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Original Contribution

ATTRIBUTE DATA MODELS

Sabin I. Ivanov

DEPARTMENT OF GEODESY, FACULTY OF TECHNICAL SCIENCES, KONSTANTIN PRESLAVSKY UNIVERSITY OF SHUMEN, SHUMEN 9712,115, UNIVERSITETSKA STR., E-MAIL: s.ivanov@shu.bg

ABSTRACT: *The article discusses non-spatial data called attributes. Each geographical object or phenomenon possesses one or more attributes that define it, describe it or represent it. The attribute can be size, density, name, date, or population.*

KEY WORDS: *Non-spatial data, GIS, Attribute data, Hierarchical database, Network database, Relational database, Object-oriented database.*

1. Introduction

Attribute (descriptive, semantic) information characterizes the properties of objects, for example, area, perimeter, etc., and is stored in files. The collection of multiple files, as it is known, is called a database. The complexity of dealing with the huge volume of files requires a more complex data management structure or system. It should be noted here that there is a difference in the concepts of "data models" and "database models".

The vector and raster methods [1,2,3,4] for representing the actual objects in the map are data models. The relational, network, hierarchical and object-oriented databases that we are about to look at are the software implementation of the data models.

From the earliest stage of GIS creation until now, three ways of structuring attribute data are known: text files, spreadsheets, and a database, also structured in different forms.

Text files

The oldest way to present semantic information is through files in text format. Such a text format is, for example, the so-called ASCII format or the American Standard Code for Information Interchange.

Spreadsheets

The information about the objects is arranged in tables by type of objects. Tables contain rows (records) and columns (fields). One spatial object is described on each row, and one attribute for it corresponds to each field. Unlike the relational data model, there is no connection between individual attributes of the objects.

Database

So far, in practice, hierarchical, relational, network and object-oriented database models are used, through which the information from the physical database is presented to the user in the form of a logical database.

Hierarchical database: In the hierarchical models (Fig.1) of the database, information about the objects is presented in a strictly hierarchical subdivision of the specific objects. Each of them is part of a common object and includes several more elementary objects. In this way, the hierarchical model resembles a tree-like structure in which records from each level are subordinated to the higher one in the hierarchy. For example, a cadastral map contains individual objects, arranged in the following hierarchical order: land (settlement), cadastral region, land property, building, independent property in a building. In this model, each spatial object corresponds to more than one attribute in the tables. For example, the attributes for a building can be: built-up area, number of floors, construction, functional purpose, year of construction.

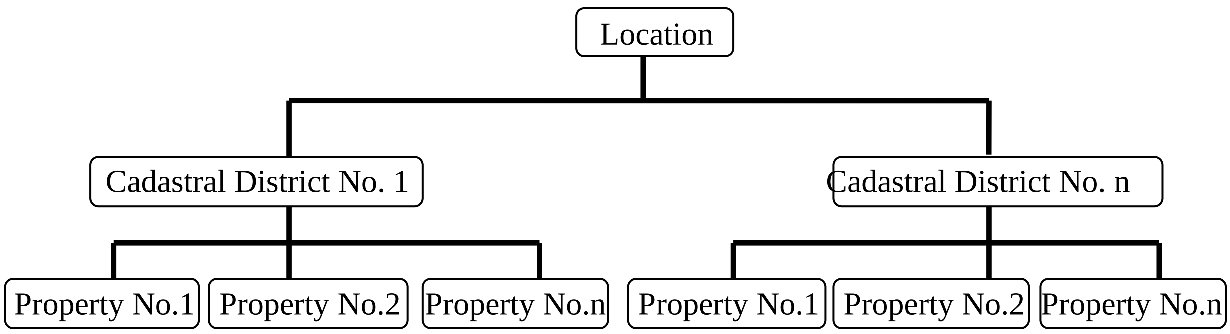


Fig. 1. Hierarchical data model

The essence of the hierarchical structure requires that before it and its rules are developed, any connection between objects must be clearly defined in advance. The main advantage of such a system is that the search becomes easy, since the structure is well defined and relatively easy to expand and new branches are added. One of the most effective properties of GIS is the detection of invisible connections between objects/phenomena. Unfortunately, the hierarchical structure is not very good in this regard due to its immutable key structure.

Network database: In database network models, entity information is represented as a network of connections in which individual entities are located. In this model, there are more complex connections between objects. In the network model, the connections that are the basis of the hierarchical model are combined, but there is more than one connection between the lower-level elements. A typical example of a network model is the river network, which is derived from the flowing main tributaries into the main river, the secondary tributaries into the main river, etc. (Fig.2)

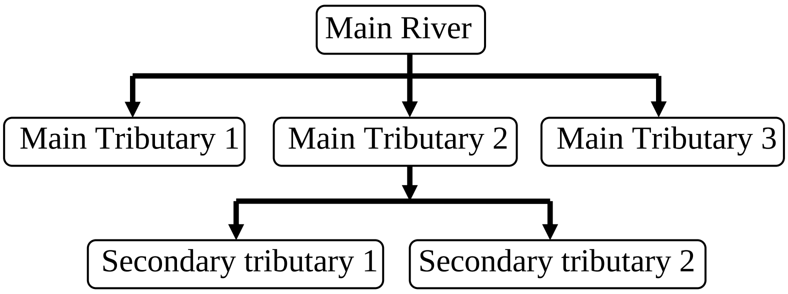


Fig. 2. Network data model

Many GIS databases make one-to-one, many-to-one, or many-to-many connections between two tables, in which a single object can have many attributes and each attribute can be associated with many objects. This eliminates the shortcoming in the search of the hierarchical data structure, which is limited only to the boundaries of the respective parent-descendant branch. Another advantage of the network over the hierarchical model of database structuring is the reduction of excess data.

Relational database: A relational data structure is a table that is formally called a "relation" (connection). In relational models, the information about the objects is presented in a table, with each row of the table corresponding to one object, and each column corresponding to a characteristic, parameter, quality, attribute, etc. Keys (codes) are used to connect the records, which can be primary and secondary. Columns are used as lookup keys. When a column does not act as a primary key, it is entirely dependent on it. The identifier of the graphic object is recorded in the attribute table and thus the connection between the graphic and its attributes is made. Connections between entity classes refer to individual attributes of entities.

Table 1 shows the links between property, owner and title deed. As you can see from the given example in the table, all relational systems share the elements described above. In our example, in the property table, the identifier connects to the graph, but also acts as a primary lookup key for the rest of the tables. In the second table of owners, the primary key is the "owner" column and it is used to link to the first and third tables. This process involves associating the primary key (column) of one table with another column from another table.

Relational systems are useful because they allow us to collect data in relatively simple tables and keep our organizational tasks relatively simple. This model is currently the most popular and used in GIS. Relational languages are used to describe and process the data, most often using SQL (Structured Query Language).

Table 1 Relational data model

Table of properties

Identifier	Type of property	Area	Method of durable use	Owner
7810400080131	Building			
7810400080131.0153	Standalone site	120 m^2	Dwelling, apartment	Ivan Petrov Petrov
781040009	Land	1200.25 m^2	Arch. monument	Petrich Municipality

Table of owners

Owner	UCN/ BULSTAT	Address	Identifier
Ivan Petrov Petrov	5706119111	City of Petrich, 15 Rockefeller Street	7810400080131.0153
Blagoevgrad Municipality	000024695	1 G. Izmerliev Square	781040009

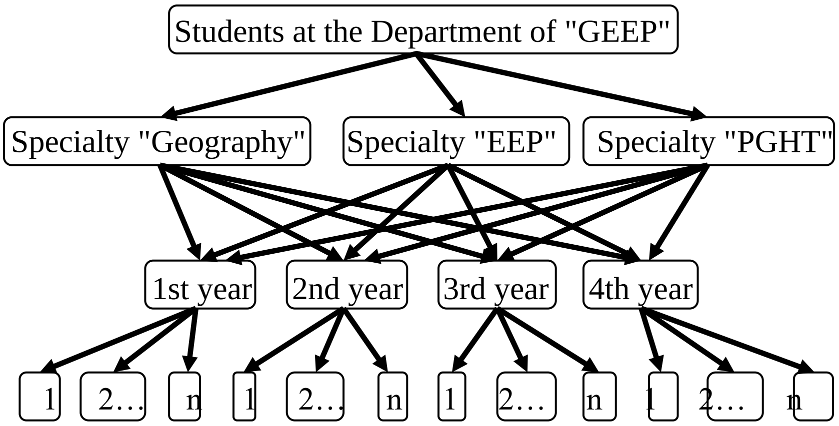
Table of ownership documents

Type of title deed	Number and date of issue	Type of ownership	Owner
Partition agreement	72/1990.02.12	Private	Ivan Petrov Petrov
ASP	15/1980	Municipal Public	Petrich Municipality

Object-oriented database: In an object-oriented structure, information is represented as an object that is a collection of data and functions, unlike other structures that represent primitives (dot, line, block, inscription, etc.). The object-oriented data structure is the further development of the hierarchical and network model.

An object is something that has certain characteristics or qualities and current state and can be anything – a property, a building, a natural phenomenon, a person, etc. Objects are the basis of all software. They can change their own state and, depending on this, are divided into active and passive. Active are those who change their condition, for example, the owner of a property. Passive are those who do not change their condition unless someone else's influence requires it (e.g. the owner's property). Objects that contain other objects are called composites. Objects interact with each other through messages.

The main property of the object-oriented model is the collection of geographical objects and the relationships between them. It groups objects with similar characteristics into classes and defines attributes and actions for each specific type of entity. Classes can be organized into a class hierarchy. With modern GIS systems, information about each class of objects is stored in the form of a tabular database. The class is also a basic unit of analysis in the object-oriented method. All geographical objects have established links with other objects of the same class or with objects of other classes (Fig.3). Three main types of interrelations are used in the object-oriented approach: topological, geographical and general. Topological relationships are basically built when defining the class. Geographic connections are based on geographic operations such as overlapping, adjacent, touching, and inserting one object into another.



Legend:
EEP – Ecology and environmental protection
PGHT – Pedagogy of Geography and History Teaching
GEEP – Geography, Ecology and Environmental Protection

Fig. 3. Object-oriented data model

The main characteristics that define the object-oriented approach can be summarized as follows: everything is an object; A program is a set of objects that communicate with each other by sending messages; each object has its own memory, built from other objects; each object has a type; All objects of a certain type can receive the same messages.

Thanks to the flexible object-oriented data model, national standards can be applied in a convenient way. In some software products (e.g. SICAD) information about objects, their methods of presentation and possible links to alphanumeric data are stored in a data dictionary that can be expanded at any time. The implementation of the object-oriented approach offers a number of advantages in the design of information systems, as well as in the maintenance of applications. Recently, most products use an object-oriented data model.

Examples of an object-oriented database are:

- Oracle 8 Spatial Data Cartridge;
- ESRI Spatial Database Engine SDE;
- Informix 2D-Spatial Data blade.

2. Conclusion

Each geographical object or phenomenon possesses one or more attributes that define it, describe it or represent it. The attribute can be size, density, name, date, or population. Attributes can express several qualities for a single entity. Here are some common types of attributes:

- An attribute can characterize a real numerical value that has been measured or calculated, such as distance or area;
- The attribute can specify integer numerical values of discrete objects, such as the number of lanes per road; width of the road, etc.;
- The attribute can represent text that characterizes the object with a name or other descriptive characteristics, e.g. names of countries, cities, climatic zones, soil types, etc.;
- The attribute can represent encoded values. These values are unique, e.g. numbers of settlements, roads, etc.;
- The attribute can mark the time of the event with a date value;
- The attribute can be a unique number (key). It is used in the database to make a connection between objects. Their values are unique and are known as identifiers (IDs).

The objects depicted on the maps usually have several attribute values associated with them. These attributes in GIS are stored in a tabular database. A table in a geodatabase can support the above and also other types of attributes. When entering them into the table, the data type and the corresponding field types are predetermined: float, double, short integer, long integer, text, date, object ID, and binary large object (BLOB). All attributes are based on one of these types.

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