RESEARCH ON THE PROGRESS AND DIRECTION OF DIGITAL CITY

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ABSTRACT:

With the development of information and communication technology, the construction of digital cities has become more feasible. It is a powerful way to elevate the city's strength, to improve the social environment and to promote national sustainable development. This paper describes the digital city's definition, content, frame, architecture, urban spatial data infrastructure (USDI) and discusses the relations between digital city and USDI. Based on the significance and strategic prospect of digital city, the paper researches the orientation of digital city in details. It also discusses the architecture of digital city according to its development trend. In the last part, the five phases of digital city are comprehensively compared and analyzed.

1. INTRODUCTION

The construction of digital city is a hot topic on geographical information sharing of current geomatics industry and consistent with the construction of spatial data infrastructure. The geomatics industry is closely related to the construction of digital earth, the development of economic society and the national defence, therefore the significance of constructing a geographic spatial framework is obvious. In order to advance the construction of "digital earth", we need to speed up the construction of digital city, especially enhance the service ability of geomatics.

Digital city is an application of digital earth in cities. Integrated with modern information technology, digital city will play an important role in the process of geomatics development.

Two of the most powerful drivers of change within global economies are the explosion of information technologies (or digital technologies) and the shift towards sustainable development. Both require us to rethink the nature of products and services. Yet there have been surprisingly few attempts to assess whether the information and sustainable development revolutions will complement or conflict with one another. Integration between the two agendas has been slow. Through the implementation of Digital cities, this work will offer a significant contribution to sustainable development.

The construction of digital city has marched into a fast implementation stage and simultaneously its process has been unprecedentedly promoted. All this indicates that the development of digital city is marching into the breakthrough scope and surmounting a historical opportunity. Therefore the progress and direction of digital city are worth being discussed and researched.

2. DIGITAL CITY AND ITS ARCHITECTURE

As a part of the information age, digital city's functionalities are to improve the city services, to elevate the quality of city management, to improve the quality of people's life and to maintain the city environment. Therefore digital city plays a very important role in the process of sustainable development.

2.1 Definition of Digital city

The digital earth is seen as a multi-resolution, three-dimensional representation of the planet, into which vast quantities of geo-referenced data can be embedded. In other words, digital earth is an information nerval meshwork and digital city is a node in the nerval meshwork.

Strictly speaking, the digital city is a dynamic concept, whose definition is still evolving. But we can understand it as follow: digital city is an open and complex application system based on internet technology and city information resource. The digital city must integrate with modern information technology and communication technology. Its aim is to promote sustainable development in the fields of environment, tourism, health, technology, sport etc.

2.2 Content and Frame of Digital city

As a node of digital earth, digital city content and frame should accord with digital earth. The content of digital earth consists of infrastructure and application engineering. Infrastructure includes Urban Information Infrastructure (UII) and Urban Spatial Data Infrastructure (USDI). UII, or information highway, is a network layer which consists of communication network and computer network. USDI includes techniques, policies, standards and manpower resource that are used in acquisition, manage, store and distribution of spatial data. Application engineering includes management of resources, environment, society, economy, region, city and application aimed towards government, enterprise and public services.

Therefore the contents and frame of digital city include infrastructure and application engineering. The difference between digital earth and digital city is only in scales. Digital earth emphasize particularly on whole earth, digital city

emphasize particularly on microcosmic (that is, one the city). Digital city's content and frame detail are presented in table 1.

Infrastructure	Network Level	Wide Band Wire Network: Internet, WWW, Great Grid; Wide Band Wireless Network: Mobile Internet, WAP, blue tooth, Mobile GGG; Wide Band Integrated Network: Mob, Web, GGG
	Data Level	Primary Geodata: DEM, DLG, DRG, DOM, Infrastructure Data: City Constructing, Traffic, Energy Sources, Communication, Social, Economic, Cultural Data: Population, Resource, Economy, Culture, Education, Science,
	Technology Level	Spatial Information Technology Platform: RS, GPS, GIS, VR, WebGIS, Management Information Technology Platform: ERP, CRM, SCM, LBS(WebMIS), …… Integrated Information Technology Platform: Web(GIS+MIS), ……
	Guarantee Level	Standard and Specification, Security, Supervision and Evaluation, Policy and Code, Education,
Application Engineering	Management Level	Management about City Planning, Traffic, Power, Communication, Accident,
	Application Level	e-Government, e-Commerce, e-CBD, e-home, ……
	Service Level	Public Information, Mobile Information, Decision-making,

Table 1 Digital City's Content and Frame

2.3 Architecture of Digital city

The construction of digital cities is an integrated application of modern technologies. Those technologies are Internet, communication, grid computing, spatial information grid, Global Positioning System (GPS), Geographical Information System (GIS), Location-Based Service (LBS), Data Mining, Virtual Reality, etc. But spatial data infrastructure is its foundation including a variety of databases, such as spatial database, image data database, geocoding database, population database, resource database etc. In the middle tier, there are some functional servers, for example, spatial data server, spatial routing and gateway server, geocoding server, attribute data server. The architecture of Geo-information system is shown in Figure 1.

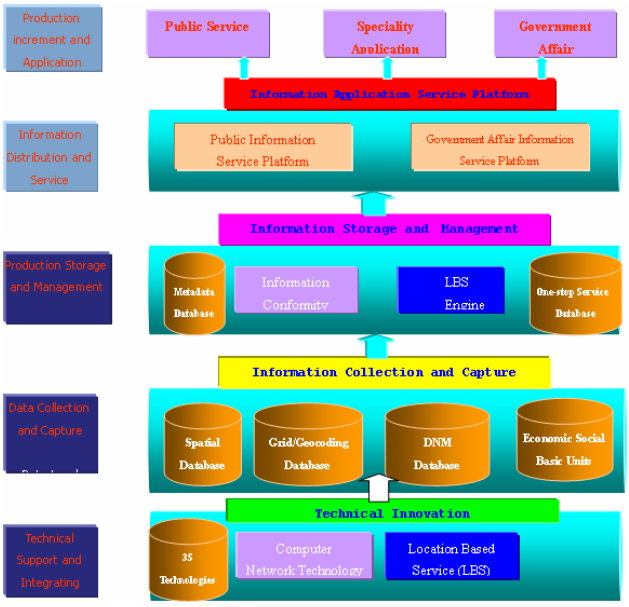

Figure 1 Architecture of Digital city

The hierarchical structure of Geo-information system includes mainly five levels, namely the technical level, the data level, the management level, the service level and the application level. The technical level involves the technical innovation, support and guarantee system. The data level includes the spatial data acquisition, database construction and updating. The management level indicates the information conformity, integration and navigation system. The service level is the socialization and industrialization application service system. The application level mainly consists of public service, government affairs and other applications. The authors explain the five levels as follows:

Application level: realize all kinds of applications involving government, the enterprise and individuals, constitute spatial application infrastructure;

Service level: realize services and applies involving spatial information sharing, constitute spatial service infrastructure;
Management level: realize the integration, fusion and management of multiple source spatial information, constitute spatial information infrastructure;

Data level: realize spatial data acquisition, database construction and updating, constitute spatial data infrastructure;
Technical level: investigate technical innovation, support and guarantee system, constitute spatial information grid infrastructure.

On microscopic level it is used for spatial datum frame system, spatial data processing service system and the foundation of spatial database. Based on the spatial datum frame, the GPS continual tracking facility and the difference datum station can be additionally built, which carries or processes GPS data or broadcasts to the public.

Based on the geographic information acquisition and the processing system, the spatial database or the integrated geographic information service system can be constructed. Through the data acquisition, collection and integration, and establishment and renewal of navigation electronic map, some services system such as Location Based Services (LBS), intelligence transportation system (ITS) could be built to provide the value-added service for some specialized industries. From the technical angle, the digital city is the result of integrating multi-disciplinary science and technology. It depends on the digitized surveying and mapping system, the realization of a geographic spatial information system and the renewal, intellectualized processing and the integrated management, the network distribution and service.

Phases Contents	Analog	Digitization	Informatization	Knowledgement	Ubiquity
Data Type	Simulation Data	Geographic Data	Spatial Data	Grid Data	Eco-Data
Focus	Ontology	Data	Information	Knowledge	Integrating of Data, Information and Knowledge
Product Model	Hand-made	DEM/DOM/ DLG/DRG	Digital Measurable Images(DMI)	Online Intelligent	Realtime Ecological-made
Technology	Tradition	GIS/GPS /RS (3S)	3S +LBS 3S in One + LBS	Global Information Grid	4A/4w
Service Base	Map Based Service	Position Based Service	Location Based Service	Routine Based Service	Ecology Based Service
Direction(USGS)	Map	Monitor	Understand	Model	Predict
Host ID	Map-maker	Geoinfo-Provider	Geomatics-server	One Stop Server	Server on Eco-Demand
Infrastructure	Archives	SDI/SII	SII/SGI	SGI/SSI	SSI/SAI
Domain direction	Surveying & Mapping	Geo-information	Spatial Information Technology	Knowledge Industry	Creative Ecology
Build Power	Surveying & Mapping	Surveying & Mapping industry	Geomatics Industry	National Hold	Social Demand
Representation of City	Archive City	Digitization City	Digital City	Grid City	Eco-city

Table 2 Five phases of Digital City Based Geomatics

Based on all these it realizes the fusion of geographic spatial information resources and the value-added service, to push forward the application of the surveying and mapping information and the technical product, to provide the multi-criteria, the multi-form services to the public.

Social activities and the development of the environment are all changed under temporal datum frame; the terrestrial space information is their carrier and mathematics foundation. In the information age the development of internet and communication network adding the portable computer terminal, will cause the popularity of spatio-temporal information service representing characteristics of current and the near future. These are also the key to operating the spatial information industry. So the construction of digital city must depend on the public service, the public product, the public platform etc.

3. THE ORIENTATION OF DIGITAL CITY

The realization of informationization can not be sole achieved from the technical angle or the management level. It needs an omni-directional system construction which involves theory, technology, management, operation and maintenance. The traditional surveying and mapping system takes production as the masterstroke, the digitized surveying and mapping system considers the technology as its masterstroke too, but the digital city selects the service as its masterstroke. Digital city is not just the informationization of surveying and mapping, the same as informationization society is not just society's informationization. Digital city is the inevitable product of specific historical stage.

Therefore, we should understand Digital city on the foundation of digitized surveying and mapping system. Digital city can be oriented with the characteristic of the automation of surveying and mapping technology, the digitization of surveying and mapping production, the network convenience of surveying and mapping service, the socialization of surveying and mapping product.

4. PHASES ANALYSIS OF DIGITAL CITY BASED GEOMATICS

It is not its ultimate objective that the surveying and mapping develops to the Geomatics stage, as the informationization society is not the ultimate society; it will not bog down but develop forwards. Table.2 shows the five phases of digital city based Geomatics.

The phases of digital city based on Geomatics is composed of analog, digitization, informatization, knowledgement and ubiquity five phases. Analog phase is the basic and primordial phase accompanied by the undeveloped and traditional surveying and mapping technology. In this phase data type is the simulation data focusing on the ontology of the real world and all products are provided in the hand-made model with the traditional and less-developed technologies. The services provided to the public in this phase are map sheet-based. Map sheets are the only vehicle for the urban planning and management and for guiding the public. From the USGS point of view, the management of city in terms of Geomatics is based on static map sheet, and the map-maker is the host ID of analog phase. Therefore the surveying and mapping is the domain direction and build power in the process of digital city, and representation of infrastructure and city is in the archive format in this phase which limits the city's management modernization progress to some extent.

With the digitization technology development, especially computer science and technology development, the representation of the city moves to the digitization phase. The description of the city from traditional map model increasingly

evolved into the 4D model, namely Digital Elevation Model (DEM), Digital Orthophoto Map (DOM), Digital Line Graphic (DLG) and Digital Raster Graphic (DRG). This is an innovation of traditional analog city representation, which results from 3S (GPS, GIS and RS) technology booming. Instead of traditional map sheet, 3S integration and digitization map and position based service has become a new service platform for the municipal governments and for the public. Geo-information has been the domain direction and Geo-information provider became the host ID. However the surveying and mapping industry still holds the position of build power in the second digitization phase. The city infrastructure is represented in the form of spatial data infrastructure (SDI) and Spatial information infrastructure (SII), and the city in this phase called digitization city which is only the interim from analog to informatization phase.

Informatization phase is the most important phase in the progress of digital city. It has been pushing and will push the city's modernization and further development. In this stage the spatial data is the main data type, and the most attention is being paid on the information extraction. The product model is the digital Measurable Images (DMI), moreover the service is not only based on the digitization maps and position based service but also based on Location Based service. Spatial information infrastructure (SII) and spatial grid information (SGI) are two formats of city Infrastructure. With more spatial information, more understanding, urban planning, the construction and the management have stepped into the scientific, effective and sustainable development phase. However Geomatics service and Geomatics providers has become the host ID and build power of digital city and spatial information technology leading the direction of digital city progress. The representation of the city in the informatization phase is further developed into a digital format from digitization format.

The forth phase Knowledgement phase of city is a further advanced stage of the city representation. Knowledgement will play an important role in this phase to promote digital city development. Grid data is the main data type of this phase and Global Information Grid and Online Intelligent are the domain characteristic which provide Routine Based Service. More advantage for the municipal governors and the Public will be gained from one stop online server. Knowledge Industry will orient the digital city to the Grid city. Infrastructure spatial Grid infrastructure (SGI) and Spatial Service Infrastructure (SSI) will be online, data-sharing and interoperational basic infrastructure of city.

With the most important characteristic of Ecology concept, Ubiquity phase will come out following Knowledgement phase and it is the most advanced phase. Data type is Eco-data, and integration of data, information and knowledge will be its most interesting features. In this phase the product model is the real time ecological data to provide ecology-based service which will answer when, where, what object and what change (4W) of city to anyone, anything, anytime and anywhere (4A). In this phase digital city direction is oriented towards the prediction of the future. Spatial Application Infrastructure (SAI) and Spatial Service Infrastructure (SSI) are the main framework of city infrastructure. Social Demand will be the key driver of Build Power. At this stage Eco-city will be the representation of city.

Each phase of digital city inherits and future develops of previous phase, but not a simple substitution process. The representation of the city evolves from archive to digitization city, and further to digital city, its future representation will be in grid and ecology.

5. CONCLUSION

Digital city is an integrated place where we work, study and live. This place is characterized by high efficiency, convenience, security and comfort. Digital City can maximize the city's strength, improve its social environment, sustain a rapid economic development, increase the cultural and living quality of people, and promote national sustainable development. Therefore in order to improve the sustainable development of the society, we must quicken the implementation of digital cities. The organic synthesis of mechanism, technology and service decides the degree of smoothness in the construction of Digital city. The extended application domain and the increment direction of the Geomatics depend on the services it provides, and this procedure is dynamic, with other characteristics such as real-time etc. In order to provide best geo-services to as many as end users as possible, this paper discusses the significance and the strategic prospects of digital city. The orientation of digital city is researched in detail. Both are research topics in academic as well as in industrial communities. The authors probe into the architecture of digital city according to its development trend. At last, we compare and analyze the five phases of digital city comprehensively. We believe this will helpful for the integration of Geomatics and other technologies. Digital city will play a central role in the sustainable development with the help of spatial information grid.

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