

Development and Application of Digital Mini-area

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ABSTRACT Based on the theory, technology and strategy of Digital Earth, the concept of Digital Mini-area is proposed. Furthermore, the technological backgrounds, structures, key technologies and application functions of Digital Mini-area are put forth. At the end, some suggestions on how to develop the digital mini-area are also given out.

KEYWORDS Digital Earth, Digital Mini-area, Development, Application

1. Introduction

Vice president Al Gore of USA gave a famous lecture ---The Digital Earth: Understanding our planet in the 21st century---on January 31, 1998. He gave an example that a young child could observe the earth in the space using a head-mounted display and a data glove. He described that the child could zoom in with higher and higher levels of resolution to see continents, then regions, countries, cities, districts, and finally individual houses, trees, and other natural and man-made objects. Moreover, the child could apperceive the related environment and acquire its information. Thus it is seen from this example that the digital earth will embodied in digital mini-areas from macroscopic to microcosmic while geospatial data resolution and accuracy getting higher and higher.

A digital mini-area is the microcosmic description and reification of the digital earth. That is to say, the digital mini-area is the effect of zooming into one small area in the digital earth. In another word, the digital mini-area is the integrated presentation of the construction and application of the network information system of one small area in the real world. It is developed with the theory, technology and strategy of digital earth for sustainable development of the area.

A digital mini-area can be simply defined as a digital and virtual small area in concept. It can be conceptually describes as such a process. At first, spatial information models of the mini-area is developed based on the global or national geographical coordination system. Thus variety of information about the mini-area is collected, sorted, processed, stored, analyzed, synthesized and optimized. Then the entities and phenomena in such fields as resource, environment, population,

society and culture of the mini-area can be digitally simulated, emulated, analyzed, represented, and therefore understood deeply.

2. Technology Background

Digital mini-area has a good technology background with information technology (IT) and spatial technology development, mainly including:

(1) Digital earth has been integrated with sustainable development strategy as soon as it is put forward. It has now evolved one important part of sustainable development strategy. As it is put into microcosmic and precision application, it will leads to digital mini-area.

(2) The 3-in-1 network system has been brought into being with the development and integration of telephone communication network, computer network and cable TV network. It will also connect to the satellite communication system and mobile communication (wireless) network system to make an integrated air-and-ground network. Furthermore, the network will be developed with wide-band and multimedia technology to form the network environment of digital mini-area.

(3) The global and national Earth Observation System (EOS) is evolved with a series of satellites, with which the global or national electrical map databases with high resolution can be set up. And the geospatial data with higher and higher resolution will lead to more and more precision application of 3S --Remote-sensing System (RS), Geographical Information System (GIS) and Global Position System (GPS)-- in smaller and smaller area. Hence, the spatial information infrastructure can be provided for the digital mini-area.

(4) The integration of network communication technology, automatic control technology and architecture technology have resulted in an

revolution in building management. Premise distributed system (PDS) or structural cabling system (SCS), intelligent building system (IBS), intelligent residence system (IRS) and intelligent mini-area system (IMS) have been progressively applied to the building construction. Herewith, these systems can make the infrastructure and network environment for a digital mini-area. Then integration, automation, digitalization and information services and applications are available for the users inside or outside the mini-area.

(5) Brought forward by Microsoft, digital nervous system is applied to enterprises, now extended to community, and even to the earth. So global digital nervous system, developed from micro to macro, is just the direction of digital nervous system. Then such functions as perception, reaction, coordination, communication and control are available for a digital mini-area.

(6) Rapidly expanded network, highly increased network population and explosive multimedia information will bring a great promise of information integration and information fusion. They also make of an information environment for the digital mini-area. Herewith, multi-dimensional information system can be set up based on geospatial information frame.

(7) Such applications as e-government, e-community, e-entertainment and e-commerce are now widely brought into practice. They show the tide of electric revolution, digitalization, and information revolution of the world. They are also application functions and representation models of the digital mini-area.

3. System Structure

(1) General structure

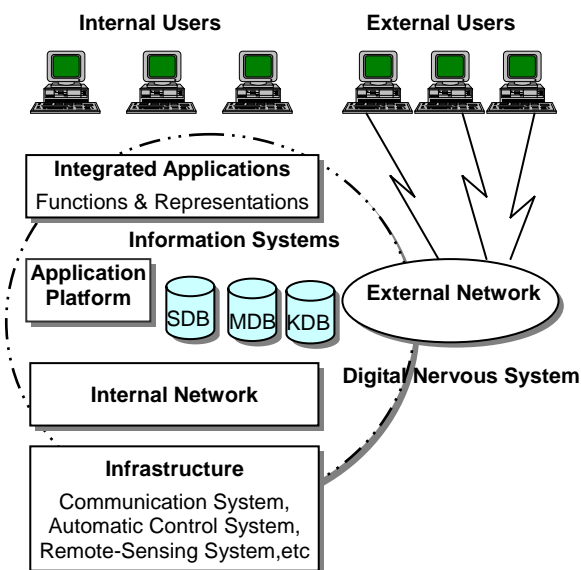


Figure 2-1 General structure of digital mini-area
The digital mini-area is generally built up with following elements as illustrated in Figure 2-1:

- 1) the intelligent infrastructure;
- 2) the wide-band multimedia network environment (Internet /Intranet);
- 3) the integrated application platform based on 2);
- 4) the information systems of the mini-area based on 2) and 3), including spatial databases (SDB), spatial model databases (MDB), methods and rules databases (RDB), knowledge databases (KDB), and so on;
- 5) the services and applications for information communities and users inside or outside the mini-area.

(2) Physical infrastructure

The infrastructure of the digital mini-area is illustrated in Figure 2-2. Thereunto, premise distributed system (PDS) or structural cabling system (SCS), is illustrated in Figure 2-3, and intelligent residence system (IRS) in Figure 2-4.

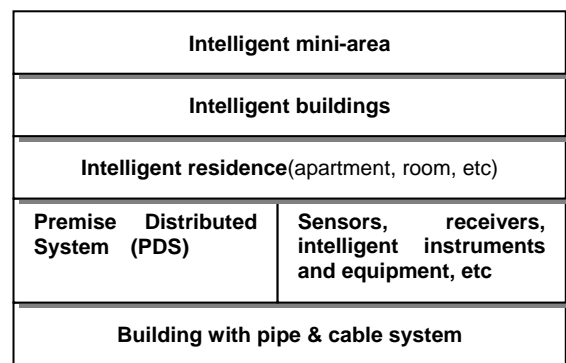


Figure 2-2 Physical infrastructure model of digital mini-area

(3) Intranet system

Figure 2-5 illustrates for Intranet system structure of the digital mini-area.

(4) Extranet system

Figure 2-6 illustrates for extranet system structure of the digital mini-area.

(5) Information model and logical structure

A digital mini-area can be logically manifested as the integration of electronic maps, geo-positions, features, attributes, and virtual reality of a real area. The digital mini-area is the digitalization simulation, emulation and representation of the entities and phenomena of the area in the past, present and future. So its digital information include spatial data about geo-position and time and their feature data

about the related entities and phenomena.

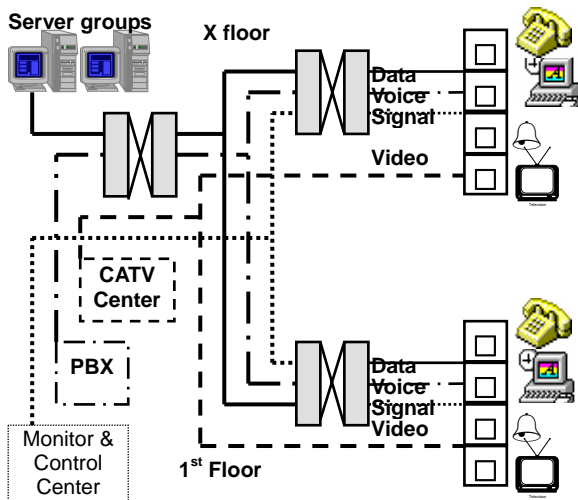


Figure 2-3 Premise distributed system of digital mini-area

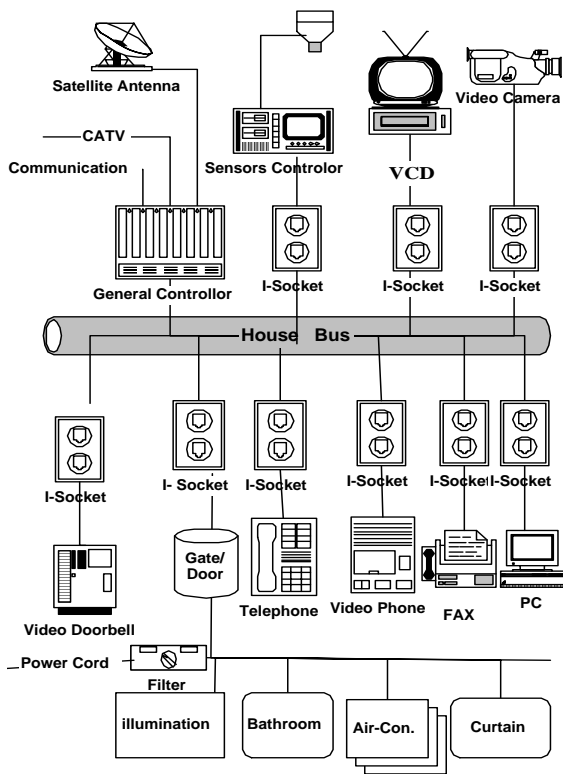


Figure 2-4 Intelligent residence system of digital mini-area

(6) Functions and applications

Based on the application platform of digital mini-area, such services and applications as e-government, e-commerce, digital entertainment, e-community, intelligent building management and

precision application and services are available for variety of information entities and users inside or outside the area.

The application platform is mainly composed of geospatial data center, public information exchange services, information agent, network control center, payment gateway, decision support services for sustainable development, and so on. It offers basic and common functions as information release, authentication, electronic payment, building automatic control and management, precise position, geospatial coordination transformation, spatial model, decision-making model, knowledge and model management, application agent, application gateway, etc.

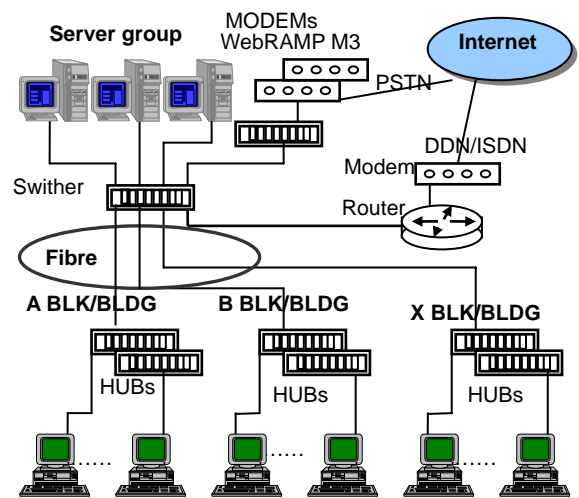


Figure 2-5 Intranet system structure of digital mini-area

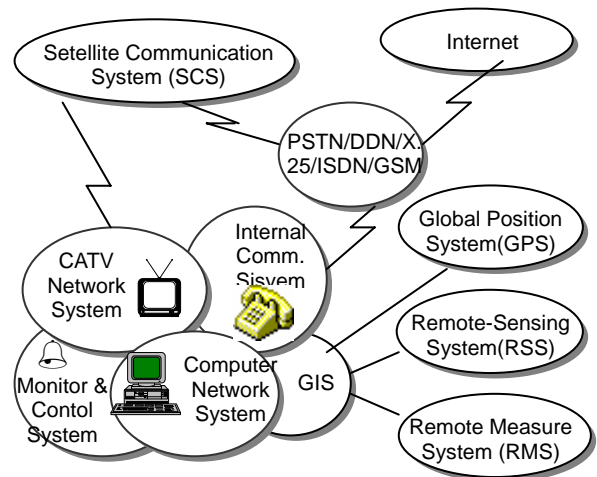


Figure 2-6 Extranet system structure of digital mini-area

(7) Decision-making model system

Visualization models are available for making decision on resources development, environment

protection, disaster prevention and cure, social sustainable development, comprehensive plan, etc.

4. Key Technologies

Since digital mini-area is the microcosmic embodiment of the digital earth, the key technologies of the digital earth are also those of the digital mini-area. Furthermore, the following technologies are very important to the digital mini-area.

(1) The technology of three-in-one network

The three-in-one network is the network that integrating telecommunication network, cable TV network and computer network to achieve the integrative functions as multimedia information processing, sending, receiving, representing and displaying. With this network, telephone, mobile telephone, cable TV, Internet and satellite are link together to make a integrative application of communication, computer and content. However, there will be a long time and a hard process to develop the three-in-one network in China because of the following factors:

- 1) The conflict of interests among different department,
- 2) The difference of ideas among the fields of telecommunication, computer and cable TV,
- 3) The weak compatibility of various of standards and systems,
- 4) The weak transparency of the interfaces between various technologies,
- 5) The poor connectivity and inter-operability between the works, etc.

(2) The technology of integrated air-and-ground network

There will be a long time to develop the integrated air-and-ground network system in China mainly because of the following factors:

- 1) Less advanced technologies of the series of earth observation satellites including meteorological satellites, land satellites and ocean satellites,
- 2) Less advanced technologies of high resolution of the series of mini satellites,
- 3) Lack of research and development (R&D) fund, etc.

(3) The technology of electronic map

It is one of the basic researches in digital earth fields that how to develop electronic maps of high resolution, multiple scale and universal spatial frame.

(4) The technology of spatial multimedia database

Although many database products in present market managing such multimedia data as voice,

video, graph and image mainly based on SQL relational structure, they have many difficulties in supporting geospatial data management. It is a key problem that how to develop spatial multimedia database model and system.

(5) The technology of spatial multimedia information condensation and transfer

Nowadays there are many technologies of data compression and on-line transfer of video, voice, animation and so on. However, some of them can not make satisfied application on Internet or Intranet, some require high system configuration and some have not come into use. It is still difficult to apply these technologies to the information infrastructure construction of the digital mini-area in the actual network conditions in China.

(6) The technology of spatial model and decision emulating

Supported by electronic maps and spatial multimedia database systems, the series of models can be developed with GIS spatial analysis functions, spatial model technology and 3D animation technology. The models are for such applications as resource monitor and prediction, environment monitor and prediction, disaster monitor and prediction, population control, area plan, industry structure optimization and sustainable development.

(7) The technology of encryption and authentication

Confronted with a number of dangers because of the opening of the network system, dealing with business on the network requires adequate control and security. The technological system of security can be set up upon the three points of the process: information transfer, transaction process and credit audit. Nowadays there are some effective standards for secure business on network, such as S-HTTP, SSL, STT and SET. And there are some common means for secure electronic business, such as public key and private key, RSA, digital digest, digital signature, digital time stamp, digital certificate, and certificate authentication (CA). However, it is a long-term and hard task to establish a CA center in China. Moreover, there are also some other technologies for the security of the intranet system, such as IP filtering, firewall, virtual private network (VPN), and calling back in dialing-up.

(8) The technology of virtual reality

Virtual reality is a three dimensional world acting on human sense organ. Furthermore, it is a world of mutual inductance and human real-time interaction.

It is a high technological system integrated with multiple subjects and multiple technologies. With the virtual reality technology, people can not only view the object in the world from outside, but also observe and experience it from inside. Thus a multiple information space of the object can be set up with kinds of ways of sense, and people can get the feeling of being personally on the scene. Virtual reality is one of the most important supporting technologies of the digital earth.

5. Application Integration

Supported by the application platform, the digital mini-area system provides for users variety of services and functions mainly including:

- (1) Network communication services, such as Internet/Intranet system, wide-band network system, cable TV system, satellite communication system, and mobile communication system;
- (2) Intelligent building management, such as security control system, fire control system, park automation system, meters (water meter, gas meter, ammeter, etc) automation system;
- (3) Digital home entertainment, such as video on demand (VOD), audio on demand (AOD), electronic games (e-games), and on-line gambling;
- (4) Intelligent home office, such as virtual office, e-commerce, and net meeting;
- (5) Digital public services, such as cyber shopping, on-line medical treatment, remote home nursing, on-line school, on-line payment, and on-line bank;
- (6) Intelligent electronic government, on-line services of population management, residence registration, public security, employment, social ensure, industry and commerce management, revenue management, etc;
- (7) Precision industry application, such as spatial information collection system, electronic maps, electronic navigation, mobility monitor, precise agriculture, and precise commerce;
- (8) Intelligent and visual decision-making support, such as resource monitor and prediction, environment monitor and prediction, disaster monitor and prediction, population control, area plan, industry structure optimization, and sustainable development.

6. Guideline of Research and Construction

Whether the digital mini-area comes to be a research project or an information system engineering project, it must be brought into effect with the guide of the theory, principle and methodology of system engineering. The basic guideline may include the following points.

- (1) For system design, some methods in principle

are to be followed, such as platform integrating, application integrating, information integrating, taking effect as fast as possibly, and implementing from experiment.

(2) For the key technology research, the following principles can be complied with.

- 1) Theory research is prior to technology development.

- 2) Adopt Existing technologies and products.

- 3) Concentrate to tackle the key problems.

- 4) Synthetically adopt various of technologies in multiple fields.

(3) Some of the system implement strategies include uniform planning, uniform designing, taking an experiment first, developing step by step, etc.

(4) In view of system implement process, there are some guidelines as below:

- 1) The first step is to set up the information infrastructure.

- 2) Set up software ready for every layer of the system.

- 3) Pay strong attention to applications and services.

- 4) It is a basic task to build up the database systems.

- 5) Make a point of information sources on the network.

- 6) Do training from the beginning to the end.

(5) Considering the system yields, the following polices should be followed.

- 1) Develop the digital mini-area system according to the conditions of the area, such as technological strength and investment.

- 2) Put the project of the most urgency into practice first.

- 3) The projects with high yields have top-priority.

- 4) Construct the system step-by-step to get phase-by-phase development.

According to the above policies and methods, an engineering project of the digital mini-area can be generally divided into several sub-projects or assignments as below:

- The projects of digital infrastructure, including planning, designing and constructing the intelligent areas, buildings or houses, and building up distributed structural cabling system, digital instrument system, intelligent equipment system, etc;

- The projects of network platform, including three-in-one network system, satellite information collecting system, GPS data collection system, etc;

- The projects of application platform, including geospatial data center, public information center, information agent, network control center, payment gateway, decision-making

- support models, etc;
- The projects of spatial databases, including multi-scale electronic map databases of the mini-area, multi-source and multi-scale remote-sensing image databases, high-resolution GPS databases, geo-coordination databases, and kinds of thematic databases;
 - The projects of application system for office, business, culture, entertainment, living, communication of the government departments, enterprises, houses and residence in the area;
 - The projects of necessary systems such as laws and rules, security system, credit audit system, certificate authentication system.

Some of the above systems are the external environment of the digital mini-area. They must be built up with social support and cooperation.

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