AN OBJECT-ORIENTED AND USER-ORIENTED DATA MODEL

Hu Ruiming, Yang Suqin
University of Hainan
Hainan Geoinformatics Center Group

Hu Jun
School of Urban Studies, WTUSM
Urban Planning and Management Department

KEY WORDS: OOP, VB, GUI, User-oriented, Data Model, Basic Object Class, User feature Object Class, Newly Increased Object Class

ABSTRACT

The GIS applications are extending into wider and wider scope, which emphasizes that the GIS applications should be more flexible and adaptable. To developing countries, because the problems of lack of capital are more serious and the level of education and technology is relatively low, an easy-to-expanded database and application model are badly needed. Object-oriented modelling has been recommended for the modelling and organization of spatial data. The core of this paper is how to make the GIS be adapted to this changeable world and gradually constantly emerging demands from the users. The OOP concepts are discussed and the investigations for using OOP methods to construct a practicable information system are explained. An example of an object-oriented and user-oriented data model implemented by an OOP language with graphic user interface (GUI) is presented.

1. Introduction

At present, the softwares for GIS are mainly written in traditional computer languages. As a kind of intelligence products, it had been carrying on by individual development, other than by group working. With the enhance of computer applications both in depth and in width, it was considered that the software that was called as "the soul of computers" is getting more and more difficult to update and maintain. Since 70s, it was realized that computer softwares must be produced in industrialization ways and the software science which mainly for large software product was formed. However, software industry developed rather slowly compared to the development of hardware technology. The essential reason is that the hardware products have assembly parts and those parts can be standardized. As a result, standardized parts made it possible to produce in a large scale level.

In the end of the eightieth century, the revolution to standardize the industry began and after that machine manufacturing industry gained a great development. Nowadays a similar revolution is happening in computer software industry. It is object-oriented programming (OOP). Object-oriented programming can increase not only the software productivity greatly, but also enable the software products to adapt to the changeable world. Furthermore, GIS were developing very rapidly especially in developing countries, such as in south-east Asia and in China. In developing countries, the problems of lack of capital are relatively serious and the foundation, e.g. the basic map database, the total education level, ... etc., is also poor. In this condition, it becomes an important matter to make limited capital the most efficient use. The current situation is completely opposite. As an example, many Chinese cities are setting up expensive GISs, but the consequences are not so satisfying. Every city and every department has different tasks. The traditional programming methods have not been able to meet the needs of such changeable circumstances. The GIS users have to build up giant application systems although over-all systems are not usually able to deal with every specific area very well. As a result, it takes time to build up, but can not come into force in practice job. When new demands come, the systems are difficult to update. Moreover, the data updating problems always are the bottleneck problem to obstruct the fully use and development of GIS existed.

The objectives of this paper are to explore a way to overcome the insufficiency of the present GIS method so that a more flexible and adaptable information system can be formed for the GISs existed and which are going to be set up. We try to apply OOP concepts and programming model to an example about a Haikou tourism system. This research will consists of an OOP database model and OOP applications for the users.

2. Substantial analysis of the GIS

No matter how complicated the world is ,GIS is mainly representing the geometric status(including the shape, size, position and topology) and non-geometrical attributes(including all necessary semantic attributes) of certain person and/or persons, certain thing and/or things near the surface of the world at certain position and time. The GIS gives possibilities for various users to understand and analyze the geometric status, non-geometric attributes and relationships among these persons and things, thereby to find out the relevant decisions for a better world;

3. Some important basic concepts of the object-oriented programming languages

The object-oriented programming (OOP) language is usually called "4th generation language" (4GL) in computer science, some various languages are available in the market now, such as: Smalltalk, Turbo Pascal for Windows, Borland C++, MS Visual C++, MS Visual Basic,..., etc. Because OOP languages have developed in the last ten years, it is rather new and it has not yet reached a common standard recognized. Therefore, some of them have more OOP mechanisms, some less. Although the "Visual Basic" is not a complete OOP language, it has touched some key concepts of the OOP, and it is developing further in this direction and will have more OOP mechanisms). It is said that the "Visual Basic" is the best language compared with many other languages which he has ever seen and used. The reason is that it has made the full use of the windows' graphic user interface (GUI).

The "Visual Basic" (VB) language is used and some important basic concepts of it compared with the other OOP languages are briefly introduced:

3.1 Object

Object includes data and procedure that are manipulated by the object and are encapsulated in the object, that is, the window or window body in the VB. In traditional programming, sequence of the procedure and control mechanism determine the control flow of the program. This flow then provides the method for how to organize the whole program in the programming creation period. Therefore, it is quite unrealistic and cumbersome when the dynamic world entities are involved in the programs. The world is changing rapidly. Therefore, we should adapt our thought and the data model to the changeful world. To grasp the logical relationships between the objects is the better choice. The OOP has precisely grasped the relationships between the objects. To send and receive the messages to and from the objects determine the control flow of the programs of the OOP. The object can understand the communication relationships between each unit in the program through the messages sent. The object responds the message sent, and sends the message to the other object. It is the message flow in the whole system rather than the data. It is not "to call a function to act to some data" (traditional viewpoint), but it is "to send a message to an object" (OOP viewpoint). For example, many programming mechanisms in the VB are to change the properties of the object, to send the message to the other object and to write programming codes for responding. Although it sounds quite complex, you will find that they simplify the programming efforts by using the GUI very well.

3.2 Encapsulation

Encapsulation has two different viewpoints: one is from the programming itself and one is from the programming users.

(a) From the viewpoint of OOP itself

The use range of the data in the object is limited in the OOP. In most circumstances a datum is designed to aim at some special conditions or functions, and is not intended to be used by any functions or statements. If you do not limit the data used, when the program is getting bigger, programmer may use the data elsewhere in the program unintentionally because of carelessness. In this way the data may be appeared elsewhere in the program, and there may be no relation at all between these data with the same name. The biggest bug of this method will take place in the following situation: if the program should be modified, added or deleted in some day later, then the programmer will have very big problem, because there is no way to find out where the data will be in the program and You have to distinguish them when you find them. You have to find them all over the program continuously. That is why you should avoid this bug in order to reduce the opportunities to introduce such bugs. This is the main purpose of the encapsulation.

(b) From the viewpoint of the users

The object includes the data and the procedure (or method), the data are its property, and the procedure is its behaviour. The encapsulation means to put the property and the behaviour of the object together in the object, this is a very popular term used in the OOP. To encapsulate the property and the behaviour of the object in the unique source code is more convenient and safe than to put them elsewhere separately in the program.

3.3 Inheritance

A serious backward of the traditional programming languages are unable to adapt the changes of the world, that is, you can not reuse the program designed when changes take place. The only way is to modify even to rewrite the whole program and leading to the resources and programmer's efforts waste.

In OOP the advanced concepts, such as: object, encapsulation, inheritance or reusability (in VB),...,etc. can be used to design the programs which can be adapted to the changes of the world. The object can be simply modified or extended for adapting to the new situations. This is called the object inheritance or the object reusability.

3.4 Dynamic application program with the automatic responding event in real time

In the VB the "change" event can automatically respond the change of the other control item. This means that the program designed can follow the changes automatically. Therefore, it is very useful for designing the dynamic application programs that follow the changes automatically.

4. About OOP database system

A mature OOP language used for GIS application has not yet been available in the market. Therefore, the database of the existing GIS software such as: ARC/INO...,etc. can still be used as the data source and graphic output device.

The traditional GIS database systems are record oriented, which is to say that the data they contain are filed record by record, rather like cards in a conventional card file. Consequently, they are not suited to representing a conceptual data model of geographic reality well. In a famous relational database, all the elements that together comprise a particular map object may put in several records in various tables. However, geometrical data and attribute data are often physically separated. They are in a separate database.

To represent the real world more faithfully, Object-oriented database systems organize the data of the world according to the objects, which are homogeneous, and with various internal and external relations among them. In object-oriented systems, it becomes possible to practice data in a similar way to store data. Objects are manipulated as independent homogeneous entities. Those entities may comprise several other objects in a hierarchy.

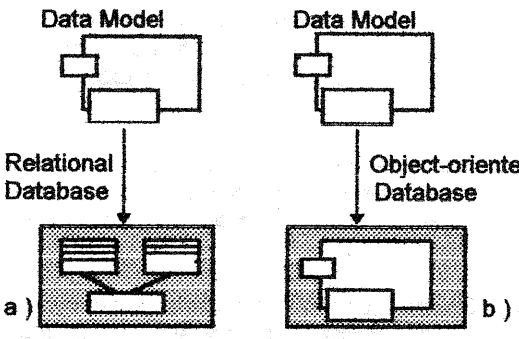

Fig. 1 Object-oriented database (b) compared to a relational database (a). (Adapted from Tor Bernhardsen)

5. Some specific explanations and analyses about the object-oriented and user-oriented data model

5.1 The variety requirements of the users

Theoretically, diversifying of the users' requirements may appear in the applications of the GIS in the following aspects:

- In the global, continental, regional (such as: Asian and Pacific region,...,etc.), national, provincial or state, county, urban, town, rural aspects,...,etc;
- In the various trades, such as: industry, agriculture, commerce, military ... etc.;
- in the various governmental departments, such as: planning, finance and taxation, industry departments,... etc.;

On or under the various lands, coastal areas, island, and in the sea...,etc.

For the GIS data modelling all these users' requirements should be considered. The problem is how to satisfy such a huge requirement.

Diversifying of the users' requirements and huge amount of the data make the GIS more and more complex and expensive. This is not only for the acquisition of the data, but also for the processing and updating of the data. However, in developing countries, it is very difficult to afford such a huge project not only for the funds, but also for the education and the new technologies involved. The GIS is rather a new technology. It integrates the computer science, surveying and mapping, remote sensing, geography, cartography, information science and,...,etc. The people involved in this field are usually not familiar with this new technology.

In order to simplify this new technology, we suggest:

For the different users the GIS can be started in a relatively small project according to their most practicable and possible requirements, and extended later according to their needs and possibilities gradually. Therefore, the data model could be designed in three classes: Basic objects class, users specific feature object class and newly increased and supplementary class.

5.2 Data classification of the GIS data model

According to the consideration above, we suggest that our data model will not be covered with everything, but the initial data model ought to predict some users' needs and their conditions, and it will be extended later according to their needs and possibilities gradually. In order to make the project simple and clear we will consider that the users can be all over the world, but all the users will be restricted for tourism in Hainan province only.

5.2.1 Basic class of the data model

The objects of the basic class will be common for all the users (tourists) who are intended to participate in the tourism in the Hainan province. The contents of this class will have:

- **Building:**

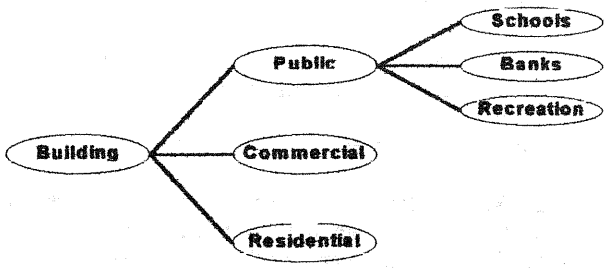

Fig.3 Building for the basic class of the data model

Building in the commercial and residential district; building of some financial institution, transportation unit, entertainment unit, sports unit, and tourist service unit;

- **Road:**

Main streets and bus lines in the city, express highways and main highways in the island;

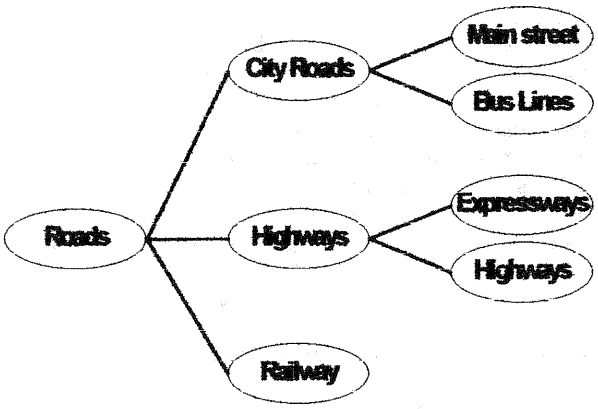

Fig.3 Road for the basic class of the data model

- **Common feature object of relatively large scale:**

Park, hospital, university, residential district.

5.2. 2 Users' feature object class of the data model

1. Analysis of the users' needs

The tourists want to know and handle the following matters:

- Collecting the information about the scenic spots and the tourist maps;
- Selecting the scenic spots, the transportation and the hotels;
- Booking the transportation, collecting the information about the banks, souvenir shops, first aid stations and may be antique shops.

2. GIS should at least provide users the following information

- Hotel facilities, rooms, dining rooms information and room booking matters;
- Transportation information about passing in and out the Island and within the Island, the price lists and the time tables for various means and lines, and the ticket booking matters;
- Banks and first-aid stations' information indicating where they are along the transportation lines and near the scenic spots, and briefly introducing what kind first-aid the station can offer.

3. According to the users' needs the contents of the users' feature object class of the data model will be:

Building:

(a) Tourist service class:

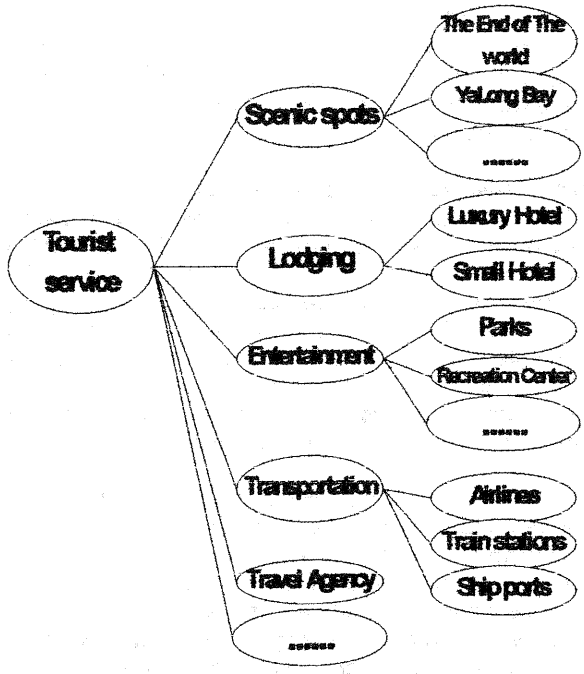

Fig.4 Users' feature object class of the data model

- Hotels information of the over night stations, including: hotel facilities, rooms, dining rooms, room booking matters, and price list;
- Scenic spots Information, including: the target scenic spots and the scenic spots along the transportation line, and the tourist maps;
- Souvenir shops Information, including:
  1. Souvenir shops and the antique shops;
  2. Photo Print Shop Information, including: Commodities and price list;
- Information about the Restaurants along the lines and near the break stops;
- Information about the banks and the first-aid stations along the lines and near the break stops.

(b) Transportation class

- Information about the positions, transportation, time tables, tourist maps, and the tickets prices;
- Long distance bus terminals;
- Airports;
- Connected bus lines terminals with the railways to the mainland;
- Docks;
- Ticket offices: for long distance buses; for airlines; for boat lines; for connected bus lines with the railways to the mainland.

(c) Culture and entertainment class

Lists and the Tel. Nos. of the following classes: Cinemas and theaters; Museums; Parks.

5.2.3 Newly increased users' feature object class of the GIS data model

Supplementary user-oriented feature object class of the GIS data model – due to missing or updating of the data the user-oriented feature objects may be supplemented by users' organizations themselves or by the software supplier according to the purchasing contract.

New user-oriented feature object class of the GIS data model – due to the extension of the GIS applications an extended new user may be added. The supplementary user-oriented feature units should be supplemented by the software supplier.

We will define a general rule here, i.e., we will take the various users' requirements as the standard for each step, such as: data acquisition, various input for the GIS database and designing the user-oriented feature objects. As the time goes on the data in the GIS should be modified, supplemented or updated according to the practical situation as soon as possible.

6. Conclusions

In the last decade a software revolution had been quietly started in the OOP languages in computer science. In this paper we have discussed and analyzed some important concepts of the GIS related items, such as: the OOP languages, the VB language, GUI of windows, the dynamic applications of the OOP languages, the object-oriented database and three classes of an object-oriented and user-oriented data model as an example. In GIS all the object can be composed by the geometric points, lines, polygons and their semantic attributes which can be displayed graphically and/or output by the hardcopies with limited semantic notations on them. All the semantic attributes of the GIS can be queried by its softwares and also can be displayed and/or printed for various users' needs. Pictures displaying, such as: scenic view from various viewpoints is possible. This paper is a part of a research project "Adapting GIS to the changeable world, dynamic applications, quicker queries, convenient analyses and powerful semantic retrieval of attributes for a better world". We are now in the process.

REFERENCES

G. Entsminger,1994. Secrets of the Visual Basic 3 Masters, Second Edition. Sams Publishing (Chinese translator: Feng Jianhua, Tao Wenzhong), Publishing House of Qinghua University, pp. 1-444.

O. Kufuniyi, 1995. An introduction to object-oriented data structures. ITC Journal, pp.1-7.

T. Bernhardsen, 1992. Geographic Information systems. Viak IT, Norway, pp.151-167.

D. F. Scott, E. Bloom, 1994. Visual Basic 3 by Example, Que Corp. (written in Chinese, translated by Zhao Jun, Wan Xinguan, Shi Haidong, Hsu Dong). Publishing House of Qinghua University, pp. 1-381.

Yang Fuqin, Chen Zhong, Zhuang Huaiyuan, 1992. Object-oriented Programming (written in Chinese). Publishing House of Beijing University, pp. 1-325.

Cai Mingzhi, 1994. Guidebook for the Use and Programmingof Borland C++ (written in Chinese). Publishing House of Qinghua University, pp.99-381.

F. Hayes, 1992. Object-oriented Programming Productivity. Unix World, August 1992, pp. 69-72.

E. L. Usery, 1992. Display of Geographic Feature from Multiple Image and Map Databases. *Proceedings of ISPRS Symposium, Commission IV*, pp. 2-9.

O. Kufoniyi, T. Bouloucos and Molenaar, 1994. An Integrated Model for Multilayer Vector Maps and DTM. *Proceedings of ISPRS Symposium, Commission IV*, pp. 664-671.

M. Pilouk and K. Tempfli, 1994. An Object-oriented Approach to the Unified Data Structure of DTM and GIS., pp. 672-679.

B. A. Shahrabi, 1994. Design of a National Topographic Databases: An Object-oriented Approach. *Proceedings of ISPRS Symposium, Commission IV*, pp. 680-687.

M. Molenaar, D.E.Richardson, Object Hierarchies for Linking Aggregation Levels in GIS. *Proceedings of ISPRS Symposium, Commission IV*, pp. 610-617.

J. van Smaalen, M. Molenaar, 1994. Feature Level Topology for ARC/INFO Using the ARC/INFO - ORACLE Interface. *Proceedings of ISPRS Symposium, Commission IV*, pp. 688-695.

M. J. D. Brand, Your Database - Can it meet the 21st Century. *Proceedings of ISPRS Symposium, Commission IV*, pp. 289-296.

M. Stonebraker, 1994. Object-relational darabase systems. Illustra Information Technologies Inc, Oakland, California, 6 pp.

J. G. Hughes, 1991. Object-oriented Database. Printice Hall, New York, 268 pp.

H. R. Searle, 1994. An OO Quadtree for Read Mostly GIS Applications. *Proceedings of ISPRS Symposium, Commission IV*, pp.170—175.