EVENT-BASED INCREMENTAL UPDATING OF CADASTRAL DATABASE

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ABSTRACT:

Incremental updating of cadastral database means that master spatial data set is updated when any change (geometric or semantic) occurs, the change can be recorded, updated and provided successively to users. During this process, a set of editing operations is needed to add, delete or amend cadastral spatial objects (intermediate points, boundary points, boundary segment, and parcels). An event-based automatic (or semi-automatic) incremental updating of cadastral database method (named as EBIU-CDB) is presented in this paper, which is based on the land subdivision event and the topological relationship between two parcels. The land subdivision event (including split, union, reallocation and modification of the common border between two parcels) is given at first; an extended 4-intersection model used to describe the topological relations between two parcels is presented, 7 kinds of possible topological relations between two parcels at the same time are concluded by this method; ***split*** event is used as an example to illustrate EBIU-CDB, 7 kinds spatial change of split event are presented, and the updating algorithm is followed. The approach was implemented using VC++ in ORACLE9I SPATIAL and MAPINFO 6.5 platform.

1. INTRODUCTION

Cadastral database is a type of database using land parcels as spatial units to collect, store, and update the parcels' location, shape, rights, and land use information (land parcel is the smallest salable area, and the geometric feature is equivalent to polygon in this paper)[Khaled K, 1992; CHEN Jun, et al, 2000; ZHOU Xiaoguang, CHEN Jun, et al, 2003]. In cadastral systems, various changes (spatial and semantic) take place incrementally through transactions based on conveying rights from one owner to another. In order to show the current status, to record the history and the cause of changes, an incremental updating is needed after a change occurred. Incremental updating means that the core cadastral database is updated when any geometric or semantic changes occur, and that the changes are recorded, the updating process can be tracked, the updates are provided successively to users [ZHOU Xiaoguang, CHEN Jun, et al, 2003;]. During such a process, a set of editing operations is needed to add, delete or amend cadastral spatial objects (intermediate points, boundary points, boundary segment, and parcels), to solve spatial (geometrical, topological) and temporal conflicts problems, maintain spatial (geometrical, topological) and temporal consistency of the records [ZHOU Xiaoguang, CHEN Jun, et al, 2002].

So far, the updating of core cadastral spatial database is carried out manually and interactively. With the incremental spatial changes information, it will be determined by data producers which objects should be added, deleted and amended, how to solve problems of spatial (geometrical and topological) conflicts and maintain the consistency of the records [Oosterom, 1997]. A large amount of editing operations are needed. As this interactive process is an error–prone and labor-intensive process, automatic execution of these editing operations is desired [Cooper A, Peled A. 2001; ZHOU Xiaoguang, CHEN Jun, et al, 2002]. This study aims to automate the updating process of cadastral database.

Since the changes of parcels are caused by land-subdivision events (such as split, union, reallocation) and different events may cause different changes to the parcels involved, the updating

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algorithms and programs for different changes will be different too. If the types of spatial changes (including geometric and topological) to each events can be known, and can be identified automatically, the updating operation of the spatio-temporal cadastral database can be formulate automatically, the automation of cadastral database' updating can be realized too. Based on this idea, a new incremental updating approach of cadastral database named as Events-Based Incremental Updating of Cadastral Database (EBIU-CDB) is proposed in this paper.

In cadastral system, any changes in size (or shape) of a parcel could affect changes in the topological relationship between this parcel and other parcels, e.g., an enlargement of a parcel will add new nodes (corners or boundary points) and links (arcs or boundary lines connecting these points) to its boundary such that its topology becomes different from what it was before. In order to distinguish the topological changes, the topological relationship between parcels must be described at first. In addition, in order to formulate the updating operations, a set of dynamic operators of spatio-temporal database (STDB) must be given at first.

The remainder of this paper is structured as follows: the definition of land subdivision events and the strategy of EBIU-CDB is presented in Section 2; the topological relationships between two parcels are described in section 3; a set of dynamic operators of spatio-temporal database is presented in section 4; the changes of split event is presented in section 5. The updating algorithm and program of split event is presented in Section 6. The summary is given in section 7.

2. STRATEGY OF EBIU-CDB

A land subdivision event is an occurrence causing the parcels' state change (geometric or thematic). Usually the geometric changing land subdivision event can be divided to four fundamental cases: (a) split, division of a zone into 2 parts; (b) union, fusion of 2 zones into a single entity; (c) reallocation, reallocation of land covered by 'n' initial zones to form 'p' new zones; (d) modification of the common border, the case of land

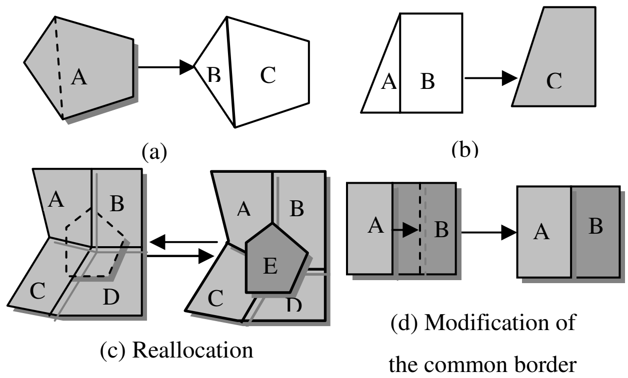

Fig.1 Fundamental land subdivision

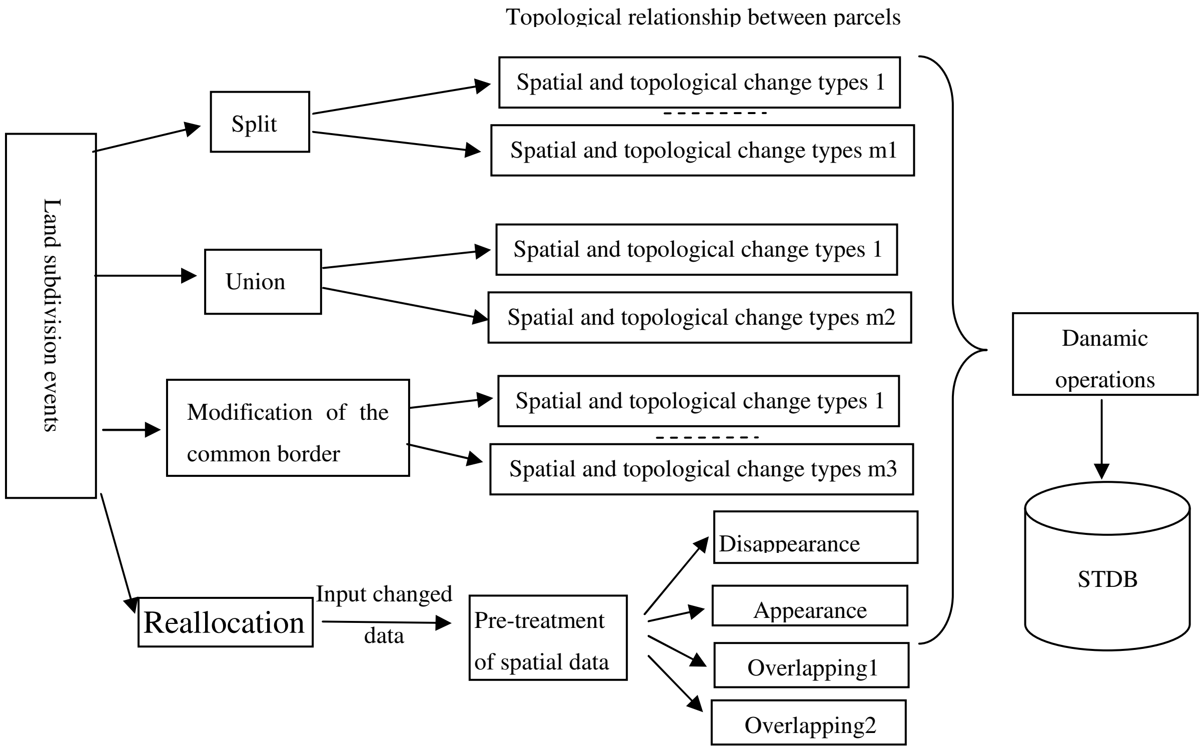

Fig. 2 Strategy of EBIU-CDB

exchange between two existing zones (Fig. 1) [Claramunt C,Thériault M., 1995].

According to [ZHOU xiaoguang, CHEN Jun, et al, 2002], there are relationship between spatial changes and dynamic operation. If the spatial changes can be determined automatically, the database updating operation can be determined automatically too. A simple event can drive appropriate database updating operations directly, and a composite event should drive a segment of change types identification program to identify the involving objects' change types (disappearance, appearance, overlapping1, overlapping2) at first, then trigger the appropriate database updating operations.

In land subdivision events, usually there are only 1 to 2 zones (and it's components) involved in the ***split, union, and Modification of the common border*** events. The spatial changes can be determined by the event type and the shape (or topological relations between) the involving entities. But the spatial changes involving in the ***Reallocation*** event are too complex to classified, the involving entities data should be pretreated at first, then be divided into disappearance, appearance, overlapping1, overlapping2. The updating strategy of EBIU-CDB is showed in Fig.2.

3. TOPOLOGICAL RELATIONS BETWEEN PARCELS

The complexity of cadastral database updating is caused by the topological relationship between parcels. A ***parcel*** is a homogeneously 2-dimensional region in IR^2 with a connected interior, which includes 2 fundamental cases: (a) a simple parcel; (b) a parcel with one hole [Fig.3]. According to our study of CHANGSHA city and LILING city, the topological relationships between these two cases almost include the all binary relationships between parcels in the real world.

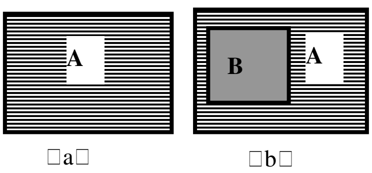

Fig .3 Two kinds of parcels

Much works have been done about the topological relations between objects, such as 4I model [Egenhofer, M., Franzosa, R.,1991], 9I model [Egenhofer, M., 1993], V9I model [CHEN Jun, LI Chengming, et al, 2001], etc. But so far, the topological relationships between these 2 fundamental cases have not been studied by anyone. Based on the description structure of topological relations between regions with holes [Egenhofer, Clementini, et al, 1994], one extended 4-intersection description method of the topological relations between a simple parcel and a parcel with one hole is proposed in this paper, which uses two 2×2 matrix (4-Intersection) to describe these topological relations (named as D-4I model). 31 kinds of topological relations between two parcels are distinguished with this method. The 7 kinds of possible topological relations between two parcels at the same time are concluded, which is important in the updating of cadastral information system (Fig. 4) [ZHOU Xiaoguang, CHEN Jun, et al, 2003a].

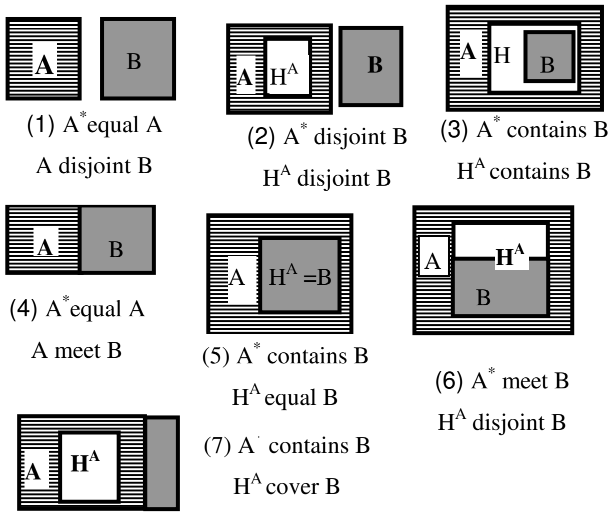

Fig.4 7 kinds of topological relations between two parcels at the same time

4. DYNAMIC OPERATORS

Operators in Spatio-Temporal Database (STDB) can be categorized as statics and dynamics. The static operations do not make essential changes to the operand objects; while the dynamic operations change the state of one or more of the operands, such as insert, delete or modify [Raza A, Kainz W., 2000; Worboys, M. F., 1995]. Dynamic operators are the basic tools of the updating of STDB.

Much works have been done about dynamic operators of STDB, such as: Raza proposed 4 kinds of dynamic STDB operations [Raza A, Kainz W., 2000]; three main types of spatio-temporal change processes in the real world have been defined by Claramunt [Claramunt C,Thériault M. 1995]; based on the three states (existence, non-existing with history, and non-existing without history) of a single entity in database, Hornsby and Egenhofer proposed 9 identity-based change operations of single entity [Hornsby K., Egenhofer M. J., 2000], etc. In this paper, we argue that dynamic operators of STDB should be a bridge to link the change processes in the real world and their representation in

STDB, and a change in the real world should have a (and only have a) dynamic operation to deal with the operand. From the object-oriented STDB management point of view, the operand of dynamic operators is single entity (or single object), the mutation between entities should be realized by the dynamic operation of single objects. Based on this cognition, a complete set of dynamic operations of STDB is presented based on the explicit description of change with respect to the real world and the states of existence and non-existence for identifiable objects in STDB, which include 8 current data' dynamic operators and 8 history data' dynamic operators [ZHOU Xiaoguang, CHEN Jun, et al, 2003b]. The 8 current data' dynamic operators are ***Create, Ex-create, Destroy, Con-eliminate, Eliminate, Se-modify, Sp-modify, Reincarnate.*** All of the 8 current data' dynamic operators except ***Destroy***, may be used in the updating process.

5. EVENT- BASED CHANGES OF PARCELS

As the preceding, the spatial changes of the ***split, union,*** and ***Modification of the common border*** events can be determined by the events and the topological relations between involving entities. Usually there are only 1 to 2 zones (and it's components) involved in such events, these events occur more than 50% [Effenberg, W. W. 1996]. According to our study on CHANGSHA city, among these events, the ***split*** event occurs most frequently. ***Split*** event will be used as an example to illustrate the updating method of EBIU-CDB in this paper. At first the changes of splitting are studied.

Split means division of a parcel into 2 parts. 2 fundamental parcels showed by Fig.3 can be involved in split event. In split process, a new edge (border) has to be inserted. It is assumed that the start node is n1 and end node is n2, the inputting edges are l1 (and l2). The simple parcel A split to simple parcel B and C; a parcel with one hole A split to C and D.

There are 7 cases in the split of parcel: (1) the simple parcel division into 2 simple parcels (Fig.5 (1)); (2) the simple parcel division into a simple parcel and a parcel with one hole (Fig.5 (2)). (3) the parcel with one hole A division into a simple parcel D and a parcel with one hole C, C meets D (Fig.5 (3)); (4) the parcel with one hole A division into 2 simple parcel (Fig.5 (4)); (5) the parcel with one hole A division into a simple parcel D and a parcel with 2 holes C (Fig.5 (5)); (6) the parcel with one hole A division into a simple parcel D and a parcel with one hole C, C meets B (the hole of A) (Fig.5 (6)); (7) the parcel with one hole A division into a parcel with one hole D and a parcel with one hole C, D*include B (Fig.5 (7)).

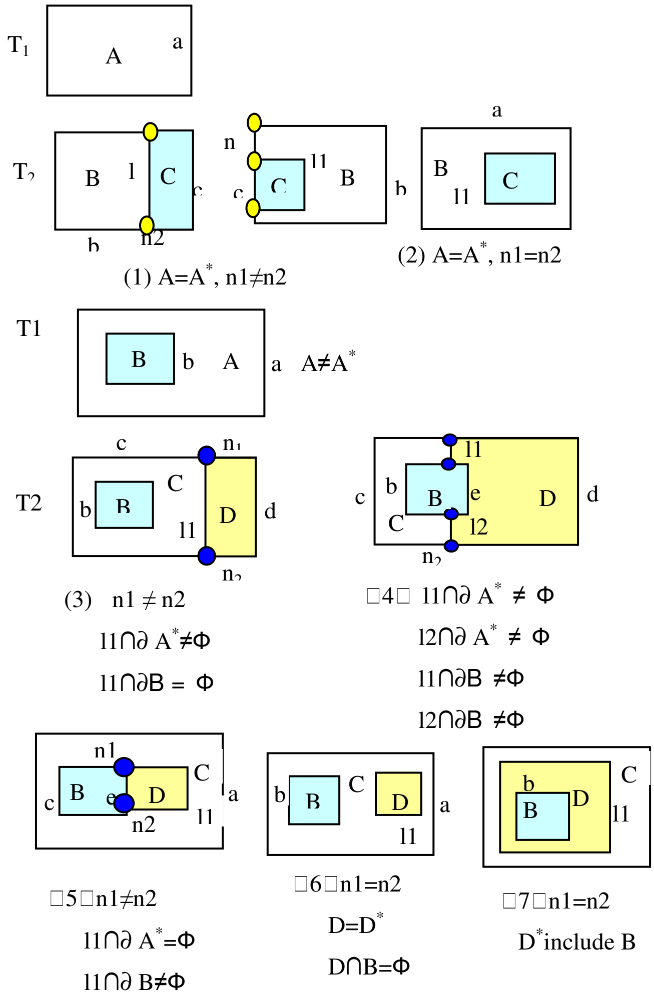

Fig. 5 the splitting of a parcel

6. THE UPDATING ALGORITHM OF SPLIT EVENT

Whenever a split event occurs, the following actions are triggered automatically (Fig.6): (1) Extract the data of split parcel (include nodes, edges, and region); (2) Input the coordinates of the new edge (l1 or l1 and l2); (3) Determination the change type according to the shape of the involved parcel and the relationship between the inputting edges (or arcs) and the involved entities: it is assumed that CASE 1 to CASE 7 is corresponding to the changes 1 to 7 showed by Fig.5. (4) Edges (or arcs) will be reconstructed if necessary, new parcels will be built; (5) the updating operation expressions will be formed; (6) the database updating operations are executed to update the records in the database; (7) semantic attribute of new entities will be asked to input; (8) the consistency of the involved records will be checked according to the consistency rules. If

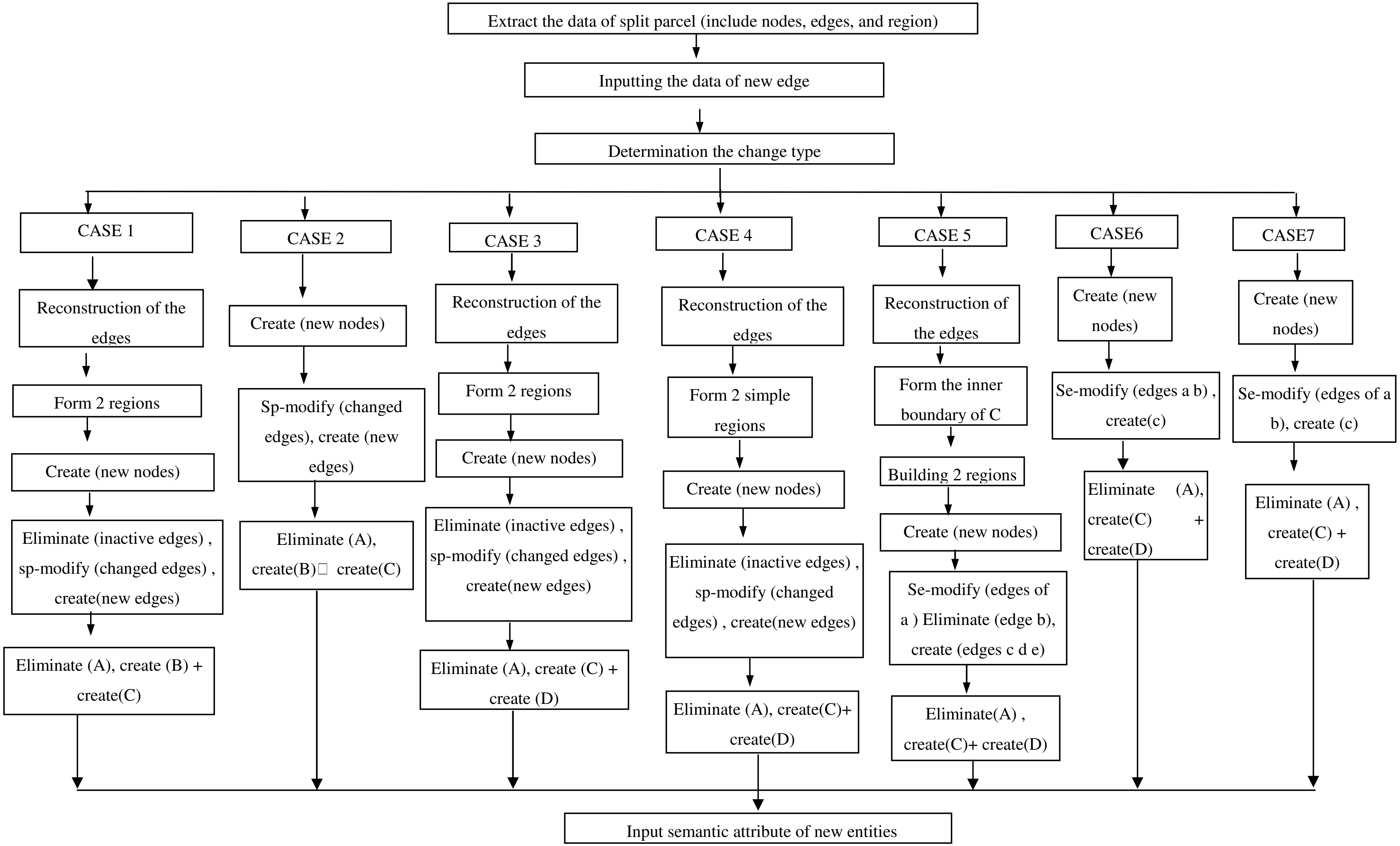

Fig.6 the updating program of split

there is no problem in the new data sets, the updating process ends; if there are some conflicts, the conflicts will be marked, and the operator will deal with them interactively. Based on the above algorithm and design, the prototype system was implemented using VC++ in ORACLE9I SPATIAL and MAPINFO 6.5 platform.

7. CONCLUSION

(1) There are 4 kinds of land subdivision event: split, union, reallocation and modification of the common border between two parcels.

(2) 31 kinds of topological relations between a simple parcel and a parcel with one hole are distinguished with an extended 4-intersection model in this paper, and 7 kinds of possible topological relations between two parcels at the same time are concluded.

(3) 7 kinds of change types of split event are presented in this paper.

(4) Events-Based Incremental Updating of Cadastral Database (EBIU-CDB) is an efficient automatic (semi-automatic) updating approach for the Cadastral Database.

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