Motivation and use cases for 3D utility network models + Utility Network ADE Core Model

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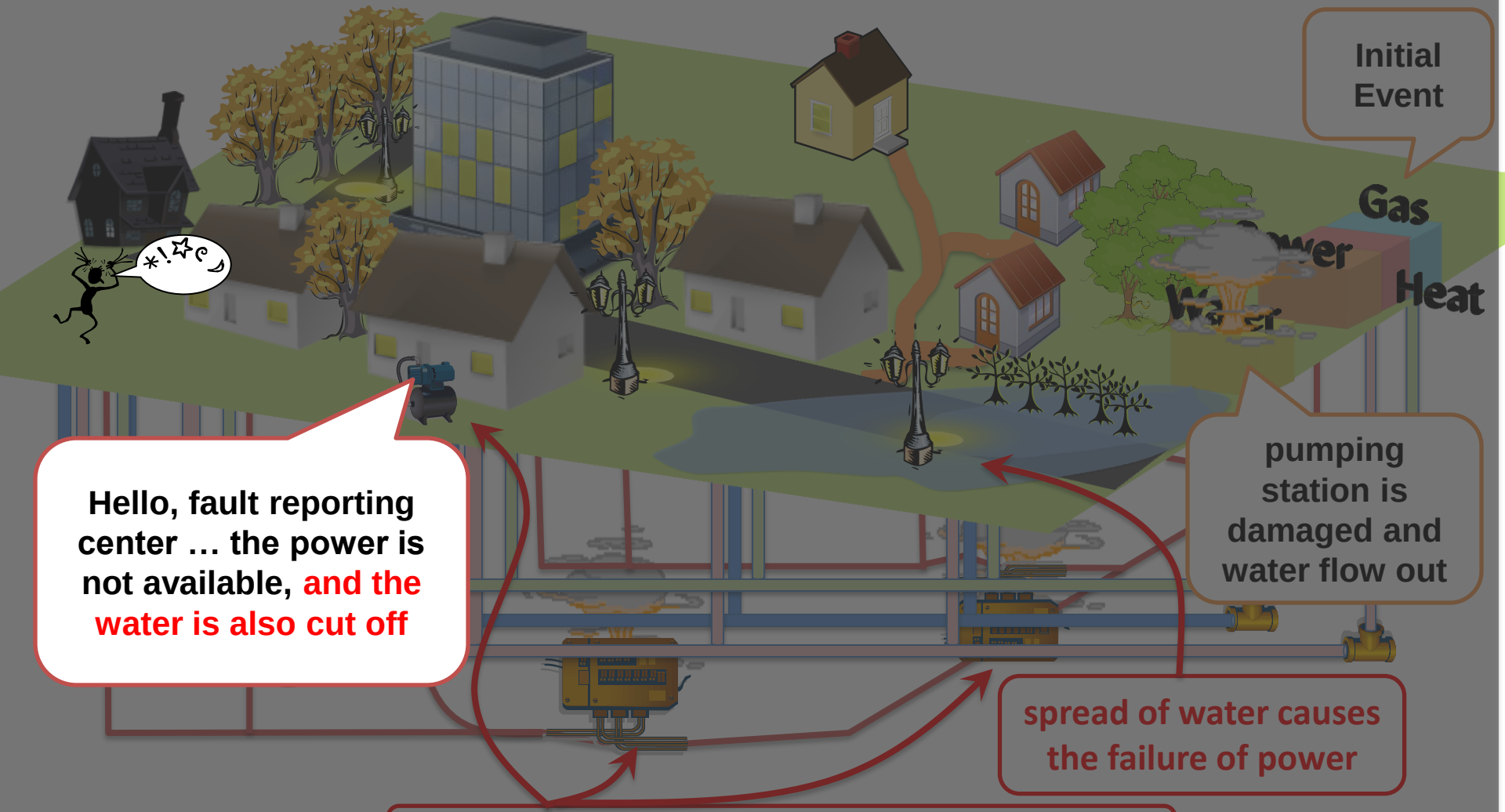
SIMKAS 3D

Simulation of intersectorial cascading effects in the failure of critical infrastructures based on the virtual 3D city model of Berlin

Research project funded by BMBF 2009-2012

Motivation


Initial Event
Gas
Heat
Hello, fault reporting center … the power is not available, and the water is also cut off
pumping station is damaged and water flow out
spread of water causes the failure of power
due to the power failure, the pumps won‘t work

Project partners

Bundesministerium für Bildung und Forschung

Berliner Wasserbetriebe

Technische Universität Berlin

Zentrum Technik und Gesellschaft

Bundesamt für Bevölkerungsschutz und Katastrophenhilfe

VATTENFALL

DHI WASY

Department of Geoinformation Science

be Berlin

inter 3 Institut für Ressourcenmanagement

Senatsverwaltung für Inneres und Sport

NETZGESELLSCHAFT BERLIN·BRANDENBURG

imss Institut für Migrations- und Sicherheitsstudien

Integration of the Utility Networks and the 3D City Model

Department of Geoinformation Science

Aim: Development of a homogenised network model for the simulation incl. the relevant thematic attributes (usage type, material, operating parameters, number of habitants etc.)

3D BUILDING MODELS

+

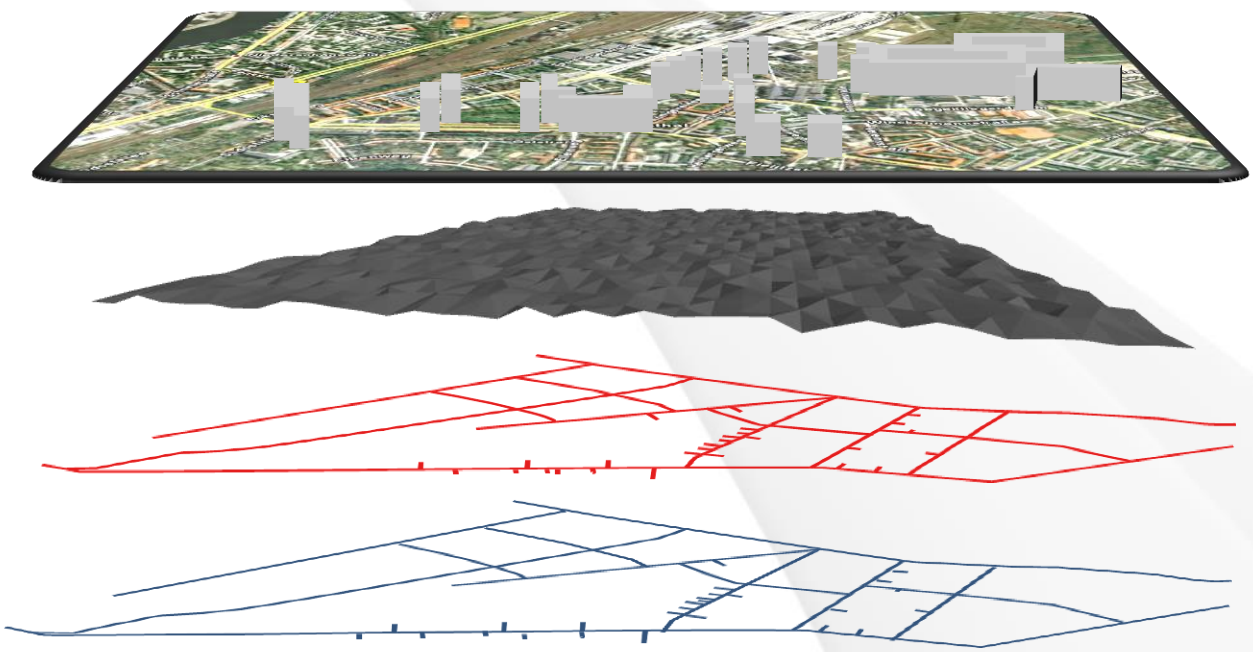
DIGITAL TERRAIN MODEL

+

UTILITY NETWORK TYPE A

+

UTILITY NETWORK TYPE B



SIMKAS 3D

Das 3D-Stadtmodell von Berlin mit integrierten Infrastrukturen

Institut für Geodäsie und Geoinformationstechnik
Technische Universität Berlin

Hinweis: Die Präsentation spiegelt lediglich einen momentanen Bearbeitungsstand wieder, soll aber trotzdem den Kontext bzw. zukünftige Entwicklungen verdeutlichen!

2D/3D Analyses & Simulations

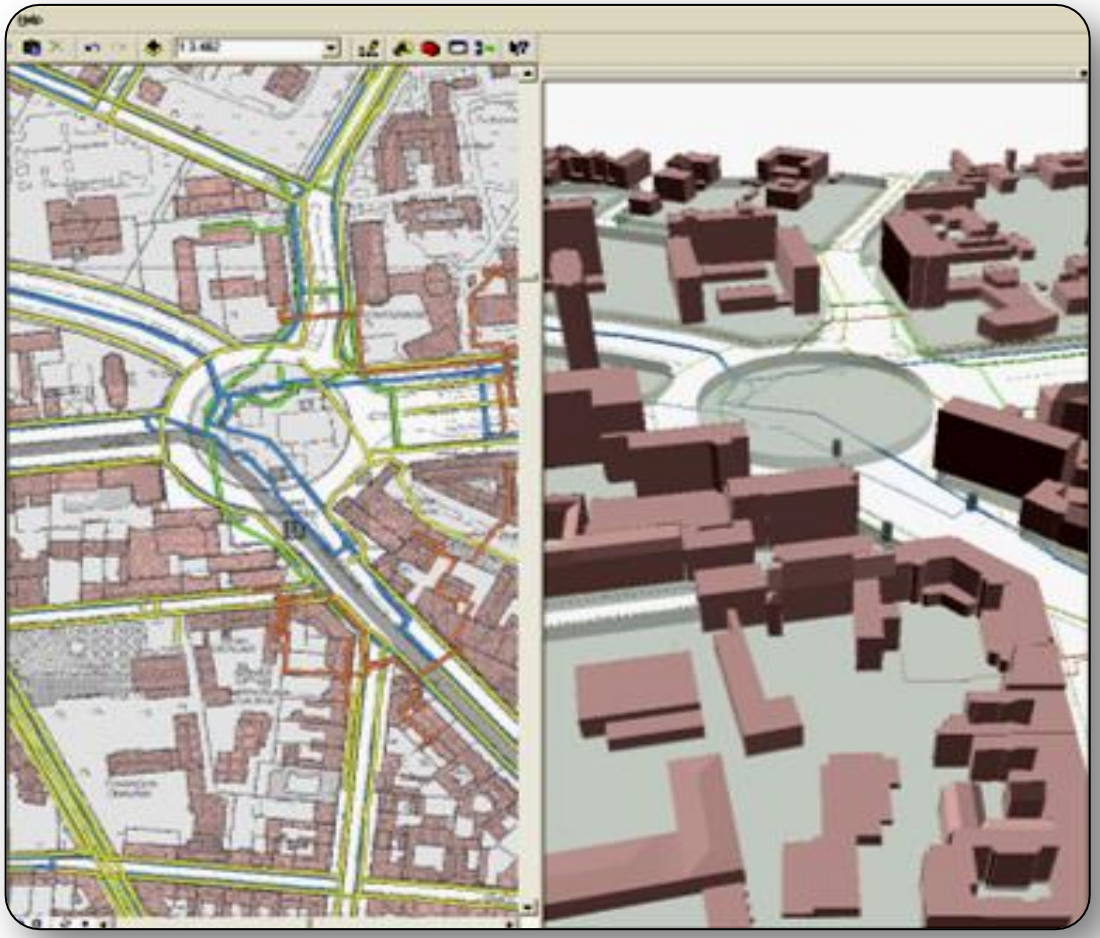
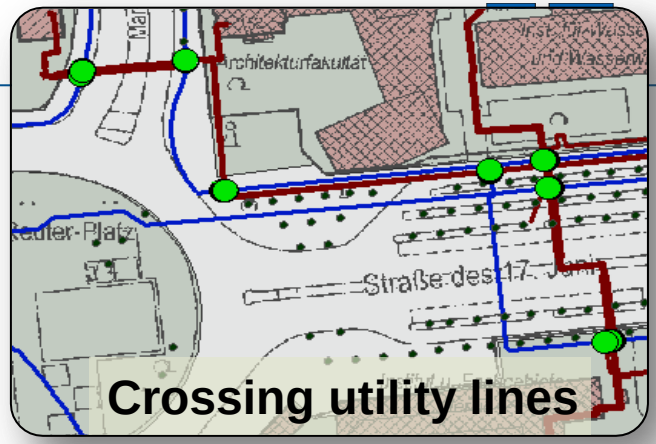
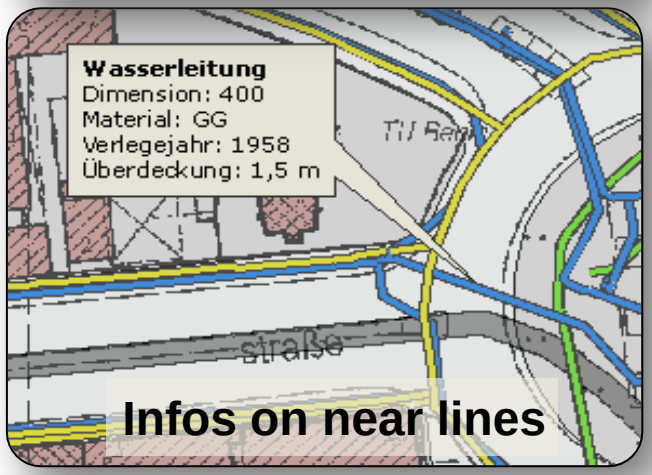


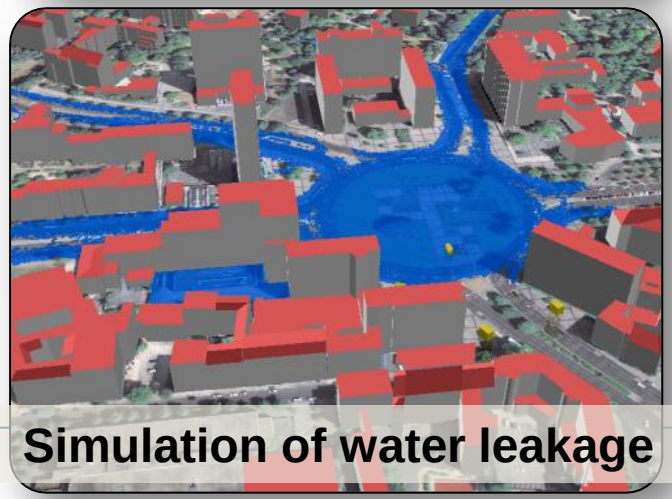
Image: DHI-WASY GmbH, SIMKAS 3D project partner



Crossing utility lines

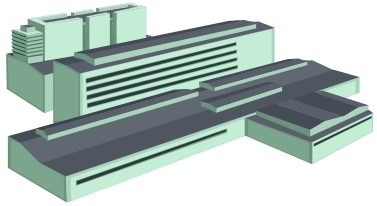
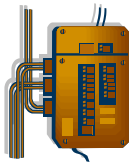
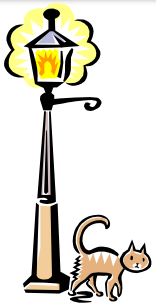
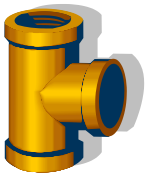


Infos on near lines



Simulation of water leakage

Components of Networks (excerpt)

	power plant, transmission station
	switch box, fuse
	Pumps, Valves …
	Streetlight, switch gear cabinet …
	Pipe, T-pipe, cable …

Each of these entities is **part of** the utility network and **essential** for the supply task.

All of these entities have:

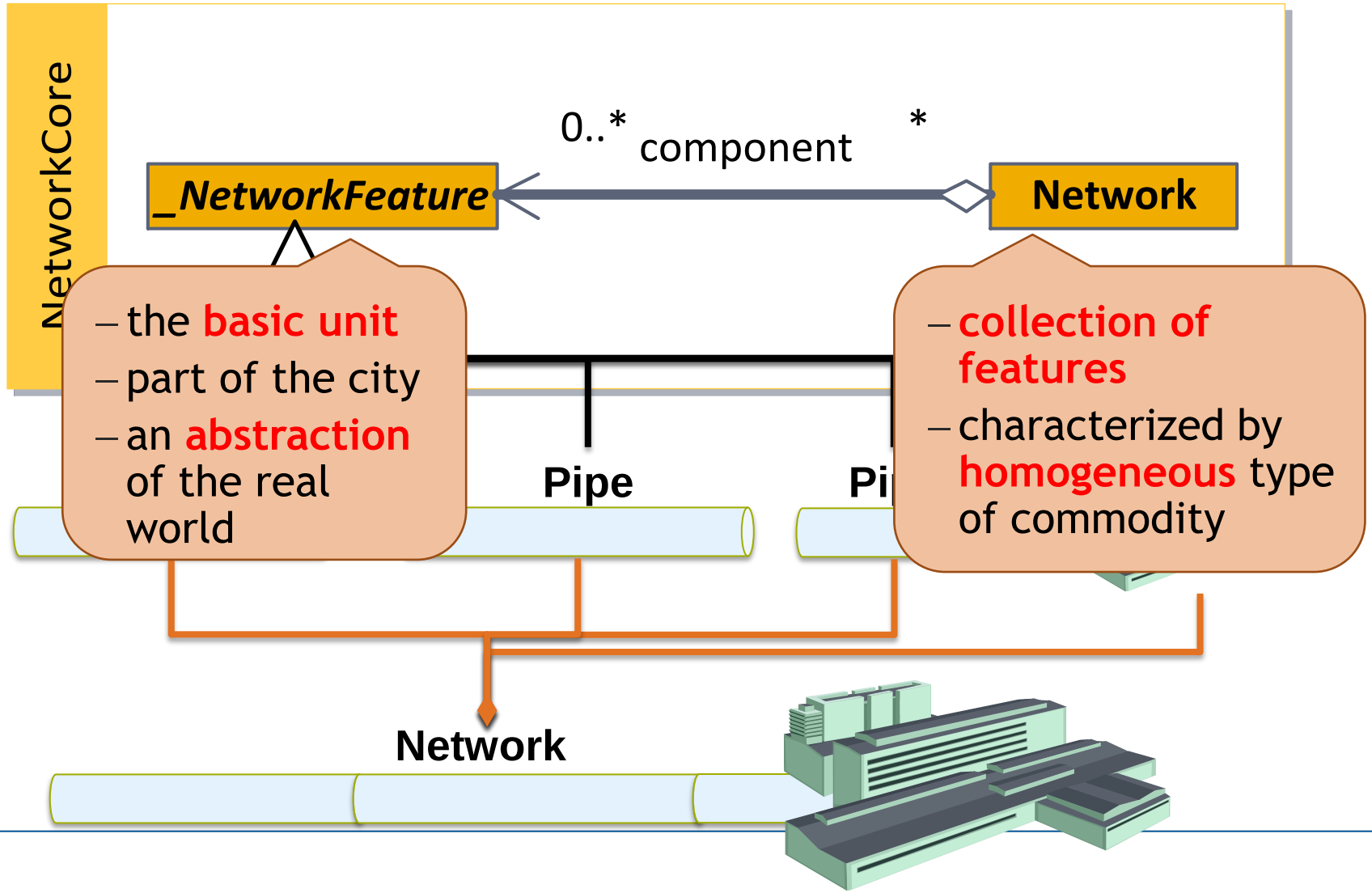
- different 3D representations
- different semantics and functions within the utility network

BUT:

From a topological, functional point of view they are **only a part of** a network!

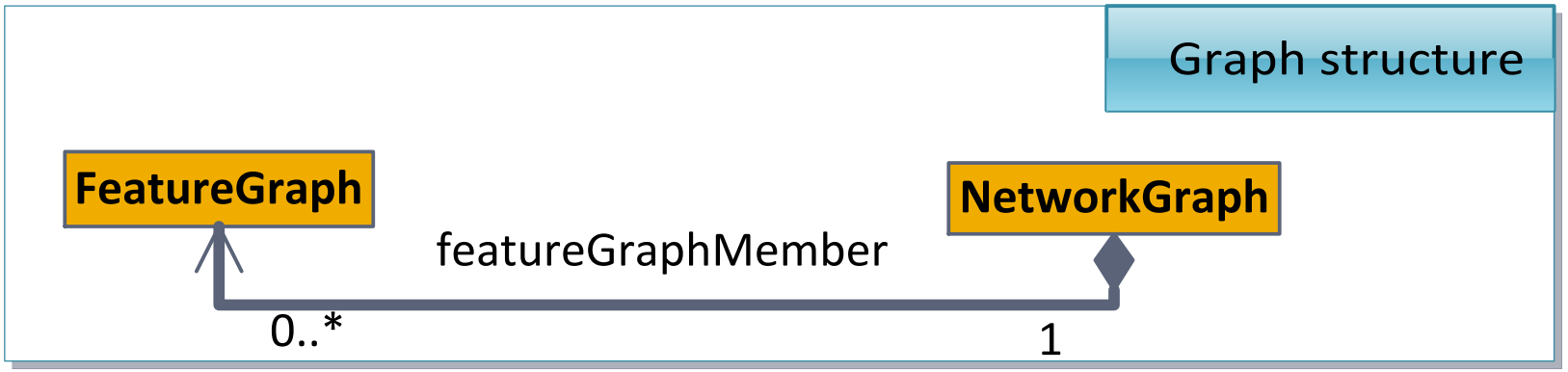
Understanding Utility Networks

All Networks are **aggregations of** atomic **entities** such as pipes, stations, cables etc.**!**



Representation of Network Entities

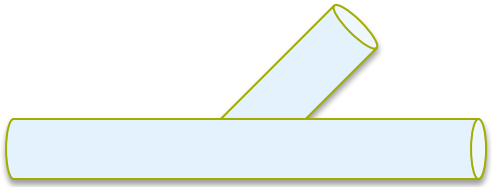
- parallel to its 3D topographic representation a network entity has functional and topological aspects
- Networks are typically represented as graph structures, and entities are separated either in line-like or point-like shapes (cf. INSPIRE, ESRI, etc.)
- **we understand a NetworkFeature as a sub graph of the whole network graph**

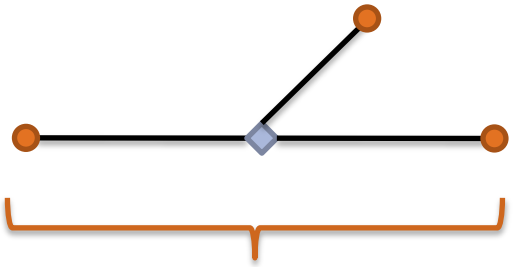


Graph Representations of Network Entities

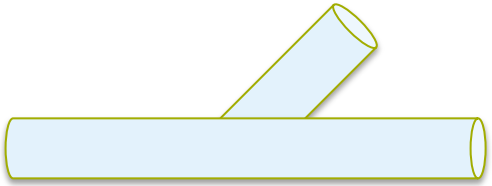
TOPOGRAPHIC MODEL

TOPOLOGICAL / FUNCTIONAL MODEL

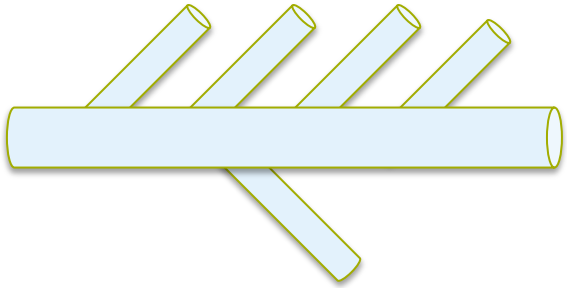


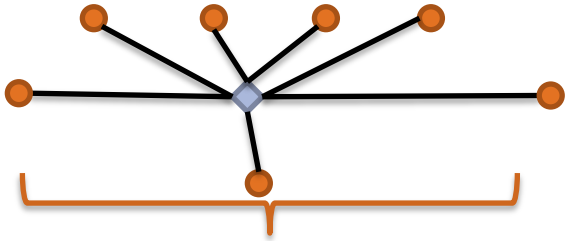


FeatureGraph



FeatureGraph





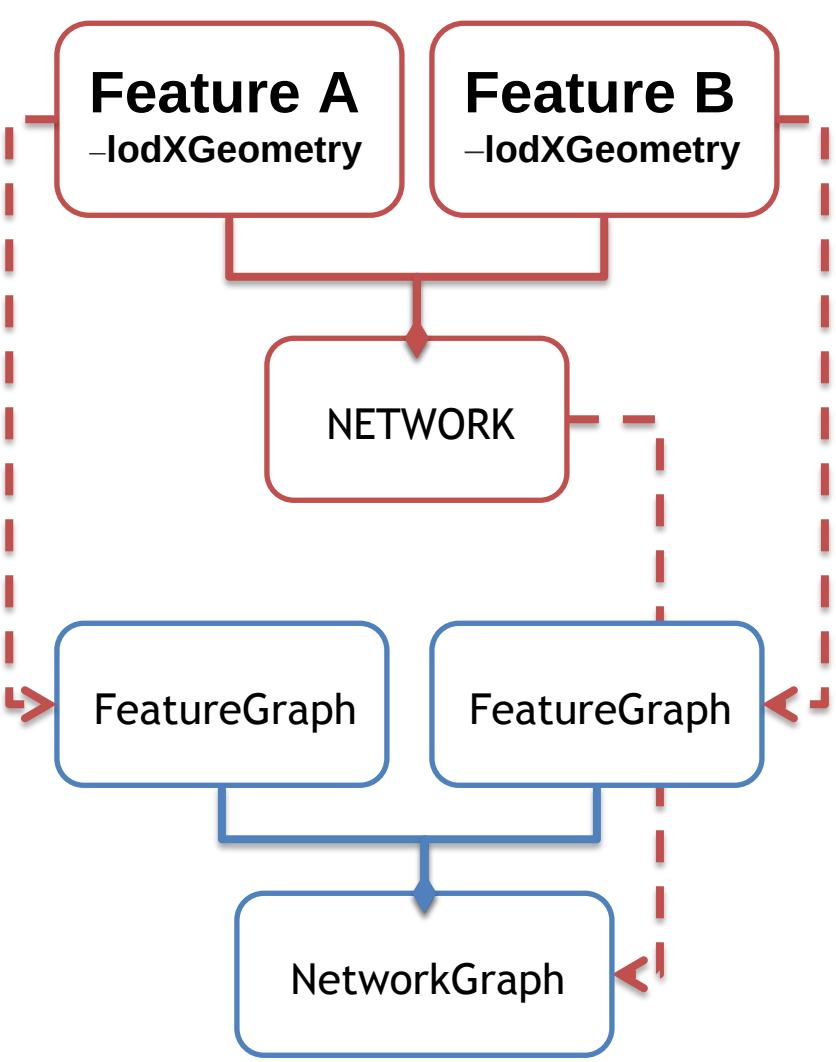
FeatureGraph

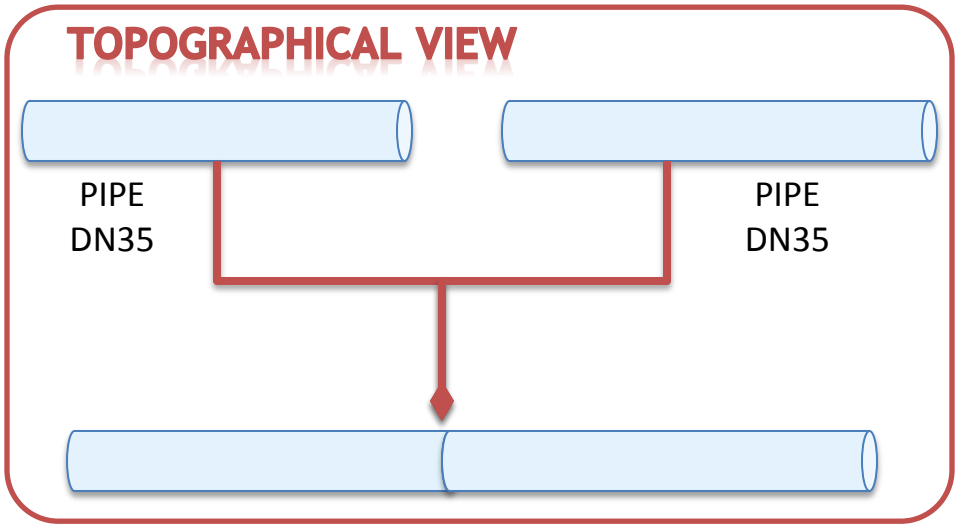
modeling of interior properties of the feature (interior link) using interior nodes allows for modeling pipe taping, valves, material change, etc

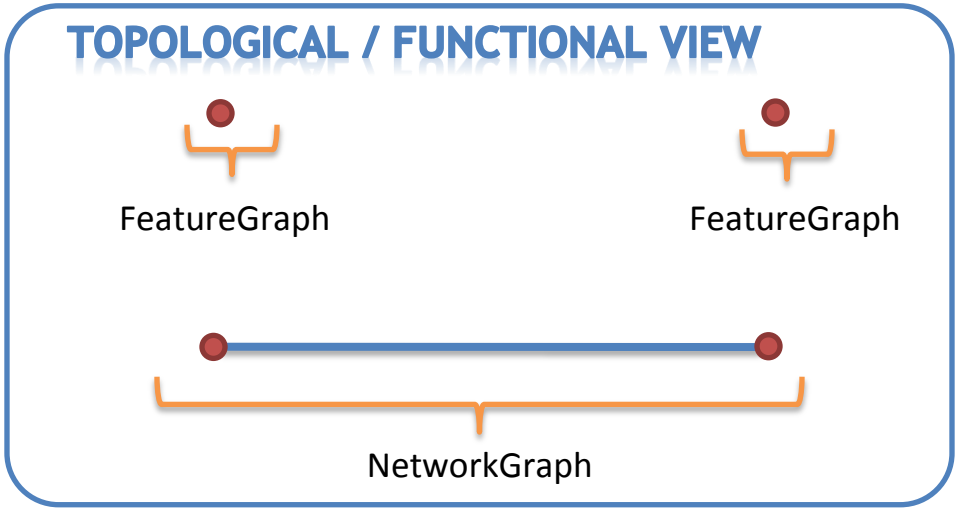
Legend

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

Joint Topographic and Functional Modelling



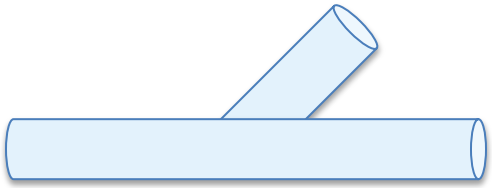


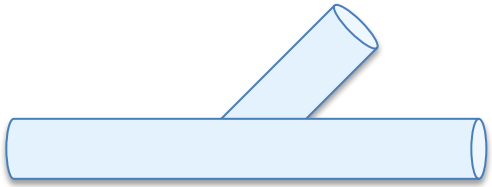


Source: SIMKAS 3D

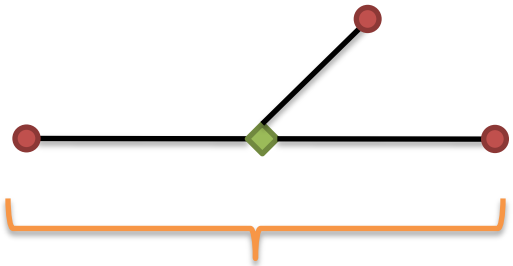
Modeling Alternatives for Network Components

TOPOGRAPHICAL VIEW





TOPOLOGICAL / FUNCTIONAL VIEW



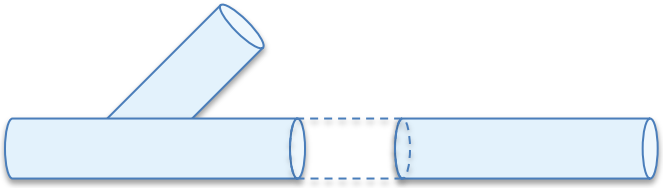
Legend

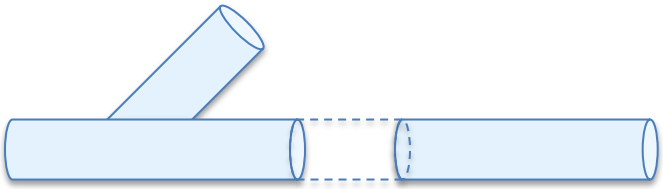
- Node (type: exterior)
- Node (type: interior)
- InteriorFeatureLink
- Network Component

Source: SIMKAS 3D

Connecting Network Components

TOPOGRAPHICAL VIEW

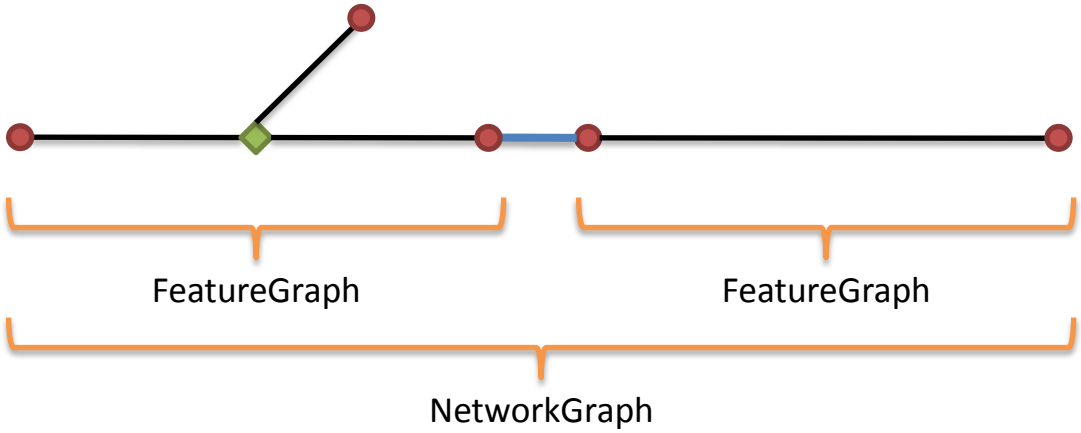


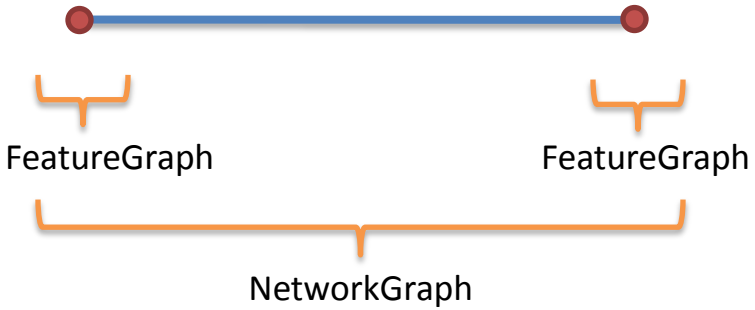


Legende

- Node (type: exterior)
- Node (type: interior)
- InteriorFeatureLink
- InterFeatureLink
- Network Component

TOPOLOGICAL / FUNCTIONAL VIEW

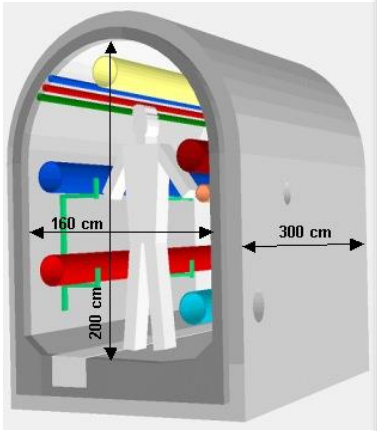




Source: SIMKAS 3D

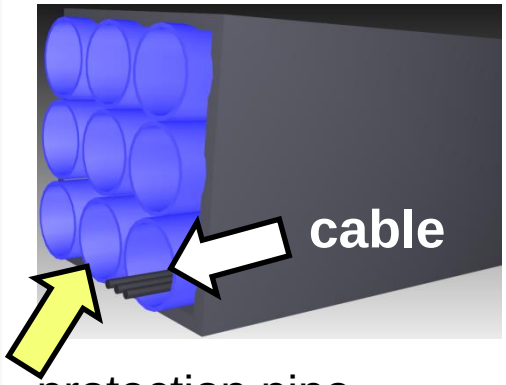
Network Hierarchies

multi-utility pipe



© Schaefer Naturstein

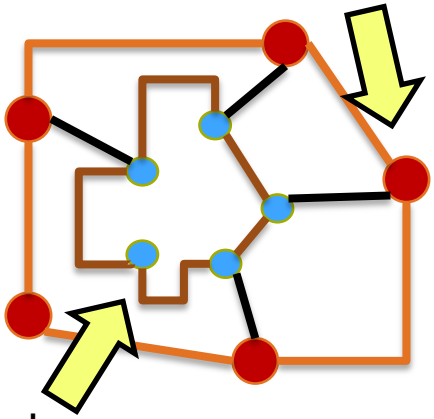
cable protection package



protection pipe

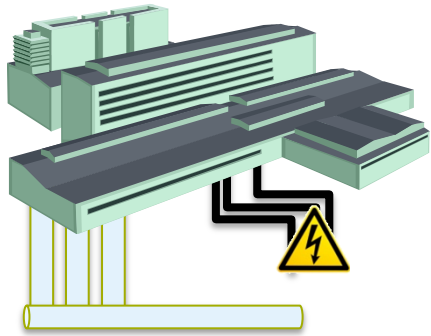
gas network

high pressure



low pressure

treatment plant



fresh water

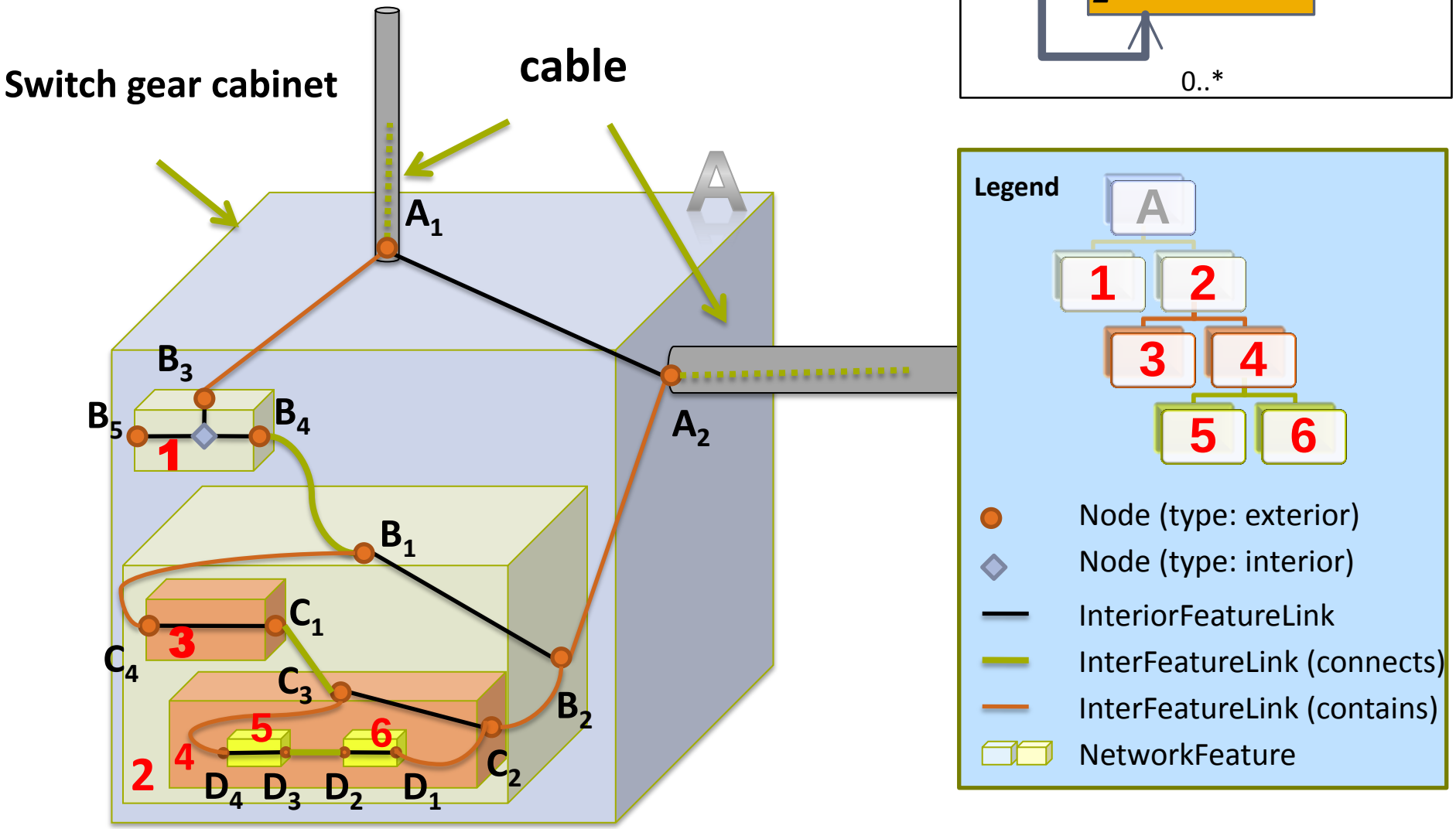
Feature Hierarchy

Network Hierarchy

Multi-Utility Networks

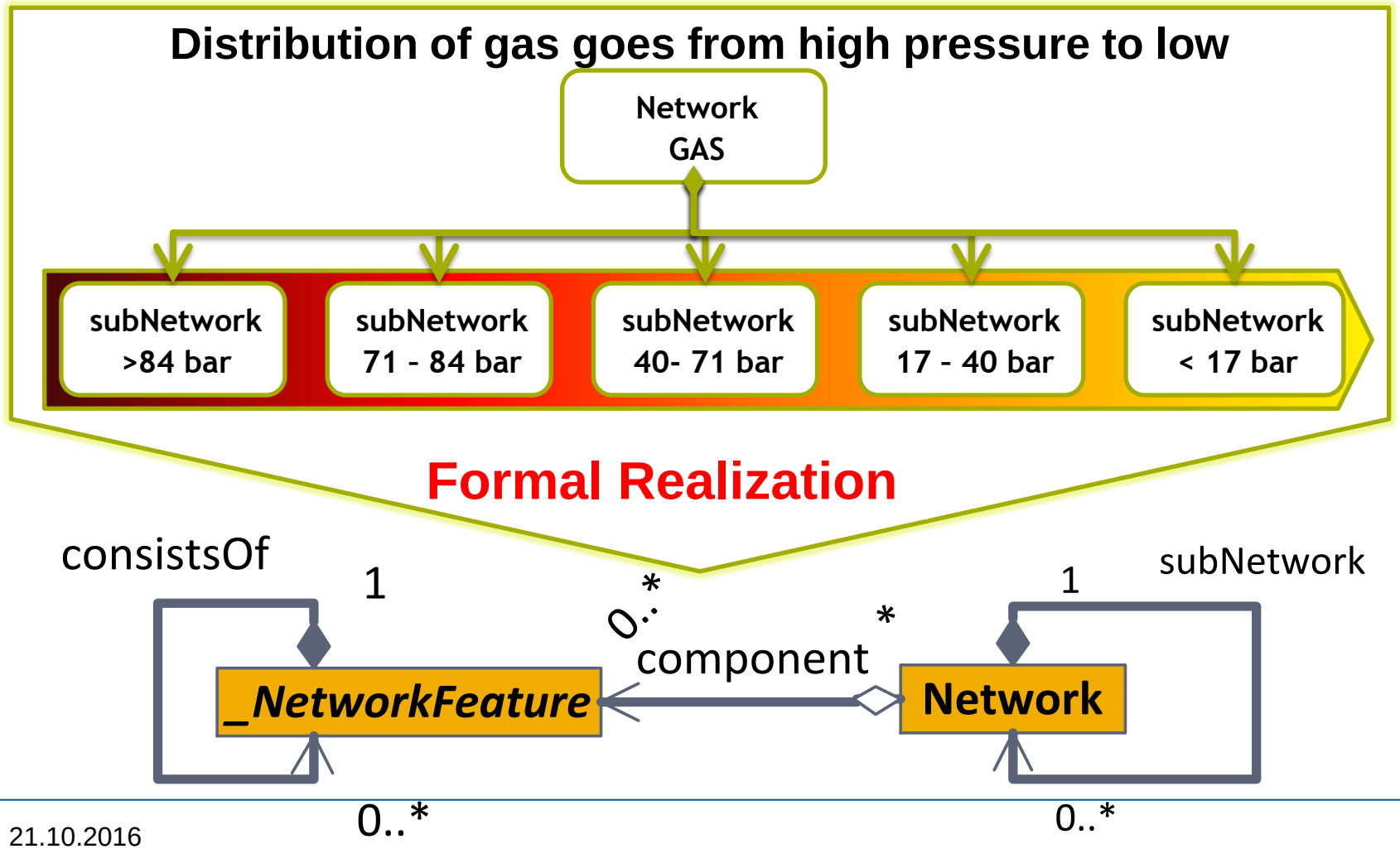
How can this be achieved by modeling NetworkFeatures / FeaturesGraphs / NetworkGraphs?

Hierarchies: Feature Hierarchy

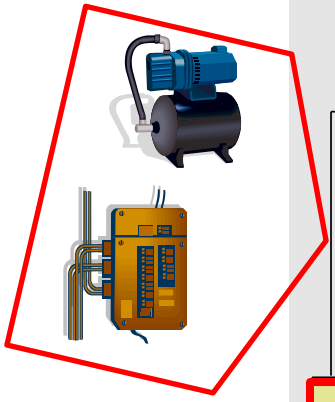


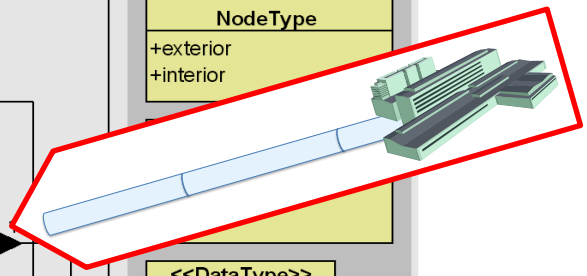
Hierarchies: Internal Network Hierarchies

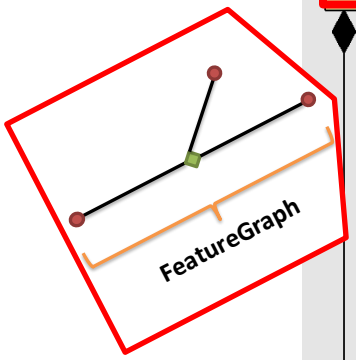
e.g. Gas network is an aggregation of sub networks of same commodity, but different pressure systems and each sub network is an aggregation of Network entities

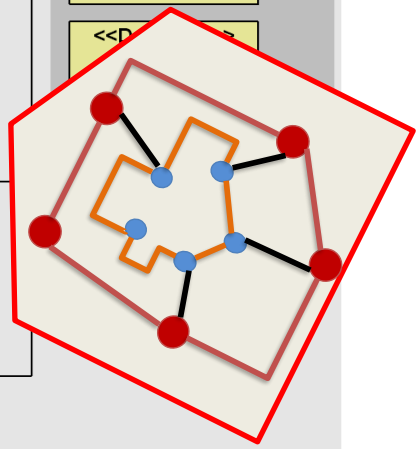


Complete Network Core Model in UML









UtilityNetworkADE

NetworkCore

Topography

«FeatureType»
Core::AbstractCityObject

«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..*]

+subNetwork 0..*
+superOrdinateNetwork 0..*
+subOrdinateNetwork 0..*
+consistsOf 0..*

Graph Representation

+topoGraph 0..1
+topoGraph 0..1

«FeatureType»
FeatureGraph

+featureGraphMember 0..*

«FeatureType»
NetworkGraph

2

+nodeMember 1..*

«FeatureType»
Node

+ type :NodeValue
+ connectionSignature :AbstractSignature [0..1]
+ linkControl :AbstractLinkControl [0..1]

GM_Primitive
«type»
Geometric primitive::
GM_Point

+realization 0..1

+start 1 0..*
+end 1 0..*

GM_OrientableCurve
«type»
Geometric primitive::
GM_Curve

+realization 0..1

«FeatureType»
AbstractLink

+ direction :Sign [0..1]
+ linkControl :AbstractLinkControl [0..1]

0..* +linkMember

0..* +linkMember

«FeatureType»
InteriorFeatureLink

«FeatureType»
InterFeatureLink

+ type :InterFeatureLinkValue

«FeatureType»
NetworkLink

0..* +linkMember

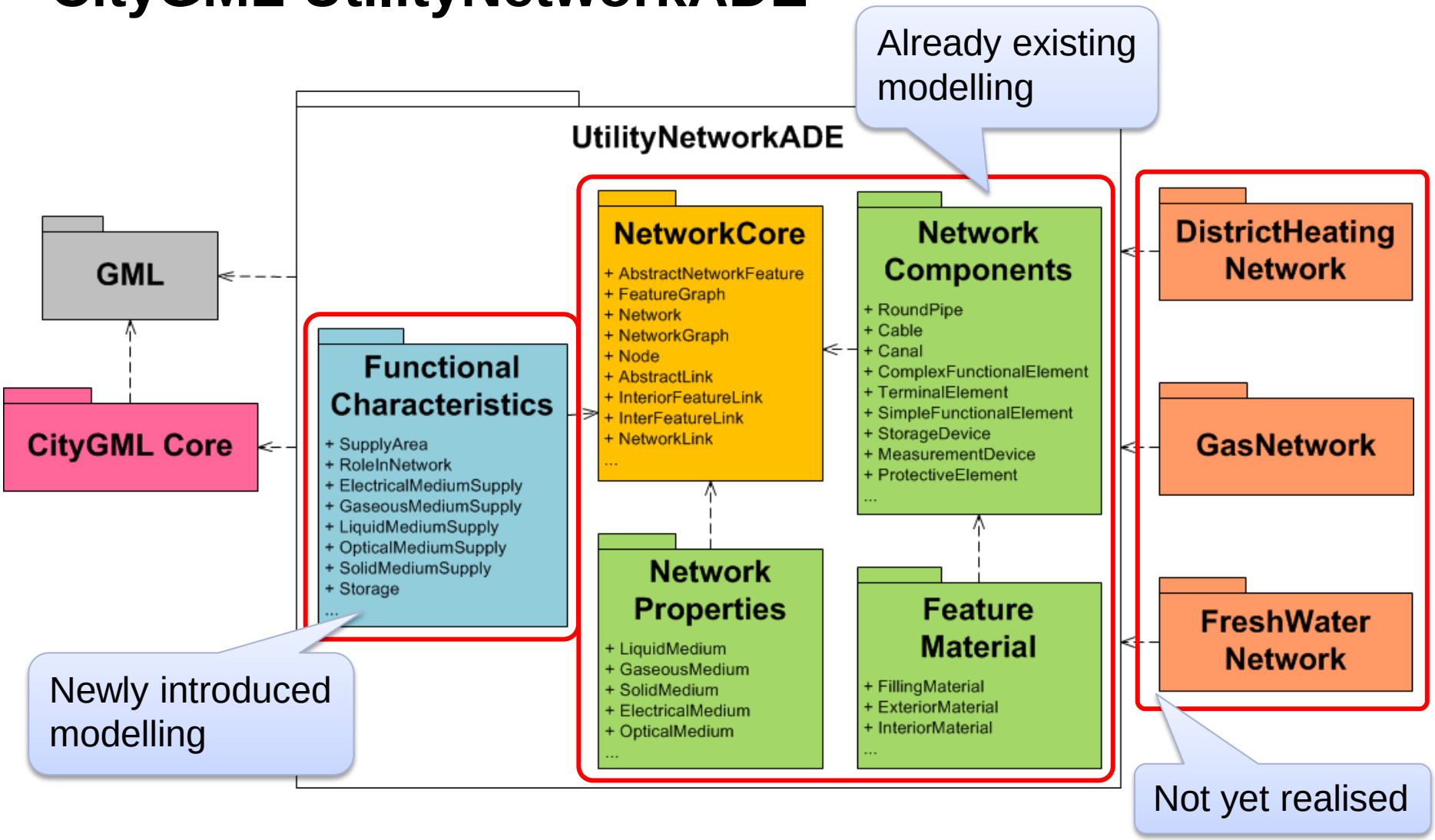
«enumeration»
NodeValue
exterior
interior

«enumeration»
InterFeatureLinkValue
connects
contains

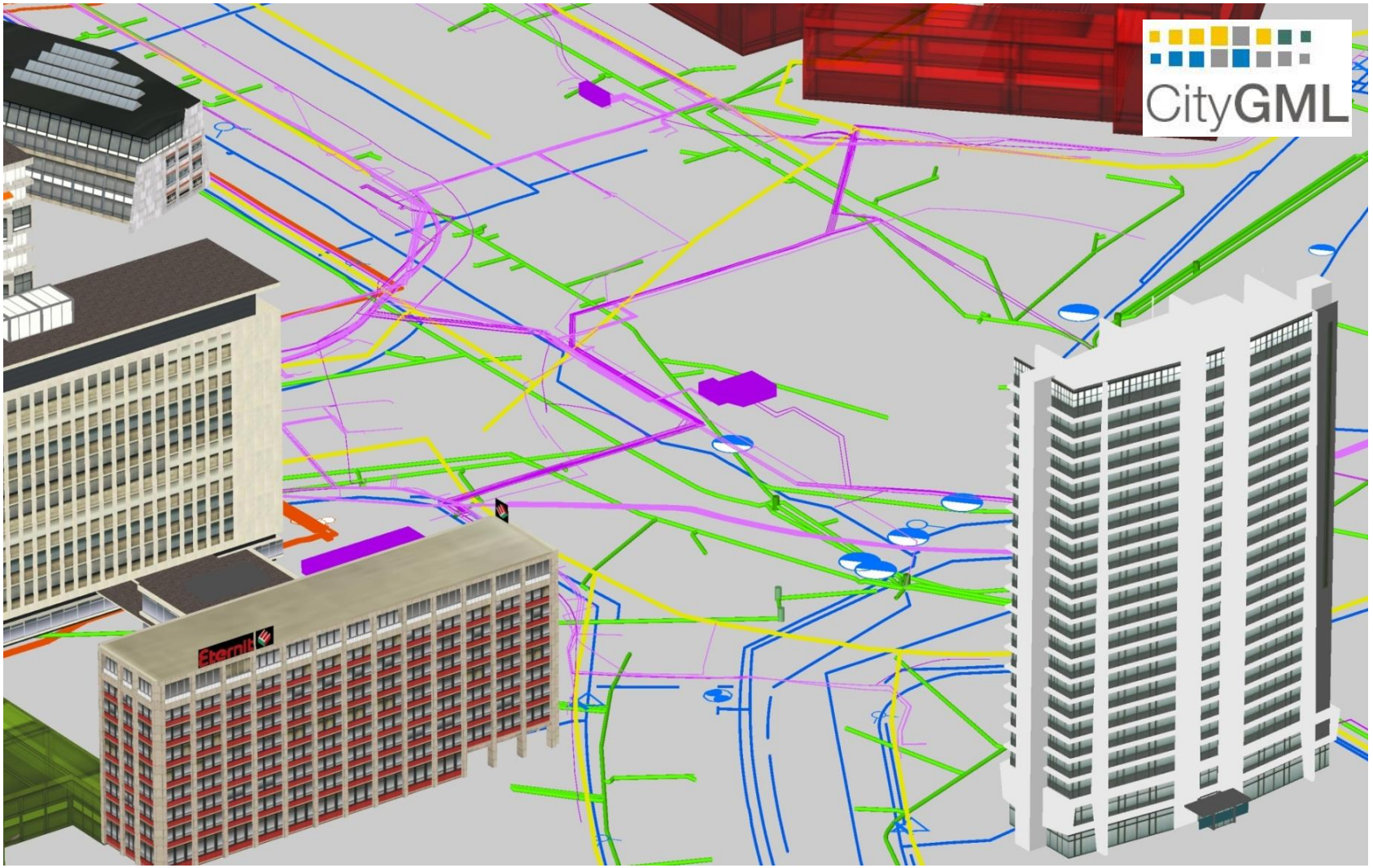
«DataType»
AbstractSignature

«DataType»
AbstractLinkControl

CityGML UtilityNetworkADE



City Model + Multiple Utility Infrastructures



Intermediate Summary

- **Core model for the representation of utility networks**
  - **3D topographic modelling**
  - **functional modelling** (includes **3D topological** modelling)
  - Support of **hierarchies**: complex objects, network hierarchies
  - Provides homogenized and integrated view on multi-utility networks
- **The core model is independent of the specific type of utility / commodity**
- **Next steps**
  - generic modeling of Network Features according to their function, e.g. distribution elements, devices, etc.
  - generic modeling of Network Types (to comprise the multiple different commidity types)