Design of Conceptual Model in Digital Map Database

ZOU Yijiang

1 Introduction

With years of development and application, the technique of database has obtained a series of fruits not only in the software of DBMS but also in the design and application of database. At the same time, fundamental theories of database have been developed and enriched gradually. The application of database technique have driven the development of digital map database properly, and the construction of digital map database has become one of the hot researches in this field. There are many researches on the construction of digital map database from institutes and individuals home and abroad, however, there are some special characteristics and requirements which are different from those of other databases for digital map database. Therefore, it is important to exploit special digital map DBMS with those characteristics.

2 Conceptual model of digital map database

The map information include mainly the spatial information, attributive information and temporal characteristics information. Spatial information can be divided into two kinds of information, which can be named the location information and topologic information. Attributive information can be divided into three kinds of information, which can be named the description information, quantitative information and place name information.

In order to design a digital map database that satisfies the demands of digital map information at present and in the future, a conceptual model of digital map database is needed, which must satisfies the following two requirements.
1) Describing the constructing information of a digital map entity.
2) Describing the relation information between digital map entities.

According to the constraints above, a conceptual model for the digital map database is presented in Fig. 1.

| Entity | Pointer of location information | Pointer of topologic relation | Pointer of description | Pointer of quantity | Pointer of place name |
|--------|---------------------------------|------------------------------|-----------------------|--------------------|----------------------|
| (a)    |                                 |                              |                       |                    |                      |
| (b)    | Series of coordinate1           | Series of coordinate2        | ...                   | Series of coordinaten |
| (c)    | Pointer of topologic relation   | Entity1                      | Entity2               | ...                | Entityn               |
| (d)    | Pointer of description          | Classification of entity     | Hierarchy of entity   | Qualitative description |
| (e)    | Pointer of quantity             | Horizontal degree            | Vertical degree       | Height degree       | Capacity degree       | Temporal entity       | Other quantity        |
| (f)    | Pointer of place name           | Place name of entity         | Alias name of entity  | Administration region | Transportation condition | Social relation |

Fig. 1 Conceptual model of digital map database

2.1 Composition of the conceptual model of digital map database

The construction of the digital map entity is shown in Fig. 1 (a), in which the digital map entity is composed of spatial information and attributive information in map. The spatial information includes location and topologic relation information of entities, and the attributive information of the digital map entity includes its description information, quantitative information and place name information. The information is connected with the pointers in the construction graph of the digital map entity.

The description of the location information of the digital map entity is shown in Fig. 1 (b), in which the coordinate data of the digital map entity is presented.

The description of the topologic relation of digital map entity is shown in Fig. 1 (c), in which the neighboring relation, connecting relation and containing relation are described.

The construction of description information of digital map entity is shown in Fig. 1 (d), in which quality characteristics of the digital map entity are described. Quality characteristics include characteristics of the classification of geographic element, the hierarchy element and qualitative description of hierarchy elements.

Quantitative characteristics of digital map entity are shown in Fig. 1 (e), in which the quantity characteristics of the digital map entity are described. But not all digital map entities possess all these quantitative characteristics; some digital map entities just possess part of them.

1) horizontal degree: quantitative measurement for the characteristics of width, thickness, diameter and radius, etc.
2) vertical degree: quantitative measurement for the characteristics of length, depth, etc.
3) height degree: quantitative measurement for the characteristics of absolute height and relative height, etc.
4) capacity degree: quantitative measurement for the characteristics of area, volume and weight, etc.
5) temporal entity: quantitative measurement for the characteristics of second, minute, hour, day, month and year, etc.
6) other quantitative: quantitative measurement for the characteristics that can not be induced with the above elements.

Place name description of digital map entity is shown in Fig. 1 (f), in which the place name and relative information of the digital map entity are described, such as the information of place name, alias name, administration relation, transportation relation and social relation of the digital map entity.

1) place name: description for the first name of a map element,
2) alias name: description for the second name of a map element,
3) administration relation: description for admin-
istration region's subjection relation of the place name region,
4) transportation relation: description for transportation condition in place name region,
5) social relation: description for the development condition in policy, economy and military in place name region.

2.2 Logic relation of the conceptual model

The logic relation among digital map entities, spatial information and attributive information in the conceptual model of digital map database is shown in Fig. 2, from which the following conclusions can be drawn.

1) A digital map entity is related to only one location information of digital map entity.
2) Many digital map entities can be related to only one description information of digital map entity. When descriptions of many digital map entities are the same, they can be described with just one description.

3) Many digital map entities can be related to only one reference description of digital map entity. When the quantity information of many digital map entities is the same, they can be described with just one quantity description.
4) Many digital map entities can be related to only one place name description of digital map entity.
When the place name information of many digital map entities is the same, they can be described with just one place name description.

5) A digital map entity can be related to many digital map entities with a topologic relation of relating, neighboring or containing.

2.3 Relation conception of the conceptual model

In the theory of database, an available method for the design of conceptual model of database is applying the conception of standardized process of relation data model, the reason for the application of standardized process is ensuring the availability of the conceptual model of database\(^4,5\). When the Normal Form of the database is lacking, problems of redundancies of data, abnormal situation exceptions of data insertion or deletion and others will happen. But when the Normal Form is high, difficulties for the maintenance and availability of database will be serious. Therefore the Normal Form of Boyce —— Coded (BCNF) is the best for normal conception model of database. The basic standard of the BCNF is that the dependencies in relation model are keywords' dependencies.

There is a construction describing the main relation model of the conceptual model of the digital map database. Because of the problems of data redundancy, insertion and deletion anomaly etc, the main relation model of the digital map construction is decomposed to sub relation model of descriptive presentation, quantitative presentation, place name presentation, topologic relation presentation and location presentation of digital map entity. On the basis of the analysis for the conceptual model of digital map database, the digital map entity is corresponding to the only keywords of the relation model of construction description. Moreover, the descriptive pointer of the digital map entity to the relation model of presentation, the quantity pointer to the relation model of quantitative presentation, the place name pointer to place name presentation, the relation pointer to topologic relation presentation, the location pointer to the location presentation, and other attribute terms depend on these keywords. Therefore the conceptual model of digital map database satisfies the BCNF. And according to the theory of database, the conceptual model of digital map database possesses the property of lossless connectivity.

3 Conclusion

The digital map database has its own characteristics which are different from those in the normal databases, and the digital map database system is different to the normal database system, which is important for the research and development of the digital map database system.

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