CityGML – UtilityNetworkADE topological concept

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Claus Nagel | virtualcitySystems, Berlin

Motivation

We need information about utility networks, about the city, about the producers, and the consumers to be able to analyze the current system for different purposes:

- Risk- and disaster management
- Energy consumption
- Carbon balancing
- City life-cycle management
- …

We need a **better understanding** of the **city system!**
Utility networks are an essential part of it!

Today

In the
and
other in small and large networks.

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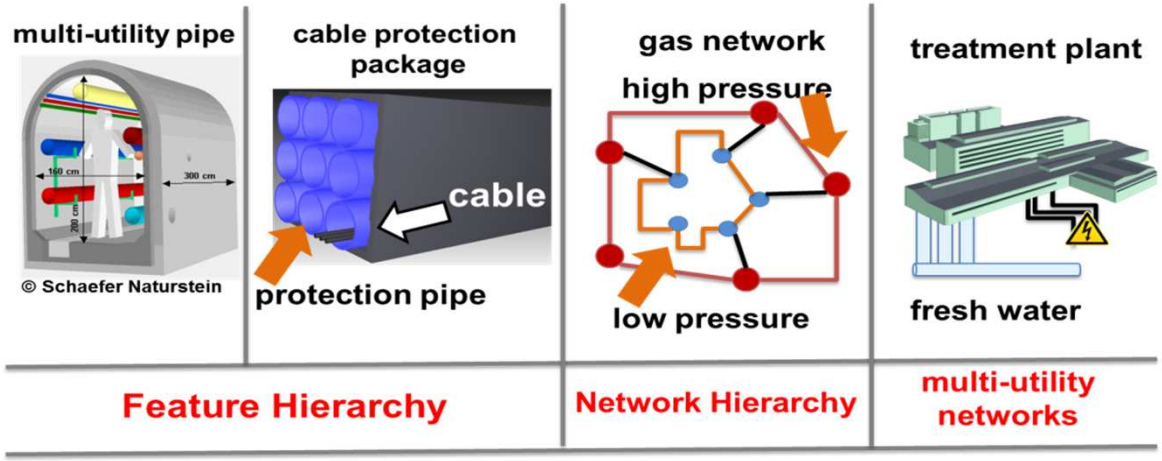
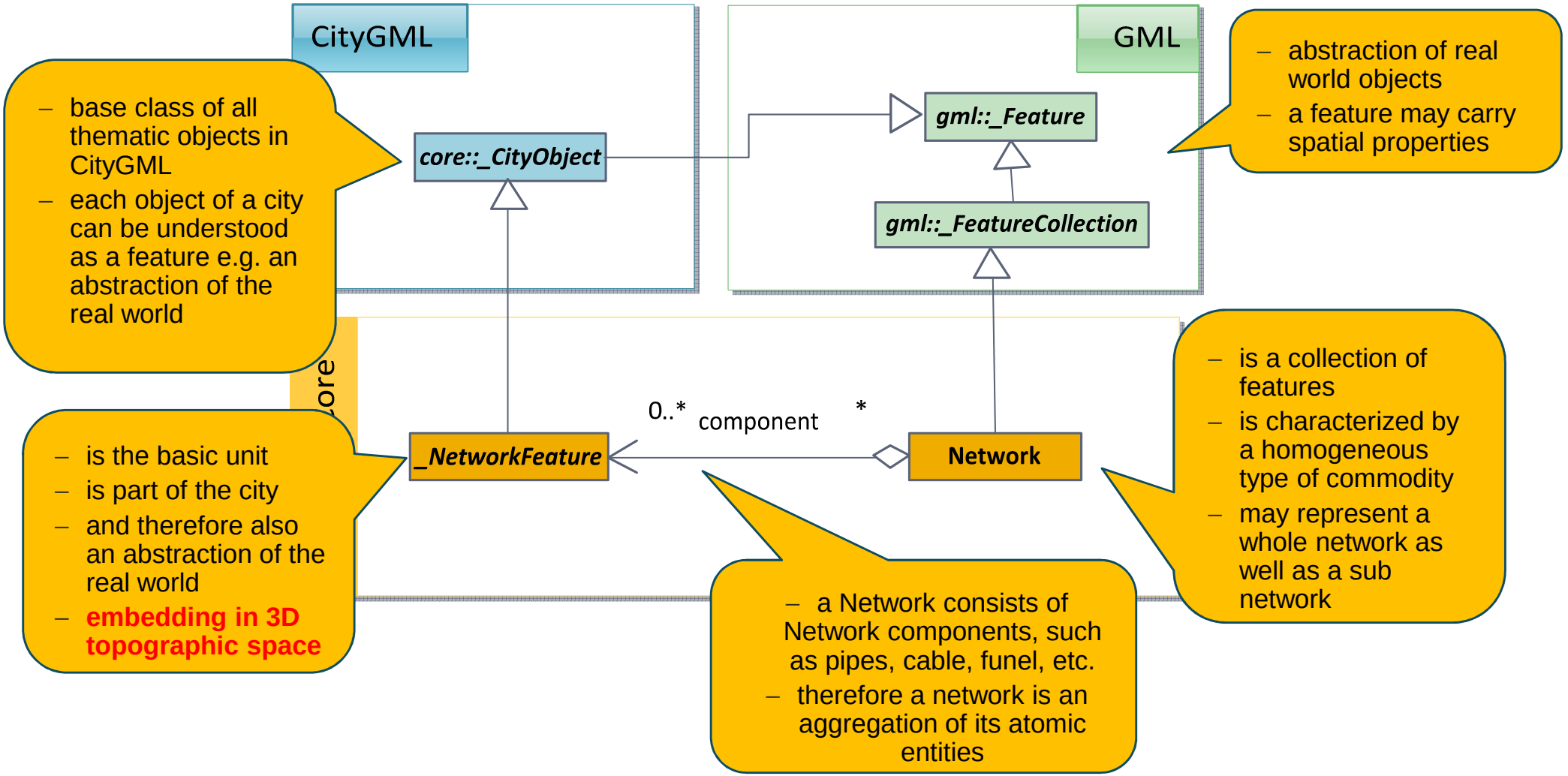
The task is (was) to create...

- **common framework** for multi-utility modeling including multi-utility network hierarchies
- **integration** of infrastructure into urban context **(CityGML ADE)**
- dual representation: **3D topography and functional** modeling
- different networks should be **easily connectable** to each other by using the NetworkLink (modeling neuralgic points)

- the model should support any type of network hierarchy



Networks and topographic embedding



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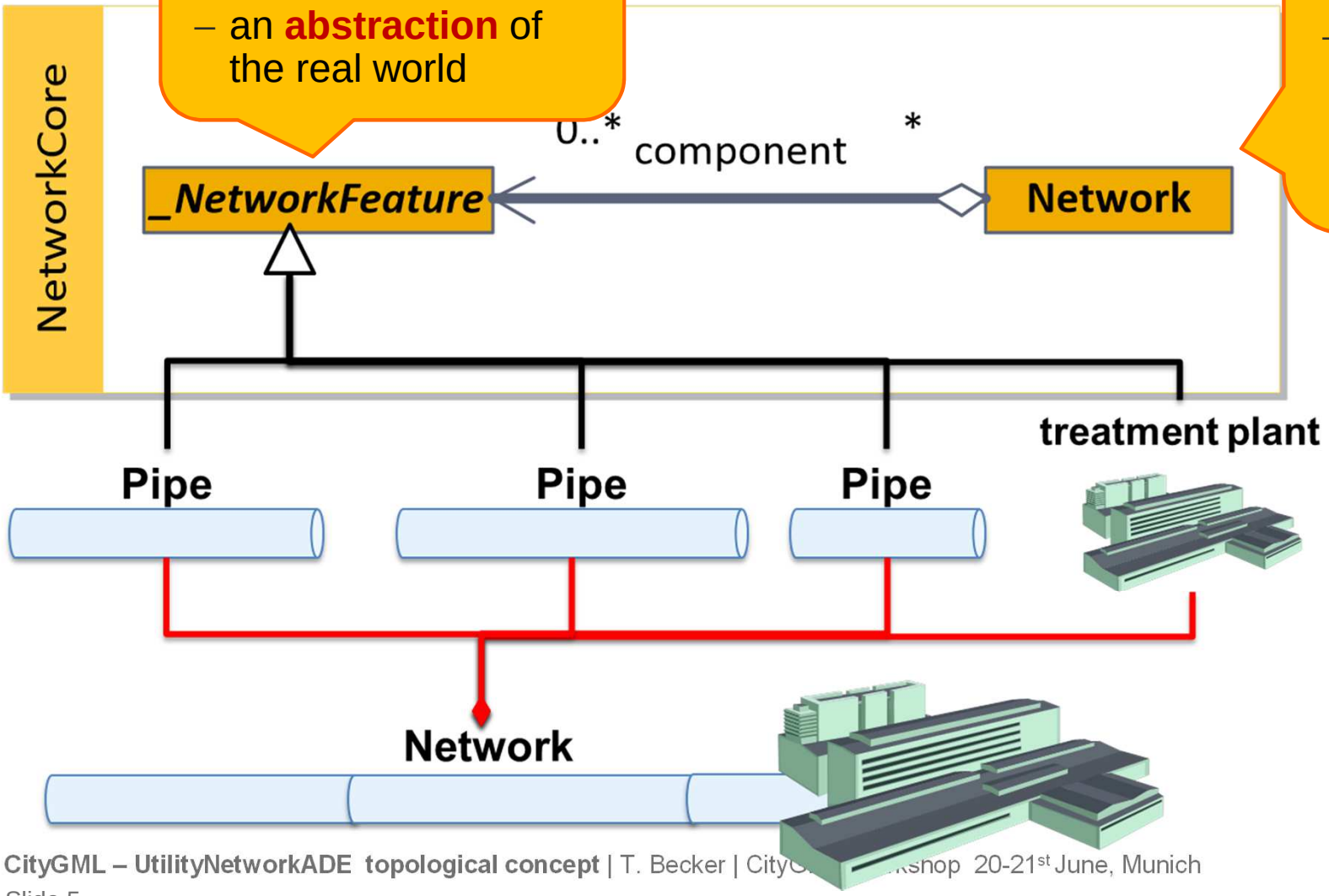
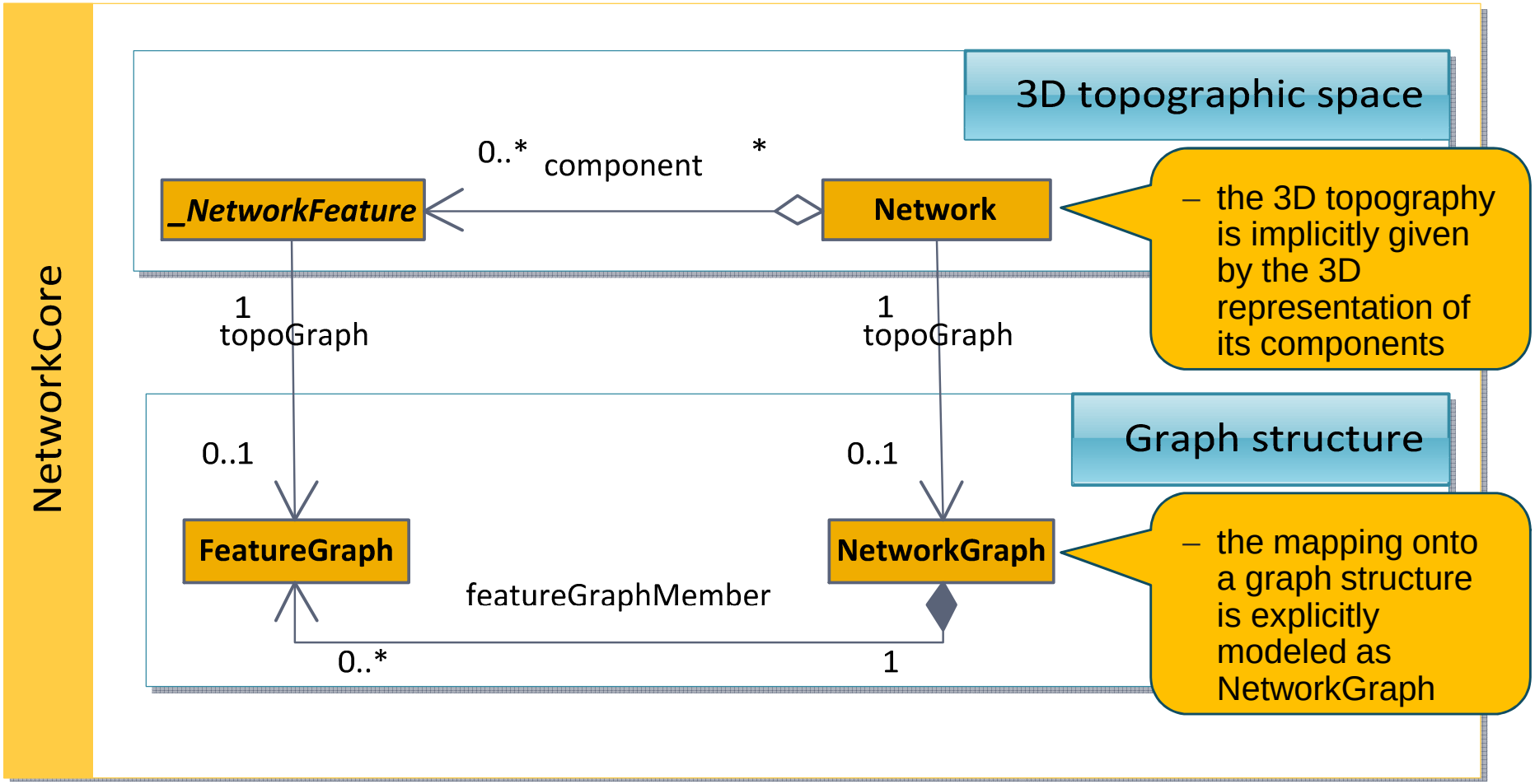
- the **basic unit**
- part of the city
- an **abstraction** of the real world

- collection of features
- characterized by homogeneous type of commodity



Dual representation of networks and entities



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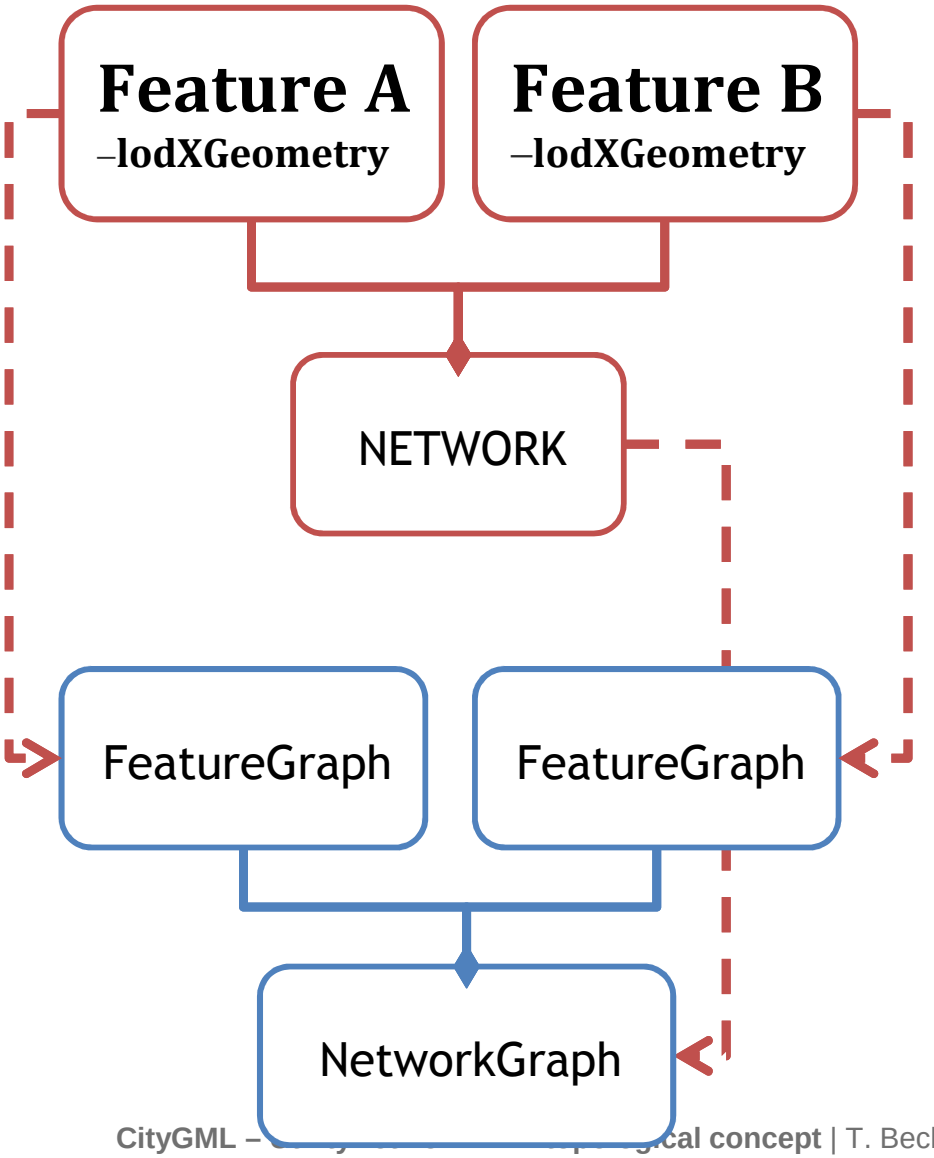
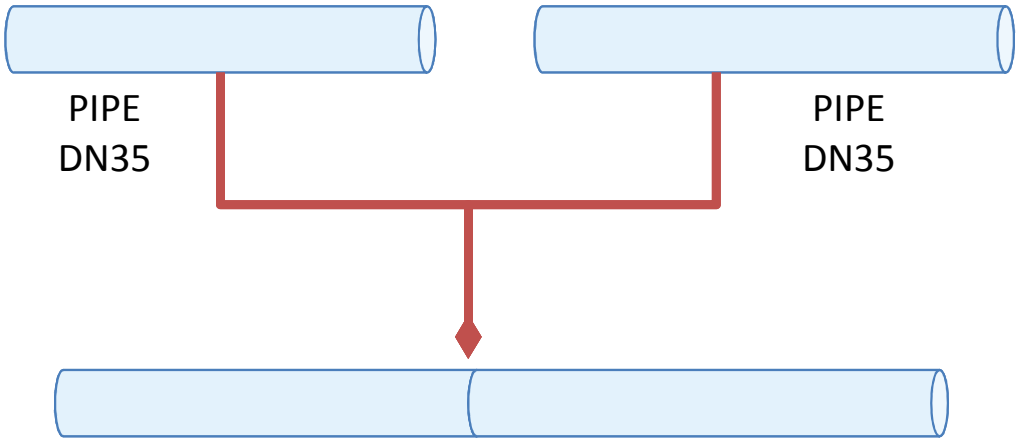
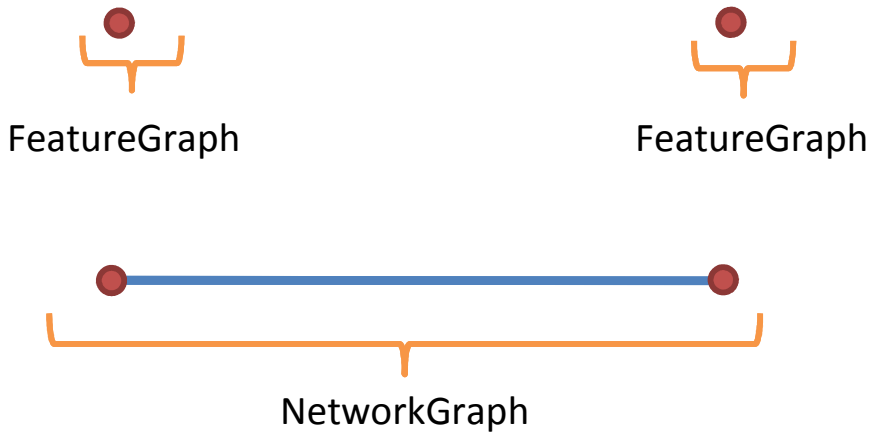


TOPOGRAPHICAL POINT OF VIEW

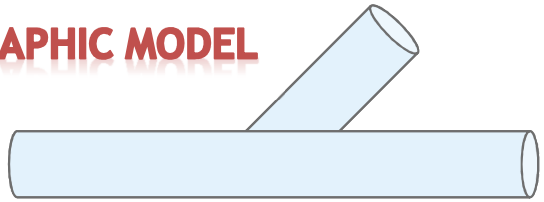


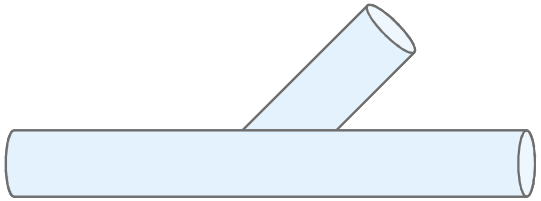
TOPOLOGICAL / FUNCTIONAL VIEW



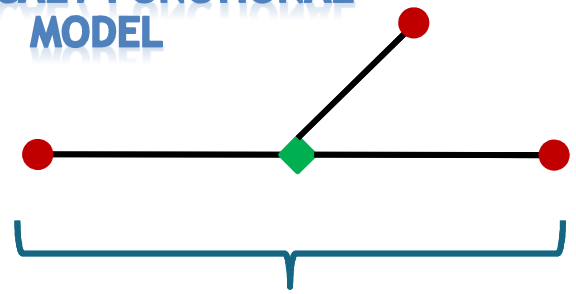
modeling example

TOPOGRAPHIC MODEL





TOPOLOGICAL / FUNCTIONAL MODEL



FeatureGraph

FeatureGraph

Legende

- Node (type: exterior)
- Node (type: interior)
- InteriorFeatureConnection
- NetworkFeature

Node (type: interior)

modeling of interior properties of the feature (interior link)
using interior nodes allows for modeling pipe taping, valves, material change, etc

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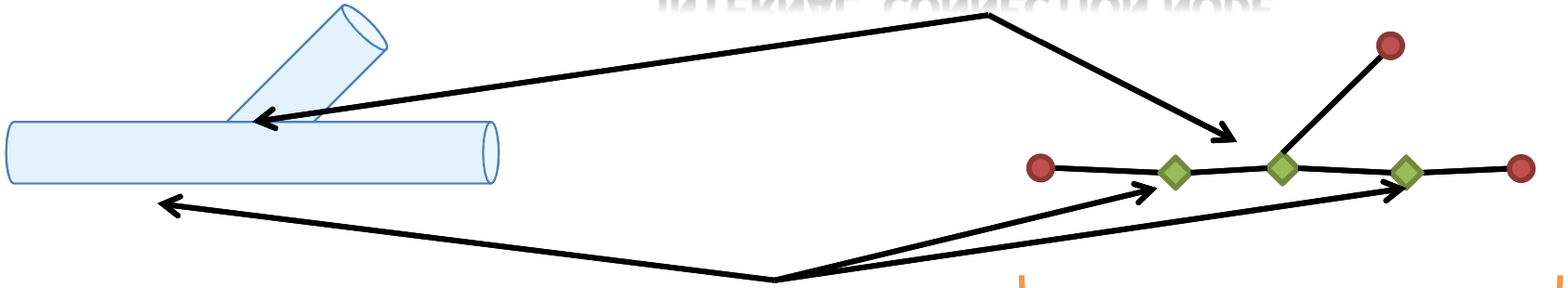
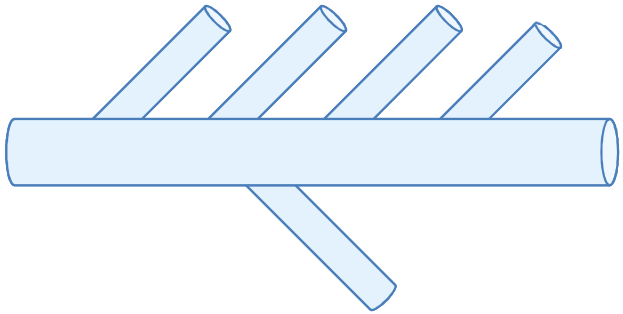
TOPOGRAPHIC VIEW

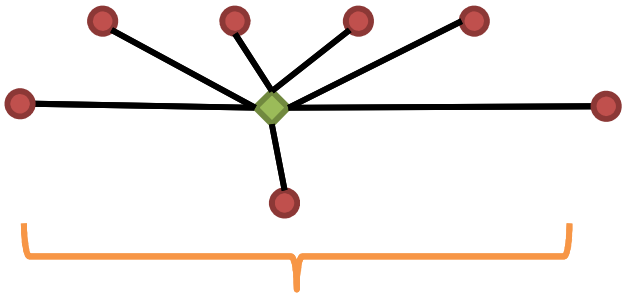
TOPOLOGICAL / FUNCTIONAL VIEW

INTERNAL CONNECTION NODE



Z.B. TUBE REJUVENATION





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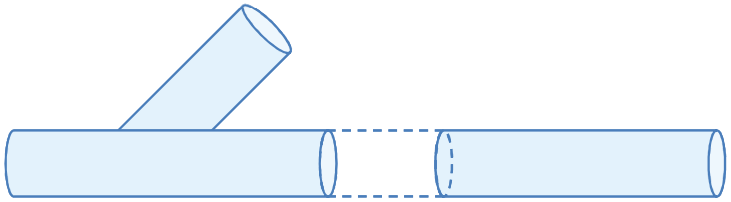
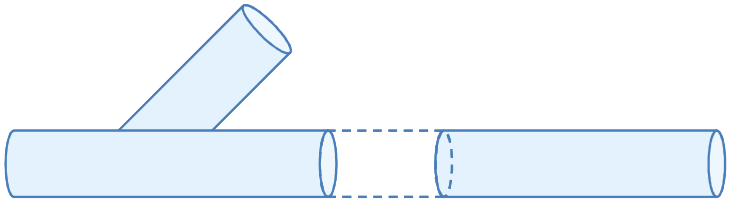
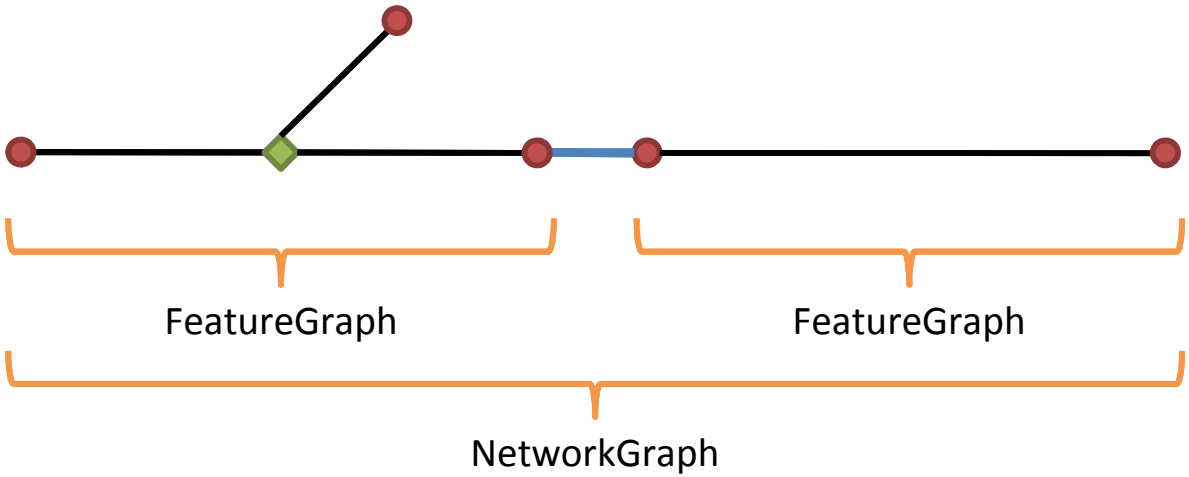
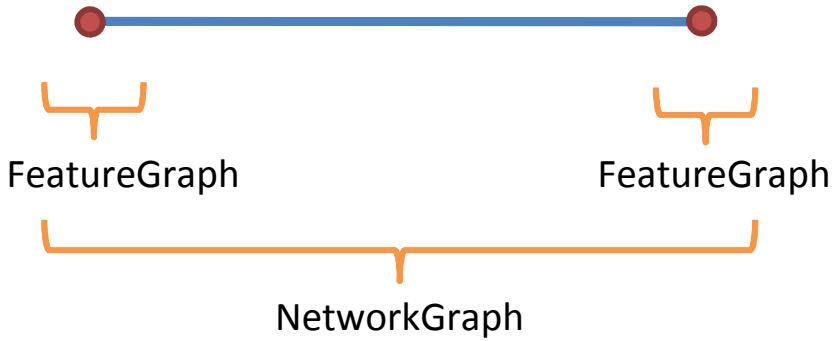




TOPOLOGICAL / FUNCTIONAL VIEW

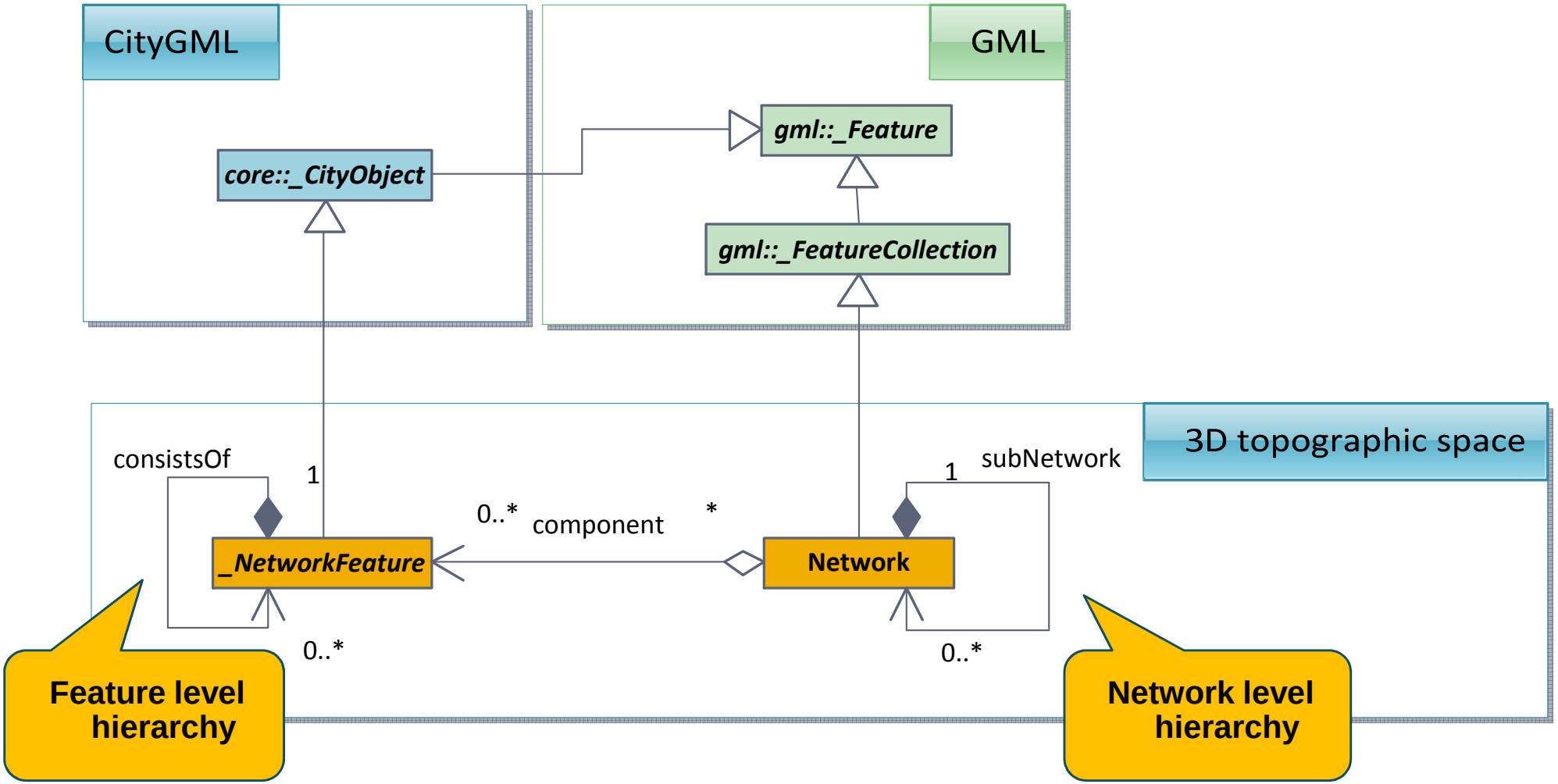




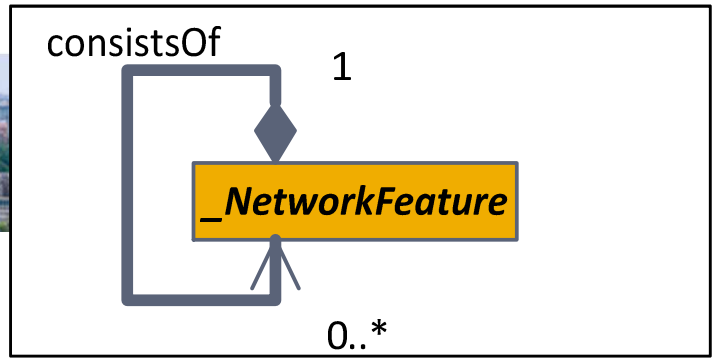
Legend

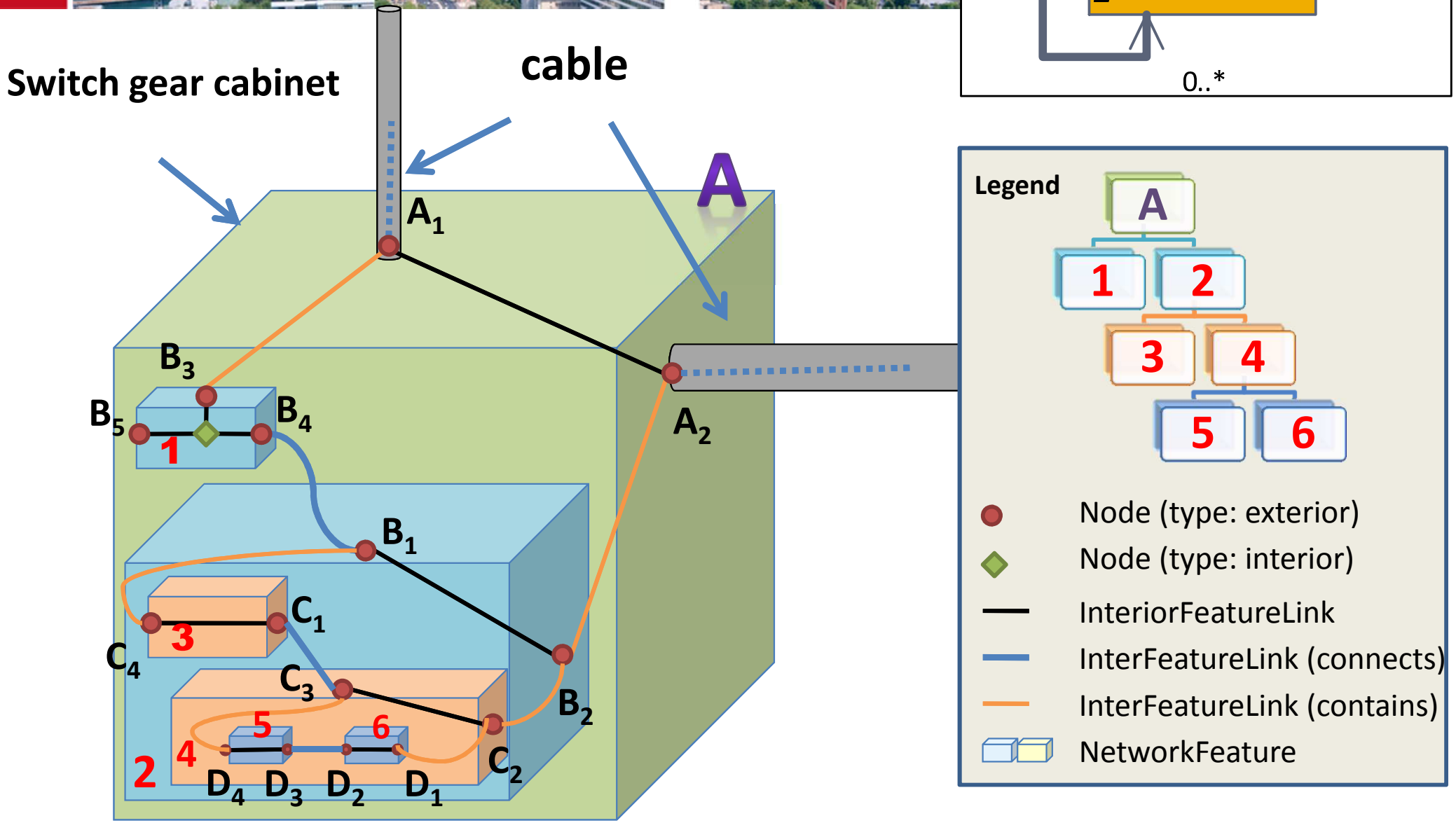
- Node (type: exterior)
- Node (type: interior)
- InteriorFeatureLink
- InterFeatureLink
- NetworkFeature

Hierarchical modeling



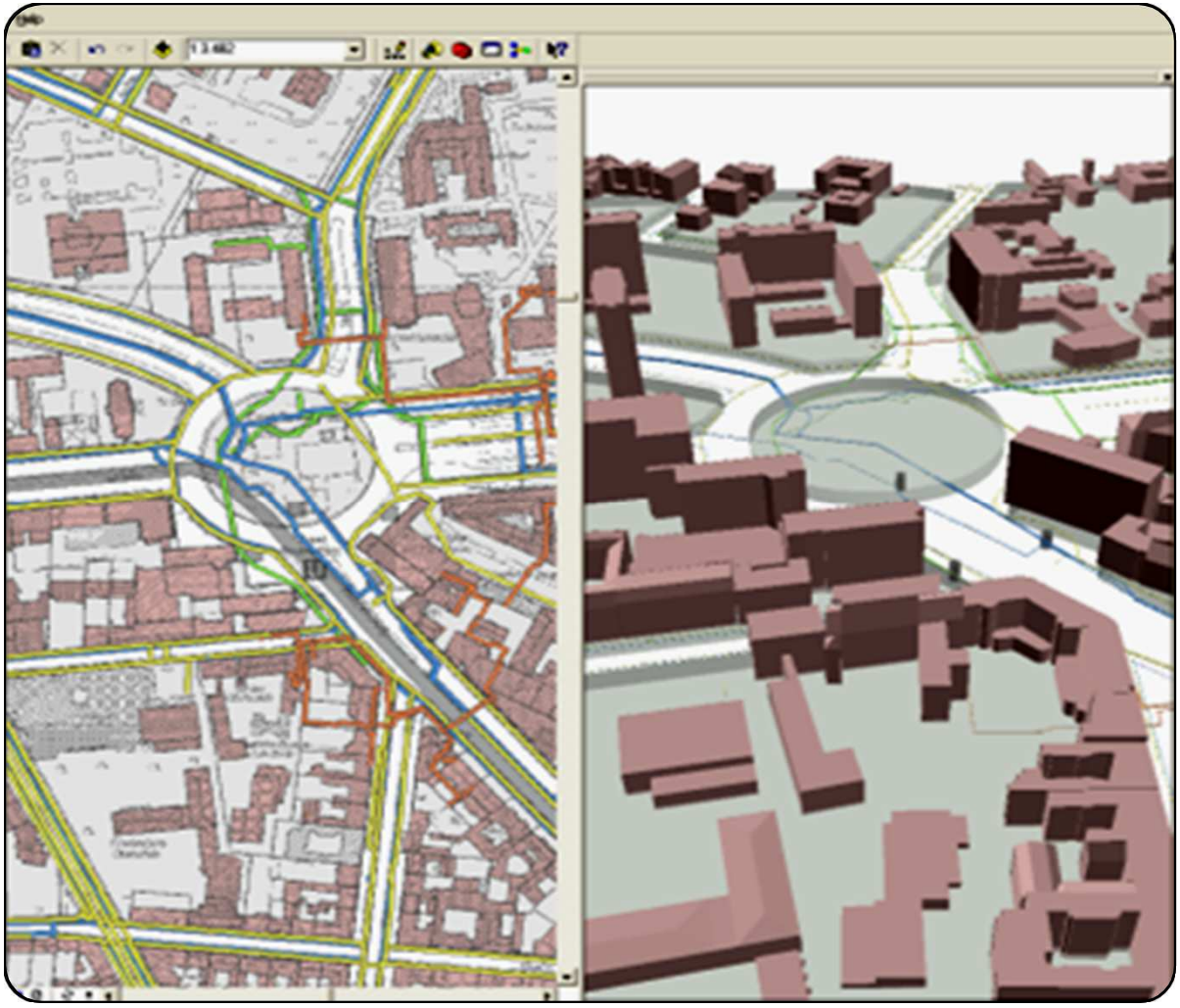
Feature hierarchy - modeling example

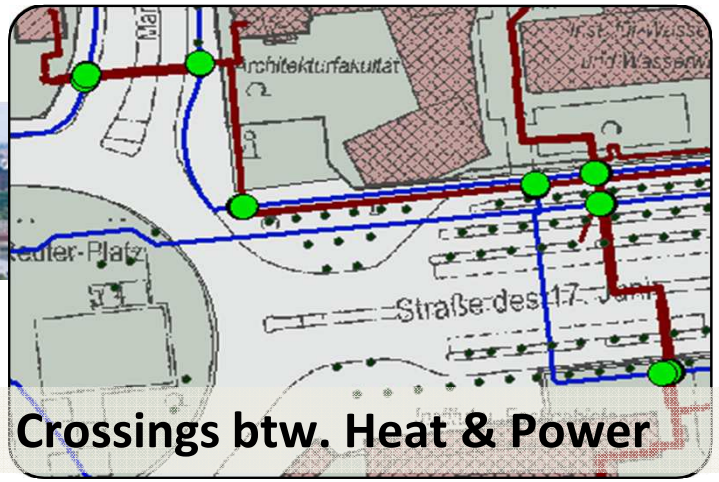




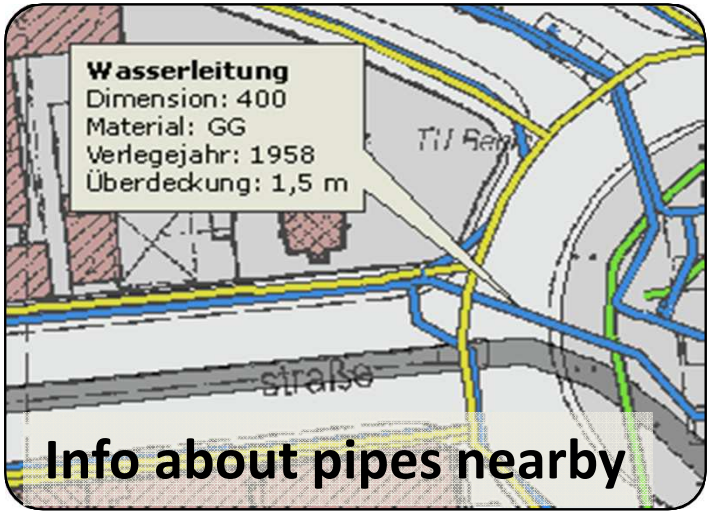
examples

2D / 3D Analysis and Simulation

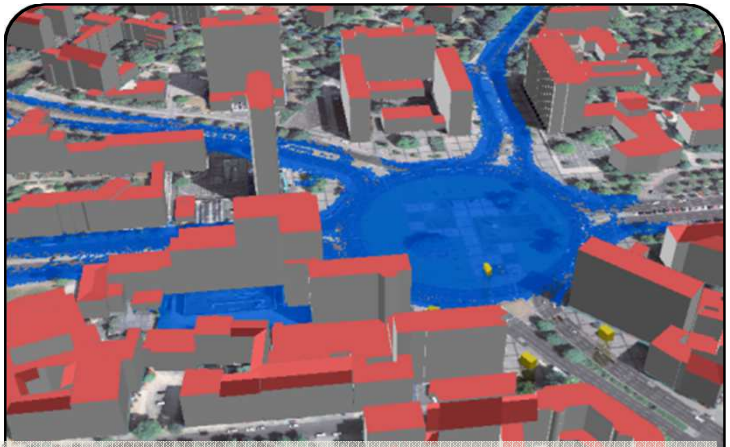




Crossings btw. Heat & Power



Info about pipes nearby



Pipeline rupture simulation

Source: DHI-WASY GmbH, SIMKAS-3D project partner

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FZK Viewer V 2.3 - [TB_IGG_Example1]

File View Display Query Extras Window ?

Browser Toolbar

- CityGML Version 2.0
  - Unknown GML Class [4]
    - utilcore:Network
    - utilcore:Network
    - utilcore:Network
    - utilcore:Network
      - Unknown GML Class [3]
        - utilcore:Network
          - Unknown GML Class [4]
        - utilcore:Network
          - Unknown GML Class [77]
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:SimpleFunctionalElement
            - utilcomp:TerminalElement
            - utilcomp:TerminalElement
            - utilcomp:TerminalElement
            - utilcomp:TerminalElement
            - utilcomp:TerminalElement
            - utilcomp:TerminalElement
            - utilcomp:RoundPipe
              - Unknown GML Class [2]
                - utilfeatmat:ExteriorMaterial
                - utilcore:FeatureGraph
                  - Unknown GML Class [1]

3D View

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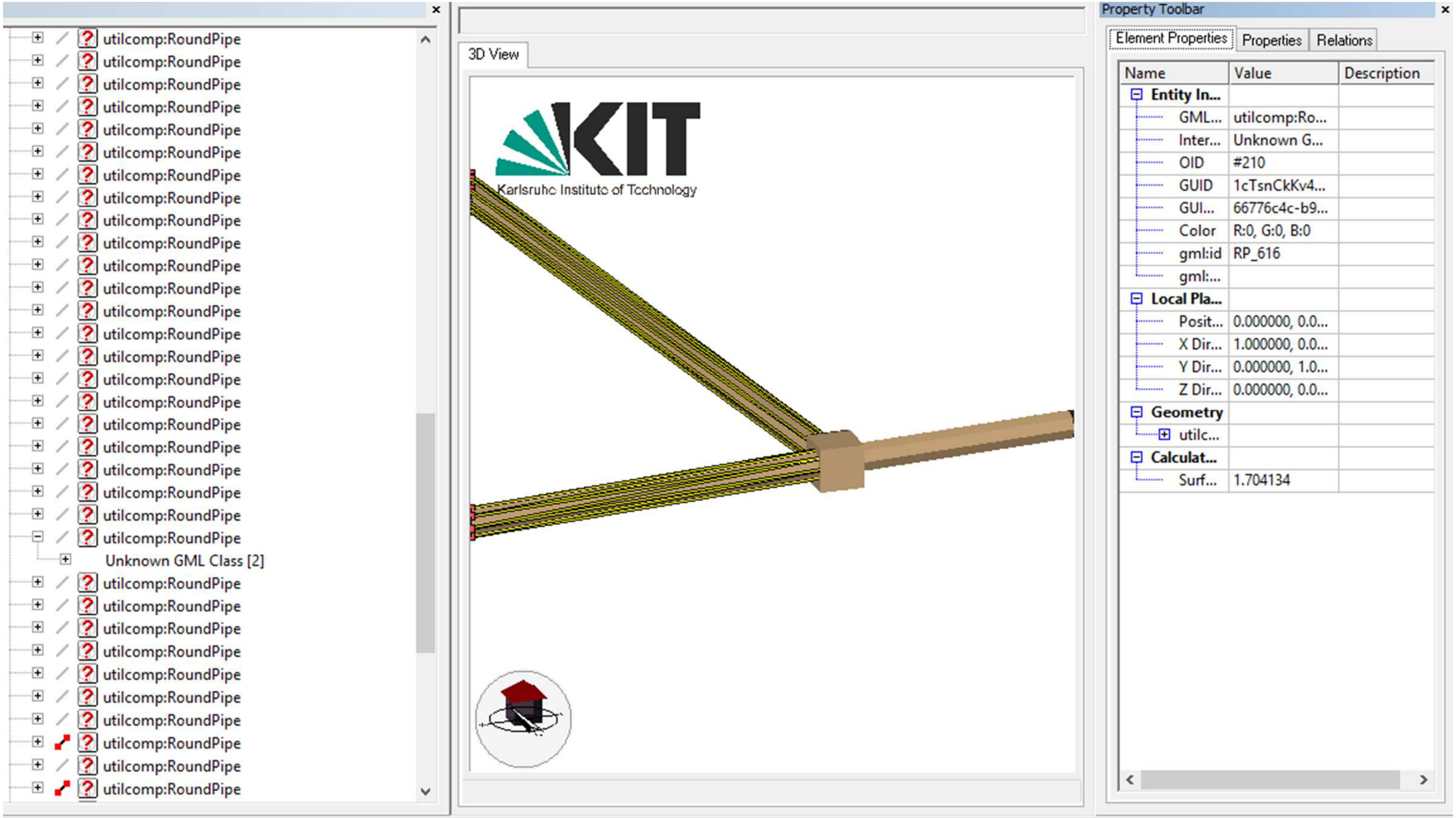

utilcomp:RoundPipe
utilcomp:RoundPipe
utilcomp:RoundPipe
utilcomp:RoundPipe
utilcomp:RoundPipe
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utilcomp:RoundPipe
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utilcomp:RoundPipe
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Unknown GML Class [2]
utilcomp:RoundPipe
utilcomp:RoundPipe
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utilcomp:RoundPipe
utilcomp:RoundPipe
utilcomp:RoundPipe
utilcomp:RoundPipe
utilcomp:RoundPipe
3D View
KIT
Karlsruhe Institute of Technology
Property Toolbar
Element Properties
Properties
Relations
Name
Value
Description
Entity In...
GML... utilcomp:Ro...
Inter... Unknown G...
OID #210
GUID 1cTsnCkKv4...
GUI... 66776c4c-b9...
Color R:0, G:0, B:0
gml:id RP_616
gml:...
Local Pla...
Posit... 0.000000, 0.0...
X Dir... 1.000000, 0.0...
Y Dir... 0.000000, 1.0...
Z Dir... 0.000000, 0.0...
Geometry
utilc...
Calculat...
Surf... 1.704134

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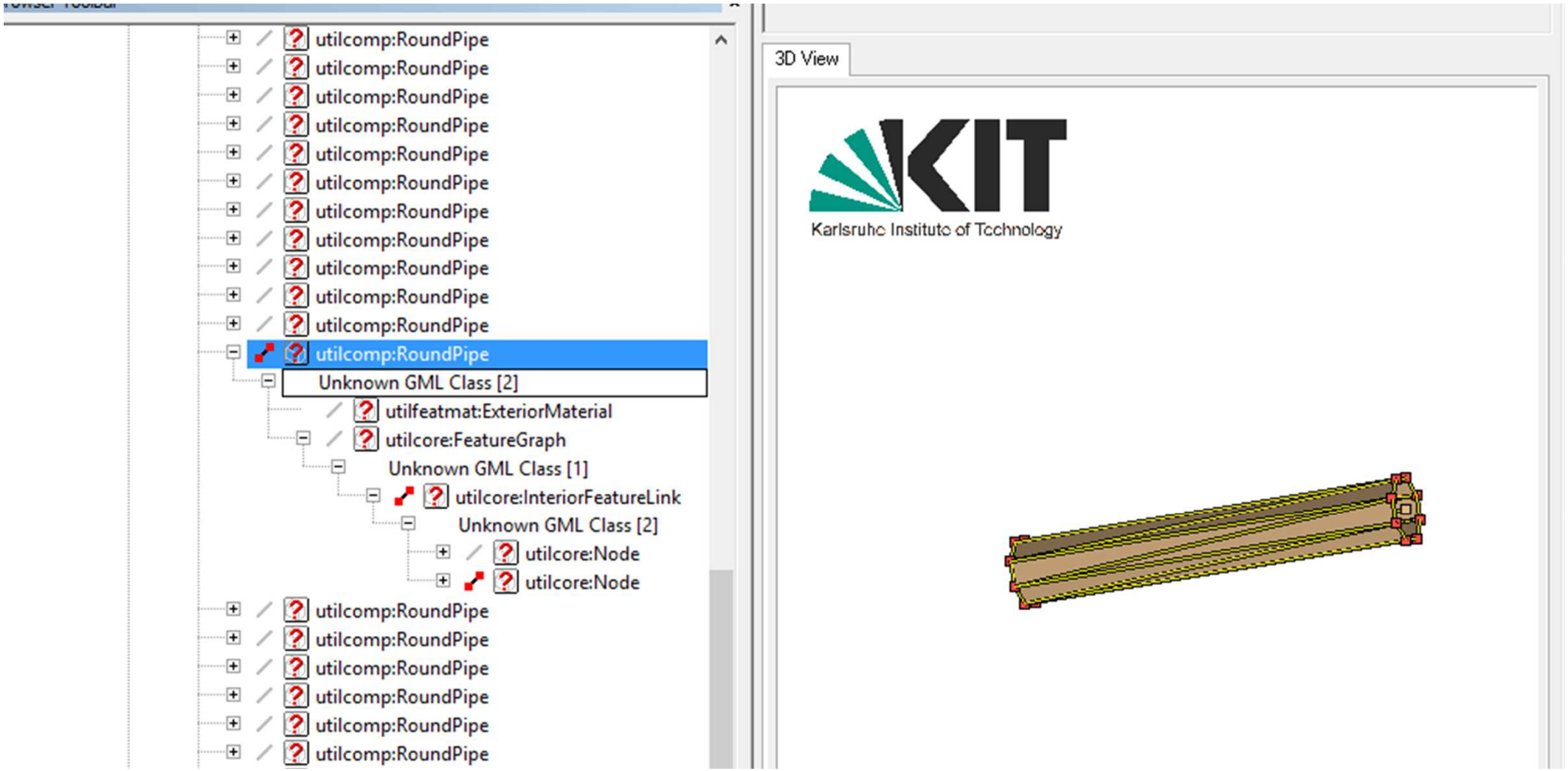
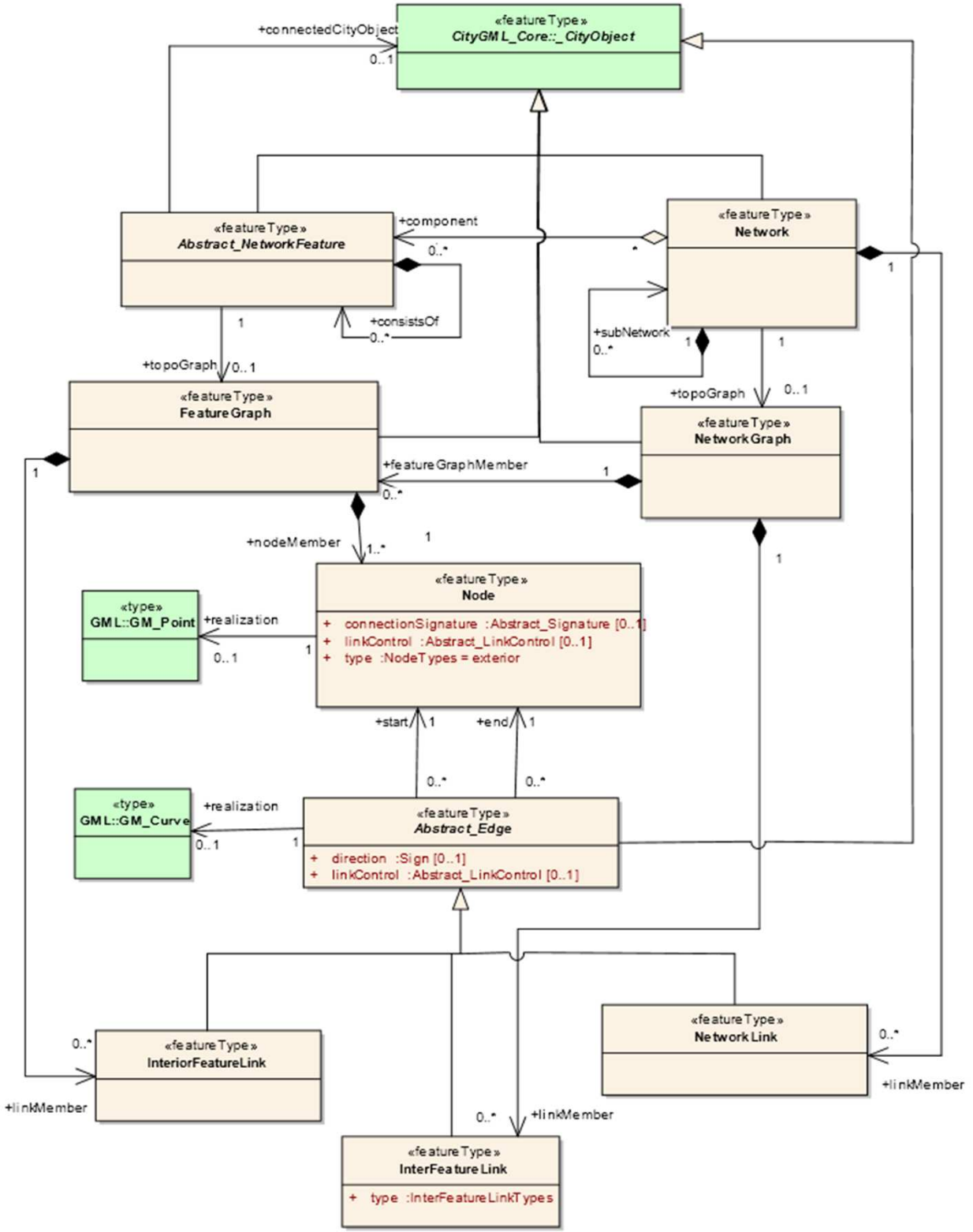


data models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CityGML_Core::_CityObject
+connectedCityObject
0..1
«featureType»
Abstract_NetworkFeature
+component
0..*
+consistsOf
0..*
«featureType»
Network
+subNetwork
0..*
1
+topoGraph
0..1
«featureType»
FeatureGraph
«featureType»
NetworkGraph
+featureGraphMember
0..*
+nodeMember
1..*
«featureType»
Node
+ connectionSignature :Abstract_Signature [0..1]
+ linkControl :Abstract_LinkControl [0..1]
+ type :NodeTypes = exterior
«type»
GML::GM_Point
+realization
0..1
+start
+end
«type»
GML::GM_Curve
«featureType»
Abstract_Edge
+ direction :Sign [0..1]
+ linkControl :Abstract_LinkControl [0..1]
«featureType»
InteriorFeatureLink
«featureType»
NetworkLink
+linkMember
«featureType»
InterFeatureLink
+ type :InterFeatureLinkTypes

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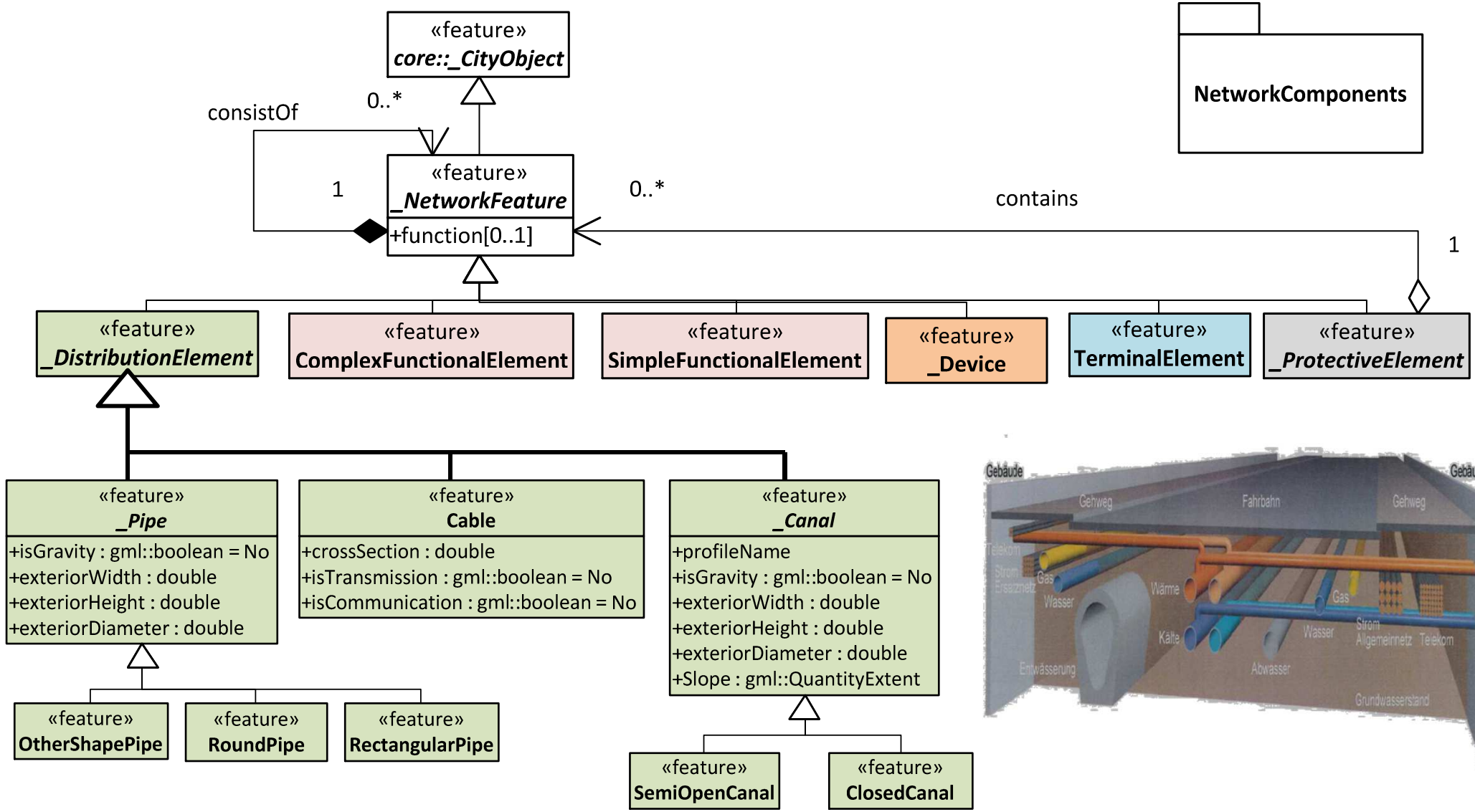

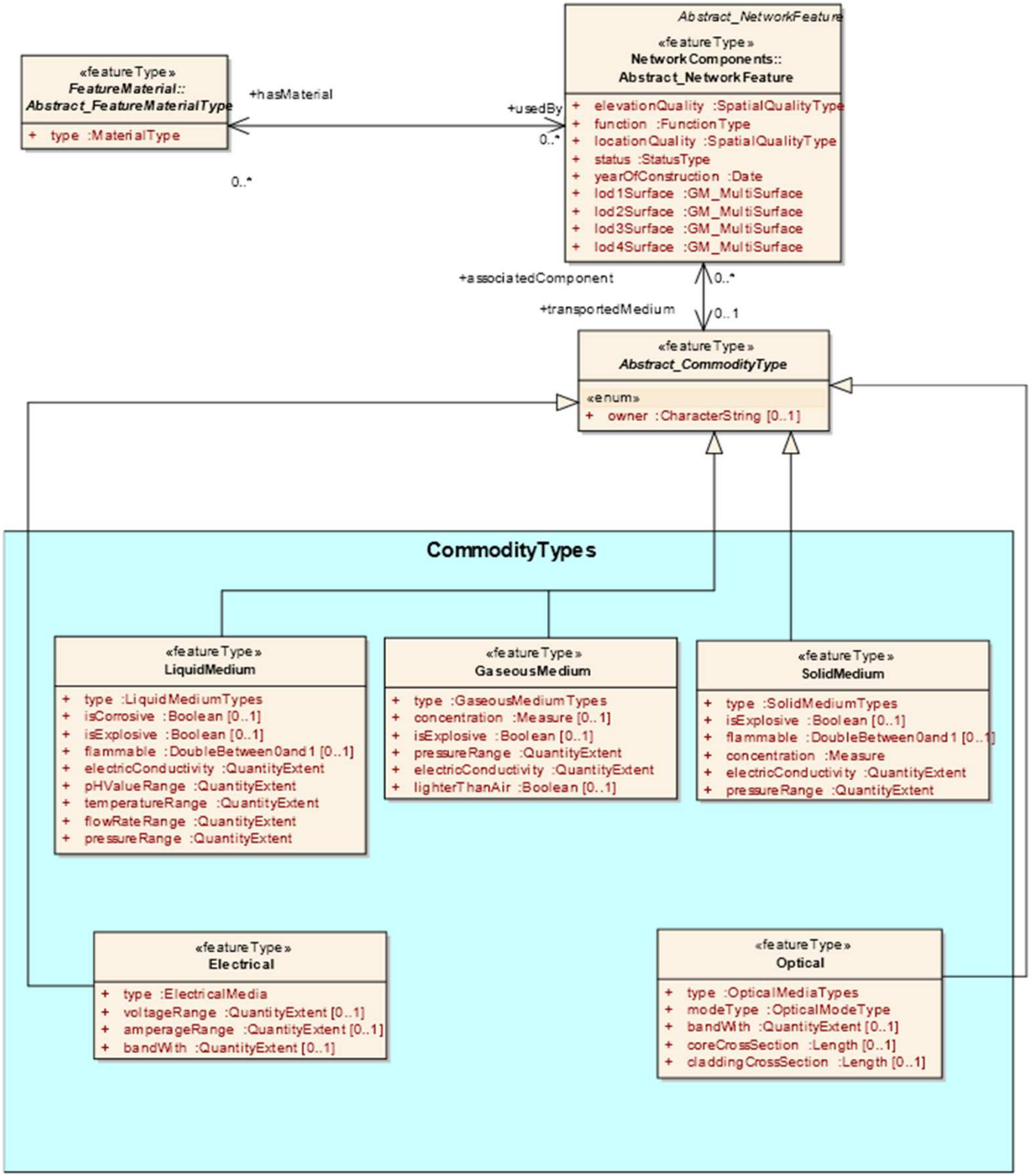
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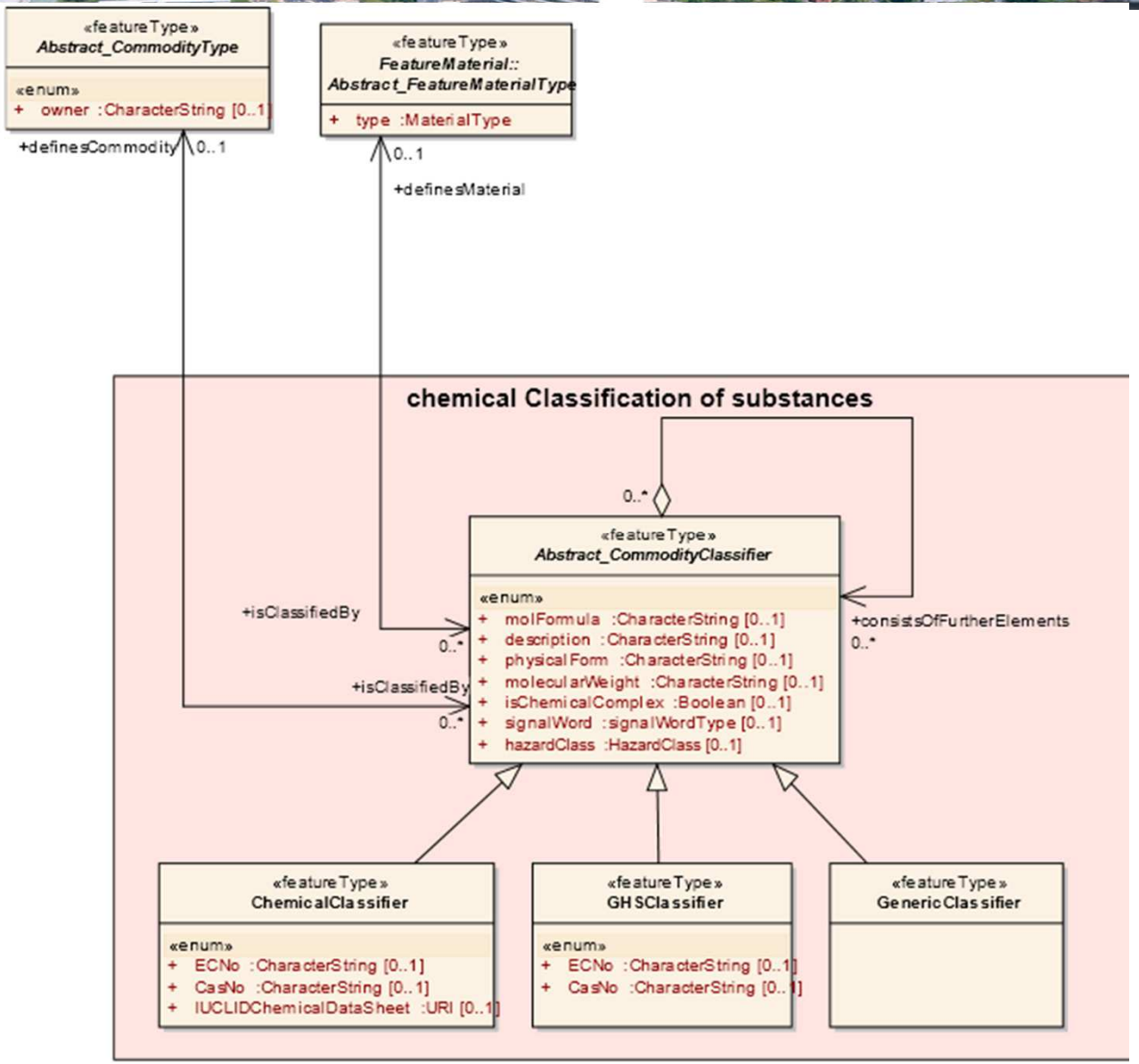
FeatureMaterial::
Abstract_FeatureMaterialType
+ type :MaterialType
+hasMaterial
0..*
+usedBy
0..*
Abstract_NetworkFeature
«featureType»
NetworkComponents::
Abstract_NetworkFeature
+ elevationQuality :SpatialQualityType
+ function :FunctionType
+ locationQuality :SpatialQualityType
+ status :StatusType
+ yearOfConstruction :Date
+ lod1Surface :GM_MultiSurface
+ lod2Surface :GM_MultiSurface
+ lod3Surface :GM_MultiSurface
+ lod4Surface :GM_MultiSurface
+associatedComponent
0..*
+transportedMedium
0..1
«featureType»
Abstract_CommodityType
«enum»
+ owner :CharacterString [0..1]
CommodityTypes
«featureType»
LiquidMedium
+ type :LiquidMediumTypes
+ isCorrosive :Boolean [0..1]
+ isExplosive :Boolean [0..1]
+ flammable :DoubleBetween0and1 [0..1]
+ electricConductivity :QuantityExtent
+ pHValueRange :QuantityExtent
+ temperatureRange :QuantityExtent
+ flowRateRange :QuantityExtent
+ pressureRange :QuantityExtent
«featureType»
GaseousMedium
+ type :GaseousMediumTypes
+ concentration :Measure [0..1]
+ isExplosive :Boolean [0..1]
+ pressureRange :QuantityExtent
+ electricConductivity :QuantityExtent
+ lighterThanAir :Boolean [0..1]
«featureType»
SolidMedium
+ type :SolidMediumTypes
+ isExplosive :Boolean [0..1]
+ flammable :DoubleBetween0and1 [0..1]
+ concentration :Measure
+ electricConductivity :QuantityExtent
+ pressureRange :QuantityExtent
«featureType»
Electrical
+ type :ElectricalMedia
+ voltageRange :QuantityExtent [0..1]
+ amperageRange :QuantityExtent [0..1]
+ bandWith :QuantityExtent [0..1]
«featureType»
Optical
+ type :OpticalMediaTypes
+ modeType :OpticalModeType
+ bandWith :QuantityExtent [0..1]
+ coreCrossSection :Length [0..1]
+ claddingCrossSection :Length [0..1]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«enum»
+ owner :CharacterString [0..1]
+definesCommodity
0..1
«featureType»
FeatureMaterial::
Abstract_FeatureMaterialType
+ type :MaterialType
0..1
+definesMaterial
chemical Classification of substances
0..*
«featureType»
Abstract_CommodityClassifier
«enum»
+ molFormula :CharacterString [0..1]
+ description :CharacterString [0..1]
+ physicalForm :CharacterString [0..1]
+ molecularWeight :CharacterString [0..1]
+ isChemicalComplex :Boolean [0..1]
+ signalWord :signalWordType [0..1]
+ hazardClass :HazardClass [0..1]
+isClassifiedBy
0..*
+isClassifiedBy
0..*
+consistsOfFurtherElements
0..*
«featureType»
ChemicalClassifier
«enum»
+ ECNo :CharacterString [0..1]
+ CasNo :CharacterString [0..1]
+ IUCLIDChemicalDataSheet :URI [0..1]
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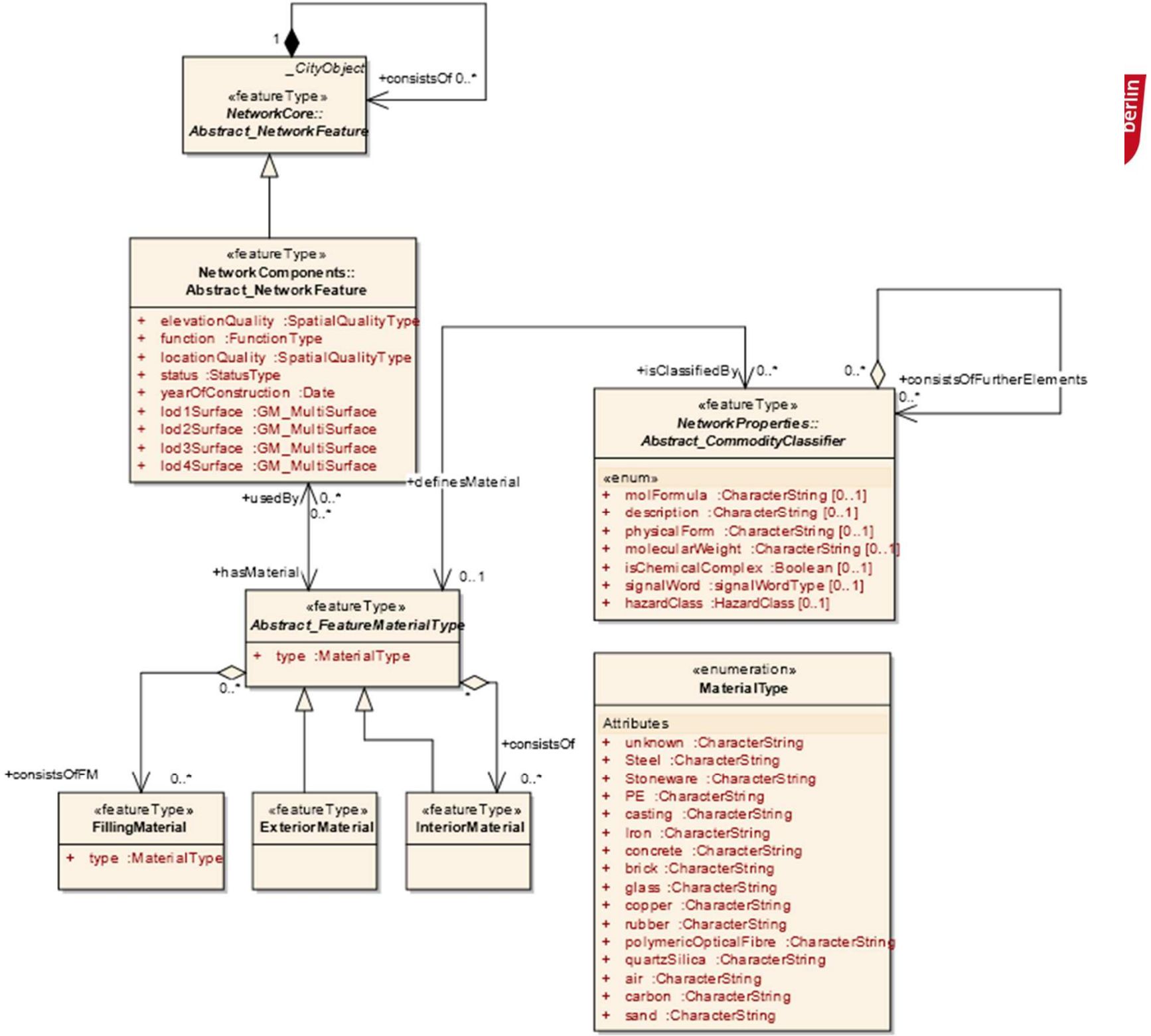
GHSClassifier
«enum»
+ ECNo :CharacterString [0..1]
+ CasNo :CharacterString [0..1]
«featureType»
GenericClassifier


1
_CityObject
+consistsOf 0..*
«featureType»
NetworkCore::
Abstract_NetworkFeature
«featureType»
NetworkComponents::
Abstract_NetworkFeature
+ elevationQuality :SpatialQualityType
+ function :FunctionType
+ locationQuality :SpatialQualityType
+ status :StatusType
+ yearOfConstruction :Date
+ lod1Surface :GM_MultiSurface
+ lod2Surface :GM_MultiSurface
+ lod3Surface :GM_MultiSurface
+ lod4Surface :GM_MultiSurface
+definesMaterial
+isClassifiedBy
0..*
0..*
+consistsOfFurtherElements
0..*
«featureType»
NetworkProperties::
Abstract_CommodityClassifier
«enum»
+ molFormula :CharacterString [0..1]
+ description :CharacterString [0..1]
+ physicalForm :CharacterString [0..1]
+ molecularWeight :CharacterString [0..1]
+ isChemicalComplex :Boolean [0..1]
+ signalWord :signalWordType [0..1]
+ hazardClass :HazardClass [0..1]
+usedBy
0..*
0..*
+hasMaterial
0..1
«featureType»
Abstract_FeatureMaterialType
+ type :MaterialType
0..*
*
+consistsOf
0..*
+consistsOfFM
0..*
«featureType»
FillingMaterial
+ type :MaterialType
«featureType»
ExteriorMaterial
«featureType»
InteriorMaterial
«enumeration»
MaterialType
Attributes
+ unknown :CharacterString
+ Steel :CharacterString
+ Stoneware :CharacterString
+ PE :CharacterString
+ casting :CharacterString
+ Iron :CharacterString
+ concrete :CharacterString
+ brick :CharacterString
+ glass :CharacterString
+ copper :CharacterString
+ rubber :CharacterString
+ polymericOpticalFibre :CharacterString
+ quartzSilica :CharacterString
+ air :CharacterString
+ carbon :CharacterString
+ sand :CharacterString

conclusions

- **common framework** for multi-utility modeling including multi-utility network hierarchies
- **integration** of infrastructure into urban context **(CityGML ADE)**
- dual representation: 3D topography and functional modeling
- in contrast to other existing models each feature is represented by a FeatureGraph
- different networks can be **easily connected** to each other by using the NetworkLink (modeling neuralgic points)
- allows network modeling from a very rough point of view to a very detailed point of view (Station as a node / Station as a collection of nodes and edges)

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http://www.citygmlwiki.org/index.php/CityGML_UtilityNetworkADE

Becker, T., Nagel, C., Kolbe, T. H., (2010). Integrated 3D modeling of multi-utility networks and their interdependencies for critical infrastructure analysis. Advances in 3D Geo-Information Sciences, 1–20.

Becker, T., Nagel, C., Kolbe, T. H., (2013). Semantic 3D modeling of multi-utility networks in cities for analysis and 3D visualization. Springer-Verlag Berlin Heidelberg, 41-62.

Semm, S., Becker, T., Kolbe, T. H., (2012). SIMULTANEOUS VISUALIZATION OF DIFFERENT UTILITY NETWORKS FOR DISASTER MANAGEMENT. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences Volume I, 159-164.

Hijazi, I., Ehlers, M.,Zlatanova, S.,Becker, T., Berlo, L. v.., (2010). Initial Investigations for Modeling Interior Utilities Within 3D Geo Context: Transforming IFC-Interior Utility to CityGML / UtilityNetworkADE. Advances in 3D Geo-Information Sciences.

Löwner, M.-O., Casper E., Becker, T., Benner J.,, Gröger, G., Gruber, U., Häfele, K-H., Kaden, R., Schlüter, S. (2012). CityGML 2.0 – Ein internationaler Standard für 3D-Stadtmodelle Teil 2: CityGML in der Praxis, Zeitschrift für Geodäsie, Geoinformation und Landmanagement, 2/2013, 131-143.

Becker, T., Bartels, M., Hahne, M., Hempel, L., Lieb, R. (2012) Cascading effects and interorganisational crisis management of critical infrastructure operators. Findings of a research project, Gi4DM 2012 proceedings. CTIT Workshop Proceedings Series

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Additional slides

Linking networks