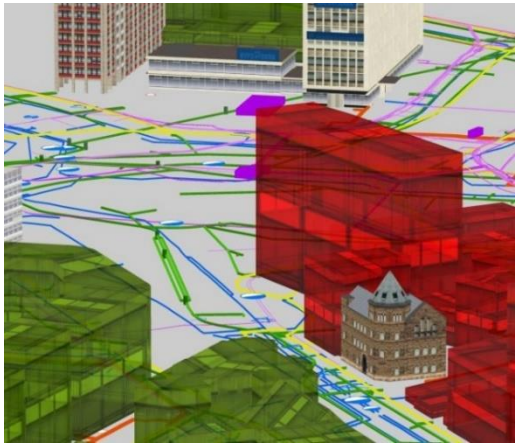
Scope and design principles of the CityGML Utility Network ADE



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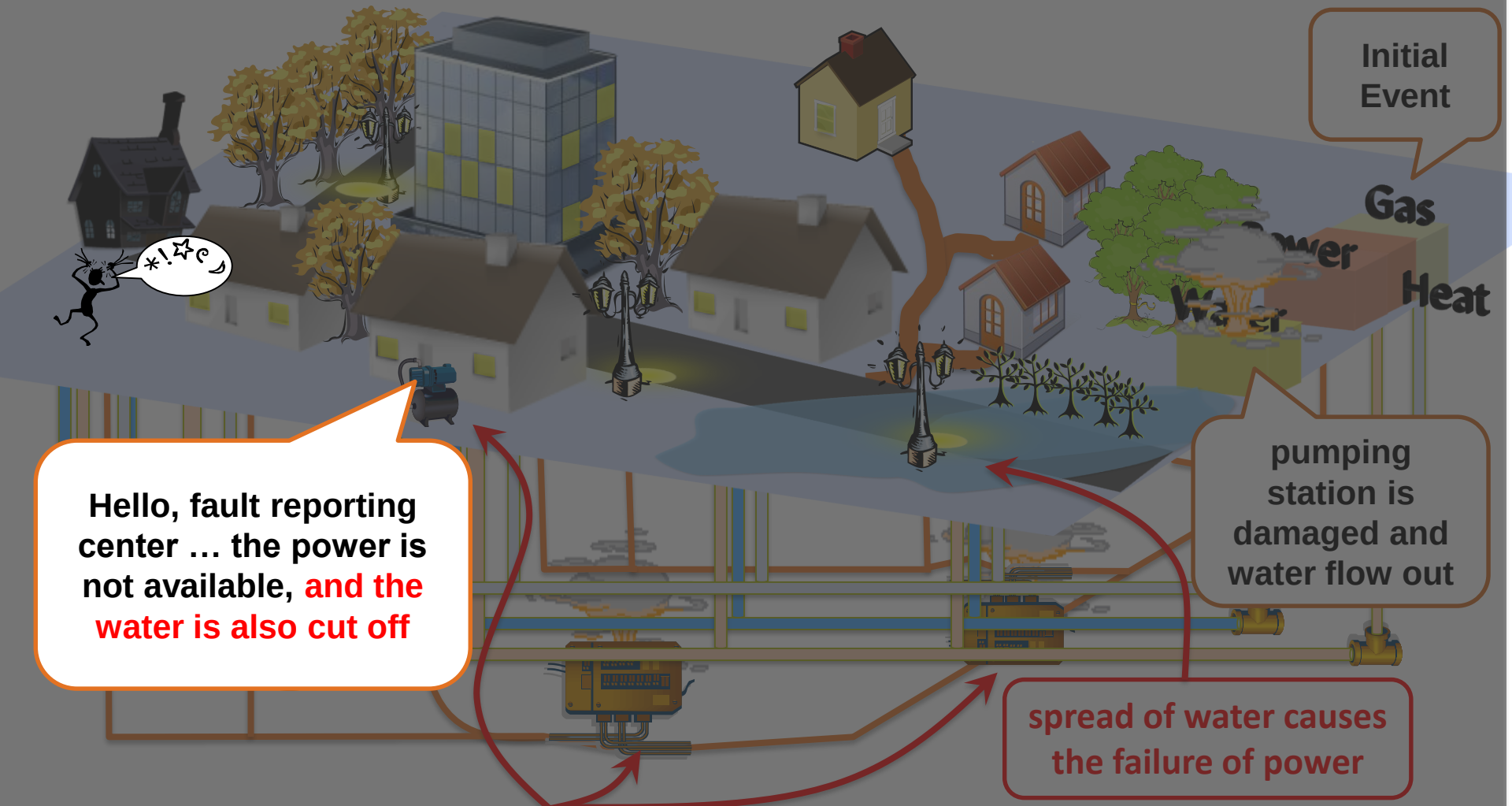
Joint Energy ADE and Utility Network ADE workshop
Karlsruhe, December 6-8, 2017

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

Modeling Critical Infrastructures

Integrated 3D modeling of multi-utility networks and their **interdependencies** for critical infrastructure analysis

Integrated Modeling:

- Geometric, topological & functional modeling of network entities
- Dual representation: topographic 3D model **and** functional model
- Simultaneous representation of heterogeneous utility networks
- Hierarchical modeling on the feature **and** network level

Interdependencies:

- Explicit relations between network entities and other city model objects
- Explicit relations between network entities of different kinds of commodity

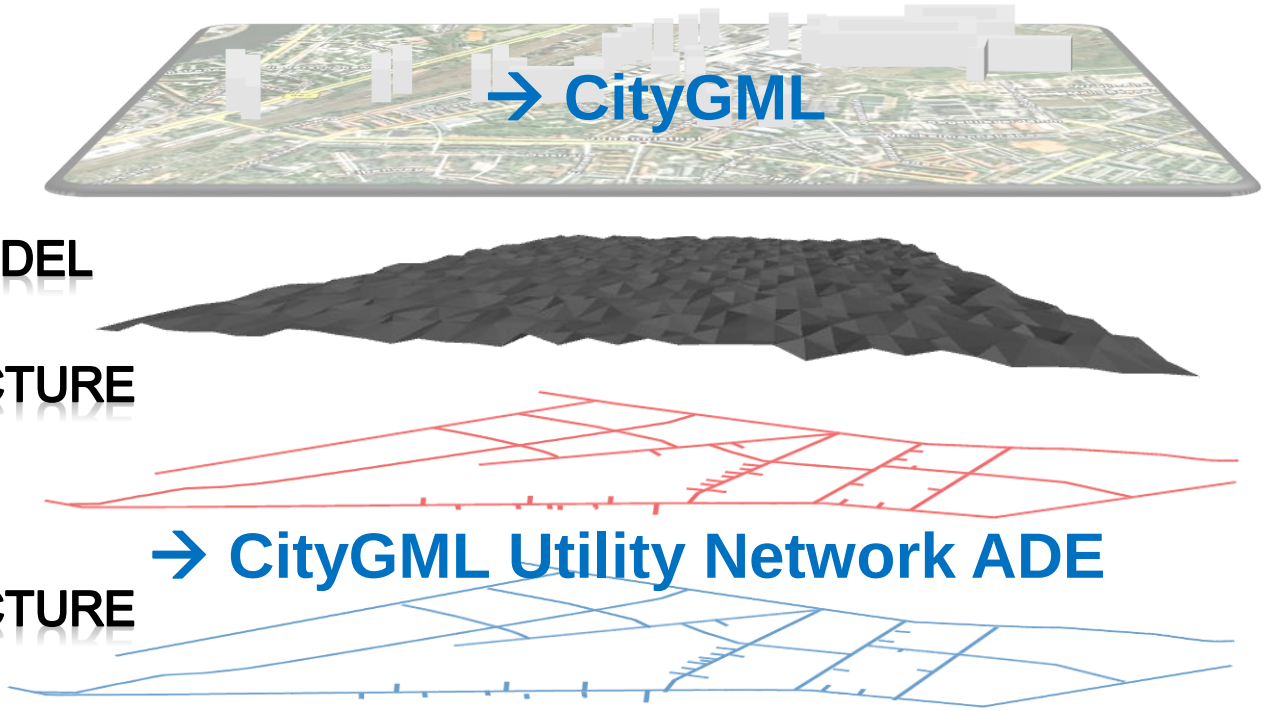
Analyses:

- **Joint visualisation** of 3D city model and 3D utility networks
- **Impact analysis:** propagation of breakdowns across multi-utilities, determination of cascading effects, estimation of the no. of affected citizens

Integration of Utility Networks into the 3D City Model

- **Goal:** Development of a homogenized 3D network model for multi-utility failure simulation including the relevant thematic attributation (usage type, commodity, materials, operating parameters, no. of affected citizens etc.)

SEMANTIC
3D CITY MODEL
+
HIGH RESOLUTION
DIGITAL TERRAIN MODEL
+
UTILITY INFRASTRUCTURE
OF TYPE A
(E.G. ELECTRICITY)
+
UTILITY INFRASTRUCTURE
OF TYPE B
(E.G. WATER)



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

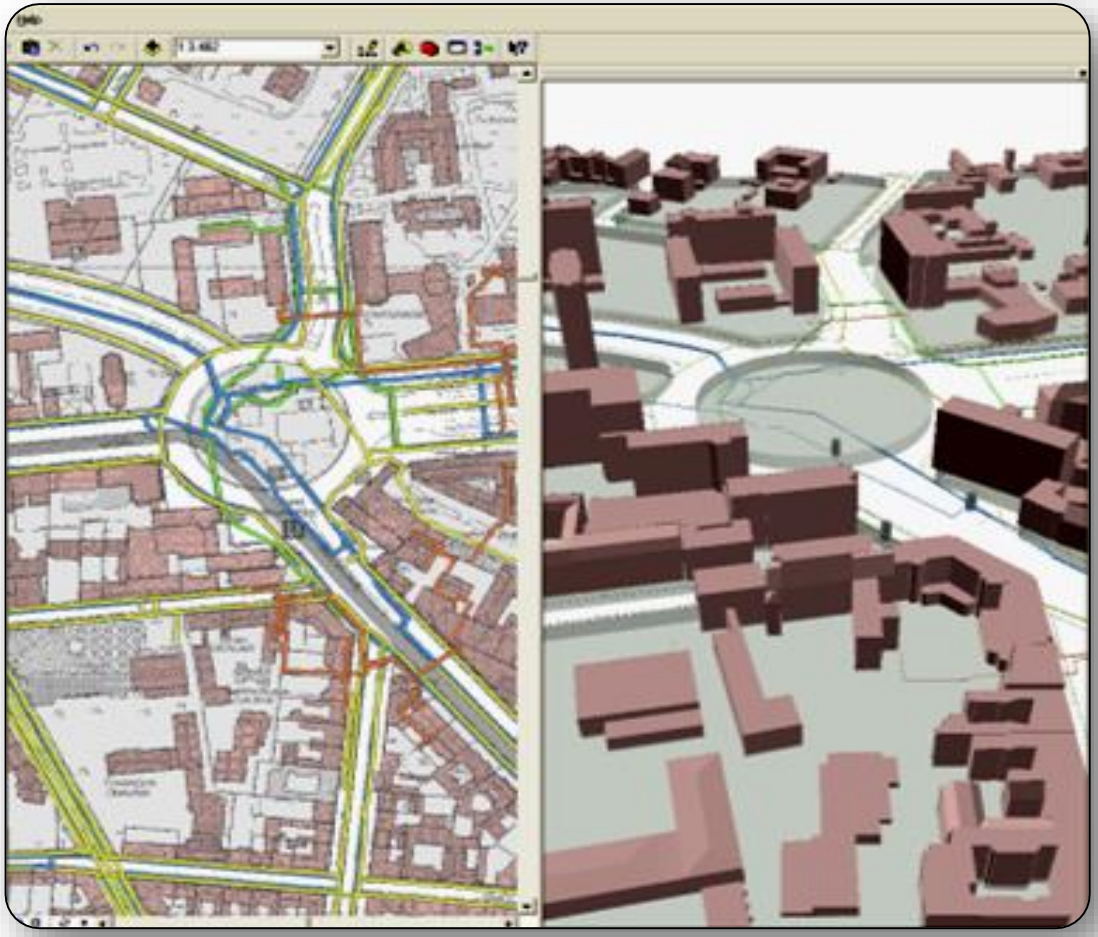
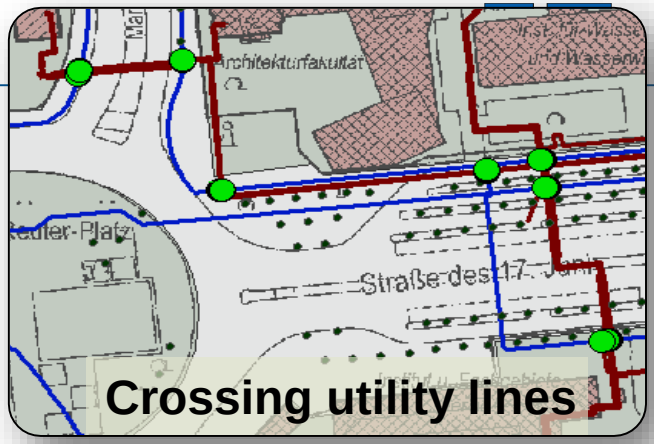
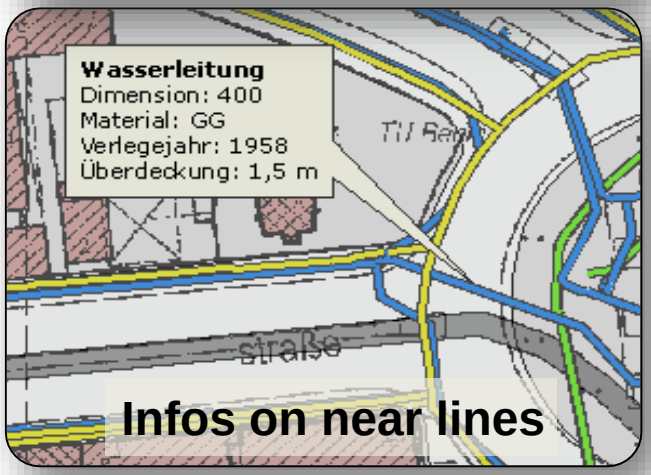


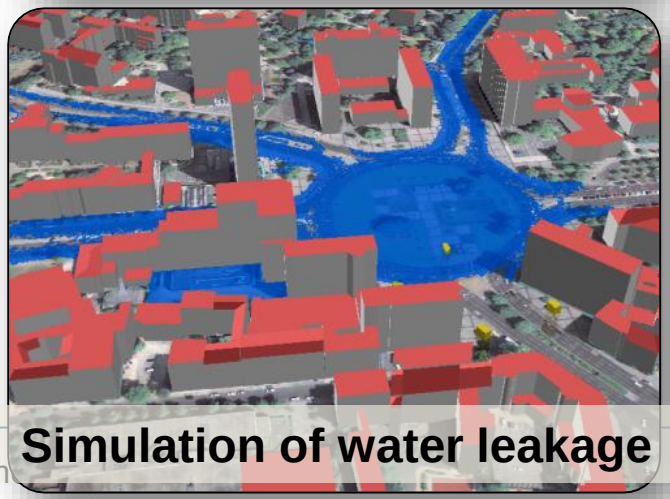
Image: DHI-WASY GmbH, SIMKAS 3D project partner



Crossing utility lines



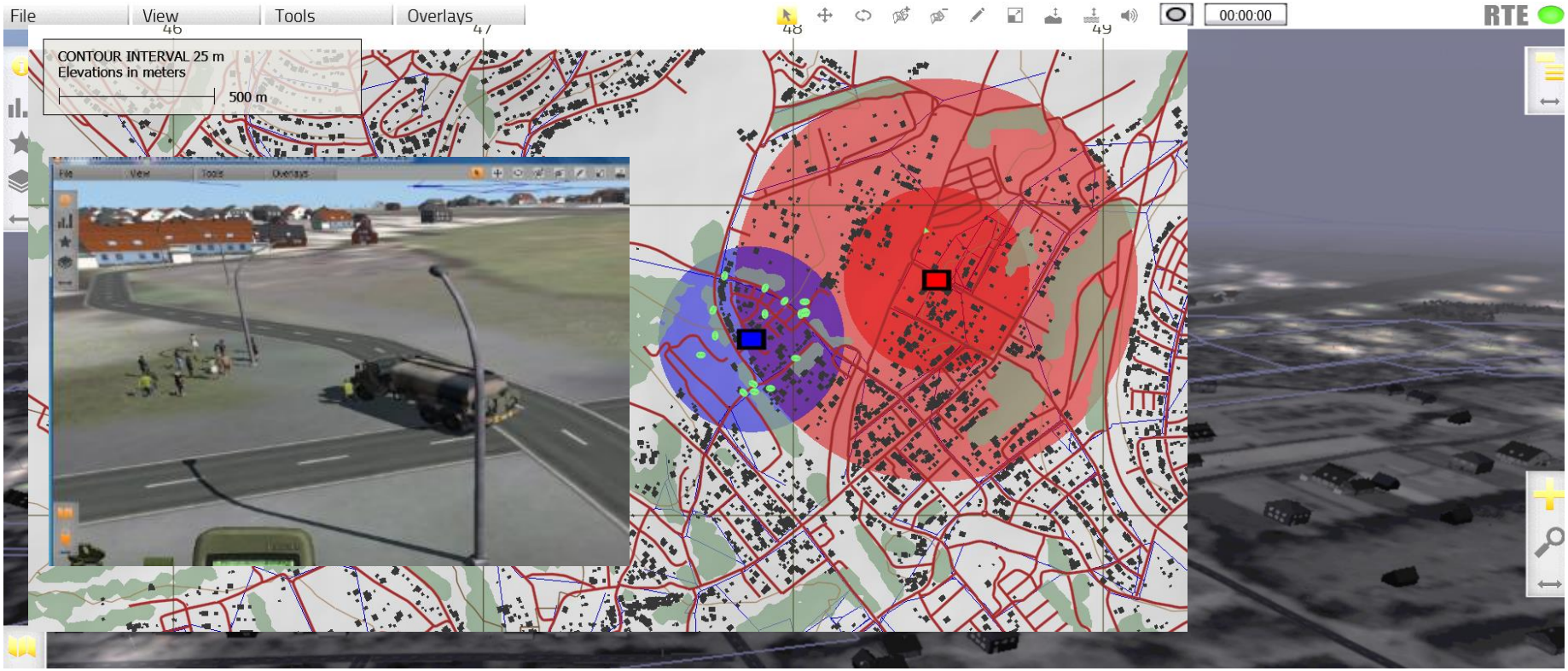
Infos on near lines



Simulation of water leakage

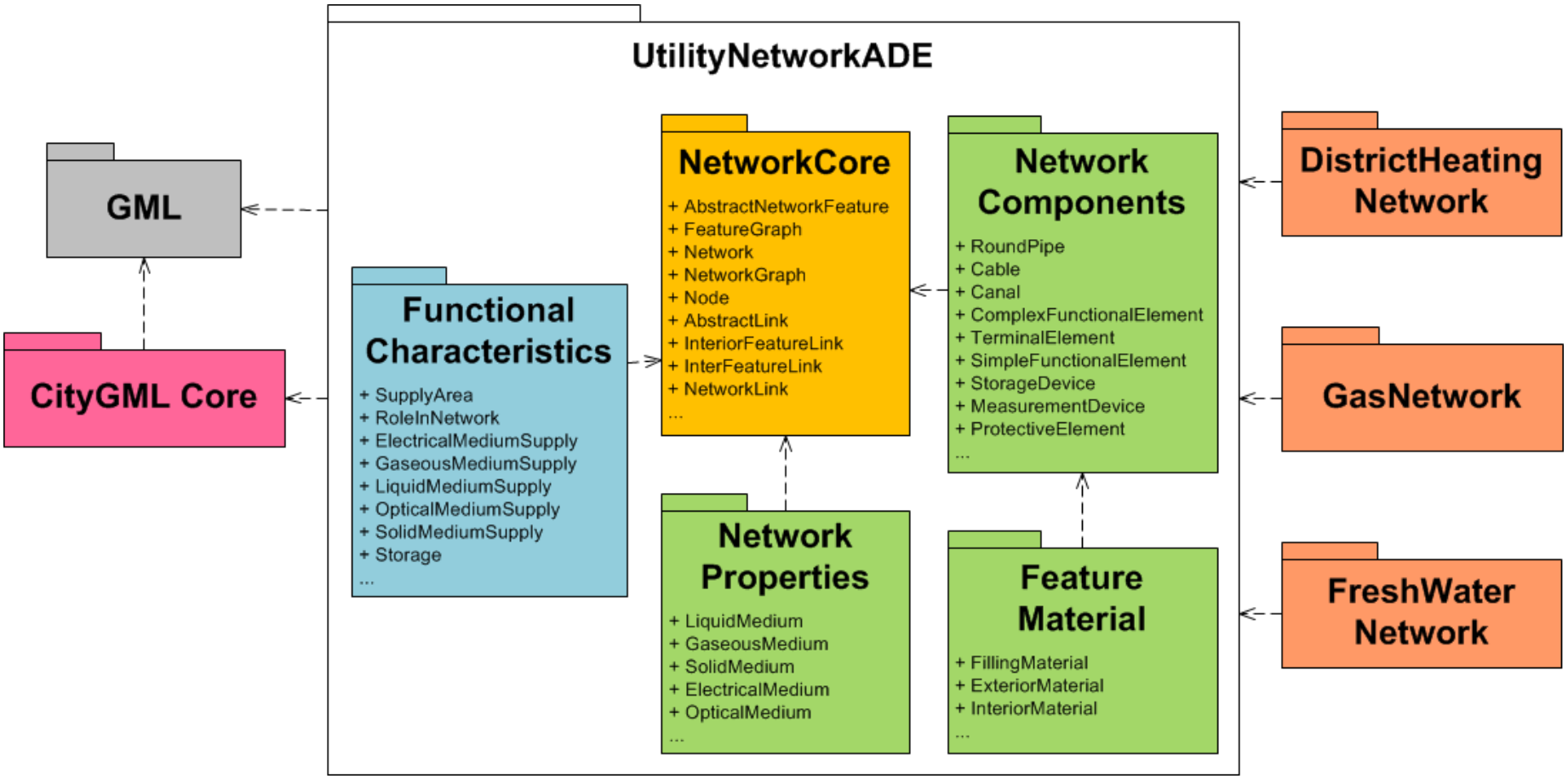
Simulation of cascading effects

- Explosion in distribution station → Power failure in a district of the city
- Cascading effects caused by power failure → Failure of water works and of water supply → Water tanks provide water to population



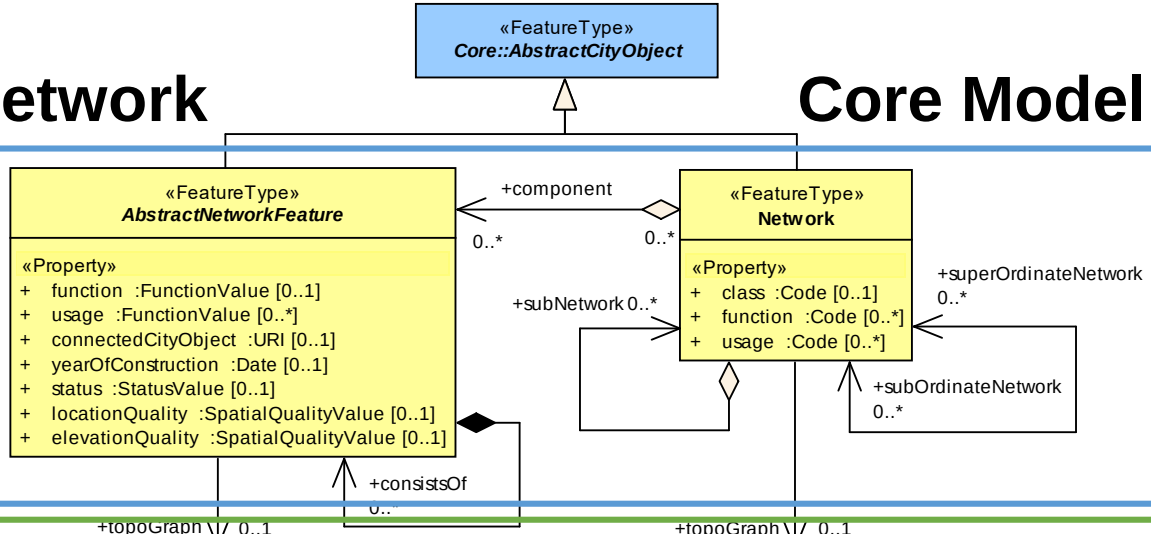
CityGML Utility Network ADE

- The **CityGML Utility Network ADE** extends CityGML by the possibility to **represent supply and disposal networks in 3D city models**

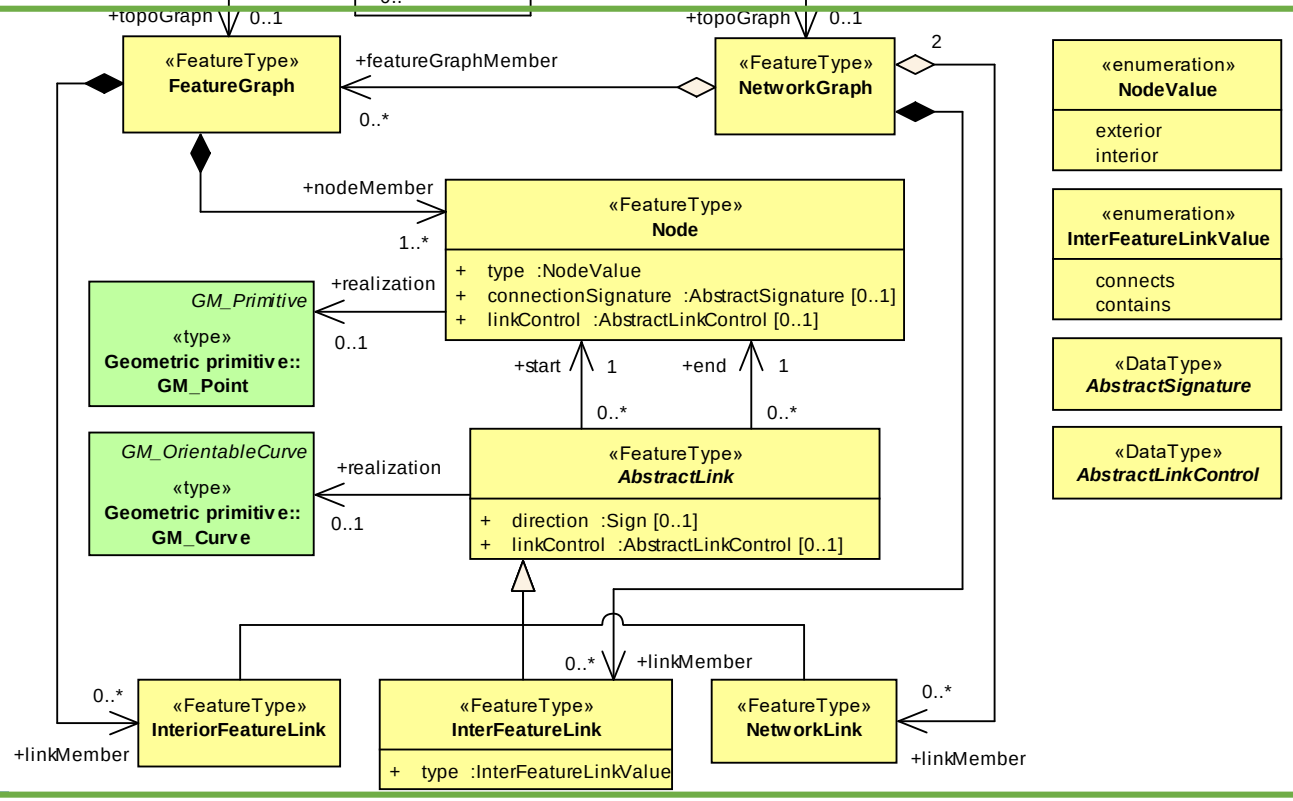


Complete Network Core Model in UML

Topography



Graph Representation



Existence of characteristics relevant to network modelling in various data models

	INSPIRE Utility Networks	IFC	ArcGIS Utility Networks	SEDRIS	Pipeline ML	CityGML Utility Network ADE
Representation of heterogeneous networks	+	•	•	+	•	++
Dual representation	+	++	+	++	–	++
Topographic/graphic aspects	++	++	++	++	++	++
3D geometries	–	++	–	+	–	+
Functional aspects	–	–	–	–	–	•
Hierarchical modelling						
• networks/ subnetworks	++	–	–	++	–	++
• components/ subcomponents	++	++	•	–	•	++
Interdependencies between						
• network features and city objects	–	•	–	•	–	++
• network features of different network types	–	++	–	–	–	++

– = no support, • = basic support, + = sophisticated support, ++ = comprehensive support

Source: Kutzer, T. & Kolbe, T. H., 2016: Extending Semantic 3D City Models by Supply and Disposal Networks for Analysing the Urban Supply Situation, http://www.dgpf.de/src/tagung/jt2016/proceedings/papers/36_DLT2016_Kutzner_Kolbe.pdf

Existence of characteristics relevant to network modelling in various data models

	INSPIRE Utility Networks	IFC	ArcGIS Utility Networks	SEDRIS	Pipeline ML	CityGML Utility Network ADE
Representation of heterogeneous networks	+	•	•	+	•	++
different network types						
– = no support, • = basic support, + = sophisticated support, ++ = comprehensive support						

- The CityGML Utility Network ADE meets best the requirements for modeling utility networks regarding the characteristics in question.
- The ADE was created based on an extended review of data models and software systems in use for utility networks.
- The **aim of the CityGML Utility Network ADE**, however, is not to replace the other models or systems, but to **provide a common basis for the integration of the diverse models in order to facilitate joint analyses and visualization tasks**, e.g. by mapping data which is based on the IFC or ArcGIS model to the ADE.

Source: Kutzer, T. & Kolbe, T. H., 2016: Extending Semantic 3D City Models by Supply and Disposal Networks for Analysing the Urban Supply Situation, http://www.dgpf.de/src/tagung/jt2016/proceedings/papers/36_DLT2016_Kutzner_Kolbe.pdf

Past development of the Utility Network ADE

Disaster Management with SIMKAS 3D

- Simulation of intersectorial cascading effects caused by a failure of supply infrastructures using the 3D city model of Berlin (2009-2012)
- Focus on
  - simulating interdependent crisis situations
  - linking of situation information with the urban space
  - implementation of a common situation map which also allows for individual views and analyses by each provider
- An ArcGIS geodatabase was implemented based on the Utility Network ADE

Risk Analysis Supply Infrastructure

- Cooperation project with the company ESG (Germany) on behalf of the German Armed Forces (2015-2016)
- Study on the possibilities of utilizing supply infrastructures in training simulators
  - for crisis scenarios (e.g. evacuation)
  - for simulating the impact of a failure on the population
  - for simulating the impact on tactical operations

Further development of the Utility Network ADE

- Since 2016 the **Utility Network ADE working group** is further developing the ADE to make it usable for other use cases as well
- Priorisation of interests from the workshop 2./3. 3. 2017:

Commodity	# votes
District heating	8
Electricity	8
Gas	8
Waste water	7
Storm water	5
Fresh water	4
Communication	4
Process steam	2
Oil	1
Waste	1
Air pressure	1

Use case area	# votes
Simulation	10
Visualisation	7
Planning	6
City System Simulation and Smart Cities	6
Vulnerability Assessment and Disaster Management	6
Network operation and monitoring	5
Operational impacts / cascading effects	5
Multi system planning	4
Documentation	4
Navigation	2
Urban Facility Management / Inspection	1

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
- **The core model is independent of a specific type of utility / commodity**
- **Utility-specific, concrete feature classes**
  - including characteristics, materials and functional aspects of the features
- The ADE allows for
  - **linking utility networks with 3D city models**
  - **modeling multi-utility scenarios**

  → **this is not supported by other existing utility modeling standards**
- **CityGML** itself already defines **object types for subsurface structures** (**buildings**, e.g. subway stations and underground parking, and **tunnels**)