



Use cases related to utilities in built environment including maintenance operation and building service system integration within the geospatial context

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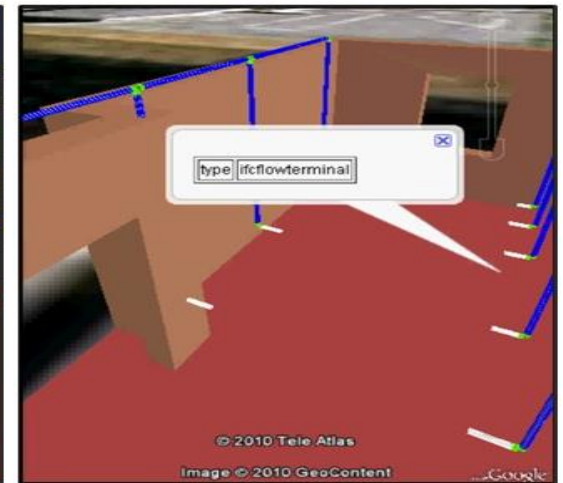
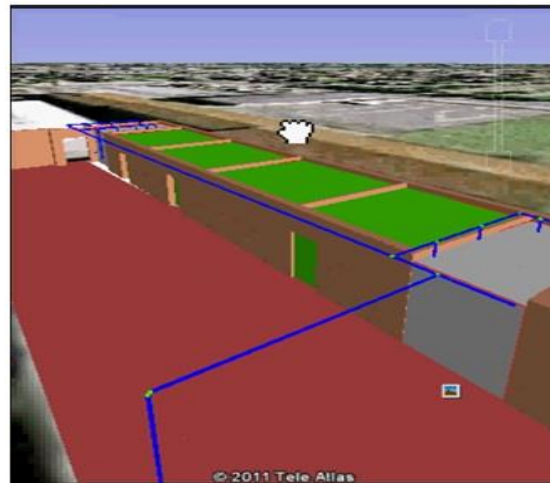
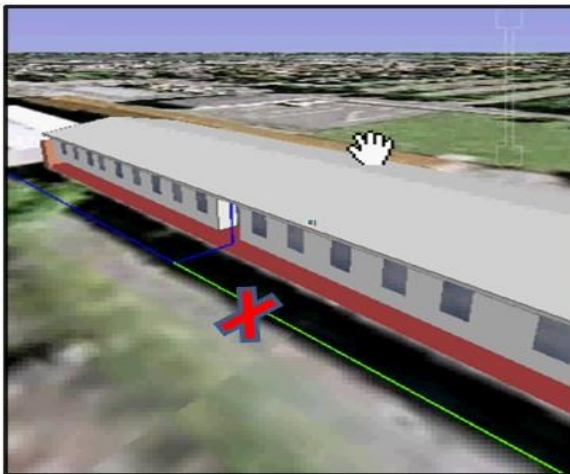
1st Joint SIG 3D and OGC Workshop on the CityGML UtilityNetworkADE
Munich (Germany), October 13-14, 2016

Agenda

- ▶ Use cases
- ▶ Comments on the use cases
- ▶ NIBU
- ▶ Further development
- ▶ IFC, UtilityNetworkADE
- ▶ Final remarks

Use case 1 – maintenance operations

- Notify residents about scheduled or unscheduled maintenance that will cause an outage of service
- Contact only the affected people, not the entire building

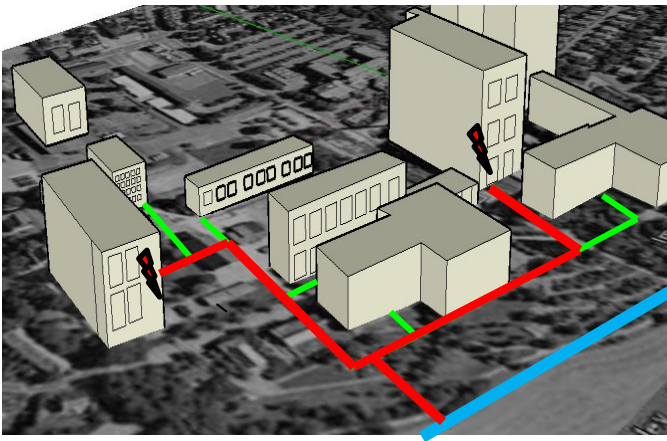


Use Case 1

- ▶ The navigation will require detailed identification and information about the spaces representing walls and all objects attached to them. This case will require 3D space and corresponding semantics.
- ▶ Shape and size of the room (walls, windows) becomes of critical importance in three directions:
 - for calculating needed materials in case of cleaning, painting after repair and
 - for transporting necessary equipment (e.g. ladders).
 - isolating the parts that could be affected from maintenance - by cover of some thing similar
 - subdivision of rooms/halls to be possible to accurately locate the area of interest

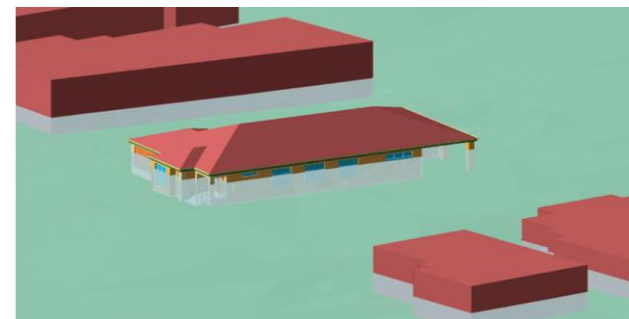
Use case 2 – city inspection – clean water act

- ▶ Inspect the city to ensure that the drainage network is not wasting drains
- ▶ Utilities lead to space inside buildings



Use case 4 - Emergency response - flood

- ▶ To expedite the process of response to residents either in the case of emergency or when providing information; an application that will help the district to respond to their residents needs in a rapid and cost effective fashion will be developed.



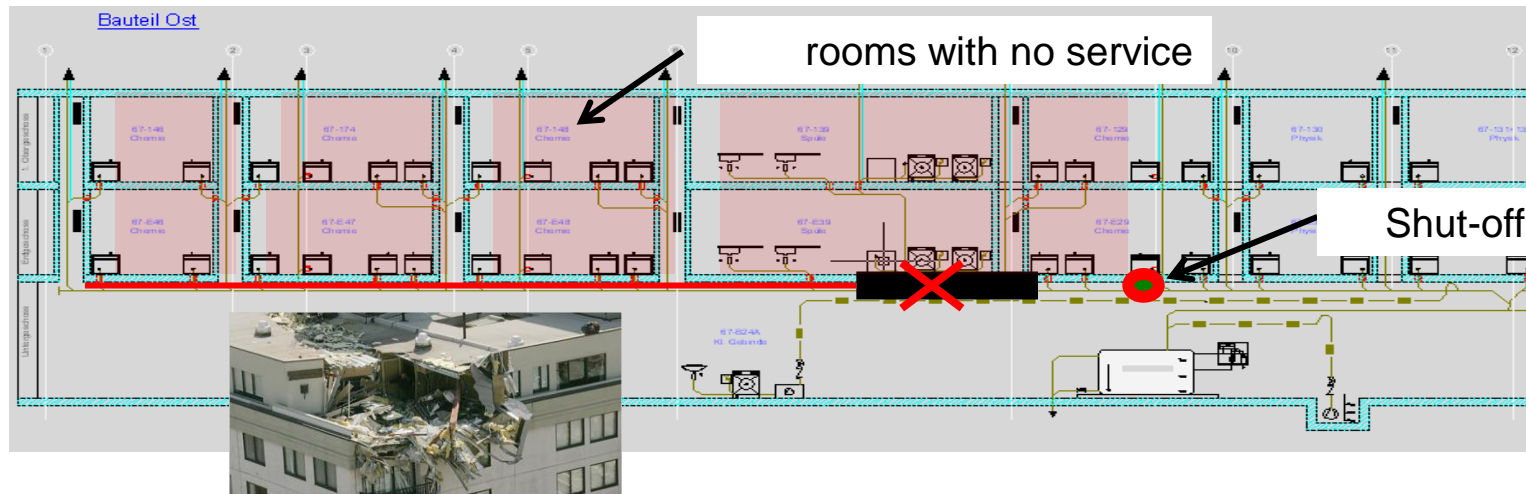
Use case 5 – relation to building elements

In case of an operation in a storey slab,

Which network elements from other systems can be affected?

Which points can be used to shutdown the utility network, to avoid further damage?

Which spaces can be affected?

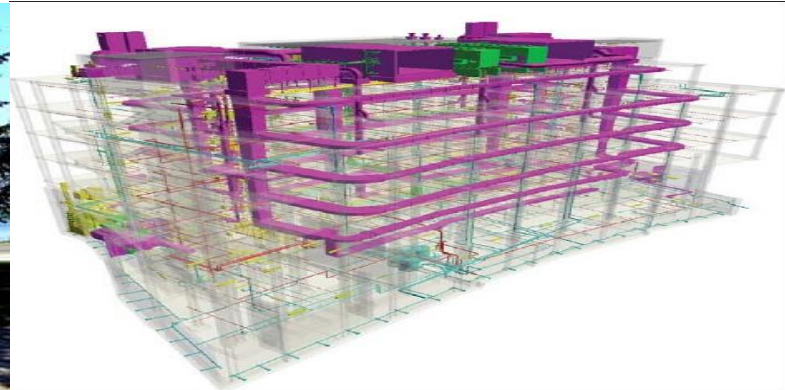




Comments on the Use Case

Built up area utility

- ▶ It is path goes through structural elements e.g. ceilings and walls, part of it contained in spaces
- ▶ Less urbanized areas referenced to road or railroad network vs. Built up utilities Interior utilities referenced to building structures.
- ▶ All use cases operation are directly connected to city objects, integration of indoor and out door utilities – specifically 3d city objects



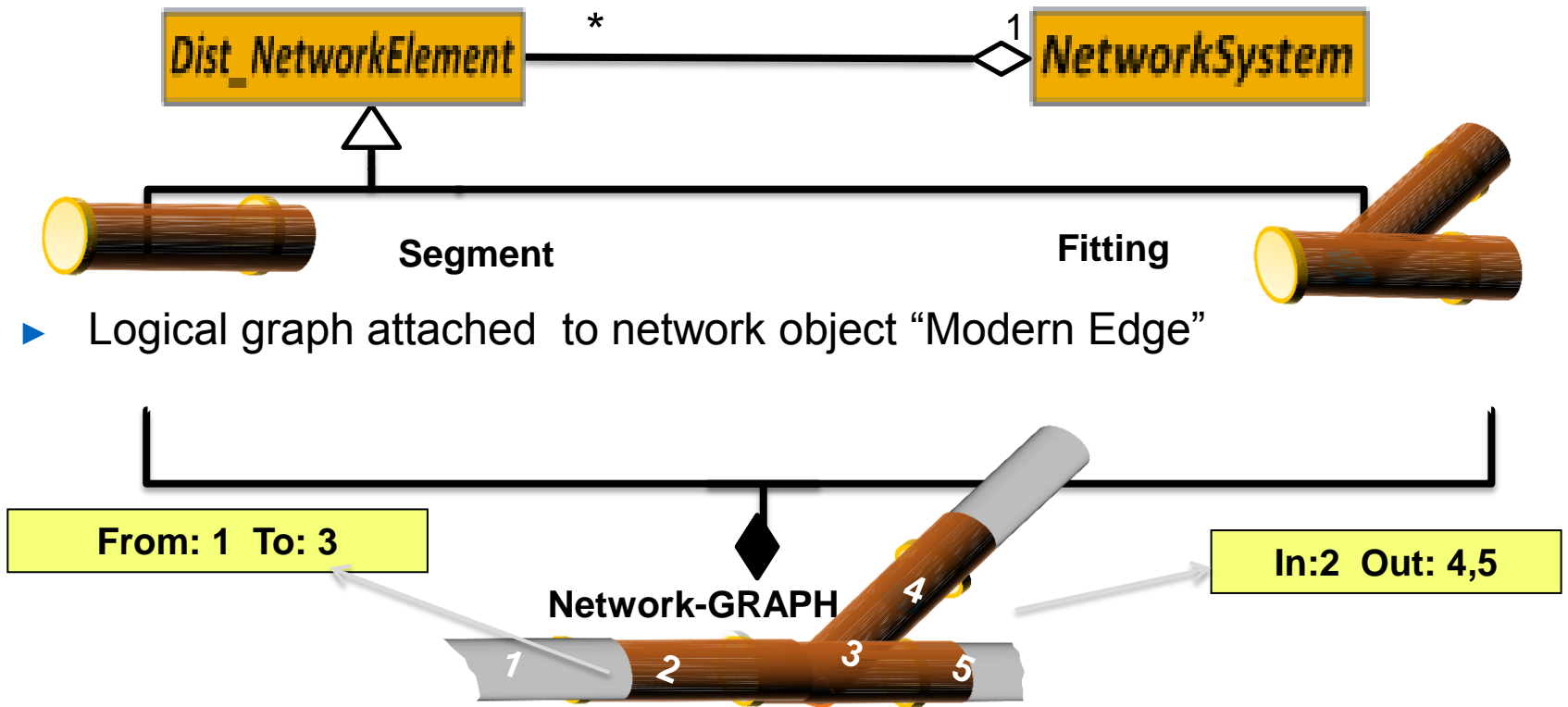


NIBU

Network for Interior building utilities

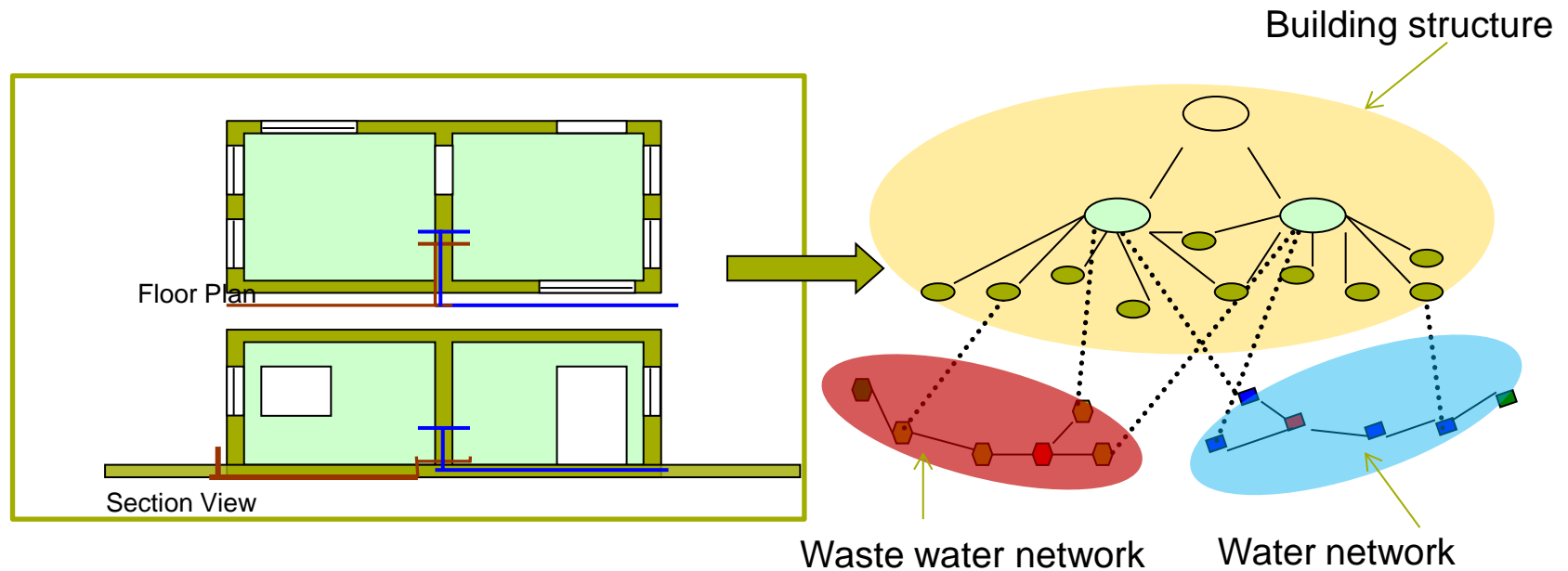
Network classes

- *NetworkSystem* is aggregation of *Dist_NetworElement* e.g. pipes, cables.

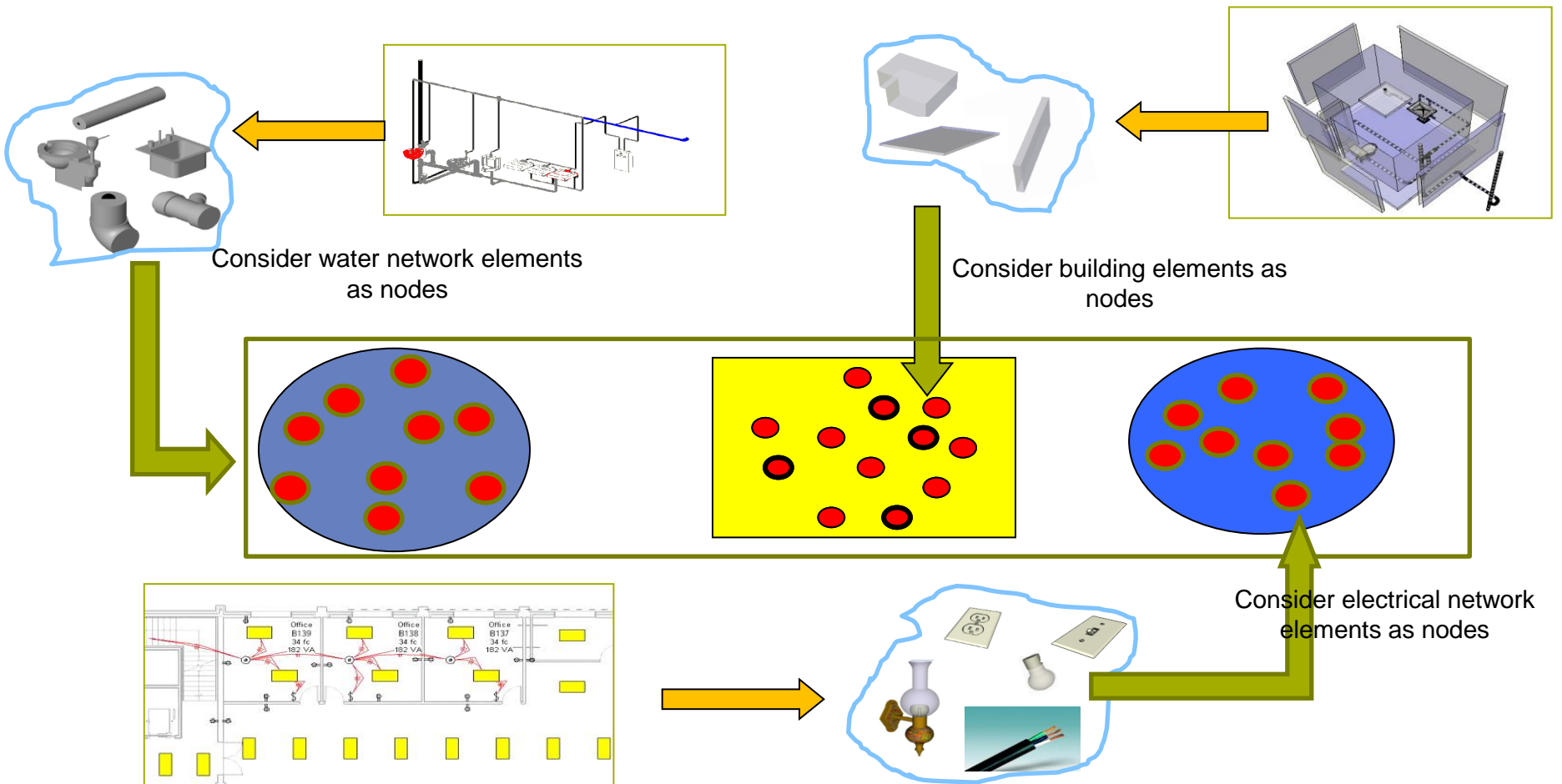


NIBU – relation to building

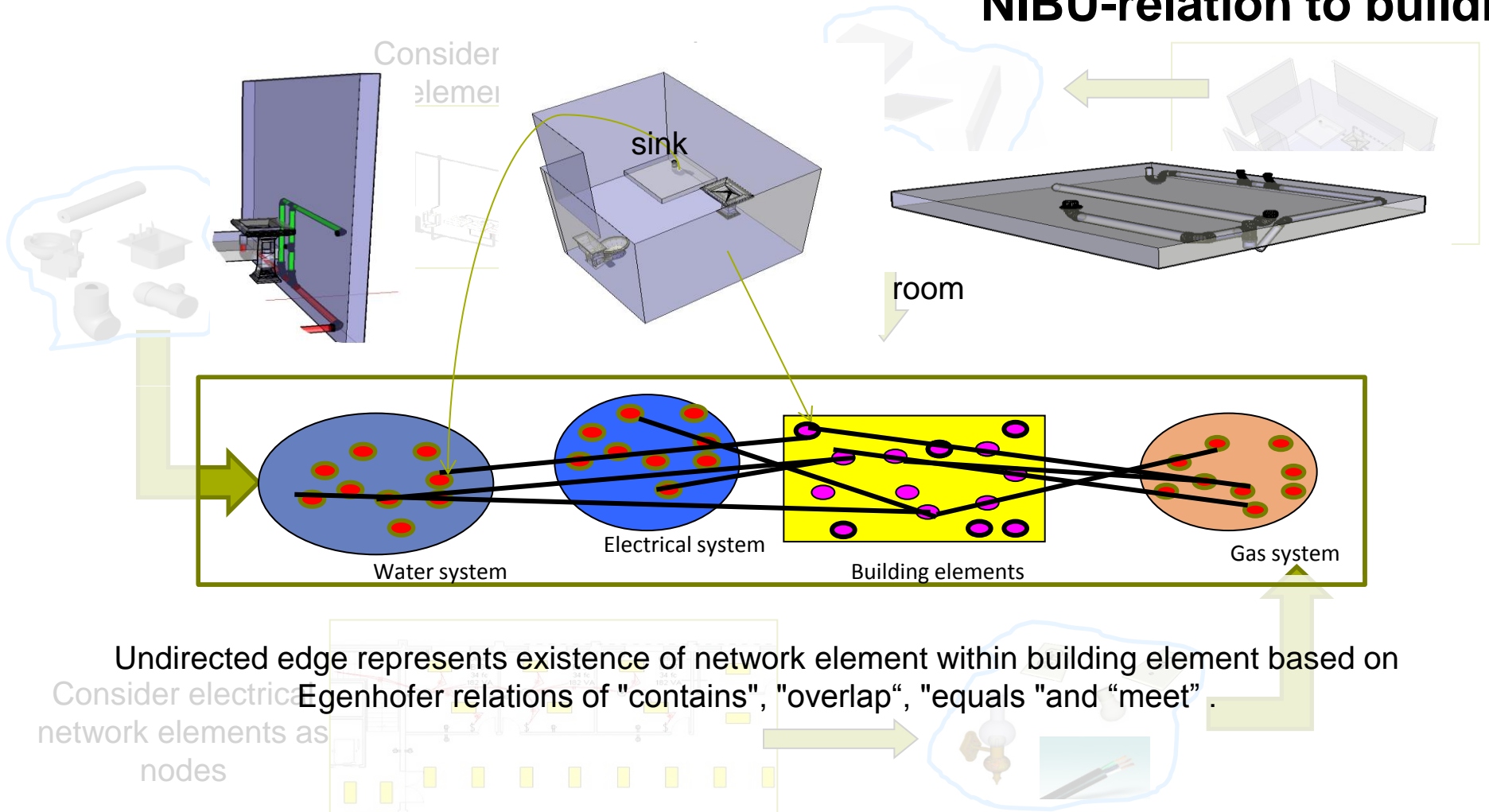
- Represent network object relation to building structure
- Proper building hierarchy



NIBU-relation to building



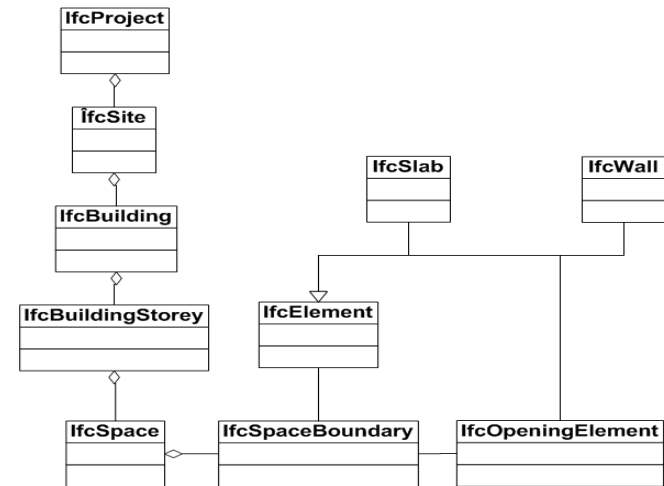
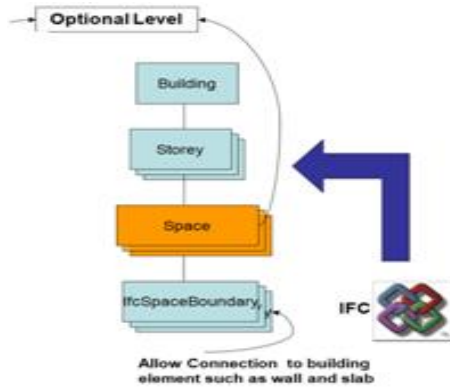
NIBU-relation to building



IFC hierarchy

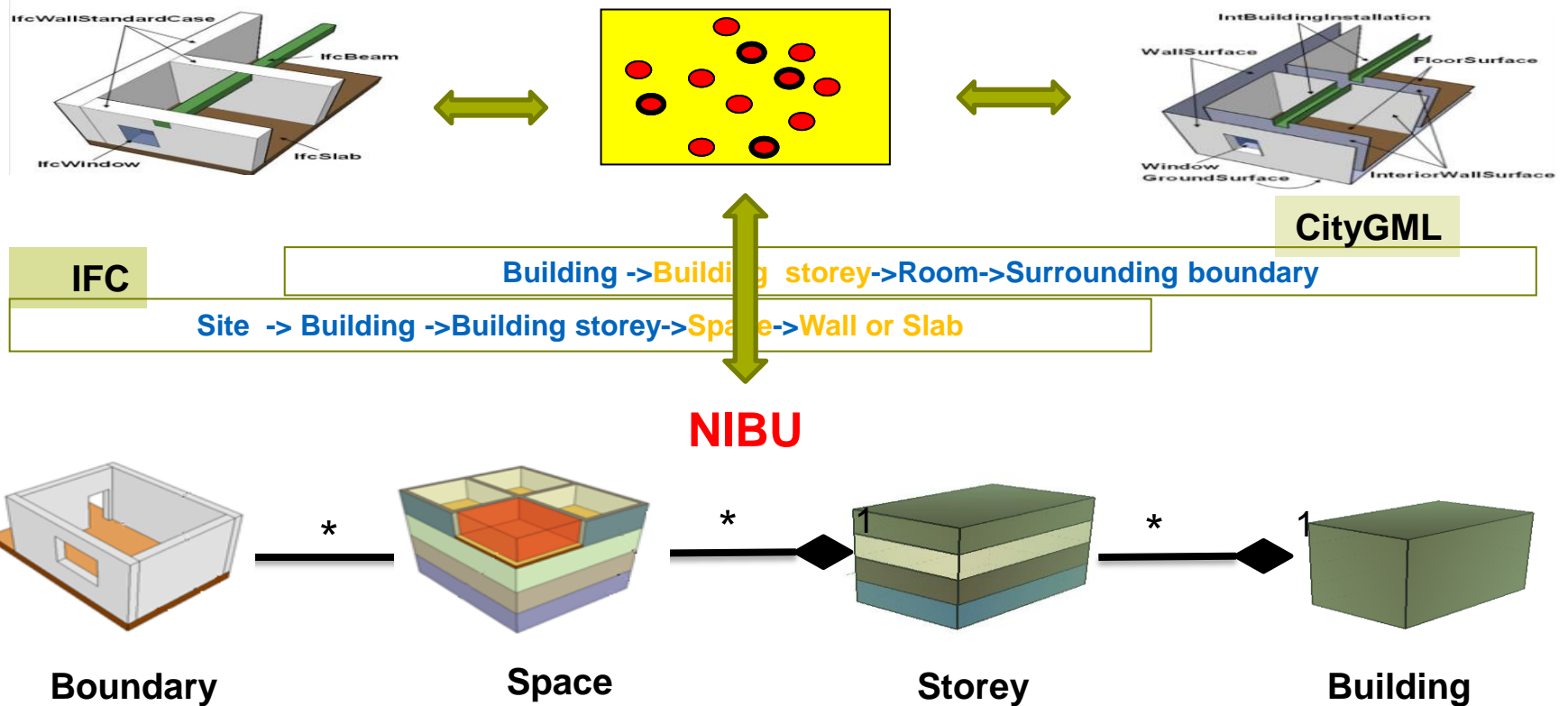
Site -> Building -> Buildingstory -> Space -> wall or slab

Whole building slab- considered one element
 Whole wall considered one building element
 Large hall considered one building element



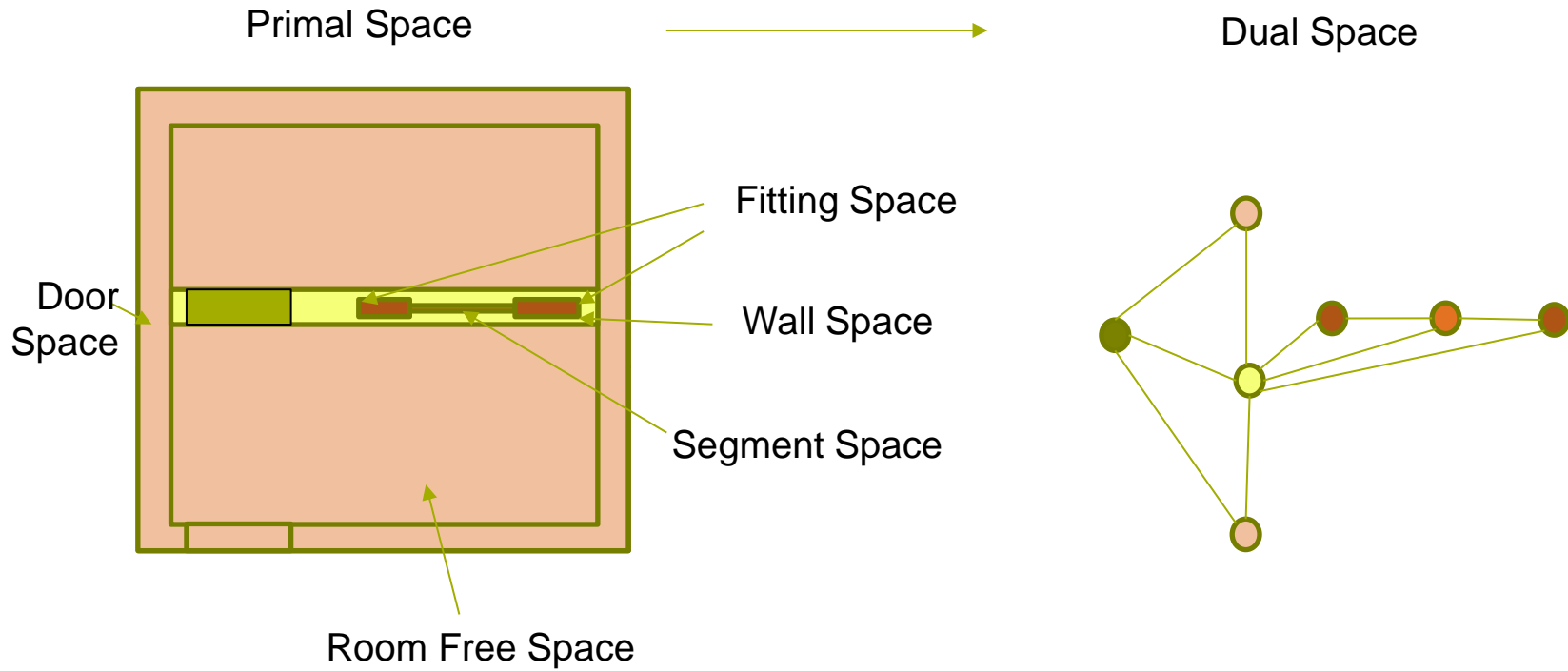
NIBU-relation to building

- Provide proper hierarchy relevant to interior utilities





Further Extension ...



Main Topographic Space (Normally utility systems are represented in as contains relationship with topographic space but in reality they have their own space and they need to be represented as topographic space for their accessibility)

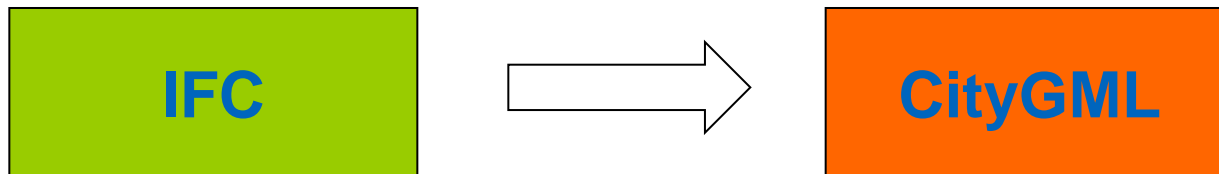


Future work

- ▶ Proof that the model support these three different level of intervention – so we support utilities operation in building
- ▶ Space Sub Division and future development regarding

BIM/IFC - CityGML

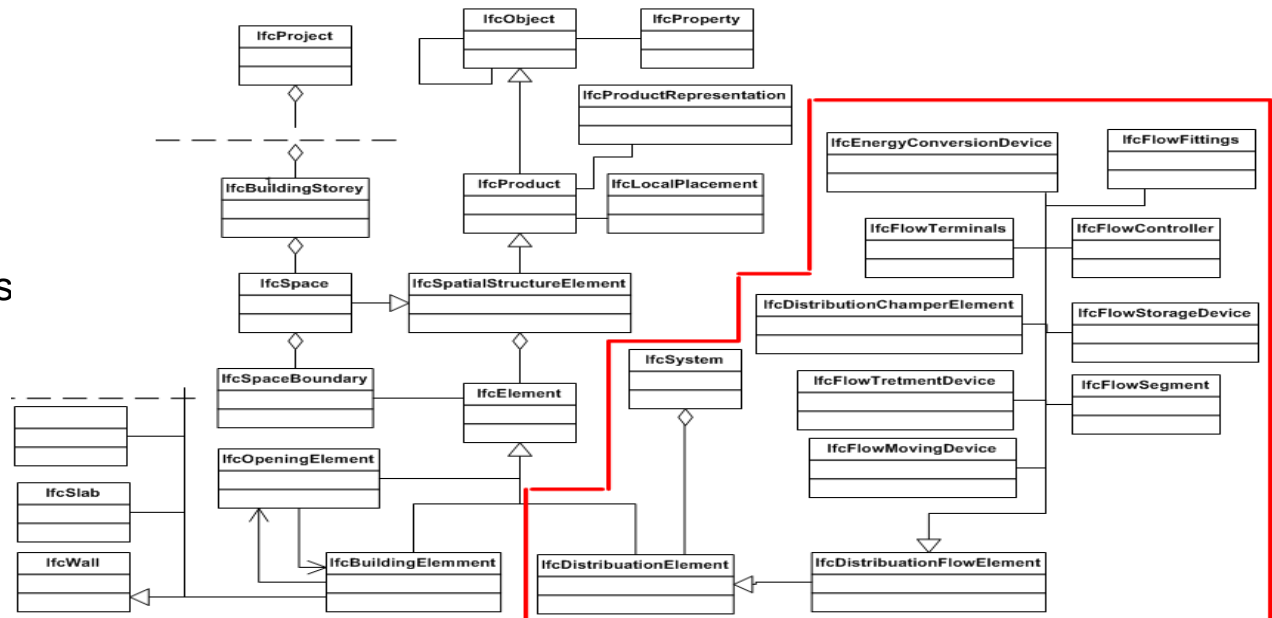
- ▶ BIM integration Through harmonized semantics
- ▶ A pragmatic approach by means of a manual inspection of both schemas to see which entities and attributes correspond.



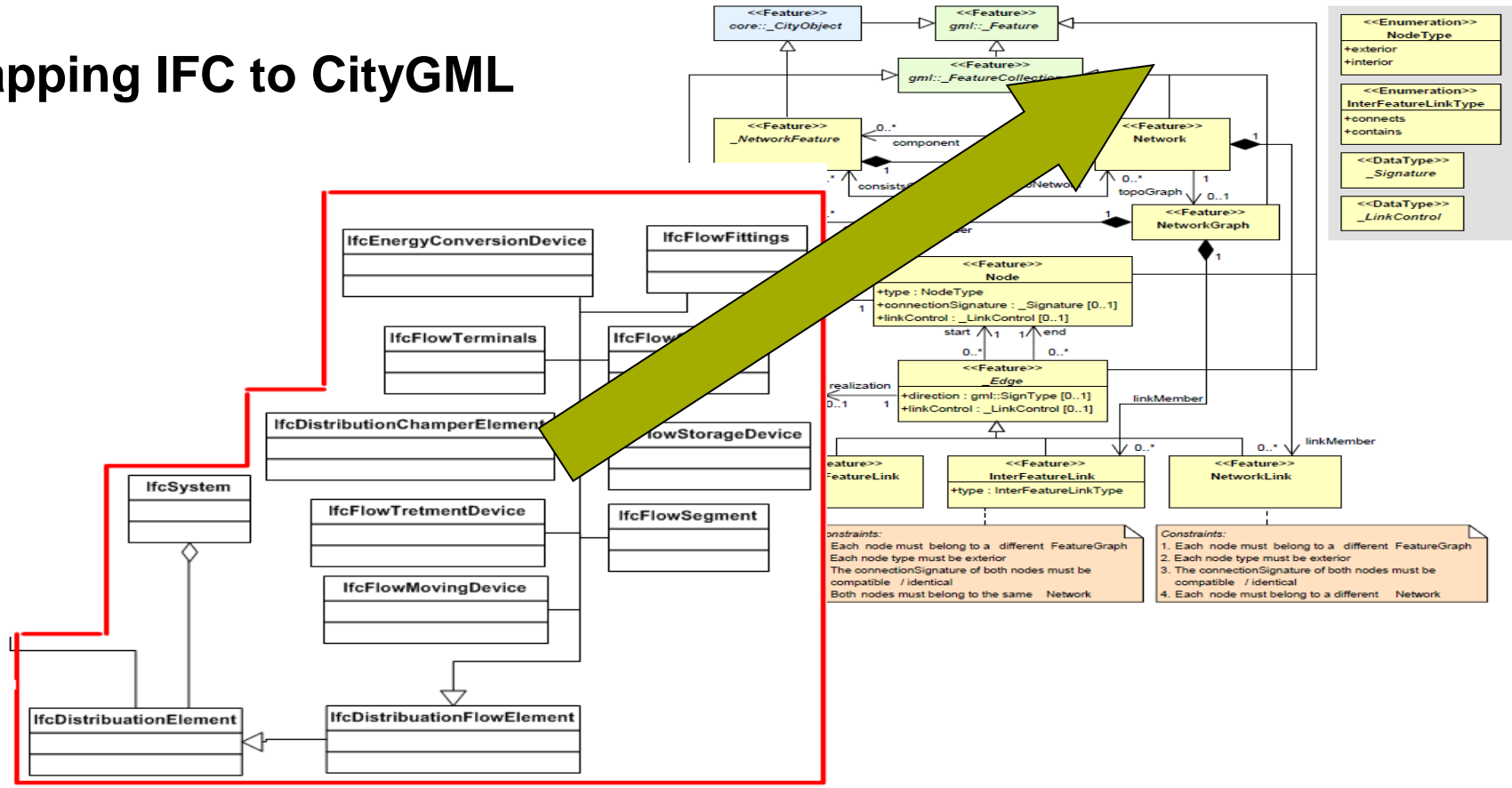
Utility in IFC – Standard

- All building service elements exchanged by subtypes inherited from *IfcDistributionElement*
 - semantics and logical structuring of the model.

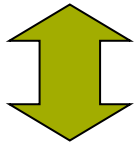
- ▶ connectivity using two methods, logical and physical connectivity.
- ▶ the real 3D shape; such as CSG, Sweeping, or SolidModel.
- ▶ concept of system;



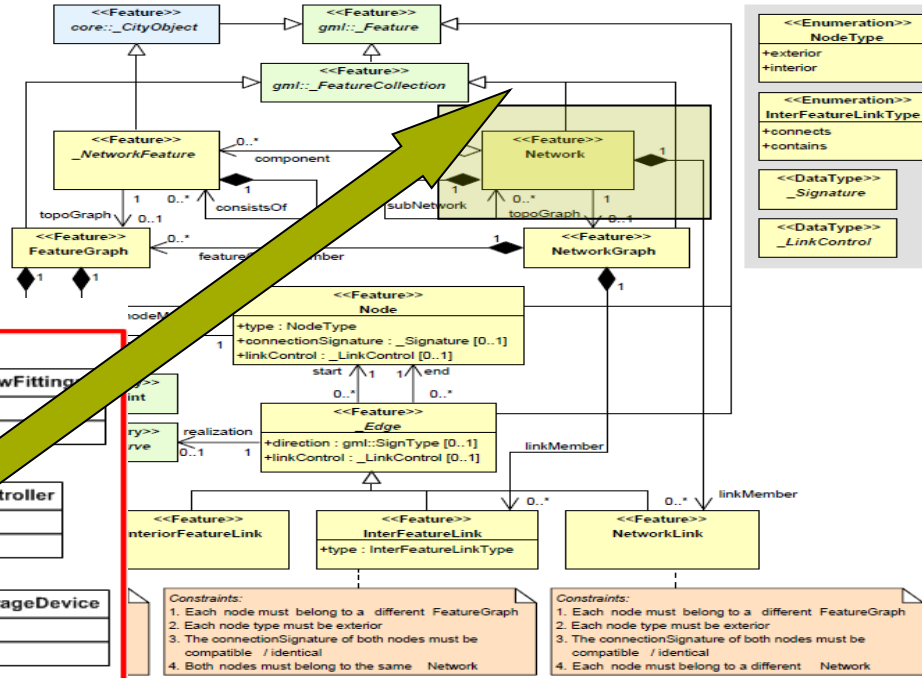
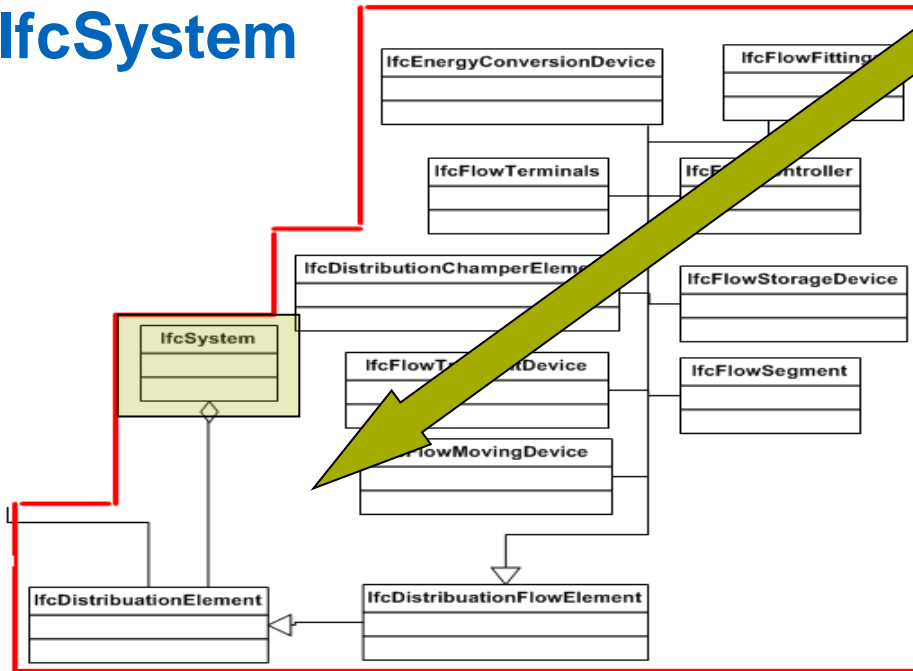
Mapping IFC to CityGML



Network Class



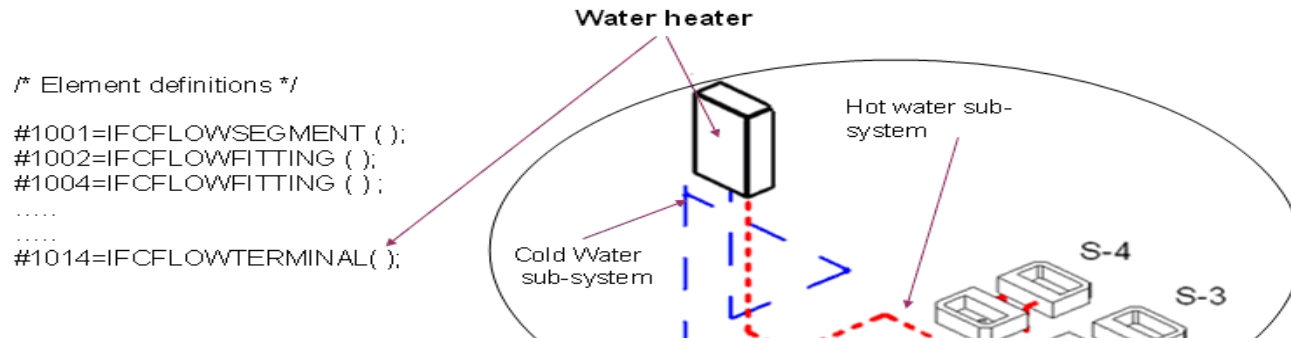
IfcSystem



Thematic Classes

- Constraints:
- 1. Each node must belong to a different FeatureGraph
 - 2. Each node type must be exterior
 - 3. The connectionSignature of both nodes must be compatible / identical
 - 4. Both nodes must belong to the same Network

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```

/* Element definitions */
#1001=IFCFLOWSEGMENT ( );
#1002=IFCFLOWFITTING ( );
#1004=IFCFLOWFITTING ( );
.....
#1014=IFCFLOWTERMINAL( );
    
```

/* System definitior

```

#2001=IFCSYSSTE
#2002=IFCSYSSTE
#2003=IFCSYSSTE
    
```

/* Assignment of EI

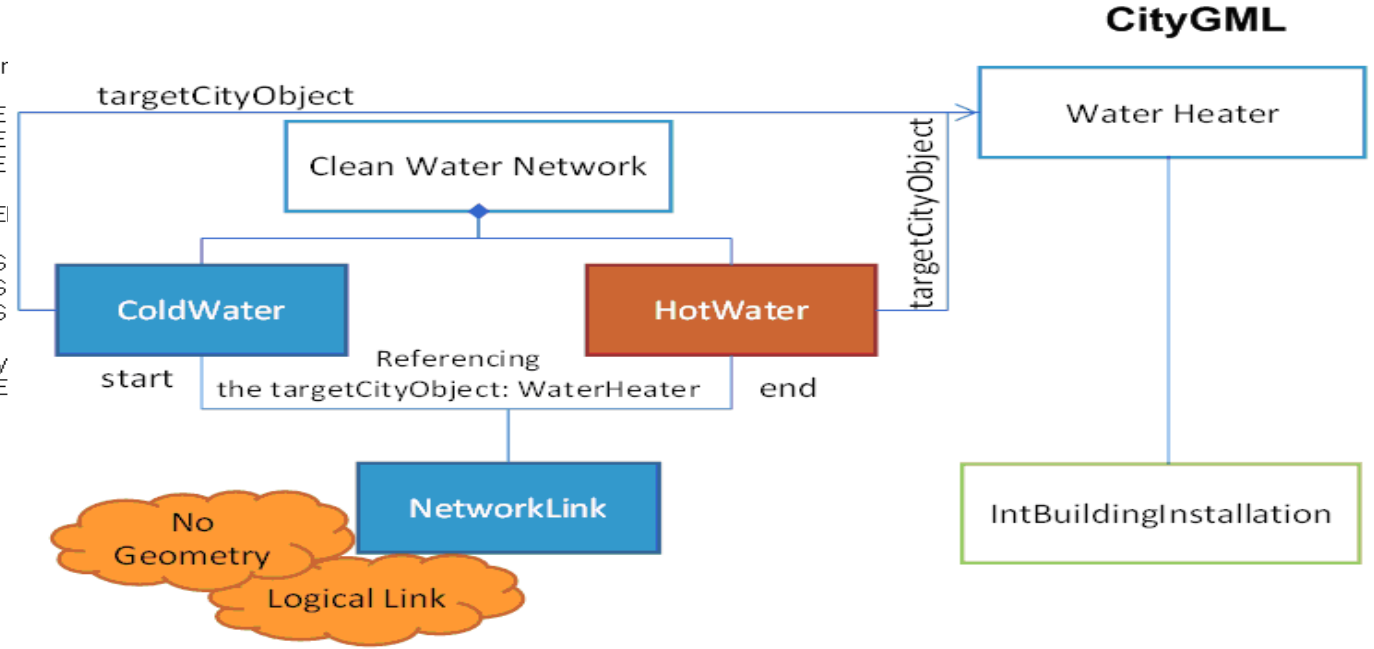
```

#3001=IFCRELAS
#3002=IFCRELAS
#3003=IFCRELAS
    
```

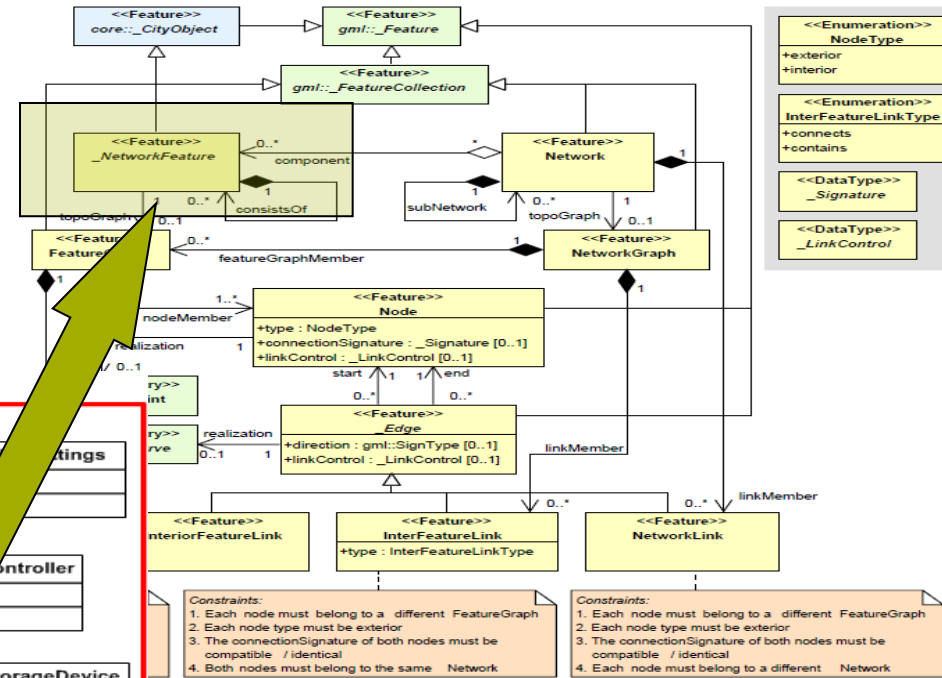
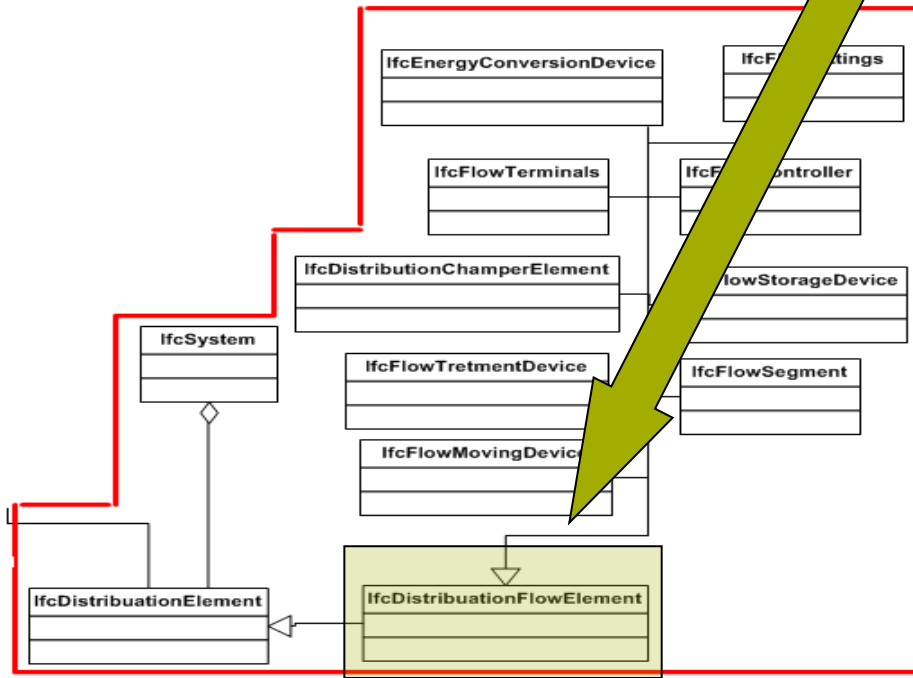
/* Nesting of subsy

```

#4001=IFCRELNE
    
```



NetworkFeature ↕ IfcDistributionFlowElement



Thematic Classes

IfcFlowStorageDevice



IfcFlowFitting



**Distribution
Flow Element**

Semantic categorization

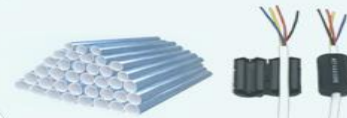
IfcFlowTerminals



IfcFlowController

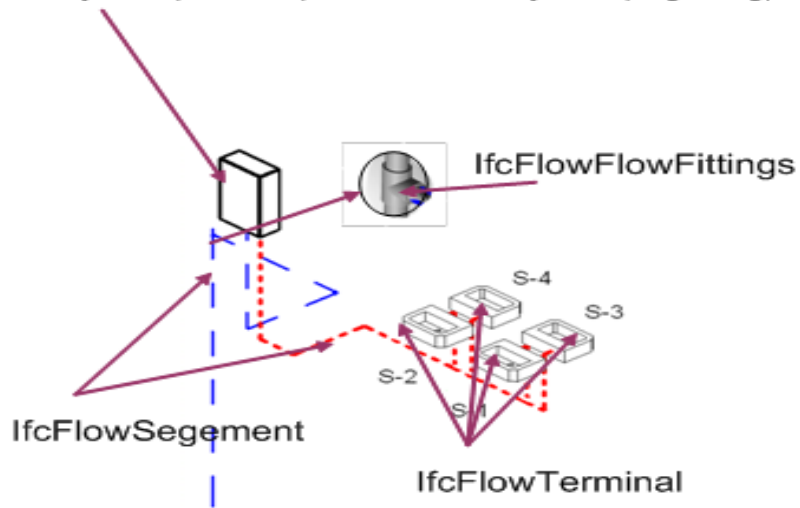


IfcFlowSegment



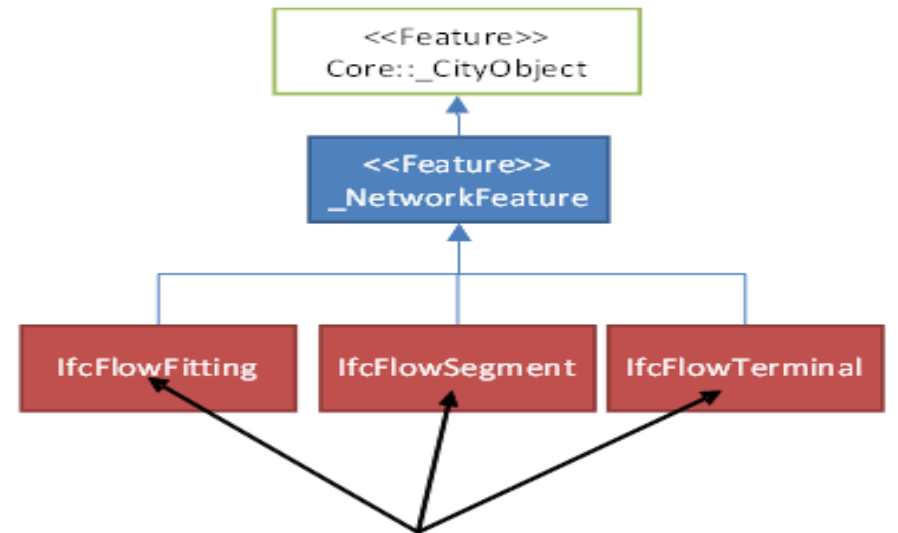
IfcFlowTerminal:

part of the electrical system (terminus), cold water system (terminus) and hot water system (beginning)



IFC

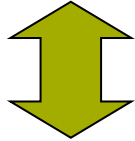
CityGML



Sub-classes derived from the `_NetworkFeature` class

Graph Structure

Graph Structure



Connectivity entities

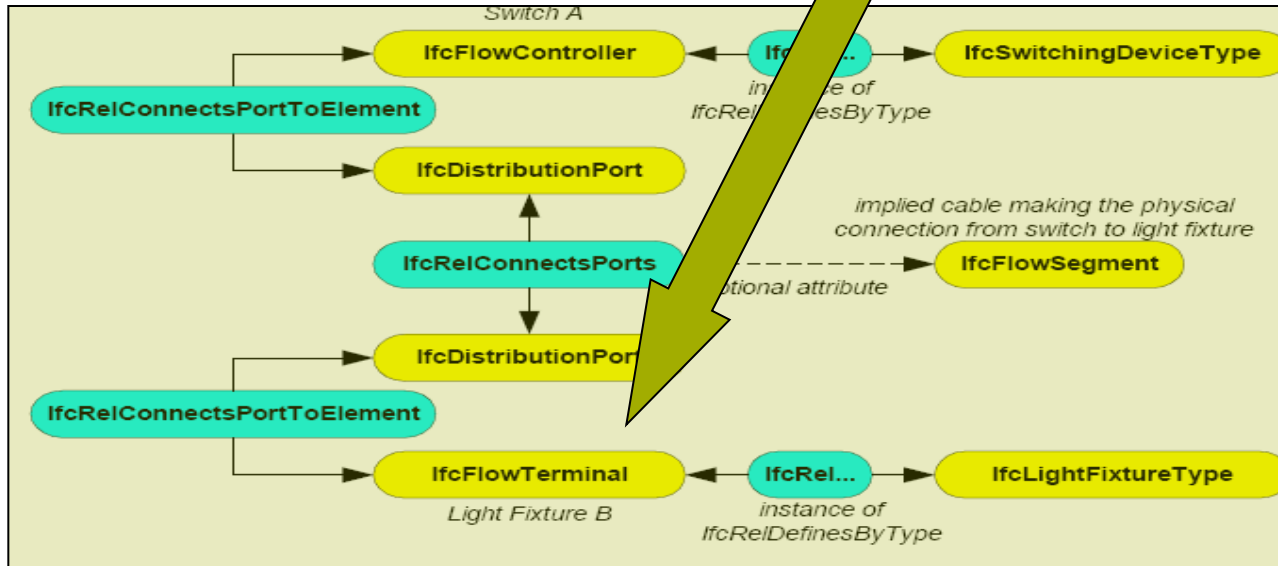
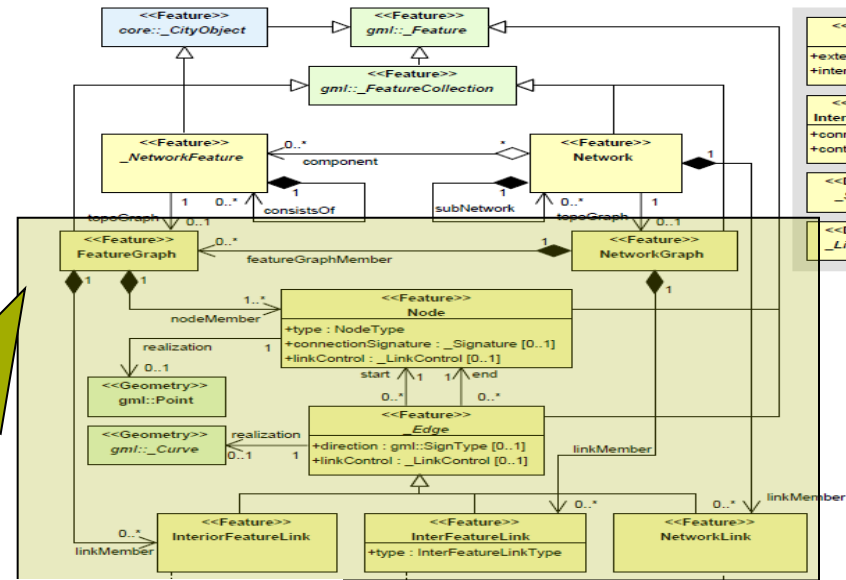


Figure 164: Entities used in logical connectivity with ports

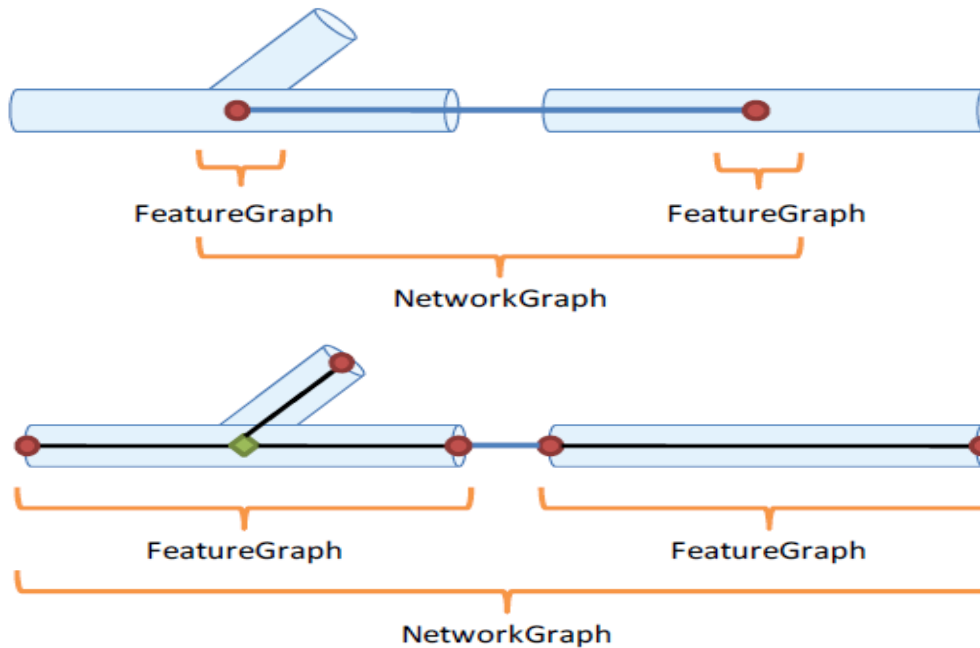


belong to a different FeatureGraph must be exterior signature of both nodes must be identical / identical belong to the same Network

- Constraints:
1. Each node must belong to a different FeatureGraph
 2. Each node type must be exterior
 3. The connectionSignature of both nodes must be identical / identical
 4. Each node must belong to a different Network

Graph structure in CityGML

Alternative B:

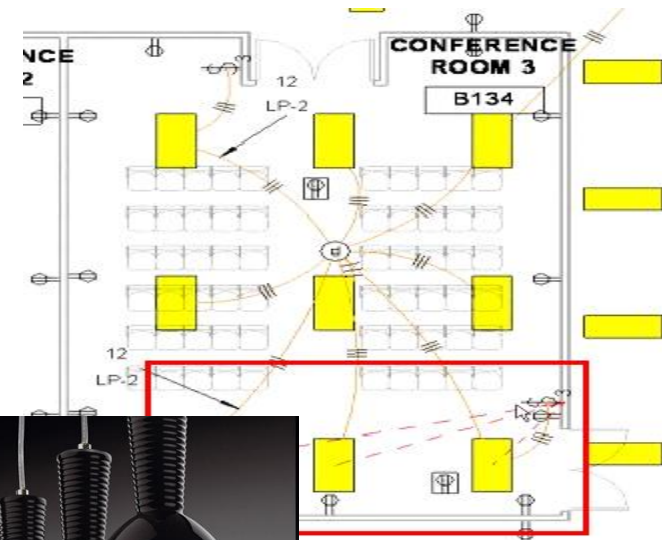


Legend

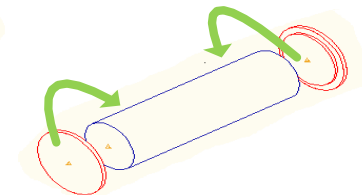
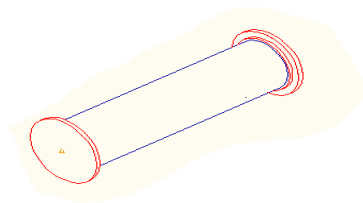
- Node (type: exterior)
- ◆ Node (type: interior)
- InteriorFeatureLink
- InterFeatureLink
- ▭ NetworkFeature

Logical and physical Connectivity

- *IfcRelConnectsPortToElement*
- *IfcRelConnectsPorts*



IFCFlowSegment- Connectivity entities



IfcFlowSegment



IfcDistributionPort



IfcRelConnectsPortToElement

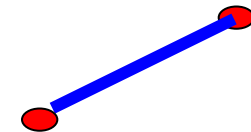
Featuregraph



InteriorFeatureLink

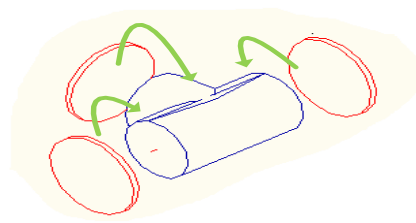
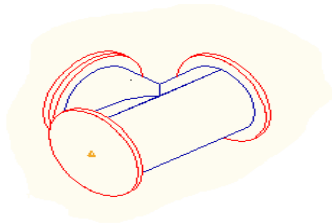


Node (type: exterior)

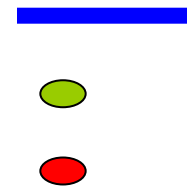


```
#240=IFCFLOWSEGMENT('ABCDEFGHIJKLMNPOQ00040',#9,'C','','$,$,$,$);
#242=IFCDISTRIBUTIONPORT('ABCDEFGHIJKLMNPOQ00042',#9,'C0','','$,$,$,$,SOURCE.);
#243=IFCRELCONNECTSPORTTOELEMENT('ABCDEFGHIJKLMNPOQ00043',#9,$,$,#242,#240);
#244=IFCDISTRIBUTIONPORT('ABCDEFGHIJKLMNPOQ00044',#9,'C1','','$,$,$,$,SINK.);
#245=IFCRELCONNECTSPORTTOELEMENT('ABCDEFGHIJKLMNPOQ00045',#9,$,$,#244,#240);
#246=IFCRELDEFINESBYPROPERTIES('ABCDEFGHIJKLMNPOQ00046',#9,$,$,$,#240,#247);
```

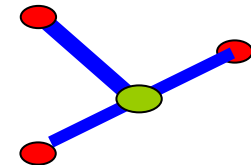

IFCFlowFitting- Connectivity entities



Featuregraph



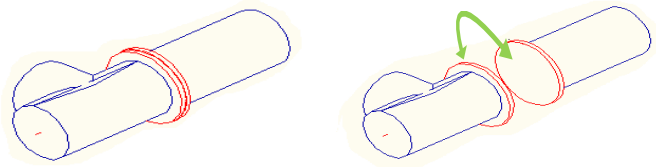
InteriorFeatureLink
 Node (type: interior)
 Node (type: exterior)



```
#310=IFCFLOWFITTING(' ABCDEFGHIJKLMNOPQ00073', #9, 'T', '', $, $, $, $);
#312=IFCDISTRIBUTIONPORT(' ABCDEFGHIJKLMNOPQ00075', #9, 'TO', '', $, $, $, .SOURCE.);
#313=IFCRELCONNECTSPORTTOELEMENT(' ABCDEFGHIJKLMNOPQ00076', #9, $, $, #312, #310);
#315=IFCRELCONNECTSPORTTOELEMENT(' ABCDEFGHIJKLMNOPQ00078', #9, $, $, #314, #310);
#317=IFCRELCONNECTSPORTTOELEMENT(' ABCDEFGHIJKLMNOPQ00080', #9, $, $, #316, #310);
```

Network

Physical connectivity in IFC

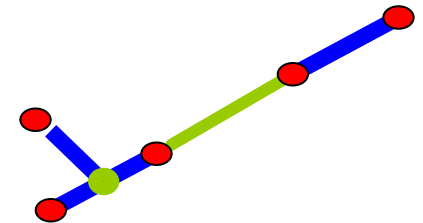


IfcRelConnectsPorts



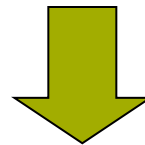
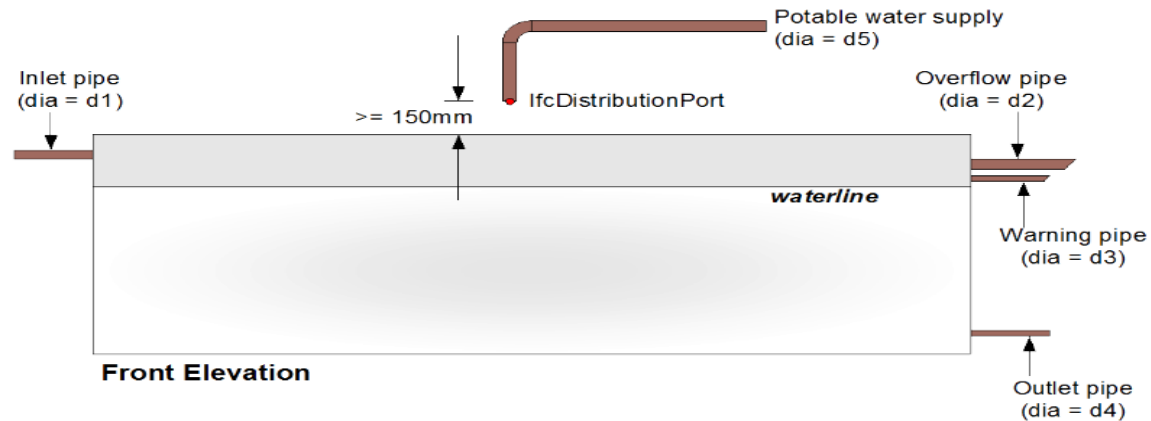
NetworkGraph

InterFeatureLink



```
#405=IFCRELCONNECTSPORTS (' ABCDEFGHIJKLMNOPQ00086' , #9, $, $, #312, #224, $) ;
```

Logical connectivity, no-ports



InterFeatureLinks

undesirable since it could break the useful concept that unfulfilled port describes an open end in pipe.

Findings

- ▶ UtilityNetworkADE provides the primary classes to model IFC interior building utilities
- ▶ *IfcFlowsegment* - a straight element in IFC - therefore it represents an *Interfeaturelink*, it is ports an exterior nodes.
- ▶ Not all IFC entities are implemented or can be converted by IFC editors (e.g. AutoCAD MEP, or ArchiCAD MEP)
- ▶ the current work - unidirectional i.e. from a BIM to CityGML.
- ▶ Bidirectional transformation - support urban upgrading and renovation related tasks where an information model of a building usually does not exist.