A Model for Integrating Multi-scale Spatial Data for e-Government and Public Service

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Key words: Geo-spatial framework, e-government, data integration, data model

SUMMARY

In recent years, significant developments have been made in Spatial Data Infrastructure (SDI) in China. Datasets of various types have been produced at national, provincial and even city levels. GIS technology has been used more and more in E-government and public services. Such application might involve different level of study in China, for example, an officer in local government might want to know where is the road cross that are having serious traffic jam, while an official in central government wants to know the location of a county that are suffering flooding. So the geo-framework should be multi-scale, multi-abstracted and multi-represented, which means one geographic feature in the real world will be modeled several times in SDI.

To build the spatial database for the discussed application, one of the key issues is to find the most suitable geo-spatial models according to the different level of study. The other is to integrate the data, which means to build and maintain the linkages among those differently represented objects.

In this paper, a data model was proposed which can integrate geographic features in different scale based on the linkages in geometry level and feature level. With this method, a sample database was implemented, including 1:1 million scale (cover the area of China), 1:250,000 scale (cover the area of Beijing city), 1:10,000 scale (cover the downtown area of Beijing) and 1:500 scale (cover one district within downtown area of Beijing). A Web-based platform that can used in E-government has been developed based on this database.

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1. BACKGROUND OF STUDY

With the development of national informationization and e-government in China, more and more geo-spatial information has been created and used. The requirements to the quality of spatial data have also been enhanced. In such application as e-government and e-business, geo-spatial information should acts as “carrier” of various spatial-related social-economic or natural resource information. When the social-economic and natural resource data is integrated with the geo-framework (as fig 1 shows), people can implement location-based query, analysis and statistics, and make more wise decisions.

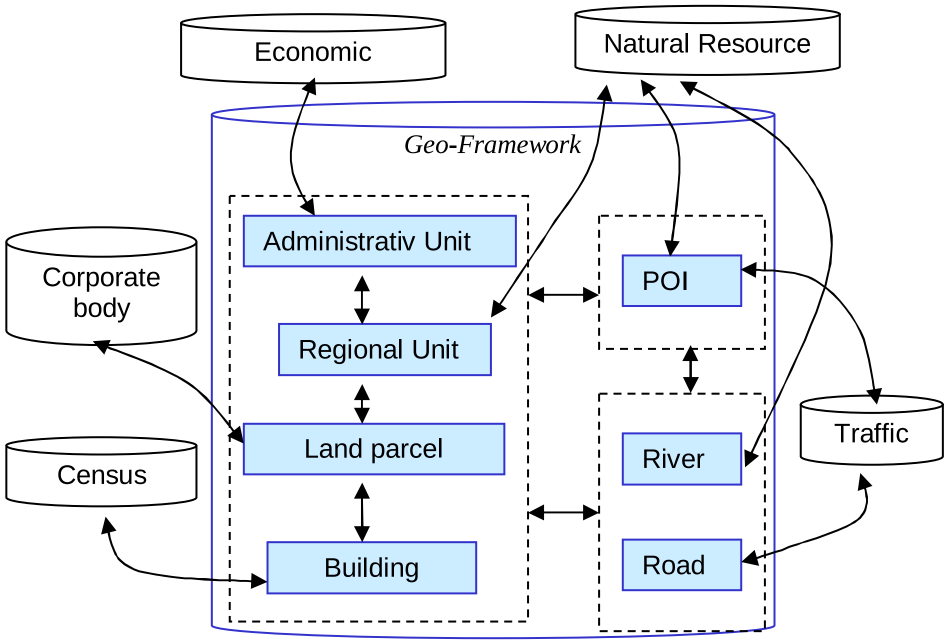

Fig. 1 Geo-framework acts as ”Carrier” of other information

The geo-framework has following characters：

1. The ideal method for improving data usability of a geo-framework would be based on a feature-oriented data model (Usery, 1996a; 1996b) . To link with various social-economic and natural resource information, the geo-spatial data must be modeled as identifiable features accroding to the geographic entities existing in the real world. In other words, the geo-spatial framework must use feature as the basic modelling unit.
2. Sometimes the geo-framework must be multi-scaled to meet the application from macro- to micro level.
3. Geo-spatial data from different region and with different scale mut be made accroding to

the same standards, including data model, projection, representation, etc. And the description of the same entity in different dataset should be consistent.

4. The relationships among features should be modeled. Multi-datasets integration must handle horizontal (adjacency)(Chrisman, 1990), vertical (overlay), and temporal integration. For example, the relations among buildings and parcels; and the relations between point feature and face feature which represent the same entity in different scale.

In the past decades China has established multi-scale spatial database covering the whole country, including 1:1 million and 1:250,000 topographic database. The construction of 1:50,000 database will be finished within this year. Some 1:10,000 databases have been established by provincial geomatics center and 1:2000 or 1:500 databases have also been set up by some cities. But there are some limitations in these datasets. One of them is that the standards use by different organizations or in different periods might not be completly same. The other is that the data modelling mainly focus on ”digitizing the cartographic maps” so that datasets or databases imitate the paper cartographic maps. The feature-based data model has not been taken into enough consideration. In addition, there are no explicit relationships between cartographic elements or geo-features in different scale datasets. This might cause confusion when people analyze information cover both macro and micro scopes.

Thus to create geo-spatial framework in China, two kinds of task should be implemented. The first one is to process current existing datasets to make them stand by same standards. The second one is to produce a feature-based geo-spatial framework with the standarized datasets. The features in this new kind of geo-spatial framework can be identified uniquely and can be easily integrated with various social-economic and natural resource information. This paper will discuss the method of the second task.

2. STATUS OF DEVELOPMENT OF MULTI-SCALE GEO-SPATIAL FRAMEWORK

Recent years, most of organization who is producing or providing service of geo-spatial information face the problem of integrating various datasets that are created separately already and improve the usability of them. For this target, significant researches has been done and some countries have initiated national projects, for example DNF project in UK(www.odnancesurvey.co.uk), National Mapping project in USA (www.usgs.gov), AFIS-ALKIS-ATKIS model in Germany（www.adv-online.de， www.atkis.de, www.sapos.de）, Geo-connections Program in Canada（http://www.cgdi.gc.ca）, etc. As results of these projects, some feature-oriented data products have been issued, such as Master Map in Ordance Survey, National Map in USGS, etc. Similar projects are also carrying on by Australia (www.anzlic.org.au) and Danmark (Daugbjerg, etc.2001).

There are some common measures in these projects:

1. First, process existing datasets to eliminate the differences in datum projections, coordinate systems, data models, spatial and temporal resolution, precision, and accuracy.
2. Designing a feature-based data model and establish a new feature-based geo-spatial

framework. Every feature in this framework can be identified uniquely.
3. Use the feature-based geo-spatial framework as a common base to integrate various thematic data, such as traffic, cadastral, natural resource, census, etc.

But we would not adopt directly such method in the upgrading of Chinese databases. The main reasons are:
1. To define every entity in the real world as an integer feature is easy when we handle face or point features, such as land parcels, buildings and POIs. But this method has limitations when it is used to describe line feature, such as rivers and roads. That's because line features always cut with other features and the boundaries of a line feature are generally difficult to define.
2. The application of such feature-based model will requir the change of data production technologies, including data collection, updating, data management, and software, etc. This kind of change is not so easy in China because there are lots of provincial and municipal geomatics centers who are used to current technologies and have already equiped with softwares that are adapted to current technologies.
3. It's difficult for this method to meet the requirement of cartograph.

Based on above analysis, the authors of this paper proposed a method for establishing the multi-scale geo-spatial framework. This model can represent the geo-entities in the real world explicitly, at the same time takes into consideration the requirements of cartography and the description of relationships between features.

3. DATA MODEL FOR MULTI-SCALE GEO-SPATIAL FRAMEWORK

3.1 Data model based on identification of cartographic element and feature

The proposed data model consisted by cartographic elements, features, feature relationships, features attributes and relations between them, as fig. 2 shows.

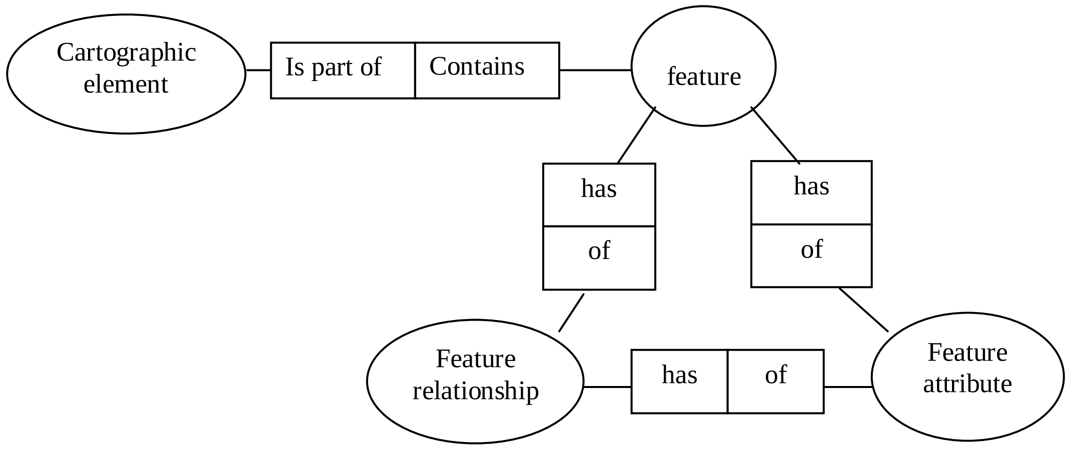

Fig 2. Data model for multi-scale geo-spatial framework

In this model, the cartographic element is the atomic construction element in a cartographic representation, i.e. node, edge and face. A feature is consisted by one or more cartographic elements. A feature is a database representation of a real world object. Feature relationship is a characteristic of a feature involving other features. Feature attribute is a characteristic of a feature which is independent of other features.

An unique identify code should be assigned to each cartographic element and feature. The code for a cartographic element is called Element ID (EID) and the code for a feature is called FeatureID (FID).

Fig. 3 is an example of the data model, where element A, B, C, D, ……compose the feature YELLOW RIVER. YELLOW RIVER, BRANCH M and BRANCH N are features, each has different attributes. YELLOW RIVER and BRANCH M has 2 kind of relationships, one is CONNECTIVITY, the other is ... IS THE BRANCH OF ....

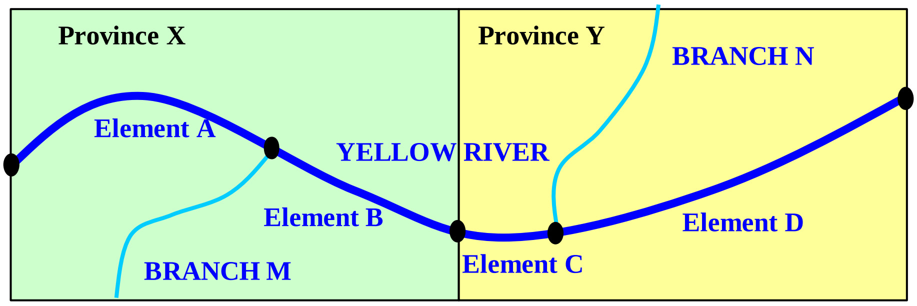

Fig 3. Example of cartographic element and feature

3.2 Representation of feature relationships

The feature relationship includes topology relationship and linkage relationship. Here we only discuss the linkage relationship. The model of the linkage relationship is shown in Fig.4.

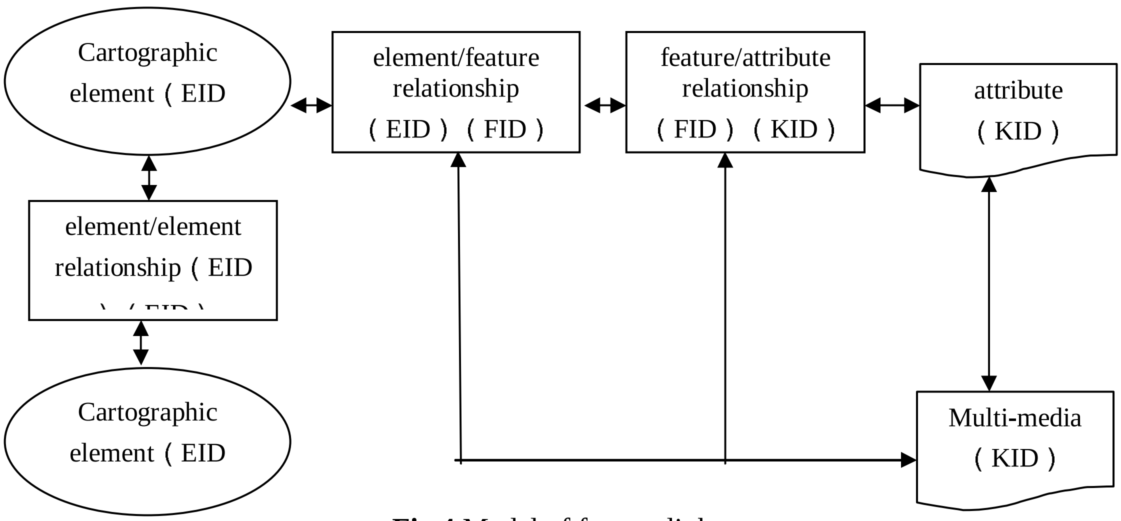

Fig.4 Model of feature linkage

3.2.1 Relationship between features in the same scale

Sometimes a feature has to be cut into cartographic elements due to data management block or map sheet. In such cases the linkage between elements that compose the same feature should be established. As Fig. 5 shows, feature YELLOW RIVER (FID = RIVER001) is cut into 2 elements by the boundary of province X and province Y. The EID of element A is A0001, and the EID of element B is B0001. A series relation tables are built up as in Fig. 6.

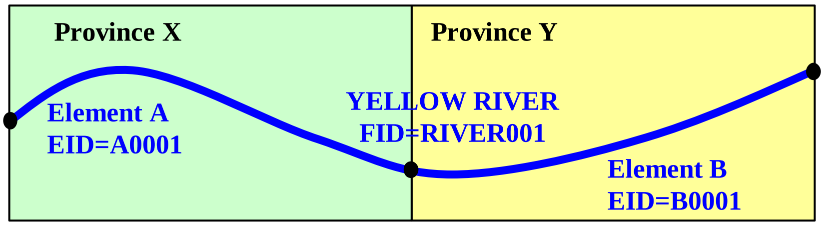

Fig. 5 A feature cut by administrative boundary

Table of Element relationship

ID of element (EID)	ID of adjoin element (EID)
B0001	A0001

Table of element and feature

ID of element (EID)	ID of feature (FID)
A0001	RIVER001
B0001	RIVER001

Table of feature and attribute

ID of feature (FID)	Name (KID)
RIVER001	YELLOW RIVER
RIVER002	YANGZI RIVER

Table of attributes

Name (KID)	length	flux
YELLOW RIVER	……	……
YANGZI RIVER	……	……

Fig 6 Example of relationship table

3.2.2 Relationship between features in different scale

An object in the real world might be represented as different types of features according to the level of abstract. For example, a city can be represented as a point in a small scale data, a face in a medium scale data, and a combination of many points, lines and faces in a large scale data. To use the representation of an organization as the example, in the 1:50,000 data, this organization is abstracted as a point feature. But in 1:500 data, this organization will be consisted of many buildings (Fig. 7).

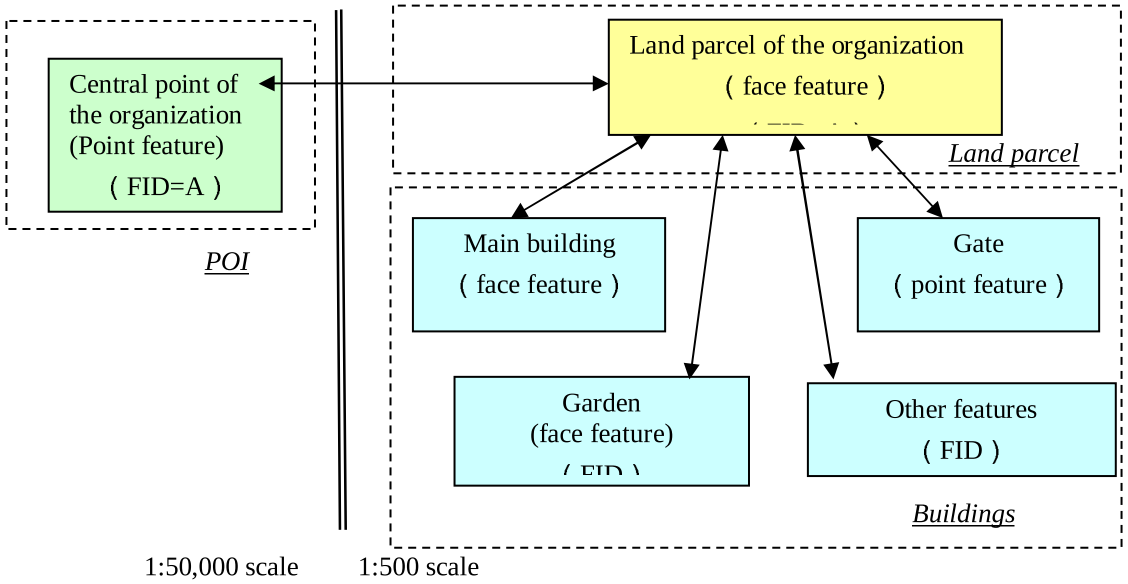

Fig. 7 representation of an object in different scale

The relationships between these features can be modeled with the tables shown in Fig. 8

The relationship between land parcel and buildings

ID of the organizaiton (FID)	ID of Building (FID)	Description
A	JF001	Main building
A	JM001	Gate
A	...	Garden
A		

Fig. 8 Table of relationship between features in different scale

4. CONCLUSION

As fig. 9 shows, the proposed method use EID and FID to link the cartographic elements, geographic features and social-economic inforamtion. The advantage of this method is that it can meet both the requirements of feature-based modelling and cartography. It can also improve the usability of geo-spatial data while keeping current data collection technology unchanged or change as little as possible. In addition, it divides the "field" of organizations of data production and data application, which will be beneficial to improve data quality and the efficiency of data production.

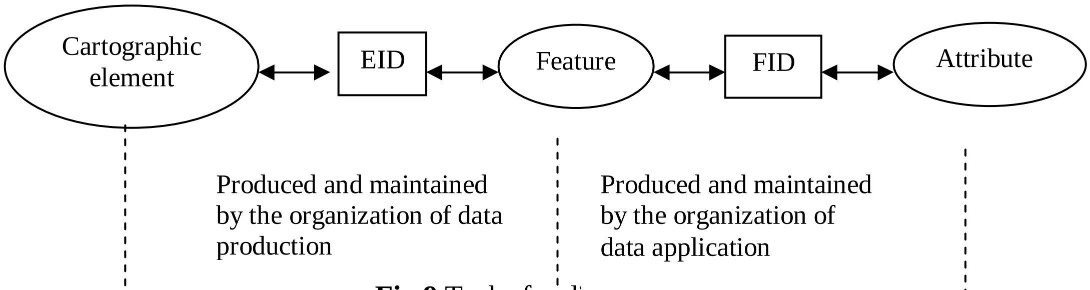

Fig.9 Tasks for di

With the proposed method, we processed some datasets, including 1:1 million; 1:250,000; 1:10,000 and 1:500 scale. To verify the method, the processed data was used in some application systems. The results of the experiments means the method is feasible.

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