Scope and design principles of the CityGML Utility Network ADE

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Joint Energy ADE and Utility Network ADE workshop
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Initial Event

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

Hello, fault reporting center … the power is not available, and the water is also cut off
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 attribution (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)

→ CityGML

→ CityGML Utility Network ADE
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

Crossing utility lines

Infos on near lines

Wasserleitung
Dimension: 400
Material: GG
Verlegejahr: 1958
Überdeckung: 1,5 m

Simulation of water leakage

Image: DHI-WASY GmbH, SIMKAS 3D project partner
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
The CityGML Utility Network ADE extends CityGML by the possibility to represent supply and disposal networks in 3D city models.
Scope and design principles of the CityGML Utility Network ADE

- 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]

- FeatureType: Network
  - Property:
    - function : Code [0..1]
    - usage : Code [0..*]

- FeatureType: NetworkGraph
  - Property:
    - class : Code [0..1]
    - function : Code [0..*]
    - usage : Code [0..*]

- FeatureType: Node
  - Property:
    - type : NodeValue
    - connectionSignature : AbstractSignature [0..1]
    - linkControl : AbstractLinkControl [0..1]

- FeatureType: AbstractLink
  - Property:
    - direction : Sign [0..1]
    - linkControl : AbstractLinkControl [0..1]

- FeatureType: NetworkLink
  - Property:
    - type : InterFeatureLinkValue

- FeatureType: InteriorFeatureLink
  - Property:
    - type : InterFeatureLinkValue

- FeatureType: InterFeatureLink
  - Property:
    - type : InterFeatureLinkValue

- FeatureType: Core::GM_Primitive
  - Type: GM_Point
  - Type: GM_OrientableCurve
    - Type: GM_Curve

- Enumeration: NetworkClassValue
  - HighVoltageNetwork
  - MediumVoltageNetwork
  - LowVoltageNetwork
  - HighPressureNetwork
  - MediumPressureNetwork
  - LowPressureNetwork

- Enumeration: NetworkFunctionAndUsageValue
  - supply
  - disposal
  - communication

- FeatureType: Core::GM_Prim itive
  - Type: GM_Point
  - Type: GM_Curv e

- Data Type: AbstractSignature

- Data Type: AbstractLinkControl

- Data Type: InterFeatureLinkValue

- NodeValue
  - exterior
  - interior

- FeatureGraphMember

- Topography

- Complete Network
  - Core Model in UML
# Existence of characteristics relevant to network modelling in various data models

<table>
<thead>
<tr>
<th>Representation of heterogeneous networks</th>
<th>INSPIRE Utility Networks</th>
<th>IFC Utility Networks</th>
<th>ArcGIS Utility Networks</th>
<th>SEDRIS</th>
<th>Pipeline ML</th>
<th>CityGML Utility Network ADE</th>
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<tbody>
<tr>
<td>Dual representation</td>
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<tr>
<td>Topographic/graphic aspects</td>
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<td>3D geometries</td>
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<td>Functional aspects</td>
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<td>Hierarchical modelling</td>
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<td>• networks/subnetworks</td>
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<tr>
<td>• components/subcomponents</td>
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<tr>
<td>• network features and city objects</td>
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<tr>
<td>• network features of different network types</td>
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= no support, • = basic support, + = sophisticated support, ++ = comprehensive support

Existence of characteristics relevant to network modelling in various data models

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<th>ML</th>
<th>CityGML Utility Network ADE</th>
</tr>
</thead>
</table>

- 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.


Different network types
- = no support, • = basic support, + = sophisticated support, ++ = comprehensive support
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:

<table>
<thead>
<tr>
<th>Commodity</th>
<th># votes</th>
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<tbody>
<tr>
<td>District heating</td>
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<tr>
<td>Electricity</td>
<td>8</td>
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<tr>
<td>Gas</td>
<td>8</td>
</tr>
<tr>
<td>Waste water</td>
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<tr>
<td>Storm water</td>
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<td>Fresh water</td>
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<td>Communication</td>
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<td>Oil</td>
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<tr>
<td>Waste</td>
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<td>Air pressure</td>
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<th>Use case area</th>
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<td>Visualisation</td>
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<td>Planning</td>
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<td>City System Simulation and Smart Cities</td>
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<tr>
<td>Vulnerability Assessment and Disaster Management</td>
<td>6</td>
</tr>
<tr>
<td>Network operation and monitoring</td>
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</tr>
<tr>
<td>Operational impacts / cascading effects</td>
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<tr>
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<td>Navigation</td>
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<td>Urban Facility Management / Inspection</td>
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7.12.2017  T. Kutzner, T. H. Kolbe - Scope and design principles of the CityGML Utility Network ADE
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)