Current state of development of the CityGML UtilityNetworkADE
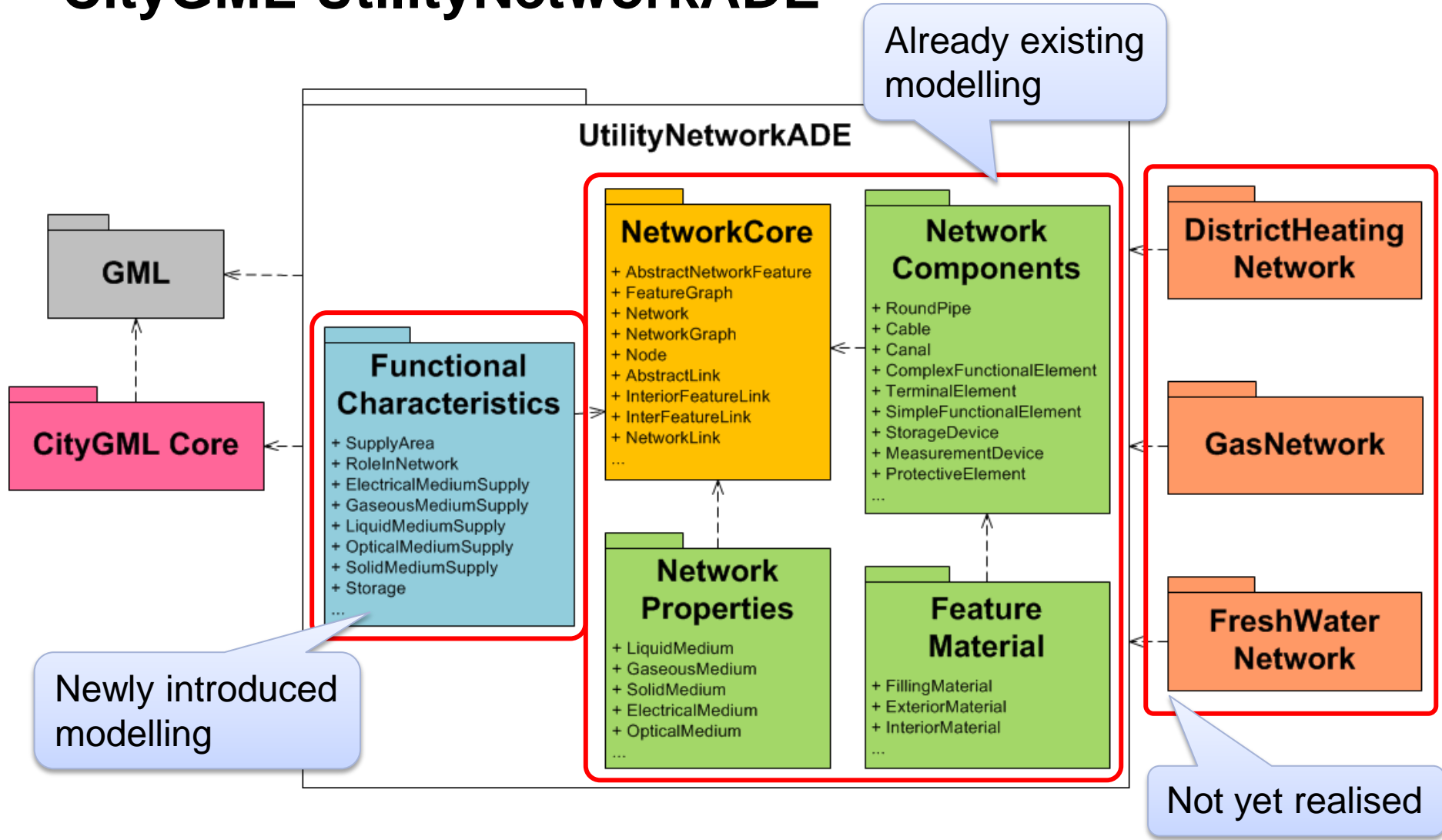
Tatjana Kutzner, Thomas H. Kolbe

Lehrstuhl für Geoinformatik
Technische Universität München

kutzner@tum.de

1st Joint SIG 3D and OGC Workshop on the CityGML UtilityNetworkADE
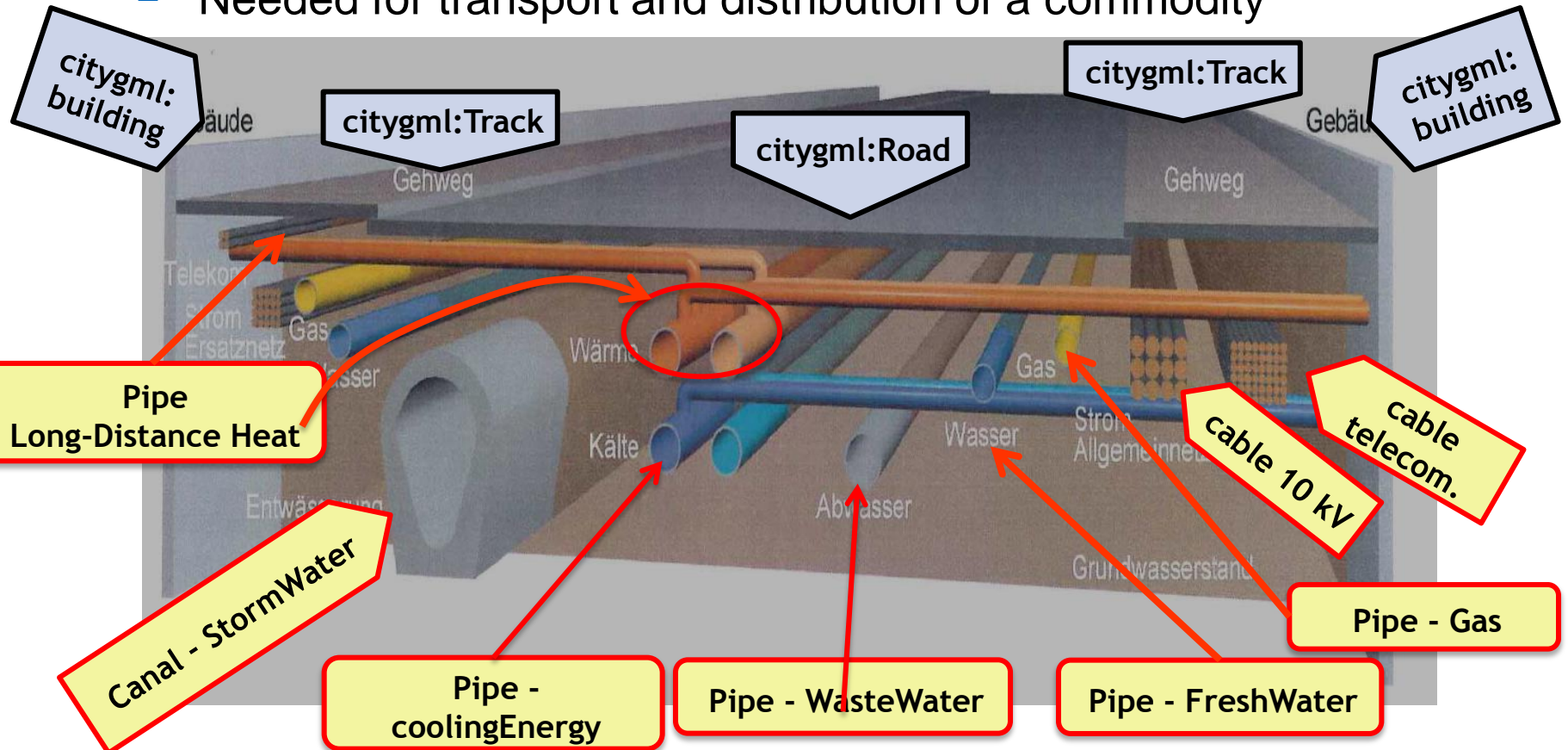Munich, October 13-14, 2016

CityGML UtilityNetworkADE

UtilityNetworkADE – NetworkComponents

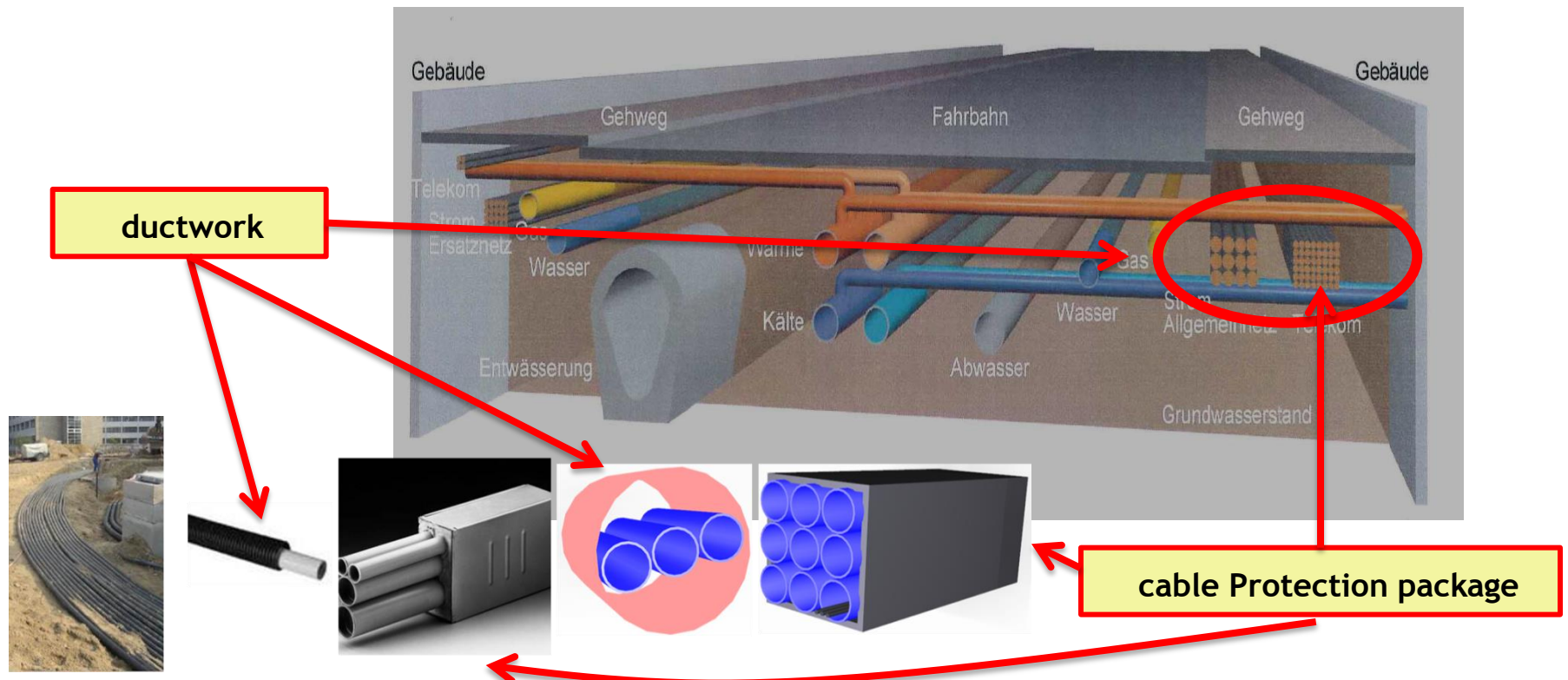► **Every** utility network consists of **3 main functions**:

1. **Distribution objects** (pipes, canals, cables etc.)
   − Needed for transport and distribution of a commodity

citygml: building

citygml:Track

citygml:Track

citygml:Road

citygml: building

Pipe Long-Distance Heat

Canal - StormWater

Pipe - coolingEnergy

Pipe - WasteWater

Pipe - FreshWater

cable 10 kV

cable telecom.

Pipe - Gas

Source: Becker, T., Nagel, C., Kolbe, T. H., Semantic 3D modeling of multi-utility networks in cities for analysis and 3D visualization, 3DGeoInfo Conference 2012 in Quebec City.

UtilityNetworkADE – NetworkComponents

► Every utility network consists of **3 main functions**:
2. **Protection elements** (cable protection package, ductwork, etc.)
   – Without any relevance for the network itself, but of some importance for network security

Source: Becker, T., Nagel, C., Kolbe, T. H., Semantic 3D modeling of multi-utility networks in cities for analysis and 3D visualization, 3DGeoInfo Conference 2012 in Quebec City.
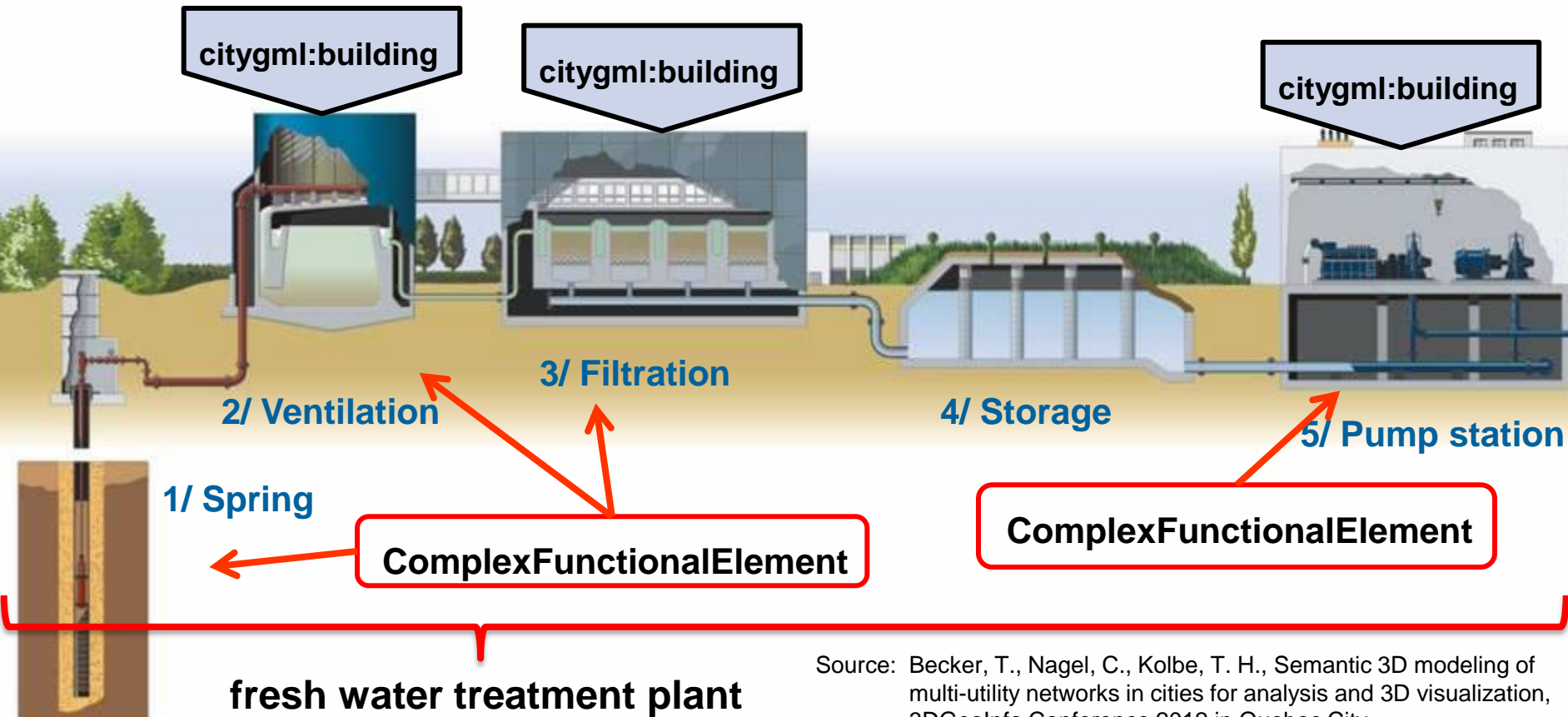
UtilityNetworkADE – NetworkComponents

► Every utility network consists of **3 main functions**:

3. **Functional objects** (manholes, station, etc.)
   − Needed for linkage, maintenance, and observation of a commodity resp. of transport elements

Source: Becker, T., Nagel, C., Kolbe, T. H., Semantic 3D modeling of multi-utility networks in cities for analysis and 3D visualization, 3DGeoInfo Conference 2012 in Quebec City.
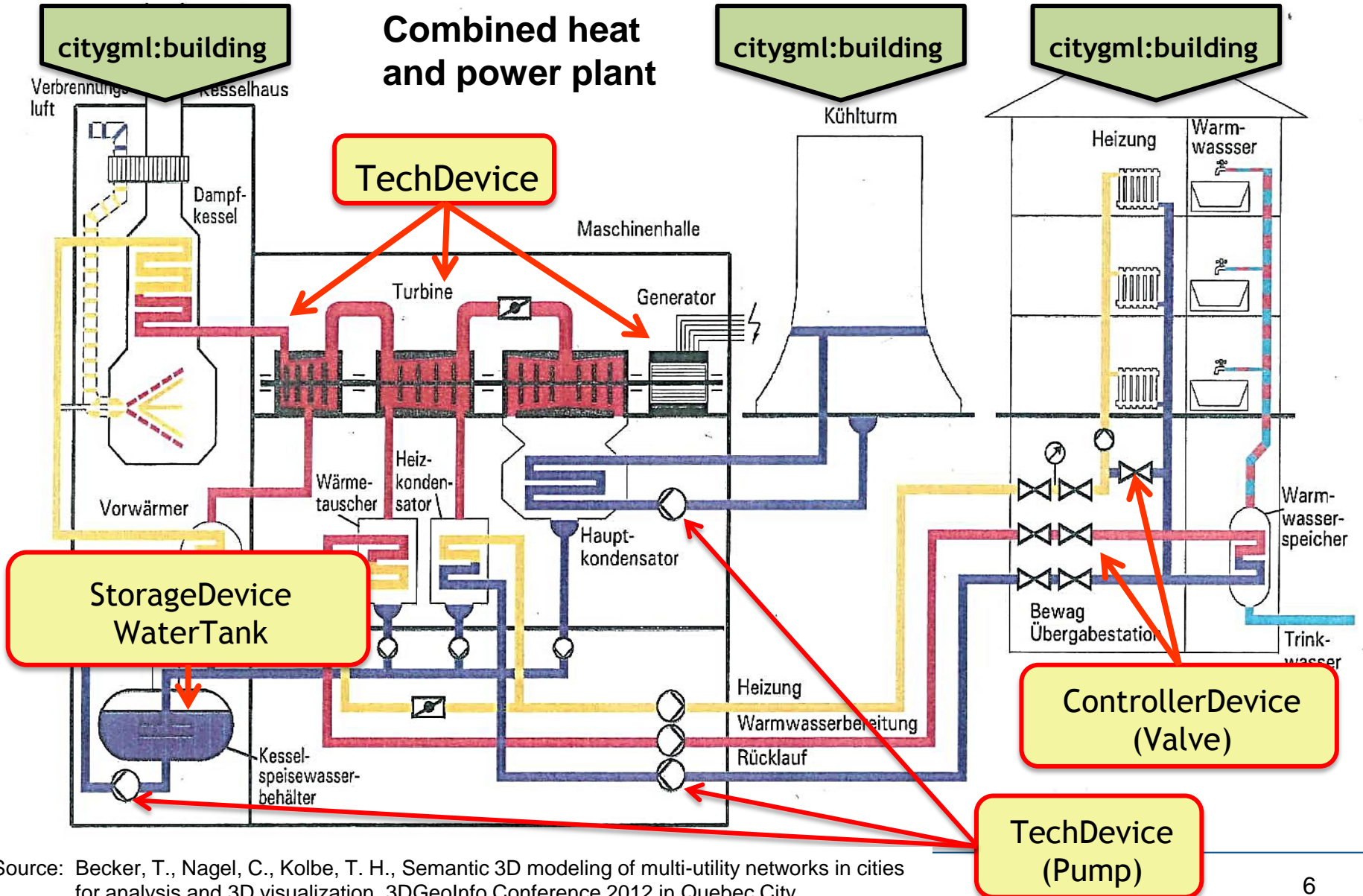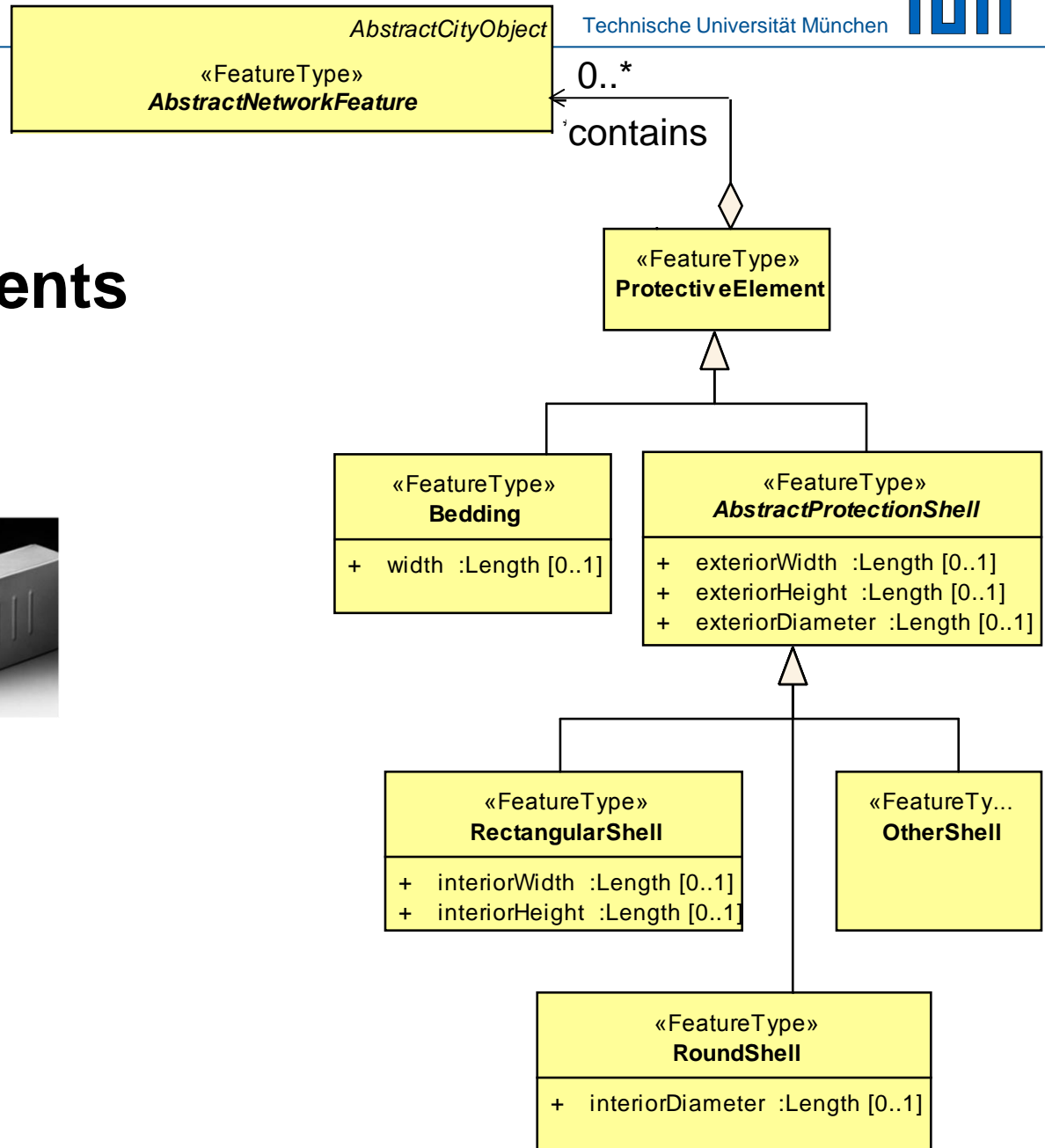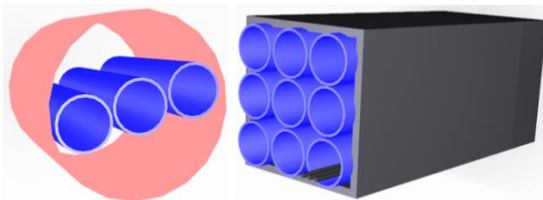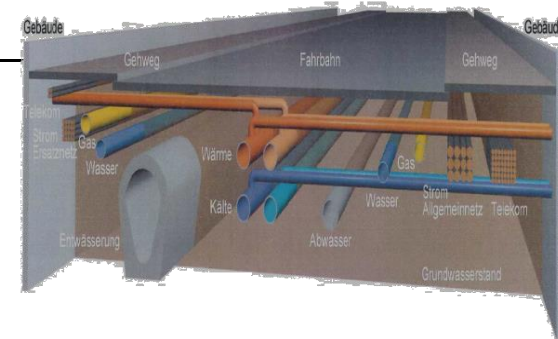
UtilityNetworkADE – NetworkComponents

Combined heat and power plant

citygml:building

citygml:building

citygml:building

TechDevice

StorageDevice
WaterTank

ControllerDevice
(Valve)

TechDevice
(Pump)

Modelling of protection elements

«FeatureType»
AbstractNetworkFeature
AbstractCityObject

0..*
'contains

«FeatureType»
ProtectiveElement

«FeatureType»
Bedding

+ width :Length [0..1]

«FeatureType»
AbstractProtectionShell

+ exteriorWidth :Length [0..1]
+ exteriorHeight :Length [0..1]
+ exteriorDiameter :Length [0..1]

«FeatureType»
RectangularShell

+ interiorWidth :Length [0..1]
+ interiorHeight :Length [0..1]

«FeatureTy...
OtherShell

«FeatureType»
RoundShell

+ interiorDiameter :Length [0..1]

Modelling of distribution objects

«FeatureType»
AbstractCityObject
AbstractNetworkFeature

«FeatureType»
AbstractDistributionElement

+ class :LineValue [0..1]
+ functionOfLine :LineMeaningValue [0..1]

«FeatureType»
AbstractPipe

+ isGravity :Boolean [0..1]
+ exteriorWidth :Length [0..1]
+ exteriorHeight :Length [0..1]
+ exteriorDiameter :Length [0..1]

«FeatureType»
Cable

+ isTransmission :Boolean [0..1]
+ isCommunication :Boolean [0..1]
+ crossSection :Length [0..1]

«FeatureType»
Canal

+ profileName :CharacterString [0..1]
+ slope :QuantityExtent [0..1]
+ isGravity :Boolean [0..1]
+ exteriorWidth :Length [0..1]
+ exteriorHeight :Length [0..1]
+ exteriorDiameter :Length [0..1]

«FeatureType»
RoundPipe

+ interiorDiameter :Length [0..1]

«FeatureType»
SemiOpen

«FeatureType»
RectangularPipe

+ interiorWidth :Length [0..1]
+ interiorHeight :Length [0..1]

«FeatureType»
Closed

«FeatureType»
OtherShapePipe

Modelling of functional objects

Modelling of different types of commodities

«FeatureType»
LiquidMedium

+ type :LiquidMediumValue
+ isCorrosive :Boolean [0..1]
+ isExplosive :Boolean [0..1]
+ flammable :DoubleBetween0and1 [0..1]
+ electricConductivity :QuantityExtent [0..1]
+ phValueRange :QuantityExtent [0..1]
+ temperatureRange :QuantityExtent [0..1]
+ flowRateRange :QuantityExtent [0..1]
+ pressureRange :QuantityExtent [0..1]

«FeatureType»
GaseousMedium

+ type :GaseousMediumValue
+ concentration :Measure [0..1]
+ isExplosive :Boolean [0..1]
+ pressureRange :QuantityExtent [0..1]
+ electricConductivity :QuantityExtent [0..1]
+ lighterThanAir :Boolean [0..1]

«FeatureType»
SolidMedium

+ type :SolidMediumValue
+ isExplosive :Boolean [0..1]
+ flammable :DoubleBetween0and1 [0..1]
+ concentration :Measure [0..1]
+ electricConductivity :QuantityExtent [0..1]
+ pressureRange :QuantityExtent [0..1]

«FeatureType»
ElectricalMedium

+ type :ElectricalMediumValue
+ voltageRange :QuantityExtent [0..1]
+ amperageRange :QuantityExtent [0..1]
+ bandWidth :QuantityExtent [0..1]

«FeatureType»
OpticalMedium

+ type :OpticalMediumValue
+ modeType :OpticalModeValue [0..1]
+ bandWidth :QuantityExtent [0..1]
+ coreCrossSection :Length [0..1]
+ claddingCrossSection :Length [0..1]

AbstractCityObject
«FeatureType»
Network

«Property»
+ class :Code [0..1]
+ function :Code [0..*]
+ usage :Code [0..*]

+associatedNetwork   +transportedMedium
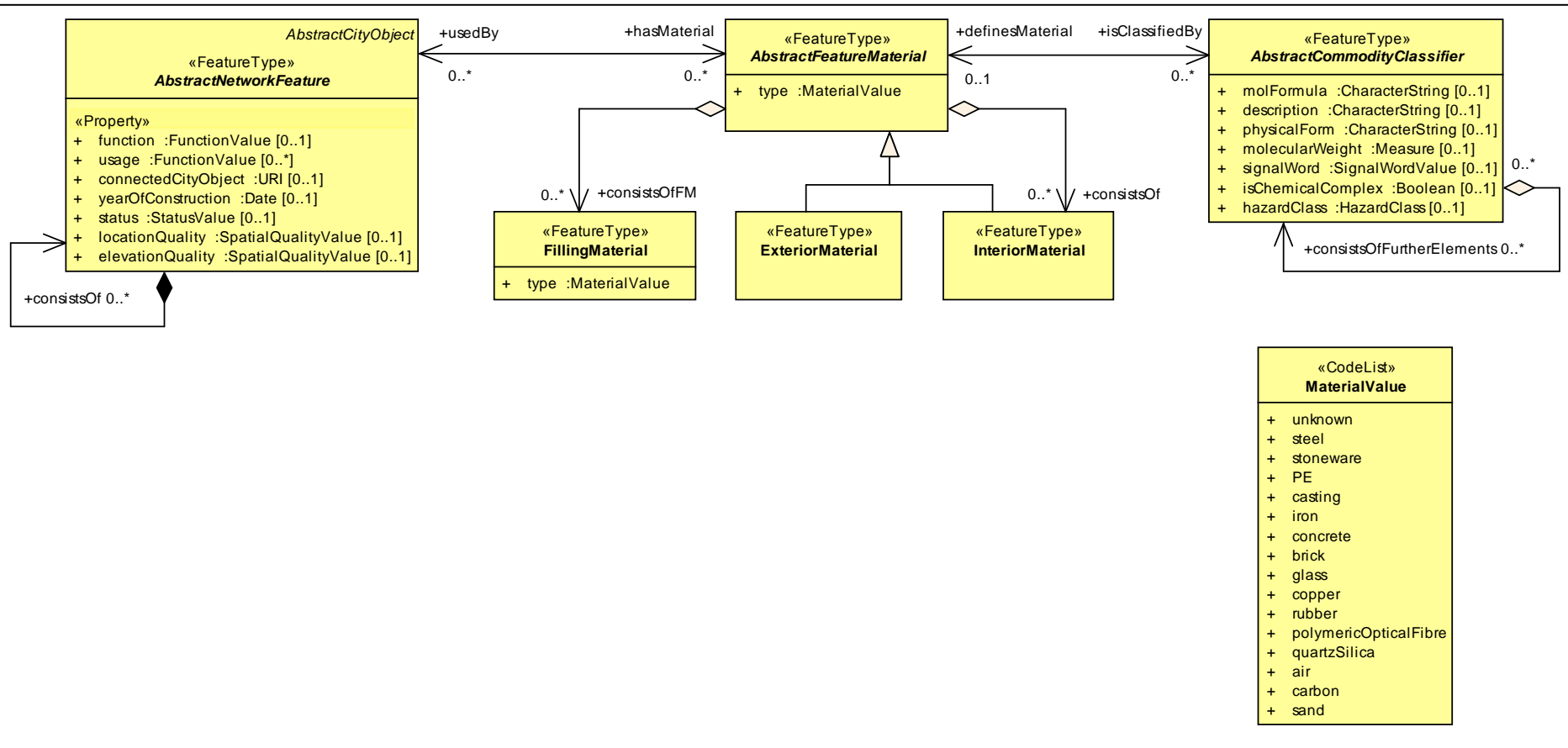
0..*   0..1

«Feat...
Abstrac...

+ owner :Cha...

Modelling of different types of commodities

▶ The ADE allows for classifying chemicals according to different chemical classification systems

«FeatureType»
AbstractCommodityClassifier

+ molFormula :CharacterString [0..1]
+ description :CharacterString [0..1]
+ physicalForm :CharacterString [0..1]
+ molecularWeight :Measure [0..1]
+ signalWord :SignalWordValue [0..1]
+ isChemicalComplex :Boolean [0..1]
+ hazardClass :HazardClass [0..1]

+isClassifiedBy

0..*

0..*

+consistsOfFurtherElements 0..*

«FeatureType»
ChemicalClassifier

+ ECNo :CharacterString [0..1]
+ CasNo :CharacterString [0..1]
+ IUCLIDChemicalDataSheet :URI [0..1]

«FeatureType»
GHSClassifier

+ ECNo :CharacterString [0..1]
+ CasNo :CharacterString [0..1]
+ hazardClass :HazardClass [0..*]

«FeatureType»
GenericClassifier

«enumeration»
SignalWordValue

unknown
nonHazardous
attention
hazardous

«DataType»
HazardClass

+ hazardClass :CharacterString [0..1]
+ categoryCode :CharacterString [0..1]
+ statementCode :CharacterString [0..1]
+ pictogramCode :CharacterString [0..1]
+ pictogramURI :URI [0..1]

UtilityNetworkADE – Feature Material

► Defines the material, a network component is made of

UtilityNetworkADE – Hollow Space
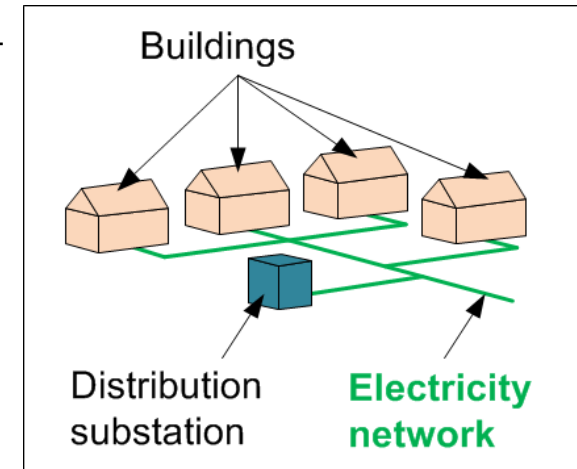
► Defines the hollow space of a network component
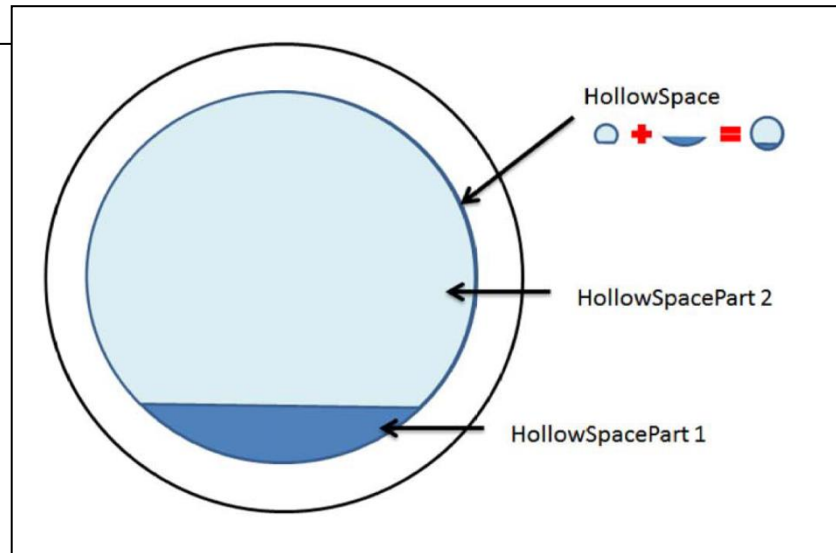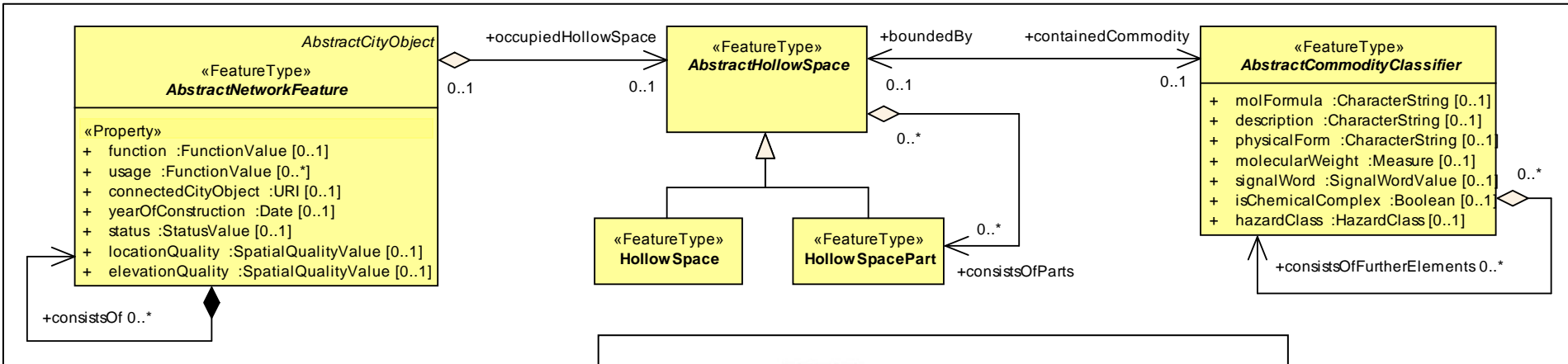
Modelling of topographical and functional aspects

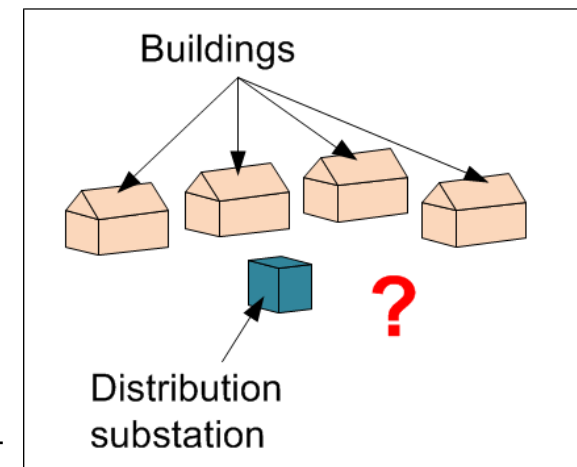► The following aspects are of particular importance in modelling supply and disposal infrastructures:

● **Topographical and topological aspects**
  ● Necessary for **representing the position, shape and extent of networks including the concrete individual network features** and for deriving spatial and computer-graphic-related answers therefrom.

Buildings

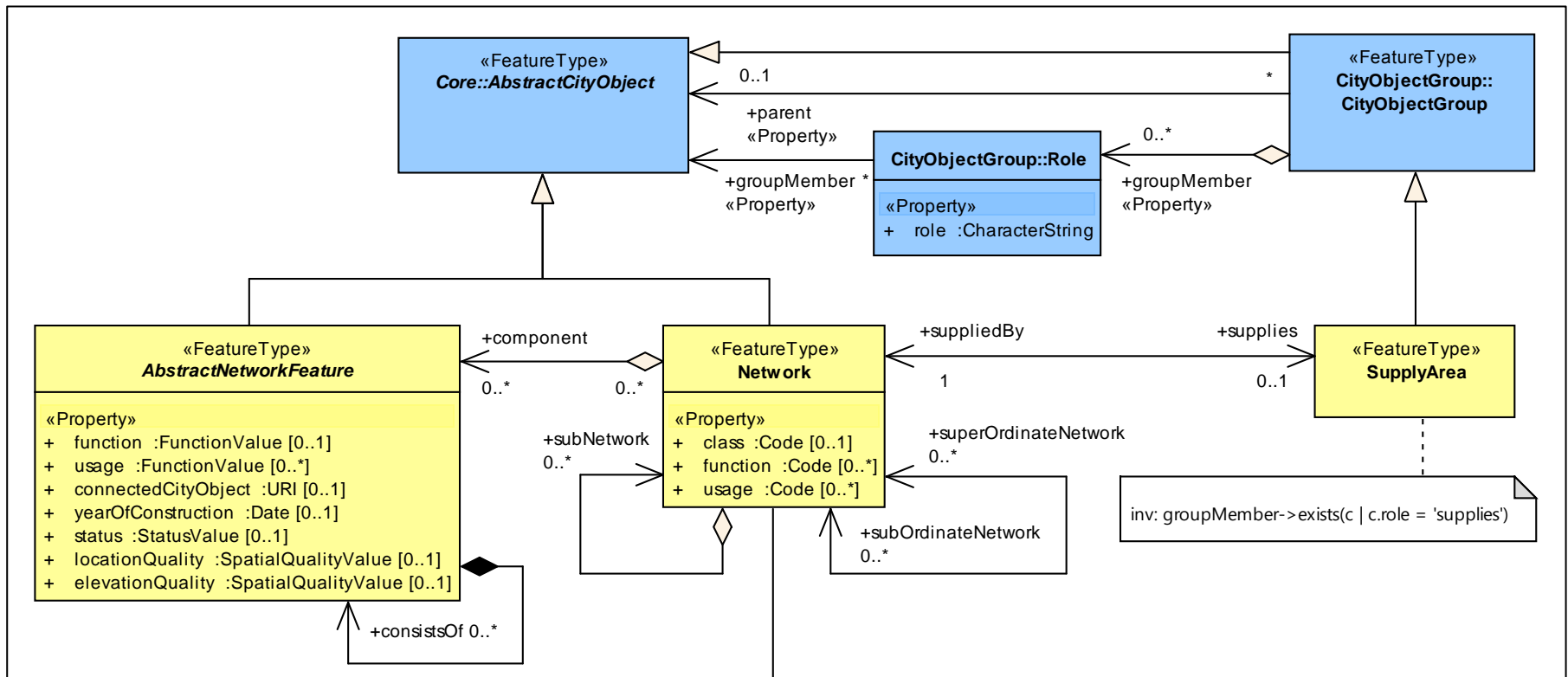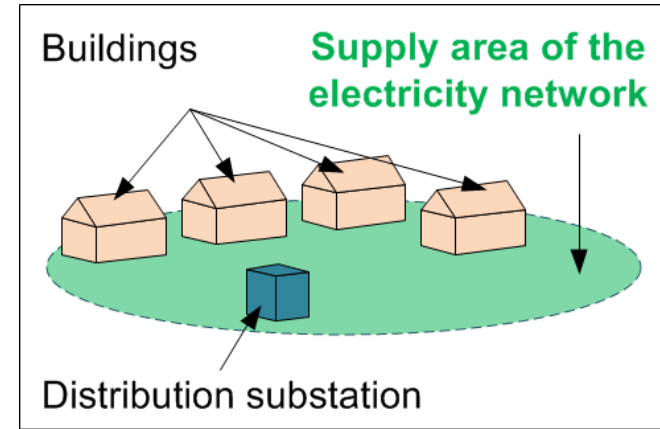Distribution substation   Electricity network

● **Functional aspects**
  ● For representing supply and disposal tasks
  ● Of importance, when **no detailed modelling of the network elements** is available, but still the **impact of a network failure on a certain region** is to be **analysed**.

Buildings

Distribution substation

Modelling of topographical and functional aspects

▶ The following aspects are of particular importance in modelling supply and disposal infrastructures:

- **Topographical and topological aspects**
  - Necessary for representing the position, shape and extent of networks including the concrete individual network features and for deriving spatial and computer-graphic-related answers therefrom.

  Are already represented extensively in the UtilityNetworkADE
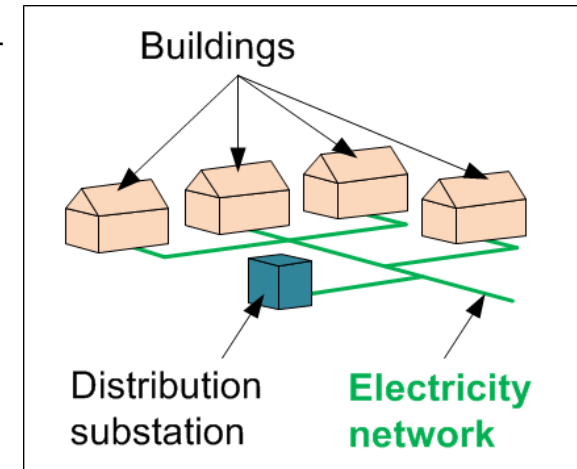
- **Functional aspects**
  - For representing supply and disposal tasks
  - Of importance, when no detailed modelling of the network elements is available, but still the impact of a network failure on a certain region has to be analysed.

  Currently only represented through the topological connection of the network features which merely allow for simulating cascading effects
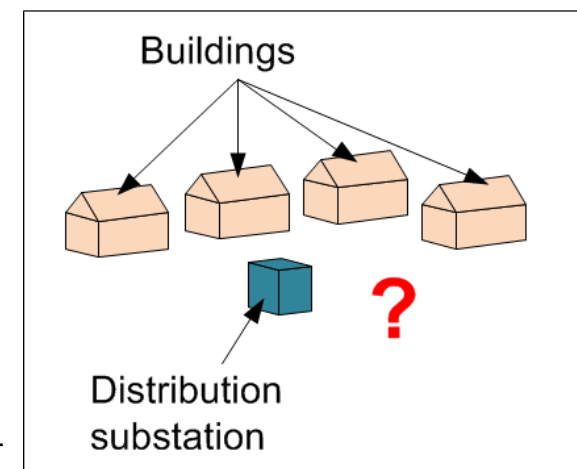
Modelling the supply area

▶ **Supply area** = the geographic region a specific commodity is supplied to by a network

- The supply area, thus, substitutes the network

Buildings — Supply area of the electricity network

Distribution substation

«FeatureType»
Core::AbstractCityObject

«FeatureType»
**CityObjectGroup::
CityObjectGroup**

0..1 ... *

+parent
«Property»

CityObjectGroup::Role

0..*

+groupMember *
«Property»

«Property»
+ role :CharacterString

+groupMember
«Property»

«FeatureType»
AbstractNetworkFeature

«Property»
+ function :FunctionValue [0..1]
+ usage :FunctionValue [0..*]
+ connectedCityObject :URI [0..1]
+ yearOfConstruction :Date [0..1]
+ status :StatusValue [0..1]
+ locationQuality :SpatialQualityValue [0..1]
+ elevationQuality :SpatialQualityValue [0..1]

+component
0..*   0..*

«FeatureType»
Network

«Property»
+ class :Code [0..1]
+ function :Code [0..*]
+ usage :Code [0..*]

+suppliedBy
1

+supplies
0..1

«FeatureType»
SupplyArea

+subNetwork
0..*

+superOrdinateNetwork
0..*

+subOrdinateNetwork
0..*

inv: groupMember->exists(c | c.role = 'supplies')

+consistsOf 0..*

Modelling of the functional roles

► Roles **source**, **sink**, **distribution** and **storage** = **representation of the flow of commodities** in a network by adding these roles to network elements and city objects

Buildings: **Sinks** — Supply area of the electricity network

Distribution substation: **Source**
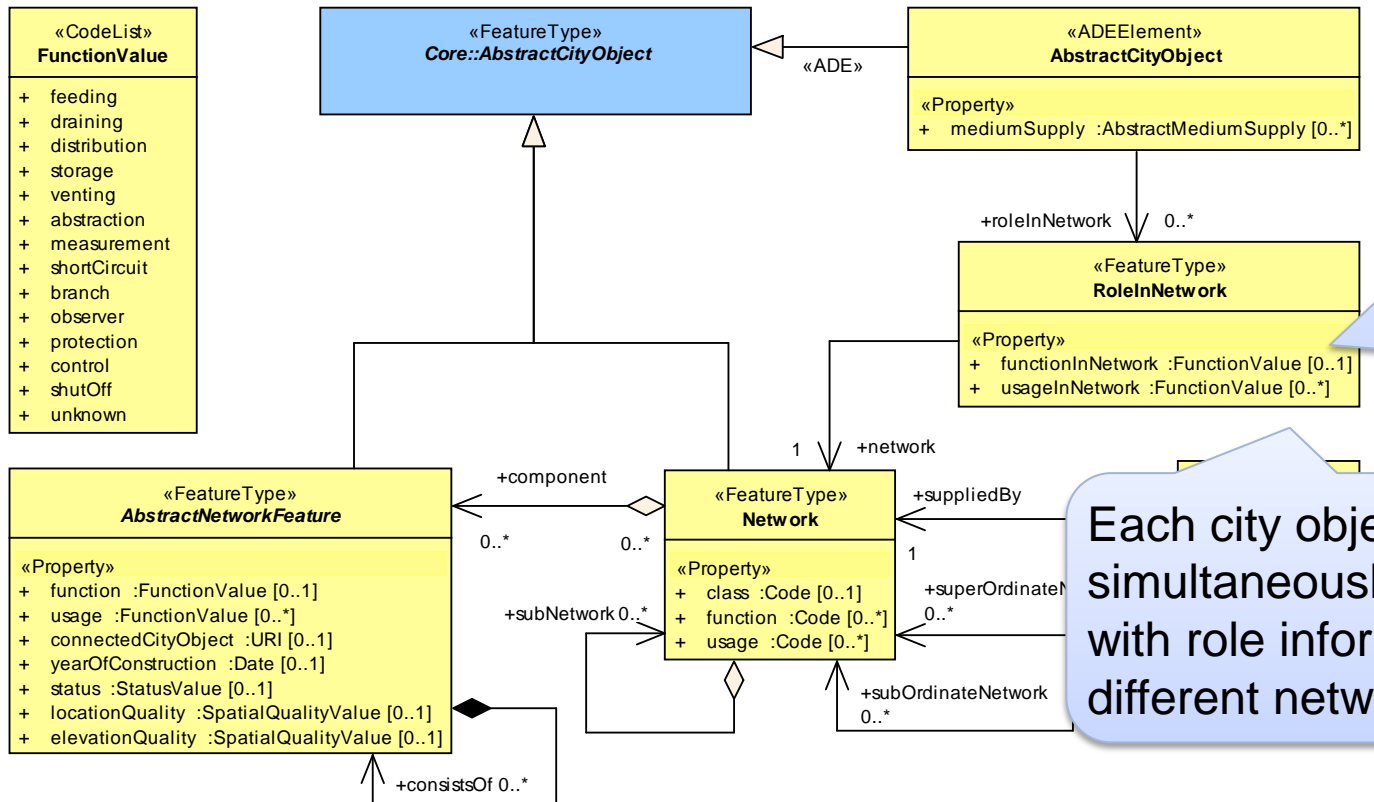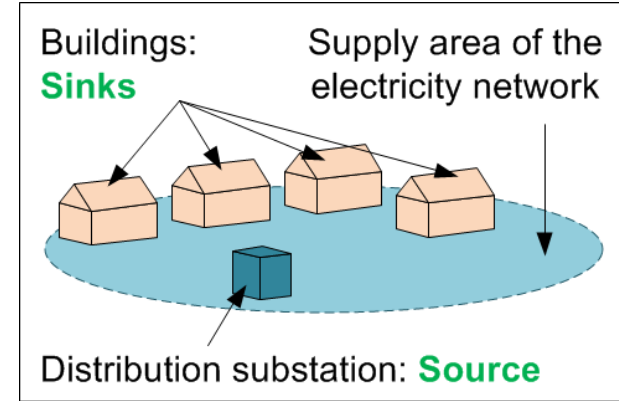
Differentiation between the **intended** and the **actual role** of network elements and city objects

Each city object can simultaneously be provided with role information about different networks

Modelling of the suppliability/suppliedness (I)

► To be able to conduct simulations also in cases when the **network information is completely missing**, the **city objects themselves** are to be **provided with informationen on their supply and disposal** as well.

► A city object can exhibit the following information:

- **Supplyability** = **potential supply** of a commodity to a city object

- **Suppliedness** = **actual supply** of a commodity to a city object at a certain point in time

- **Storage** = can the city object supply itself in case of network failures
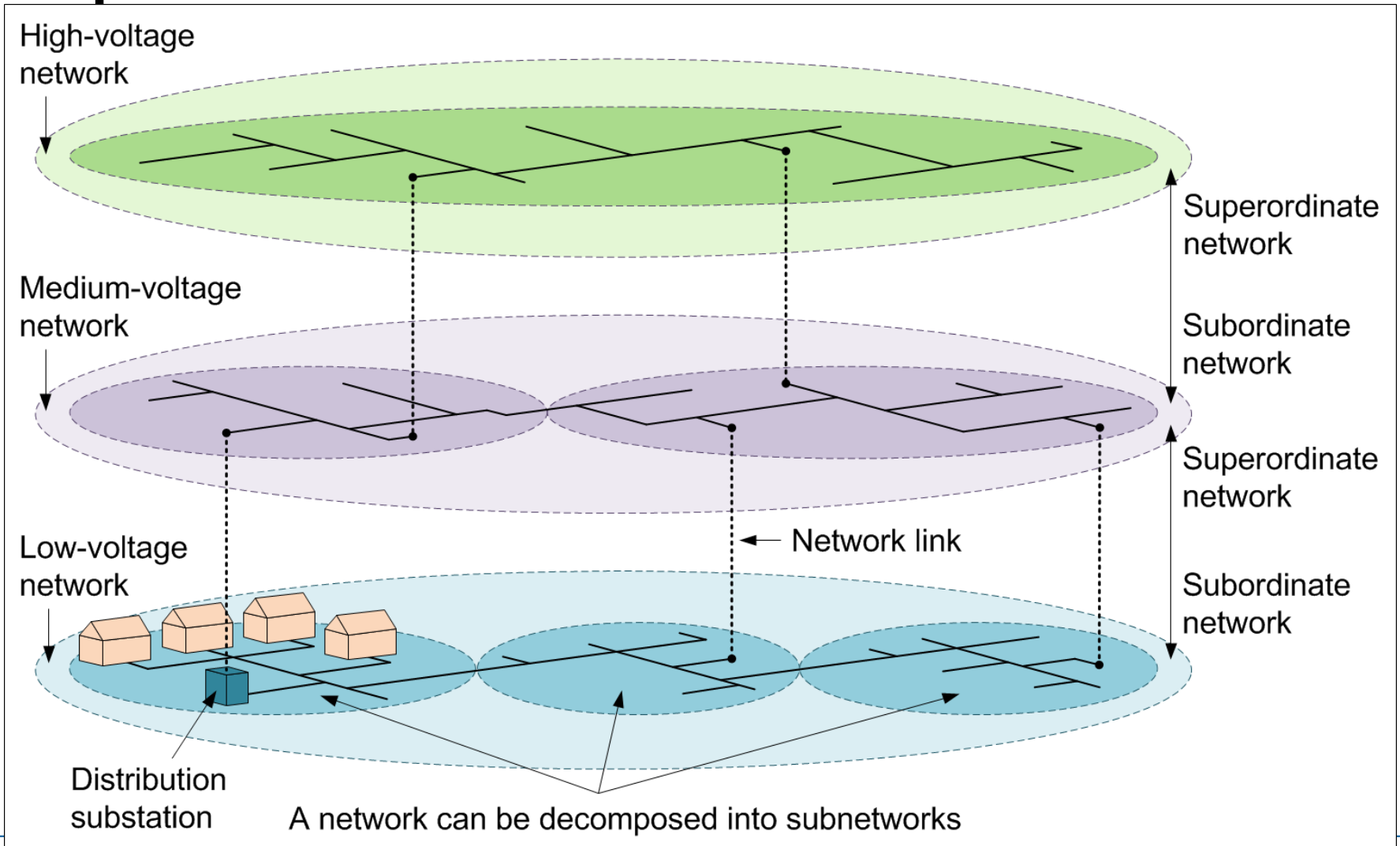
Modelling of the suppliability/suppliedness (II)
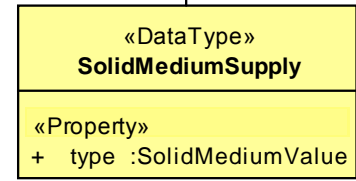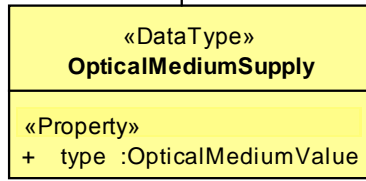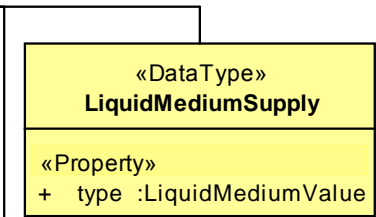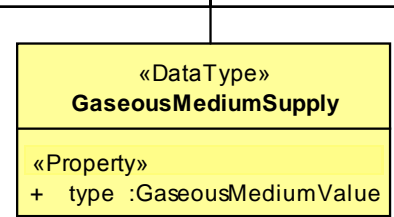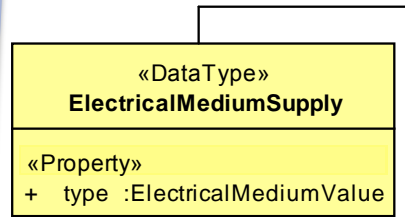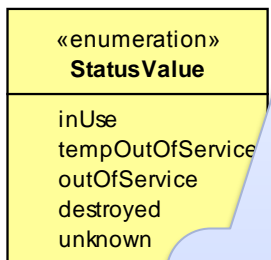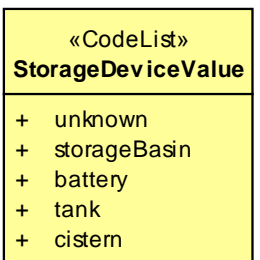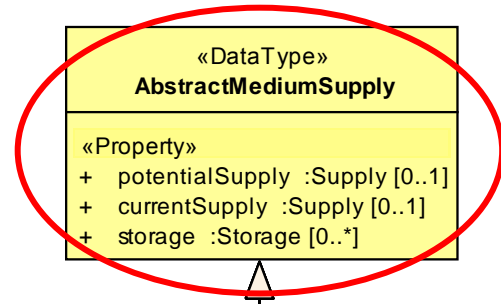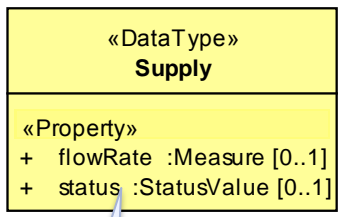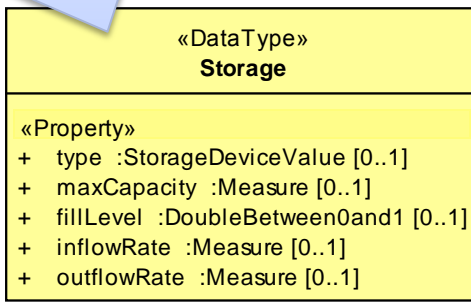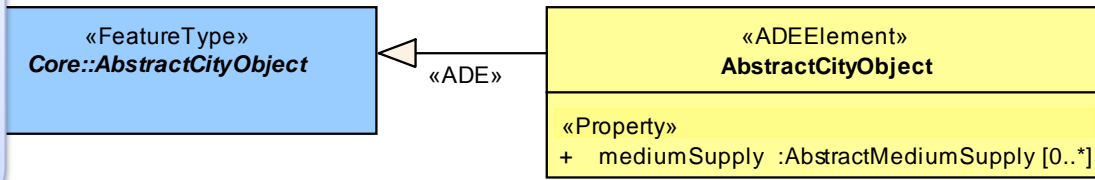
Modelling of subnetworks as well as superordinate and subordinate networks

Exemplary realisation within SIMKAS 3D
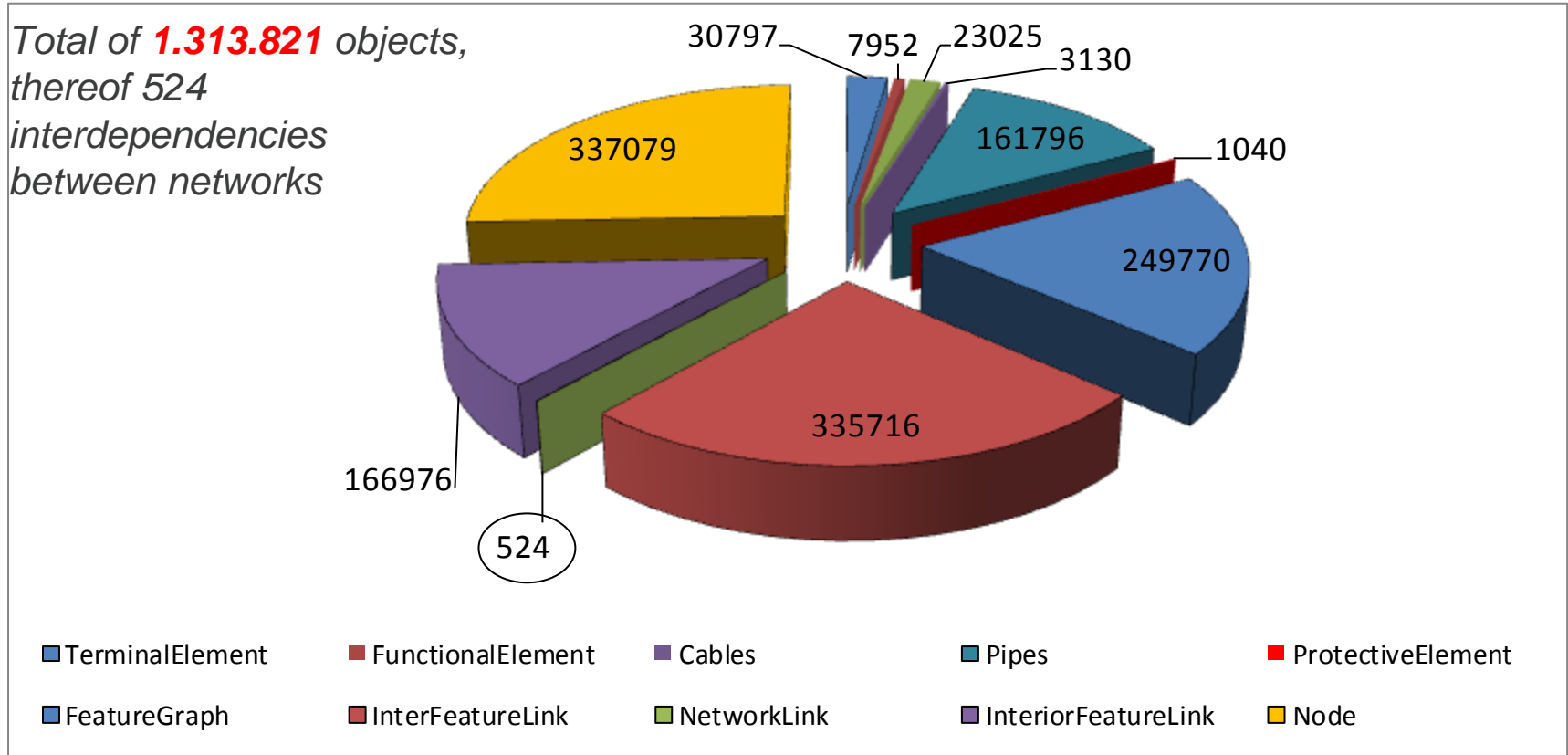
*Total of **1.313.821** objects, thereof 524 interdependencies between networks*

- Legend: TerminalElement, FunctionalElement, Cables, Pipes, ProtectiveElement, FeatureGraph, InterFeatureLink, NetworkLink, InteriorFeatureLink, Node

Values shown: 30797, 7952, 23025, 3130, 161796, 1040, 249770, 335716, 524, 166976, 337079

Source: Becker, T., Nagel, C., Kolbe, T. H., Semantic 3D modeling of multi-utility networks in cities for analysis and 3D visualization, 3DGeoInfo Conference 2012 in Quebec City.
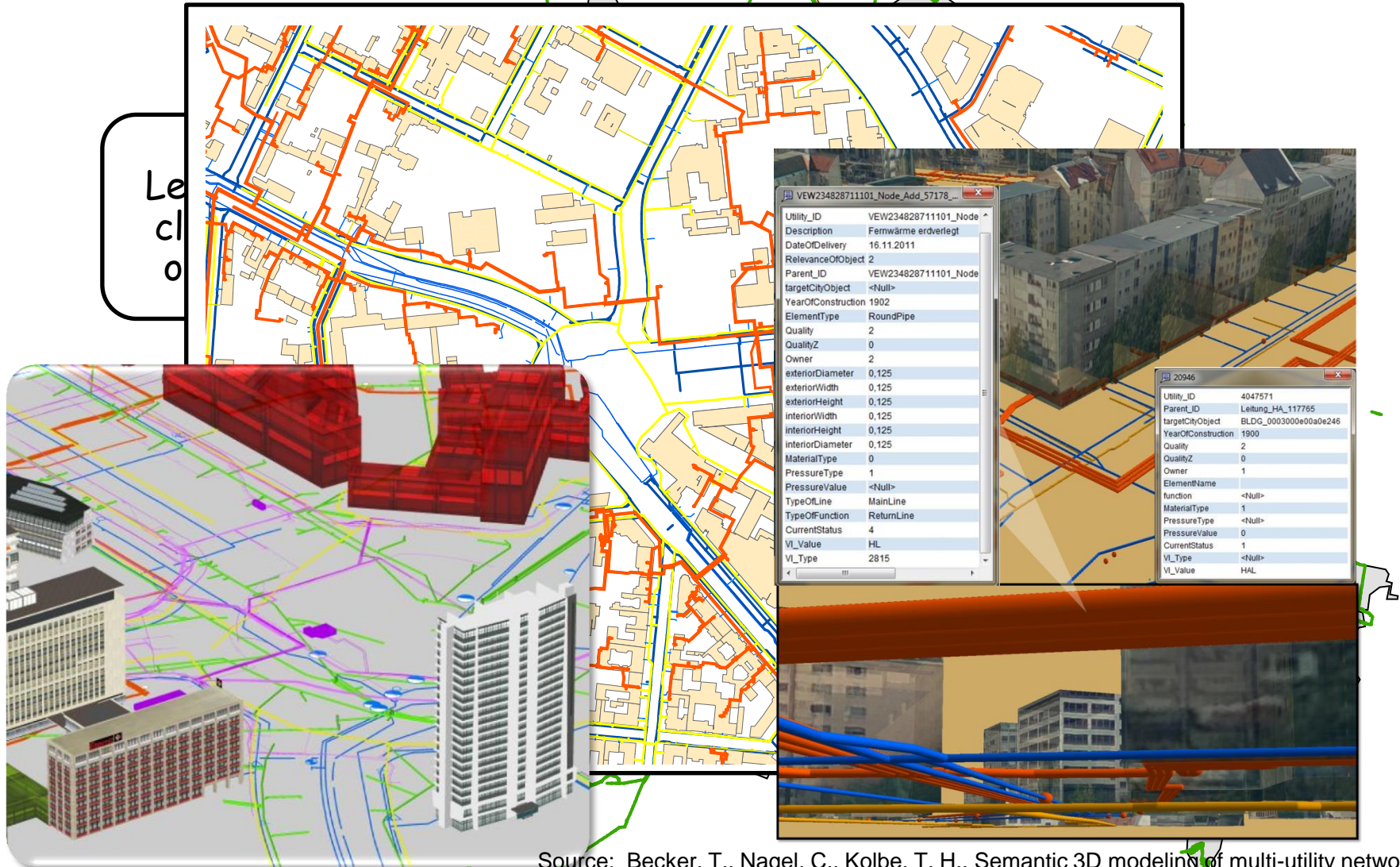
Exemplary realisation within SIMKAS 3D

Source: Becker, T., Nagel, C., Kolbe, T. H., Semantic 3D modeling of multi-utility networks in cities for analysis and 3D visualization, 3DGeoInfo Conference 2012 in Quebec City.

Current state of implementation

► The current version of the UtilityNetworkADE UML model was modelled using Enterprise Architect based on

- the CityGML EA UML model available at:
  ftp://ftp.lrz.de/transfer/DidVfCGML/

- and the information available at the CityGML wiki:
  http://www.citygmlwiki.org/index.php/CityGML_UtilityNetworkADE

► An XSD was derived using ShapeChange

- The XSD was successfully applied in the project „Risk Analysis Supply Infrastructure" by transforming source data to a CityGML data set using FME

Further information on the UtilityNetworkADE

CityGML Wiki:

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

Publications:

- Becker, Thomas; Nagel, Claus; Kolbe, Thomas H. (2012) Semantic 3D modeling of multi-utility networks in cities for analysis and 3D visualization: http://mediatum.ub.tum.de/doc/1145724/287720.pdf

- Becker, Thomas; Nagel, Claus; Kolbe, Thomas H. (2011) Integrated 3D Modeling of Multi-utility Networks and Their Interdependencies for Critical Infrastructure Analysis: http://mediatum.ub.tum.de/doc/1145740/358854.pdf

- Kutzner, Tatjana; Kolbe, Thomas H. (2016) Extending Semantic 3D City Models by Supply and Disposal Networks for Analysing the Urban Supply Situation. In: Lösungen für eine Welt im Wandel, Dreiländertagung der SGPF, DGPF und OVG, 36. Wissenschaftlich-Technische Jahrestagung der DGPF: https://mediatum.ub.tum.de/doc/1304227/1304227.pdf

Summary

▶ **Core model for the representation of arbitrary utility networks**
- **3D topographic** modelling
- **3D topological** and **functional** modelling
- Support of **hierarchies**: complex objects, network hierarchies
- Provides homogenized and integrated view on multi-utility networks

▶ **Utility-specific, concrete feature classes**
- **Distribution elements**: pipes, cables, canals
- **Functional elements**: terminals, devices (controller, storage, measurement, etc.), simple & complex functional elements
- **Protective elements**: beddings, shells

▶ **Extension by the functional concepts supply area, functional roles, suppliability/suppliedness**

→ Allows for conducting functional analyses
- Uselful in regions, where no detailed data on networks are available
- Information can be collected by observation and exploration