Propose New Structure for the Buildings Model

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Abstract

Urban data model (UDM) is a three-dimensional (3D) geography information systems (GIS) data model. The paper proposes the time class into UDM to manage historical of changes on the spatial properties of Point (0D), Line (1D), Surface (2D) and Body (3D) object. The changes would store explicit in database. The LOD (levels of detail) class of 3D objects adds also to show buildings at four levels from simple to complex. Event class in the model should record the reasons to create changes on the 3D objects in their evolution. The last model named LT-UDM.

Keywords: *3D, GIS data model, spatio-temporal model.*

1. Introduction

The rapid growth in the field of economy and population has led to the speed of rapid urbanization. People wish to apply information technology in management of urban problems and 3D GIS solutions be discussed. Management issues need attention in 3D GIS: traffic management, land management, management of buildings. . . The management of the buildings considered one of the focal issues.

One of the keys in 3D GIS applications is data model design. The design model will affect how the data represent, how to store data, how data access and data analysis. Characteristic of these models is more structured, more objects than 2D model. The models are classified by the model on surface, the model under the surface, model of the surface. Objects in the model have both non-spatial, spatial attributes. Over time the value of these properties were changing. The changes can be discrete or continuous and evolutionary history should be stored in the full database to serve many purposes. There are two important purposes: knowing the trend for future mobilization of objects and providing information to support human decision-making. 3D urban information systems are divided into two groups: 3D GIS urban and 3D GIS geological. 3D GIS in urban models include [4]: transportation space model, trees space model, buildings model. Buildings model is emphasized among the models.

In recent years, many 3D models have been proposed [1, 12]. 3DFDS model of Molenaar 1990, TEN of Pilouk 1996, the OO model of DelaRosa 1999, the SSM model of Zlatanova 2000, SOMAS of Plund 2001, the UDM of Coors in 2003, the CityGML model of Groger 2007, the B_REP+CSG of Chokri et al 2009 [3] and EUDM of Tuan Anh N.G 2010. Characteristics of these 3D models follow: the 3D objects are represented at low levels as the 3D volume box. They are not represented the details as the roof or structure within the buildings [5, 6, 8]. The 3D models do not reflect the relationships the topology of space objects as well as lack of information about the semantics. While semantic information is needed, for example, we need to know the build time of a building A or the owner of the house B [4].

In addition, the studies of temporal-spatial data models also remarked. These issues also attracted many researchers for years [2, 8]; many models have been proposed with different authors: Event-Based model of Peuquet 2001, Chen 2000, Workboy 2005, State-Based model of Armstrong 1988, Langran 1992, and Liu 2006. 3D object-oriented data models Worboy 2005, Raza 1999. Most of these models performed for 2D objects [2]. These remarks show that these available 3D GIS models have the disadvantages:

- The time dimension absences.
- 3D objects are only represented by one level.

The objectives of paper are to limit these disadvantages. Contents of the paper include presentation summarize for UDM and disadvantages of it (2). Propose adding the levels of detail on 3D objects by requirements the user. Levels of detail are four levels: 0, 1, 2, and 3 (3.A). Propose integration dimensions of time and events to keep track of changes on the properties of space-time. The changes will be stored fully and explicitly in the database (3.B). (4) Represent the experiments in Oracle 11g and C# language.

2. UDM and Disadvantages

UDM (Urban data model) which is a model of 3D GIS for urban management proposed by Coors in 2003 [1, 11]. UDM built on four main subjects 0D, 1D, 2D, 3D by Point, Line, Surface and Body. Model (fig.1) used two geometric objects Node and Face. Node is described by three coordinates X, Y, Z. A Face is a triangle; it is represented by three Nodes. UDM is a 3D model that only describes the spatial properties of objects in a real world. UDM model has two main characteristics: size of data storage is small because the model omitted objects Arc (1D) and the model-represented surface of 3D block is good by triangulation.

In 2010, Tuan Anh N.G proposed some innovations for 2D and 3D objects of UDM [10]. 3D objects were specified by cylinder, prism, cone and pyramid. These bodies were represented by new methods instead of represented by triangles. The innovations reduced query time and data size, name of this model is EUDM.

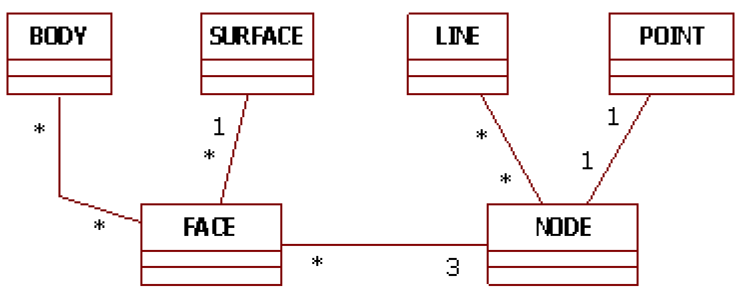

Fig. 1. Urban Data Model

However, the model UDM or EUDM is still limited and this is the basis for recommending the proposes of this paper .

These disadvantages of UDM are:

- UDM has not mentioned the time dimension to manage the evolution of the objects.
- The representation of the geometric objects in UDM only describe in a fixed level.

3. Proposals

3.1 Additional Display of 3D Building According to the Different Levels of Detail

Displaying 3D objects depend on the following: viewpoint, distance between the observer and the position of objects, the size of real 3D objects, a range of importance of objects in a specific application and different requirements of users. Table 1 presents the criteria levels of detail in the building management applications. Levels of detail divided into four (table 1).

Table 1. Levels of Detail (Lod) to Represent a Building

	Lod0	Lod1	Lod2	Lod3
Model	2D	3D	3D	3D
Level of overview		Buildings as blocks	Buildings have floors	Buildings have roof, windows, balcony
Structure of the roof	None	Flat	Flat	Close to reality
Size (can change)		>5x5x5(m)	>3x3x3 (m)	>2mx2mx2 m
Sub construction		Important construction	As blocks	Close to reality

Figure 3 describes a building is presented in levels 0, 1, 2, 3. Line is specified (Fig.2) by Real-Line and Edge. Edge class is used to describe the segments in showing the building at Lod2, Lod3. Real-Line class describes 1D Lines that has in real world as streets, rivers. Surface is specified (Fig.2) by Polygon and Window. Window class is used to describe windows of apartments in showing the building at Lod3 (Fig.2).

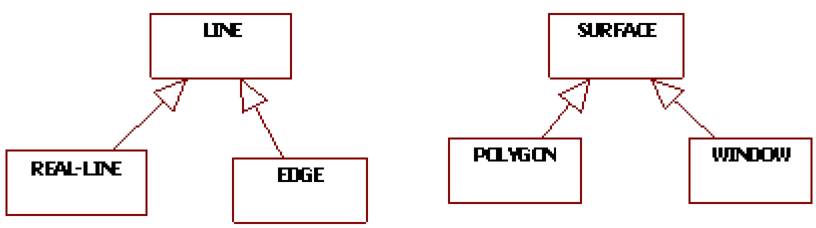

Fig. 2. Specifying Line and Surface Class

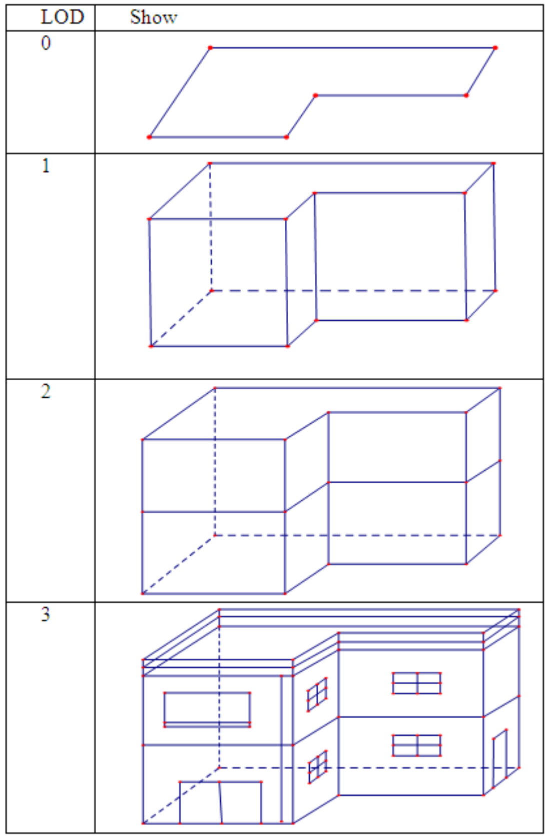

Fig. 3..Lod0, Lod1, Lod2, Lod3 of a Building.

Analyzing figure 3, three rules are recognized. A Building has many Bodies at many LODs. A Body exists in many Buildings at many LODs. A Building has many Surfaces at many LODs. A Surface exists in many Buildings at many LODs. A Building has many Lines at many LODs and a Line exists in many Buildings at many LODs. So there are links between objects: Building, LOD, Body; Building, LOD, Surface and Building, LOD, Line.

The data model after proposal 3.A has as Figure 4.

BUILDING (#IDBD, NAME, DESC)
LOD (#IDLOD, NAME, DESC1, DESC2, DESC3, DESC4)
LODLINE (#IBBD, #IDL, #IDLOD)
SURFACELOD (#IDBD, #IDS, #IDLOD)
BODYLOD (#IDBD, #IDB, #IDLOD)
BODY (#IDB, DESC)
SURFACE (#IDS, DESC)
LINE (#IDL, DESC)
LINENODE (#IDL, #IDN, SEQ)
NODE (#IDN, X, Y, Z)
POINT (#IDP, DESC, IDN)
TRIANGLE (#IDT, IDN1, IDN2, IDN3, IDS)
Notation:
#: Primary key.

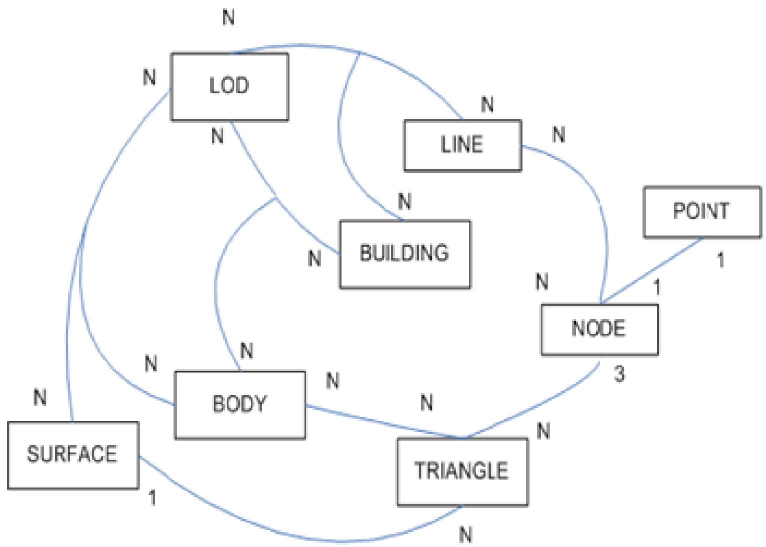

Fig. 4. UDM after Adding Lod Classes.

3.2 Additional Time Dimension to UDM

Non-temporal GIS only represents states of spatial properties. Temporal GIS represents only states but also events and evidences. The historical management of the spatial changes over time is an objective of GIS applications. To sole this problem, time class will be added to the model. Classes and links added to dimensional time in the model as figure 5.

Time class is divided into two types of time, instant or an interval of time. For example, a building B built on 01/01/2010; 01/01/2011 is instant time. If B built on January 2, 2009 to January 2, 2011 then [2/01/2009, 2/01/2011] is an interval of time.

DMY class is described by the day, month, year, hour, minute and second attributes.

Event-Type class: is described by the name attributes of event.

Event class: Event provides the information about the changes of objects. Event has the relation with the evolution of objects. Each event has a begin time and end time in real world and database. Begin time and end time can be instant or interval time. Table 2 is an example for state, event and evidence.

Table 2. Example for State, Event and Evidence

State	Event	Evidence
House	Planning	Survey
Bridge	Earthquake	Aerial Photography
Road	Flood	Remote sensing

Link between Time and Body: describes time of begin and the end of each Body. A Body has both times, begin time and end time in real world and database. Begin time and end time can be instant or interval time. Similar, link between Surface and Time: describes for the time begins and ends of Surface in real world and database. Link between the Line and Time:

describes time that Line begins and ends in real world and database. Link between the Point and Time: describes time that Point begins and ends in real world and database.

Link between Body and Event describe a Body is created by what event.

Thus, the objects 0D, 1D, 2D, 3D always has 4 times, the begin time, the end time in real world and database. They are IDT1, IDT2, IDT3, IDT4. These times may be instant time or interval time. If it is instant time then INT-INST=0.

UDM after two improvements used to integrate time, LOD classes has as figure 5 and the model named LT-UDM.

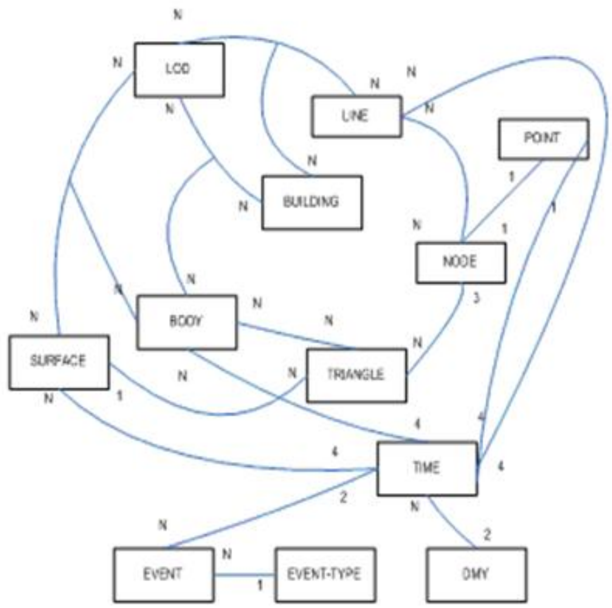

Fig. 5. Model LT-UDM After Adds Recursive Link.

The model as figure 5 is analyzed into 16 relations

BUILDING (#IDBD, NAME, DESC)
LOD (#IDLOD, NAME, DESC1, DESC2, DESC3, DESC4)
NODE (#IDN, X, Y, Z)
LINENODE (#IDL, #IDN, SEQ)
TRIANGLE (#IDT, IDN1, IDN2, IDN3, IDS)
DMY (#IDMY, D/M/Y, H/M/S)
EVENTYPE (#IDET, NAME)
TIME (#IDT, IDDMY1, IDDMY2, INT-INST)
EVENT (#IDE, IDT1, IDT2, IDT3, IDT4, IDET)
LODLINE (#IBBD, #IDL, #IDLOD)
SURFACELOD (#IDBD, #IDS, #IDLOD)
BODYLOD (#IDBD, #IDB, #IDLOD)
BODY (#IDB, DESC, IDT1, IDT2, IDT3, IDT4).
SURFACE (#IDS, DESC, IDT1, IDT2, IDT3, IDT4)
LINE (#IDL, DESC, IDT1, IDT2, IDT3, IDT4)
POINT (#IDP, DESC, IDT1, IDT2, IDT3, IDT4, IDN).

3.3 Parent and Children Relationship of Buildings

Body class describes the Bodies. The recursive link of Body describes their parent and children relationship. For example, at 2006 as figure 6, with four Bodies B1, B2, B3, B4. At 2008: B1, B2, B3, B4 are merged to create B5. At 2010, B5 is divided into B6, B7. B5 is said the child of B1, B2, B3 and B4. B1, B2, B3 and B4 are said the parent of B5.

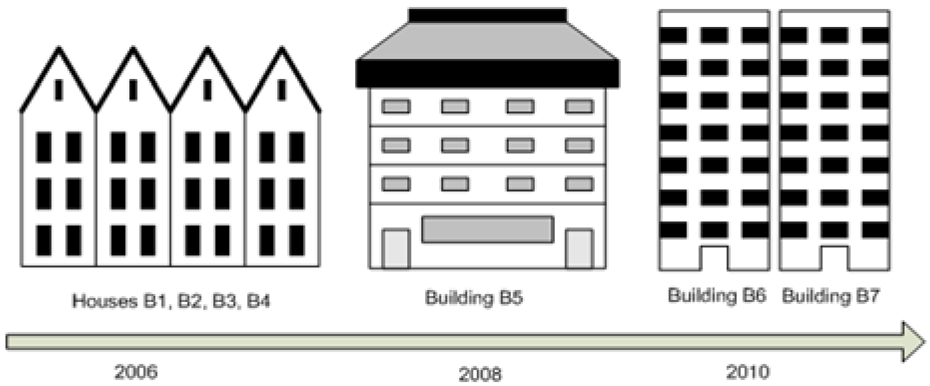

Fig. 6. B1, B2, B3, B4, B5, B6 at years 2006, 2008, and 2010.

The model LT-UDM adds a recursive link of Body class as figure 7

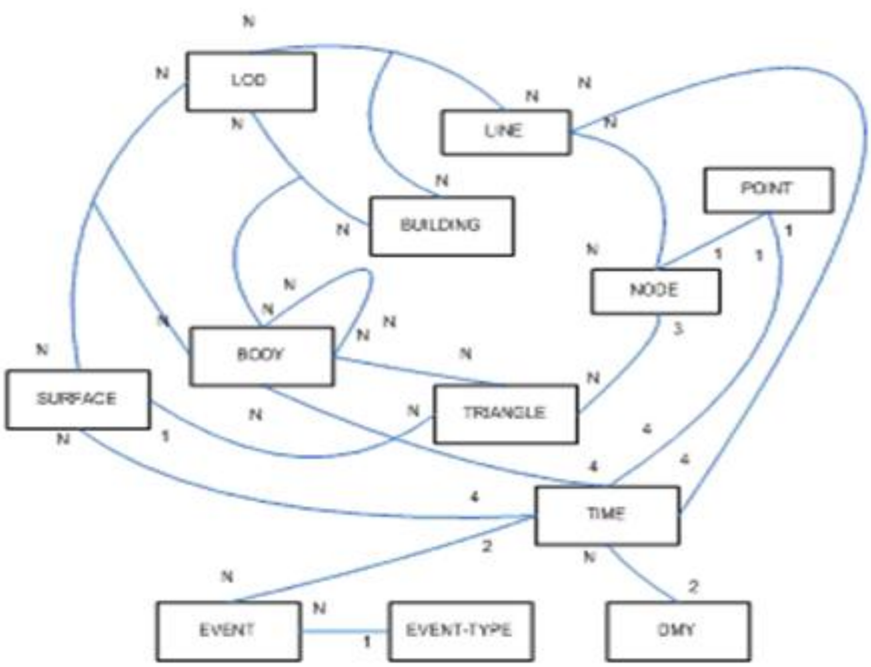

Fig. 7. Model LT-UDM After Adds Recursive Link.

A Body can has many parent Bodies and a Body can has many child Bodies. This model creates a new relation about parent and child of Bodies: BODY-CHIL-PAR

BODY-CHIL-PAR (#IDBPAR, #IDBCHIL)
#IDBPAR: Parent Bodies.
#IDBCHIL: Child Bodies.

Data in BODY-CHIL-PAR describes figure 6 as Table 3.

Table 3. Data in BODY-CHIL-PAR

#IDBPAR	#IDBCHIL
B1	B5
B2	B5
B3	B5
B4	B5
B5	B6
B5	B7

B1, B2, B3, B4 have child B5 or parents of B5 are B1, B2, B3, B4. B5 is parent of B6, B7.

The model LT-UDM is designed to integrate easy with EUDM.

4. Experiments

The following experiments are installed in Oracle 11g and C #. Relational database management system does not support spatial data type and the operations in these data, so relational database management system need to extent. The result of extent creates the new database management system: relational-object [9]. This new system supports for spatial data type, and Oracle 11g have chosen. Two relations BODY (#IDB, DESC) and BODYFACE (#IDB, #IDF) in relational database would merge one relational-object BODY. Data structure of table BODY in Oracle 11g is created by:

```
Create table BODY.
(Idb number primary key, Desc varchar2 (50),
 Shape mdsys.sdo_geometry);
```

In Oracle 11g, data type mdsys.sdo_geometry uses the storage set data. Code to insert one data row in BODY:

Insert into BODY values (150,'1 cylinder block', 26, 35, 15, mdsys.sdo_geometry (2003, null, null, mdsys.sdo_elem_info_array (1, 1003, 1),

mdsys.sdo_ordinate_array (25,0, 33,6, 23,6, 21,4, 16,4, 18,6, 8,6, 0,0, 25,0)));

The sample data in database have inserted 30 buildings B1 and 20 buildings B2 (Fig.8) and they are built in different years.

The content of sample query is showing the buildings that are built from 2008 to 2009. Results of spatial query for time and LOD are presented through the forms. Form1 illustrates two the buildings were built from 2004 to 2005 and their data are shown in the level 0 as planes (Fig.9). Form2 illustrates the buildings was built above time and their data are shown in the level 1 as the blocks (Fig.9).

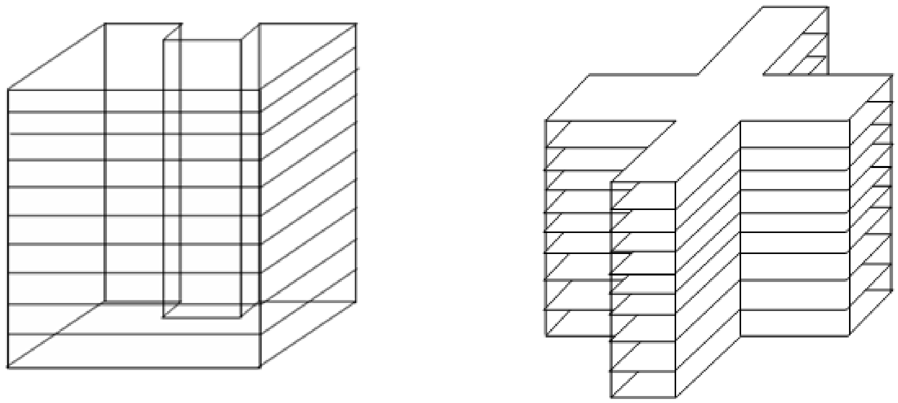

Fig. 8. (Left) Buildings B1 and (Right) B2

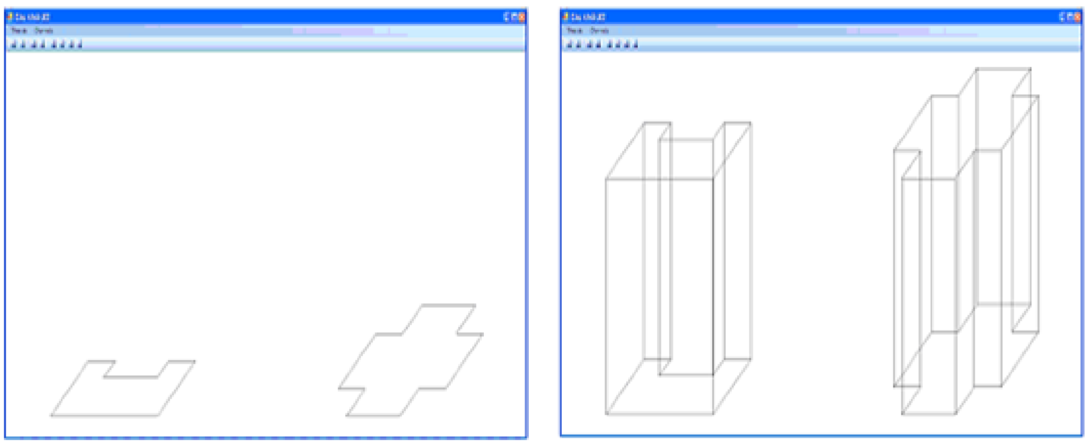

Fig. 9. Form1 (Left) and Form2 (Right)

Form3 illustrates the buildings was built as query and their data are shown as the building has 10 floors (Fig.10). Form4 illustrates the buildings was built from 2008 to 2009 and their data are shown as the building has 10 floors and windows of apartments (Fig.10).

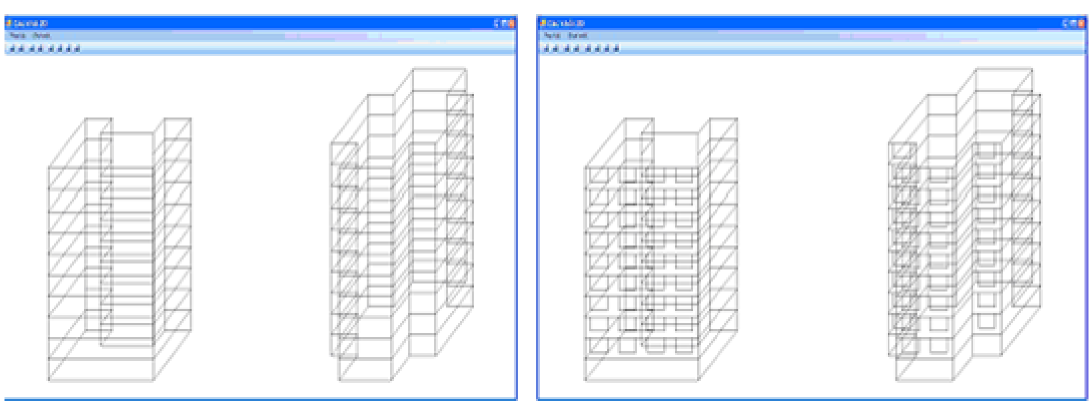

Fig. 10.Form3 (left) and form4 (right)

5. The References Section

The paper offers time dimension on the concept data model to record the evolutionary history of 0D, 1D, 2D, 3D objects over time. Time topology relationship between the buildings is described explicitly in the database. Finally, the paper also suggested adding LOD class into the model to server visualization of buildings at different levels.

Last model reflects full GIS information for managing the building in the urban, including a full range of attributes: spatial, temporal and LOD. Particularly changes in the properties of spatial-temporal objects are stored completely in the database for the exploitation of information needs over time.

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