# Research on Electronic Map-Based Hypermedia Data Model

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## Abstract

Map, a symbol of space cognition, has become one of three cultural tools for human being to recognize and know about the world. As a new type of carrier of space information, electronic map possesses many features: dynamic, interactive, multimedia integration, etc. Multimedia electronic map combines several medias such as graphs, images, texts, charts, sound, animations, videos etc., and can express spatial information directly, visually and vividly via sense perceptions like vision, hearing, sense of touch. Based on an electronic map-based hypermedia data model (EMBHDM), this thesis makes a study on the technologies of nonlinear storage, organization, management and browsing of information as well as organization of data on the basis of the relationship between multimedia information of electronic maps. The functions of the can be concluded as the following:

1. It can form information network by using various multimedia information (graph, image, text, chart, sound, animation, video etc), i.e. nodes.
2. It is convenient for users to create nodes and set up corresponding links.
3. It can support to search and browse multimedia database.
4. Information is organized and managed in associative and non-linear manner, which conforms to users' reading habits and is more convenient to operate.

This thesis first analyzes some features of electronic maps and hypermedia technology, and then illustrates the creation of EMBHDM with some examples. Experiments show that this model can efficiently organize and express multimedia data.

## Introduction

Aspen Movie Map developed by Massachusettes Institute in 1978 can be counted as the first hypermedia system in the world. The system uses a set of CD-ROMs, in which the images of spring and autumn views of all the streets in Aspen, as well as some photos of the interior parts of some buildings are stored. All graphs are linked according to mutual positional relationship. Using Aspen, users may "wander" throughout the town, even browse the buildings' interior.

At present, many organizations and institutions about hypertext and hypermedia technology have been set up both home and abroad, including SIGLINK of ACM in the United States, Hypermedia study group(LINKS) in Australia, hypermedia research laboratory of computer science department of A&M, Institution of unification of publication and information system of Darmstardt in Germany, and GBH of GuangXi Computer etc in China. Now hypertext /hypermedia has been penetrating into all fields of computer science. Every year many international conferences involve upon hypertext technology, e.g. digital library, multimedia education, WWW information knowledge management, hypertext, hypermedia design, multimedia etc. In these international conferences, hypertext is an important theme.

In the field of cartography, cognitive view defines cartography as a science of recognizing surrounding real world through chart model. Map is a model of graphic symbol representing the real world. The latest definition formally given by ICA is "Cartography is a discipline concerning

conceptualization, production, distribution and research of maps." ; and "A map is a conventional image designed for concern of spatial relationship and used for expressing certain elements and features selected from the real world." (Board, 1991)

As a new type of carrier of space information, electronic map possesses many features: dynamic, interactive, multimedia integration, etc. Multimedia electronic map combines several medias such as graphs, images, texts, charts, sound, animations, videos etc., and can express spatial information directly, visually and vividly via sense perceptions like vision, hearing, sense of touch.

EMBHDM, which is studied in this paper, is based on electronic maps and makes use of hypermedia technology. In this model, geographical and spatial entities connecting multimedia information are defined as nodes of information; spatial relationships between objects of geographical entities are taken as links; and mutual associated relationships between nodes and links constitutes a complicated information network. Accordingly, visualization of geographical objects and such functions as inquiry of spatial information, spatial search, spatial analysis can be realized. Adopting graph and image processing, technology of spatial database management, layered information management model and user-oriented interface design, EMBHDM offers convenient and flexible graph editing, view display, data process, self–definition of node and link information, abundant information link connections and expressive forms.

## The definition of hypermedia

Hypertext is a kind of computer technology involving non-linear storage, organization, management and browsing of information in accordance with relationship between information. The distinction between hypertext and traditional computer technology lies in the following aspects. First, hypertext attaches great importance not only to information needed to be managed but also to creation and expression of relationships between information. Hypertext creates and expresses various knowledge and systems in the real world by means of relationship between information. Therefore, hypertext provides a new way of communication between computer and human beings, which is conforms more to people's habits.

Hypertext technology combines natural language text and computers' ability to interactively shift and dynamically display linear text. Its essence and basic feature is to establish relationship inside a text as well as between texts. It is the relationship that provides a non-linear organization for texts. In other word, hypertext is composed of nodes which store information and links which describe relationships between information. A node is a natural data unit related to some theme in hypertext system. A link is an entity in hypertext system showing relationship between information. It conceals behind information and is recorded in application system. If no marks were intentionally made for these links, the users would feel existence of link only when they shift from one node to another. It is with links that hypertext becomes nonlinear. Only with help of links can users find related information along relative links.

Information network is thus formed with nodes and links. Different from traditional information technology, users' operation of checking up information in hypertext is carried out according to relationships between information (that is links). From the angle of application, browse is an activity users undertake at their will. Whether browsing may fulfill its goal or not, whether efficiency of browsing is high or low is closely related to the design of hypertext system.

Hypermedia technology makes use of hypertext technology to organize and manage

multimedia information. In other words, hypertext technology is adopted to manage multimedia information such as graphs, images, texts, sound, videos, animations etc.

## The features of electronic map

Through digits, digital map shows space information, that is traditionally represented in traditional paper map by means of graph, symbol, color, annotation, etc. With the help of computer, under the support of spatial data management of GIS and processing software, digital map can fulfill some processing activities of spatial information that traditionally people fulfill through using and reading map. Due to combination of digital map and high efficient and accurate processing function of computer, it is very easy and flexible for digital maps to produce all kinds of models of new products satisfying different demands.

Maps of digital form become more abundant and variable in content. We can find its main expression in introduction of three dimensional information and dynamic information. Digital technology should make it possible for integration of graphs and images, vertical connection of the different scales maps and horizontal seamless connection of the same scales maps about city, province, county and world.

Multimedia revolution makes computers not only process digits, texts etc, but also begin to store and show multimedia information such as text, photo, sound, animation and video, etc. On the basis of spatial reference for users provided by visual digital map of different details, computers can represented spatial distribution of various spatial entities and connection through information with multimedia information (text, sound, photo, video, etc), so they offer users more vivid and direct information for displaying object.

Based on cartographic database, storing in outer memorizer of computer in the form of digits, electronic map (also called screen map or instantaneous map) is a visual map which can be in the electronic screen. Electronic map technology is a combination of many modern technologies: GIS technology, digital cartography technology, multimedia technology and virtual reality technology etc. Taking a kind of visual electronic map as background, with the aid of text, photo, chart, sound, animation, video, multimedia as expressive means to display whole appearance of city, enterprise, tour scenic spots, multimedia electronic map is a product of modern information. It may be stored in outer memorizer of computer, spread by means of CR-ROM, networks etc, and offer users in the form of desktop computer or touch screen computer.

Because the product of electronic map integrates visual function of digital cartography technology, searching data and analyzing function of GIS technology, information expressive means of multimedia technology and visual reality technology, and the role of spreading technology of modern electronic map, the appearance attracts immediately social wide interests, particularly governmental departments, section of enterprises management and the people. It enjoys the reputation of “Popular GIS”.

The features of electronic map are listed as follows:

(1) Electronic map is a carrier of spatial information. It is dynamic, interactive, multimedia integrated, inquiry and search and so on.

(2) Complicated heterogeneous data and data relationship.

Electronic map is the carrier of spatial entity whose features can be represented in two aspects: spatial character and non-spatial character. Their corresponding data types are spatial data and property data. The former can be divided into vector data and raster data according to the way data

are organized. For instance, digital map belongs to vector data, remote sensing images belong to raster data. Property data is classified into structural data and nonstructural data according to organization of data structure. For example, property based on RDBMS is mainly structured data, while photo, sound, video are usually nonstructural data. Spatial entities do not exist in isolation. There are many complicated spatial or non-spatial relationship between entities, among which topological is one, In addition, complicated relationship between entities can be also shown by the relationship between non- spatial information (i.e. relationship between semantic information). Complicated data type and data relationship result in many troubles in data storage and management.

(3) rich and various information content.

Map is a symbol of spatial cognition. The specific objects that map represents are point features, line features, area features of man-made or natural spatial entity, which can be tangible or intangible, visible or invisible. The contents that maps convey can be synthetic or thematic. The scope of the object may be local, district or global.

Owing to the limit of scale, map scope and capacity etc, the amount of information that paper maps can reflect is limited. The properties of features are reflected only by using structures of map symbols, colors and sizes. However, the amount of information electronic maps can reflect is much larger. Besides all kinds of map symbols, it can cooperate with external database. Management of larger information can be achieved by adopting compress technology of data, stratified technology, open window technique, visual technology etc.

(4) complicated information relationship

Maps should not only express such features of the geographic object as geometrical (positional) feature, property feature and time feature, but also reflect the special relationship and property relationship between different geographic objects. In addition, geographic objects include simples ones and complex ones. Thus the information relationships are complicated.

(5) share of information

After maps are digitalized, they can be easily copied and disseminated and thus achieve information sharing. Accordingly, electronic maps can be copied in great amount without any damage and spread through computer network. Maps stored in CD-ROM, DVD-ROM has been popular abroad. When connected with map database on Internet, all types of maps in many areas of the world can be download rapidly and conveniently.

Advantages of hypermedia technology are demonstrated as follows:

(1) flexible and convenient management of complicated neterogeneous data

(2) capability to manage complicated relationships between information.

(3) simple, convenient and visual operation by users

(4) abundant expressive ways

(5)convenience in sharing data with other application owing to the open hypertext technology

(6)convenience in integration and enlargement of the system due to hypertext technology

Accordingly, hypermedia technology can better express multimedia information based on electronic maps.

## Electronic map-Based Hypermedia Data Model

Hypermedia is made up of nods in which multimedia information is stored and links which describe relationships between multimedia information. EMBHDM, which is based on electronic

map, employs hypermedia technology to organize and manage complicated map objects and relationships between objects.

In a system which contains a great amount of information, it is difficult to cover all the information with one or two maps. In this case, several maps may be used. These maps are connected by certain logical relationships Their connections may be horizontal and vertical. Vertical connection is demonstrated by the connection of the maps which cover the same area in various scales. For instance, the world map, national maps, or provincial maps, maps of all cities and towns in China can constitute a multi-scale map system. The maps at lower layer are amplifications of certain parts of the maps at their upper layer.

Horizontal connection is showed by the spatial seamless. Maps of different areas are connected automatically by certain standard such as a unified geographical coordinate system.

**1. Node**

A node is a natural data unit related with certain theme in the hypermedia system. For users' convenience, certain forms of marks are made on nodes in the hypermedia system, indicating the existence of links. These marks are given different names in different systems such as button, hot region, anchor and so on. They have similar basic function in spite of their different names and realizing mechanism. For instance in 3W system, these marks are made by using HTML.

According to features of electronic map, in EMBHDM, nodes are classified by its geometrical features into the following types:

[1]Point Node : items which cover small areas, can not be scaled, but should be located, such as stations, tourism sites. They can be connected with arc nodes to form direction line nodes;

[2]Arc Node: having no significant meaning, can be connected with point node to form direction line node;

[3]Line Node: Items on the earth surface which are line-shaped or belt-shaped, such as roads, rivers, frontier lines;

[4]Rout node : Items on the earth surface which are line-shaped or belt-shaped, and have directions, such as traffic net, tube-net- system, mainly used for net construction.

[5]Area Node: Items which are located in areas which can be classified into circle, square and polygon, such as blocks, lakes and forests.

[6]Complex Node: are composed of two or more nodes mentioned above, such as bus route with stations and path.

[7]Text node: nodes defined by the marks(annotations) on the map, such as names of places or units.

Nodes are classified into three kinds according to their functions: system node, map node, theme node.

A system node is the node connected with system function. It mainly executes certain function in the system and accomplishes certain function. In EMBHDM, system nodes can be further classified into 3 types:

[1] File Node: accomplish operation functions related to the file

[2]View Node: accomplish operation function as zoom in, zoom out, pan, auto multi-scale

[3]Media Node: accomplish demonstration of the multimedia information (e.g. photos, characters, sound, video)

[4]Search Node: accomplish the searching of space objects; It has searching functions of point form, circle form, square form, polygon form.

[5]Analysis Node: accomplish spatial analysis function, such as distance calculation, buffer zone analysis, net analysis.

A map nodes is the node connected with maps, that is, to fulfill the connecting of maps. In EMBHDM, maps includes cover, group, main map, map, sub-map, control map, super-map, multi-scale map. The cover is the general map (similar to the home page on internet) which manages the whole system. A main map together with several maps, sub-maps, control maps, super-maps, multi-scale maps composes a group. The main map is the map that manages maps of every theme and bridges the group and maps. Each group has one main map. A map is the map which shows content of certain theme. An sub-map is the sub map related to map, showing content of certain theme. A control map is the symbolic map designed for avoiding losing way. When browsing maps, customers often find themselves in this situation: when they are supposed to reach certain location they often have several choices of the routes at a intersection. In this case, they are likely to lose their ways when they are back. Control maps can help customers back to certain position quickly, and to some degree, help solve the problem of “loss of the way”. Its function resembles that of the general map. A super-map is a map containing several maps of different places in the same scale, it can realize seamless connection of the space. A multi-scale map is a map containing several maps covering the same place in different scales, it can realize multi-expression of the space.

Theme node is a root node, which is not connected with other nodes. It can be used to inquiry and display of the multimedia information of the objects such as graph, photos, charts, sounds, animation, video, text, etc.

**2. Link**

Link is the entity used in hypermedia system to display the relationship among information. It is the key to represent spatial features of hypermedia. Links are set freely by the author, can display the relationships among information to the greatest degree and reveal the true color of present system. Different authors can create different information system with the same information aggregate, even the same node aggregate. Even the same author can organize information from different points of view. Incorporating different ideas into one system can not only avoid digital redundance but also satisfy different requirements of different users. For instance, information can be organized according to information types, contents, creation time, information clues and son on. Consequently, customers can get different information according to their own points of view. As the nodes (except systematic node) and links can be set freely, EMBHDM offers great freedom in creation of multimedia electronic maps and can meet varied demands of different authors. Thus they can produce all kinds of multimedia electronic maps. In EMBHDM, five basic modes of connection are realized: the connection between covers and their group; the connection between groups and their main maps; the connection between maps; the connection among maps and sub-maps; the multimedia connection between main map or maps or sub-maps and nodes.

**3. Data Model**

The hypermedia data model based on electronic map is a three-layer structure data model: the layer of customers' interface, logic layer, physics layer.

[1] the layer of interfaces

The layer of interfaces is displaying layer, used for display of hypermedia. It supplies to the customer the definition, edit, dealing with nodes and the tool to operate information network

structure. In this layer customers communicate with hypermedia with the tools provided by the system. This layer is the interface for the interaction between users and the hypermedia system.

Interface layer provides abundant flexible hypermedia network structure editor to realize

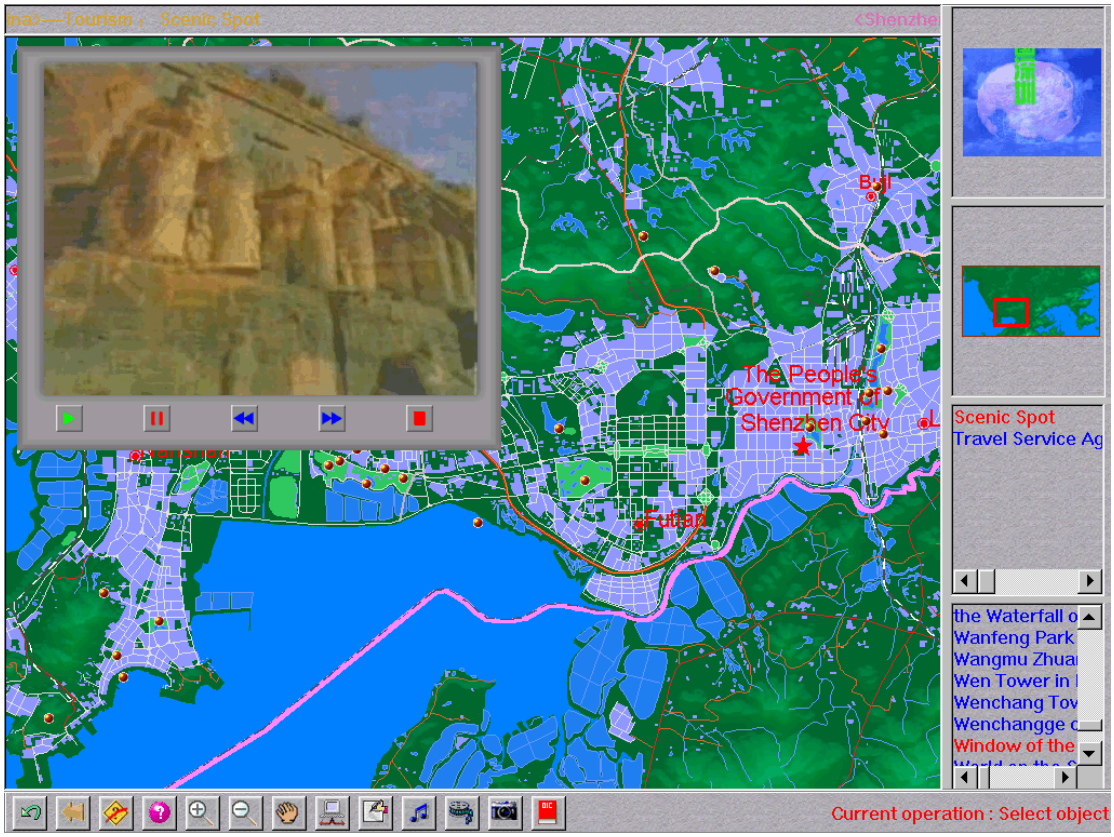



Figure 1. One page created by EMBHDM

connections between nodes, semantic connection links between map elements and various medias involved as well as the relative connection between map elements and nodes of the maps. Besides, this layer supports the semantic connection from various medias to nodes, as well as the semantic connection from tables and fields to various medias (See Figure 1). In this layer, the following functions can be completed:

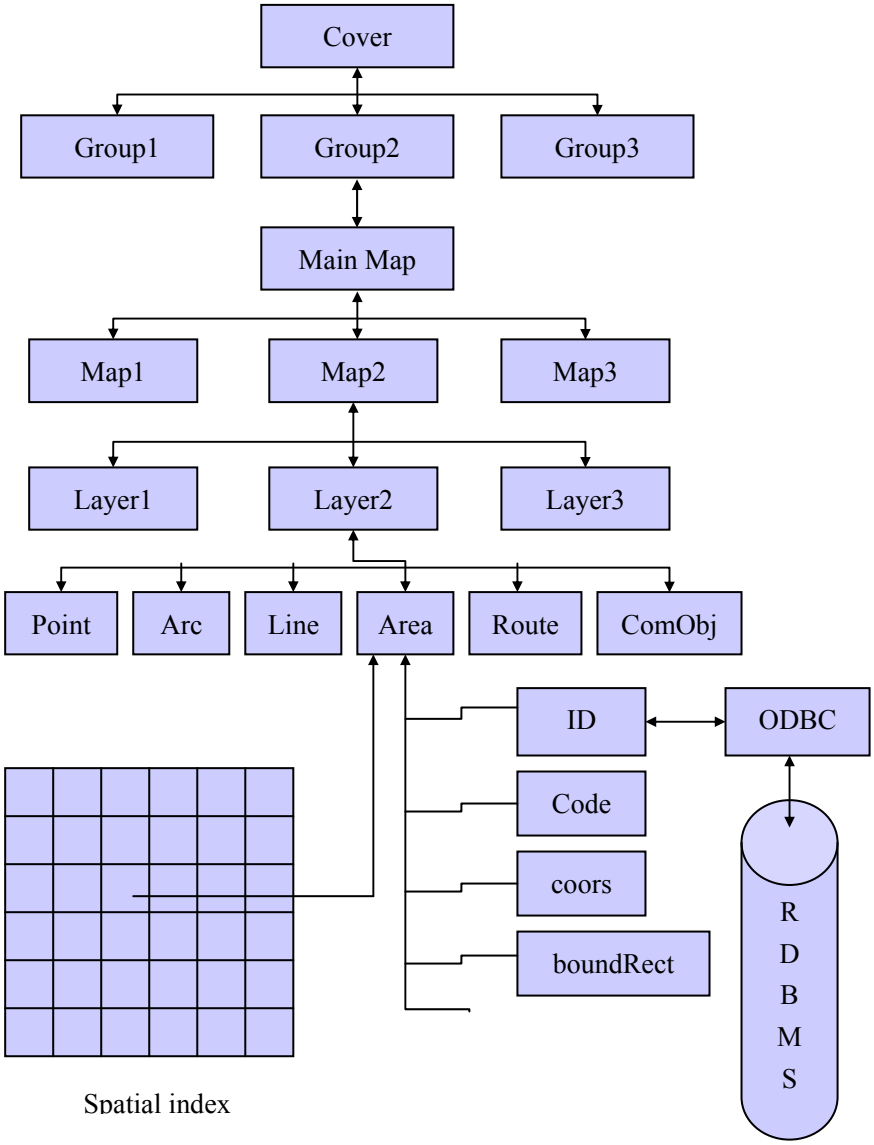
- rich edit functions for spatial data.
- convenient operations for users to define nodes node such as point, line, area, text, etc, and set up corresponding links.
- management and displaying of the spatial data made up of vector data and raster data.
- inquiry of spatial information and spatial analysis based on electronic map.
- connection between spatial data and feature data with ODBC technology.
- making and displaying of 3D map
- displaying, zooming, roaming of multi-scales map
- management and displaying of several maps covered large range.

[2] logic layer

According to the idea of Hybrid Model, spatial data and non-spatial data are respectively managed. By adopting OOP technology, spatial data are managed through spatial data model. However, the non-spatial data are managed through RDBMS technology. Both are connected together by a unified a unified identification (ID).

In EMBHDM, the data are abstracted described as cover, group, main-map, map, layer,

geometry object (include point, arc, line, route, area, annotation, complex object). The layer structure from top to bottom is: cover → group → main-map → map (include sub-map, control




map, super-map, multi-scale map) → layer → geometry object. ( See Figure 2).

Figure 2. the logical structure EMBHDM

[3] physics layer

In EMBHDM, the group is regarded as a unit. Adopting structure of directory and file, the map data and media data are separately stored by group. In this way of data organization, It will be propitious to avoid data redundance and data share. Also it satisfy different requirements of different users. Because the data can be used independently many times for the different targets. It is convenient for users to extend or perfect application system.

## Conclusions

Based on the features of electronic map and hypermedia, this paper makes a study on the technologies of nonlinear storage, organization, management and browsing of information as well as organization of data on the basis of the relationship between multimedia information of electronic maps.

The tests prove that based on an electronic map-based hypermedia data model can better express multimedia information based on electronic maps. The author believe that the development of electronic map would have a good prospect in hypermedia fields, if a hypermedia language adapting to electronic map appear in the future.

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