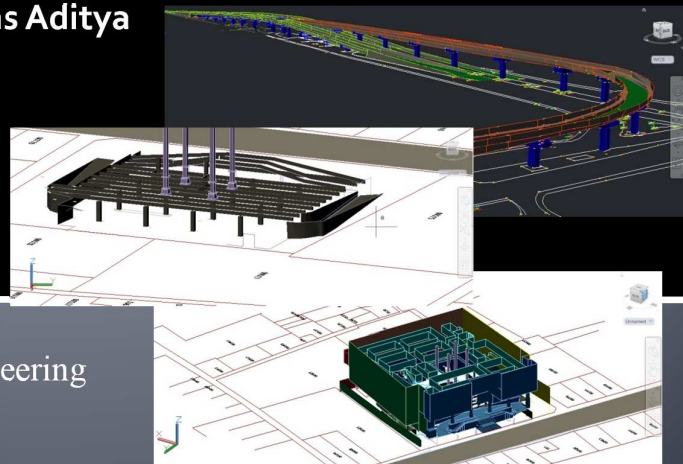




XXV FIG CONGRESS
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Development of Structure-based Topology of 3D Spatial Databases for Storing and Querying 3D Cadastre Cases

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Trias Aditya



Department of Geodetic Engineering
Faculty of Engineering
Gadjah Mada University
Indonesia

Utilization of Space

43 - 2D representation for 3D objects registration: Apartment registration only, below and top of the land surface has not been regulated

KONSEP TAMPILAN DAN ARSITEKTUR

Sudirman Station Interchange

STASIUN KA BANDARA

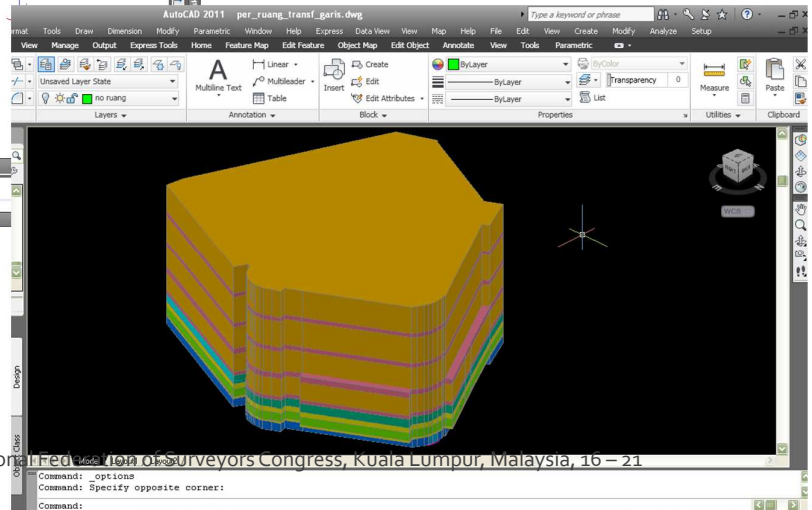
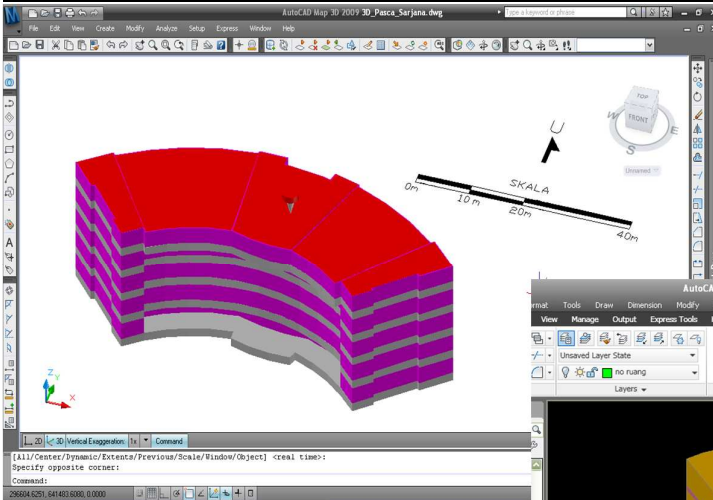
SUDIRMAN STATION INTERCHANGE

Current Situation on 3D registration in Indonesia

3D registration needs effective 3D spatial databases



Visualization

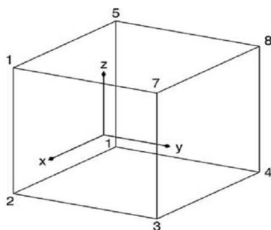


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3D Spatial Database

Geometry-based



BODY

FACE

BID	FID	FID	sdo_ordinate array
1	1	1 (lower face)	x4,y4,z4, x3,y3,z3, x2,y2,z2, x1,y1,z1, x4,y4,z4
1	2	2 (side 1)	x3,y3,z3, x4,y4,z4, x8,y8,z8, x7,y7,z7, x3,y3,z3
1	3	3 (side 2)	x4,y4,z4, x1,y1,z1, x5,y5,z5, x8,y8,z8, x4,y4,z4
1	4	4 (side 3)	x1,y1,z1, x2,y2,z2, x6,y6,z6, z5,y5,z5, x1,y1,z1
1	5	5 (side 4)	x3,y3,z3, x2,y2,z2, x6,y6,z6, z7,y7,z7, x3,y3,z3
1	6	6 (upper face)	x5,y5,z5, x6,y6,z6, x7,y7,z7, z8,y8,z8, x5,y5,z5

Topology-based



- Hypothesis
- To increase data quality and data consistency
- Execution time of spatial operation faster

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Data

- Spatial Data of Rusun Plasa Simpanglima Semarang.
 - 3D coordinates (X, Y, Z)
 - Format : CAD
 - Reference Coordinate System : Universal Transverse Mercator (UTM)
 - Survey Instrument : Total Station (TS) Leica reflectorless TCR805
 - Years of Measurement : 2011

- Attribute Data of Rusun Plasa Simpanglima Semarang



Methods



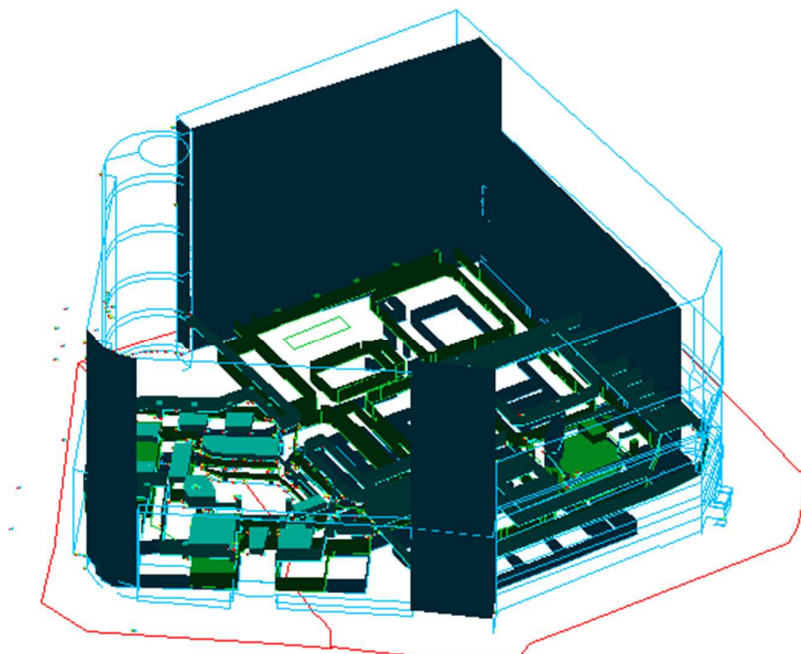
Phases of the Data Analysis

1. Spatial Data Editing
2. Spatial Data Storing into PostgreSQL
3. Creating Tables and Updating the Database Attribute
4. Development of the Topology-Based Structure
5. Analyses



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June 2014

1. Spatial Data Editing... (I)

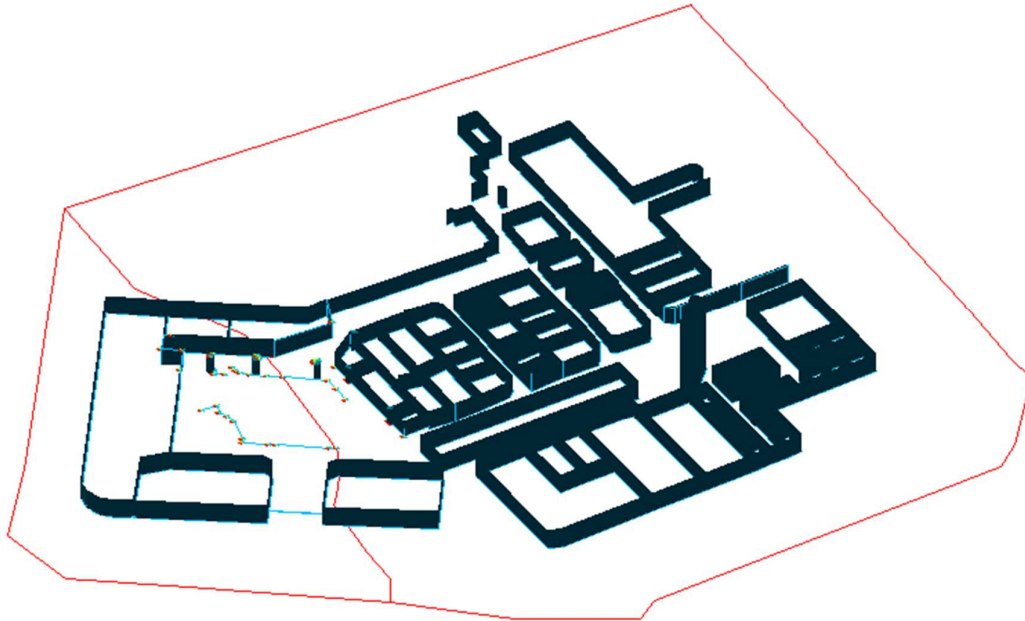


Rusun Plasa Simpanglima

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June 2014



1. Spatial Data Editing ... (II)

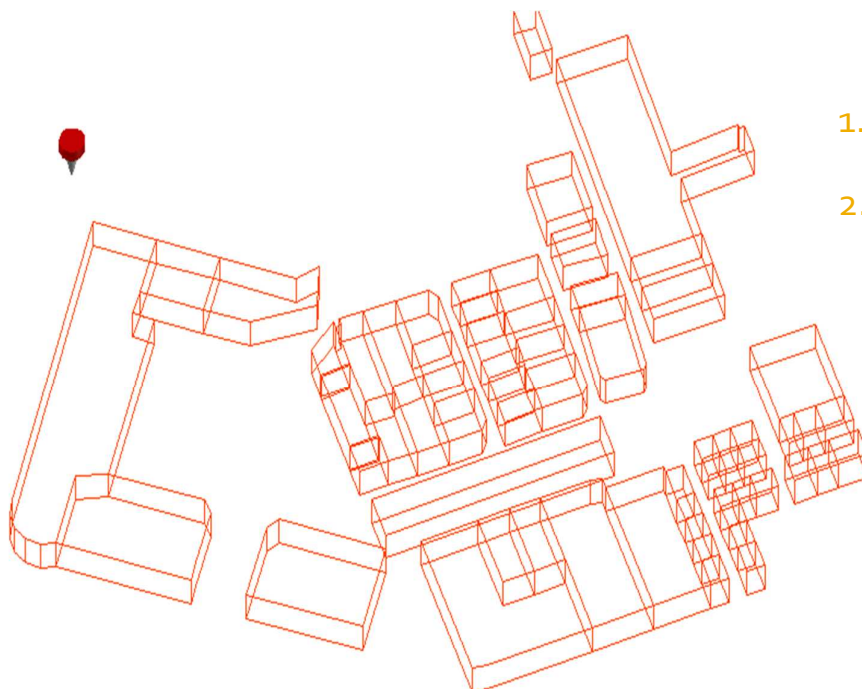


First Floor of the Rusun Plasa Simpanglima

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1. Spatial Data Editing ... (III)




1. Boundary Parcel
2. Rooms

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2. Spatial Data Storing into PostgreSQL ... (I)

I. Importing Spatial Data into KML Format

```


41 </Style>
42 <MultiGeometry>
43 <LineString>
44 <altitudeMode>relativeToGround</altitudeMode>
45 <coordinates>
46 110.4246289198149,-6.9898418124004,38.705 110.4245119089336,-6.9899102182508,38.705
47 </coordinates>
48 </LineString>
49 <LineString>
50 <altitudeMode>relativeToGround</altitudeMode>
51 <coordinates>
52 110.4245119089326,-6.9899102182518,38.705 110.4245596617195,-6.9899917637659,38.705
53 </coordinates>
54 </LineString>
55 <LineString>
56 <altitudeMode>relativeToGround</altitudeMode>
57 <coordinates>
58 110.4245596617186,-6.9899917637669,38.705 110.4246672913477,-6.9899288804181,38.705
59 </coordinates>
60 </LineString>
61 <LineString>
62 <altitudeMode>relativeToGround</altitudeMode>
63 <coordinates>
64 110.4246672913467,-6.9899288804191,38.705 110.4246701775111,-6.9899123091870,38.705
65 </coordinates>
66 </LineString>
67 <LineString>
68 <altitudeMode>relativeToGround</altitudeMode>
69 <coordinates>
70 110.4246701775101,-6.9899123091880,38.705 110.4246289198159,-6.9898418123994,38.705
71 </coordinates>
72 </LineString>
73 </MultiGeometry>

```



2. Spatial Data Storing into PostgreSQL ... (II)

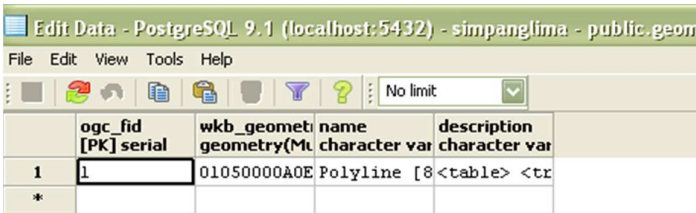
II. Conversion KML Format into PostgreSQL




```

D:\SimpangLima\project_kml\garis>ogr2ogr -f "PostgreSQL" PG:"host=localhost user=postgres dbname=simpanglima password=postgres" 1_a.kml -nln geometri -t_srs "EPSG:32749"

```



ogc_fid	wkb_geomet	name	description
[PK] serial	geometry(Mu	character var	character var
1	01050000A0E	Polyline [8	<table><tr
*			



```

D:\SimpangLima\project_kml\garis>ogr2ogr -append -f "PostgreSQL" PG:"host=localhost user=postgres dbname=simpanglima password=postgres" 2_a.kml -nln geometri -t_srs "EPSG:32749"

```

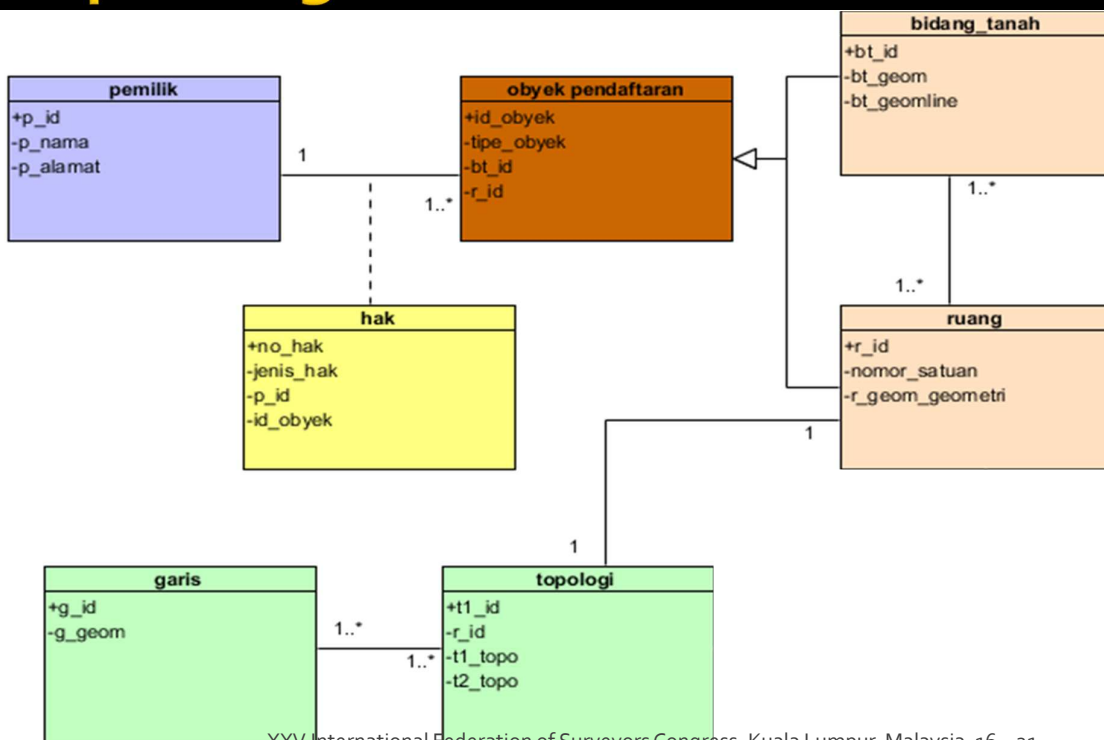


2. Spatial Data Storing into PostgreSQL ... (III)

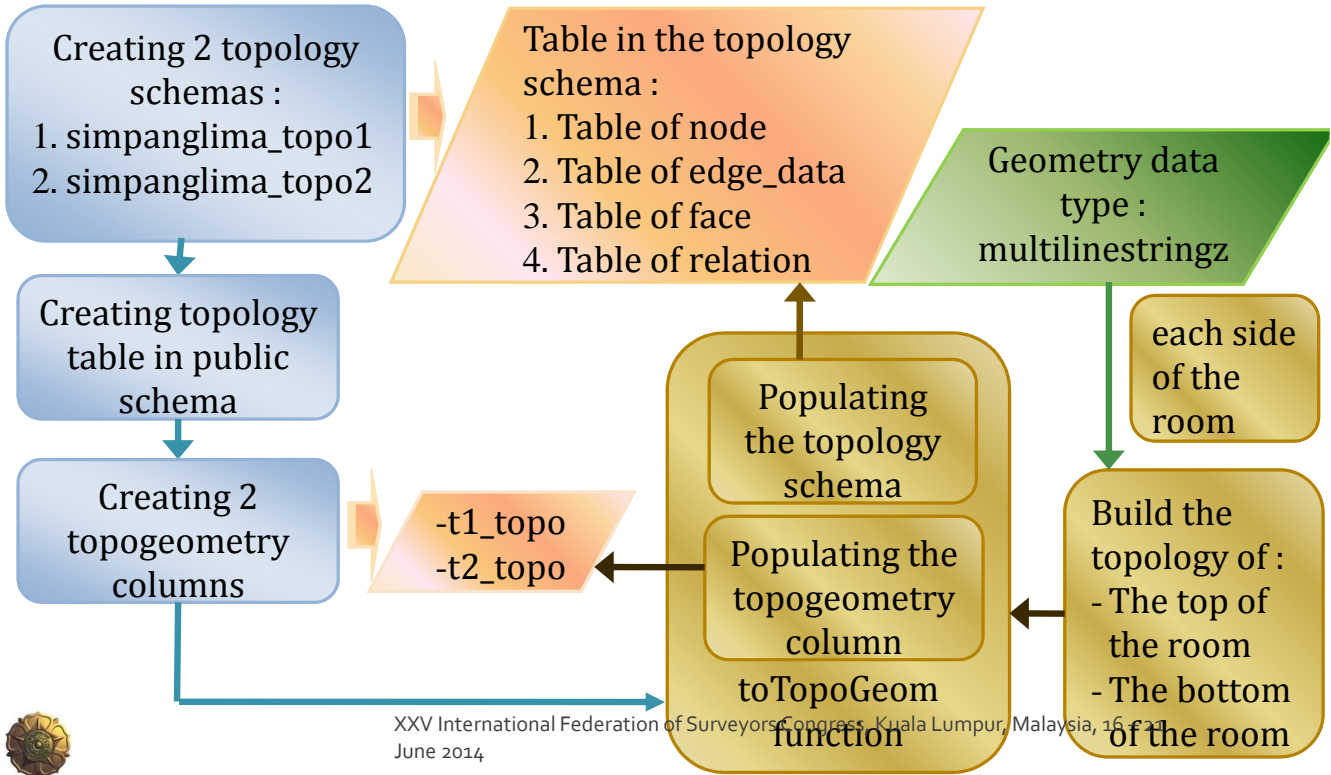
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3. Creating Table and Updating Database Attribute

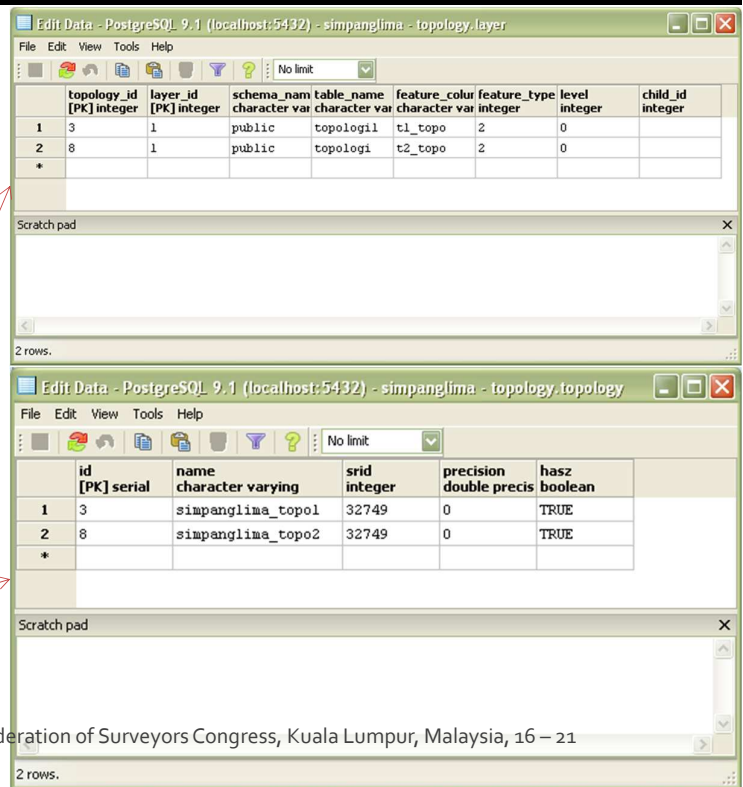
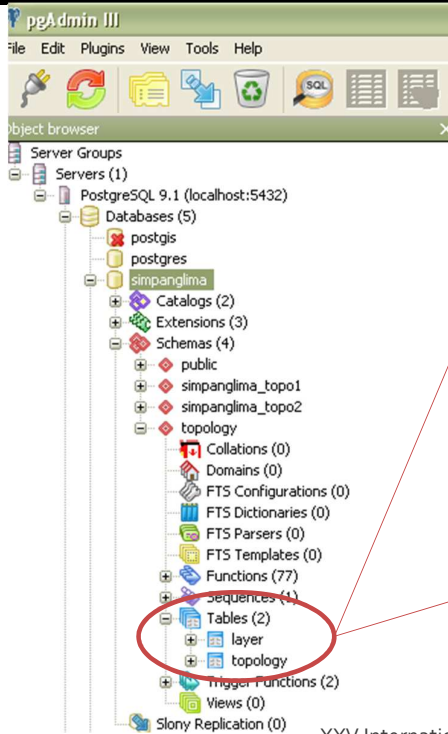


4. Development of the Topology-based Structure



Results

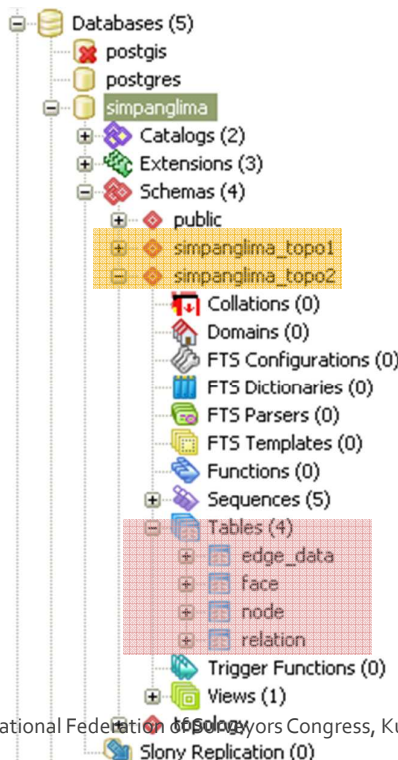
Topology-Based Structure Database ... (I)



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Topology-Based Structure Database ... (II)



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Topology-Based Structure Database ... (III)

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Topology-Based Structure Database ... (IV)

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Topology-Based Structure Database ... (V)

	face_id [PK] serial	mbr geometry(Polygon,32749)
1	0	
2	1	0103000020ED7F00000100000005000000
3	2	0103000020ED7F00000100000005000000
4	3	0103000020ED7F00000100000005000000
5	4	0103000020ED7F00000100000005000000
6	5	0103000020ED7F00000100000005000000
7	6	0103000020ED7F00000100000005000000

Scratch pad

65 rows.

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Topology-Based Structure Database ... (VI)

	topogeo_id integer	layer_id integer	element_id integer	element_type integer
1	1	1	4	2
2	1	1	6	2
3	1	1	1	2
4	1	1	2	2
5	1	1	3	2
6	1	1	7	2
7	1	1	5	2
8	1	1	8	2
9	2	1	9	2
10	2	1	3	2
11	2	1	10	2
12	2	1	4	2
13	3	1	11	2

Scratch pad

316 rows.

	t1_id [PK] integer	r_id character var	t1_topo topogeometry	t2_topo topogeometry
1	1	r_001	(3,1,1,2)	(8,1,1,2)
2	2	r_002	(3,1,2,2)	(8,1,2,2)
3	3	r_003	(3,1,3,2)	(8,1,3,2)
4	4	r_004	(3,1,4,2)	(8,1,4,2)
5	5	r_005	(3,1,5,2)	(8,1,5,2)
6	6	r_006	(3,1,6,2)	(8,1,6,2)
7	7	r_007	(3,1,7,2)	(8,1,7,2)
8	8	r_008	(3,1,8,2)	(8,1,8,2)
9	9	r_009	(3,1,9,2)	(8,1,9,2)
10	10	r_010	(3,1,10,2)	(8,1,10,2)

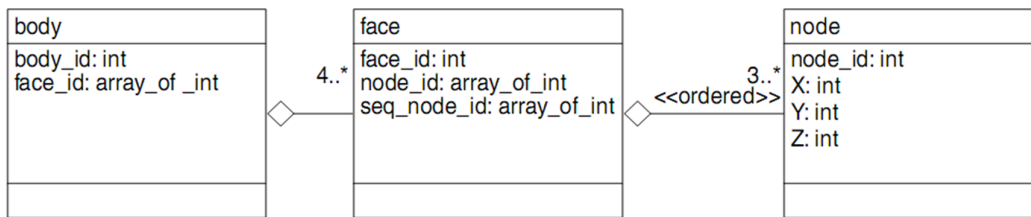
Scratch pad

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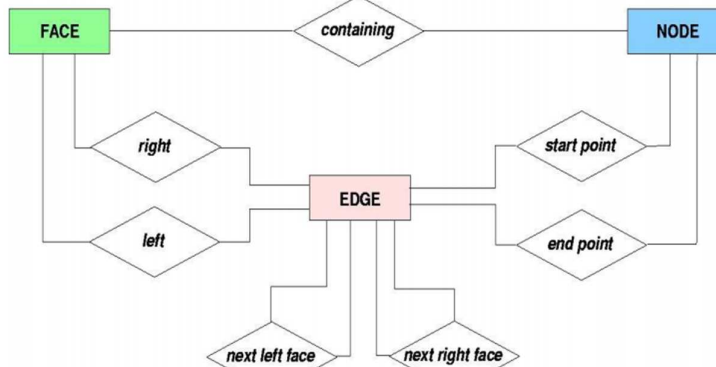


Topology-based structure

- The relationship:

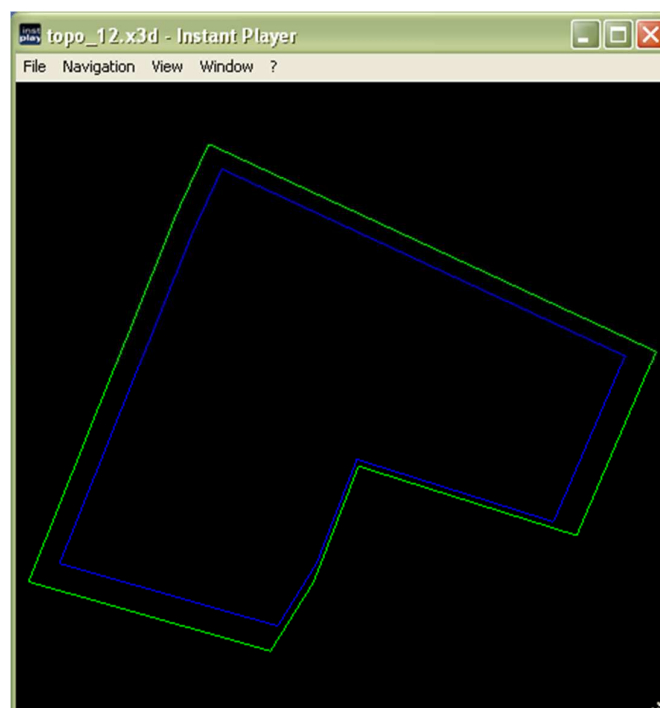


- 2.5 D Topological approach of PostGIS 2.0:



Sandro Santilli <strk@keybit.net> XXV International Federation of Surveyors Congress, Kuala Lumpur, Malaysia, 16 – 21 June 2014 <http://strk.keybit.net>

Topology-Based Structure Database ... (VII)



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Analyses



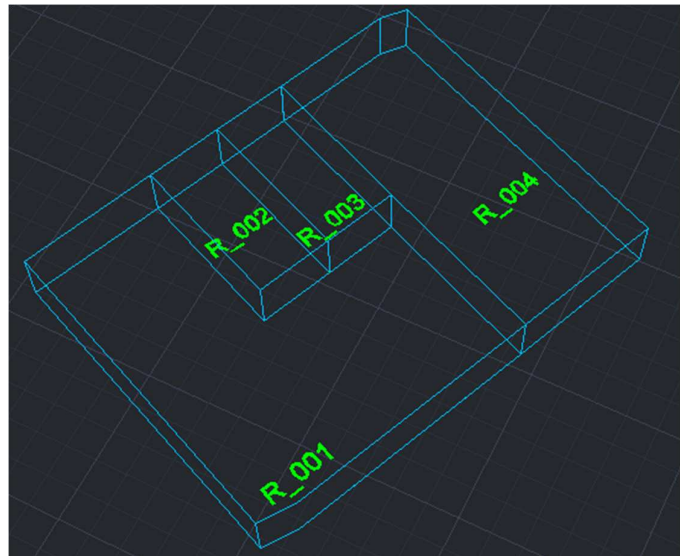
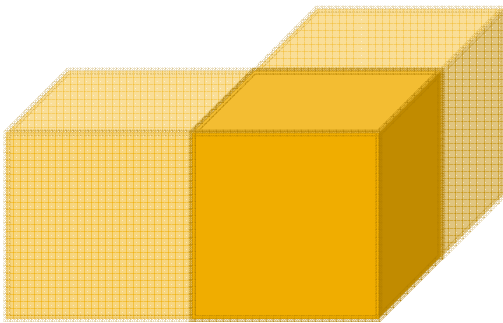
Analyses of Real Cadastre Case ... (I)

From 12 possible cases, 5 cases that can be resolved

- Case 1 : Shows the room which is directly adjacent to a specified room (in a horizontal direction).
- Case 3 : Indicate in which land parcel the room on the first floor was located.
- Case 5 : Inform rooms on the first floor that their entire room floor are above a certain land parcel.
- Case 7 : Mention rooms on the first floor which is above the two land parcels at once.
- Case 9 : Shows the line geometry that is the boundary of the wall directly adjacent to or shared with in a horizontal direction.



Case 1



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Analyses of Real Cadastre Case ... (II) :: Resolving Case 1 ::



Query - simpanglima on postgres@localhost:5432 - [D:\SimpangLima\project_sql\simpanglima...

File Edit Query Favourites Macros View Help

SQL Editor Graphical Query Builder

Previous queries [v] Delete Delete All

```
-- Menunjukkan ruang mana saja yang bersebelahan secara langsung di kiri, kanan, depan,  
-- maupun belakang ruang 001 (r_001) (arah horisontal)  
  
select r_id as ruang  
  
from (select st_asewkb(tl_topo) as p from topologi where r_id='r_001') as a,  
(select r_id, st_asewkb(tl_topo) as q from topologi where not r_id = 'r_001') as b  
  
where st_overlaps(st_geomfromewkb(a.p),st_geomfromewkb(b.q))
```

Output pane

Data Output Explain Messages History

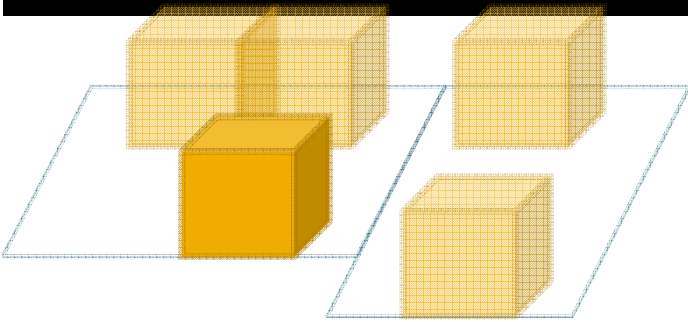
	ruang character varying(10)
1	r 002
2	r 003
3	r 004

OK. Unix Ln 1, Col 1, Ch 1 3 rows. 62 ms

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Case 3



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Analyses of Real Cadastre Case ... (III) :: Resolving Case 3 ::



Query - simpanglima on postgres@localhost:5432 - [D:\Simpanglima\project_sql\simpanglima...

File Edit Query Favourites Macros View Help

SQL Editor Graphical Query Builder

Previous queries [v] Delete Delete All

```
-- Menunjukkan di bidang mana tepatnya ruang 024 (r_024) pada lantai satu berada di atasnya  
select geom2.bt_id as bidang_tanah  
  
from (select st_asewkb(t2_topo) as a from topologi where r_id='r_024') as geom1,  
      (select bt_id, st_makepolygon(st_addpoint(geom.g, st_startpoint(geom.g))) as b  
       from (select bt_id, bt_geoline as g from bidang_tanah) as geom) as geom2  
where st_contains(st_geomfromewkb(geom2.b), st_geomfromewkb(geom1.a))
```

Output pane

Data Output Explain Messages History

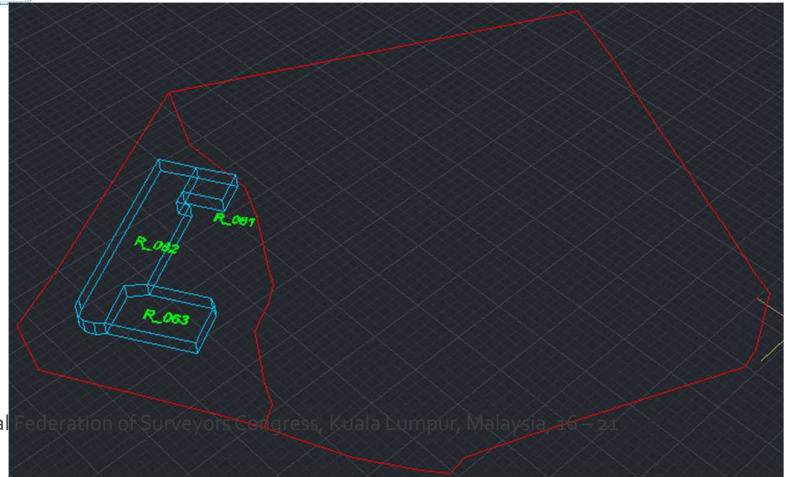
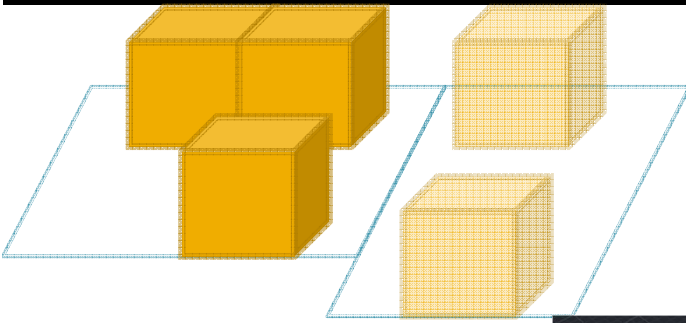
bidang_tanah
integer
1

OK. Unix Ln 1, Col 1, Ch 1 1 row. 110 ms



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Case 5



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Analyses of Real Cadastre Case ... (IV) :: Resolving Case 5 ::



Query - simpanglima on postgres@localhost:5432 - [D:\Simpanglima\project_sql\simpanglima...

File Edit Query Favourites Macros View Help

SQL Editor Graphical Query Builder

Previous queries [v] Delete Delete All

```
-- Menginformasikan ruang-ruang mana saja pada lantai satu yang keseluruhan ruangan tersebut  
-- berada di atas bidang tanah dengan bt_id adalah 2  
  
select geom1.r_id as bidang_tanah  
  
from (select r_id, st_asewkb(t2_topo) as a from topologi) as geom1,  
(select st_makepolygon(st_addpoint(geom.g, st_startpoint(geom.g))) as b  
from (select bt_geomline as g from bidang_tanah where bt_id=2) as geom) as geom2  
  
where st_contains(st_geomfromewkb(geom2.b), st_geomfromewkb(geom1.a))
```

Output pane

Data Output Explain Messages History

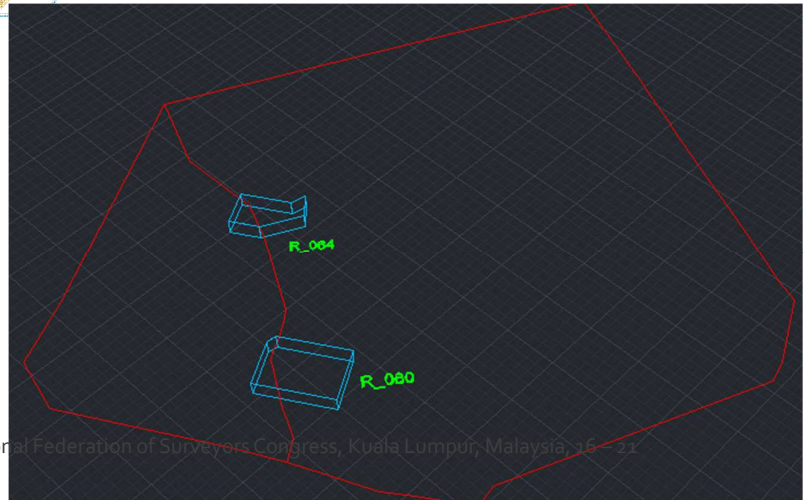
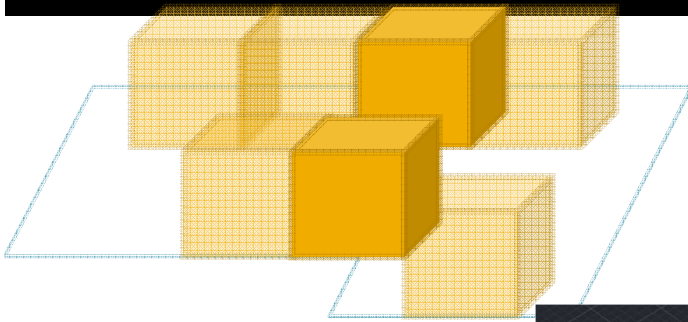
	bidang_tanah character varying(10)
1	r 061
2	r 062
3	r 063

OK. Unix Ln 1, Col 1, Ch 1 3 rows. 78 ms

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Case 7



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Analyses of Real Cadastre Case ... (V) :: Resolving Case 7 ::



Query - simpanglima on postgres@localhost:5432 - [D:\Simpanglima\project_sql\simpanglima...]

SQL Editor

```
-- Menyebutkan ruang-ruang mana saja pada lantai satu yang berada di atas dua bidang tanah  
select geom1.r_id as bidang_tanah  
  
from (select r_id, st_asewkb(t2_topo) as a from topologi) as geom1,  
(select st_makepolygon(st_addpoint(geom.g, st_startpoint(geom.g))) as b  
from (select bt_geoline as g from bidang_tanah where bt_id=1) as geom) as geom2,  
(select st_makepolygon(st_addpoint(geom.g, st_startpoint(geom.g))) as c  
from (select bt_geoline as g from bidang_tanah where bt_id=2) as geom) as geom3  
  
where st_intersects(st_geomfromewkb(geom2.b),st_geomfromewkb(geom1.a))  
and st_intersects(st_geomfromewkb(geom3.c),st_geomfromewkb(geom1.a))
```

Output pane

	bidang_tanah character varying(10)
1	r 060
2	r 064

OK. Unix Ln 1, Col 1, Ch 1 2 rows. 125 ms

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Analyses of Real Cadastre Case ... (VI) :: Resolving Case 9 ::

```

Query - simpanglima on postgres@localhost:5432 - [D:\Simpanglima\project_sql\simpangliman...
File Edit Query Favourites Macros View Help
SQL Editor Graphical Query Builder
Previous queries
-- Menunjukkan garis-garis yang merupakan batas dinding yang bersebelahan secara langsung
-- atau dipakai bersama pada ruang 002 (R_002) (arah horizontal)
BEGIN;
create view tab1 as
select b_r_id as id1, st_astext(st_geomfromwkb(a.p)) as geomt1
from
  (select geom2.g2 as p
   from (select t1_topo as g1 from topologi where t1_id =2) as geom1,
        (select geom as g2 from simpanglima_topol.edge_data) as geom2
   where st_contains(geom1.g1,geom2.g2) as a,
        (select r_id, st_asewkb(t1_topo) as q from topologi where not r_id = 'R_002') as b
   where st_within(st_geomfromwkb(a.p),st_geomfromwkb(b.q));

create view tab2 as
select d_r_id as id2, st_astext(st_geomfromwkb(c.r)) as geomt2
from
  (select geom2.g2 as r
   from (select t2_topo as g1 from topologi where t1_id =2) as geom1,
        (select geom as g2 from simpanglima_topo2.edge_data) as geom2
   where st_contains(geom1.g1,geom2.g2) as c,
        (select r_id, st_asewkb(t2_topo) as s from topologi where not r_id = 'R_002') as d
   where st_within(st_geomfromwkb(c.r),st_geomfromwkb(d.s));

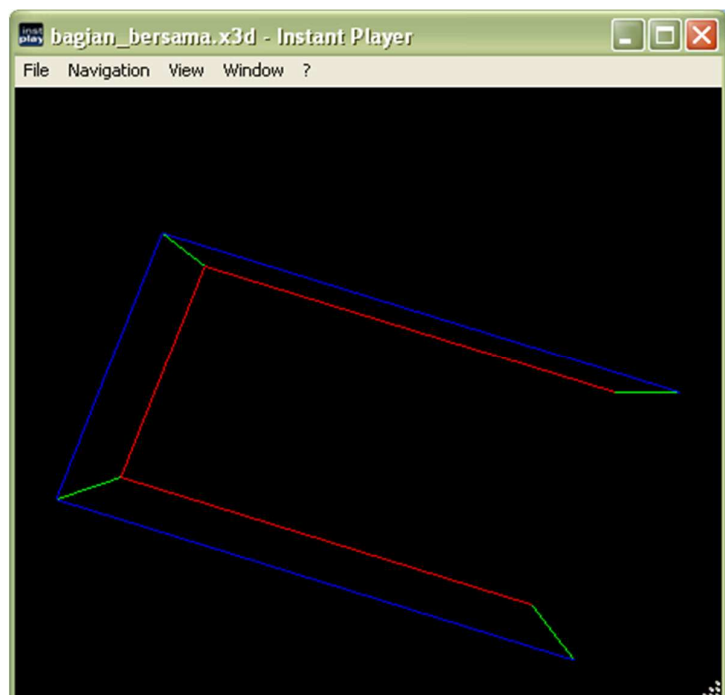
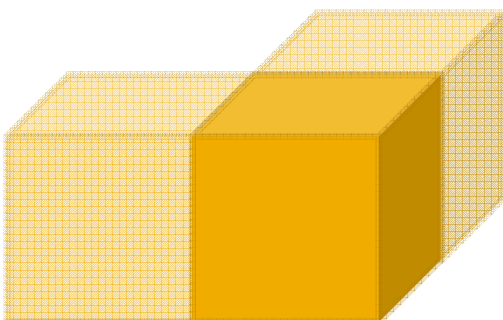
create view tab3 as
select f_r_id as id3, st_astext(st_geomfromwkb(e.t)) as geomt3
from
  (select g_geom as t from garis,bagian_dari where garis.g_id=bagian_dari.g_id
   and t1_id=2) as e,
  (select r_id, g_geom as u from topologi,garis,bagian_dari
   where garis.g_id=bagian_dari.g_id and bagian_dari.t1_id=topologi.t1_id
   and not bagian_dari.t1_id=2) as f
  where st_3dintersects(st_geomfromwkb(e.t),st_geomfromwkb(f.u));
COMMIT;
Output pane
Data Output Explain Messages History
Query returned successfully with no result in 15 ms.

```

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Case 9



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Analyses of Real Cadastre Case ... (VII) :: Resolving Case 9 ::

Query - simpanglima on postgres@localhost:5432 *

File Edit Query Favourites Macros View Help

SQL Editor Graphical Query Builder

Previous queries [] Delete Delete All

```
select geomt1
from tabl
```

Output pane

Data Output Explain Messages History

	geomt1
	text
1	LINESTRING Z (436434.432879508 9227308.00282599 41.705,436426.549310549 9227311.
2	LINESTRING Z (436426.549310549 9227311.31197872 41.705,436424.948509122 9227307.
3	LINESTRING Z (436432.832039771 9227304.17754396 41.705,436424.948509122 9227307.

OK. Unix Ln 1, Col 1, Ch 1 3 rows. 297 ms

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Analyses of Real Cadastre Case ... (VIII) :: Resolving Case 9 ::

Query - simpanglima on postgres@localhost:5432 *

File Edit Query Favourites Macros View Help

SQL Editor Graphical Query Builder

Previous queries [] Delete Delete All

```
select geomt2
from tab2
```

Output pane

Data Output Explain Messages History

	geomt2
	text
1	LINESTRING Z (436434.432879508 9227308.00282599 38.705,436426.549310549 9227311.3
2	LINESTRING Z (436426.549310549 9227311.31197872 38.705,436424.948509122 9227307.4
3	LINESTRING Z (436432.832039771 9227304.17754396 38.705,436424.948509122 9227307.4

OK. Unix Ln 1, Col 1, Ch 1 3 rows. 312 ms

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Analyses of Real Cadastre Case ... (IX)

:: Resolving Case 9 ::

Query - simpanglima on postgres@localhost:5432 *

File Edit Query Favourites Macros View Help

SQL Editor Graphical Query Builder

Previous queries [] Delete Delete All

```
select geomt3
from tab3
```

Output pane

Data Output Explain Messages History

	geomt3
	text
1	LINESTRING Z (436432.832039771 9227304.17754396 41.705,436432.832039771 9227304.177
2	LINESTRING Z (436434.432879508 9227308.00282599 41.705,436434.432879508 9227308.002
3	LINESTRING Z (436426.549310549 9227311.31197872 41.705,436426.549310549 9227311.311
4	LINESTRING Z (436424.948509122 9227307.48678827 41.705,436424.948509122 9227307.486
5	LINESTRING Z (436424.948509122 9227307.48678827 41.705,436424.948509122 9227307.486

OK. Unix Ln 2, Col 10, Ch 24 5 rows. 16 ms



Analyses of Real Cadastre Case ... (X)

:: Resolving Case 9 ::

instant play bagian_bersama.x3d - Instant Player

File Navigation View Window ?

The image shows a 3D wireframe model of a polygon with vertices connected by lines in blue, red, and green. The model is displayed on a black background within a window titled 'instant play bagian_bersama.x3d - Instant Player'.



Conclusions

1. The topology-based data structure is not capable of describing the object as a whole space either as a solid or as a skeleton-shaped object.
2. 3D spatial database can provide information in relation to space (one space next to other space), indicate underlying land, inform the entire space above the ground plane, show a space located above two parcels, and exhibit adjacent spaces.



References ... (I)

- _____, 2011a, "Undang-Undang Nomor 20 Tahun 2011 tentang Rumah Susun".
- _____, 2011b, "Final Report on the Development of Space Information System", Department of Geodetic Engineering Faculty of Engineering Gadjah Mada University and BPN-RI, Yogyakarta.
- Butwilowski, E. and Breunig, M., 2010, "Requirements and Implementation Issues for a Topology Component in 3D Geo-Databases", 13th AGILE International Conference on Geographic Information Science, Portugal.
- Chen, T.K., Abdul-Rahman, A., and Zlatanova, S, 2007, "3D Spatial Operations in Geo DBMS Environment for 3D GIS", Ed. Gervasi, O. and Gavrilova, M., ICCSA 2007, LNCS 4705, Part I, pp. 151–163, Springer-Verlag, Berlin Heidelberg.



References ... (II)

- Chen, T.K., Abdul-Rahman, A., and Zlatanova, S., 2008, "3D Spatial Operations for Geo-DBMS : Geometry Vs. Topology", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science, Vol. XXXVII, Part B2, Beijing.
- Egenhofer, M.J., Sharma, J., and Mark, D.M., 1993, "A Critical Comparison of the 4-Intersection and 9-Intersection Models for Spatial Relations : Formal Analysis", Ed. McMaster, R. and Armstrong, M., Autocarto 11.
- Lee, S. and Lee, J., 2010, "Efficient Topological Data Models for Spatial Queries in 3D GIS", A special joint symposium of ISPRS Technical Commission IV & AutoCarto in conjunction with ASPRS/CaGIS 2010 Fall Specialty Conference, Orlando, Florida.
- Shekhar, S. and Chawla, S., 2003, "Spatial Databases A Tour", Pearson Education, Inc., New Jersey.



References ... (III)

- Stoter, J. and Oosterom, P.V., 2006, "3D Cadastre in an International Context", Taylor & Francis Group, New York.
- Ying, S., Guo, R., Li, L., Oosterom, P.V., Ledoux, H., and Stoter, J., 2011, "Design and Development of a 3D Cadastral System Prototype based on the LADM and 3D Topology", 2nd International Workshop on 3D Cadastres, Netherlands.
- Zichar, M. and Szeghalmy, S., 2010, "Network Topology in 3D GIS", Proceedings of the 8th International Conference on Applied Informatic Eger, Vol.1, pp.211–219, Hungary.



THANK YOU

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