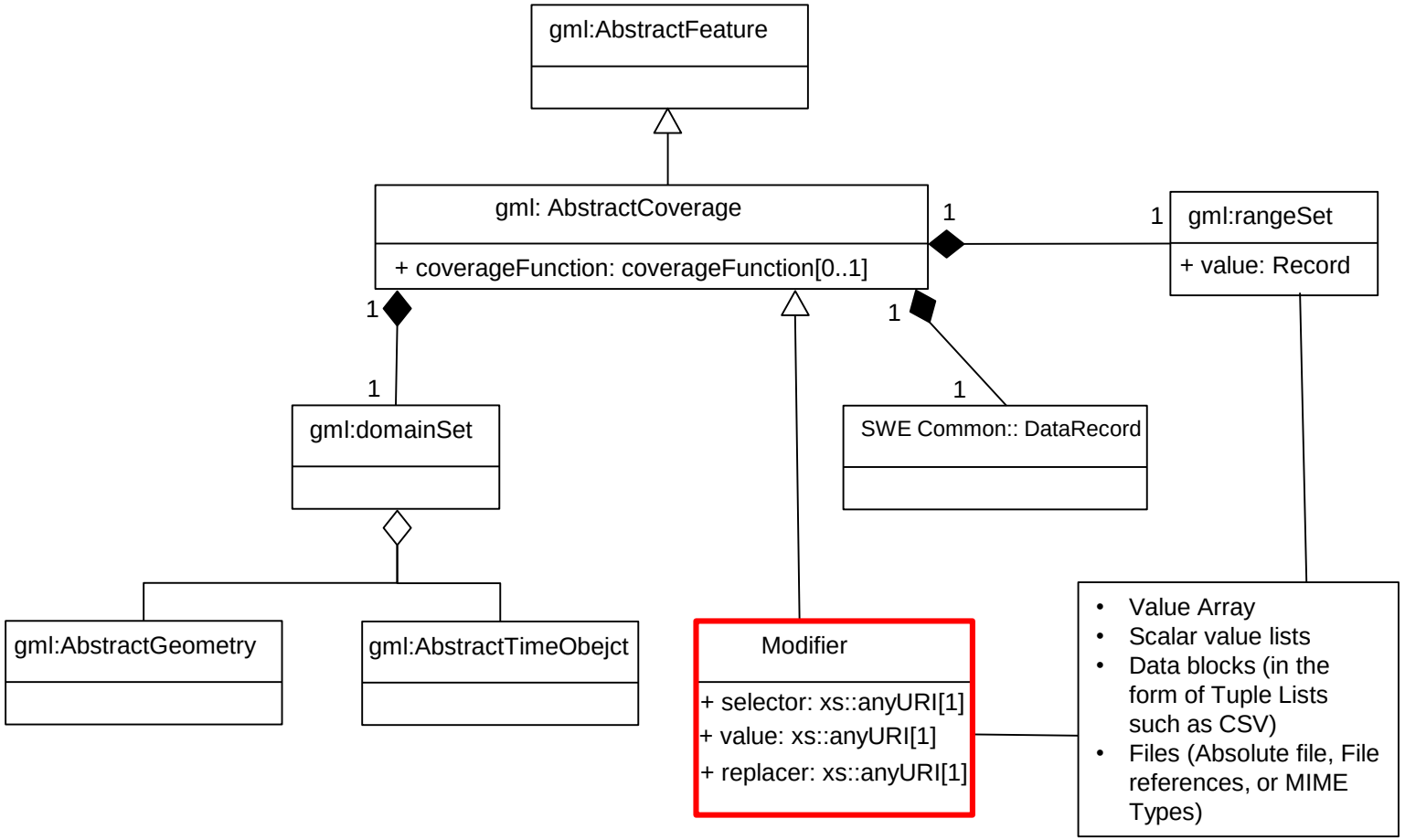


Source: OGC 09-146r1 GML Application Schema - Coverages

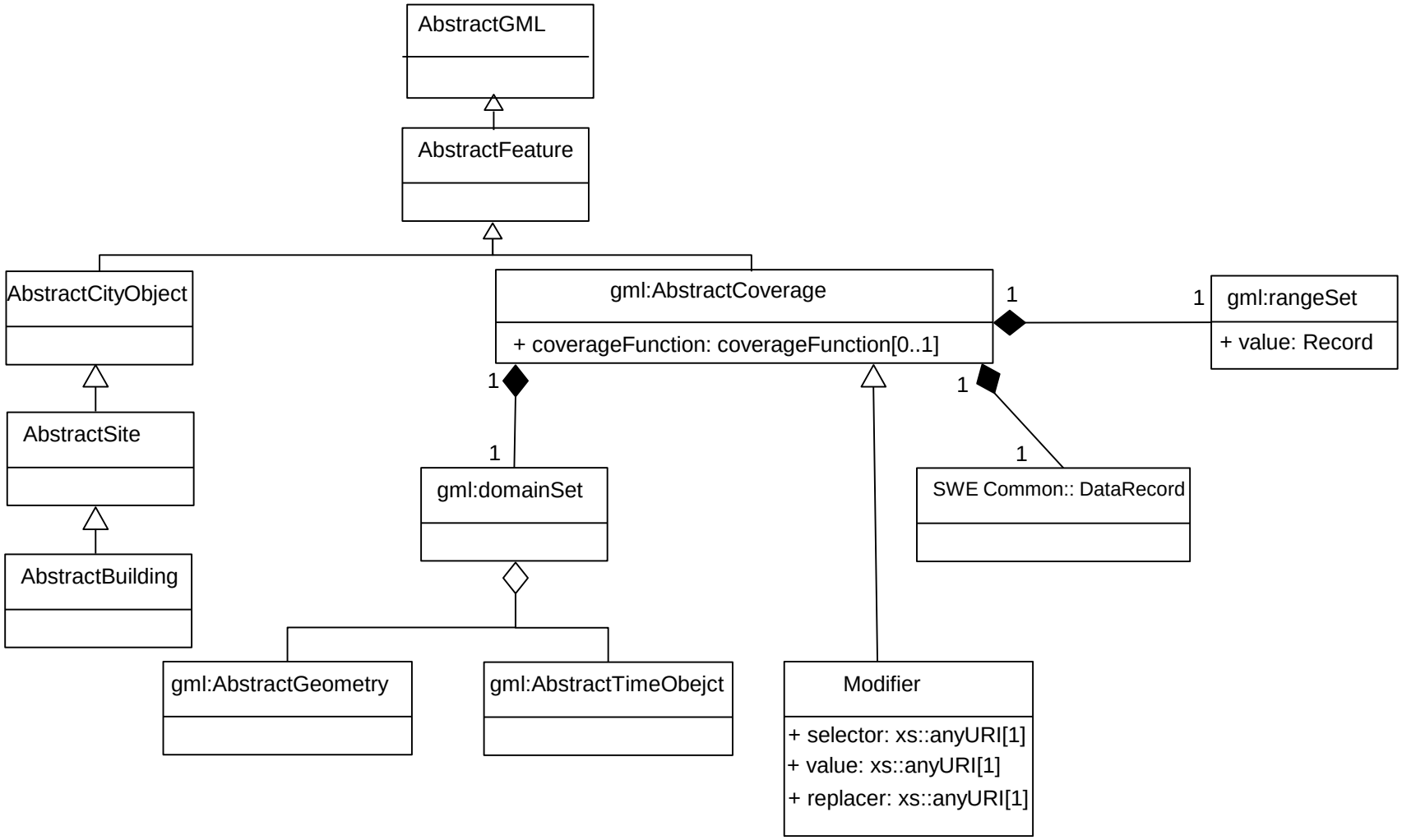
ISO 19123 - Schema for coverage geometry and functions



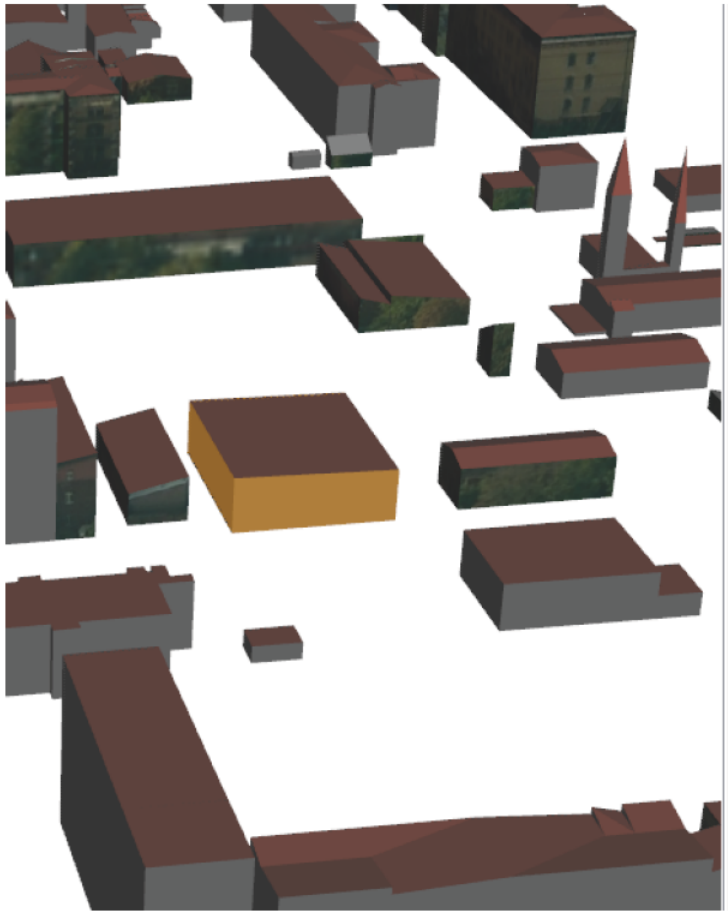
Temporal Coverage



Temporal Coverage



Use Case1 – Solar Irradiation Analysis



fme_geometry (string)	fme_aggregate
fme_type (string)	fme_surface
gen_diffus_apr (encoded: utf-16)	7554.65
gen_diffus_aug (encoded: utf-16)	8213.94
gen_diffus_dez (encoded: utf-16)	274.52
gen_diffus_feb (encoded: utf-16)	4600.47
gen_diffus_jahr (encoded: utf-16)	69606.76
gen_diffus_jan (encoded: utf-16)	482.12
gen_diffus_jul (encoded: utf-16)	11931.95
gen_diffus_jun (encoded: utf-16)	13079.98
gen_diffus_mai (encoded: utf-16)	10403.0
gen_diffus_mar (encoded: utf-16)	4737.59
gen_diffus_nov (encoded: utf-16)	832.79
gen_diffus_okt (encoded: utf-16)	2259.43
gen_diffus_sep (encoded: utf-16)	5236.35
gen_direkt_apr (encoded: utf-16)	12639.64
gen_direkt_aug (encoded: utf-16)	15168.42
gen_direkt_dez (encoded: utf-16)	167.63
gen_direkt_feb (encoded: utf-16)	1559.45
gen_direkt_jahr (encoded: utf-16)	112276.57
gen_direkt_jan (encoded: utf-16)	337.61
gen_direkt_jul (encoded: utf-16)	22262.78
gen_direkt_jun (encoded: utf-16)	23320.57
gen_direkt_mai (encoded: utf-16)	19819.66
gen_direkt_mar (encoded: utf-16)	5903.84
gen_direkt_nov (encoded: utf-16)	610.18
gen_direkt_okt (encoded: utf-16)	2771.61
gen_direkt_sep (encoded: utf-16)	7715.23
gen_svf_max (encoded: utf-16)	0.45
gen_svf_mean (encoded: utf-16)	0.4
gen_svf_median (encoded: utf-16)	0.42135
gen_svf_min (encoded: utf-16)	0.3
gml_id (encoded: utf-16)	UUID_a44d18ae-1155-4dec-bed7-5ba78e7113e3
gml_parent_id (encoded: utf-16)	UUID_a194f0a5-6922-4670-b975-72d84e537460

Source: [Zahn, 2015]

Example Instance Data

```
<modifier>
 <cityObjectMember>
  <Building gml:id = "building1">
        <gen:doubleAttribute name = "diffuseWallSurface">
                <gen:value = 7554.65 />
        </gen:stringAttribute>
  </Building>
 </cityObjectMember>
```

City Object generic attribute

```
<gml:domainSet>
        <app:multiTimeInstants>
                <app:TimeMembers>
                        <gml:TimeInstant gml:id = "building1_T1">
                                <gml:identifier>b1_TimeInstant</gml:identifier>
                                <gml:timePosition>2013-01-01</gml:timePosition>
                        </gml:TimeInstant>
                        <gml:TimeInstant gml:id = "building1_T2">
                                <gml:identifier>b1_TimeInstant</gml:identifier>
                                <gml:timePosition>2013-02-01</gml:timePosition>
                        </gml:TimeInstant>
                </app:TimeMembers>
        </app:MultiTimeInstants>
 </gml:domainSet>
```

Temporal Domain Set

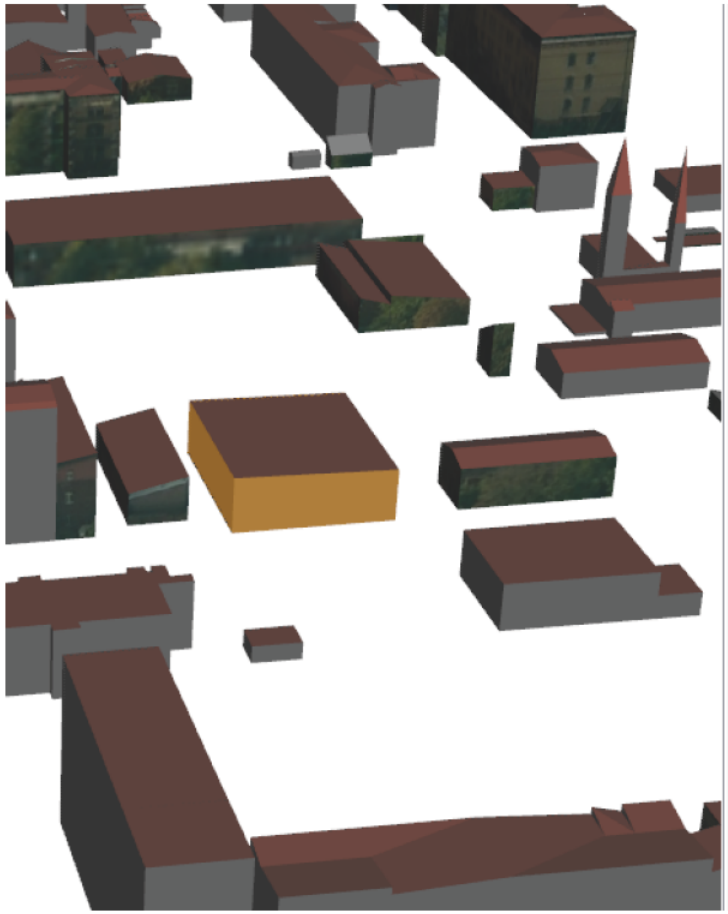
```
<gml:rangeSet>
        <gml:valueArray>
                <gml:valueComponents>
                        <diffuseWallSurface>7554.65<diffuseWallSurface>
                        <diffuseWallSurface>8213.94<diffuseWallSurface>
                </gml:valueComponents>
        </gml:valueArray>
 </gml:rangeSet>
```

Range Set

```
 <selector xlink:href = "//@gml:timePosition" />
 <value xlink:href = "//@diffuseWallSurface" />
 <replacer xlink:href = "//building [@gml:id = 'building1']/[@name = ‘diffuseWallSurface']" position = 'attributes'>
                <attribute name = 'value'> {@value} </attribute>
 </replacer>
</modifier>
```

Modifier

Use Case1 – Solar Irradiation



fme_geometry (string)	fme_aggregate
fme_type (string)	fme_surface
gen_diffus_apr (encoded: utf-16)	7554.65
gen_diffus_aug (encoded: utf-16)	8213.94
gen_diffus_dez (encoded: utf-16)	274.52
gen_diffus_feb (encoded: utf-16)	4600.47
gen_diffus_jahr (encoded: utf-16)	69606.76
gen_diffus_jan (encoded: utf-16)	482.12
gen_diffus_jul (encoded: utf-16)	11931.95
gen_diffus_jun (encoded: utf-16)	13079.98
gen_diffus_mai (encoded: utf-16)	10403.0
gen_diffus_mar (encoded: utf-16)	4737.59
gen_diffus_nov (encoded: utf-16)	832.79
gen_diffus_okt (encoded: utf-16)	2259.43
gen_diffus_sep (encoded: utf-16)	5236.35
gen_direkt_apr (encoded: utf-16)	12639.64
gen_direkt_aug (encoded: utf-16)	15168.42
gen_direkt_dez (encoded: utf-16)	167.63
gen_direkt_feb (encoded: utf-16)	1559.45
gen_direkt_jahr (encoded: utf-16)	112276.57
gen_direkt_jan (encoded: utf-16)	337.61
gen_direkt_jul (encoded: utf-16)	22262.78
gen_direkt_jun (encoded: utf-16)	23320.57
gen_direkt_mai (encoded: utf-16)	19819.66
gen_direkt_mar (encoded: utf-16)	5903.84
gen_direkt_nov (encoded: utf-16)	610.18
gen_direkt_okt (encoded: utf-16)	2771.61
gen_direkt_sep (encoded: utf-16)	7715.23
gen_svf_max (encoded: utf-16)	0.45
gen_svf_mean (encoded: utf-16)	0.4
gen_svf_median (encoded: utf-16)	0.42135
gen_svf_min (encoded: utf-16)	0.3
gml_id (encoded: utf-16)	UUID_a44d18ae-1155-4dec-bed7-5ba78e7113e3
gml_parent_id (encoded: utf-16)	UUID_a194f0a5-6922-4670-b975-72d84e537460

Source: [Zahn, 2015]

Example Instance Data

```
<modifier>
 <cityObjectMember>
  <Building gml:id = "building1">
        <gen:doubleAttribute name = "diffuseWallSurface">
              <gen:value = 7554.65 />
        </gen:doubleAttribute>
        <gen:doubleAttribute name = "direktWallSurface">
              <gen:value = 12639.64 />
        </gen:doubleAttribute>
  </Building>
 </cityObjectMember>

 <gml:domainSet>
        <app:timeList gml:id = "time_domain">
              <app:list>2013-01-01 2013-02-01 2013-03-01 2013-04-01 …..</app:list>
        </app:timeList>
 </gml:domainSet>
 <gml:rangeSet>
        <gml:File>
              <gml:rangeParameters>
                    <gml:compositeValue>
                          <gml:valueComponents>
                                <diffuseWallSurface>….</diffuseWallSurface>
                                <direktWallSurface>….< direktWallSurface >
                          </gml:valueComponents>
                    </gml:compositeValue>
              </ gml:rangeParameters >
              <gml:FileName> http://www.somedata.org/table.dat</gml:FileName>
              <fileStructure> recordInterleaved</gml:FileName>
        </gml:File>
  </gml:rangeSet>
  <selector xlink:href = "//@gml:timePosition" />
  <value1 xlink:href = "//@diffuseWallSurface" />
  <replacer xlink:href = "//building [@gml:id = 'building1']/[@name = ‘diffuseWallSurface']" position = 'attributes'>
              <attribute name = 'value'> {@value1} </attribute>
  </replacer>
  <value2 xlink:href = "//@direktWallSurface" />
  <replacer xlink:href = "//building [@gml:id = 'building1']/[@name = ‘direktWallSurface']" position = 'attributes'>
              <attribute name = 'value'> {@value2} </attribute>
  </replacer>
</modifier>
```

City Object generic attributes

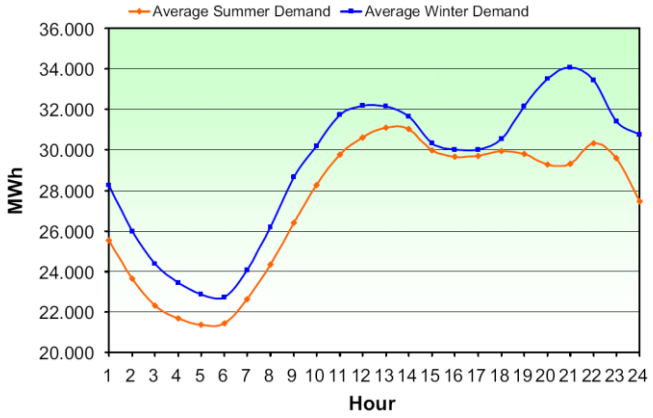
Temporal Domain Sets (Lists)

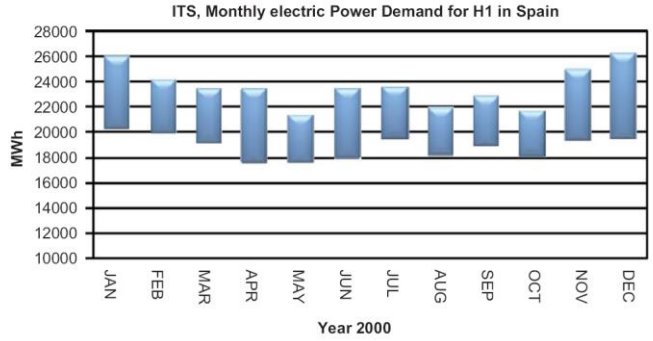
Range Set

Modifier

Use case 2–Energy demand using time intervals

- As described in [1], the demand forecasting can be done depending on the time horizon selected
  - Short term from 1 hour to 1 week
  - Medium term from a week to a year



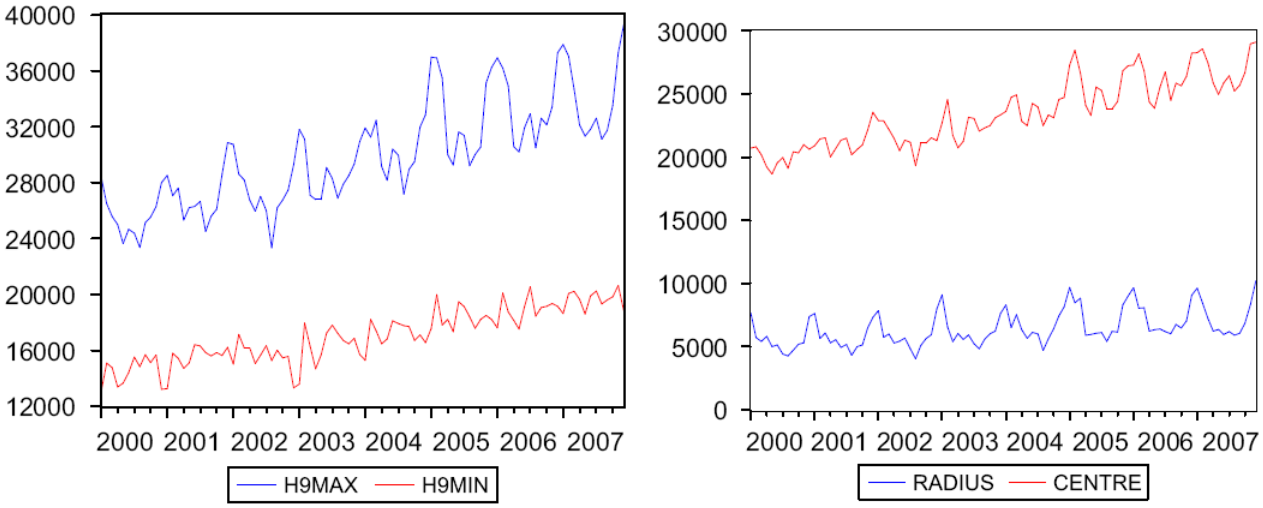


Upper Bound	26091	24219	23513	23491	21373	23445	23609	22008	22842	21768	24956	26302
Lower Bound	20328	19920	19137	17679	17582	18000	19494	18198	18909	18141	19342	19523
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Source:[1]
C. García-Ascanio and C. Maté, “Electric power demand forecasting using interval time series: A comparison between VAR and iMLP,”*Energy Policy*, vol. 38, no. 2, pp. 715–725, Feb. 2010

Use case 2–Energy demand using time intervals

- Long term for more than a year

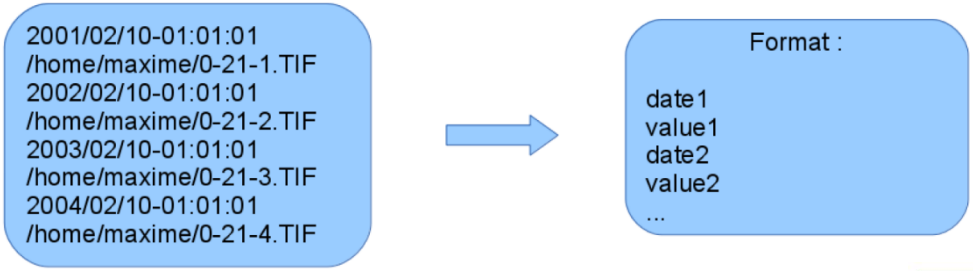


- All the three scenarios can be mapped within temporal coverage using gml:TimeInstant or gml:TimePeriods

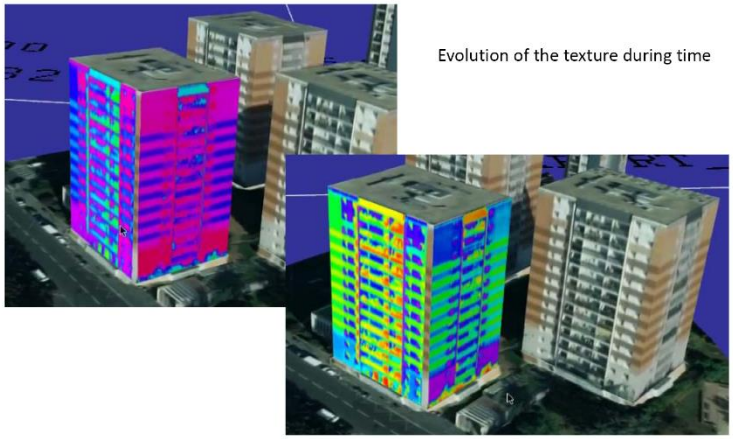
Source:[1]
C. García-Ascanio and C. Maté, “Electric power demand forecasting using interval time series: A comparison between VAR and iMLP,”*Energy Policy*, vol. 38, no. 2, pp. 715–725, Feb. 2010

Use case 3:Evolution of building texture during time

- [2] describes the use case of texture temporalization, showing the evolution of tempurature
- The different TIFF images have been used as textures with respect to different time instants



- The result can be shown as



Source:[2]
https://github.com/opengeospatial/CityGML-3.0/blob/master/WP%2006%20Resources/Meetings/2nd/2014_09_08_Temporal_CityGML_Gesquiere.pdf

Use case 3:Evolution of building texture during time

Example Instance Data

```
<modifier>
 <cityObjectMember>
  <Building gml:id = "building1">
        …….
  </Building>
 </cityObjectMember>
 <app:appearanceMember>
    <app:Appearance>
        <app:GeoreferencedTexture>
            <app:imageURI> /home/maxime/0-21-1.TIF </app:imageURI>
        </app:GeoreferencedTexture>
    <app:Appearance>
 </app:appearanceMember>
 <gml:domainSet>
        <app:timeList gml:id = "time_domain">
            <app:list>2013-01-01 2013-02-01 2013-03-01 2013-04-01 …..</app:list>
        </app:timeList>
 </gml:domainSet>
 <gml:rangeSet>
        <gml:File>
            <gml:FileName> /home/maxime/0-21-1.TIF </gml:FileName>
            <gml:FileName> /home/maxime/0-21-2.TIF </gml:FileName>
            <gml:FileName> /home/maxime/0-21-3.TIF </gml:FileName>
            <gml:FileName> /home/maxime/0-21-4.TIF </gml:FileName>
            <fileStructure> recordInterleaved</gml:FileName>
        </gml:File>
  </gml:rangeSet>

  <selector xlink:href = "//TimeList[@gml:id='time_domain‘]" />
  <value xlink:href = "//gml:File[@gml:fileName]" />
  <replacer xlink:href = "//building [@gml:id = 'building1']/…/app:GeoreferencedTexture" position = 'attributes'>
            <attribute name = 'value'> {@value} </attribute>
  </replacer>
</modifier>
```

City Object with appearance

Temporal Domain Sets (Lists)

Range Set

Modifier

Open questions

- How can we reference an OGC Web Sensor Observation Service using temporal coverage or any other approach in GML?
  - The aim can be to retrieve sensor data using a URL, for example, http://opendap.co-ops.nos.noaa.gov/ioos-dif-sos/SOS?service=SOS&request=GetObservation&version=1.0.0&observedProperty=air_temperature&offering=urn:ioos:station:NOAA.NOS.CO-OPS:8454000&responseFormat=text%2Fcsv&eventTime=2015-03-12T00:00:00Z/2015-03-12T23:59:00Z
- How can we add periodic/cyclic patterns in coverage domain set?
  - GML 3.2 does not support periodic/cyclic patterns. However, AIXM supports schedulers, which might be helpful here.
- Should we allow superposition of different coverage functions which can be used to determine a final result? An example would be the multiplication of two coverages (e.g. multiplying a trend with a regular function)