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Simplifying and Exchanging 3D Utility Network Objects Using CityModels

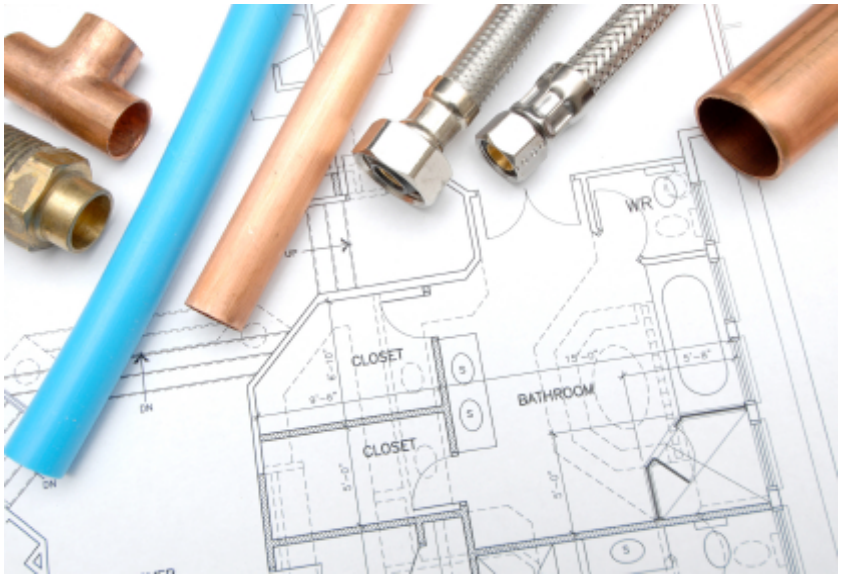

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Table of Contents

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Introduction

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CityGML


Disaster management
Kreis Recklinghausen
Radio network planning
Noise immision mapping
Stapelfeldt GmbH
CityGML
for 3d city models
Police simulator
Rheinmetall Defence Electronics
Business development
& tourism
Kaufhof
Springfield
Leffers
Münsterplatz
Navigation
Facility management
Urban planning
Architecture
Architekturwerkstatt SenStadt Berlin

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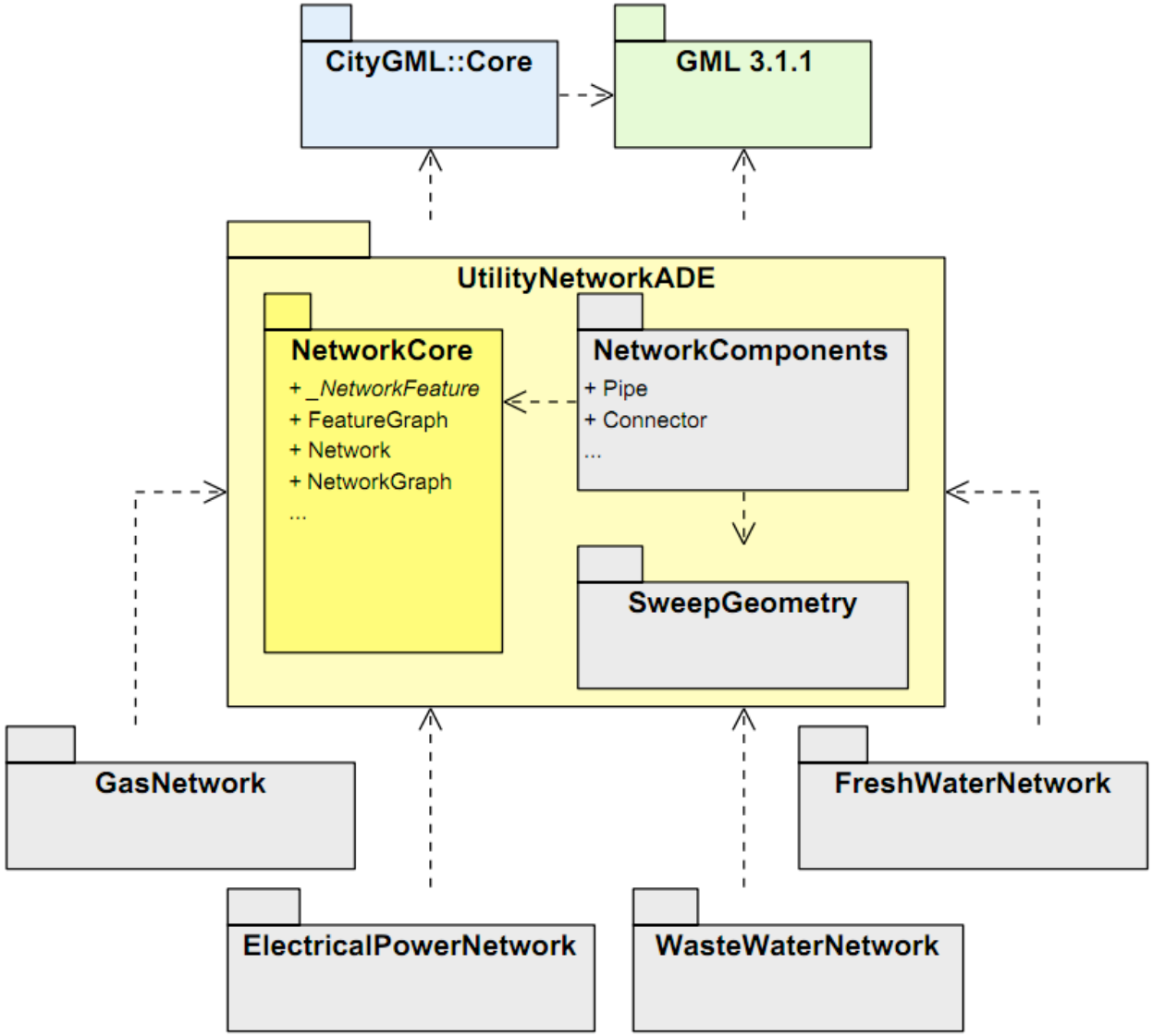
Utility Network ADE



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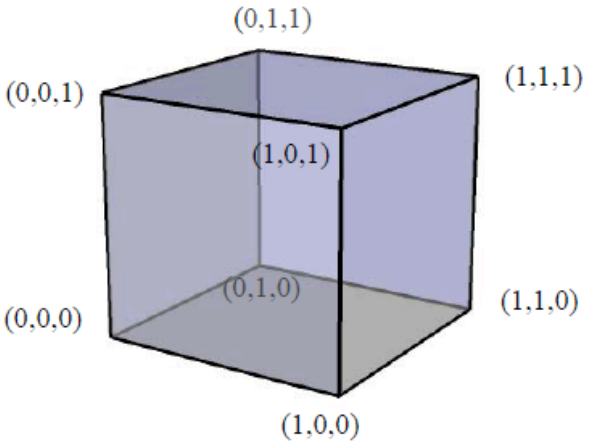
Boundary Representation (BREP)



ID	Vertices
V1	(0,0,0)
V2	(1,0,0)
V3	(1,0,1)
V4	(0,0,1)
V5	(0,1,0)
V6	(1,1,0)
V7	(1,1,1)
V8	(0,1,1)

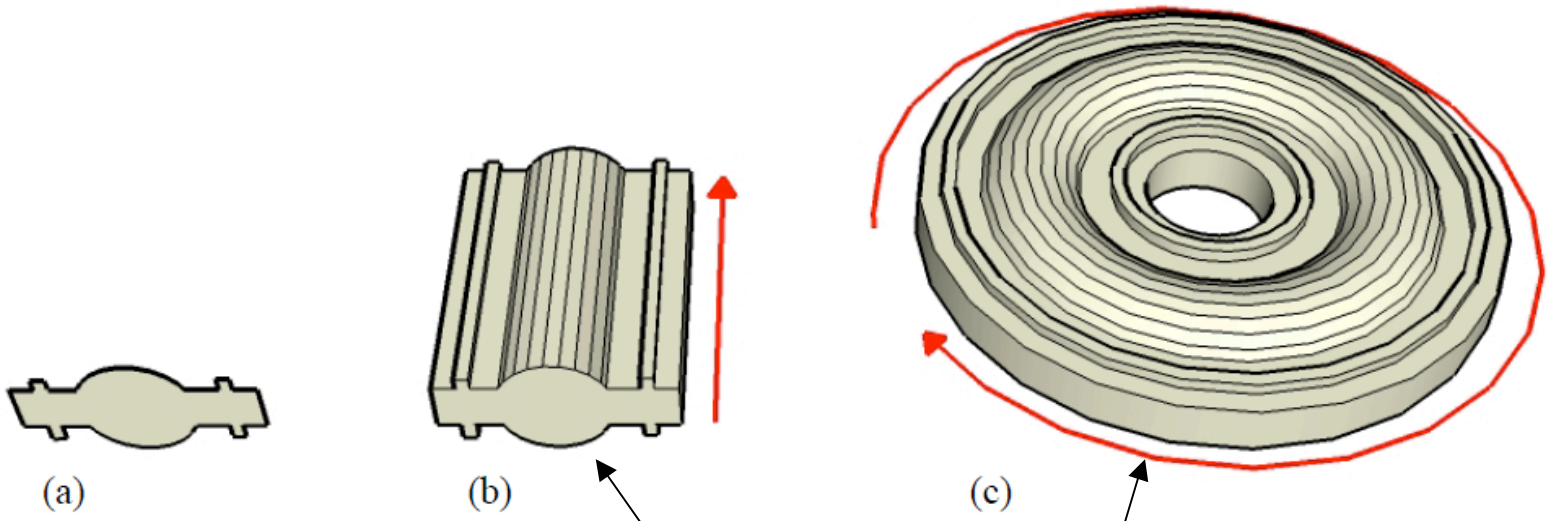
ID	Edges
E1	V1,V2
E2	V2,V3
E3	V3,V4
E4	V4,V1
E5	V1,V5
E6	V2,V6
E7	V3,V7
E8	V4,V8
E9	V5,V6
E10	V6,V7
E11	V7,V8
E12	V8,V5

ID	Faces
F1	E1,E2,E3,E4
F2	E1,E5,E6,E9
F3	E2,E6,E7,E10
F4	E4,E5,E8,E12
F5	E3,E7,E8,E11
F6	E9,E10,E11,E12

(Ekberg 2007)

- ***Commonly used in GIS***
- ***Used by CityGML for objects***
- ***Requires a lot of storage space, especially for network objects***
- ***Low precision***

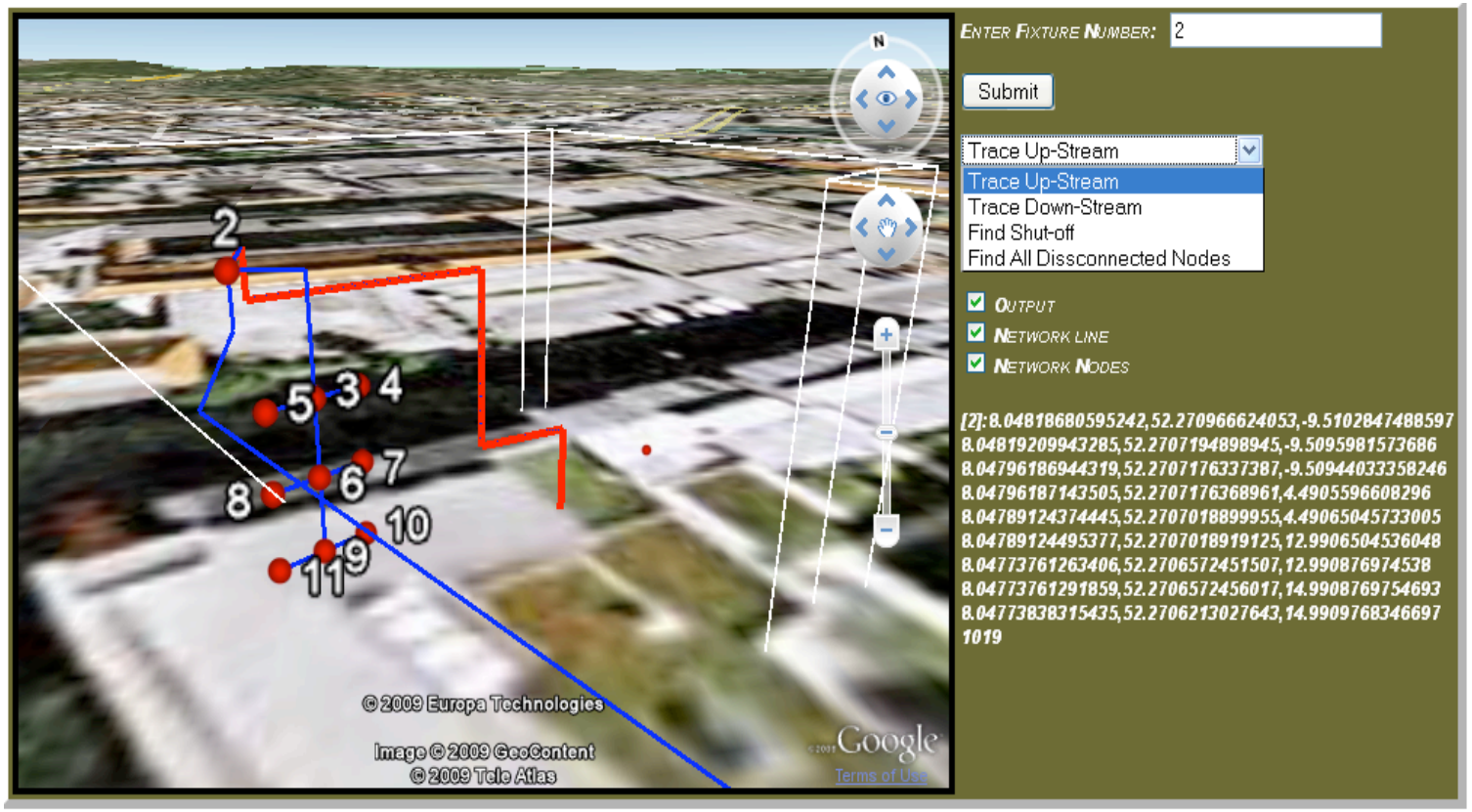
Sweep Representation



(Ekberg 2007)

- *Used in CAD*
- *Suitable for objects with translational or rotational geometry*
- *Proposed by CityGML Utility Network ADE*
- *Requires minimal amount of storage space*
- *High precision*
- *Lack of datatype in GIS*

Application of Sweep Representation



(Hijazi et al 2010)

3D Graph for topological analysis (trace up- and downstream)

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Project Objectives

- *Suggest new GIS datatype compatible to sweep representation*

  → same detail as BREP, less storage space

- *Propose methods for simplification of BREP to sweep representation*

- *To show feasibility: methods for Re-creation the BREP*

- *Output sweep representation conforming to CityGML Utility Network ADE*

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Simplifying 3D Utility Network Objects

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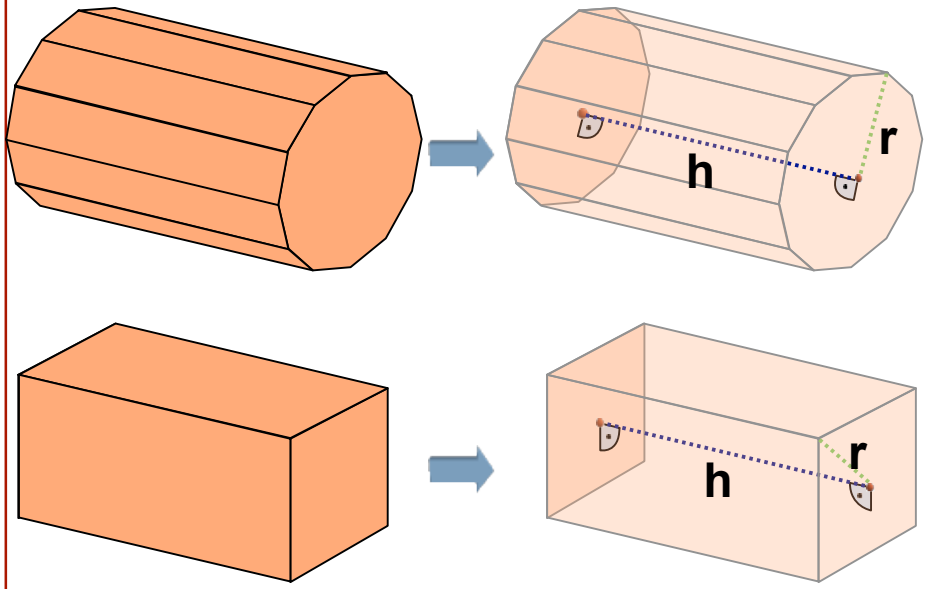
Basic Principle

Basic Idea for Simple Straight Network Objects



- *Centerline = line between ports (h)*
- *Additionally store radius (r)*

→ *Storage as sweep representation*

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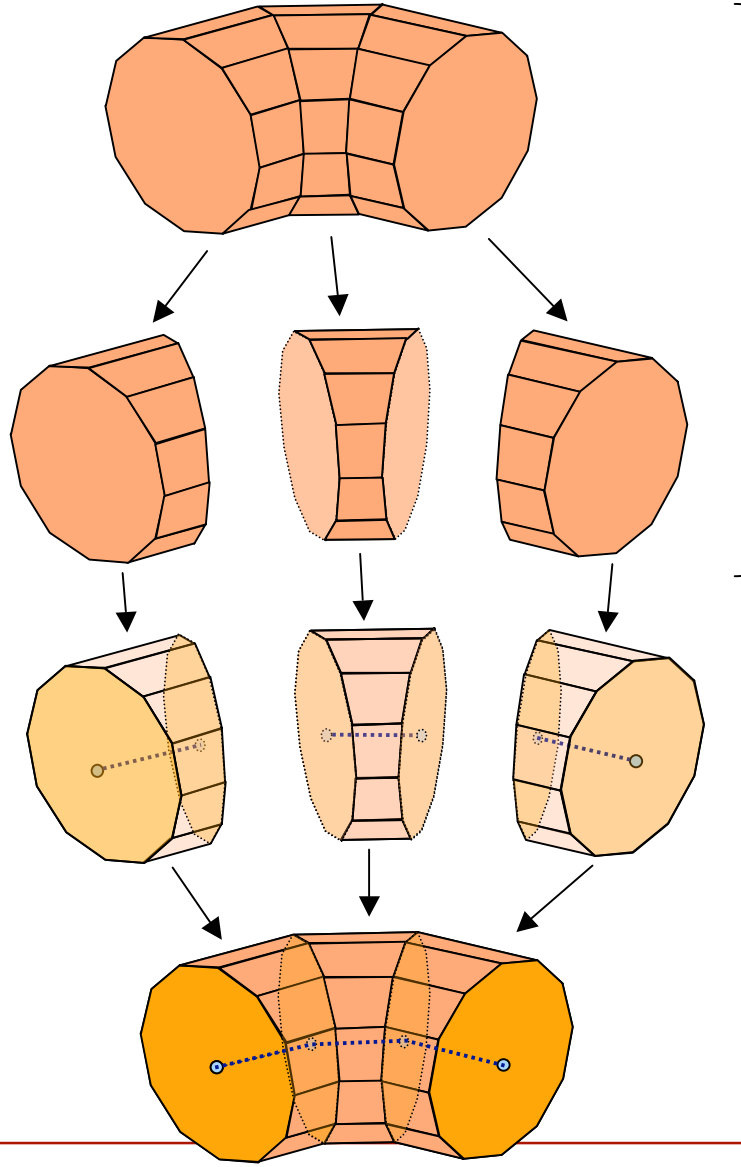
Network Objects with Turns



Each segment = to be treated like singular network object

Extract centerlines

Concatenate!

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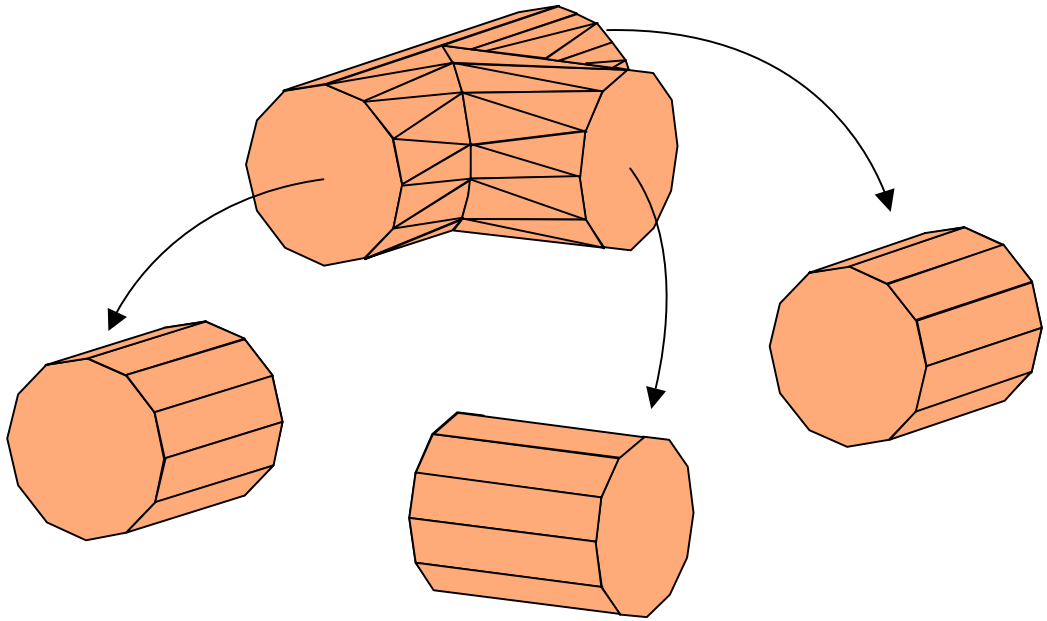
Fittings: Same Idea?



Problem: underneath overlapping parts the faces are cut!

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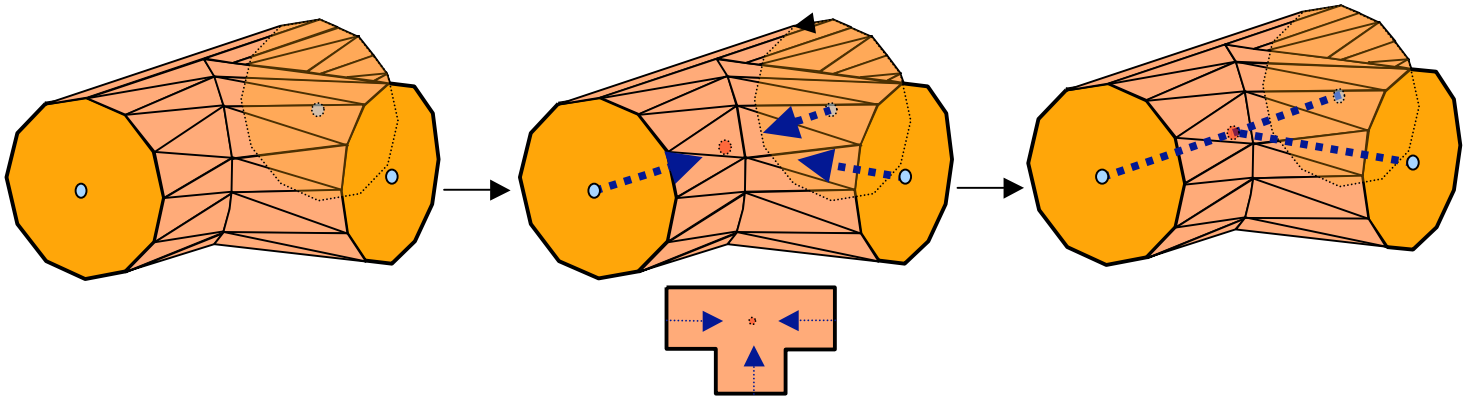
Fittings: Algorithm



1. Calculate centroids

2. Perpendicular to the ports, move towards the inside and determine the intersection point.

3. Connect central point with centroids

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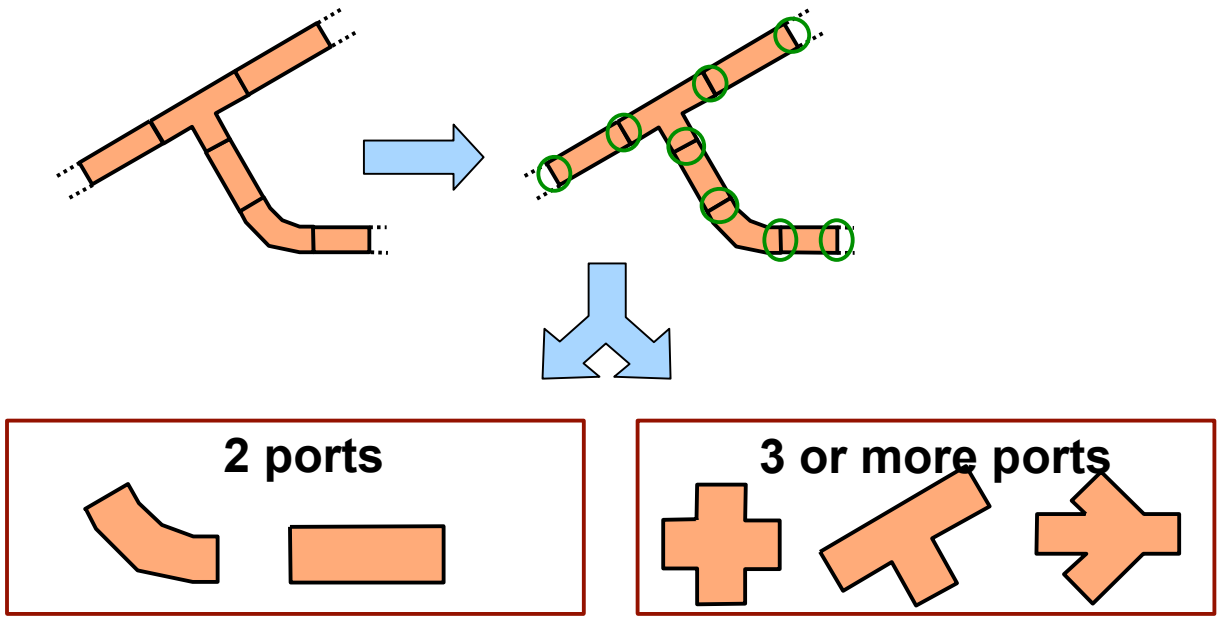
The Utility Network as a Whole



Determine number of ports. For network objects with...

a) ...2 ports: run algorithm for network objects with turns

b) ...3 or more ports: run algorithm for fittings

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Re-Extraction of Boundary Representation

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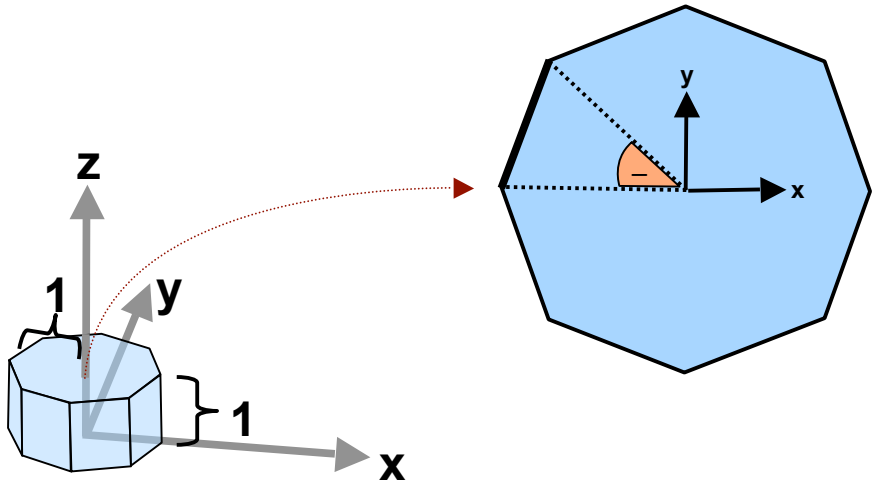
The Idea



1. Create cylinder with known default parameters.

2. Use 3D transformations to fit each segment of the centerline to the axis of the default cylinder.

3. Use the reverse parameters for transforming the cylinder (and the centerline) back to the centerlines original position.

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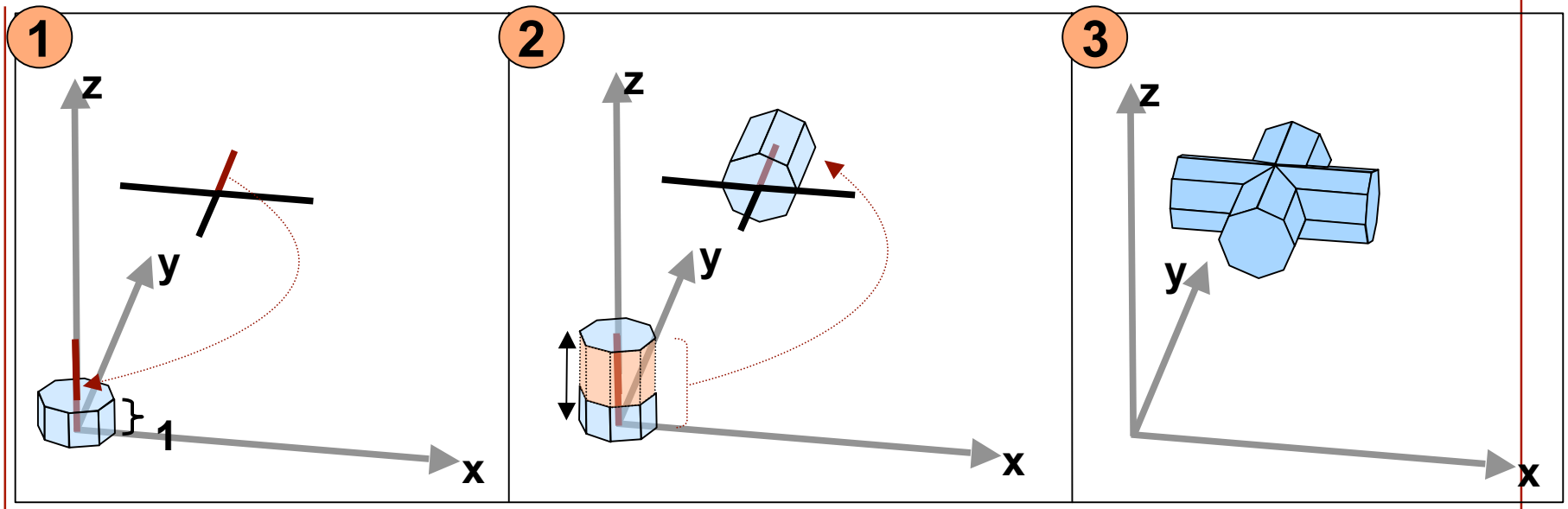
Individual Segments of Centerlines and Fittings



a) Translate into point of origin.

b) Rotation around z-axis into x/y-plane.

c) Rotation around x-axis into z-axis.

d) Scale cylinder into positive z-axis direction to length of centerline.

e) Reverse transformations for c, b, and a.

f) Do this for all segments.

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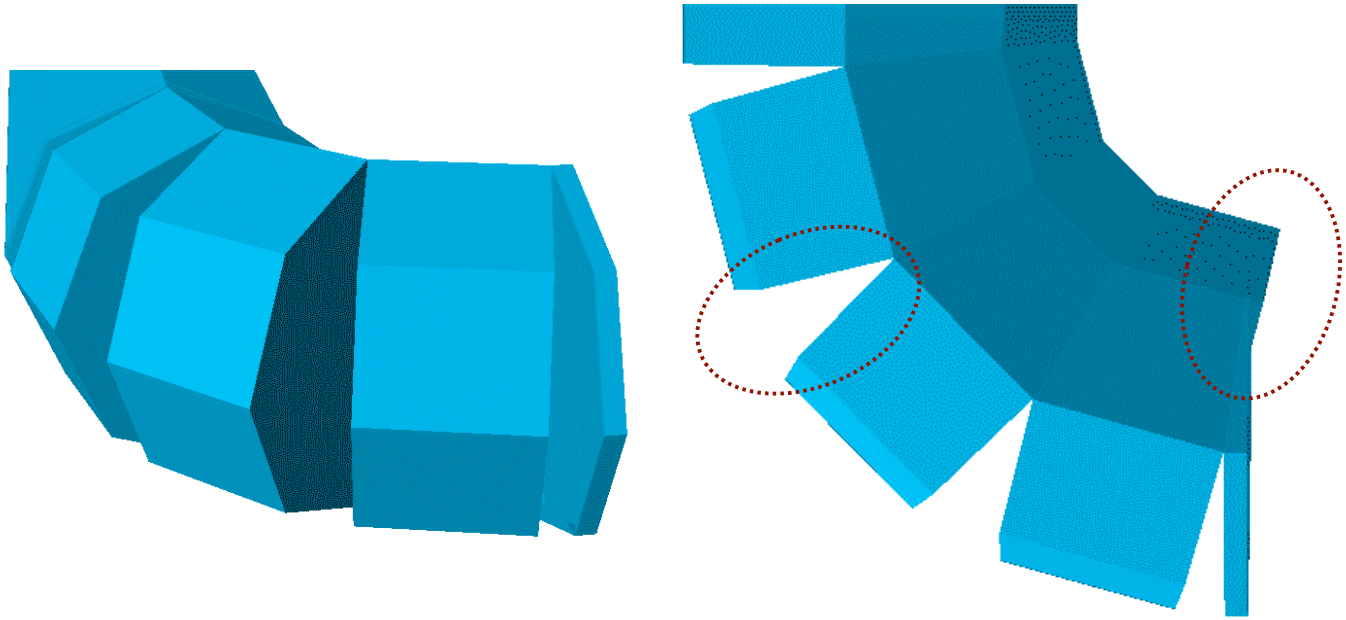
Network Objects with Turns (1): The Problem



Problems applying the previously introduced approach

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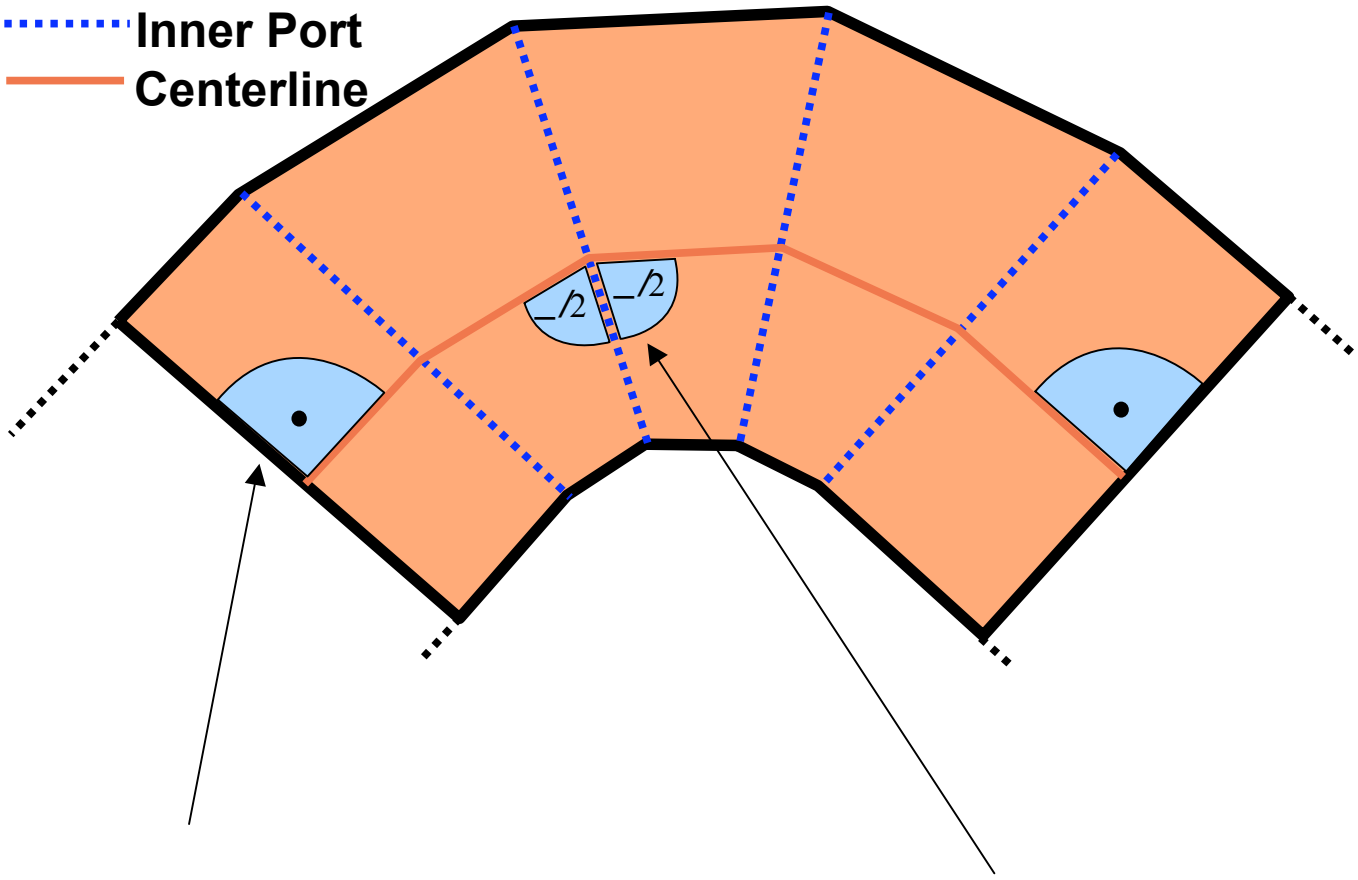
Network Objects with Turns (2): Solution



Outer ports perpendicular

Inner ports not!

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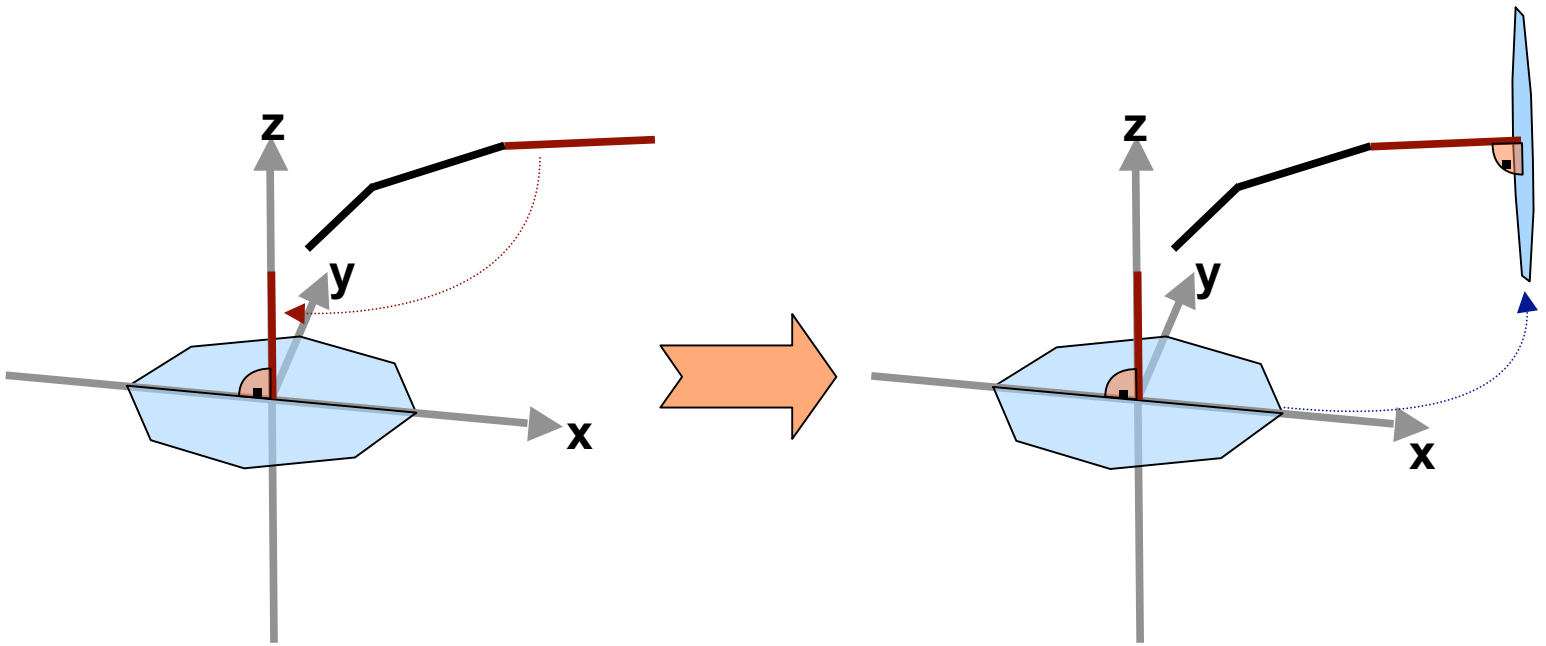
Positioning of Outer Ports



a) Transform first segment into z-axis with starting point into the point of origin.

b) create port in x/y-plane.

c) Reverse both transform back.

d) Same for last segment and end point.

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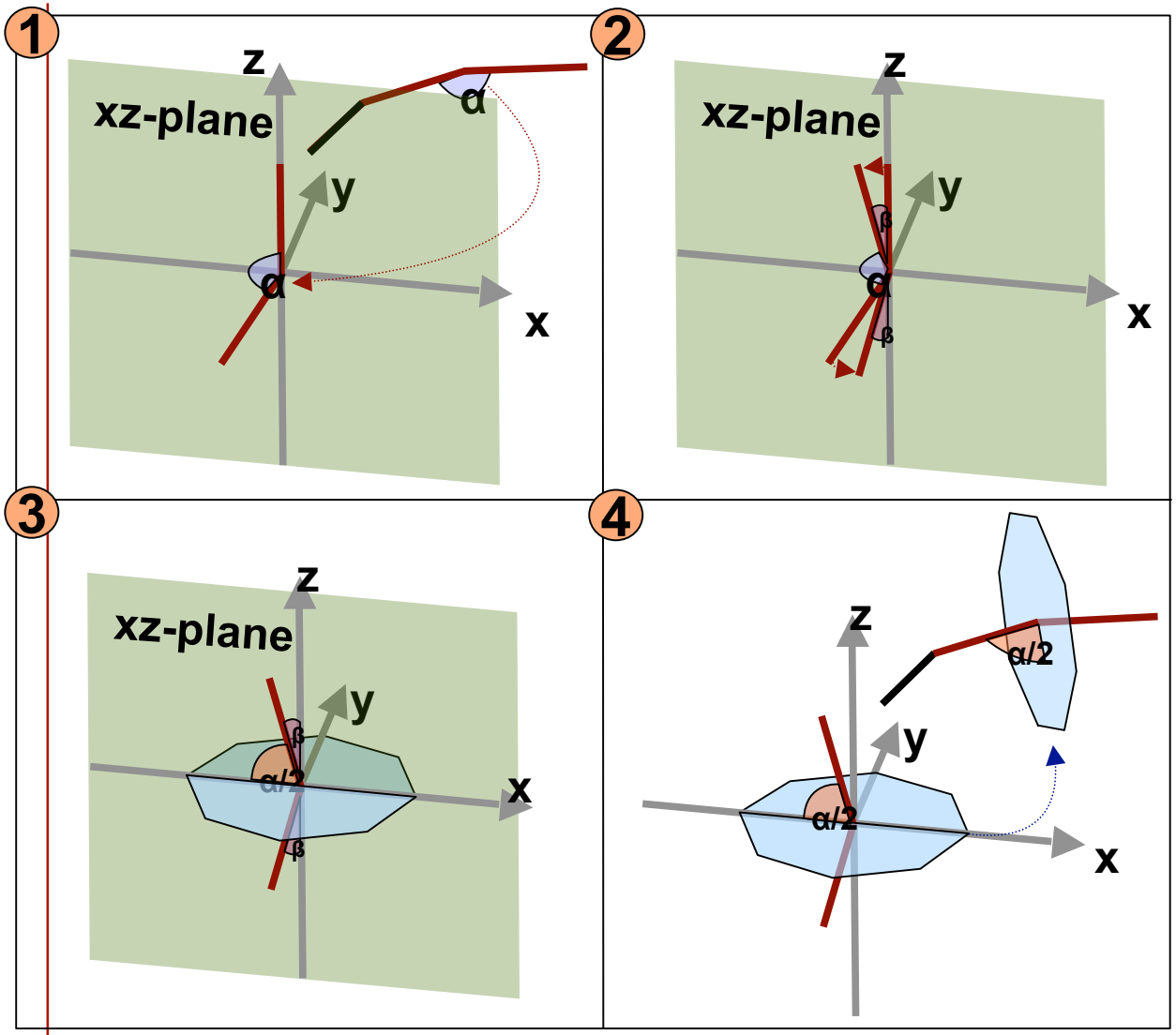
Positioning of Inner Ports



1. Transform consecutive line segments with sharing point matching point of origin with angle α staying the same

2. Rotate segments around y-axis, so x-axis halves α

3. Create port in x/y-plane again

4. Reverse transform

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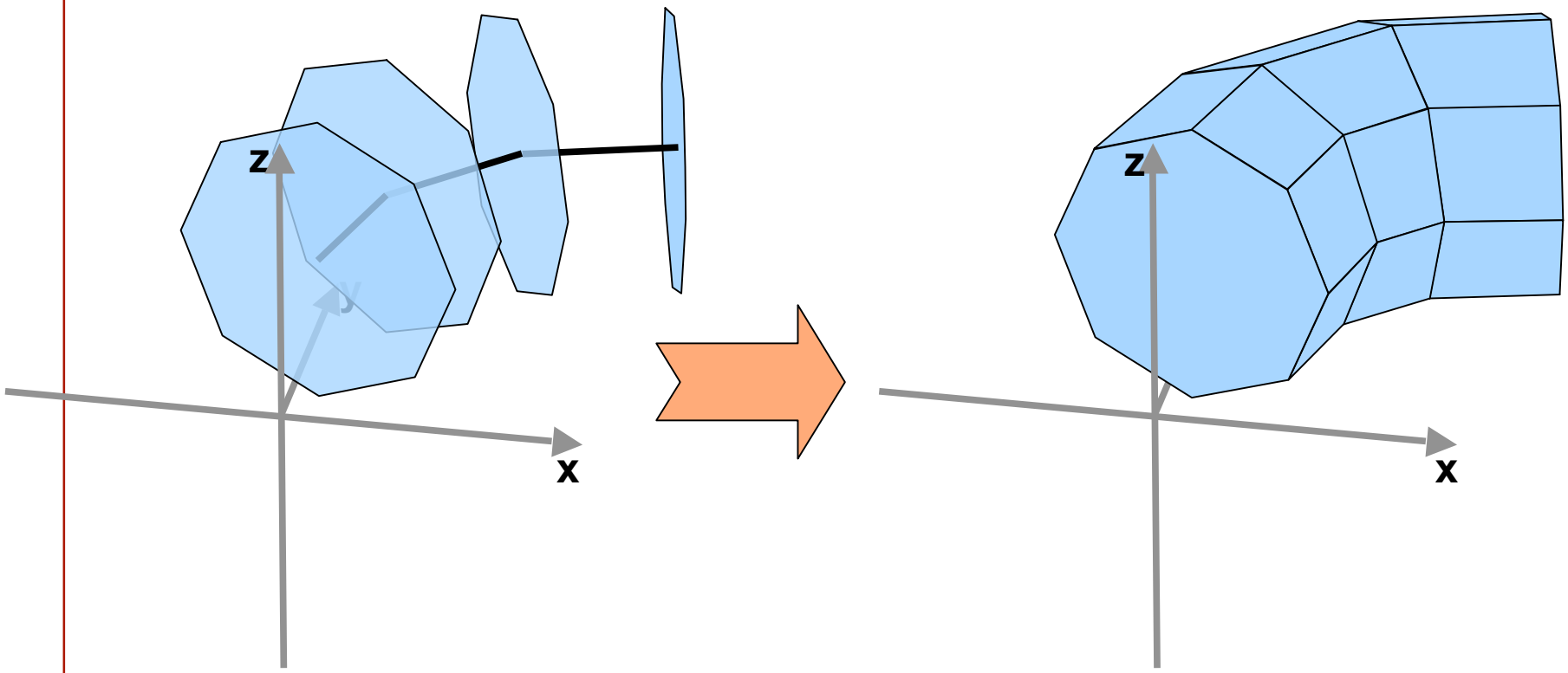
Creating Surfaces for the Lateral Area



Create surfaces for lateral area by connecting the ports.

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Implementation and CityGML Output

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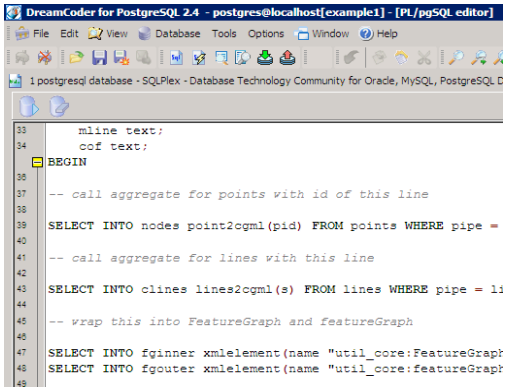
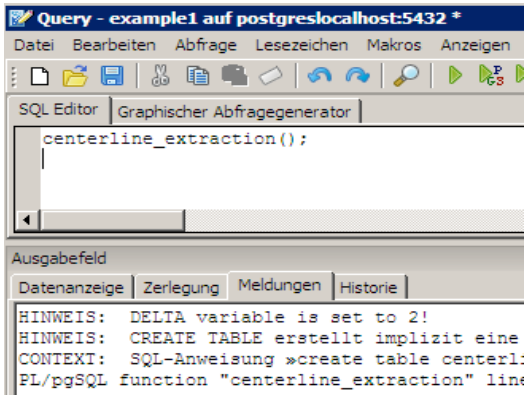
Development Environment

DreamCoder



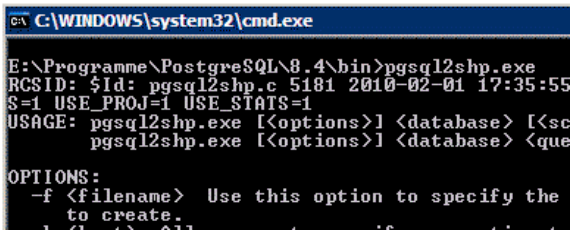
DBMS Input

pgAdmin



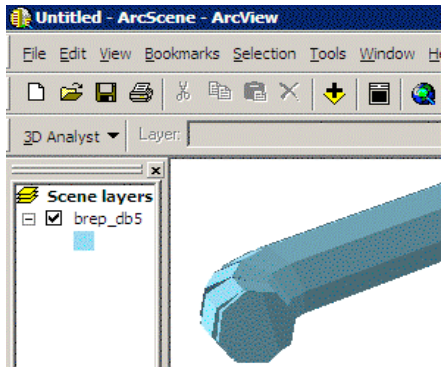
Shapefile Output

pgsql2shp



Visualization

ArcScene



Revision

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Comparison of Memory Requirements

Database	n	Network Objects	Vertices B-rep	Vertices Sweep Rep.	Ratio
example1	12	4 simple, 1 cross fitting (4 segments)	3960	16	0,0040
example2	12	3 simple, 1 t-fitting (3 segments)	2367	12	0,0051
example3	12	3 simple, 1 t-fitting (3 segments)	1955	12	0,0055
example4	12	4 simple, 1 cross fitting (4 segments)	2921	16	0,0055
example5	12	1 simple, 1 with turns (5 segments)	1470	8	0,0054
example6	12	2 simple, 1 with turns (5 segments)	1732	10	0,0058

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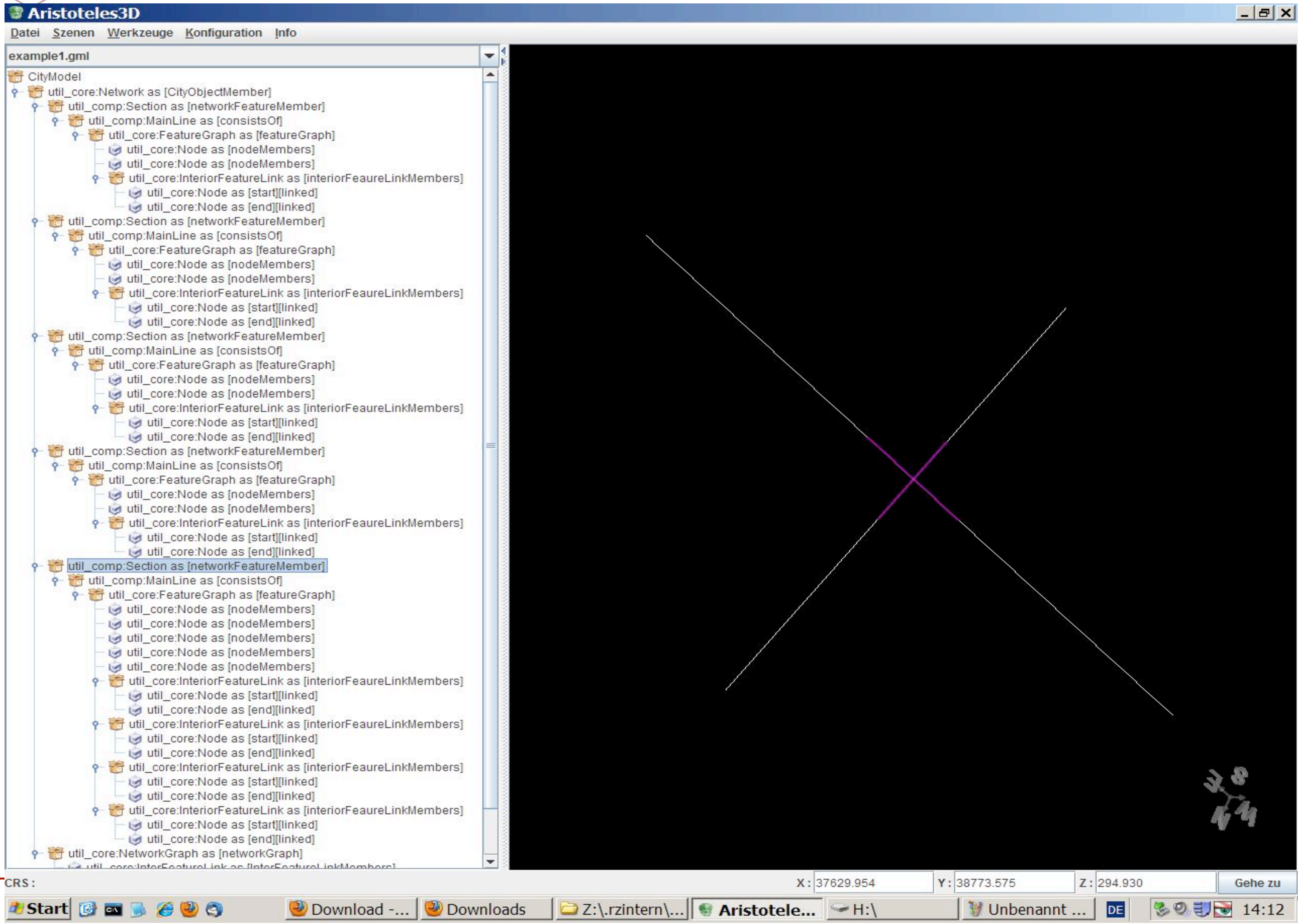
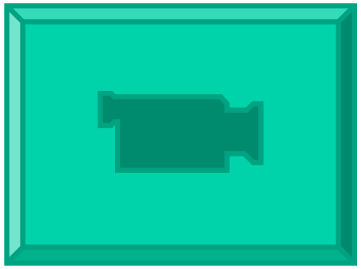
CityGML Output





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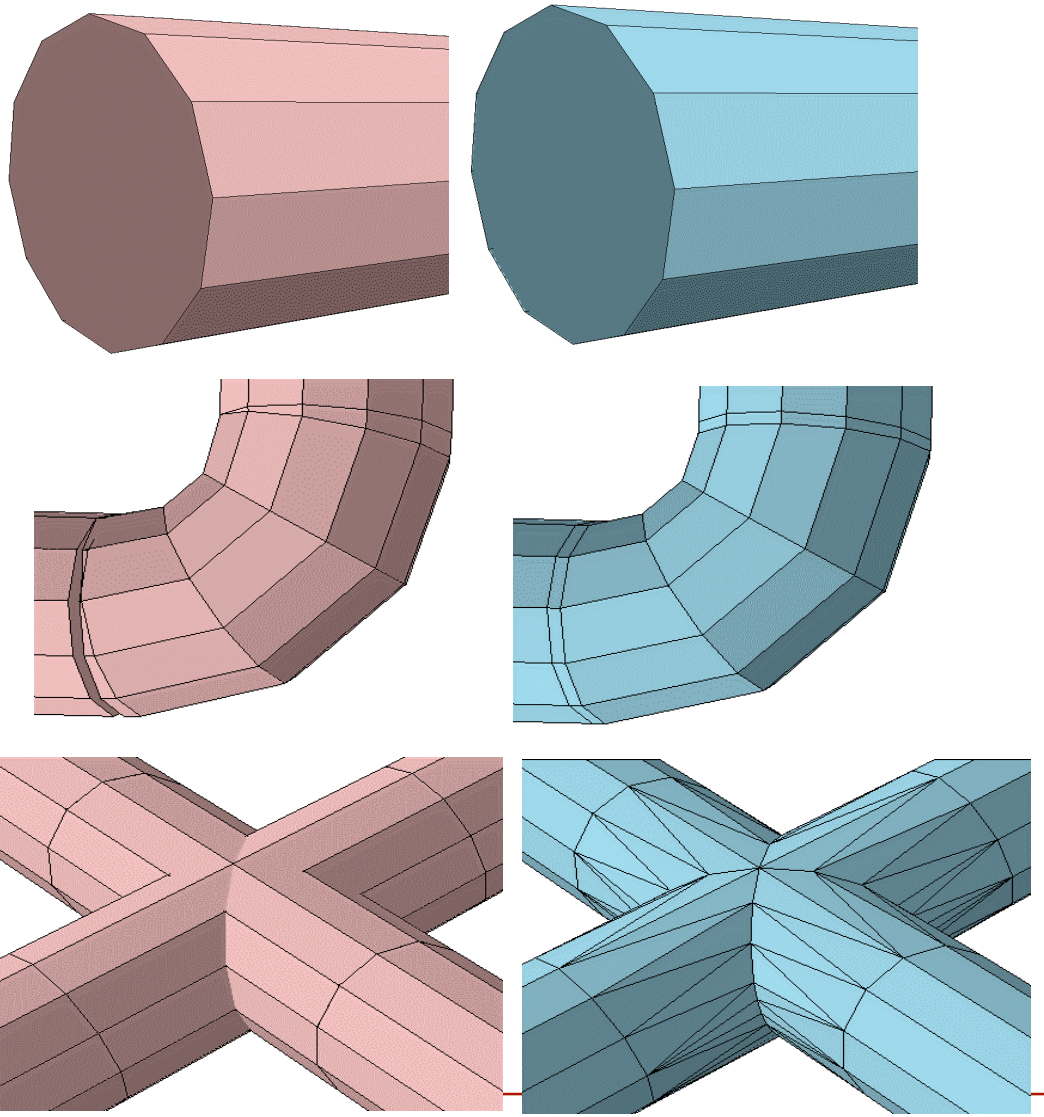
Comparison to Original BREP

SWEEP REP

BREP



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Conclusions

- *New GIS datatype compatible to sweep representation as used in CAD provides similar detail as BREP*
- *Storage space is reduced by a factor of 1:300 – 1:500*
- *BREP can be transformed to sweep representation*
- *BREP can be recreated from sweep representation*
- *Output sweep representation conforms to CityGML Utility Network ADE*

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For more Information please contact

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