Modelling utilities by developing a domain ontology

Utility Network ADE workshop

13-05-2019

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UNIVERSITY OF TWENTE.

Introduction

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2014 – 2017 MSc Construction Management and Engineering

The potential of data analytics within and between multiple performance contracts

2016 – 2019 Professional Doctorate in Engineering

Modelling utilities by developing a domain ontology

2019 – 2022 PhD in Construction Management and Engineering

A trade-off in the utilities domain: Ground Penetrating Radar versus test trench

Project context

Motivation

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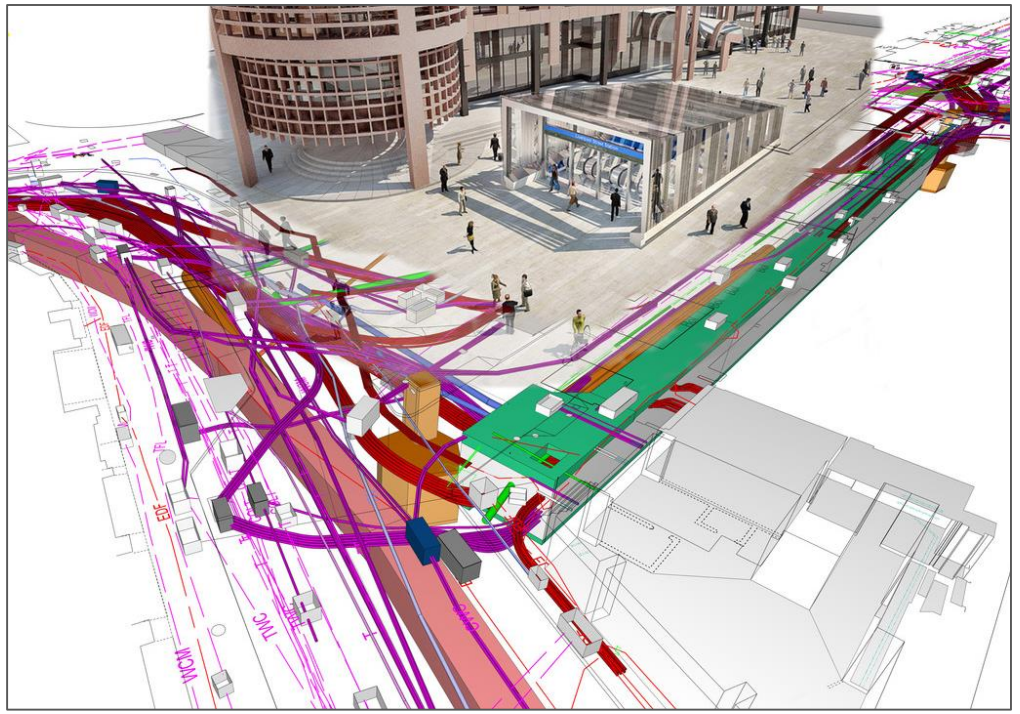
Lifecycle management oriented approach

The creation of ‘digital twins’



Lack of a digital modelling standard

Misunderstanding and confusion

Current digital modelling standards are, content-wise, not focused on the domain of operations and maintenance

Standard	Focus
INSPIRE	Cross-border interoperability and exchangeability.
IMKL	Exchanging utility information to prevent excavation damages.
Utility Network ADE	Multi-utility (failure) simulation including thematic attribution.

Result:

Misunderstanding and confusion at the preparation and execution of works in the utility sector

Problem investigation

Analysis of stakeholders and phenomena

Analysis of phenomena:

Utility modelling practices: Qualitative case study at a Dutch engineering firm

Standardization efforts: e.g. INSPIRE, IMKL, and CityGML UtilityNetwork ADE

Organizational standards

Justifying the development of an ontology

Plethora of utility modelling practices to model domain knowledge, all describing utility concepts using different (1) attributes, formats, relations and (2) semantic terms.

Lack of coverage of operations and maintenance required utility information in existing standards.

Project aim and scope

A domain ontology

Development of a domain ontology that includes the relevant concepts and relations for the operations and maintenance of utilities.

Utility infrastructure – infrastructure with the purpose of transporting commodities.

i.e. (1) electricity, (2) oil, (3) gas, (4) chemicals, (5) sewage, (6) water, (7) thermal, (8) telecommunication

Operations and maintenance – Set of activities performed and strategies implemented with the goal to preserve and extend the service life of the utilities.

Design

Rationale

Ontology design choices:

1. Based on CityGML UtilityNetwork ADE
2. UML as development language
3. Enterprise Architect as development tool
4. End-user engagement to ensure completeness

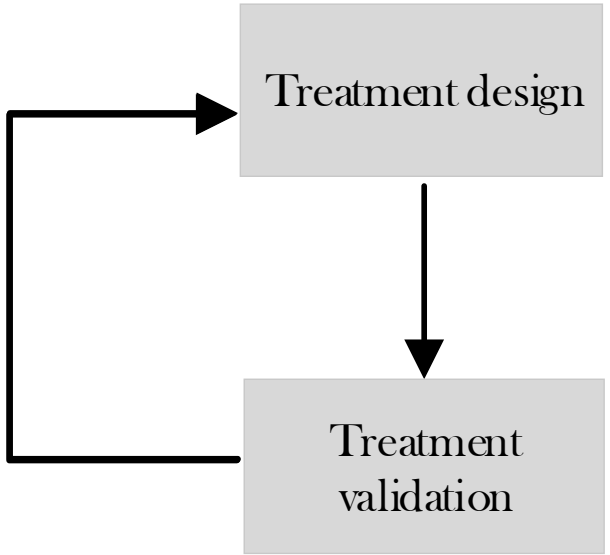
Development language	Development tool
	

Design

Continuous input and refinement

End-user engagement

- Acquisition of real data
- Active involvement
- Collaboratively defined competency questions



Expert involvement

- Three expert panel sessions
- Several individual sessions
- Utility owners, information managers, standardization establishments

An iterative process

Design

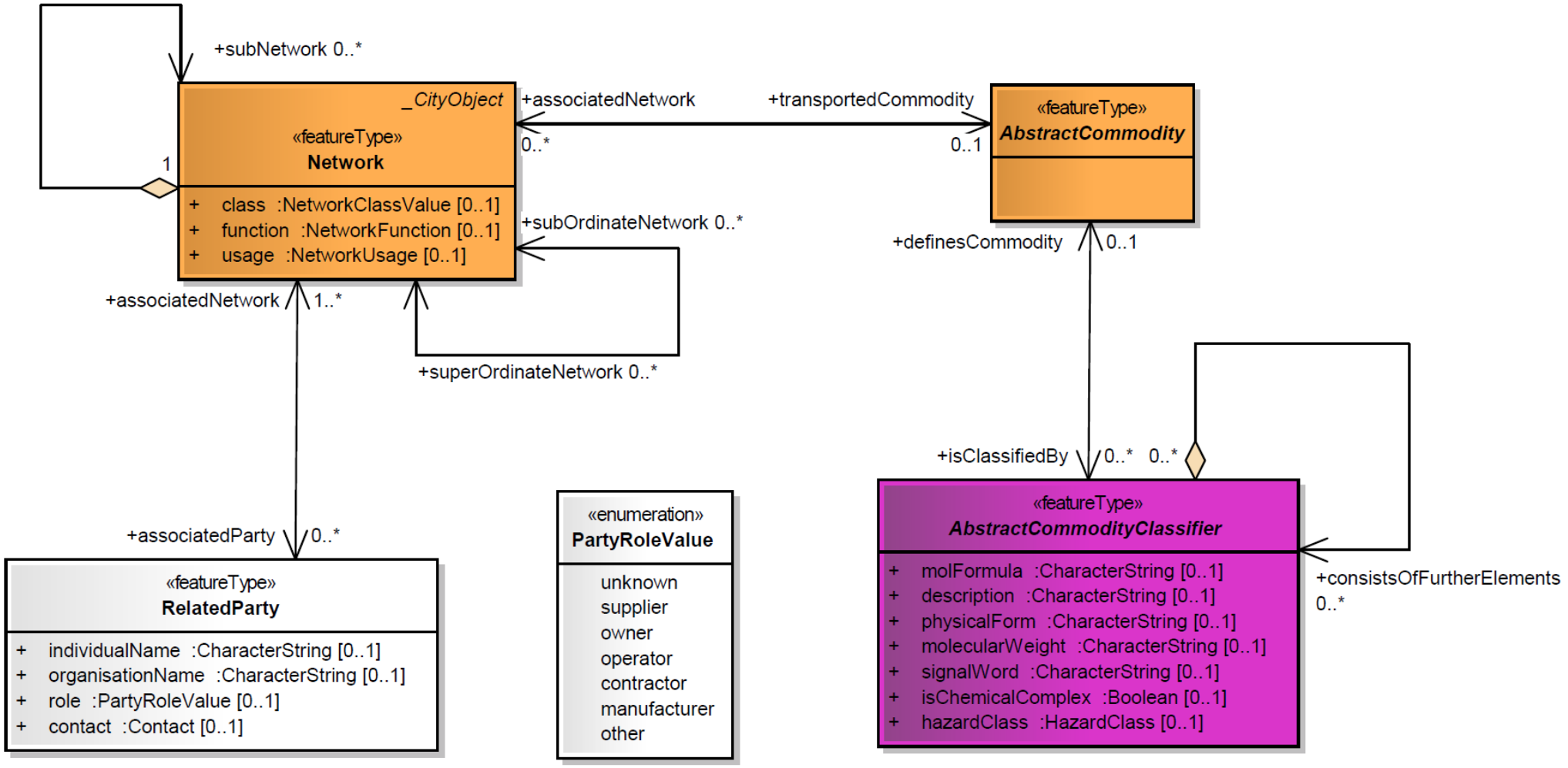
Color of classes

Purple : copied from CityGML UtilityNetwork ADE version 0.9.2

Orange : copied with alterations from CityGML UtilityNetwork ADE version 0.9.2

White : newly added to CityGML UtilityNetwork ADE version 0.9.2

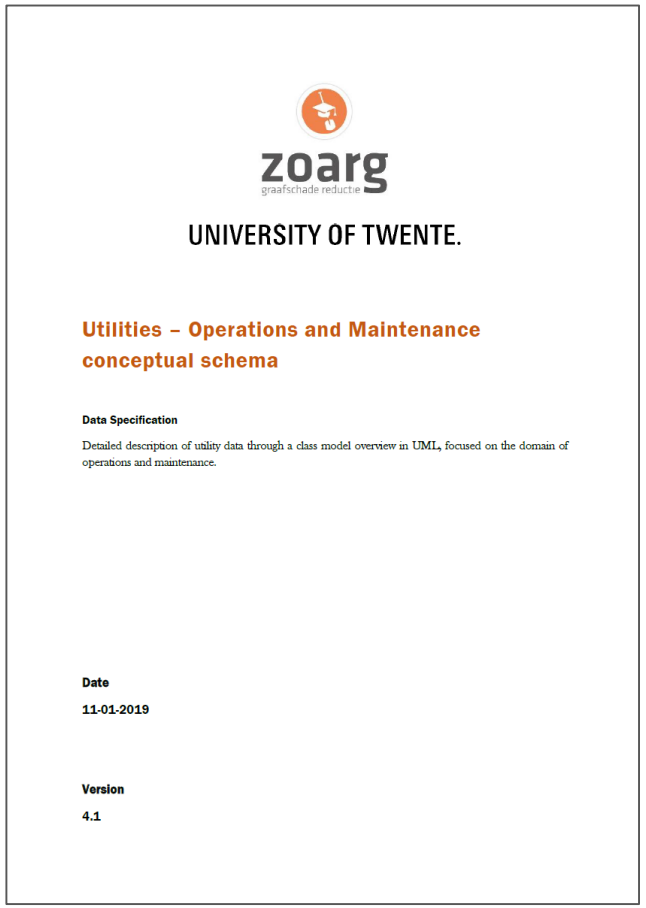
The domain ontology



Documentation

Three in total

Data specification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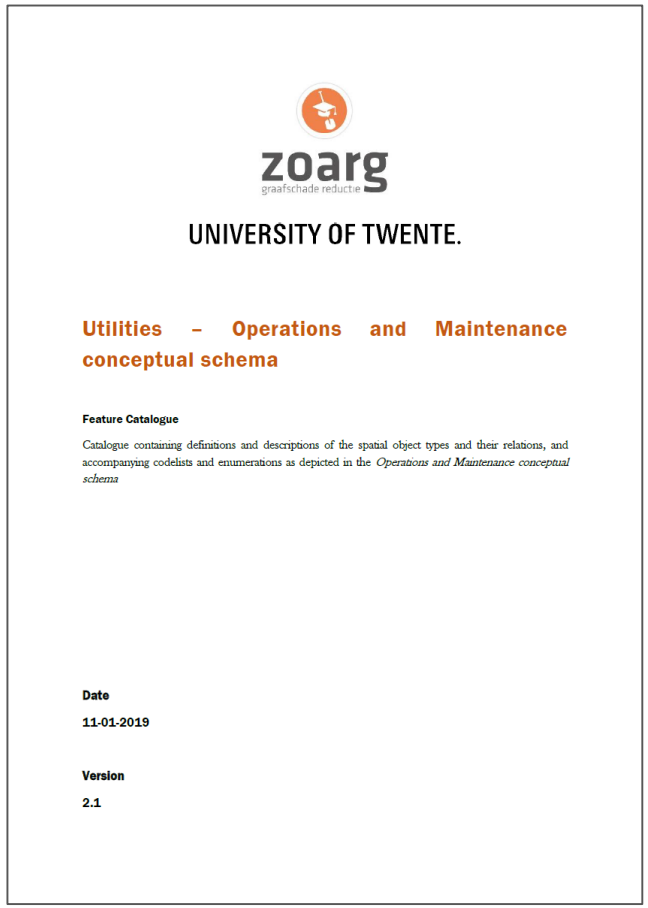
Utilities – Operations and Maintenance conceptual schema
Data Specification
Detailed description of utility data through a class model overview in UML, focused on the domain of operations and maintenance.
Date
11-01-2019
Version
4.1

Feature catalogue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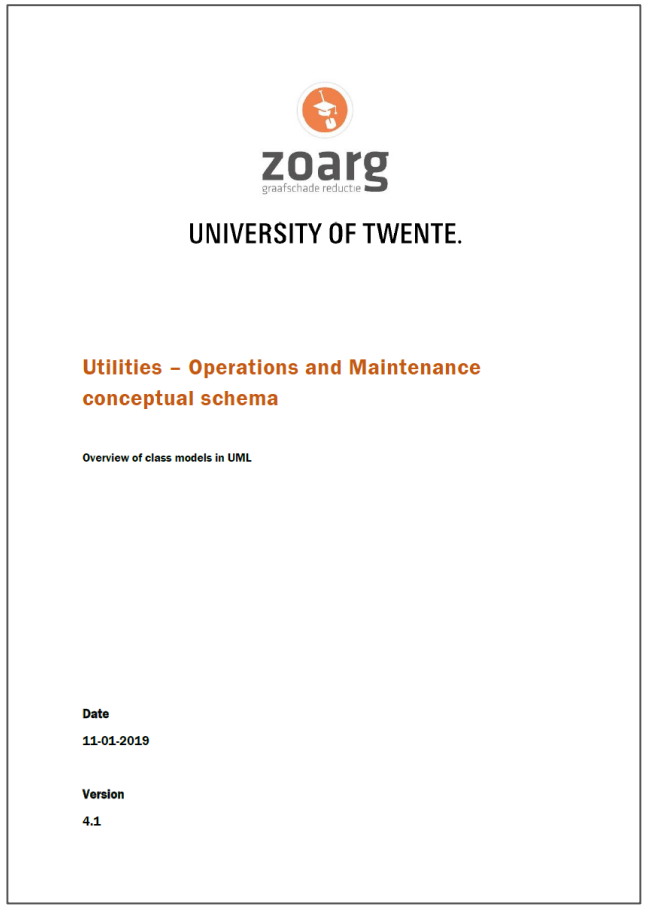
Utilities – Operations and Maintenance conceptual schema
Feature Catalogue
Catalogue containing definitions and descriptions of the spatial object types and their relations, and accompanying codelists and enumerations as depicted in the *Operations and Maintenance conceptual schema*
Date
11-01-2019
Version
2.1

Overview of class models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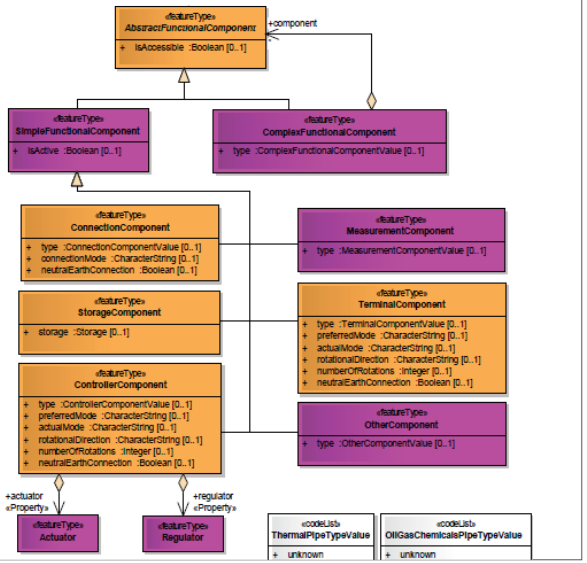
Utilities – Operations and Maintenance conceptual schema
Overview of class models in UML
Date
11-01-2019
Version
4.1

Implementation

Small proof of concept

Application domain : Spatial asset management and GIS software

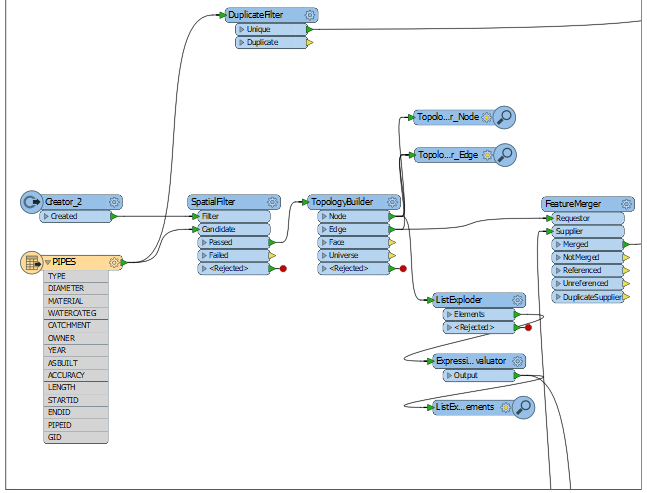
Unified Modelling Language (UML)



Extensible Markup Language (XML)

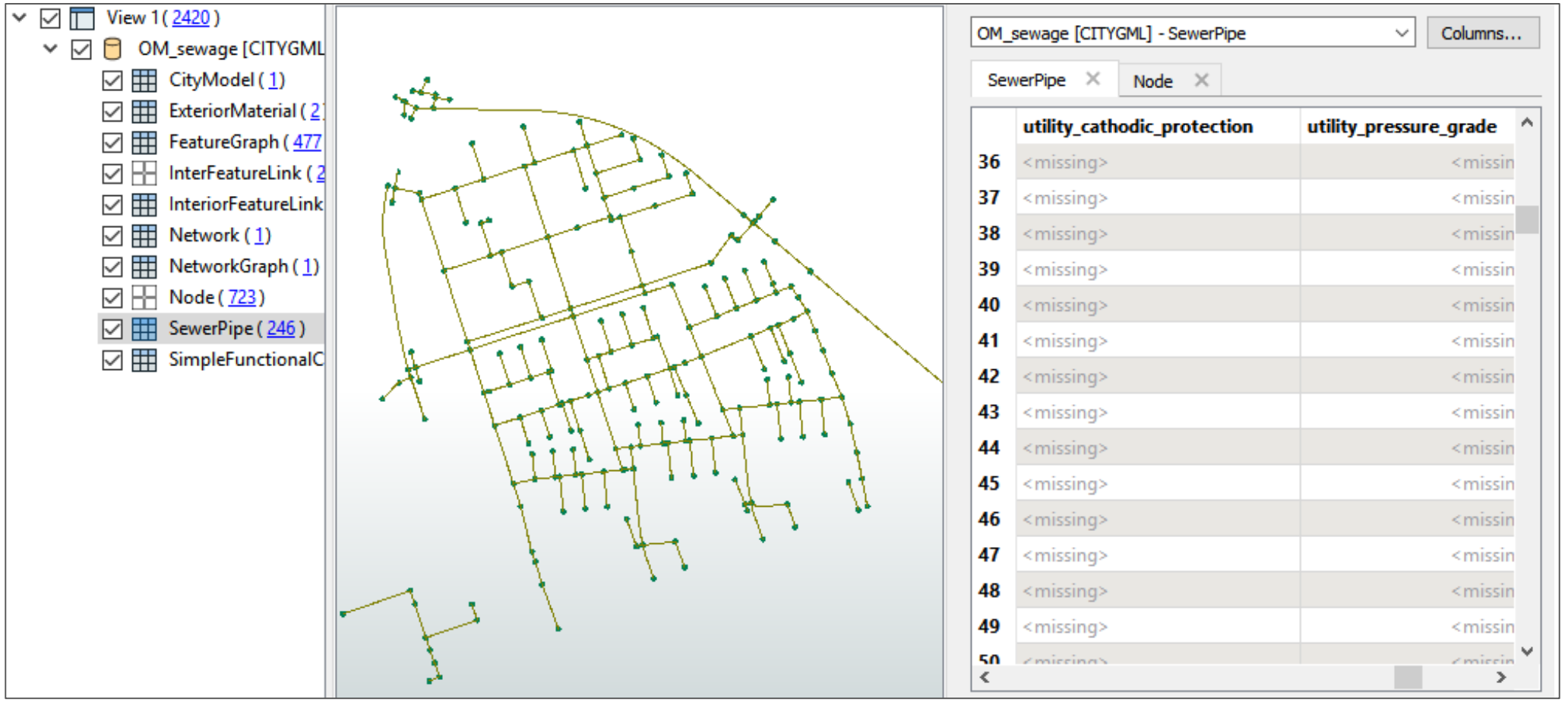
```
type="utility:ComplexFunctionalComponentType"/>
  <complexType name="ComplexFunctionalComponentType">
    <complexContent>
      <extension base="utility:AbstractFunctionalComponentType">
        <sequence>
          <element minOccurs="0" name="type" type="gml:CodeType"/>
          <element maxOccurs="unbounded" minOccurs="0" name="component"
type="utility:AbstractFunctionalComponentPropertyType"/>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <complexType name="ComplexFunctionalComponentPropertyType">
    <sequence minOccurs="0">
      <element ref="utility:ComplexFunctionalComponent"/>
    </sequence>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </complexType>
  <element name="ConnectionComponent" substitutionGroup="utility:SimpleF
type="utility:ConnectionComponentType"/>
  <complexType name="ConnectionComponentType">
    <complexContent>
      <extension base="utility:SimpleFunctionalComponentType">
```

Geography Markup Language (GML)



Sewage

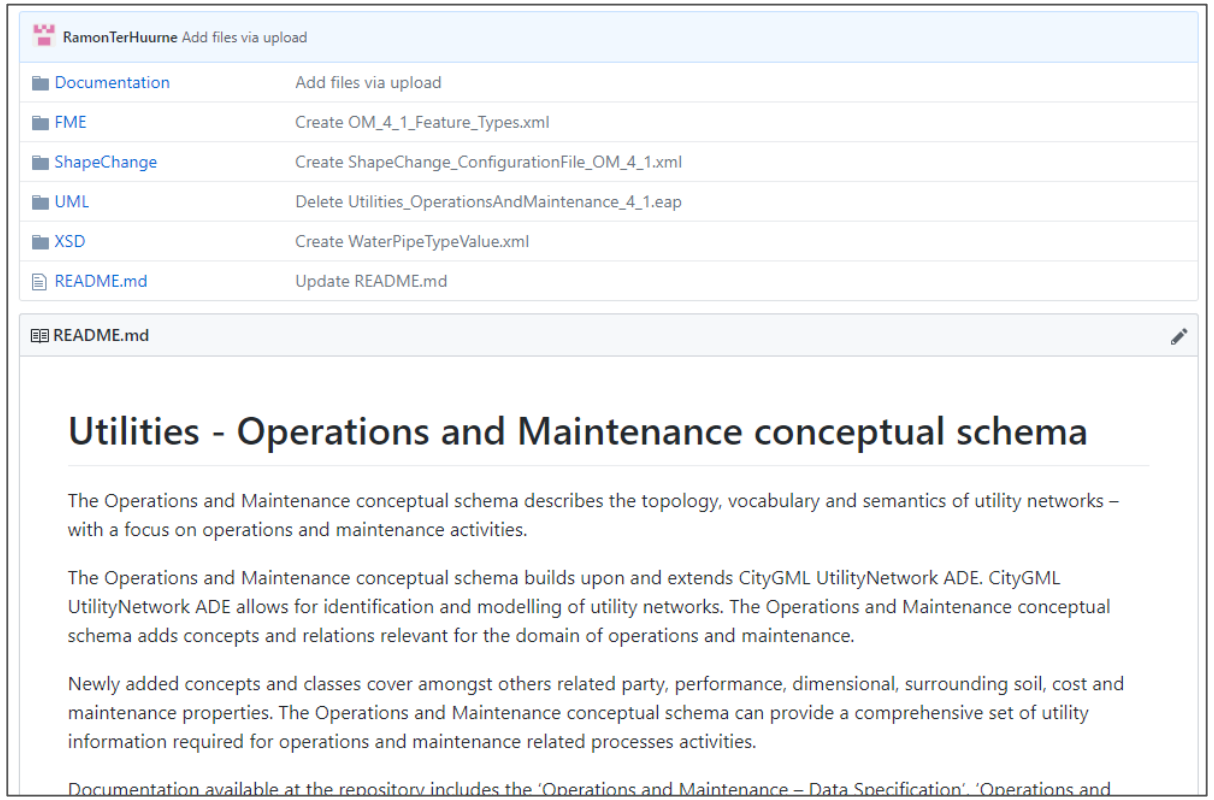
Snapshot of sewage data in QGIS



Online repository

Open access GitHub

https://github.com/RamonTerHuurne/UtilityNetwork-OperationsAndMaintenance



Future work

Further development, further adoption

Further development

Implementation: Full implementation in (spatial) asset management software to evaluate ontology.

Further adoption

Uptake: Appliance of ontology to IT applied within the utility sector.

Thank you

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