REASEARCH ON THE CHANGE-OF-FEATURE BASED SPATIO-TEMPORAL OBJECT RELATIONAL DATA MODEL

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ABSTRACT:

The spatio-temporal data is our cognition to external matter and the spatio-temporal data model is the fundamental basic to manage the spatio-temporal data. The spatio-temporal object is always changing so we need a spatio-temporal data model which can reflect the change information and change reason and roundly and exactly describe the spatio-temporal world. At the same time more and more demands to spatio-temporal data are proposed, but now the research of the spatio-temporal data model still is on the stage of theory research and can not implement the real application. We proposed a new model-the change-of-feature based spatio-temporal object relational data model by researching and analyzing the current spatio-temporal data models. This model reflects the changes of object and changing reason. Because it used the object relational way to implement it is easy to combine with current mainstream database- relational database. The article mainly developed the feature change and introduced the concept model and its implement and finally gave an example of implementing our model in the agriculture management. The article is an attempt to resolve the implementation of the spatio-temporal data model.

1. PREFACE

The research about the spatio-temporal data model sprang up in 1970s and until now many scholars had designed and proposed many Spatio-Temporal models. At the same time more and more demands to spatio-temporal data were proposed. But until now there is no really commercial spatio-temporal database software and current spatio-temporal data model cannot well effectively integrate with the mainstream relational database technology. Now the instances of really exporting the spatio-temporal database to GIS are few. The reason causing this problem included: (1) the matter of the spatio-temporal data model. The most of spatio-temporal data model having proposed emphasized particularly on theory research and divorced from the real application; (2) the matter of the spatio-temporal database implement technology. The spatio-temporal data include four dimensions information but the storing way of mainstream relational database is two dimensions relational table, so it is very difficult for relational database to directly manage spatio-temporal data.

Now the spatio-temporal data models (Cao, 2001; Langran,1992; Peuquet et al, 1995; Cui et al,2004,; Jang et al , 2005; Zhai et al ,2005) generally included the following: Snapshots (Ross 1985), Spatial Temporal Cube(Hagerstand 1970; Rudcer 1977; Szego 1987), Base State with amendments(Langran 1990; Peuquest, 1994), Space-time Composite (Chrisman, 1983), Spatial Temporal Domain （Peuquest,1994），Event Based Spatio-temporal Data Model （Peuquet D.J ,1995），feature-based spatial-temporal data model（ W.H.Cui and W.Z.Shi,1995）and ect. These models had respective advantage and disadvantage and among them the feature-based spatial-temporal data model was a modeling way on higher abstract level and was built on good cognitive view on geographic information. At the same time it defined and built spatial relation and aspatial relation by using object-oriented principle and method. But this model can not carry out in depth study on change process and change reason of the spatio-temporal object so it cannot implement application. The article expands the feature-based spatial-temporal data model and then proposes the change of feature based spatio-temporal object relational model, which emphasizes the concept of event and state and implements the model by object relational way. The article attempts to promote the research and the extensive application of spatio-temporal data model.

The rest of this article is structured as follows. In Section 2 we introduced the conceptual model, implementing way and advantage of the change of feature based spatio-temporal object relational model. Section 3 described how implement the model and gives an example of application. Finally Section 4 gives some conclusions.

2. THE CHANGE OF FEATURE BASED SPATIO-TEMPORAL OBJECT RELATIONAL MODEL

2.1 Outline of the feature based GIS

How to organize data is an important issue in GIS system construction. The problems in GIS are to large extent aroused by the design of data model and the expression way of data (Peuquet, 1984; Tang et al, 1996). In the development process of GIS with the increasing development of the cognitive manner and cognitive means to the objective world there are two ways to organize data: layer based organization of data and feature based organization of data. The human's cognition to world is based on the geographic feature so the feature based organization of data can effectively describe the geographic object or phenomena and is easy to implement, at the same time it can be more easily understood and accepted by users

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(Ma and Dai, 2003). Many institutions and scholars had began to study feature based GIS, such as USGS(Unite State Geological Survey), ISO/TC211 (International Standard Organization/ Technology Committee) Geographic information/Geomatics,, OGC(OpenGIS Consortium), Usery.E.L、Tang.A.Y, Ma.R.H, Chen.C.S, Cui.W.H, Shi.W.Z, Li.X.J, Li.H.G, Lu.F et al. Cui.W.H and Shi.W.Z combined the feature based idea and the study on spatio-temporal data model and then proposed the feature based spatio-temporal data model (see figure 1). From the perspective of feature the feature based spatio-temporal data model basing on the identifying feature type and feature instance analyzed the attribute, function and relationship of feature instance, built the comprehensive and organic expression on attribute, function and relationship of geographic information using the feature instance as unite on the frame of temporal and spatial reference system(Li, 1999).
The feature based spatio-temporal data model is consistent with the way of people's cognition about the world, so it can truly and compactly describe the people's understanding the external world. This model describes the change of the spatio-temporal object in a certain extent but can not make an intensive study. The article basing on this model pays attention to the research and expression of event and state and makes an intensive study of the change of spatio-temporal object.

2.2 Study on the change of feature

Describing spatio-temporal phenomena with respect to change opens new doors to understanding the underlying components of change and recognizing the semantics associated with change (Hornsby and Egenhofer, 2000). Various models of change have been developed by mathematicians, geographers, philosophers and computer scientists. The change is one of the basic characters of spatio-temporal object and the research on change of feature is basic to expose the changing process, changing reason of spatio-temporal object and carry out spatio-temporal reasoning.
Feature includes two levels: feature type is on the abstract level and feature instance represents the material geographic phenomena. Because the change is closest to material object or phenomena and the change of feature instance is more common we use the change of feature instance to represent the change of feature.
The change of feature consists of three elements:
(1)Changing object: it is core and basis;
(2)Event: it is the driving force for the change. Research on event can trace the change reason and help to carry out forecast
(3)Changing process: includes quantitative change or qualitative change. It decides that the result is creating new object or not changing the essence of object.
From above we can see that to describe the change need feature instance, event and state. So we added the concept of event and state into the feature based spatio-temporal data model and made it able to reflect the change reason and change process.

2.3 State and event

A comprehensive spatio-temporal data model should easily reconstruct history state and forecast feature and are convenient for building the simulation model of spatio-temporal process. Event and state are absolutely necessary to build such model. When we add the concept of event and state into the spatio-temporal data model the spatio-temporal data records not only the change of spatio-temporal object but also changing process and changing reason, which makes the model easy to carry out the causality reasoning of state of the spatio-temporal object.

Many experts had noticed the significance of the research on the event and state and started corresponding study. In artificial intelligence field in 1986 R. Kowalski and M. Sergot firstly introduced the concept of event calculus to formalize the reasoning about events and changes (Kowalski and Sergot, 1996). In spatio-temporal data model field in 1995 Peuque.D.J firstly proposed the event based spatio-temporal data model(ESTDM)(Peuquet and Duan, 1995), Claramunt and Theriault research the change process altering the object(Claramunt and Theriault,1995), Yuan.M study how to express the time, event, state and process(Yuan, 2001). In our country Jiang.J (Jiang, 2000), Huang.X.Y(Huang et al,2001), Zhen.K.G(Zhen et al ,2001), Lin.G.F(Lin,2000), Xu.Z.H(Xu et al 2002) et cl respectively made intensive studies of event, state and relationship between them from the model or semantic point of view. Now in all the event based spatio-temporal data models the definition of event can be classed into two types: one thought that the event was process of changing of the spatio-temporal object and another thought that the event was reason causing the spatio-temporal object to change.

The article proposes that event is significant action causing the changing of feature instance at some instant, which includes actions caused by inner reasons or exterior reasons. The change of feature instance includes: the birth and die of feature instance, the spatial change and attribute change of feature instance. The article thinks the feature instance has two states: one is steady state in which all attributes do not vary; another is changing process caused by external or inner action, namely changing state or unstable state. They are one after the other in time. It is difficult to judge their happening time which is one of important problems needed be resolved.

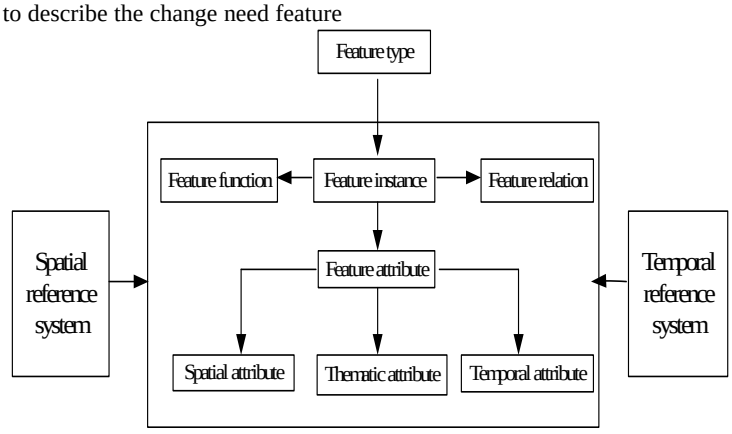

Figure1. Frame of feature based spatial-temporal data model (CUI.W.H,1999)

2.4 Structure of the model

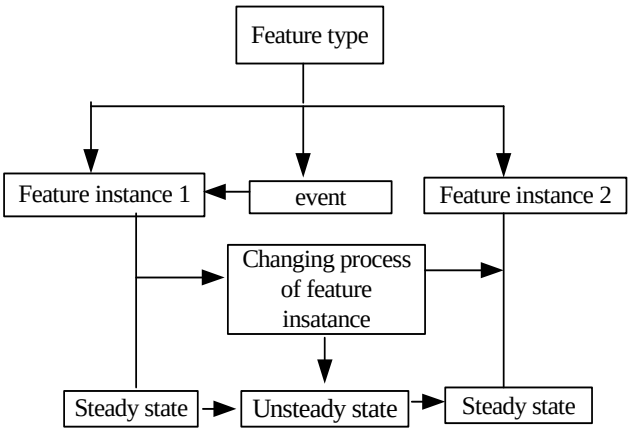

Figure2. Conceptual frame of the feature change based spatio-temporal data model

The article adds the concept of event and state into the feature based spatio-temporal data model and designs the change-of-feature based spatio-temporal object relational data model.

Model include following meanings:
(1) Driven by event the geographic object transforms from the steady state into the changing state and then comes to next steady state.
(2) The feature instance one is different from the feature instance two. There are two cases: one is that the feature instance one has same identifier with the feature instance two. Their essential attributes are same and they are different in some no- essential attributes; the other case is that the feature instance one occurs the qualitative change and transforms into the feature instance two so they have different identifier and different essential attributes.

2.5 Implementation of the model

The feature based spatio-temporal data model is object-oriented so now its realization is mainly object oriented way——hypergraph -based data model. Hypergraph-based data model can well integrate with the feature based spatio-temporal data model but the real implementation is difficult. Now the mainstream database is relational database which does not support the object-oriented idea and cannot store four dimensions spatio-temporal data. The best way to implement the spatio-temporal data model is the object relational data model (Le, 2004). The object relational data model is the expanded relational model (Jin et al 2004), which makes the relational model effectively use the object oriented technology to express and operate the complex data by user-defined expanding data type and operation on data type. So using the object relational model to implement the feature based spatio-temporal data model is easy to combine the model and usual relational database and realize the application of spatio-temporal data. The article uses the object relational way to implement our model.

3. EXPERIMENT

When managing the tobacco farmland we need record and manage the planting information, owner information and growth state information ect al. The article chooses the object relational database-PostgreSQL as the basic database, uses the change-of-feature based object relational data model to modeling the management on tobacco farmland and builds the spatio-temporal database management by using the development toll- ArcEngine and C# to connect the database and spatio-temporal application.

PostgreSQL is an open source object relational database system which has the most powerful function and the most plenty attribute. It supports almost all SQL standards and has all kinds of native programming interfaces to satisfy all development demand (Peng, 2001). PostgreSQL provides PostGIS module to supports all types in OGC simple features specification and allows the database to store and operate GIS object.

When we dump the shape file into PostgreSQL we can find that the database automatically creates two tables: geometry_columns and spatial_res_sys which respectively record the space field information and project system information. We add the changing information table, event information table, changing state information table and deletion information table. The time information is added into each table as time fields. Every table connects with another table. Considering the cycle of tobacco planting is one year we create a result table to record the finial information of the fields at the end of the year and use it as basic table for next year planting information. So in database there are many basic tables and when we need query the information of some filed at some time we firstly confirm which year it belong to in order to confirm which basic table we will use, then query the changing information basing on the basic table and finally we overlay the basic table and changing information to get the query result and show it with map to user.

The tobacco farmland spatio-temporal information management system includes two main functions showing in figure 3.

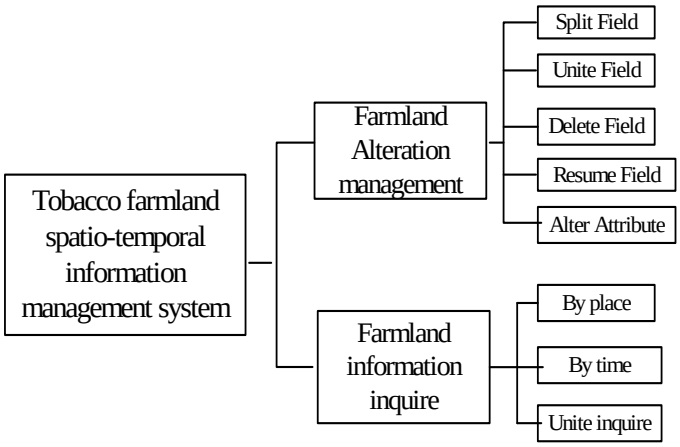

Figure 3 the structure of tobacco farmland spatio-temporal information management system

4. CONCLUSION

The article systemically analyzes the problems existing among the spatio-temporal data models and then proposed a new spatio-temporal model- the change-of–feature based spatio-temporal data model. Our model has following advantages: basing on the feature idea, describe the

spatio-temporal change reason and change process, more objectively and more comprehensively express the spatio-temporal world, is easy to go on spatio-temporal reasoning and forecasting.

In future we also need perfect the query and index to make it truly be applied to practice.

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