DESIGNING A GEODATABASE MODEL FOR URBAN INFORMATION SYSTEM AT THE BASIC LEVEL

(Case study in Nguyen Du Ward, Hai Ba Trung District, Hanoi City)

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Abstract

Nowadays, the urban life of Hanoi City can be described as a giant organism with many thousands of different activities, which are related each to others. Thus, a single activity can not be successfully carried out without consideration of its relation to other ones. This reality makes the role of information support for urban management of Hanoi City to be more important than in anytime before.

Being aware of these problems, the authors have developed a geodatabase model which consists of 8 thematic layers: Base map, Administrative areas, Cadastre, Transport, Environment, Infrastructure, Inhabitant-Service, and Society-Economics. These 8 thematic layers are realized by 89 tables and feature classes in the geodatabase with strong topological relationships between spatial feature classes.

For managing the designed urban geodatabase, the authors have developed a software which is based on ArcObjects library and ADO data access components. The system has been tested in Nguyen Du Ward, Hai Ba Trung District and gives preliminary positive results.

Keywords: Geodatabase, Thematic layers, Urban information system, Urban management, Hanoi City

1. Introduction

Nowadays, the urban life of Hanoi City can be described as a giant organism with many thousands of different activities, which are related each to others. Thus, a single activity can not be successfully carried out without consideration of its relation to other ones. This reality makes the role of information support for urban management of Hanoi City to be more important than in anytime before. Meanwhile, the city still does not have an urban information system and the lack of timely and comprehensive information makes a lot of difficulties to urban management. This paper presents our vision of Hanoi urban geodatabase model and some aspects of its realization in order to help the local government to establish their own urban information system. Some of our concepts were adapted from urban data models developed by other authors (Grisé, 2003; Takashi et al., 2003; Xiao-sheng et al., 2004).

2. Geodatabase design

2.1. Thematic layers

The urban geodatabase is designed as a set of eight thematic layers. Fig. 1 displays the organization of these layers and their entities.

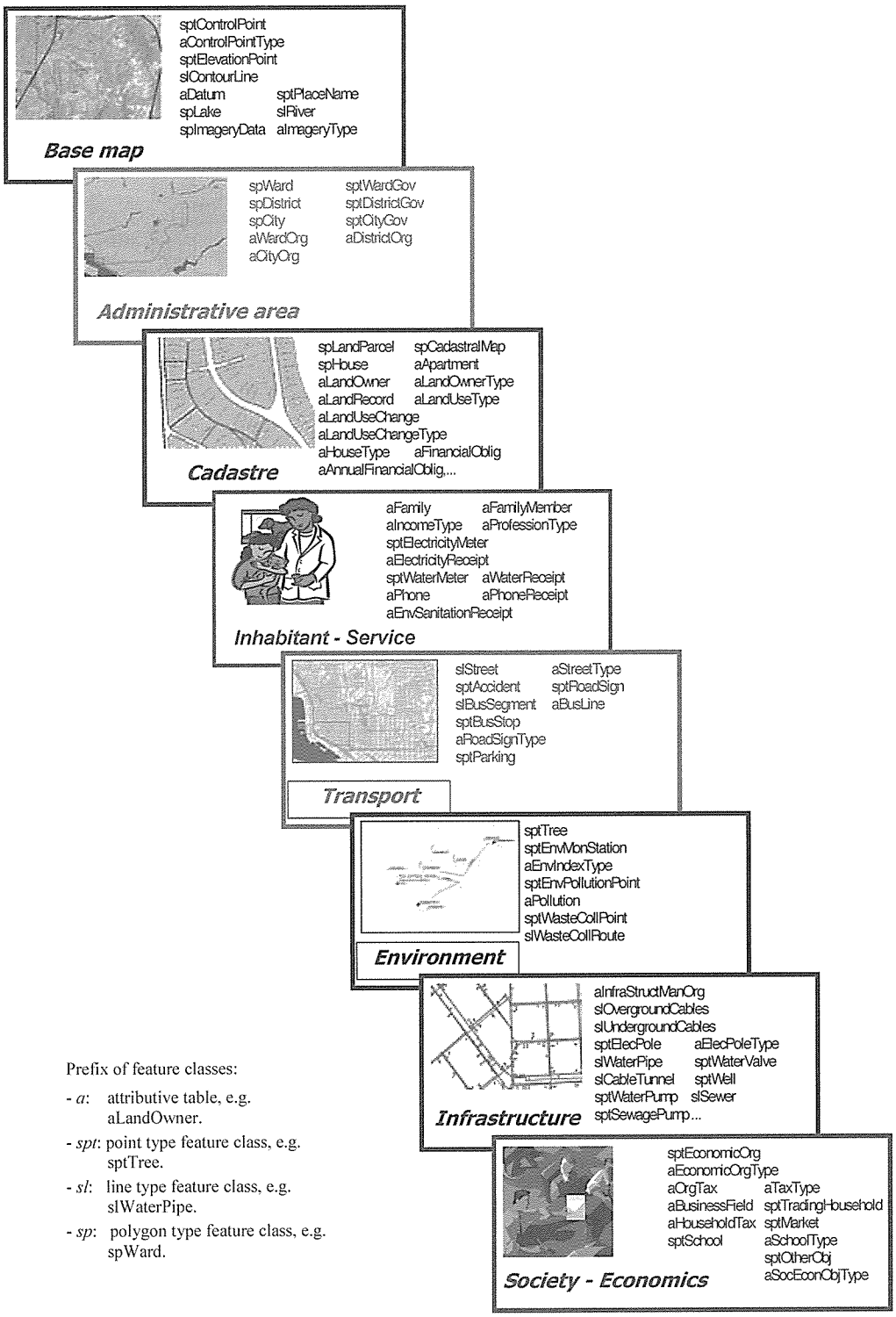


Fig. 1. Thematic layers of Hanoi urban geodatabase

- *Base map layer*: contains information about datum, state control network, topography, airphoto and satellite imagery.

- *Administrative area layer*: contains information about administrative units (ward, district, city) and organizations belong to those units.

- *Cadastre layer*: contains information about land parcels, land owners, land records, house, apartments,...

- *Inhabitant - Service layer*: contains information about households and services related to each household, such as electricity, water supply, telephone,...

- *Transport layer*: contains information about streets, roads, road-signs, parking zones, bus lines, bus stops,...

- *Environment layer*: contains environmental monitoring data and objects that make environmental pollution.

- *Infrastructure layer*: contains information about electricity networks, tele-communication networks, water supply networks,...

- *Society - Economics layer*: contains information about socio-economic organizations, and socio-economic objects.

2.2. Main geodatabase entities

There are 89 entities in the designed urban geodatabase. Table 1 displays main characteristics of these entities. All the entities have primary key fields called ID (Identification). As it shows in Fig. 1, the following prefixes are used for entity naming convention:

- "*a*" (attributive): the entity is an attribute table, i.e. has only attributive data;

- "*sp*" (spatial polygon): the entity is a polygon and has an attached attribute table;

- "*spt*" (spatial point): the entity is a point and has an attached attribute table;

- "*sl*" (spatial line): the entity is a line (or polyline) and has an attached attribute table.

Among above four types of entities, the last three are spatial objects and will be referred as feature classes.

Some entities, for example, schools or parks, are represented in the geodatabase as points, though they actually are polygon. This is done with the aim to simplify the topology relationship between feature classes. The area of these point feature classes is determined by the area of corresponding land parcels.

Table 1. Entities of the designed urban geodatabase

No	Name of entity	Type of entity	Description	Relation to other entities	Main data fields
Base map thematic layer					
1.	sptControlPoint	Point	Points of state and local control networks	aControlPoint Type	Point ID, Point Name, Point Class, Point Coordinates, Point Scheme, Metadata
2.	aControlPoint Type	Table	Classification of control points	sptControlPoint	Point Class ID, Description
3.	aDatum	Table	Various datum parameters		Datum ID, Datum Name, Ellipsoid, Transformation Parameters To VN-2000 Datum
4.	slContourLine	Line	Contour lines		Contour ID, Elevation, Type
5.	sptElevation	Point	Specific elevation points		Point ID, Elevation, Name,

No	Name of entity	Type of entity	Description	Relation to other entities	Main data fields
	Point				Description
6.	sptPlaceName	Point	Specific place name		Place Name ID, Description
7.	slRiver	Line	Rivers and streams		Name, Flow, Water Levels
8.	spLake	Polygon	Lakes and dykes		Name, Volume, Depth
9.	spImageryData	Polygon	Metadata and shortcut to airphoto and satellite imagery	aImageryType	Path, Scale, Resolution, Coordinate Domain, Accuracy,...
10.	aImageryType	Table	Classification of imagery	spImageryData	Class, Description
Administrative area thematic layer					
11.	spWard	Polygon	Data on administrative units	spDistrict, sptWardGov	ID, Name, Area, District
12.	spDistrict	Polygon	Data on administrative units	sptWardGov, spCity, sptDistrictGov	ID, Name, Area, City
13.	spCity	Polygon	Data on administrative units	spDistrict, sptCityGov	ID, Name, Area
14.	sptWardGov	Point	Ward's People Committee	spWard, aWardOrg	Ward, Address, Contacts
15.	sptDistrictGov	Point	District's People Committee	spDistrict, aDistrictOrg	District, Address, Contacts
16.	sptCityGov	Point	City's People Committee	spCity, aCityOrg	City, Address, Contacts
17.	aWardOrg	Table	Organization at ward level	sptWardGov	Name, Type, Address, Contacts
18.	aDistrictOrg	Table	Organization at district level	sptDistrictGov	Name, Type, Address, Contacts
19.	aCityOrg	Table	Organization at city level	sptCityGov	Name, Type, Address, Contacts
Cadastre thematic layer					
20.	spLandParcel	Polygon	General information on land parcels	spCadastralMap, spHouse, aLandRecord	Parcel ID, Map ID, Area, Value
21.	spCadastralMap	Polygon	General information on cadastral maps	spLandParcel	Map ID, Ward ID, Scale, Date, Mapping Organization
22.	spHouse	Polygon	Data on houses in land parcels	spLandParcel, aHouseType, aApartment,...	House ID, Parcel ID, Area, Storey, Direction
23.	aHouseType	Table	Classification of houses	spHouse	House Class ID, Description
24.	aApartment	Table	Attributive data on apartments in a house	spHouse	Apartment ID, Area, Floor, Number Of Rooms, Photo
25.	aLandOwner	Table	Data on land owners	aLandOwnerType, aLandRecord	Land Owner ID, Type, Name, Address, Document No
26.	aLandOwnerType	Table	Classification of land owner	aLandOwner	Type ID, Type Code, Description
27.	aLandRecord	Table	Records fixing land use right	spLandParcel, aLandOwner	Record ID, Parcel ID, Shared Area, Private Area, Land Use Right Title, Land Use Type
28.	aLandUseType	Table	Classification of land use	aLandRecord	Type ID, Type Code,

No	Name of entity	Type of entity	Description	Relation to other entities	Main data fields
			types		Description
29.	aFinancialOblig	Table	Financial obligation for a land parcel (one-time)	aLandRecord	FinObl ID, Record ID, Land Area, House Area, Tax, Amount, Debt
30.	aAnnual FinancialOblig	Table	Annual financial obligation for a land parcel	aLandRecord	AnnFinObl ID, Record ID, Year, Amount, Debt
31.	aLandSeller	Table	Data on sellers of land, house, or department	aLandRecord, aPropertyType	Seller ID, Record ID, Property Type ID, Price, Description, Telephone
32.	aLandBuyer	Table	Data on buyer of land, house, or department	aPropertyType	Buyer ID, Price, Property Type ID, Telephone
33.	aPropertyType	Table	Classification of properties for transaction	aLandSeller, aLandBuyer	Property Type ID, Description
34.	aPropTransaction	Table	Successful transactions (deals) of property	aLandSeller, aLandBuyer	Seller ID, Buyer ID, Deal Price, Date, Description
35.	aLandUseChange	Table	Track information on land use change	aLandOwner, spLandParcel, aLandOwner,...	Change ID, Parcel ID, Change Type, Date, New Parcel ID, New Land Owner ID,...
36.	aLandUseChangeType	Table	Classification of land use change	aLandUseChange	Land Use Change ID, Description
Inhabitant - Service thematic layer					
37.	aFamily	Table	Data on each family	aFamilyMember, aApartment, spWard,...	Family ID, Ward ID, Number of Member, Householder, Telephone
38.	aFamilyMember	Table	Data on each member of a family	aFamily, aProfessionType, aIncomeType	Member ID, Name, Date of Birth, Profession ID, Income ID, Family ID, Telephone
39.	aProfessionType	Table	Classification of profession	aFamilyMember	Profession ID, Description
40.	aIncomeType	Table	Classification of income level	aFamilyMember	Income ID, Max, Min of Income Class, Description
41.	sptElectricityMeter	Point	Data on electricity meter of each family	aFamily, aElectricityReceipt	Meter ID, Family ID,Model, Contract, Paying person
42.	aElectricityReceipt	Table	Data on monthly payment of electricity	sptElectricityMeter	Receipt ID, Meter ID, From Date, To Date, Start KWh, End KWh, KWh, Amount, Is Payed
43.	sptWaterMeter	Point	Data on water meter of each family	aFamily, aWaterReceipt	Meter ID, Family ID,Model, Contract, Paying person
44.	aWaterReceipt	Table	Data on monthly payment for water supply	sptWaterMeter	Receipt ID, Meter ID, From Date, To Date, Start M3, End M3, M3, Amount, Is Payed
45.	aPhone	Table	Data on fixed line phone of each family	aFamily, aPhoneReceipt	Phone Number, Family ID, Contract, Conditions
46.	aPhoneReceipt	Table	Data on payment for fixed	aPhone	Receipt ID, Phone Number,

No	Name of entity	Type of entity	Description	Relation to other entities	Main data fields
			line phone		From Date, To Date, Start Number, End Number, Amount, Is Payed
47.	aEnvSanitation Receipt	Table	Data on payment for quarterly environment sanitation service	aFamily	Receipt ID, Family ID, From Date, To Date, Amount, Is Payed
Transport thematic layer					
48.	slStreet	Line	Data on streets and roads. If a street intersects two of more wards then it is divided into parts	aStreetType, spWard, sptAccident, sptRoadSign,...	Street ID, Name, Street Type ID, Ward ID, Width, Direction (one-way, two-way), Condition
49.	aStreetType	Table	Classification of streets	slStreet	Street Type ID, Description
50.	sptAccident	Point	Data on transport accidents	slStreet	Accident ID, Street ID, Date, Number of Victims, Description
51.	sptRoadSign	Point	Data on various road sign	slStreet, aRoadSignType	Road Sign ID, Street ID, Road Sign Type ID, Install Date, Uninstall date, Photo
52.	aRoadSignType	Table	Classification of road sign	sptRoadSign	Road Sign Type ID, Description
53.	sptBusStop	Point	Data on bus stops	slStreet	Stop ID, Name, Street ID, Address, Photo
54.	slBusSegment	Line	Data on bus segment (line between two stops)	sptBusStop, aBusLine	Segment ID, Bus Line ID, Start Stop ID, End Stop ID, Travel Time
55.	aBusLine	Table	Data on bus lines	slBusSegment	Bus Line ID, Line Number, Start Stop ID, End Stop ID, Ticket Price, Start Time, End Time, Contact Telephone
56.	sptParking	Point	Data on parking areas	slStreet	Parking ID, Street ID, Address, Capacity, Price, Telephone
Environmental thematic layer					
57.	sptTree	Point	Data on urban green trees	slStreet	Tree ID, Tree Number, Street ID, Planting date, Height, Description, Record
58.	sptEnvMonStation	Point	Data on environmental monitoring stations	aEnvIndexType	EnvStation ID, Location, Index Type ID, Monitored Value, Date
59.	aEnvIndexType	Table	Classification of monitoring environmental index	sptEnvMonStation	Index Type ID, Description, Standard Low, Standard High
60.	sptEnvPollution Point	Point	Data on environmental pollution source	aPollution	Pollution Point ID, Address, Managing Organization
61.	aPollution	Table	Detailed information on each of pollution type generated by a pollution source	sptEnvPollution Point, aEnvIndexType	Pollution ID, Pollution Point ID, Index Type ID, Pollution Radius, Pollution Volume, Processing measures, Notes
62.	sptWasteCollPoint	Point	Data on waste collection	slStreet,	Collection Point ID, Location,

No	Name of entity	Type of entity	Description	Relation to other entities	Main data fields
			points	slWasteCollRoute	Waste Volume, Street ID, Collection Route ID
63.	slWasteCollRoute	Line	Data on waste collection routes	sptWasteCollPoint	Collection Route ID, Waste Volume, Managing Organization, Telephone
Infrastructure thematic layer					
64.	aInfraStructManOrg	Table	Data on organizations managing urban infrastructure	Most of FC in Infrastructure layer	Managing Org ID, Name, Address, Telephone, Manager
65.	slWaterPipe	Line	Data on running water pipes	sptWaterPump, sptWaterValve	Pipe ID, Pump ID, Diameter, Pressure, Install Date, Managing Org ID
66.	sptWaterValve	Point	Data on valves of water supply network	slWaterPipe	Valve ID, Input Pipe, Output Pipe, Location, Photo
67.	sptWaterPump	Point	Data on water pump stations	slWaterPipe	Pump ID, Productivity, Pressure, Managing Org ID
68.	slSewer	Line	Data on pipes of sewage system	sptSewagePump	Sewer ID, Sewage Pump ID, Section, Discharge, Managing Org ID, Last Dredging Date
69.	sptSewagePump	Point	Data on pumps of sewage system	slSewer	Sewage Pump ID, Productivity, Managing Org ID
70.	slCableTunnel	Line	Data on tunnel for underground cable system	sptWell	Tunnel ID, Section, Depth, Managing Org ID, Cables
71.	sptWell	Point	Data on wells of underground cable tunnel system	slCableTunnel	Well ID, Tunnel ID, Section, Location, Managing Org ID
72.	slUnderground Cables	Line	Data on underground cable system	slCableTunnel, sptWell	UG Cable ID, Type, Well 1 ID, Well 2 ID, Tunnel ID, Section, Managing Org ID, Description
73.	sptElecPole	Point	Data on electric pole	aElecPoleType, slOvergroundLines	Pole ID, Pole Type ID, Height, Location, Install Date, Managing Org ID
74.	aElecPoleType	Table	Classification of electric pole	sptElecPole	Pole Type ID, Description
75.	slOvergroundLines	Line	Data on overground cable system	sptElecPole	OG Cable ID, Type, Pole 1 ID, Pole 2 ID, Section, Managing Org ID, Description
76.	sptRoadway Lighting	Point	Data on street lighting system	sptElecPole	Lamp ID, Pole ID, Type, Lighting Radius, Install Date, Managing Org ID
Society - Economics thematic layer					
77.	sptEconomicOrg	Point	Data on economic organizations operating in the managed area	Most of FC in Society - Economics layer	Org ID, Name, Org Type ID, Business Field Type ID, Trade Permit, Address, Telephone, Manager, Capital, ...
78.	aEconomicOrg	Table	Classification of economic	sptEconomicOrg	Org Type ID, Name, Description

No	Name of entity	Type of entity	Description	Relation to other entities	Main data fields
	Type		organizations		
79.	aBusinessField	Table	Classification of business fields of economic organizations	sptEconomicOrg	Business Field Type ID, Description
80.	aOrgTax	Table	Tax for economic organization	sptEconomicOrg, aTaxType	Org Tax ID, Tax Type ID, Org ID, Year, Amount, Debt
81.	aTaxType	Table	Classification of taxes for economic organization	aOrgTax, aHouseholdTax	Tax Type ID, Name, Calculate Method
82.	sptTrading Household	Point	Data on households doing small business, mainly in trading area	aFamily, aBusinessField	Trading Household ID, Family ID, Brand, Trading Permit, Business Field Type ID, Address, Inspection Result
83.	aHouseholdTax	Table	Tax for trading households	sptTrading Household	TH Tax Type ID, Tax Type ID, Trading Household ID, Year, Amount, Debt
84.	sptMarket	Point	Data on markets, supermarkets and trading centers	sptEconomicOrg	Market ID, Name, Address, Goods, Org ID, Inspection Result
85.	sptSchool	Point	Data on schools in the managed administrative area	aSchoolType	School ID, School Type ID, Name, Address, Number of Pupils, Number of Teachers, Educating Profession, Service Area, Telephone
86.	aSchoolType	Table	Classification of school	sptSchool	School Type ID, Description
87.	sptPark	Point	Data on parks and public gardens	sptEconomicOrg	Park ID, Name, Org ID, Address, Telephone, Opening Time, Closing Time, Schema
88.	sptOtherObj	Point	Data on other socio-economic objects	sptEconomicOrg, aSocEconObjType	Object ID, Object Type ID, Name, Org ID, Address, Telephone, Opening Time, Closing Time, Working Days, Description
89.	aSocEconObjType	Table	Classification of socio-economic objects	sptOtherObj	Object Type ID, Description

2.3. Topological relationship between spatial feature classes

The topological relationship between spatial feature classes plays an important role in maintaining data integrity and consistency in the geodatabase. For example, two land parcels can not overlap since if it is happen, a conflict in land use right is raised.

If the topological relationship rule is clearly defined, then the software maintaining the geodatabase can check and do not allow the users to violate the rule. Thus, the data are remaining consistent when updated.

For the feature classes of the designed urban geodatabase, we have defined topological relationship rules as listed in Table 2.

Table 2. Topological relationship between spatial feature classes

No	Feature class	Has topological relationship	To feature class
1.	spLake	Must not overlap	self
2.	spWard	Must not overlap	self
3.	spDistrict	Must not overlap	self
4.	spCity	Must not overlap	self
5.	spWard	Must be covered by	spDistrict
6.	spDistrict	Must be covered by	spCity
7.	spWard	Contains point	sptWardGov
8.	spDistrict	Contains point	sptDistrictGov
9.	spCity	Contains point	sptCityGov
10.	spLandParcel	Must not overlap	self
11.	spHouse	Must be covered by	spLandParcel
12.	spLandParcel	Must be covered by	spWard
13.	sptWaterMeter	Must be covered by endpoint of	slWaterPipe
14.	slStreet	Must not overlap	self
15.	sptAccident	Must be covered by line	slStreet
16.	sptBusStop	Must be covered by endpoint of	slBusSegment
17.	slBusSegment	Must be covered by feature class of	slStreet
18.	sptParking	Must be covered by endpoint of	slStreet
19.	sptWaterPump	Must be covered by endpoint of	slWaterPipe
20.	sptWaterValve	Must be covered by endpoint of	slWaterPipe
21.	sptSewegePump	Must be covered by endpoint of	slSewer
22.	sptWell	Point must be covered by line	slCableTunnel
23.	slUndergroundCables	Must be covered by feature class of	slCableTunnel
24.	sptElecPole	Must be covered by endpoint of	slOvergroundCables
25.	sptWasteCollPoint	Point must be covered by line	slWasteCollRoute
26.	spPark	Must not overlap	self

3. Software development

For managing the designed urban geodatabase, we have developed a software called UIMS (Urban Information Management Software).

Generally, there are two ways to develop a software for geodatabase management:

- Develop the software from scratch. This may give the best performance but required a lot of programming efforts.

- Develop the software by using existing software library. This way is more rapid, requires lesser programming efforts but may give some penalties in performance. In some cases, an investment must be made to buy a suitable software library.

In this work, we chose the second way since our primary intention is to demonstrate possibilities of the designed urban geodatabase. For managing spatial data, we use ArcObjects library developed by ESRI (Environmental Systems Research Institute) since it is the most powerful GIS software library at present (ESRI, 2006). For managing attributive data, we use ADO ActiveX components - a popular software library for database management developed by Microsoft. The software uses the libraries via COM (Component Object Interface) and manages the geodatabase as shown in Fig. 2.

UIMS is developed in Borland Delphi 6.0 development environment. The user interface is based on VCL (Visual Component Library) supplied with Delphi. Since the software is used for local needs, it only has a Vietnamese user interface. The English user interface is not supported at this time.

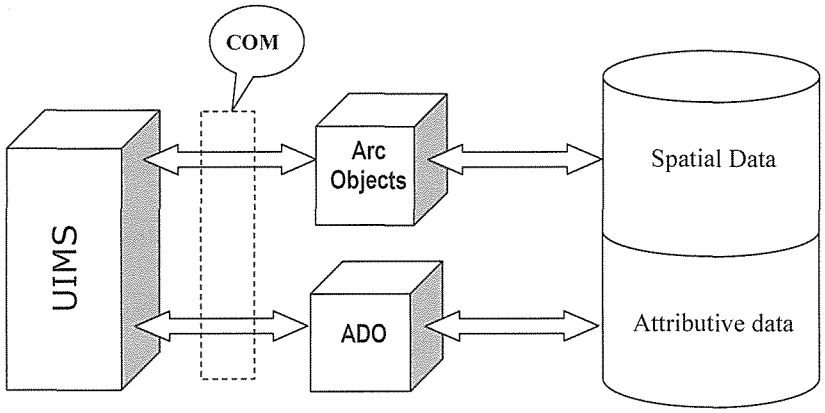


Fig. 2. The way UIMS manages the geodatabase

4. Some test results

The designed geodatabase is tested in Nguyen Du Ward, Hai Ba Trung District, Hanoi City. The ward is located near center of Hanoi City in the south-west direction. It has in total 17 narrow and wide streets, the most important ones are Nguyen Du, Tran Nhan Tong, Ba Trieu, and Yet Kieu streets. The area of the ward is about 38 ha, and the population is 10250 people. Being urbanized for a long time ago, Nguyen Du has two main land use types: urban living land and specialized land. There are no unused land and agricultural land in the ward.

As in the most of administrative units of Vietnam, the urban management of Nguyen Du Ward is mainly based on the traditional paper system. Computers are only used for text editing and printing. There is no idea about creating a database for urban management at the local government. The computer system available at the ward's People Committee has a small quantity and still is un-networked. Thus, in the present conditions of Nguyen Du Ward, the designed urban geodatabase will be very helpfull to the local urban management.

In the study area, we have collected data from the following sources:

- Ward's People Committee: cadastral data and data on administrative and infrastructure management.

- Internet and mass media: data on economics, society and environment.

- Cadastral Information Center (Ministry of Natural Resources and Environment): topographical maps at 1:25000 scale and airphoto of the study area.

- Field survey: data on inhabitants, infrastructure, transport, and environment.

For system deployment, we use the installation scheme shown in Fig. 3.

For system log-on, the user must enter his account name and password. The system control user rights at account level: each account is allowed or not allowed to read, create, or edit records of specific geodatabase entities. In Fig. 4, the user "tttham" can read (D), edit (S), and create (M) new records of the entity sptWardGov, but he can only read the entities sptDistrictGov and sptCityGov.

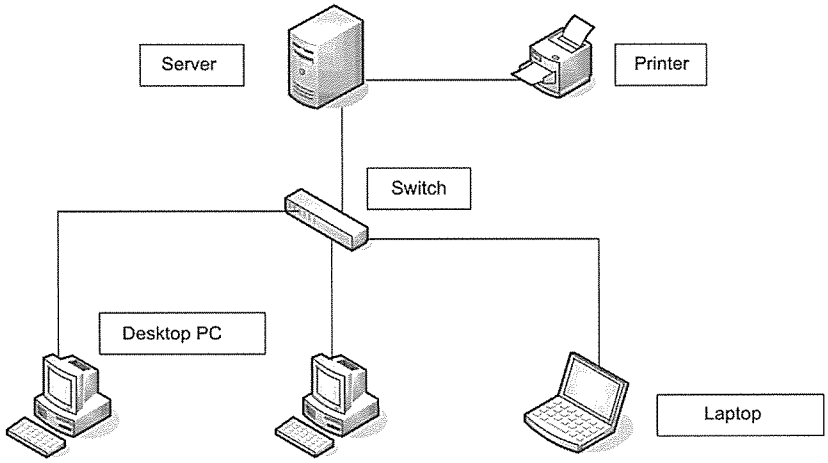
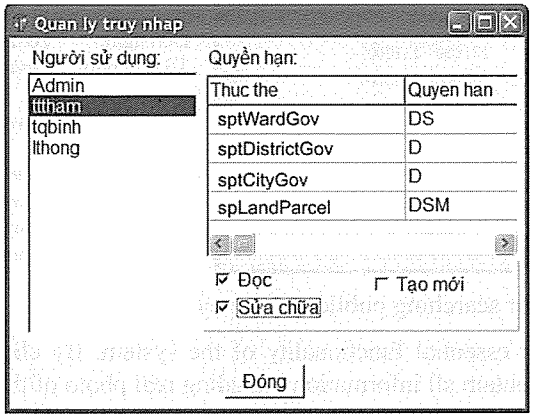


Fig. 3. Installation scheme of the test system

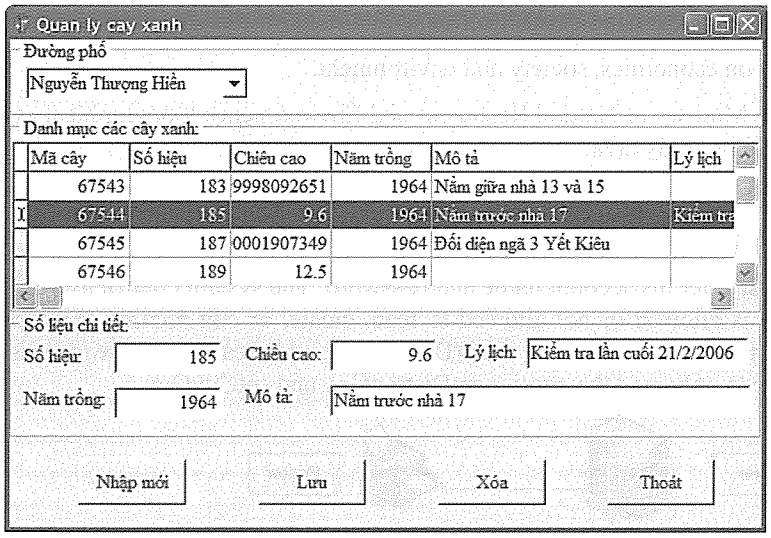


Translation:

Người sử dụng:	*User name*
Quyền hạn:	*User right*
Đọc (D):	*Read only*
Sửa chữa (S):	*Edit*
Tạo mới (M):	*Create*

Fig. 4. User right management

For viewing, editing and creating records of main entities, the system supplies a corresponding form with standard interface. Fig. 5 is an example of the form managing data on trees planted along streets. If the user has a suitable right, he can select the street where is located the interested tree. Once the tree is selected in the list, its detailed data are displayed in the lower part of the form. The user can edit these data and save to the geodatabase, or he can create records about new trees.

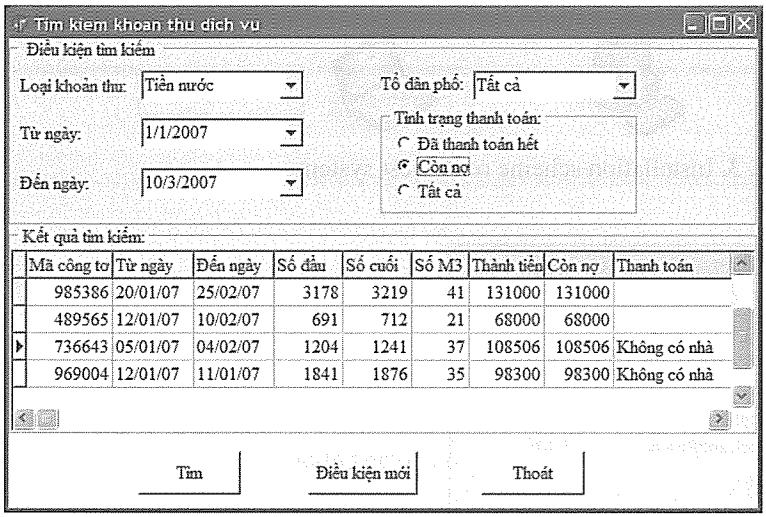


Translation:

Đường phố:	*Street*
Danh mục:	*List of trees*
Mã cây:	*Tree ID*
Số hiệu:	*Tree number*
Chiều cao:	*Height*
Năm trồng:	*Planting date*
Mô tả:	*Description*
Lý lịch:	*Tree's record*
Nhập mới:	*Create record*
Lưu:	*Save*
Xóa:	*Delete*

Fig. 5. The form managing data on trees planted along streets

For searching data, the system has corresponding forms in which the user can define various search conditions. Fig. 6 is an example of search for public utility payments. The use can enter search conditions such as payment type (electricity, water, telephone service,...), date, area, payment state,... The table in the lower part of the form will display all records that meet the search conditions.



Translation:

Loại khoản thu:	*Payment type*
Từ ngày:	*From date*
Đến ngày:	*To date*
Tổ dân phố:	*Living quarter*
Tình trạng thanh toán:	*Payment state*
Kết quả tìm kiếm:	*Search result*
Tìm:	*Search*
Điều kiện mới:	*New search condition*

Fig. 6. The form for searching public utility payments

Data exploitation on the map is the most essential functionality of the system. By clicking on the interested object on the map, the user can obtain all information including real photo of the object. Fig. 7 is an example of data exploitation on the map for land parcel No 44 at address 176 Ba Trieu St.

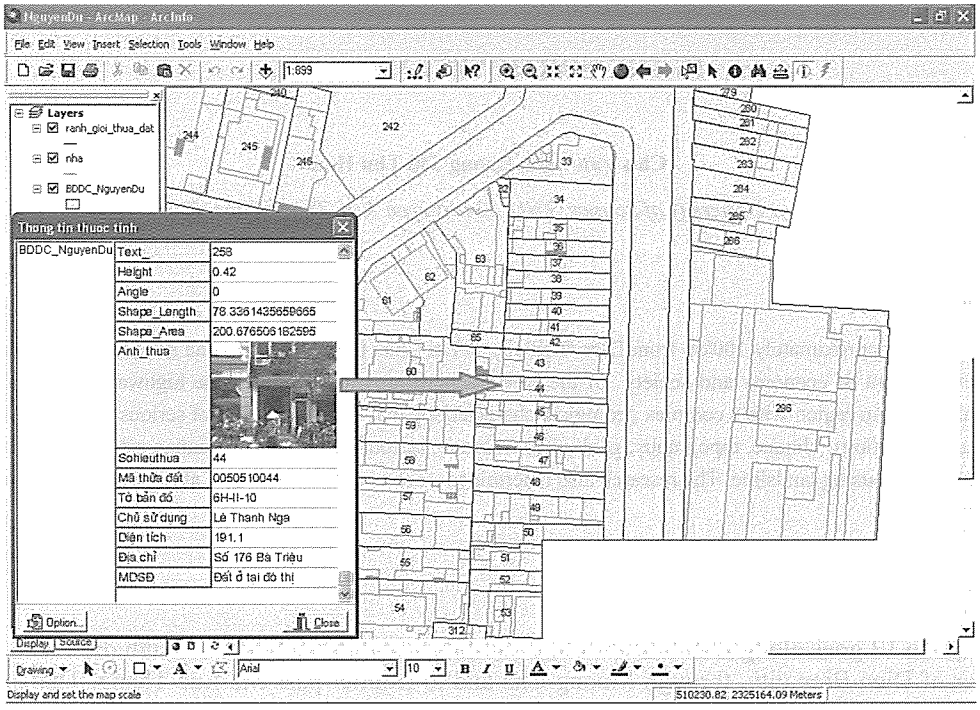


Fig. 7. Data exploitation about land parcel on the map

5. Conclusions

Establishment of urban information systems is one of the most effective measures to improve capacity of Hanoi urban management system. In this work, we have designed an urban geodatabase with 8 thematic layers: Base map, Administrative areas, Cadastre, Transport, Environment, Infrastructure, Inhabitant-Service, and Society-Economics. These thematic layers are realized by 89 entities in the geodatabase.

For managing the designed urban geodatabase, we have developed a software which is based on ArcObjects library and ADO data access components. The system has been tested in Nguyen Du Ward, Hai Ba Trung District and gives preliminary positive results.

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