제10차 GIS 국제세미나

The 10th International Seminar on GIS
NGIS Policy in Ubiquitous Compution Environment
유비쿼터스 시대를 향한 국가GIS 추진전략

November 14~15, 2005
Seoul Education & Culture Center, Seoul, Korea
Organized by Korea Research Institute for Human Settlements

후원 : 대한주택공사, 한국토지공사

History of International Seminar on GIS

구분	Theme	Date	Place	Organizing Committee	
				Chair	Member
1st (1996)	Strategies for NGIS Development	4.18-19	Seoul Education & Culture Center, KRIHS	Young-Pyo Kim, Director, Geospatial Information Center	Woo-Seok Cho, Mi-Jeong Kim
2nd (1997)	GIS Applications in the Public Sector	10.16-17	Seoul Education & Culture Center	Young-Pyo Kim, Director, Geospatial Information Center	Yong-Bok Choi, Mi-Jeong Kim
3rd (1998)	GIS Development Strategies for the 21st Century	9.10-11	Renaissance Seoul Hotel	Young-Pyo Kim, Director, GIS Research Center	Mi-Jeong Kim, Sung-Mi Park
4th (1999)	GIS in Local Government	9.16-17	Renaissance Seoul Hotel	Young-Pyo Kim, Director, GIS Research Center	Mi-Jeong Kim, Sung-Mi Park, Hong-Jun Choi
5th (2000)	Toward a Knowledge-based Society: NGIS Policy and Technological Development	9.28-29	Ritz-Carlton Seoul Hotel	Young-Pyo Kim, Director, GIS Research Center	Sung-Mi Park, Hong-Jun Choi
6th (2001)	Present and Future of GIS Technologies	5.17-18	Seoul Education & Culture Center	Young-Pyo Kim, Director, GIS Research Center	Sung-Mi Park,
7th (2002)	GIS Workshop & Seminar	11.8	COEX Intercontinental Hotel	Hyung-Min Yeom, Director, GIS Research Center	Dong-Han Kim
8th (2003)	Envisioning Cyber-geospace and Spatially enabled E-government	11.20-21	COEX	Young-Pyo Kim, Director, GIS Research Center	Jung-Hun KIm, Dong-Han Kim, Seung-Mi Hwang, Ki-Hwan Seo
9th (2004)	Emergency and Disaster Response with GIS	9.8-9	Seoul Education & Culture Center	Young-Pyo Kim, Director, GIS Research Center	Jong-Taek Park, Dong-Han Kim, Ki-Hwan Seo
10th (2005)	NGIS Policy in Ubiquitous Computing Environment	11.14-15	Seoul Education & Culture Center	Byoung-Nam Choe, Director, GIS Research Center	Jung-Hun Kim, Dong-Han Kim, Jung-Yeop Shin Jin-Hyeong Park

GIS국제세미나 개최실적

구분	회의주제	개최일	장소	행사준비	
				총괄책임	주관팀
1차 (1996년)	국가GIS 구축 및 활용을 위한 국제세미나	4.18-19	서울교육문화회관 국토개발연구원	김영표 국토정보센터장	조우석, 김미정
2차 (1997년)	공공부문 GIS활용에 관한 국제세미나	10.16-17	서울교육문화회관	김영표 국토정보센터장	최용복, 김미정
3차 (1998년)	21세기를 향한 GIS발전전략에 관한 국제세미나	9.10-11	르네상스서울호텔	김영표 GIS연구단장	김미정, 박성미
4차 (1999년)	지방자치단체의 GIS활용에 관한 국제세미나	9.16-17	르네상스서울호텔	김영표 GIS연구단장	김미정, 박성미, 최홍준
5차 (2000년)	지식기반사회를 대비한 국가GIS정책 및 기술개발방향	9.28-29	리츠칼튼호텔서울	김영표 GIS연구센터장	박성미, 최홍준
6차 (2001년)	GIS기술의 현재와 미래	5.17-18	서울교육문화회관	김영표 GIS연구센터장	박성미
7차 (2002년)	GIS국제세미나·워크샵	11.8	코엑스 인터컨티넨탈호텔	염형민 GIS연구센터장	김동한
8차 (2003년)	사이버국토 구축과 전자정부 발전방안	11.20-21	삼성동 코엑스	김영표 GIS연구센터장	김정훈, 김동한, 황승미, 서기환
9차 (2004년)	GIS기반 방재국토 구현전략	9.8-9	서울교육문화회관	김영표 GIS연구센터장	박종택, 김동한, 서기환
10차 (2005년)	유비쿼터스 시대를 향한 국가GIS 추진전략	11.14-15	서울교육문화회관	최병남 GIS연구센터장	김정훈, 김동한, 신정엽, 박진형

Opening Address

Honoured Dr. David Maquire from ESRI; In-Ui Hong, Vice president of Korea National Housing Corporation; and distinguished participants and professionals,

On behalf of the Korea Research Institute for Human Settlements, I would like to welcome all of you to the 10th International Seminar on GIS.

The Korea Research Institute for Human Settlements has annually invited scholars and professionals from home and abroad since 1996 to discuss development directions of GIS policy and technology and today, we greet the 10th anniversary.

NGIS started in 1995, since then, it has progressed greatly to build National Spatial Data Infrastructure successfully.

The effectiveness has been increased for administrative work in government as they adopted a digital map for managing land and public facilities. Administration service toward the public has been improved enormously. Also GIS became a common tool for

our daily life.

In the modern society, Information Technology is a motive of creating various cultures and a new life pattern.

At present, we have been moving from information based society to ubiquitous one. In the ubiquitous society, we can gain or give any information in any time, any device and anywhere.

Intelligent home, intelligent road, remote medical treatment will be common in our everyday life in the near future. At that time, micro electronic chip will be set inside all places and objects such as houses, facilities and products. In the intelligent home, users will be able to operate home appliances by simply using a mobile phone. On the intelligent road, it will be possible that drivers can communicate with cars and roads. In addition, people will not need to go to the hospital as they can check their health condition via remote medical treatment.

This new paradigm leads us to build cutting-edge ubiquitous cities such as u-SongDo, u-YongIn, u-Paju and u-Busan.

GIS, a software which represents real world into a computational environment, is a fundamental technique to actualize the ubiquitous space. This will be an important motive to come true a new world along with various techniques like u-sensor and u-network.

I hope the 10th seminar will help to discuss successfully to find the most appropriate strategies for new ubiquitous era of NGIS. In addition, I expect it will also be a groundwork for activating businesses in GIS through sharing various new GIS techniques and discussing many related topics.

Please allow me to extend once more my sincere gratitude and appreciation to presenters, panels, all the honoured participants and professionals.

Finally, I would like to take this opportunity to extend my appreciation to all the related agencies including the Territorial Information Planning Team in the Ministry of Construction and Transportation, Korea Land Corporation, and Korea National Housing Corporation to their devoted efforts for this seminar.

Thank you.

November 14 , 2005

Kyu-Bang Lee, President
Korea Research Institute for Human Settlement

Seminar Program

< November 14, 2005 (Monday) >

12:00 - 13:00   Registration

13:00 - 13:20   Opening Address (Kyu-Bang Lee, President of KRIHS) CongratulatoryRemarks (In-Ue HongVice President, Korea National Housing Coporation)

13:20 - 14:00   Keynote Speech "Ubiquitous GIS Software: architectures and capabilities " (David Maguire, ESRI, USA)

Session 1   Connection of GIS and Ubiquitous Technology

14:00 - 14:50   Steps towards Realizing UbiGIS: the Relationship of GIS and Ubiquitous Computing: Alexander Zipf (University of Applied Science Mainz, Germany)

14:50 - 15:40   Geographic Context in Ubiquitous Computing: Ki-Jun Lee (Pusan National University, Korea)

15:40 - 16:00   Coffee Break

16:00 - 16:50   Ubiquitous GIS for Hydrogeologic Fieldwork and Analyses: Douglas Flewelling (State University of New York at Buffalo, USA)

16:50 - 17:40   Role of GIS in Building u-City: Jae-Won Kim (National Computerization Agency, Korea)

< November 15, 2004 (Tuesday) >

Session 2   GIS Integration Plan for Ubiquitous Computing Environment

10:00 - 10:40   Integration of Local Governments' GIS for Ubiquitous Age (Young-Ok Kang, SDI, Korea)

10:40 - 11:00 Coffee Break
11:00 - 11:40 GIS Integration Technology for Ubiquitous Age: Byoung-Nam Choe (KRIHS, Korea)

11:40 - 13:30 Luncheon

Session 3   Retrospect and Prospect of NGIS

13:30 - 14:10 NGIS in Korea: Myeong-So Eo (Ministry of Construction & Transportation, Korea)
14:10 - 14:50 NSDI in USA: Alan Stevens (Federal Geographic Data Committee, USA)
14:50 - 15:10 Coffee Break
15:10 - 15:50 NGIS in Japan: Hiromichi Fukui (Keio University, Japan)
15:50 - 16:30 Comparative Study on NGIS Policy: Eun-Hyung Kim (Kyungwon University, Korea)

Plenary Session   Policy Implication for NGIS

Moderator: Hae-Young Bae (Inha University, Korea)

16:40 - 17:30 Panel Discussion

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The Technologies and Applications of Ubiquitous Geographic Computing

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In recent years a new computing wave hasbrought new opportunities for building and using geographic (or location-based) information. Advances in hardware, networks, software and data now make it possible to distribute and embed geographic sensor, analysis and display systems within other applications and hardware architectures. Ubiquitous computing, also called pervasive computing, is a relative new field of information technology which examines how computers are embedded in the environment – in cars, in home appliances, as telephone hand sets and even sewn into cloths. Ubiquitous computing enables both distributed and mobile applications, and offers interesting implications for geographic information users.

Michael Goodchild (in Longley et al 2005) offers an interesting perspective on the implications of geographic information systems (GIS)becoming more distributed. He suggests that there are four distinct locations of significance to distributed GIS: the location of the GIS user and user interface, denoted by U; the location of the data being accessed by the user, denoted by D; the location of data processing, denoted by P and, finally, the area that is the focus of a GIS project, denoted by S. Traditionally, in GIS projects $U=D=P \neq S$, that is, the user interface, the data and data processing all occur at the same location, and these occur in a laboratory rather than at a field site (S). In the new era of distributed and mobile GIS it is possible for $U \neq D \neq P = S$, that is the user interface, the data and data processing can be at different locations, and some or all of them can be in the field. This offers some intriguing possibilities for harnessing the power of geography in consumer, business and scientific application areas.

Wearable

In Car

Hand-held

Phones

<Figure 1> Ubiquitous devices and applications.

   Perhaps the most exciting area of computer system development continues to be in hand-held devices.   There is a much greater variety in form factor (size, configuration, or physical arrangement of computer hardware), chip type and operating system than on desktop and server systems that have standardized on the Windows, Linux and Unix operating systems and very similar form factors.   Seldom do hand-held GIS exist in isolation, rather they represent the user's interaction with a wider system (Li and Maguire 2003) that in its most complete form comprises the following key elements: a hand-held client device with in-built location technology (e.g. GPS); a GIS application server with mapping, geoprocessing and data management capabilities (usually provided by a separate data server); and a wireless / wire-line network for device-server communication.
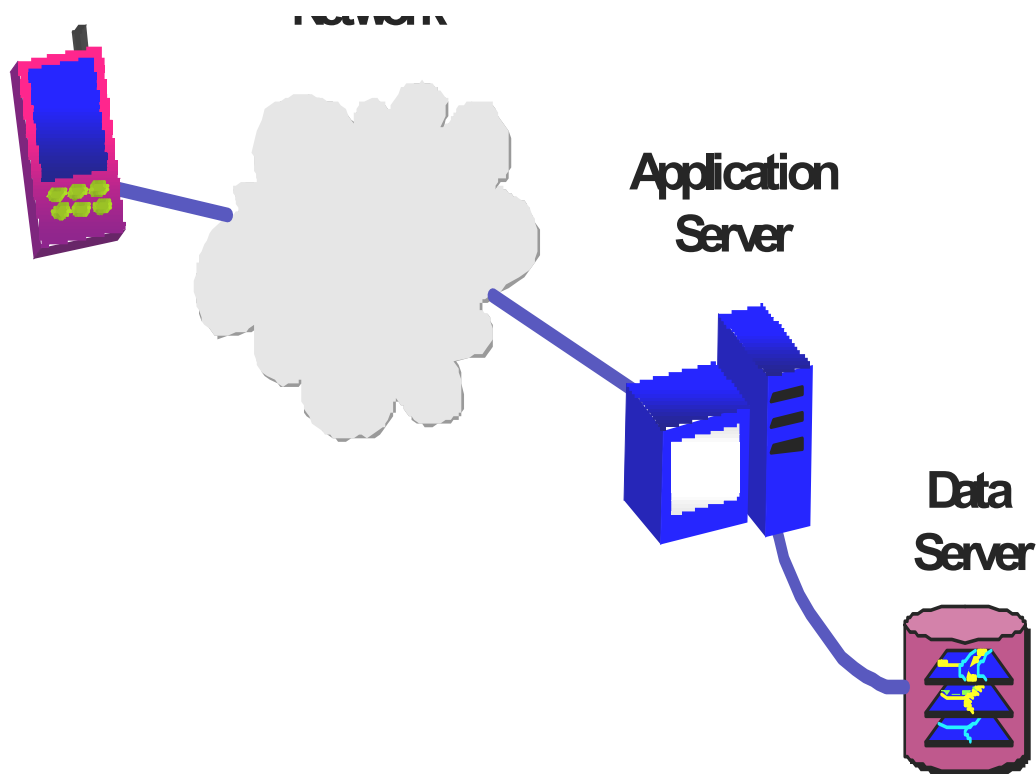
<Figure 2> Mobile GIS platform.

There is a wide array of hand-held devices that can be classified into three types based on weight, power, cost and functional capabilities: Portable PCs, PDAs and Mobile Phones.

- Portable PCs. These are powerful devices with advanced CPUs and local data storage and processing capabilities. Such systems can operate for extended periods disconnected from a network because they have local storage and processing capabilities. They are able to host advanced GIS data models and functions, and are suitable for advanced data collection tasks. Tablet PCs and laptops running full-featured desktop GIS products on the Windows operating system fall into this category. Unfortunately there is a cost to using such systems – they tend to be heavy and have restricted battery life (4-6 hours). As a consequence they are often used in vehicles or for specialist tasks of short duration (e.g. updating utility work orders with 'as-built' information or dynamic fleet-vehicle routing).

- PDAs (personal digital assistants). These are medium capacity devices that balance weight/power/cost with functionality. The PDA devices that run the Windows Mobile operating system are archetypal examples of this middle category. With a small form factor, battery life in excess of 8 hours and a sub-$500 price tag these systems are the mainstay of personal GIS data collection and mapping. Specialist hand-held GIS software solutions (e.g. ESRI ArcPad) have been developed that exploit the capabilities and deal with the restrictions (medium speed processors, limited screen size and resolution, and no keyboard) inherent in PDA hardware devices. A major feature of significance in PDA devices is that they have interfaces for peripheral devices. Initially, serial ports were used, but cable unreliability and inconvenience has seen an almost complete shift to the use of wireless connectivity using, for example, Bluetooth. The range of peripherals of interest to geographers includes GPS, digital cameras, barcode readers, and laser range finders.

- Mobile Phones. These are lightweight, personal hand-held devices. This category is dominated by mobile telephones and similar devices (e.g. Blackberry pagers). Such devices assume an always connected model because they have limited local storage and processing capabilities, and therefore rely on services provided by servers. The availability of mobile phones with embedded GPS and advances in server/network location fixing technologies have opened up a wide range of geographic uses for these devices. The devices in this class of hand-held system are most suitable in situations where mobility (lightweight, long battery life) is of paramount importance, and where there is a wireless connection to a server. Paradoxically, wireless signals are least reliable in urban canyons where most mobile telephone users are based, and in remote areas, where the advantages of lightweight devices and long battery life are most important.

An interesting trend of the last few yearsis the fusing of PDA and mobile phone technologies to create hybrid devices that have both good connectivity and local processing and storage. The connectivity is usually provided by a wireless telephone service (e.g. GSM - Global System for Mobile communication), as well as local area network access (e.g. 802.11 or WiFi). The standard devices have a ¼VGA resolution screen and 256 MB RAM storage, with at least a 600 MHz processor. These devices are capable of running quite powerful hand-held GIS mapping and data collection applications.

<Figure 3> GPS-enabled Blackberry-based emergency locator application.

A key feature of mobile, hand-held GIS is their ability to determine their location.Several technologies are available for this (Spinney 2003, Li and Maguire 2003).Some, such as GPS, are embedded in the hand-held device where location is exposed through mobile software development kits (SDKs), while other methods use the wireless network to query the device －usually accessible through server APIs.Handsets with GPS typically offer the highest accuracy and accelerated time-to-fix through the use of network aiding-GPS servers. Network solutions such as AFLT (Advanced Forward Link Trilateration) vary in speed and accuracy depending on the wireless technology they employ.The Cell-ID of a mobile phone is easy and quick to estimate, but has a comparatively low accuracy (100-10000m) depending on cell size.Often multiple handset and networked-based solutions are used together and complement each other depending on the specific application location accuracy requirements.

<Figure 4> Hand-held GIS on a smartphone and Windows Mobile PDA

A world which is networked, especially one in which wireless communication dominates, offers some very interesting possibilities for distributed computing. Several of these have already been discussed, and one other trend of significance is development of the sensor web (Delin et al 2005). A sensor web is a collection of typically small, low cost sensor devices that communicate between each other or to one or more central servers. According to Delin et al the purpose of a sensor web is to extract knowledge which can be used to react intelligently and adapt to changing surroundings. Sensor web capabilities are useful in a diverse set of outdoor applications ranging from critical infrastructure protection, to at risk disaster management and crowd monitoring. They can form a sophisticated sensing mesh that can be draped over an environment allowing identification of anomalous or unexpected events. In this type of system only the sensor is in the area of study, all other components of a distributed system can be located on a network.

One of the key reasons for the success of the Internet has been its ability to overcome distance: typically you do not know whether the web site you are using is located in the same town or in another town half-way across the world. Francis Cairncross has written about what she calls the 'death of distance' caused by the Internet (Cairncross 2001). It is now clear that while the Internet has certainly changed the impact of geography on business, government, education, etc. it has certainly not rendered it irrelevant (see The Economist 2003 for a response to Cairncross' arguments). In fact in recent years there have been several attempts to link the virtual world of the Internet with the real geographic world. Some notable examples include:

- Geolocation – mapping the physical infrastructure of the Internet usually based on IP address (quova.com, digitalenvoy.com, netgeo.com). This has applications in advertising, e-commerce and security. The figure below shows geocoded IP address using Digital Envoy API's of users of ESRI ArcWeb Services.

- Reverse geolocation – finding Internet infrastructure based on a real world address, for example, the closet WiFi 'hotspot' (wifinder.com, hotspotlist.com)

- Geoparsing – a geographic text search engine for web documents that is able to find information on the web based on geographic filters (metacarta.com).

- Geocaching – a game that involves searching for objects listed on a web site using GPS (geocaching.com)

- Geoencryption – a technique that only allows decoding of encrypted documents in certain locations determined by GPS

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<Figure 4> geographic computing

REFERENCES

Cairncross F 2001 *The Death of Distance 2.0: How the communications revolution will change our lives* Harvard: Harvard Business School Press

Delin K A, Jackson S P, Johnson D W, Burleigh S C, Woodrow R R, McAuley J M, Dohm J M, Ip F, Ferré T P A, Rucker D F, Baker V R 2005Environmental Studies with the Sensor Web: Principles and Practice *Sensors* 5 103-117

Goodchild M F, Johnston D M, Maguire D J, Noronha V T (2004) Distributed and mobile computing. In McMaster RB, Usery E L (Eds) *A Research Agenda for Geographic Information Science*. Boca Raton: CRC Press, pp. 257–286

Li Chao, Maguire D J 2003 The handheld revolution: towards ubiquitous GIS. In Longley P A, Batty M (Eds) *The CASA Book of GIS*. ESRI Press, Redlands 193-210

Longley P A, Goodchild M F, Maguire D J, Rhind D W 2005 *Geographical Information Systems and Science.* Second Edition. John Wiley & Sons Inc, New York John Wiley & Sons Inc, New York 517 pp

Shiode, N, Li C, Batty M, Longley P, Maguire D J (2004) The impact and penetration of location-based services. In H. Karimi and A. Hammad (eds.), *Telegeoinformatics: Location Based Computing and Services*, London: Taylor and Francis

Spinney J E 2003 Mobile positioning and LBS applications *Geography* 88(4) 256-65

The Economist 2003 *The Revenge of Geography*. March

Steps Towards Realizing UbiGIS
The Relationship of GIS and Ubiquitous Computing

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1. UbiGIS – A short introction to Ubiquitous GI Services

Ubiquitous Computing (UbiComp, UC) is regarded as one of the coming long term trends in information technology (after Mainframe Computing, Personal Computing and the current Internet/Distributed Computing area). This term coined by Mark Weiser from XeroX Parc designates the pervasive use of computer services the possibility of the use of computer aided services as a ubiquity. Weiser envisions the pervasiveness of smallest, wireless connected computers, which are integrated into a multitude of objects of everyday life (Weiser 1991). Similarily scientists believe computers will be ubiquitous and globally connected so they will be regarded collectively as a single Global Universal Computer (GUC). Among others, the following items characterize Ubiquitous Computing:

- spontaneous networks, service description, service discovery
- wireless and mobile communication
- new man machine interfaces and interaction paradigms
- adaptation to context and situation (in particular localization)

The focus of this paper will in particular lay on the last items in the list, which have a fundamental relationship to GIS.

In the light of UbiComp, the relationship between spatial data infrastructures (SDI) and LBS becomes obvious: Both concepts support the access to GI services at any time at any place using different clients based on an infrastructure providing open interfaces. This desire for transparent access to computerized services independently of further restrictions is also one of the main objectives of UbiComp. As a broader topic behind all of this we suppose the following question: "How can we (GIScience) support the ubiquitous access to and use of the wide variety of geographic information and applications in an optimal way?" So the term "ubiquitous" extends the anywhere, anytime, to anyone approach of Location Based Services (LBS) to the paradigm: the "right" information at the "right" time the "right" way to the "right" person(s).

Through the rise of interoperable SDI and through the developments within the area of mobile computing and Human Computer Interaction, one can expect (or demand) that also GI services will be available ubiquitously to users in some future. For this the term *Ubiquitous Geographic Information Services = Ubiquitous GIS = UbiGIS* has been suggested (Zipf 2004, www.ubigis.org). This term may be defined as:

Pervasive services based on UbiComp technology and devices, supporting context dependent (i.e. adaptive) interaction, realized by information and functions of geographic information services based on interoperable SDI.

See Jiang and Zipf (2005a,b) for results of the first international workshop on UbiGIS.

We now want to discuss some of the aspects relevant to UbiGIS. These include

a) „Integration „as a major driving force behind it leading to integration of GI data and services into

b) interoperable spatial data infrastructures (SDI) as a fundament for syntactic integration of GI data and services,

c) the ongoing integration of computer ressources into a universal computing infrastructure – the GRID   and

d) work on semantic aspects of integration of data and services resulting in spatial ontologies.

After a short discussion of these technical and infrastrucure issues we need to discuss the other side of the coin: This includes the application and aggregation of basic GI services

built on top of the infrastructures mentioned into value added services for actual end users in a easy to use way. Enhancing ubiquitous usability with new types of pervasice interaction for situation aware services is the goal. This is regarded to be even more challing from a reseach perspective, as it includes soft and fuzzy aspects like cognition, interests, tasks and situation models etc. Examples of actual applications of adaptive GI services and new ways of interaction will be presented in the last section.

2. „Integration" as driving force for GI

A major trend that can be observed in many areas of IT is "Integration" (Reuter and Zipf 2005). Many research efforts are directed at integrating information and services from different domains and contexts. The success of XML and Web services is due to the strong momentum behind the idea of integration. Global ubiquitous computing will require deeply integrated facilities for locating devices, for navigation, and for many types of spatial referencing. These integration will be built on two technical infrastructures: SDI and GRID Computing.

2.1. The Technical Infrastructure   Spatial Data Infrastructures (SDI)

The current main effort regarding the integration of GI services and data is the development of spatial data infrastructures (SDI). From a simplified technical point of view, SDI can be seen as the provision of distributed GI services and geodata by means of web services using open standards. On the other hand mobile GI services offer location dependent GI functionality on handheld computers (e.g. for mapping, navigation, data acquisition etc.). This requires exactly such an infrastructure of GI services as a "wireless SDI". It is out of the scope o this paper to discuss the relevant organizational issues, but National Spatial Data Infrastructures (NSDI) are currently evolving in all parts of the world. This shall lead to a new quality of improved access to spatial data in the future.

2.2. Geospatial GRID Computing (GeoGRID) as future computing infrastructure

UbiGIS will be influenced by the development of new platforms, such as the GRID. The Next Generation GRID 2 report (NGG2 2004) contains a number of scenarios illustrating the need for sophisticated spatial referencing. The concept of Grid Computing (CG) put the simple way states that: computer processing power will be available ubiquitously the same

way as electricity, water or telephone. This shows the close relationship to UbiGIS. While there exist multiple definitions of the GRID (from Data GRID, Sensor GRID to ComputingCluster GRID etc.) Foster presents a Grid checklist by stating that a GRID

- coordinates resources that are not subject to centralized control
- uses standard, open, general purpose protocols and interfaces e.g. for authentication, authorization, resource discovery, and resource access etc.
- to deliver nontrivial qualities of service so that the utility of the combined system is significantly greater than that of the sum of its parts

So GRID Computing (GC) is a new concept for distributed high performance computing through a coordinated use of geographically distributed large virtual collections computation resources realized through use of computer clusters (apparently it should no be confused with the term "Grid" in the sense of data structure for GIS raster data). GC applications utilize high speed networks and a new generation of middleware linking network, computing resources and traditional geospatial applications. Tasks of the middleware include for example security and resource management. As the concept of CG also supports the aim to make high performance computer processing power available ubiquitously, just as other infrastructure, there is a clear relationship to Ubiquitous Computing, which is also highlighted in the NGG2‐report (NGG2 2004). Through the distribution of data, software and computing resources we find several aspects of GC related to GIS. In order to realize a Grid the use of standards and open protocols and interfaces is necessary which builds a bridge to the already mentioned activities of both the OGC and the development of SDI.

A scenario where all of this can easily be integrated would be the case of support for disaster management, that really brings together the vision of Ubiquitous Computing and Grid computing (NGG2 2004, Zipf 2004) with several clear relationships to GIScience and therefore realizes an ideal scenario for UbiGIS. First actual examples of GI application using GC technology as the Globus Toolkit middleware for spatial interpolation or wathershed modeling on raster data have already being presented (Wang et al. 2002). Also in 2002 started the TerraGrid project by the National Science Foundation (NSF).

2.3. Semantic Integration by Spatial Ontologies for UbiGIS

While we have disccussed some issues of integration through syntactic standardization of web services developing SDI based on OGC standards, a major problem in integration is the lack of true understanding of the information and services in question (Kuhn et al). This leads to the need for semantic modelling of all relevant resources. The dominant effort in this direction is the Semantic Web (Berners Lee et al. 2001). This is an extension of the current web in which information is given well defined meaning, better enabling computers and people to work in cooperation. In today's Web the representation of information is for processing by machines at the syntax level. The future Semantic Web, however, shall allow machines to process and reason at the semantic level. This shall be achieved through languages as the Web Ontology Language OWL, which builds on the Resource Description Framework (RDF) (Smith et al. 2003). OWL allows to define and instantiate ontologies in the sense of knowledge engineering, which are explicit formal descriptions of concepts or classes in a domain of discourse, which express a shared specification of a conceptualization. In contrast Ontology in philosophy refers to the "truth" prior to perception or language (Guarino 1998). OWL therefore provides the possibility to express information associated with people, events, devices, places, time, and space etc. Moreover, it provides means for sharing such context knowledge, thus minimizing the cost of sensing. Such ontologies then need to be integrated into the current major standardisation effort for GI services and data   the OGC open web services (OWS).

But there is also a further relationship between ontologies and UbiGIS. Ontologies are also needed to model the diverse aspects of the context of a situation. And this is relevant in order to provde context asware applications, e.g. adapted maps or tour planning etc. as explained later in the section on context aware and adaptive GI services. Seen from the perspective of ubiquitous computing, one can already find examples for draft ontologies (e.g. Chen 2004) identifying domains relevant for ubiquitous applications. The information about the environment can be (and has been) categorized in many ways, but an agreed on formalization is still missing. While first context aware systems have presented progress, improvements are still necessary for supporting knowledge sharing and context reasoning. Typically such UbiComp ontologies tend to include the following domains:

- Spatial Ontology
- Temporal Ontology
- Person Profile/User Model

- Event Ontology
- Device Profile
- Digital Document Model
- Security and Privacy Policy

The Spatial Ontology hereby describes physical space and spatial relations. Related ontologies include e.g.: DAML Space, OpenCyc, SUMO and the Region Connection Calculus (RCC). We are not surprised that modelling space is regarded as relevant for ubiquitous or pervasive computing. So the relationship between UbiComp and GI is bidirectional as both can benefit from the results of the other. While we agree that ontologies are necessary to model and represent semantic knowledge, the task to actually apply this semantic knowledge within an application still remains. There is still a lack of work in that direction. This usage of context information for adaptive UbiGIS applications will be discussed in the next chapters. We regard this as a major issue for future ubiquitous GI services (UbiGIS).

3. Context Aware adaptive GI Services

Until lately simply the position of a mobile device (and thus its user) was taken into account as parameter when developing LBS. But in UbiComp and in particular UbiGIS a more general approach is needed, taking into account the context of the overall situation. Thus the research area of *Context Aware Computing* has a strong influence on UbiGIS. Classical computer systems produce an output dependent on a certain input (black box). But if is it possible to include also further context elements (position as trivial example) apart from the explicit input of the user to parameterize a request, one can speak of context aware computing. Dey and Abowd characterize context as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant for the interaction between a user and an application, including the user and the application themselves.e" Therefore any information that is available at the time of an interaction can be considered as context information.

It is obvious that position is core for LBS as well as ubiquitous GI services. While we cannot discuss all relevant issues, we want to remind that also indoor positioning needs to be considered for UbiGIS. Quite some work has been done also in mobile computing,

leading also to location models that are not based on earth bound coordinate systems we are accustomed to in GIS. So UbiGIS needs to provide mappings between emerging ego centric or object centric location models or such based for example on network topology (see e.g. Beigel et al, Grossmann & Specht etc.) as depicted in figure 1 3 and conventional geographic or geodetic spatial reference systems. Applying these for example to intelligent positioning and navigation support include the combination of several approaches, which mutually improve or replace themselves in case of partial failure [Kray 02].
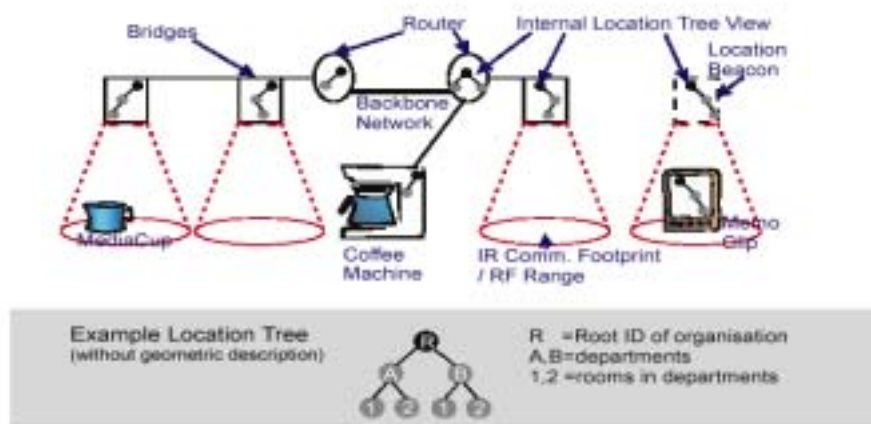
<Figure 1> Location models based on network topology
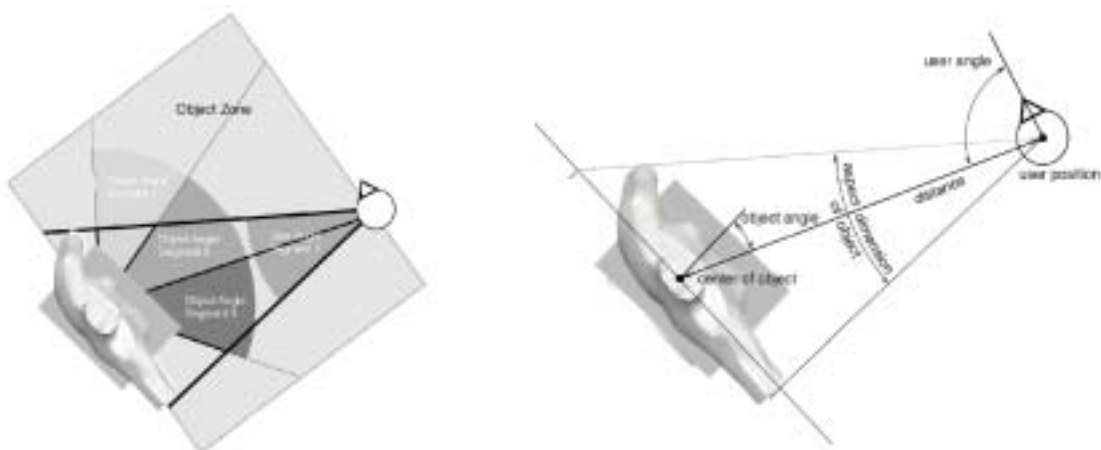
<Figure 2> Not geo centric but ego centric or object centric location models [Goßmann & Specht 02]

In GIScience first work on context awareness beyond pure location awareness has started recently in particular in the area of mobile maps (Meng, Reichenbacher und Zipf 2004, Zipf 2002), navigation support (Kray 2002) or wayfinding with landmarks (Winter et al. 2004). There are still a lot of open research questions in this area as formal specifications of most issues still are missing, as well as hints on the actual values of the different factors and how these influence the adaption of GI services.

But apart from the possibility to use context as parameter for adapting GI services, there is one even more important aspect to context what makes it important for the GIScience community to work on this issue in more detail: Context parameters are related to space! This is in fact sort of a corollary from Toblers First Law of Geography (Tobler 1970). According to Schmidt (2002) the following principles apply to context:

- Context has an origin location.
- The relevance of the context reaches its maximum at this origin
- The relevance of the context decreases with distance from that origin
- Exceeding a certain distance the context is no longer relevant
- If there are multiple identical sensors (for sensing context information) available, the one which is spatially most close has the highest relevance.

This relationship can be modelled by fuzzy function in space as depicted in figure 3. Generally this is not a constant and stationary shape, but can move (e.g. with the user) in time and space and may be distorted in a direction, e.g. where the user walks to. Furthermore there are usually a large range of context factors present which overlap in space. All of these principles apply not only to space, but also to time, resulting in a nice spatio temporal modelling task.

The adaptivity of GI services to context parameters inclduing aspects like task, interests and abilities of its users in addition to the physical parameters of the current environment can be seen as one of the next steps for GIScience research in order to achieve more intuitively usable GI systems. Conventional GIS did lack this concept completely so far.

Within this paper we only can present hints on what adaptation might be suitable for ubiquitous GI services. This list is derived from first results regarding adaptive mobile GI services in our projects. We have identified the following categories for possibilities for

adaptation with regard to GI:

- adaptation of the visual presentation of the contents offered – both of the text and the graphic information (pictures, maps, video, VR models.).

- adaptation of route planning (by individual weighting and restrictions)

- adaptation of retrieval queries (combined location and interest based tips)

- adaptation of the offered contents (e.g. concerning detailedness, topic).
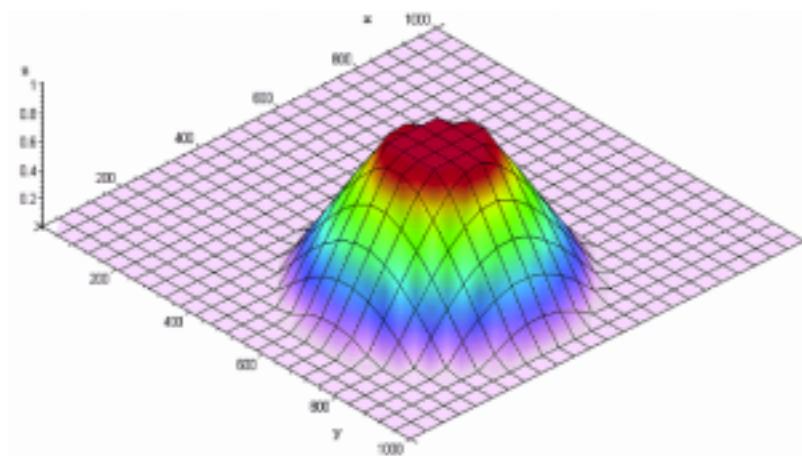
<Figure 3> Modelling Spatial Relevance with Fuzzy Functions (Schmidt 2002).

The adaptation of cartographic representations appears to be of particular interest, since interactive maps are used in a multitude of mobile applications. Further examples for adaptive GI applications include e.g. the computation of routes based on context related criteria (Zipf & Röther 2000, Jöst & Stille 2003) or user aware spatial push of information (Zipf and Aras 2002).

Regarding adaptation of the visual presentation within maps, it has become more and more accepted, that the design of such maps needs to consider a broad range of parameters in order to present the right information needed in the current situation (Zipf 2000,2002, Meng et al 2005). After focusing on technical limitations of mobile devices (storage, processing, interaction, display size, bandwidth etc.) the focus of research in mobile maps shifted recently to cognitive aspects, e.g. navigation and wayfinding support. In order to actually apply such ideas on adaptive maps to an automated system we need to consider three different main aspects:

- What are the indicators influencing the design of a map (which attributed describing the current task, user, situation etc. – we can refer to this as the *User Model* and *Context Model*. They (are sometimes combined) and deliver the structure and possible value domains describing the situation.

- How do these attributes actually influence the design of the map? For answering this we need to components: a.) knowledge about cognitive aspects how to present which information the best way to the user and b.) a mathematical or computational framework for actually applying this within a computerized system – telling how to calculate the values for the weighting the adaptation etc.

- A technical framework how to apply this in a standards based open system.

As an example a short overview on how to model the user within such an adaptive map based system is given. An ontology based approach is proposed for adaptive GI services employing different machine learning methods based on stereotype reasoning, domain inference etc. in order to calculate dynamic user properties. These user properties for example include the current interest of the user in specific types of objects. Zipf and Jöst (2005) present a XML schema (see figure) for a user model that also includes demographic attributes and account data. The most important property is the *interest* of the user modelled as "*UMInterest*". This is described by name, description and further type definition. The UMConfidence property stores the probabilities (individual and normalized over all users) calculated by a software module, that calculates individual user preferences and their probabilities dynamically from the different data sources, as well as the algorithm used for this. This gives a measure for the validity of the calculated interest values. Storing this explicitly allows taking them into account when applying the interest values for adapting a service offered to the user.

4. UbiGIS User Interaction   Multimodal Communication with the user

The previous example on map interaction leads us to the question on how to improve communication between a cumputer system and user about geographic phenomena. The more general research area here is the area of Human Computer Interaction (HCI), but not solely interaction and presentations issues need to be covered, but again the question of semantics. As an example Worboys (2001) examined the – more general – question on

semantic equivalence of different types of representations of geospatial information. He stressed the importance to research on how to handle and communicate the "content" of geographic information rather than "syntax" or "quantity" from the perspective of the theory of information flow (Dretske, Barwise, Seligman etc.). He has proposed the application of this theory to spatial phenomena – including accuracy and precision, issuing a range of questions that need to be addressed in future GIScience research like: how to determine the informational content of a spatial dataset or comparing two spatial data sets with each other, including data quality issues and vagueness and supporting multiple representations (e.g. graphic and linguistic) of equivalent information content and reasoning based on these.
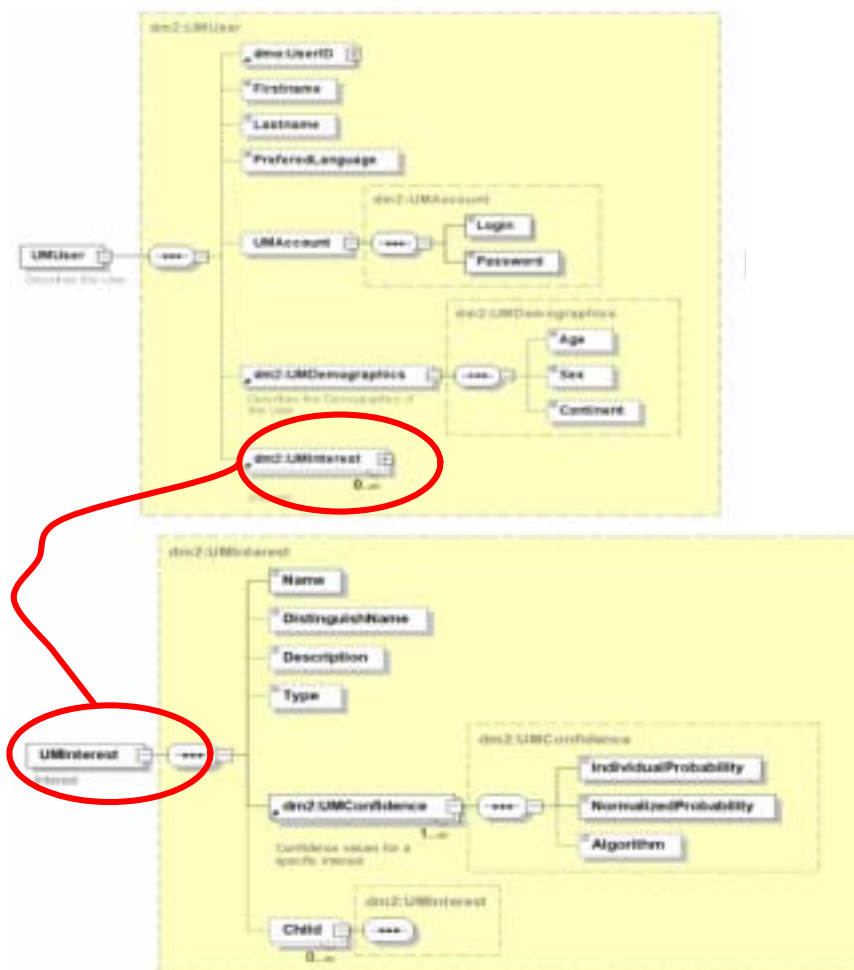
<Figure 4> User Model User & UMInterest XML Schema including confidence elements [Zipf and Joest 2005]

Within UbiGIS in particular we increasingly have the need to cover multiple representations of spatial information and on multiple devices with multiple modalities including new interaction paradigms. So the issue of suitable "presentation" (in contrast to internal "representation") of the spatial information to the user to support understanding and ease of use arises. This deals with personalised, contextualized and multidimensional representations (first of all visualization) as well as multi modal interaction with geospatial information.

While research on supporting personalization and contextualization has only recently become an issue for GIScience, work on multi modal interaction with has already been conducted by Oviatt etc. For example Egenhofer and Schlaisisch investigate an interaction method that mimics the natural communication between people. "Natural communication" includes here the combination of talking and sketching apart from traditional interaction methods. Other examples analyze the interaction with GIS on wall scale displays or tangible interfaces. The early work was mostly conceptual or empirical due to the limitations of technology at that time, but with the recent technical progress it becomes possible to actually develop such systems. This allows testing hypotheses, as well as developing new ones and evaluating these with actual systems. This is certainly a step where we needs to go, as a lot of questions on how to support situated interaction with multiple modalities for easing the use of geographical information are still open, lacking both a sound theoretical as well as an empirical underpinning.
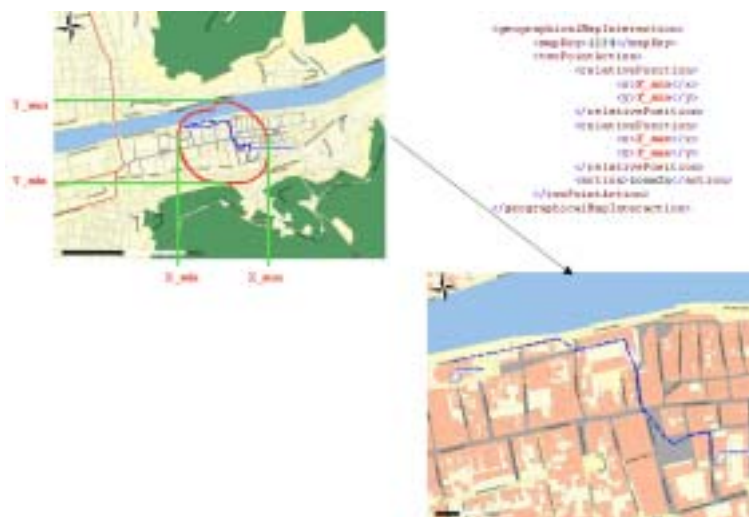
<Figure 5> Spatial interaction with guestures on mobile devices
(Zipf & Häussler 2004).

A dominant factor for adaptation is the task the user wants to perform. Also here we need formal models to describe these within a computer system. See figure 3 for a recent example of a task ontology that has been developed by Jöst and Zipf 2005 extending the ideas of Reichenbacher (2002).
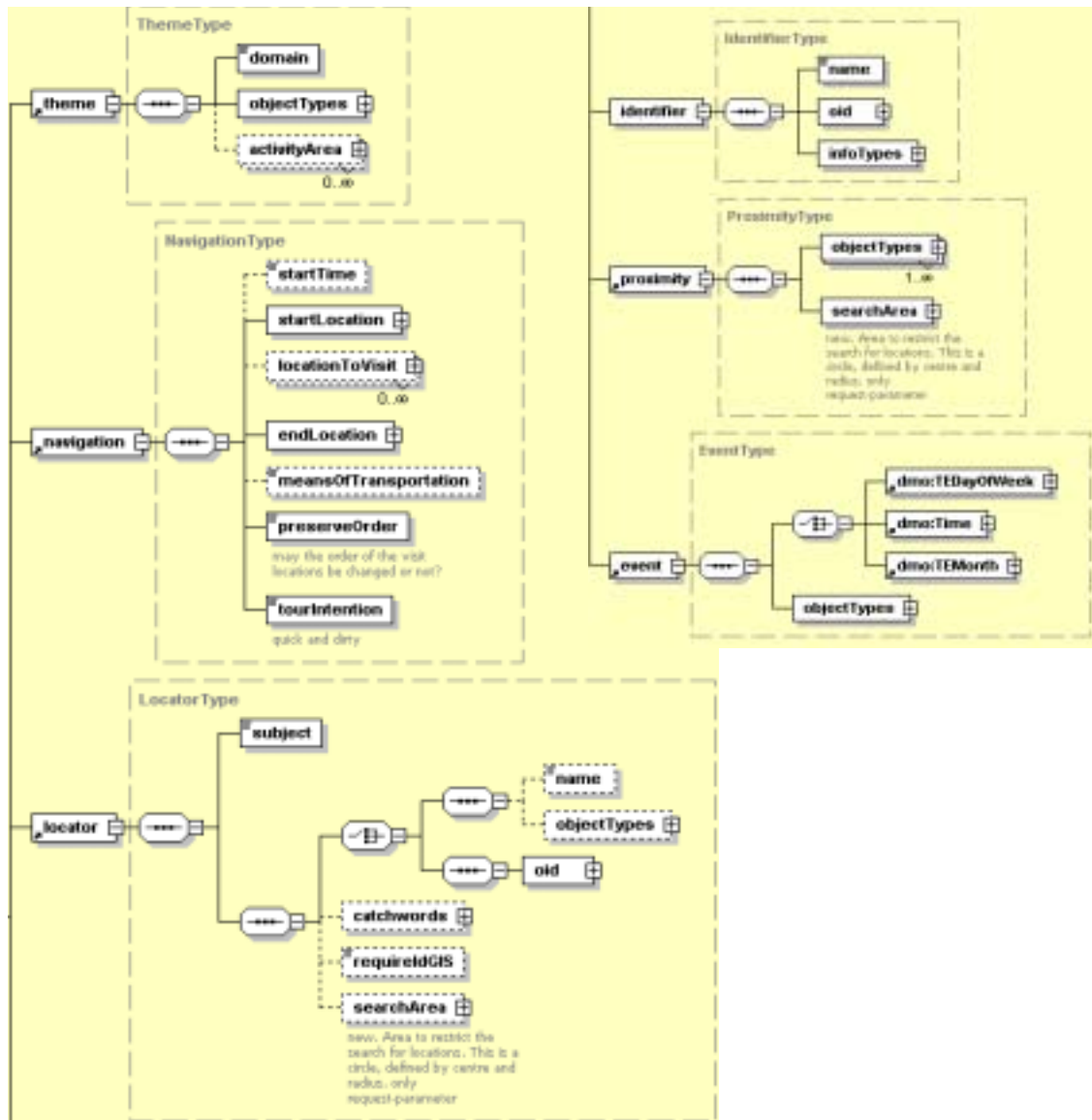
<Figure 6> Extract of XML schema of the "MapTask" model (extending work by Reichenbacher 2002).

5. Summary and Outlook

The vision of UbiGIS requires more than an infrastructure for wireless communication and data access, but also aims for user friendliness through context adaptation and pervasive interaction. If this come true, it will be possible to utilize GI services from everywhere without need to care for computer locations or networks. In order to realize the possibilities outlined, still various research questions need to be solved, of which we could only mention a small selection.

For example we neglected the broad range of questions regarding the usage of new sensors from "Smart Dust" to "Intelligent Rooms" (see figure) for sensing all kinds of context information. Conventional sensors in the context of GI comprise those build for measuring environmental data (remote sensing being the most prominent example), but recently networks of stationary or mobile sensors for heterogeneous parameters come into the attention due to their increasing availability. Therefore researchers and also the OGC deal with the interoperable integration of sensors through the OGC Sensor Web Enablement initiative. Apart from this classical view, location aware sensors for whatever parameters constitute important elements for both context awareness and personalization within UbiComp. Through the availability of such new sensors the development of adaptive applications becomes possible. Such a location aware interoperable sensor infrastructure even is important for non GI applications, because of the relation between space and context as outlined above. Recently these sensors are extended with basic processing and communication capabilities. See figure 5 as an example for "building an instance of a ubiquitous computer" .

When we now envisage such large future networks of sensors delivering masses of data all the time (again Remote Sensing as primary example) we are faced with the problem to be able to analyse these masses of distributed data sources for interesting pattern, which leads us to another area of computer science research: that of GRID computing being covered in the next section.

Besides technical questions a range of social issues need to be examined in which we could not dig into, e.g. concerning acceptance, privacy, data security and social consequences. (e.g. Dobson and Fisher 2003). For example it is often claimed, that the acquisition of personal and context information needs to be open to the end user, which is in fact seldom realized. This means that the user always should have full knowledge and control over the data that is being collected and that only authorised persons and systems

can access these.

<Figure 7> A Ubiquitous Computing environment (MobileHCl 2003)

REFERENCES

Barwise J. and Seligman J.: Information Flow. Cambridge University Press, Cambridge, England, 1997.

Berners Lee T, J Hendler, and O. Lassila. The semantic web. Scientific American, may 2001.

Beigl, M., Zimmer T., C. Decker: A Location Model for Communicating and Processing of Context, Personal and Ubiquitous Computing Vol. 6 Issue 5 6, pp. 341 357, ISSN 1617 4909, 2002

Beigl et al. (eds): Proceedings of the Workshop on Location Modeling for Ubiquitous Computing, September 30, Atlanta, Georgia, 2001.

Chen, H. (2004): SOUPA Standard Ontology for Ubiquitous and Pervasive Applications. http://pervasive.semanticweb.org/

Dey, A. K.. Providing Architectural Support for Building Context Aware Applications. PhD thesis, Georgia Institute of Technology, 2000.

Dobson, J. E., and P. F. Fisher (2003): Geoslavery, IEEE Technology and Society Magazine 22(1): 47 52.

Egenhofer, M.: Toward the Semantic Geospatial Web. ACM GIS 2002, McLean, A. Voisard and S. C. Chen (eds.), November 2002.

Ferriera, J. S., A. Câmara, E. Nobre; I. Franco,(2004): Tangible Interfaces for visualization of geographic data in collaborative environments. In: Jiang, B. and Zipf, A.(guest eds.) (2005): Secial issue on "LBS and ubiquitous GIS". The Journal of Geographic Information Sciences. CPGIS. Berkeley. California.

Gossmann J. and Specht, M. (2001): Location Models for Augmented Environments. In: Beigl et al. (eds): Proceedings of the Workshop on Location Modeling for Ubiquitous Computing, September 30, Atlanta, Georgia, 2001.

Guarino, N., 1998: Formal Ontology and Information Systems. In: Guarino, N. (Ed.), 1st International Conference on Formal Ontology in Information Systems. IOS Press, Trento, Italy, pp. 3 15.

Häußler, J.; Jöst, M. and Zipf, A. (2003): GIS Support for Multi Modal Mobile Map Interaction. Poster: COSIT 2003. Conference on Spatial Information Theory. 24 28 September, 2003. Ittingen, Switzerland.

Hornsby J. Florence, K., and Egenhofer M. 1996 The GIS WallBoard: Interactions with Spatial Information on Large Scale Displays Seventh International Symposium on Spatial Data Handling (SDH '96), Delft, The Netherlands. M. J. Kraak and M. Molenaar (eds.), pp. 8A.1 15.

Jiang, B. and Zipf, A.(guest eds.) (2005a): Secial issue on "LBS and ubiquitous GIS". The Journal of Geographic Information Sciences. CPGIS. Berkeley. California.

Jiang, B. and Zipf, A.(guest eds.) (2005b in press): Secial issue on "LBS and ubiquitous GIS". CEUS, Computers, Environment and Urban Systems. An International Journal. Pegamon Press, Elsevier. To appear.

Kray C. 2003: Situated Interaction on Spatial Topics. PhD. thesis, DISKI series vol. 274, AKA Verlag, Berlin, 2003.

Kuhn 2000: How to produce ontologies. In: Winter, S. (Ed.), 2000: Geographical Domain and Geographical Information Systems. Proceedings of the EuroConference on Ontology and Epistemology for Spatial Data Standards, France. GeoInfo Series Vol. 19, Institute for Geoinformation, Technical University Vienna, Austria.

Meng, L., Zipf, A,. and Reichenbacher, T. (eds.) (2005): Map based mobile services –

Theories, Methods and Implementations. Springer Geosciences. Springer GeoScience. Heidelberg.

NGG2: Next Generation Grids Report, final report by EU expert group on next generation grids, June 2004, available via www.cordis.lu.

Oviatt S.L., Multimodal interfaces for dynamic interactive maps, in Proceedings of Conference on Human Factors in Computing Systems: CHI, 95 102, 1996.

Reichenbacher, T., Angsüsser, St. & Meng, L. (2002): Mobile Kartographie eine offene Diskussion. In: Kartographische Nachrichten, 52. Jg., H.4. Bonn, Kirschbaum, 2002: 164 166.

Reuter, A. and Zipf, A. (2005 in print): Geographic Information Science Where Next? In: Wilson, J.P. and Fotheringham S. (eds.): Handbook to GIS. Blackwell Publishers.

Schmidt, A. 2002: Ubiquitous Computing – Computing in Context. PhD Thesis, Computing Department, Lancaster University, U.K.

Smith M. K, C. Welty, and D. McGuinness. Owl web ontology language guide. http://www.w3.org/TR/owl guide/, 2003.

Schlaisich I. and Egenhofer M. Multimodal Spatial Querying: What People Sketch and Talk About. 1st International Conference on Universal Access in Human Computer Interaction, New Orleans, LA, C. Stephanidis (ed.), pp. 732 736, August 2001.

Schilit B., A. Norman, and W. Roy. Context aware computing applications. In IEEE Workshop on Mobile Computing Systems and Applications, Santa Cruz, CA, US, 1994.

Tobler, W.R., 1970. A computer movie: simulation of population change in the Detroit region. Economic Geography 46: 234 240.

Wang S., M. P. Armstrong, and D. A. Bennett (2002): Conceptual Basics of Middleware Design to Support Grid Computing of Geographic Information.

Weiser, M. (1991): The Computer for the Twenty First Century. Scientific American. September 1991. pp. 94 104.

Winter, S., Raubal, M. and Nothegger, C. (forthcoming 2004): Focalizing Measures of Salience for Route Directions. Springer (Publisher), A. Zipf, L. Meng and T. Reichenbacher (Editor/s). Map based mobile services – Theories, Methods and Implementations, Berlin.

Worboys M. F. (2001): Communicating geographic information in context.

Zipf, A. and Aras, H. (2002): Proactive Exploitation of the Spatial Context in LBS through Interoperable Integration of GIS Services with a Multi Agent System (MAS). AGILE 2002. Int. Conf. on Geographic Information Science of the

Association of Geographic Information Laboratories in Europe (AGILE). Palma. Spain.

Zipf, A. (2002): User Adaptive Maps for Location Based Services (LBS) for Tourism. In: K. Woeber, A. Frew, M. Hitz (eds.), Proc. of the 9th Int. Conf. for Information and Communication Technologies in Tourism, ENTER 2002. Innsbruck, Austria. Springer Verlag, Computer Science Series, Heidelberg.

Zipf, A and Jöst, M. (2005 in press): Implementing Adaptive Mobile GI Services based on Ontologies Examples for pedestrian navigation support. In: CEUS Computers, Environment and Urban Systems An International Journal. Special Issue on LBS and UbiGIS. Pegamon Press, Elsevier.

Zipf, A. and Häußler, J. (2004): An Evaluation of the OpenLS Specifications for multi modal mobile applications. In: The Journal of Geographic Information Sciences. Special Issue on LBS and UbiGIS. CPGIS. Berkeley. California. Vol.10, No2. December 2004. pp. 117 127.

Zipf, A. (1998): DEEP MAP A prototype context sensitive tourism information system for the city of Heidelberg. In: Proc. of GIS Planet 98, Lisbon, Portugal.

Geographic Context Awareness in Ubiquitous Computing Environment

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Abstract

Recent progress of the technologies on wireless communication and mobile devicesresults in a fundamental change of computing environment and emergence of a new computing paradigm called ubiquitous computing. It is expected that dramatic changes on geographic information systems would take place due to this new computing environment. Geographic information systems will play an important role for completing it as well. In this paper, we will investigate the relationship between geographic information systems and ubiquitous computing. In particular, the requirements of ubiquitous computing to geographic information systems will be analyzed in terms of geographic context awareness. And the difficulties and methods to provide geographic context awareness will be presented in this paper.

1. Introduction

The evolution of computing environment is composed of several generations. The first generation can be described as the era of mainframe that contains most of functions and components in a machine. In 1980s, the second generation arrived thanks to the advent of PCs, which dramatically changed the computing environment. PC has widened the use of computers to our daily life. The internet in the third generation from 1990s allows us to access and share the information spread over all computers in the world from PCs to

mainframes. Recent advances on wireless communication and mobile computing provide a new age of computing environment, *the fifth generation computing*, which Dr. Weiser called *ubiquitous computing* [2] in 1993. Ubiquitous computing environment differs from the precedent computing environments in several aspects.

- First, mobility is the essential property of ubiquitous computing. Although some devices in ubiquitous computing environment are stationary, most of devices are mobile.

- The second difference lies in wireless communication of ubiquitous computing, where several types of wireless communicationare possible and more than a type of wireless communication media may be employed at a same time for an application of ubiquitous computing.

- Third, mobile devices of ubiquitous computing are tiny in most cases. The energy supply is limited, the size of memory is small and computing power is limited as well as the communication speed.

- In ubiquitous computing environment, the scalability is a very important requirement. The number of devices in ubiquitous computing is in general very large like telematics application, where the number of nodes is greater than the number of vehicles. For example, more than three millions vehicles are in Seoul. Suppose that one vehicle send their location information to a server per every 10 seconds, the server must process each location report within 1/3 10-6 second, which is a nearly impossible requirement.

- The fifth important aspect of ubiquitous computing is related with the context-awareness of mobile nodes. Each mobile node gathers its environmental information such as temperature, humidity, location, and velocity, etc. to trigger proper reactions and to provide augmented reality.

- The last important requirement of ubiquitous computing is to provide the above functions in real-time. In fact, it is difficult to meet this real-time constraintdue to the limit of wireless communication, the tiny hardware and scalability problem.

Among these aspects, the mobility and context-awareness are directly related with geographic information systems. In order to realize the mobility of devices, we need to provide several functions, and the location-awareness is the most important one as pointed

out by Prof. Imielinski [3], who is a leading researcher of ubiquitous computing. Each mobile device should be always aware of its location. He considered location and time information as so-called first class citizen data in ubiquitous computing environments [4]. The location awareness does not only include the location data itself but also useful information derived and extracted from its past and current location data, and other related information. For example, the trajectory data of vehicles is very useful in analyzing and planning traffic control.

The context-awareness of ubiquitous computing does not imply only location-awareness but contains more broad sense. It means that each mobile device should be aware of its environment information, in addition to its location data, including its geographic context. For example, avehicle moving along a street should be aware of its current location and the geographic information around the vehicle, such as the distance to the first gas station along the street, the three nearest restaurants as well. We call this kind of environment information *Geographic Context.*

The mobility and geographic context-awareness are difficult to implement by conventional approaches. In particular, the mobility and tiny hardware of device make it further difficult to realize these requirements by traditional methodologies and architectures of geographic information systems. For example, it is nearly impossible to store a large amount of geographic data and carry out a complex spatial analysis within a tiny device. Consequently, novel approaches and architectures are required to realize geographic context awareness and eventually ubiquitous computing.

In this paper, we will investigate requirements of geographic information systems for ubiquitous computing. In particular we will introduce the concept of geographic context and present problems and methods to implement geographic context awareness in ubiquitous computing environments.

2. Evolution of Geographic Information Systems

In order to understand the relation between ubiquitous computing and geographic information systems, we need to give a glance on the evolution of geographic information systems, which can be classified as follows,

- 1st Generation: monolithic system architecture
- 2nd Generation: separation of DBMS from GIS

- 3rd Generation: distributed environment via middleware
- 4th Generation: web environments
- 5th Generation: ubiquitous environments

2.1. the First Generation: Monolithic System Architecture

The first generation of GIS covers the 1970s and 1980s, the era of first GIS since the Canadian Geographic Information System [5]. In this generation, GIS had been first developed to meet industrial and social demands as independent applications. For this reason, the architecture and development methodologies of GIS were relatively primitive without integration of other computing technologies, such as data base technology and the system architectures of GIS were monolithic in a sense that every function required by users was built in a single system.

2.2. the Second Generation: Separation of DBMS from GIS

The progress of DBMS technologies in 1980s had greatly influenced on GIS that the distinction between GIS and databases was made and first introduced. Several GIS in the late 1980s and early 1990 were developed on the top of commercial DBMS.GIS has been no more a huge monolithic system from this generation and geographic data becomes an independent part of GIS. This implies an important progress of GIS that the databases of GIS can be independently built, managed and shared by several GIS. It leads GIS to the distributed environment of the third generation.

2.3. the Third Generation: Distributed Environment

As mentioned in the previous subsection, it seems that the separation between the second and third generations of GIS is unclear and the transition was made in a progressive manner. But the third generation of GIS differs from the precedent generation in several points. First, the producer and consumer of geographic information have become different. The progress of technologies in the late 1980 and early 1990 on distributed systems apparently affected the transition from the second to the third generation. In distributed environment, the provider of data, server and client became separated systems on one hand and they incorporate via middleware on the other hand. Second, the transferof geographic data, the standardization, and interoperability have become hot issues from the third generation for this reason. This trend becomes more evident in the late 1990s due to the

advance on distributed component technology.

2.4. the Fourth Generation: Web Environment

The advent of internet computing since the 1990s has fundamentally changed the computing environments and greatly influenced on GIS. The distributed environments become mature by meansof Web technology. Via a standard environment of Web, we can provide and access any kind of information at any place where the internet is accessible. The simplicity of Web interface extended the user of GIS to simple and naïve users, and brought GIS to our daily life, while the users of GIS to the former generation were limited and specialized.

2.5. the Fifth Generation: Mobile and Ubiquitous Environments

With the rapid progress of mobile and wireless communication environment since the late 1990s, the area of GIS application is being extended. For example, cellular phone becomes a portable device of GIS by its wireless communication and increasing capability of memory and computing. This trend can be regarded as a perfection of distributed environmentand web GIS of the third and fourth generations, since it provides a massively distributed environment and web environments become smaller and broader. The mobility of small devices with wireless communication like cellular phones allows user to access to GIS with its own data or data of other systems. Furthermore the sensor technology including position sensor like GPS and RTLS provides so-call augmented reality. These trends and progress constitute a basis of ubiquitous computing environment. In ubiquitous computing environment, GIS will be no longer a set of functions provided by a single or limited number of machines but a set of small and massively distributed systems, where each small system will be capable of capturing its environmental information, communicating with other systems and performing tasks with the collaboration of other tiny systems.

3. Location-Awareness and Handling Location Data

Dr. Mark Weiser, who firstly introduced the concept of ubiquitous computing, pointed out that the most important aspect of ubiquitous computing is nomadic property. In other words, each computing node should be capable of moving and communicating with other nodes via wireless network. Several functions are indispensable to provide mobility, among which the location-awareness is one of the most important ones.

Since 1990s, a number of sensors and equipments have been developed such as GPS and RTLS to gather the location of mobile nodes and the accuracy of these sensors has been improved. However the currentlocation sensor techniques have several important problems. In this section, we will summarize the problems and investigate the methods to overcome these obstacles. The limits are

- difficulty of capturing indoor location,
- discrete input of location data, and
- scalability problem

While most current positioning techniques such as GPS aim at outdoor environments, a number of applications of ubiquitous computing need indoor positioning as well as outdoor positioning. For example, we need to get the level information in a building in addition to two dimensional data. Due to many obstacles and visibility problem, positioning technology for indoor environment still stay in an immature stage and several methods are being developed.

The second problem of the current positioning technology is the discrete inputs of position data. If the speed of mobile objects is relatively slow or relative positions between mobile objects are rarely used, it would be not a substantial problem. But in the case where the speed is high and the relative position is important, the discrete inputs may cause serious problems. In particular, it becomes an important problem if the local clocks of mobile devices are different as shown by figure 1.
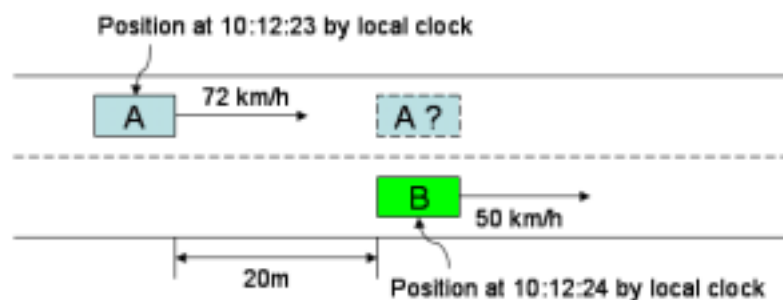
<Figure 1> Discrete inputs of location and time data

Suppose that we want to know the distance between A and B at a given time such as 10:12:24 in figure 1, where the location data are gathered at different times. In this case, the distance between two mobile objects may be inaccurate, since the location of A was captured at one second earlier than B. In order to get the current location data of A, only the prediction of location for Ais possible instead of capturing the real data. Most prediction methods assume the linear movement of mobile objects, which is often incorrect for several reasons like non-linearity of streets. Furthermore, the prediction becomes more inaccurate if the local clocks of A and B are not exactly synchronized. For example, we are not sure that the location at A has been acquired one second ago if the local clocks of mobile devices are synchronized. Since the position of mobile device is determined as a function of time, the temporal information should be accurate if we want to get accurate position data.

A simple way to overcome the discrete property of location data is to increase the frequency of gathering location data. But it may dramatically increase the load of server and communication overhead and result in an important degradation of performance, if the number of mobile devices is large.

While the first and second problems of location-awareness are related with positioning techniques, the third problem, scalability, concerns how to handle location data. Once the location data is acquired from mobile devices, they should be sent to other devices or server to handle and analyze location data for extract useful information. However, the large number of mobile devices results in the scalability problem of ubiquitous computing. The transmission cost of location data to the server via wireless network and processing cost at the server are so expensive that the centralized approach would be no longer feasible for ubiquitous computing. Instead, fully distributed approaches such as broadcasting, sensor network or P2P look more promising. Several researches havebeen done for these approaches since 2000′s.

4. Geographic Context Awareness

In this section, we will introduce the concept of geographical context-awareness, which is a kind of context-awareness of ubiquitous computing and plays a key role in integrating geographic information systems and ubiquitous computing.

4.1. Ubiquitous Computing and Geographic Context-Awareness

The context-awareness of ubiquitous computing environments aims at the adaptation to dynamic changes of environments. If no change occurs in the environment of mobile device, context-awareness would be meaningless. The changes of environment take place due to two reasons,

- changes of environments, and
- changes of location of mobile device itself.

The first type of changes is caused by changes of external context such as drops of temperature. However the second type is due to the movement, although the external environments remain constant. The first type of changes is gathered by sensors, while thesecond type of changes is determined by the current location and the geographic information around the current position. For this reason, the context changing by the movement of mobile nodes can be considered as geographic context. For example, the location information of the nearest gas station on high way to my car is a geographic context. While map data may be a typical type of geographic context, any kind of geographic information can be used to provide geographic context. And the context-awareness forthe second type of change is called geographic context-awareness in this paper.

4.2. Requirements for Implementing Geographic Context-Awareness

The most simple and naïveway to implement geographic context-awareness is to store the entire geographic information on the region where mobile devices will possibly move. Due to the hardware limitations of mobile devices, this approach is almost infeasible. For example, it may be possible to store a small fraction of a map on a country, but the entire map is too huge to be stored in a tiny mobile device. Consequently, the following constraints of mobile device should be carefully taken into account when we implement geographic context-awareness.

- communication overhead,
- hardware constraints of mobile device such as size of memory,

- egocentric mapping, and
- heterogeneous environment.

4.3. How to get Geographic Context Information?

In this subsection, we will present several methods to get geographic contextual information introduced in the precedent section. In general the contextual information of a mobile node in ubiquitous computing can be acquired from

- sensors,
- labels, or
- other nodes

Sensors are the most typical way of gathering contextual information in ubiquitous computing environments. For example, temperature data can be easily taken by sensors. GPS belongs to this category to get location context data. Labels are the second method to acquire contextual information. The last method to acquire contextual information is to request other nodes.

RFID is a typical method to realize label. A small amount of geographic data such as UFID(Unique Feature Identifier) or location information can be easily stored in a RFID. Although simple geographic information can be provided by labels, complex and large amount of geographic contextual information cannot be stored in a small label. In this case, two alternatives are possible as follows,

- server or other mobile nodes provide geographic contextual information, or
- find geographic information by in-network query processing

Providing Geographic Context Information from Servers or other Mobile Nodes

The first method to provide geographic contextual information is to get it from a server or other mobile nodes. As mentioned in the precedent subsection, a scalability problem

arises if a centralized server provides such information to every node in real-time. Instead, two alternatives have been paid attention to overcome the scalability problem, which are a massive distribution of geographic context information to every small mobile devices and periodically broadcasting it to mobile nodes

Each node in massively distributed environment manages a small fraction of geographic context concerning its own environment for ubiquitous computing and sends it to its neighbor nodes in case of demands. For example, each vehicle on a road has its velocity data along the streets it has passed through, and it sends this data to other vehicles on their demands. If there is no vehicle found around a given vehicle having useful geographic contextual information or too many vehicles are around it, then a more complicated searching mechanism is required to find the vehicle that contains the useful information. This mechanism will be explained in the next subsection.

While a centralized server may cause the scalability problem, broadcasting method is a promising approach to achieve the scalability even though it also relies on a centralized server. The server storing geographic contextual information periodically broadcasts it to mobile devices without causing scalability problem. Then each mobile device takes only its interesting information from the entire broadcasted data. For example, a broadcasting server transmits traffic information to all vehicles within the coverage area and each vehicle extracts only the traffic information around it.

This approach provides a high degree of scalability but has some weak points that the direction of transmission is one-way and the bandwidth of communication is relatively limited. To overcome this weakness, several hybrid methods are being studied, such as spawn protocol [8].

In-Network Query Processing

We can provide geographic contextual information by integrating distributed data over mobile devices and analyzing them as well as by stored data in a server. For example, we want to know the average temperature in a region where a number of mobile sensors are installed. Then we first gather the temperature data from the sensor nodes in the region and second calculate the average. This kind of operations requires the data from several devices and integration of data via wireless network. We call this type of operation in-network query processing, which handles of data spread over a number of devices connected via wireless network, instead of data stored in a centralized server.

Another type of in-network query processing is to find the node having useful information. For example, if we want to find the nearest ambulance to an accident place, we do not know the node with the information on the nearestambulance. In general, we first select a set of candidate mobile nodes by forwarding the query message to the neighbor nodes till this message will be arrived at the query region and second we examine the candidate nodes with care to find the nearest ambulance. The first step of processing is called routing phase, while the second step is called refinement phase. The performance of in-network query processing is mainly determined by the routing phase rather than the refinement phase.

In-network query processing often assumes ad-hoc network, which does not require the infrastructure network or P2P environment, where each node possesses an IP address on an infrastructure network. A number of researches have been done for in-network query processing for ad-hoc network or P2P environments. Unfortunately, few researches on in-network spatial or geographic query processing are found.

5. Conclusion

Ubiquitous computing technology is under a rapid progress with significant advance of wireless communication and mobile device since 2000′s. Its influence on computing environment is so profound that it is often considered as a paradigm shift. Geographic information systems are also under the influence of ubiquitous computing technologies and contribute to the development of ubiquitous computing at the same time. Geographic information systems provide location-awareness and geographic context-awareness, which is the most important contribution to ubiquitous computing. While a number of researches have been done for providing location-awareness, geographic context-awareness has been almost ignored despite its importance. In this paper, we investigated the relationship between ubiquitous computing and geographic information systems and introduced the concept of geographic context-awareness and presented the requirements for implementing geographic context-awareness.

Ubiquitous computing is still on the first stage of development and has a lot of issues and challenges to stabilize the techniques. Consequently the relation between ubiquitous computing and geographic information systems is still dynamic and unstable. But it looks obvious that geographic information systems will play a key role to completing ubiquitous computing.

References

Ronald Azuma, "Tracking requirements for Augmented Reality", Communications of the ACM Vol.36, No.7, pp.50-51

Mark Weiser, "The Computer for the 21-th Century", Scientific American, Vol.265, No.3, pp.94-104

Tomasz Imielinski, Badri Nath, "Querying in highly mobile distributed environments", Proc. VLDB 1992, pp.41-52

Tomasz Imielinski, Badri Nath, "Wireless Graffiti-Data, data everywhere", Proc. VLDB 2002, pp.9-19

Roger Tomlinson, "The Canada Geographic Information System" in *The History of Geographic Information Systems*, ed. By Timothy W. Foresman, Prentice-Hall PTR, 1998

Mark Weiser, "Nomadic Issues in Ubiquitous Computing", in http://www.ubiq.com/hypertext/weiser/NomadicInteractive/

Kris Pister, "Smart Dust", in http://robotics.eecs.berkeley.edu/~pister/SmartDust/

Shirshanka Das, Alok Nandan, and Giovanni Pau, "SPAWN: A Swarming Protocol For Vehicular Ad-Hoc Wireless Networks", in Proc. VANT 2004

Ubiquitous GIS for Hydrogeologic Fieldwork: A Case for Self-Improving Spatial Databases

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ABSTRACT

While ubiquitous computing is becoming closer to a reality in many urban environments, ubiquitous computing to support the natural sciences presents unique challenges. Foremost among these is the seamless integration of data collected at very local scales and used to create analyses at much broader synoptic scales. This paper examines the issues around supporting hydrologic fieldwork with an object oriented approach to storing and manipulating continuous fields like representations of natural phenomena. A prototype database query tool that incorporates automated model simplification is presented.

Key Words: Spatial Databases, Ubiquitous Computing, Environmental Modelling, Spatial Objects and Fields

1. Introduction

Currently the meaning of ubiquitous computing is being constantly extended to accommodate the technology we use to connect and control the things around us. Weiser (1991) emphasized that the goal of ubiquitous computing is to enhance computer use by making many computers available throughout the physical environment, at the same time

making them effectively invisible to the user. According to Huber and Huber (2002), there are two ways that we can be supported by computers wherever we go. One is that computers are embedded in everything around us. The other is that we carry a device or tool that can communicate with any other computer, chip, and sensor in the network.

These approaches are usually designed for largely urban areas where there is a potential for a return on investment by providing services to a large number of users. The geosciences have a different set of problems to be addressed. While in the field, scientists need geographic information at a wide range of conceptual scales. Spatial data may need to be highly generalized for synoptic analysis of large physical processes, and it may also need to be highly detailed for navigation and location of samples and field measurement. Because samples and measurements have a direct effect on the synoptic models used by the scientists, these various versions of the geographic space must be tightly integrated through a shared spatial framework. In addition, because the physically based models used by the scientists often are built using estimates for unknown parameters, the models must adapt to new information that replace initial estimated values with better estimates or observations as they are collected.

In addition, because the territory being studied is often quite large and possibly be in a relatively wild state there is a need to establish large arrays of cheap sensors that are capable of relaying information to the small number field scientists wandering over the territory. This means that the sensor array needs to sensitive to a researcher's movement and location by becoming active in local portions of the array near the scientist while conserving power elsewhere. Good models for classifying movement behavior of individuals moving through a study area of interest to hydrogeologists have been proposed (Lee and Flewelling, 2005). Also, the primitive nature of the study areas of interest to hydrogeologists offers many mundane challenges such as reliable power supplies, communication in obstructed terrain, and reliability in harsh environments.

While sensor behavior and operating environment constraints are hardly trivial, at this time we will leave such things to the electrical engineers and concentrate on the underlying spatial data management issues and their supporting database models. The remainder of this paper will be organized in the following manner: after a discussion of the interaction between types of hydrogeologic data in the next section, Section 3 will address an object oriented database approach that accommodates object versioning to support progressively improving a groundwater model as new data are collected. Section 4 will discuss a spatial model for spatially extended points (SEP) that offers the potential for better descriptions of

the movement of a scientist through a sensor array space.

2.Treating Fields as Objects

In a field representation of data, every location in the spatial domain is associated with one or more attributes. In an object representation, attributes are assigned only to discrete positions in the spatial domain. Although most phenomena in natural sciences are continuous and, therefore, best described as fields, the human mind tends to process and store information as objects. Mount Everest, for instance, is typically conceptualized and communicated as an object. In reality, Mount Everest is an intensification of an elevation field. There is no crisp delineation between one mountain and the next, or a mountain and a foothill.

In GIS practice, continuous fields are represented as large groups of objects by discretizing the field through a tessellation scheme. Elevation fields, for example, are typically represented in a digital elevation model as a regularly spaced grid or as a triangular irregular network. This approach to representing field type data is contrary to the way we store information in our minds. The human mind creates a hierarchy of categories containing objects both abstract and concrete. In each category there is a basic level category that is the most useful and tends to reflect the perception of objects in reality (Mennis et al., 2000). Thus, "apple" is a more useful category than "fruit". There is no atomic level category in a digital elevation model. A pixel of data does not "mean" anything to the human mind other than a data point, rather the information comes from the gestalt of the pixels. As a result, creating relational connections to tessellated fields via attribute tables is a difficult task.

Cova and Goodchild (2002) suggest that one way to store fields in a rational manner is to associate each field, or a zone of each field, with an object. The resulting "object fields" are continuous fields in which locations are mapped to objects. The objects provide the cognitive relationship for the field. Cova and Goodchild (2002) present the example of a topography that is stored with respect to particular viewing locations. The topography then becomes a series of viewsheds that can always be related to a specific location, with assigned attributes. This approach has the advantage over a typical digital elevation model of being similar to the way in which humans perceive topography. We can only perceive one view at a time.

People do not directly perceive fields. Rather, we recognize the forcing function. For this

reason, the nightly weather report consists of discussions of high and low pressure cells and weather fronts rather than barometric maps. Given fundamental principles of transport, we can fill in the field. We recognize that the high pressure front moving toward our city will result in winds and eventually sunshine, because we recognize the fundamental physics of air mass movement from experience. In the language of mathematics, these forcing functions are boundary conditions. The fields are filled in by physically based equations, usually partial differential transport equations. Thus, if spatial data are represented using physically based mathematical models, the database user need only think about an assemblage of objects (high pressure cell, low pressure cell) and rules (air flows from high pressure to low pressure).

Another tremendous advantage of representing fields through mathematical equations rather than tessellated data is that spatial resolution need not be chosen at the time of storage (Wolf, 1991). The user can chose to calculate the desired result at any point, or over any grid resolution. The necessity of choosing a resolution for data is currently a major problem in field storage and subsequent analysis. As an example, digital elevation models are typically set at a resolution of 10 m or 30 m cells. If the required resolution is 100 m, the stored database becomes unnecessarily large. If a 1 m resolution is required, the level of information will be insufficient. Interpolation can aid in converting among resolutions, but most interpolation schemes do not check for physical consistency. Converting from a 10 m to a 30 m grid resolution, for example, may result in streams running up hill (Hutchinson, 1988).

Fields consist of scalar, vector, or tensor data. For purposes of this paper, we consider fields to be everywhere continuous and well behaved, meaning that derivatives of the data exist throughout. Most phenomena in natural science can be represented by mechanistic or stochastic differential equations that describe transport of energy or mass. Weather fronts, ocean currents, water table elevation, earthquake energy, volcanic plume dispersal, are all natural phenomena that have been described by transport equations. Measured data are usually collected as a scalar (e.g. barometric pressure) or vector (e.g. wind speed). By considering the field to be everywhere continuous, scalar and vector information can usually be related through a transport equation.

3. Two way Communication between a GIS and Model

3.1. Hydrologic Models with Fields and Objects

Using GIS to drive theoretical models is not new. In the field of hydrology, for example, GIS is used to create flood predictions by feeding topography to a numerical flood routing model (Maidment, 2002). We are not aware of any example, however, in which a model returns data to a GIS database, other than for display purposes. That is, predictive model results are not included in the data model. A data model has already been constructed for use with the industry standard GIS program ArcGIS®. This so called "ArcHydro" data model allows for the storage, manipulation, display, and export of many types of hydrologic data that are intended for use with numerical hydrologic simulators. There is no facility, however, for the return of data from the simulator to the objects that provided data to the simulation. Future analyses cannot benefit from prior results.

This disjoint between models and GIS can be alleviated. If the model, the model parameters, and the input data, are all stored in the GIS, model results are reproducible. As a result, a data model can be designed to incorporate both model input and model output, so that the simulation model becomes part of the data model. The sophistication of the data returned to the database can vary. If only a selected number of database objects are used by the model to create a field, the model simply returns a list of objects that were used, and a version number. Subsequent fields are generated with a different subset of objects.

A more sophisticated level of data can be returned once the model is designed to estimate some of the attributes of objects in the database. For example, some objects may be designated as "known" and will act as static boundary conditions for the model. Other objects might be designated as estimates or "unknowns", and the attributes of the objects assigned by the model (Figure 1). In a model of stack emissions, for example, the location of the stack and the prevailing wind velocity may be known, as are several air level measurements downwind, but the emission rate from the stack is unknown. An air dispersion model may be calibrated to the measured concentrations by varying the emission rate until the predicted air concentration field best matches the measured air concentrations. This stack emission rate then becomes an attribute of the stack, subject to an error estimated by the calibration procedure. This attribute is related to a particular model run, such that the calculations can always be repeated if necessary. The model run is related to the properties of all the objects that defined the run, so that the model parameters may be retrieved without re running the model.
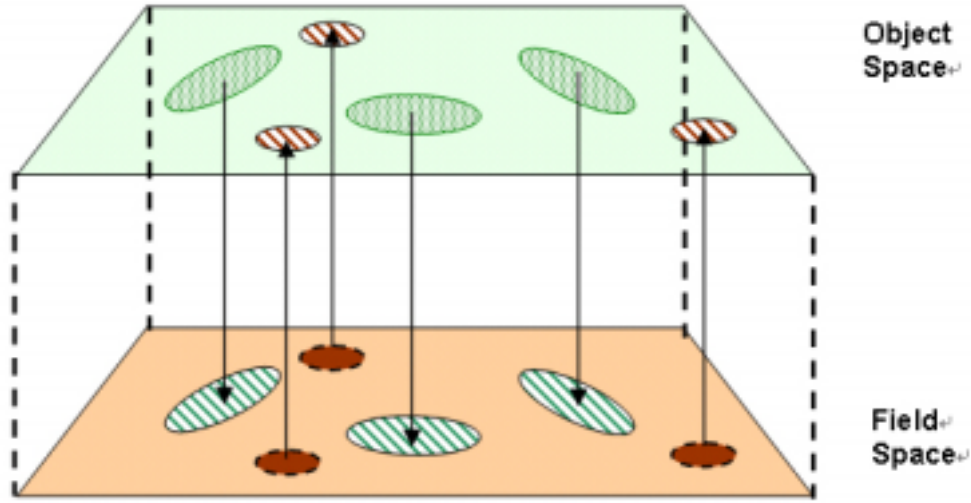
<Figure 1> Communication between objects and field representations. Some objects are used to bound a field (dotted) while others are used to query a field (solid). The field exists everywhere, but is only expressed where queried by objects.

3.2. GIS Framework

In this database structure, a field is classified as dataset having a spatial or temporal resolution that is infinitesimally small. We distinguish a field from a *raster*, which we define as a group of objects of finite size whose attributes are of the same theme. Raster objects are usually rectangular pixels that have a vector of values. A field, *f(x, y)*, and a raster *r(x,y)* are, therefore, related through the size of their smallest resolvable element. If a raster has pixel size *Dx* by *Dy*, for example, then a field representation of the same information is expressed as:

$$f(x,y) = \lim_{\Delta x, \Delta y \to 0^+} r(\Delta x, \Delta y)$$

(1)

The essential difference between the expression of a field and a raster is that a field exists at any point (x, y) where it is queried, whereas a raster exists only at predefined points of resolution (*Dx, Dy*). Although irregular or adaptive grid methods allow a better fit between raster resolution and information needs, raster data are limited by the fact that their resolution is set by the author rather than the user of the database. In practice queries at locations between the known raster cell centers are interpolated using a variety on

methods (Oliver and R., 1990; Swain, 1976). Interpolations often introduce spatial relationships that are not physically possible in the real surface and require post interpolation analysis (Hutchinson, 1988).

The relationship between objects and fields in the data structure is illustrated in Figure 2. Fields do not exist independent of objects. A mathematical model acts as an operator or function that applies a rule set (mathematical equation) to a group of objects (boundary conditions). As fields have no static attributes of their own, fields generated from the database can always be traced back to an object. Different instantiations of the field are implied through different attributes of the object. For example, two fields can be generated from O1, O2, O3, in Figure 2 because O1 has two possible attributes, a1, a2, that affect the field.
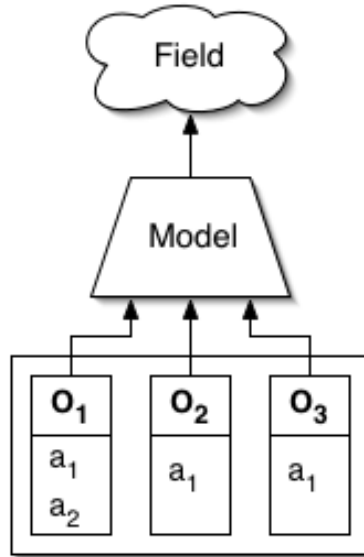
<Figure 2> Data structure for creation of fields from a model and objects,
O1..O3, each with attributes, *a*.

The data structure in Figure 2 depicts only one way data flow: from objects to model to field. In practice, however, fields are often hypothetical representations of a natural phenomenon. In the domain of hydrogeology, the field of interest is hydraulic potential (measured as water levels in wells) and the objects are pumping wells, rivers, and lakes. Potential is a related to hydrologic objects through Darcy's equation:

$$\widetilde{q} = -\widetilde{\widetilde{K}}\,\nabla h \qquad\qquad (2)$$

where $\widetilde{q}$ is the specific discharge vector, $\widetilde{\widetilde{K}}$ is the hydraulic conductivity tensor, and ∇h is the gradient of the hydraulic potential, h. Equation 2 is the physically based model, calculated via the use of a computer program. Each object represents a point, line, or area of known head or known discharge, i.e. boundary conditions for Equation 2. If the ground water discharge at a river is not known, for instance, but the potential is known at several monitoring wells, then one might vary the assumed discharge to the river until the modeled potential best matched the measured potential at the monitoring well positions. This process is known as model calibration (Anderson and Woessner, 1992).

The derivation of hydrologic parameters from calibration of a model to measured data is called inverse modeling (Poeter and Hill, 1997). In *inverse modeling*, the guiding parameters of a physically based model are adjusted until the predicted data best fit measured data. These data are traditional head and stream flow, but more recent efforts have included differential streamflow measurements, temperature, ground water chemistry, isotope information (Becker et al., in press; Saiers et al., 2004). As the variety of data sources for inverse modeling increases, so too does the need for logical and efficient databases to keep track of these data.

When calibration is carried out through a computer algorithm, the best estimate for discharge at a river (based on measured and calculated potential) is returned by the model. The estimated discharge can then be stored as an attribute of the river, along with estimated error and other standard information generated by calibration routines (Figure 3). If the same deterministic routine is always used with the same input parameters, the calibration algorithm will always return the same best fit potential field. As a consequence, the best fit field and the attributed stored in the attribute table are related uniquely. Even in the case of calibrated or hypothetical fields, there is no need to store the fields themselves. Multiple "realizations" of the potential field are implied through multiple entries in the attribute tables of objects. This is a vastly more parsimonious than storing field realizations explicitly. For example, if each object in Figure 2 had 3 possible attributes, there would be 8 possible unique realizations of the field that would require storage.
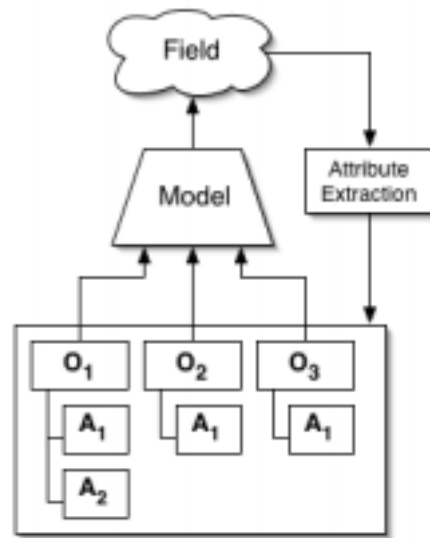
<Figure 3> Modified Data Model showing feedback to the spatial
database from the Field. Attributes (An) are separate entities
managed by the database objects (On).

4. Multi Scale Support for GIS and Groundwater Modeling

4.1. The ArcAEM GIS Interface to Groundwater Modeling

As an example of the application of these methods and our prototype ArcAEM package, we will consider aquifer protection in the Ischua Creek watershed, Cattaraugus County, New York. This valley fill aquifer has been contaminated in several areas by small industry that had been located over ground water recharge areas (Fredrick et al., 2004). A GIS database was constructed of available data related to geology, hydrology, soils, topography, and potential contamination sites. Surface water hydrology was imported as a digital line graph (DLG). Because we were interested in the watershed scale, the hydrography was too detailed for the application. Representing every DLG line segment as an analytic element (as required in the existing software) would have led to slow computation times and possibly computational artifacts at points where the stream geometry was not accurately represented. The DLG hydrography was simplified through a multi criteria line generalization scheme (Figure 4). This scheme reduces the number of line segments while still retaining the general position and shape of the hydrography. Research by Sinha and Flewelling (2002) suggests that by incorporating multiple criteria in line simplification factors other than line shape, such as changes in gradient, surface geology, or

proximity to wells, can effect the resulting selection of elements. These higher level operations are not currently part of off the shelf GIS, but were built as extensions to commercial software. Although generalized line simplification is already implemented in ArcAEM, multicriteria refinement of this simplification is still in a development stage and will be based in regions of anomalously high or low error. An important aspect to these simplification algorithms is that they are fully automated. By simplifying objects rather than the raster, resolution variation is repeatable by different users and can be related in the database to resulting field calculations. In this multi criteria line generalization scheme, attributes such as segment length that would be affected by the geometric simplification can be maintained as an attribute of the feature rather than a value calculated by the AEM software.
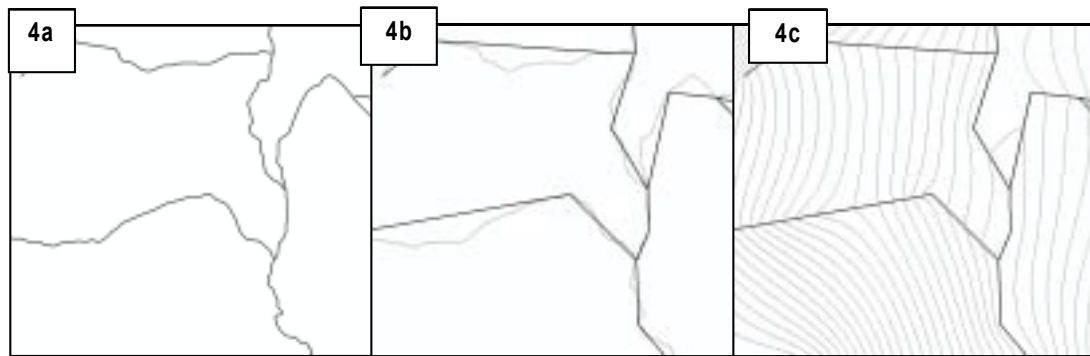
<Figure 4> Generalization of digital line graph (DLG) of hydrology (a) to analytic elements (b) which were used to compute the ground water potential field (c).

After simplification of the line elements, surface water stage information was extracted at each line segment junction from a georeferenced 30 m digital elevation model. This stage was communicated to the AEM code as a constant head boundary or, in AEM parlance, a constant head line element (Haitjema, 1995). Changes in hydraulic conductivity were estimated from existing geologic maps. An existing hard copy surficial geology map was digitized and georegistered to the GIS database. Surficial geology was manually interpreted to polygons that represented regions of varying hydraulic conductivity (K in Equation 2). In AEM parlance, changes in hydraulic conductivity are represented as equations referred to as conductivity "heterogeneities". AEM heterogeneities were simplified from the hydraulic conductivity polygons through a scheme similar to the line simplification scheme noted above (Figure 4). With the hydraulic conductivity and hydraulic head boundaries thus

represented, the ground water potential field was calculated. As one of the important parameters for aquifer protection is depth to water table, the ground water potential was calculated at the center of each digital elevation model pixel, and subtracted from the surface elevation. The depth to water table map was produced is shown in Figure 5 (Fredrick et al., 2004).
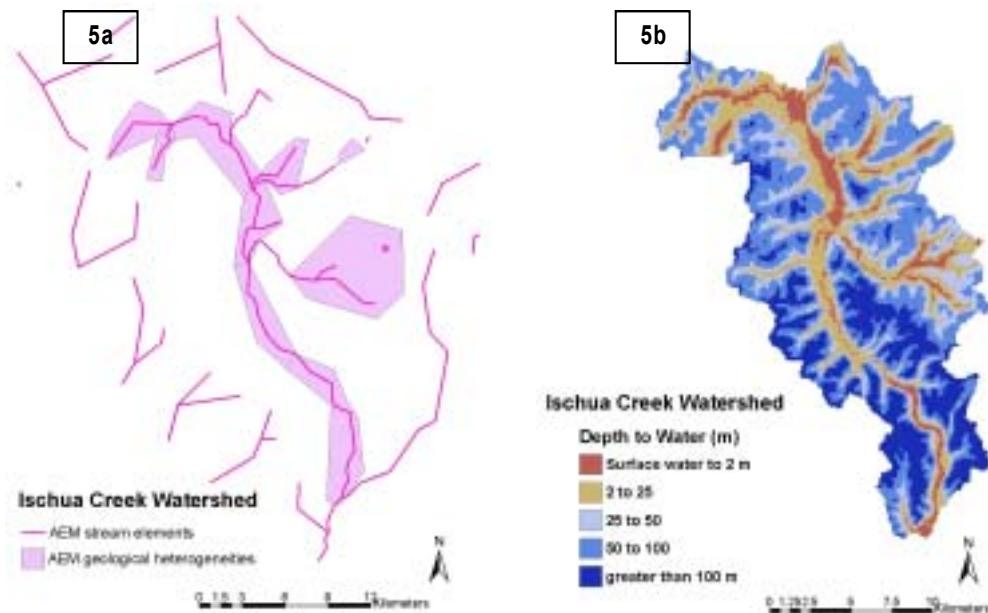
<Figure 5> Analytic element representation of the Ischua Creek Watershed (5a) and the resulting depth to water table map (5b).

The hydraulic conductivities corresponding to each of the AEM heterogeneities displayed in Figure 5a were not known prior to creation of the model. Only rough estimates were available from well yield and literature values for similar sediments. In practice, however, even when point measurements are available, regional scale hydraulic conductivity is usually derived from ground water flow models. In this example, hydraulic conductivity of each of the elements was manually varied until the measured potential matched water levels observed in wells distributed throughout the watershed. Computation of the potential field implies fluxes from the streams (line elements) in the modeling domain. As is the case in all available GIS ground water interfaces, the calibrated hydraulic conductivity values, the measured fluxes to the streams, and errors between measured and calculated potential were not returned to the database. Consequently, we cannot query the database to separate gaining and losing streams, find the most conductive sediments, or to determine where the

model error was greatest. Nor can we relate this information to the particular water table map shown in Figure 5a. In the course of this study, many realizations of the potential were generated based upon different assumptions about geology and confidence in available hydraulic data. The parameters that led to the water table were lost to the database after the field was generated.

If the model parameters had been returned to the database, each water table realization could have been referenced to object in the model using a unique identifier. For example, if the water table in Figure 4a was designated WT10, then the input parameters such as stream stage and conductivity, as well as calculated values such as stream flux, could be referenced by this unique identifier. Referencing becomes more complicated, however, when objects are created, destroyed, or moved. In this case, multiple versions of objects must be referenced to the computed field. Since each each field is associated to its objects through the model that created it (figure 2) it will be necessary to retain objects in the database even when they are no longer needed.

These versioning issues are often dealt with by temporal databases (Elmasri and Navathe, 2000), but with a slight advantage since time is a 1 dimensional ordered attribute. We can always answer the question of which version came after another and therefore is most current. Values derived from analyses are not necessarily ordered by time; more valid (more reliable) versions may occur at any time.

There are several approaches to creating multiple version databases. The first is to simply maintain multiple copies of the entire database whenever significant changes are made. However this creates significant consistency challenges since there are multiple copies of objects that have not changed. A second approach would record a transaction log in which changes to objects are recorded, it the same way a transaction log is used in some database management systems to support data integrity and prevent data loss in the event of a system failure. For analyses that required testing of several different hypotheses there would be a significant overhead to reconstructing to the database to any given version.

Our approach will maintain separate versions of attributes for each object and maintain the versions through methods associated with each class of object. Each attribute will also carry information about its origin as a measurement, estimate, or calculation from a model. As shown in Figure 6, this approach will extend the object model shown in Figure 2 by having attributes be a separate database object that is related to a spatial object and a specific source. When a model is being created the user decides how to deal with multiple attribute value versions. In some applications it would be acceptable to take the mean of all

the measurements, but ignore the estimates and calculated values. In other cases, where measured values are unavailable, the calculated values might be chosen over those estimated from the literature.

5. Conclusions and Future Work

This paper has presented preliminary work on the creation of an automated approach to model simplification. The object model spatial database is used to represent discrete spatial entities. These object and their attributes are in turn used to bound a spatial field. Once the field is calibrated, objects can be informed with attribute value derived from the field representation at any scale desired. This approach supports ubiquitous computing in fieldwork by providing seamless movement between conceptual scales as they are need. The introduction of new measurements to attribute to a specific object can in turn propagate through the model to objects that are dependent upon them.

Management of versions and histories of object is a critical need for supporting scientific hypotheses. Multiple paths of thought need to be supported for geoscientists to examine consequences of different starting conditions. Once a line of inquiry is abandoned it may be necessary to rollback the database to earlier versions.

Database subsetting for model input development for a particular model is also needed. Presently this quite time intensive with the analyst intimately involve with choice of simplification parameters. New tools are currently being developed to support heterogeneous data simplification in response to local object interactions such as proximity of wells to streams and lakes.

and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

References

Anderson, M. P. and W. W. Woessner (1992). "Applied groundwater modeling; simulation of flow and advective transport." 381.

Becker, M. W. and R. J. Charbeneau (2000). "First passage time transfer functions for groundwater tracer tests conducted in radially convergent flow." Journal of Contaminant Hydrology 45(4): 361 372.

Becker, M. W., T. Georgian, et al. (in press). "Estimating ground water discharge using stream temperature and velocity." Journal of Hydrology.

Becker, M. W. and J. W. Schuetz (2003). "An introduction to ground water modeling using Virtual Reality Modeling Language (VRML)." Journal of Geoscience Education. 51(5): 506 511.

Bice, L. A., R. D. Van Remortel, et al. (2000). Source Water Assessment Using Geographic Information Systems, U.S. Environmental Protection Agency.

Cova, T. J. and M. F. Goodchild (2002). "Extending geographical representation to include fields of spatial objects." International Journal of Geographical Information Science 16(6): 509 532.

Draemer, S. R., H. M. Haitjema, et al. (2000). Working with WhAEM2000 source water assessment for a glacial outwash wellfield, Vincennes, Indiana, United States EPA.

Elmasri, R. and S. B. Navathe (2000). Fundamentals of Database Systems. Reading, Massachusetts, Addison Wesley.

Fredrick, K. C., M. W. Becker, et al. (2004). "Enhancement of Aquifer Vulnerability Indexing using the Analytic Element Method." Journal of Environmental Engineering 45(8): 1054 1061.

Haitjema, H. M. (1995). "Analytic element modeling of ground water flow." 394.

Huber, A. J., and J. F. Huber, (2002). UMTS and Mobile Computing: Norwood, USA, Artech House.

Hutchinson, M. F. (1988). Calculation of Hydrologically Sound Digital Elevation Models. Third International Symposium on Spatial Data Handling, Sydney, Australia,

International Geographical Union, Commission on Geographical Data Sensing and Processing.

Jankovic, I. and R. Barnes (1999). "High order line elements in modeling two dimensional groundwater flow." Journal of Hydrology 226(3 4): 211 223.

Lee, B. and D. M. Flewelling (2005). Qualitative Behavior of a Point Object in an Ubiquitous Computing Environment. 13th International Conference on Geoinformatics, Toronto, Canada.

Maidment, D. R., Ed. (2002). Arc Hydro: GIS for Water Resources. Redlands, California, ESRI.

Mennis, J. L., D. J. Peuquet, et al. (2000). "A conceptual framework for incorporating cognitive principles into geographical database representation." International Journal of Geographical Information Science 14(6): 501 520.

Oliver, M. A. and W. R. (1990). "Kriging: A method for interpolation for geographical information systems." International Journal of Geographic Information Systems 4(3): 313 332.

Poeter, E. P. and M. C. Hill (1997). "Inverse models: A necessary next step in ground water modeling." Ground Water 35(2): 250 260.

Rabideau, A. J., M. W. Becker, et al. (2000). A High Performance Analytic Element Model: GIS Interface, Calibration Tools, and Application to the Niagara Falls Region, Funded by the Environmental Protection Agency.

Saiers, J. E., D. P. Genereux, et al. (2004). "Influence of calibration methodology on ground water flow predictions." Ground Water 42(1): 32 44.

Seaberg, J. K. (2000). Metropolitan Area Groundwater Model Project Summary: Overview of the Twin Cities Metropolitan Groundwater Model, Minnesota Pollution Control Agency.

Shapiro, A. M., Margolin, J., Dolev, S., Ben Israel, Y. (1997). A graphical user interface for the U.S. Geological Survey modular three dimensional finite difference ground water flow model (Modflow 96) using Argus Numerical Environments, U.S. Geological Survey Open File Report 97 121: 50.

Sinha, G. and D. M. Flewelling (2002). A Framework for Multicriteria Line Generalization to Support Scientific and Engineering Modeling. Second International Conference on Geographic Information Science, Boulder, Colorado, Association of American Geographers.

Swain, C. J. (1976). "A FORTRAN IV program for interpolating irregularly spaced data using the difference equations for minimum curvature." Computers and Geosciences

1: 231 240.

Vermulst, J. A. P. H. and W. J. De Lange (1999). "An analytic based approach for coupling models for unsaturated and saturated groundwater flow at different scales." Journal of Hydrology 226(3 4): 262 273.

Weiser, M., (1991). "The computer for the twenty first century." Scientific American, p. 94 100.

Wolf, G. W. (1991). Characterization of Functions Representing Topographic Surfaces. Auto Carto 10, Baltimore, Maryland, American Congress on Surveying and Mapping and the American Society for Photogrammetry and Remote Sensing.

Zheng, C. and G. D. Bennett (1995). "Applied contaminant transport modeling."

GIS Integration Strategy in Local Government : Centering on Construction of Enterprise GIS

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Abstract

In the 21st century, which is called the Information Era, to develop a system for easy data sharing and networking is imperative. The current situation in Korea is that the central governments pursuing various computerization projects respective of ministries while local governments, whose survival depends on increased competitiveness, are working on their information system, lacking standardization. Given the circumstances, to build an integrated system that can manage various data and updates in keeping with technological developments, it is a matter of particular importance to pursue information integration among local governments seeing the local government as one enterprise hence, the name Enterprise GIS. Enterprise GIS has the following advantages: First, it removes duplicate data building, enables smooth data sharing and common use, and integrates management of data. Second, it enables an easy update of digital topographical maps, a core information for GIS, which used to cost a huge amount of the budget for local governments. Third, Enterprise GIS linking the spatial information with various administrative information, will be a turning point in upgrading the current facilities management-oriented GIS system to a system that can be a reference in decision making. As we go forward to the age of ubiquitous, it is necessity to build an information strategy based on GIS integration in local government level.

1. Introduction

IT projects of local government are largely divided into three folds: GIS related project drived mainly by the Ministry of Construction and Transportation, e-government project drived mainly by the Ministry of Government Administration and Home Affairs, and U-Korea project pursued mainly by the Ministry of Information and Communication. Some IT projects of local governments are pursued independently by the local government itself according to its demands while other projects are performed by the central government and then distributed to the local governments. Individual division in central government act independently of others on its works while local government has to do general administration which includes the works of all division. As information and social revolution are progressed, individual business area are gradually becoming more complex. And as each individual division has independently pursued its own IT projects, there are lots of redundancies in the area of data, application system, and hardware and software. At this point there are huge demands to set the base to remove the redundancies of the system, manage it systematically, and to use it efficiently. By considering this kind of environment, central government are pursuing Enterprise Architecture(EA) projects to manage all business processes, applications, data, and information technologies of the nation. Local government which handle general administration is keenly aware of the necessities of integrating all its own information resources.

On the side of local government which is pursuing GIS project, local government should make a foundation to remove the redundancy of data construction, share the data, and manage GIS related IT resources efficiently. In addition, there is a pressing need to get synergy effect by linking the spatial data with the one obtained by other IT projects. Enterprise GIS is a newly focused concept in GIS to integrate all information resources in an organization.

In this paper, first diagnose the existing information status of local government, secondly examine the concept of Enterprise GIS and the foreign references, and thirdly introduce the implementation of spatial data warehouse of Seoul city which has had a same experience with other local government, and lastly propose the information strategy on the basis GIS under the circumstance of rapidly changing IT environment.

2. Status and Future Tasks of the GIS Development at Local Government

2.1. Status

GIS development at local government levels needs broad review from the perspective of various computerization projects being pursued by the central government and departmental computerization of local governments.

GIS building at local government, led by the Ministry of Construction and Transportation, began in 1995 with the First National GIS Construction Project and picked up speed with the Second GIS Construction Project in 2000. Digital topographic map production led to the development of numerous GIS application systems; the land information system, parcel based land information system, underground facilities management system and others developed by the central government; road management system, waterworks management system, sewer management system and other developed by local governments. Recently, urban planning information management system, new address management system, fire prevention and rescue system, everyday living geographic information system, transportation information system, land ground information system, fishery zone analysis system, land analysis for cash crop farming and other various systems suited to the needs of local governments. (Tab.1)

<Table 1> Major GIS construction (related to local government)

Govern−ment	Area	Name	Competent Minister/ Level of Usage
Central Govern−ment	Database	Digital Topographical Map, Aerial Photograph, Digital orthophoto, Digital Elevation Map, Land Cover, Land Use	National Geographic Information Institute
		National land Ground Information, River Map, Underground Facility Map, Road Map	Ministry of Construction & Transportation
	System	Underground Facility Management System, Underground Water Management System, Land Management Information System	Ministry of Construction & Transportation
		New Address Management System,	Ministry of Government Administration and Home Affairs
		Industrial Location Information System	Ministry of Commerce, Industry and Energy
	Etc	National Geographic Information Clearinghouse	Ministry of Construction & Transportation
		Satellite Imagery Information Management	Electronics and Telecommunications Research Institute
		GIS standardization	Ministry of Information and Communication, National Geographic Information Institute
		Training of GIS Specialist	Ministry of Construction & Transportation, Ministry of Information and Communication
Local Govern−ment	Database	BiotopMap, Cultural Relic Distribution Map	
	System	Road Management System, Urban Planning Information System, Every Living GIS, Water Supply Management System, Sewage Management System, Emergency management System	systems used by many local governments
		Traffic Information System, Land Ground Information System, fishery zone analysis system, land analysis for cash crop farming	systems used by a few local government

Beside GIS, various computerization projects are being carried out by the central government. Of those, e-Government projects are particularly close to GIS development. The E-government Ad-Hoc Committee established to take charge of the electronic government project, decided on 11 key projects for phase one. The project is in its second phase actively pursuing 31 key tasks. Of the 31 key tasks, the "e-Local Government project" is particularly close to local government. Another 9 projects as well are closely related to local government businesses. (Tab.2)

<Table 2> Priority tasks for E-Government

Area	11 key projects(2001 ~2003)	31 key tasks (2003 ~ present)
Front Office	Government for Citizen, Interconnected Information System for the Four Major Types of Social Insurance, Government Procurement Services(G2B), Home-Tax-Service via Internet(HTS)	Enhanced Internet civil service*, Integrated national safety management service, Integration and enhancement of construction · land · registry*, Enhancement of comprehensive tax service, Integrated national welfare information service*, Integrated food and drug information service*, Integrated employment information service, Internet administrative court service, Single window for business support service, Integrated national logistics information service, e-Trade service, Integrated foreigner support service, Support for exporting e-government solutions, expanded online participation of the citizens
Back Office	National Financial Information System, Informatization in Local Government(Cities and Districts), National Education Information System, Personnel policy Support System	Online processing of document handling*, Integration of central and local government financial information*, e-Local government*, Online auditing, e-Assembly, Integrated criminal legal system, HR administration integration*, Foreign affairs and trade information system*, Real time management of national tasks, Expanded administrative information sharing
Infra	e-Approval and e-Document, Implementation of Public Key Infrastructure and the Government Digital Signature, BPR/ISP of Governmental Integration system	Government wide integrated information environment, Enhancement of e-government network, Application of government wide information technology architecture(ITA), Building the information security system, Enhancement of IT staff and organizations, e-Government and security related legal reform

* Closely related to Local government

In addition, the Ministry of Information and Communication is pursuing U-Korea through the IT 839 strategy. The IT 839 strategy will make the most out of the value chain characteristics of IT industries: the government builds infrastructure for IT industries, the IT infrastructure creates new service industries, and the new service industries in turn create needs for building additional infrastructure, thus making the IT industries an engine for national growth through private and public cooperation. IT839 includes eight new services, three infrastructure, nine new growth engines, and is presently constructed market monitoring system to be put into commercial use. In response to the strategy of the Ministry of Information and Communication and recent technological trends, local government are working on plans and actively carrying out various projects to make 'ubiquitous cities'.

Besides the information systems developed by the central government and made available for local government access, local governments have built register database networks for residences, cars, land, buildings, taxable property, and have statistical data such as population and housing census data, basic statistics of business entities and others.

2.2. Future tasks

GIS development has made huge strides since the first project in 1995. In the rush to accomplish more, the result has been a faulty database lacking accuracy and other system problems. Some systems and data developed and distributed by the central government as part of the national computerization project are government-oriented lacking the comprehensive understanding of local government's information systems, causing difficulties for data and system sharing among local governments. Departmental individual GIS development by local government was often carried out without the benefit of having a broad picture for comprehensive utilization of the system, causing duplicate database building and poor data sharing.

Ideally, local government's GIS systems dealing with spatial information and the central government's e-Government systems for computerizing various administrative works are built to have ready access to each other. In reality, this is not the case at all. It often happens that the same data needs to be put into the administrative information system and GIS system separately. Spatial information and administrative data (attribute data) can not be linked, thus making GIS no more than 'facilities management information'. Other reasons for the local government's GIS development be in a stand still are a manpower shortage, absence of a nationwide data and system standardization, lack of education and other detail guidelines that should be put in place by the central government.

While acknowledging current difficulties, in order to upgrade the local government' GIS system and to encourage its further use, the structure of the current facility management-oriented GIS system needs to be able to incorporate the local government's GIS resources and in turn be linked to various administrative data so that the system can be used in decision making and civil services. Considering 70~80% of GIS development expenses go toward data building, to develop systems for data sharing and linking is of supreme importance.

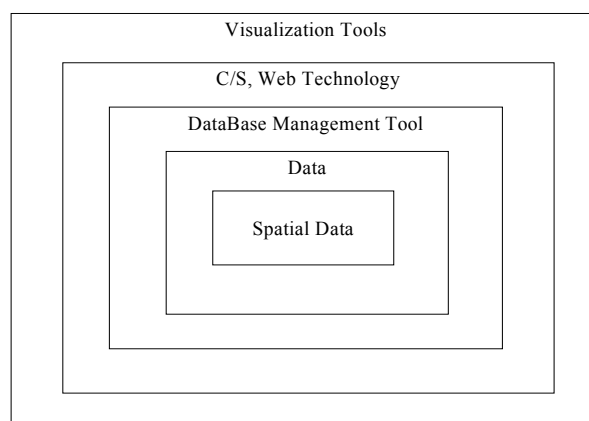# 3. Concept of Enterprise GIS and Foreign References

3.1. Concept of Enterprise GIS

GIS went through changes from a stand-alone system for a small number of specialists to a tool used for specific purposes and problem solving. Thanks to system building expense reduction and computer technology developments, a stand-alone system for specialists was

replaced with a GIS for specific projects or departmental use. Furthermore, it became a general practice that each department developed a GIS system for their own use. Coming into the 1990s, departmental GIS building and project-based GIS were found to have various problems including data sharing, duplicated investments and others. The recent developments in the areas of information and communication network and database management system made possible new GIS building. Enterprise GIS is the most widely discussed GIS building method.

Enterprise GIS emerged an important issue in the 1960s when data sharing was found to be a serious problem in the course of statewide GIS building in New York, Maryland and in Minnesota. In the 1980s, it came to be used as a marketing term to sell corporate GIS systems and has since come to mean 'linking various data of organization to related data using GIS technology.'

Though only several years since Enterprise GIS was first introduced, it has become a general system in the public GIS. Emergence of Enterprise GIS is closely related to GIS development. At first, GIS began to be used as a special tool to analyze and understand various spatial changes of specific area of studies dealing with space. Over the years, GIS came to be selected as a solution for specific works, and it began to be used as a tool for efficient task management. As many organizations collect spatial information, compile and then reorganize them to specific needs using GIS, these respective organizations accumulated new and valuable information. Naturally, GIS came to be recognized as an important asset of the organizations. Recently, GIS, not only a tool database management, it came to be used as an enterprise solution effecting entire organizations. <Figure 1> describes the structure of Enterprise GIS.

<figure>
Visualization Tools
  C/S, Web Technology
    DataBase Management Tool
      Data
        Spatial Data
</figure>

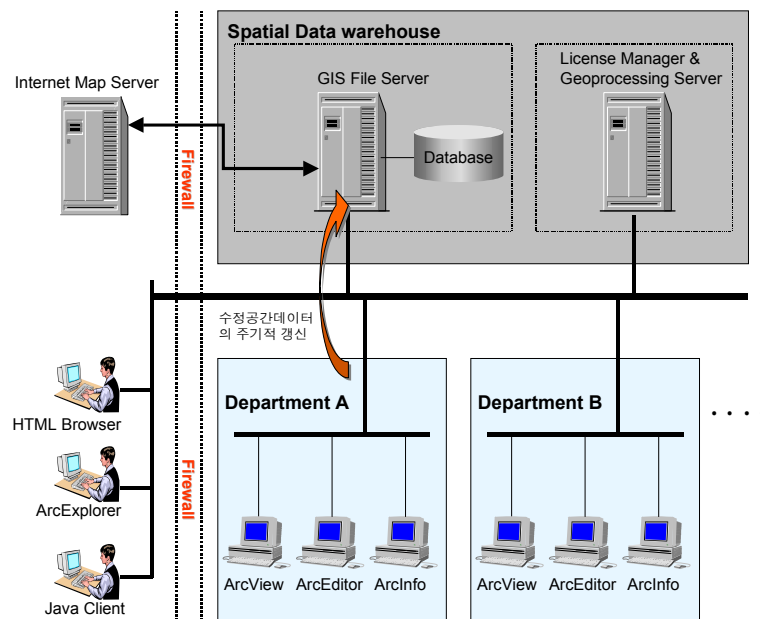<Figure 1> Structure of Enterprise GIS

3.2. Implementation References in Foreign Cities

3.2.1. SDW of King County, Washington State in the U.S.A

The Washington County, located in Washington State in the U.S.A, has a population of 15 million and an area of 5600 square kilometers. The Washington County, which is the 12th largest population county in the U.S.A, is composed of 7 independent organizations such as congress, finances, administration, police, prosecution, justice and has 12 execution divisions under administration. King County established 'King County Technical Resource Center' in 1993 because the existing organizational structure has not satisfied the demand of enterprise GIS implementation. This new center analyzed that the key GIS tasks of King County can be executed efficiently by the share of key spatial data that the accuracy and revelation are guaranteed.

In 1994, King County in its GIS business plan decided to get the master data which can evaluate the accuracy and integrity of revised spatial data and to get rid of the spatial data redundancy which can be expected to happen in each region and division, and set the goals such as the implementation of key spatial data and the supply of hardware and network which are necessary to access the spatial data. King County selected the spatial data which becomes the master of all GIS data of King County and pursued the GIS business plan on the focus of GIS tasks such as tax evaluation, city growth administration, infra management, water resource management, emergency rescue, facility location and permission, and transportation plan.

King County, in its business plan in 1998, accomplished the GIS data integrity and the sharing structure of data stored independently each division system, and pursued the SDW implementation by considering the environmental change of King County and IT development necessary for data sharing. SDW, implemented in King County GIS Center, is composed of Internet Map server, License manager, Geoprocessing server, and GIS file server and more than 500 users are using the SDW through WAN. Revision and maintenance of key data of SDW are performed by 18 divisions of 7 independent organizations and the users have to pay its operating expenses according to the amount of the usage.
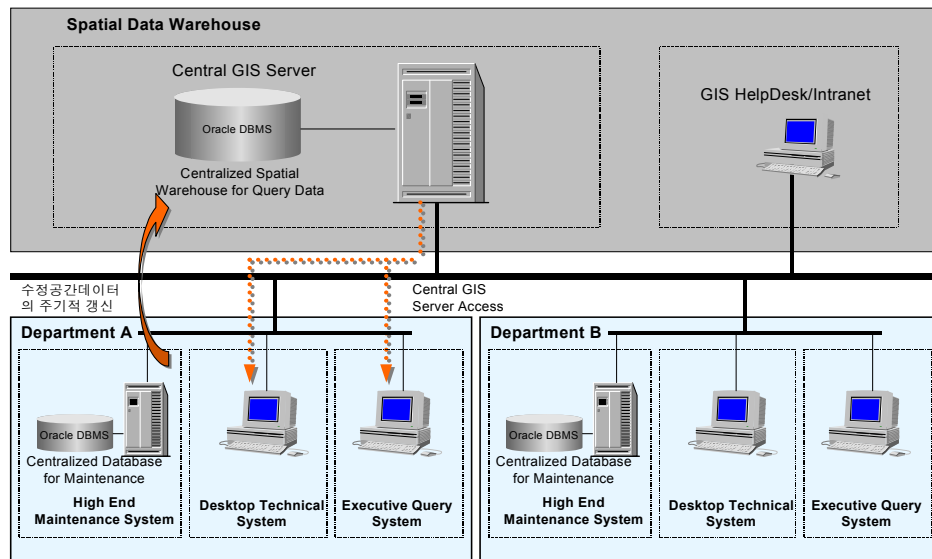
<Figure 2> Spatial Data Warehouse Architecture of King County

3.2.2. Nassau County, New York State in the U.S.A.

Nassau County, which has a population of 1.2 million and an area of 300 square miles, is a local self-administration district composed of 470 administration division. Nassau County, as a successful case of the implementation of the enterprise GIS, is considered to be a model for a large data sharing to improve the efficiency of administration works. Enterprise GIS of Nassau County integrate as a single GIS data base by collecting and transforming the various spatial and attribute data stored in several different legacy data base and then provide various functions such as management, analysis, display and output of spatial data to the users of every class. Now 340 users in 8 different divisions such as tax, strategy, prevention of disasters, civil service, health, police, public are using the GIS for the purpose of their daily work and displaying of spatial data. Also, 15 ARC/INFO users are responsible for data management and maintenance.

Nassau County in 1995 introduced the concept of spatial data warehouse based on client/server structure. Legacy GIS data base has problems which can not interchange each other because spatial data, CAD data, and other attribute data are stored in different format. The spatial data warehouse solves these kinds of legacy GIS database problems by storing all kinds of spatial data and relational data in one integrated data base and then provide the foundation for the development of integrated application system.[1]

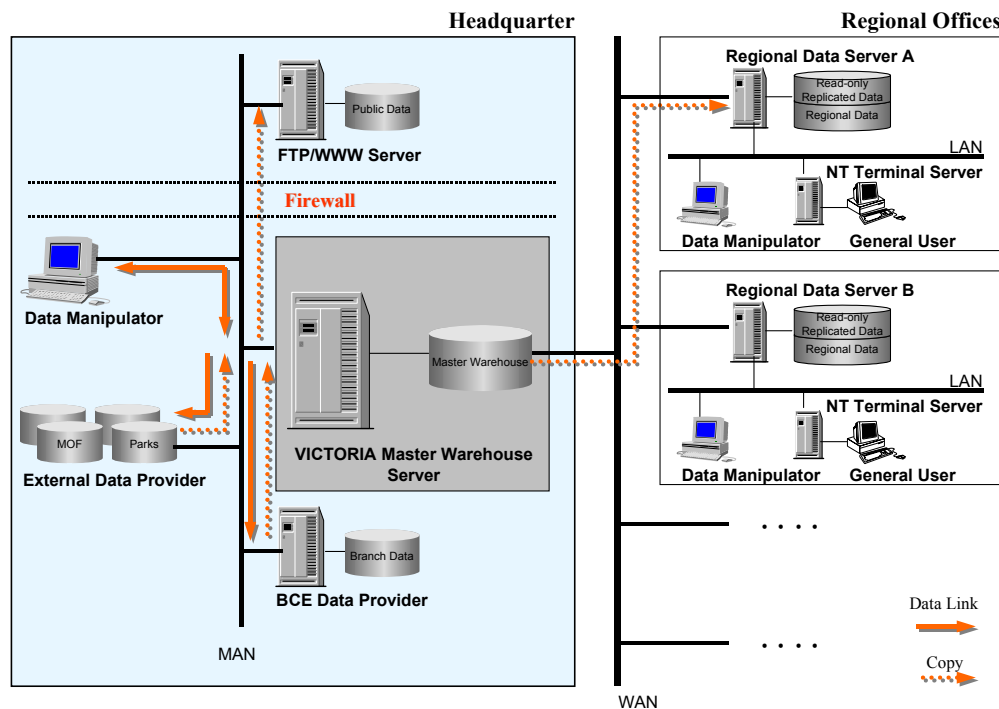<Figure 3> Spatial Data Warehouse Architecture of Nassau County

3.2.3. MELP (Ministry of Environment, Lands and Parks) of British Columbia in Canada

British Columbia, which is the largest state in western area among 10 states in Canada, has a population of 4 million and an area of huge 9500 million hectares, introduced GIS in an early stage in order to manage the government owned land (95% of the whole land) efficiently. MELP, as one organization among 20 administrative organizations in state government, is using GIS as an important supporting tool for the environment related works and the land management policy decision by successfully implementing integrated GIS which covers all central and local organizations.

MELP is constructing the data sharing system and communication network for easy access of spatial and attribute data stored in different legacy data bases in order to link all data bases of 7 central and 7 local organizations. In 1990, MELP constructed GIS promotion committee by representing 'Corporate GIS' and established GIS Action Plan for the purpose of efficient sharing and management of spatial data.

In order to realize the 'Corporate GIS' MELP introduced data warehouse based on 2 years research on target of two areas. MELP constructed decentralized data warehouse in each region to decrease the burden of infra and system implementation and has realized the 'Corporate GIS' through the yearly evaluation process by strong organization operation.

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1) R. Annitto, and B. Patterson, 1998, 「The Nassau County Spatial Data Warehouse - A System Integration Challenge」, URISA 98 Annual Conference Proceedings

<Figure 4> Spatial Data Warehouse Architecture of MELP

3.2.4. SDW of Montreal City Government in Canada

Montreal City in Canada, which is a local government located in Quebec in Canada and has a population of 1.01 million and an area of 177 square kilometers, is divided into 16 administration regions, Montreal City implemented data warehouse in 1992 for sharing various data stored in different systems of each division such as MapInfo, SAS, MapGuide, Integraph, Microstation which had constructed in early GIS projects. In addition to data warehouse, other projects such as meta data implementation and data editing were also pursued, but data conversion rate of the system was not efficient. Data warehouse system and related technologies were reevaluated in 1995 and Central system and software are changed to GEOMAX product that various data conversion is possible in 1996. As a result, SDW server started to be operated successfully with the cooperation of data producers such as public, environment, economy, city development, and prevention of fire in 1999. As GEOWEB tool, which is an intranet, was installed in 2000, 160 public officers were becoming to use the system on September in 2000 and 215 public officers who are working in 12 different divisions were becoming to use the system on July in 2001 by the continuous training and technical support to the users. Nowadays Montreal City are

pursuing new system development to perform all intranet functions in internet space and are also studying the way of data conversion through the use of XML.

<Figure 5> Spatial Data Warehouse Architecture of Montreal

3.2.5. Summary and implications of references

As analyzing the foreign references of the implementation of enterprise GIS, the implications are as follows;

First, the purpose of the implementation of enterprise GIS is for users to access the data easily by standardizing the scattered data in different systems and by implementing the sharing environment. Also by implementing enterprise GIS, one can improve the use of data and get rid of data redundancy under the foundation of the sharing of the spatial data.

Second, system architectures of enterprise GIS are composed of client/server structure. Central spatial data warehouse stores metadata, common data, and frame data. Client data search program is also installed for each user to search and obtain data. Another case like MELP shows the implementation of the local data server in addition to the central server to improve the speed of user access.

Third, in many cases communication networks are added to synchronize the data between

GIS data sever that the data size is huge unlike the general data. Also lots of infra investment such as hardware and software has been realized for the system to share data.

Fourth, even though the organization size for the maintenance of the spatial data warehouse is dependent upon the scale, population, and the volume of data of reference site, there is an organization who are wholly responsible for the maintenance of the spatial data warehouse. The people are responsible for data management such metadata management, data revision, data accuracy check, system maintenance, technical support, and user training.

Fifth, for better environment of data sharing, they are upgrading the server and adopting new technologies. Also in order to provide various data with lots of users, they are planning to implement Web based application program and trying to standardize data, data base, and system.

Sixth, they are trying to reinforce the partnership with data producers to get more data and to extend the data sharing environment, and are also in charge of selling data with private enterprises. The maintenance expenses of spatial data warehouse comes from the profits through the infra usage and the data sales.

4. Seoul Metropolitan Government's Spatial Data Warehouse as an Example of Enterprise GIS

4.1. Background of construction of Spatial Data Warehouse

In 1995, Seoul Metropolitan Government set up 'Seoul Metropolitan Government Geographic Information System Development Plan' according to which production of 1:1,000 and 1:5,000 scale digital topographical maps of entire regions of Seoul began. Presently, department-business-based Seoul GIS system is under development. Also currently, road management system, waterworks management system, urban planning information system, fire and disaster prevention system, and underground facility management system have been completed. Department of GIS in Seoul Metropolitan Government is continuously working on digital topographical map revision and management, integrated management system for underground facility and aerial photo imaging database building. By the year 2001,

nationwide land management information system was completed and made available to the public. In order to make geographic information produced at various public organizations available to wider use, the Korean government is working on a national geographic information sharing system and other preparatory works needed for establishment of an organization to oversee the system building.

Prior to the Spatial Data Warehouse building, Seoul Metropolitan Government GIS developed by department, and there were overlapping database buildings and updated data could not be shared among departments. Application systems were without consideration of overall system integration similar systems were developed by each ward office, causing convertibility and system integration problems. Various governmental projects as well had the same problem of redundant data building and inability of intra-departmental data sharing due to systems based on departmental businesses.

Such data sharing difficulty, on the one hand, increased the need for prevention of overlapping database building and for better accessibility to updated data while maintaining individual department independence. On the other hand, the needs to link various administrative data produced at various administrative offices became evident for a more accurate multi-faceted analysis.

4.2. System Architecture of Spatial Data Warehouse

Seoul Metropolitan Government's Spatial Data Warehouse[2] is designed to solve the problems of Seoul Metropolitan Government's existing GIS system and to change it to Enterprise GIS : (1) it saves and manages framework data[3] and common data[4] that are commonly used in the Seoul Metropolitan Government GIS (2) it searches spatial data from the unit application system of the Seoul GIS (maintenance and management of the metadata) and (3) it is a gateway to Seoul Metropolitan Government's spatial data.

As shown in <Figure 5>, the Central Data Server of the SDW is the central station of

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2) Three different system architectures were considered as an Enterprise GIS system types; Spatial Data Warehouse, Integrated system, and distributed system. Among them, Seoul Metropolitan Government selected Spatial Data Warehouse as a system architecture for Seoul Metropolitan Government Enterprise GIS. It guarantees a smooth progression of existing GIS building, efficient sharing, and maintenance and management of common GIS data. Considering the current GIS related technologies, progress and management skill of Seoul Metropolitan Government regarding GIS, this system is considered the most appropriate.
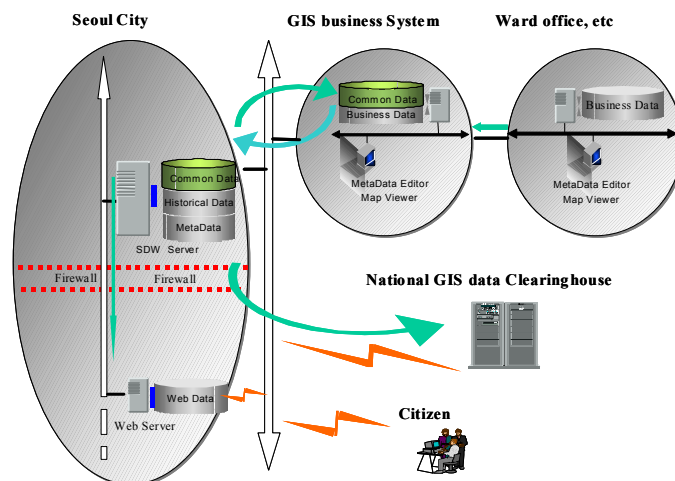
3) Framework Data refers to the most basic and core data among common data. It is considered a standard for all data.

4) Common Data means, of various data being used in entire organizations, the data that is frequently used in various departments.

Seoul Metropolitan Government GIS data. It is designed to save commonly used data (common data, framework data, basic data, block data) so that various application systems and individual users can access it. It also has metadata that helps search for the location of data and check contents. Historical data included in common data is arranged by period for user's convenience so that it can be a source of valuable references with easy accessibility for various planning and policy /decision making.

Overall flow of data shows how the unit application system data are synchronized with that of the SDW system: Revised updated common data from each administrative office and other organizations is sent to the unit application system at City Hall, and the sent data is regularly saved at the SDW after they have gone through checking to see if the sent data is correct or wrong. The collected common data is either sent regularly to the systems that need the data to be used at each application system or to a web server to make the data available at the Internet. In addition, updated data are linked to the National GIS Data Clearing House for data sharing and utilization nationwide.

Data acquisition process is as follows : user first checks the location of data through the metadata searcher and according to the search result, is obtained either from the common database built within the SDW or directly from the unit application system concerned through the SDW gateway. In order to protect data and system, the system is only for registered users that log in.

<Figure 6> Structure of Spatial Data Warehouse System

4.3　Database Contents

The database built in the SDW is composed of meta data, common data, framework data, basic data, block data and historical data.

4.3.1. Common data and framework data, common register

Common data refers to the most frequently used data by many Seoul Metropolitan Government departments and it is composed of common spatial data, common register, common statistical data and others. Framework data is core information of all GIS data, and very basic geographical information such as location and other details. It is used in building other GIS application system, saving time and expense, increasing credibility and accuracy, and thus enabling easy GIS data building.

For the selection of common data at the SDW, map scale and frequency of use of spatial data and related registries among departments and systems considered. To get this information, researchers made visits to all departments within Seoul Metropolitan Government government and conducted a survey. To set up a standard was the most important factor in selecting common data and framework data. For common data selection, the following considerations were looked at: first, the number of departments who used the data (more than 5 departments) second, possibility of using a data concerned third, the degree of importance of the data. The standard in selecting the framework data were : first, entire clauses of the 'basic geographical information' stated in the NGIS laws and the framework data items of the Korea Research Institute For Human Settlements were reflected ; second, frequency of data use based on the results of surveys by questionnaire ; third, emphasis was placed on basic and fundamental spatial data most appropriate for the Seoul Metropolitan Government considering its GIS development status ; lastly, the selection brought in researches done by the Seoul Development Institute in 1999 and framework data items in the overseas researches considered.

Based on those research results, the Seoul Metropolitan Government Spatial Data Warehouse handles a total of 90 common data. <Table 3> is the status of spatial data, revision period respective of layers and its system.

Besides the above-mentioned spatial data, administrative register are linked to spatial data. For example, population and housing census statistics are linked to administrative district; buildings register, account book for taxation, census on basic characteristics of establishments, population of resident registration linked to building; land register, building authorization register linked to plots of land.

<Table 3> Common Spatial Data

System	Layers	Quantity	Revision period
Urban planning Information Systems	· Zoning Area, Zoning district etc.	13	· once a week
Road Management Systems	· Road(Area), Road facility, Crossroad, etc.	6	· two times a year
WaterSupply management Systems	· WaterSupply Pipeline, Fireplug	2	· quarterly
New Address Information Systems	· Building, SubwayMap	2	· everyday
Digital Topographic Map	· Rail, River, Contour, etc.	27	· anytime when update is needed
Underground Facility Integrated Information Systems	· Communication pipeline, electric pipeline, heating pipeline etc.	5	· quarterly
Land Information Management Systems	· Edited Cadastral map	1	· once a week
Sewerage Management systems	· Drainageway, Sewerage treatment Area, etc.	9	· quarterly
Thematic Map	· Green zone, Flood Area,	25	· anytime when update is needed
Total		90	

4.3.2. Basic Data and Block Data

(1) Basic Data

Urban planning needs comprehensive reference materials for planning and management such as population, housing, land, building, industrial economy, environment, transportation, urban fire and disaster prevention facilities, infrastructure and so forth. Research institutes and enterprises which do urban planning are unable to do enough comprehensive data collection and in-depth analysis as it takes a lot of time and effort. In addition, as there were no standards for data collecting and data classification, duplicate work respective of companies did happen and collected data was often discarded after one time use. In order to solve this problem, Seoul Metropolitan Government Urban Planning Information System set up a standard for collecting data respective of categories, for example, building, land, population, industry, urban planning, infrastructure, transportation, environment, topography, and others <Table 4>, and a database was built from data compiled as of 2002 and 2004.

<Table 4> Basic data

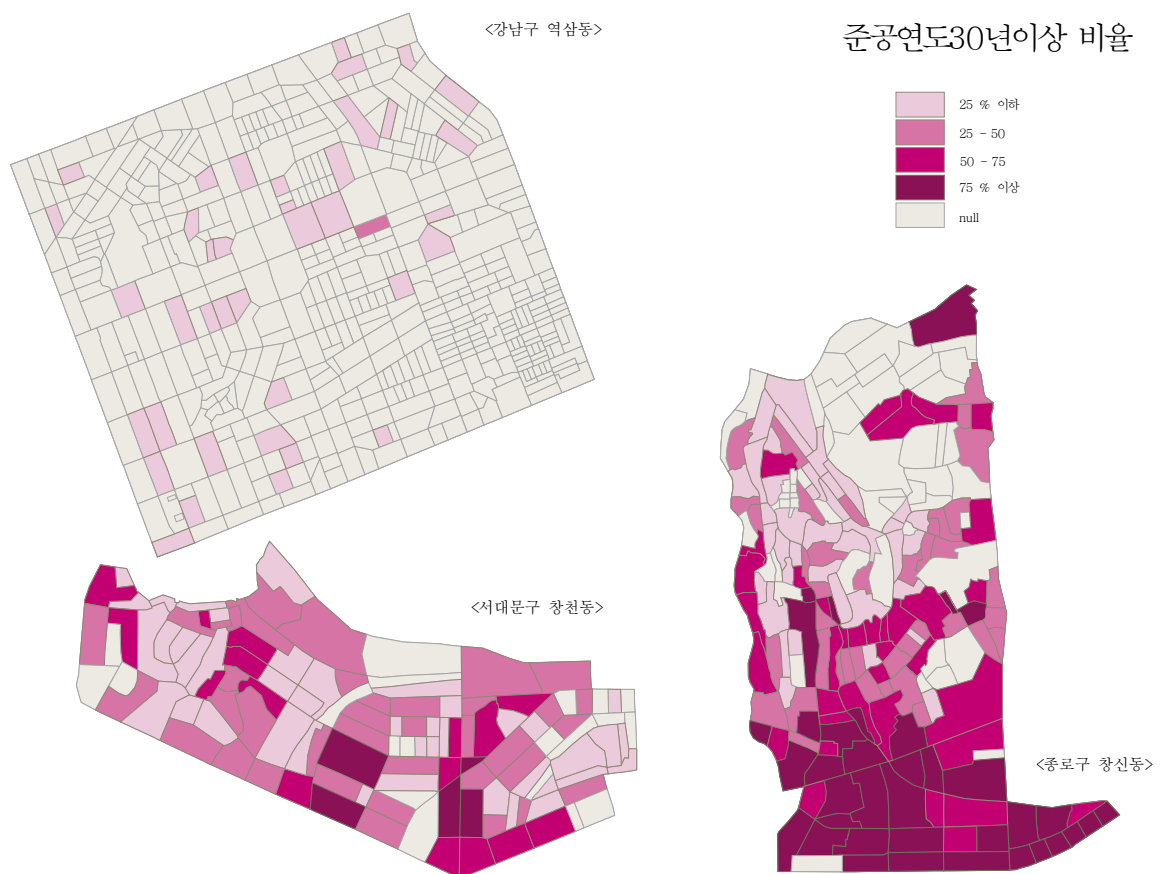| Domain	Item	Related Spatial Data	Source
Building		Building group	New Address Management systems
	• address(old/ new), building name	Building	
	• lot area, building area, total floor area, coverage ratio, main use, completion date, number of household, permission date, structure, roof, height, floor	Building, edited Cadastral map	Building register
	• gross floor area, coverage ratio, usage, completion date, permission date, date of start	edited Cadastral map	Building permission register
Parcel	• scale, area, classification of owner/land use, parcel level	edited Cadastral map	Land Information Management system, Cadastre
	• price, zoning area, zoning district, landuse, access to road.	edited Cadastral map	Survey of Land Use
Popula-tion	• birthday, sex, revised date, revised reason	Building, edited Cadastral map	Resident Management System
	• amount of transference (move in, move out)	Administrative boundary	
	• number of population group (sex, age, education, …) • number of household (lent/own, apartment/duplex/studio..) • house, completion date, size of house, kind of house	Administrative boundary	Population and Housing Census
Industry	• use, area	Building, edited Cadastral map	Taxable property register
	• CEO's sex, character of organization, classification of industry, number of employee	Building, edited Cadastral map	Basic statistics of business entities
Urban planning	• location, name, size, information	Zoning	Urban Planning Information System, LMIS
Facility	• road, centerline of road, pavement, road facility,..	Road	Road Management system
	• watersupply pipeline	Water	Underground Facilities Management system
	• sewage pipeline	Sewage	
	• school	School	Office of education
	• park	Park	
Traffic	• number of vehicle, traffic flows	Point	Traffic Census
	• average speed	Section	Traffic Census
Topology		Digital Topographic Map	Digital Topographic Map
	• elevation, slope, aspect	DEM	
		Areal photo	Areal photo
		Satellite Image	Satellite Image
	• soil	Soil Map (1/25,000)	National Institute of Agricultural Science & Tech
	• geological classification	Geological Map (1/50,000)	Korea Institute of Geoscience and Mineral Resources
etc	• administrative boundary(name, code, area)	Boundary	National statistical office (Census block)
	• lawful boundary(name, code, area)	Boundary	LMIS

(2) Block Data

Urban planning requires not only the statistical references on current status but analysis on current trends and forecasting, and there is much need for management of historical data. If basic data is built by period, Metropolitan Government or administrative district statistics are too large while statistics by land parcel or building are too small for accurate analysis. In this regard, the basic unit for reference compilation that may trace back historical changes of a region should be smaller than administrative district, bigger than land parcel or building, and if possible, data should be compiled by identical spatial unit.

Seoul Metropolitan Government named such spatial unit a 'block'. Here a question arose 'what size of spatial scope should be termed a 'block''. To answer this question, Seoul Metropolitan Government did studies on various concepts of a 'block': the block set at the Biotope survey, the block for subdividing residential areas, Japan's standard for Grid data and the basic unit of district of the Kora National Statistical Office. They chose the Korea National Statistical Office's spatial unit and used the standard size 'block'. The Korea National Statistical Office's block was chosen because it is convenient for housing identical data in the block and can also be used in subdividing residential areas that take place every five years.

Data to be included in the Block Data were selected through analysis on urban planning works and reference materials used for urban planning and was finalized after the preliminary contents went through questionnaire survey screening with the Metropolitan Government planning related specialists. Data to be linked to the Block can be divided into two types: land/building data of smaller space than those of the Block and the data larger than the Block unit. Items included in the Block Data and sources are shown in <Table 5>, an example of a thematic map using block data in <Figure 6>.

<Table 5> Block data

Domain	item	Source
Building	· Number of building, Gross floor area, Floor area ratio, Building Area, Lot Area, Coverage ratio	Building register
	· Building permit	Building permit register
	· Structure, Use, Floors, Use of each floor, completion date	Building register
	· Use	Taxable property register
	· population(household)	Resident registration
	· Number of business/employee	Basic statistics of business entities
Parcel	· classification of land, Area, Owner, Land use, Price	Cadastre
Planning	· Zoning Area	Urban Planning Information Systems

<Figure 7> An example of a thematic map using block data
: buildings over 30 years old (based on the buildings register)

4.3.3. Metadata

Metadata 'Data About Data' refers to content, quality, status, other specifications of data. It provides the information needed for data use to give an outline of the given data for the convenience of data users. It plays a role of a guidebook for huge and comprehensive spatial data, contributing to improvement of data convertibility and data use.

For selection of items of the Seoul Metropolitan Government GIS Metadata, ISO Standard, National GIS Data Clearing House items, the Metadata items of Georgia State based on the FGDC standard items, ANZLIC of Australia and New Zealand were used as references. Seoul Metropolitan Government GIS Metadata is designed based on the National GIS Data Clearing House items and parts of ISO Metadata 19115 were added considering thus far GIS developments. Seoul Metropolitan Government GIS Metadata is composed of 10 categories of information and each has sub items. Refer to <Table 6>.
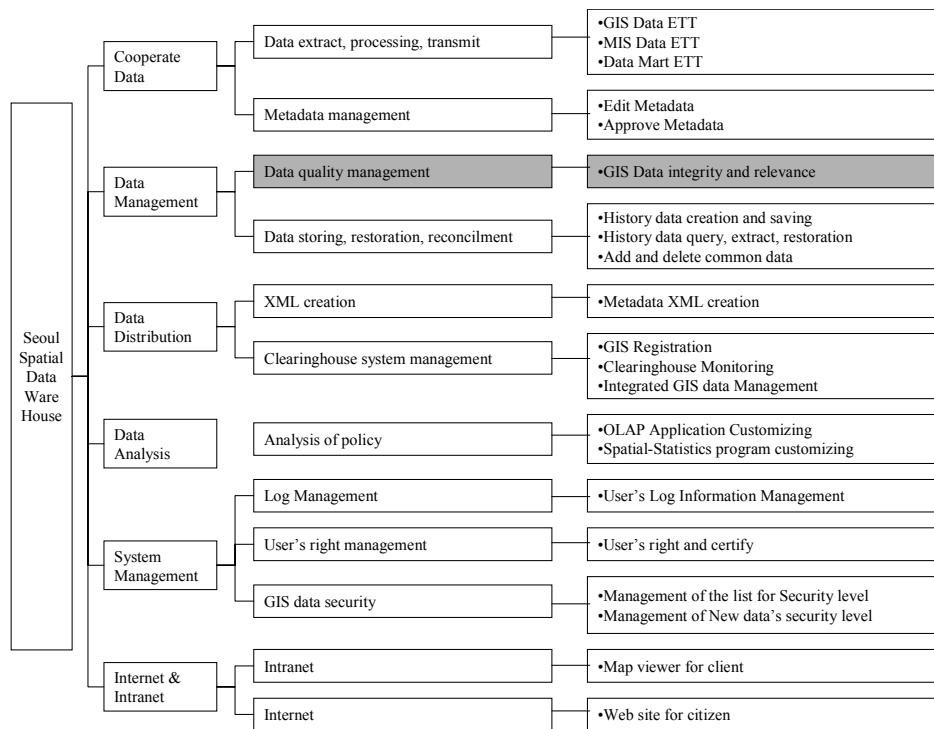
Table 6. Metadata entities for Seoul

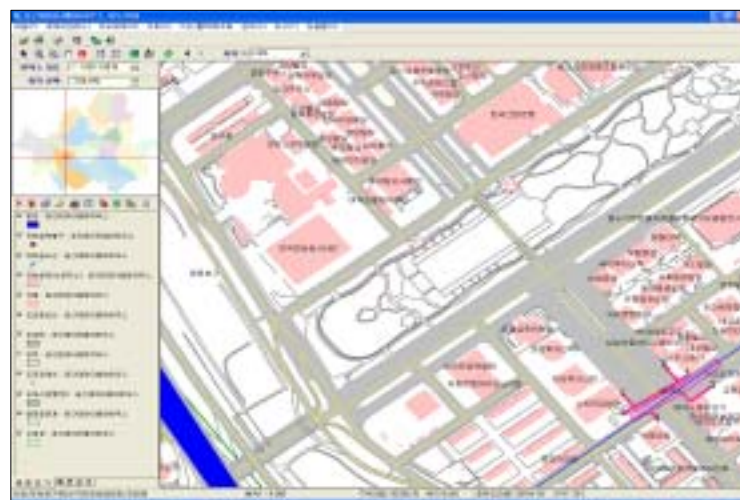| Entity	Definition
Metadata entity set information	· An aggregate of other packages. main package
Identification information	· Information to uniquely identify a resource or resources
Data quality information	· Scope, lineage (information about events or source data used to construct the data), and data quality element information
Reference system information	· Description of spatial and temporal reference system(s)
Distribution information	· Information about the distributor of and options for obtaining a resource
Constraint information	· Restrictions on access and use of a resource or metadata
Maintenance information	· Scope and frequency of updating data
Extent information	· Metadata elements that describe the spatial and temporal extent of the referring entity
Citation and responsible party information	· Data types for citing a resource (dataset, feature, source, publication, etc.) and information about the party responsible for a resource.
Content information	· Information about the feature catalogue used and/or information describing the content of a coverage dataset

4.4 Functions of the System

The Seoul Metropolitan Government Spatial Data Warehouse is designed and equipped with functions to ensure smooth circulation and sharing of data. <Figure 7> describes the functions of the System.

- Data synchronization : It refers to a process of making the SDW data and the data of each application systems consistent. Changed data is picked up from a application system of departments or bureaus. The data is then sent to SDW either on-line or off-line, for revisions and then sent to application systems for use there. This process requires data extraction, processing, transmission functions plus Metadata management functions as it is sent together with changed data.

- Data management : The data sent from each application system, after it has gone through checking for data quality and Metadata contents, is registered and saved at the SDW and the saved data is sent to other application systems. Quality checking refers to a process of checking whether the sent data from application systems is consistent with the SDW data. (Figure 9)

- Data sharing : Data sharing involves various functions needed to distribute Seoul Metropolitan Government spatial data linked with the National GIS clearing house System. These functions are making Metadata into XML, developing and managing the geographical information catalog, managing clearing house system, and managing geographical information supplier.

- Data analysis: Using the data complied at the Spatial Data Warehouse, this function analyzes data by subject. This system needs OLAP application program customizing and spatial statistics analysis program customizing functions.

- Internet & Intranet: This is the function that Seoul citizens through the Internet, and Seoul Metropolitan Government departments through the Intranet can search various data, maps and Metadata from the Spatial Data Warehouse.

Seoul Spatial Data Ware House	Cooperate Data	Data extract, processing, transmit	•GIS Data ETT •MIS Data ETT •Data Mart ETT
		Metadata management	•Edit Metadata •Approve Metadata
	Data Management	Data quality management	•GIS Data integrity and relevance
		Data storing, restoration, reconcilment	•History data creation and saving •History data query, extract, restoration •Add and delete common data
	Data Distribution	XML creation	•Metadata XML creation
		Clearinghouse system management	•GIS Registration •Clearinghouse Monitoring •Integrated GIS data Management
	Data Analysis	Analysis of policy	•OLAP Application Customizing •Spatial-Statistics program customizing
	System Management	Log Management	•User's Log Information Management
		User's right management	•User's right and certify
		GIS data security	•Management of the list for Security level •Management of New data's security level
	Internet & Intranet	Intranet	•Map viewer for client
		Internet	•Web site for citizen

<Figure 8> Function of Spatial Data Warehouse Systems
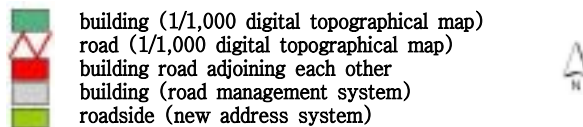

<Figure 9> Map Viewing Interface of SDW

(a) Buildings and roadside in
a 1:1,000 digital topographical map

(b) Buildings in the new address system and
roadside in a road management system

▧	building (1/1,000 digital topographical map)
△▽	road (1/1,000 digital topographical map)
▨	building road adjoining each other
▢	building (road management system)
▨	roadside (new address system)

<Figure 10> Renovated buildings with roads remain unrepaired.

5. Conclusion and Suggestions

In the 21st century, which is called the Information Era, to develop a system for easy data sharing and networking is imperative. The current situation in Korea is that the central governments pursuing various computerization projects respective of ministries while local governments, whose survival depends on increased competitiveness, are working on their information system, lacking standardization. Given the circumstances, to build an integrated system that can manage various data and updates in keeping with technological developments, it is a matter of particular importance to pursue information integration

among local governments seeing the local government as one enterprise hence, the name Enterprise GIS.

The integrated management of information has been tried in GIS under the title Enterprise GIS and it has been employed by many local governments and organizations of overseas countries. Seoul Metropolitan Government built the Spatial Data Warehouse, an Enterprise GIS. Enterprise GIS has the following advantages: First, it removes duplicate data building, enables smooth data sharing and common use, and integrates management of data, which in the past were difficult due to departmental system building with a low level of standardization. Second, it enables an easy update of digital topographical maps, a core information for GIS, which used to cost a huge amount of the budget for local governments. Third, Enterprise GIS linking the spatial information with various administrative information, will be a turning point in upgrading the current facilities management-oriented GIS system to a system that can be a reference in decision making.

But the Enterprise GIS building, as shown in the case of Seoul city's Spatial Data Warehouse, requires some pre-conditions. First, beside data circulation, a system function that can maintain consistency among updated data at respective application systems is needed. Second, continuous supplementary works are needed to solve discrepancy between administrative data and spatial data. A solution to the second problem requires joint efforts by all the organizations concerned from a broad perspective.

References

Annitto, R. and B. L. Patterson, 「The Nassau County Spatial Data Warehouse - A System Integration Challenge」, Annual Conference Proceedings, URISA, 1998

Chris, G., 1996, "Developing a Vision for the Implementation of Corporate GIS", GIS '96 conference in Vancouver, March 19.

Cooney, G., 1996, "BC Environment's Corporate Implementation of GIS", GIS '96 conference in Vancouver, March 19.

ESRI white paper, 「Enterprise GIS for Municipal Government」, July 2003.

Gangnam-gu, 「Strategic Plan of Construction of Urban Information System using GIS」, 1999

Harry Singh, 「Data Warehousing: Concepts, Technologies, Implementations, and Management」, Prentice Hall PTR, 1998

_____, 「Data Warehousing: Architecture and Implementation」, Prentice Hall PTR, 1999

Jin Hui-chae and Seung-ryeol Chung, 2001, "Implementation of the Spatial Data Warehouse to Distribution System", 2001 Conference Proceedings of Open GIS.

Kim, Hag-Yeol, Yoon-Jong Kim, and Joonkee Kim, "Designing Database Contents of Spatial Data Warehouse and its Data Synchronization with Distributed Geographic Information Systems in Seoul Metropolitan Government" The Journal of GIS Association of Korea, Vol. 11, No.2, 119-130, July 2003.

Korea Computerization Agency, 「A Proposal for Integration of Geographic Information Distribution System」, 2001

Korea Research Institute for Human Settlements, 「A Study on building the National Spatial Data」, 1998

Korea Research Institute for Human Settlements, 「Enactment of laws to facilitate spatial information distribution and use」, 1997

Korea Research Institute for Human Settlements, 「Korean model development for GIS Information distribution」, 1999

Lee, Bong-gyu and Ji-yong Song, "A Study on Laws Regarding GIS Information Distribution", Open GIS Journal, Vol.2, No.1, pp.73~81,

Ministry of Construction and Transportation, 「A Study on network building for dissemination of geographical information and establishment of spatial Data Clearinghouse」, 2001

Park, Soohong, 1999. "A New Implementation Strategy and Conceptual System Architecture for the Seoul Metropolitan Government's GIS", The Journal of GISAK, Vol. 7, No. 2, pp. 237-253.

Poe, V., 1994, "Guidelines for Warehouse Development", Database Programming & Design, September.

Seoul Development Institute, 「A Study on Construction of Seoul Metropolitan Government's GIS (III)」, 1999

Seoul Metropolitan Government, 「A Plan for the Development of Urban Planning Information System for the Seoul Metropolitan Government」, 2000

Seoul Metropolitan Government, 「A Prototype Development of the Spatial Data Warehouse」, 2002

Seoul Metropolitan Government, 「A Study on the Development of Basic Data for the

UPIS of Seoul Metropolitan Government」, 2001

Seoul Metropolitan Government, 「Construction Guide for the Spatial Data Warehouse,2001

Todd Glover and Don Morgan, 2000, "Multi-Agency Geographic Information Warehousing in Northwestern BC". The Northern BC GIS Conference in Prince Geor

von Meyer, Nancy R. and R. Scott Oppman (eds), 「Enterprise GIS」, 1999.

Local Government's GIS Application Strategy for u-City Realization:
Focused on GIS-based Local E-government

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ABSTRACT

There are not enough information and services in current e-government practice because it only relies on text based information services. To make e-government more attractive and successful, scope of information and services should be broaden. To do so, GIS is necessary in the development process of e-government. This paper aims at exploring theories and technologies related to e-government and suggesting strategies for developing GIS based local e-government. In this paper, we particularly pay attention to the role of GIS for local e-government. Since many of local government data has spatial components, we believe that GIS would play a crucial role in developing local e-government. Thus, this paper tries to examine how GIS contribute to successful implementation of e-government. Then, it attempts to build a developmental model for GIS based e-government. Finally, it suggests strategies and policy measures for each development stage.

1. Introduction

According to the research of National Academy of Public Administration (NAPA), 80% of federal government tasks are related to spatial information. In fact, administrative work such as urban planning, urban facility management, land use management might not conduct if there is no spatial information. However, e-government for improving efficiency of administration and civilian services are focused mainly on text-typed information. For this reason, information and services provided by e-government has many limitations.

To solve above problems, GIS based e-government should be needed to deal with spatial information electrically for various kinds of administrative works. However, there has been few concepts for the GIS-based e-government and little attention paid to how to realize it. Previous studies only show system development strategies mainly for individual administrative works, and they cannot suggest a framework for GIS based E-government or any specific strategy.

The purpose of this research is to propose the model of development stages of a GIS-based local e-government as a fundamental framework and strategy, from the questions that what local e-government should aim for and how to advance it. In order to do it, existing development stages of local government informatization and e-government development stage model have been analysed. In addition, it reflected the construction of spatial information and development process of GIS operation system which was adopted by local government since beginning of 1990.

Research areas are local governments. Local government is a self-organization as it aims to improve the quality of life of all citizens and at the same time, it is an element of consisting whole nation. In this research, local e-government considers same as a e-government. local e-government is a small e-government for self-organization and local residents at a regional level and also fundamental element to consist e-government at a national level.

2. Examination of Other Research

2.1. Administrative Work informatization

To promote administrative work informatization, construction of database and development of applied system were conducted. This process continued until end of 1990. Development stage model has been suggested by many researchers (See table 1).

The first information system development stage model was suggested by Gibson and Nolan (1974). They categorized information systems management model based on stage of growth in four stages.

In the Initiative stage, information system started to be constructed in the field where cost reduction is available. In the Expansion stage, applicable fields of information technology is expanded into the overall organization. In the Formalization stage, application of new

function is suspended and also systematic check and control are enhanced. Lastly, in the Maturity stage, it will evolve the database system which is shared and linked information of existing models.

In 1991, Venkatraman suggested another information development stage model. Venkatraman(1991) suggests five stages to explain application of information technology and applying it to the model. First, it is a Localized exploitation and the Second is an Internal integration stage. Third, it is a Business process redesigned stage. Fourth, it is a Business network redesign stage. Lastly, it is a Business scope redesign stage. This research showed how the development of organization is influenced by information technology. However, this research could not explain about what information technology acted in each stage in more details.

Crain and MacDonald(1984) suggest development of GIS applied system with three stages. First stage is an Inventory Application and in this stage, data computerization and informatization can be done. It can be applied for simple query such as finding location of spatial objects and searching attributes. Next stage is an Analysis Application, and in this stage, more complicate spatial analysis function such as location determination, analysis for finding the most suitable place can be realized. Last stage is a Management Application, and in this stage, it will combine with statistical analysis and spatial modelling techniques and develop for decision making supporting system. As this research generalized the GIS development stages, it could not show enough what kind of strategiese are needed in each stage.

On the other hand, Suk-Je Lee (2001) categorized the GIS development in three stage as Infancy, Adolescence and Maturity. Infancy is a stage of base information construction and it promotes the computerization of paper map. Adolescence is a stage of leap and expansion of information. In this stage, existing spatial information is colligated. Maturity is an advanced stage. Based on the development of previous stage, it will contribute to drive a rationale decision determination. However, this model considers GIS as an internal operation system therefore it cannot reflect GIS character which has been developing for public service system.

<Table 1> Researches on administrative information system development stage

Researcher	Category	Development stage
Gibson and Nolan(1974)	Administration	① Initiation ② Expansion ③ Formalization ④ Maturity
Venkatraman(1991)	Administration	① Localized exploitation ② Internal integration ③ Business process redesign ④ Business network redesign ⑤ Business scope redesign
Crain & MacDonald(1984)	Administration (GIS)	① Inventory Application ② Analysis Application ③ Management Application
Suk-je, Lee (2001)	Administration (GIS)	① Infancy ② Adolescence ③ Maturity

2.2. Customer Oriented Informatization

Customer oriented informatization is a developed concept from administration informatization. In this concept, it shares information and improves the effectiveness. In addition, customer(residents) can participate in the process of administrative work. This concept has been introduced to local government since end of 1990. There are many researches about development stage model which explains customer oriented informitization process (see Table 2). Some of them explain E-government development stage focus on information technologies (Kim Suk-Ju, Oh gang Tak, 2001; Seo Sam-young, 2001). Others emphasize on the information services. In this side, E-government development stage is suggested to understand how government delivers public services to customers such as citizens and enterprises (UN, 2000; National Computerization Agency, 2000; Deloitte Research. 2001; Gartner Group. 2001; Accenture. 2001). However, above researches overlook the objective and value-aimed aspects.

Kim (2004) reviewed the existing e-government maturity models and GIS development stage models and based on them, Kim (2004) suggests "e-government and GIS related promotion model." In vertically, this model suggests that e-government promotes GIS like in the field of "service", "technology", "organization", and "base construction," In horizontally, it suggests four stages of GIS developments. This model is mainly focused on understanding how GIS applies e-government development stage and evolving. However, it does not mean that if GIS is added into the stage of e-government development, they (E-government) develop and widen their applicable fields. On the contrary, GIS should be amalgamated into the e-government as a foundation. GIS adaptation and applying will have a great influence

on the information quality, system quality and service quality of e-government.

<Table 2> Researches on e-government development stage

Researcher	Category	Development state
National Computerization Agency(2000)	E-government	① Web Presence ② Interaction ③ Transaction ④ Transformation/Integration
Gartner Group(2001)	E-government	① e-Service ② Collaborative Government ③ Knowledge Polity ④ Competitive Government
Sam-Young, Seo(2001)	E-government	① Start ② Promotion ③ Focused on Citizens ④ Convert for quality improvement
Suk-Ju,Kim,Gang-Tak, Oh (2001)	E-government	① Introduce ② consist of foundation ③diffusion and integration ④ideology
Deloitte Research(2001)	E-government	① Information Publishing/Dissemination ② Official Two-Way Transactions ③ Multi-Purpose Portals ④ Portal Personalization ⑤ Clustering of Common Services ⑥ Full Integration and Enterprise Transformation
Accenture(2001)	E-government	① Publish ② Interaction ③ Transaction
UN(2002)	E-government	① Emerging ② Enhanced ③ Interactive ④ Transactional ⑤ Seamless
Hyoung-Eun, Kim (2004)	E-government+ GIS	① construction of fundamental information ② leap and diffusion (partially focused on citizen) ③ leap and diffusion(participation of citizens) ④ advance

2.3. Limitations of Prior Researches

The information development stage model which is focused on administrative work explains well about the development process of administrative work informatization. However, it has some limitations to explain G2C and G2B. Customer oriented informatization development stage model cannot show systematic aim and promoted strategy for mutual development. In addition, e-government development model is developed in the view point of web based online e-government. The e-government is not only about to turn offline civil service into a front office but also electronic process into a back office. The e-government development stage model should suggest clearly about what is the aim for

mature development. In addition, it should be able to suggest development strategy for each stage. In this point of view, previous studies are not sufficient for framework and strategy to fulfill GIS based local e-government. This research suggests GIS based local e-government development stage model to improve above limitations.
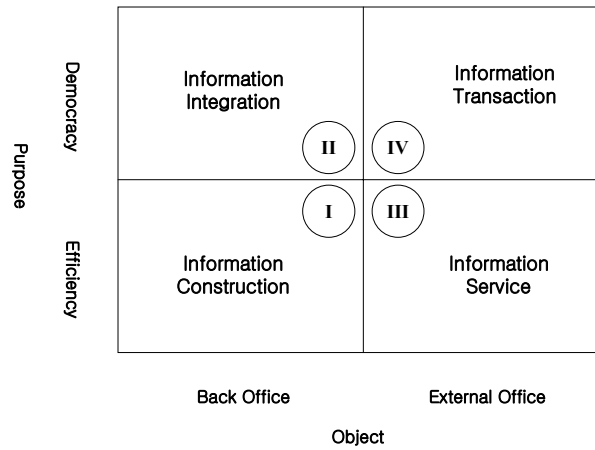
3. GIS-based Local E-government Model

3.1. Research Framework

E-government and local e-government can be said to be little different substantially in terms of an eventual ideology and implementation. Like a local government, a local e-government is a part of an e-government. Realization of a local e-government means introduction of information technology in order to enhance productivity of local administration and to improve information service to citizens. From this viewpoint, we can think of the objectives which a local e-government aims for and the methods to fulfill the objectives. GIS can be a method to realize a local e-government, and the method can differ for its purposes and objects.

The purpose of realizing local e-government is related to the question why a local e-government should be realized. The local e-government aims for efficiency and democracy through innovation of local government(Kim. 2000; UN. 2001; Oh. 2001). Efficiency means promotion of work productivity such as time and cost saving, while democracy means transparency and enhanced openness by constructing local e-government. In terms of the purpose and methods, we can ask "how can we realize local e-government for what?"

In terms of objects to be realized, there will be a question what of local government should be realized for local e-government. With regard to it, local administration can be categorized into two: back office and front office (Deloitte. 2000; Accenture. 2001; NCA. 2001). The back office means internal work procedures and decision making, while front office means information service to citizens. In terms of realized objects and method, we can ask the question "how local administration should be realized for what?"

Based on these viewpoints, this research divide domains of realizing local e-government in terms of the purpose and objects (see figure 1). Figure 1 divides the purpose of the realization into two (efficiency and democracy), and divides the realized objects into two (back office and front office). Therefore, each domain in figure 1 represents required points that local e-government should take, and characteristics of methods in GIS viewpoint.

<Figure 1> Domains of local e-government

3.2. Characteristics of Domains

3.2.1. Information Construction (Domain I)

In this domain, analog-typed data will be digitized, and based on it, GIS will be constructed to manage and utilize digitized data, for the purpose of enhanced efficiency of internal works in the local government. For it, the main objects for digitalization and utilization are public utilities and land parcels in the central and local government. Water supply and sewage management system in Kwangju city (1992), Land administrative information system in Kangnam-gu, Seoul (1997) are good examples by local government in this domain. Other examples by central government are Cadastral digitalization Project (1996) by Ministry of Government Administration and Home Affairs, Parcel-based Land Information system (1998), Water Supply utility management system (1999), Water Sewage utility management system (1999) by Ministry of Construction and Transportation. The enhanced efficiency of internal work eventually will affect advanced information service to citizens positively. However, in this domain, the focus is mainly on the enhanced efficiency of internal work with a priority.

The main technological methods to make individual work informative in this domain are 'Project GIS' (for individual use) or 'Department GIS' (for department use). As the informatization projects for individual work are implemented, several potential problems

may occur such as lack of sharing among individual information systems, duplicated investments, which may demand constructing integrated spatial data infrastructure, and developing standardized systems.

In addition, we can think about potential problems such as organizational inefficiency, inappropriate institutions built in the analog age. To solve these problems, construction of national topographic digital maps, standardization of digital maps and their procedures, and distribution systems will be implemented. In this domain, there can be also an external information service system, but it may be mainly for making propaganda for local governments via information Web sites, which usually lacks of information contents with poor maintenances. This case is quite different from the external information service system that local e-government aims for in terms of the concepts, functions and roles.

3.2.2. Information Integration (Domain II)

In domain II, the integrated spatial data infrastructure will be constructed and individual information systems will be shared, in order to solve the problems such as inefficiency to share information among individual systems, duplicated investments. To share spatial data among individual information systems, physical or local linkages/integrations among the systems will be implemented and based on it, the spatial decision making support system (SDSS) for a policy establishment will be available. The examples for a linkage is the case of Kangnam-gu, Seoul (2002), which integrated between Land administrative information system and Building administrative information system. From the integrated information system, the related officers will share and search land and building information in the integrated viewpoint. Another example is to share base topographic maps and utility maps among City of Seoul, Korea Electric Power Corporation, Korea Telecom. By sharing administrative information among the related departments or organizations, the administrative working procedures will be open to others and it eventually affect the enhanced transparency of the works.

Also, in this domain, there will be an improvement of the information service for citizens using internal administrative work system, e.g. remote public documents service. For example, via the remote service, a citizen can see a landuse document of Jeju Island in Seoul. However, it is different from the external information service system for citizen in that it is not the system only for citizens. Rather it can be said an intermediate information service from a PR-based Web site to the information service mainly for citizens.

In domain II, the integrated spatial data infrastructure will be constructed from individual spatial information, and to share them, Enterprise GIS[1], Web GIS will be applied. Also, spatial data warehouse will be constructed for supporting spatial decision making, and in some cases, data mart will be constructed for departmental works.

3.2.3. Information Service (Domain III)

In this domain, information service in provider side is transferred to it in user side, and the information service system with direct interaction between government side and citizens such as Web Portal Service is available. The integrated spatial data infrastructure constructed in the internal administrative work system will be partially connected to the external information service system in order to serve information contents to citizens. Through this linkage between internal and external information systems, the real time information service of the results of an administrative work will be available. For example, if there will be changes in a land parcel(e.g. desegregation or merge of a parcel), the resulted parcel will be served via internet in real time. In addition, a citizen will monitor the civil appeal process via internet in real time. Sharing relevant information in the process of the electric approval enables it to be realized.

In order to make real time citizen-sided information service possible in this domain, the integrated spatial data infrastructure in domain II should be already constructed, because internal administrative work system has to have a role as a service provider and provide the information to the external information service system. In domain III, the Web GIS technology will be utilized in order to manage the integrated spatial data infrastructure.

3.2.4. Information Transaction (Domain IV)

In this domain, spatial information of local government and data contents of the private side will be integrated and interacted. if, external information service system in domain III is G2C (Government to Citizen) based, in domain IV, providers and consumers will be diversified e.g. G2B (Government to Business), B2C (Business to Citizen). For example, spatial data infrastructure of a local government will be provided to the companies who are developing information contents, and the companies will create more advanced information,

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[1] Regarding defining Enterprise GIS, it can be said as construction of integrated information infrastructure for sharing internal administrative work systems in a narrower viewpoint, and as integrated information infrastructure including external information service via Internet. In this research, we will define the first explanation as Enterprise GIS, and the second as Web (Mobile)GIS.

and provide the citizens. Usually, the public agencies tended to create and manage the spatial information, but they have limitation to develop various kinds of spatial information contents, mainly due to lack of creativeness, marketing ability, related IT. For this reason, it will be useful to have a partnership relationship between the public side (for constructing spatial data and public information) and private companies (for creating value-added information contents).

Like domain III, in domain IV, technologies for Enterprise GIS, Mobile/Web GIS will be applied to e-government and the tailored information service and bi-directional communication service will be available.
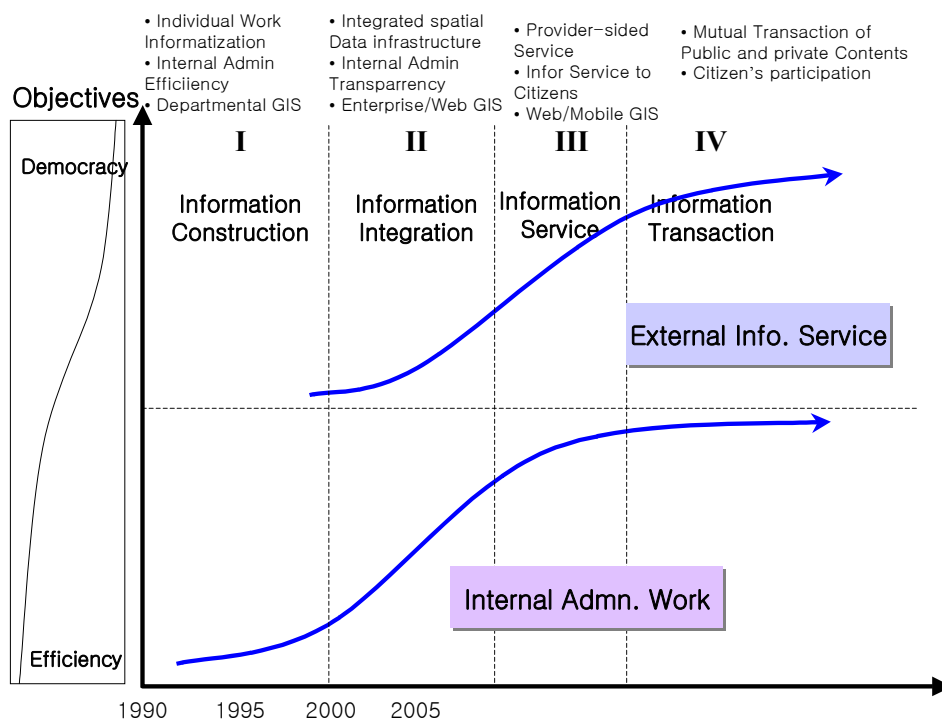
4. Development Stages for GIS-based Local E-government

For implementing local e-government, if we allow more participation of the citizen and enhancement of citizen services, without preparing information-based administrative work services such as online-one stop service, realtime-automatic information processing service, the officers will have difficulty in operating their services. It will be very difficult to realize democracy of citizen, with keeping the existing administrative office system. For this reason, it will be needed to share the information using information technology, to simplify office work procedures with efficiency, and based on them, eventually, to realize transparency and democracy in e-government.

The efficiency and democracy in outside-information service domain will be affected by degree of information infrastructure construction, and administrative work procedures. That is, the construction of an internal administrative system will affect the operation of the external information service system for citizens. For this reason, the internal administrative work domain should be informatized in advance.

With consideration of relationships of domains, each domain has a series of development stages as below. First, domain I will be evolved into domain II. In domain I, spatial information will be digitalized and the database will be constructed by work level, and applied to the work, but it will be difficult to go to domain III, IV due to lack of standardization and integration. Second, domain II will go to domain III. In domain II, spatial databases by an individual system will be integrated into one spatial data infrastructure and the information will be shared vertically and horizontally in the local government. Based on it, the user-sided citizen service will be implemented in domain III. Third, domain III will be evolved into domain IV. In domain III, various kinds of spatial

information will be open and served to citizens in the user viewpoint. From the review of the relationships among the domains, each domain is not separate, but rather a series of continuous stages with connecting each domain. If a domain has appropriate and enough situations and factors, it will be evolved into the next step of domain. As shown in figure 1, an administrative service will evolve from domain I to IV with fulfillment of required situations and components.

<Figure 2> Development stages for GIS-based local e-government

5. GIS-based Local E-government Development Strategy

Every local government has not started at the same level and time, and it did not have same periods of evolution. For example, a local government may start at stage I, but not enter into stage II, while another government may already on the stage II, preparing for stage III. These differences in situation of each local government may be more clear by the strategy to establish local e-government based on GIS with consideration of development

stages. In general, the factors to make the degree of satisfaction for an information system higher, can be said as quality of information, system, human services (DeLone & McLean. 2001; Pitt. 2001). With this viewpoint, the development strategy can be established based on development stages of the GIS-based local e-government proposed above.

First, the quality of information should be improved appropriate for each development stage, in order to develop local e-government by stage. The criteria to decide quality of information provided by local e-government are accuracy, up-to-dateness, completeness, variety, relevance, integrity of information contents. In order to get information contents with the satisfied data quality, we need the integrated strategy of information infrastructure by stages below; (1) the various kinds of information construction strategy such as text-based, spatial, image and multimedia information in stage I, (2) the construction strategy for an integrated spatial data infrastructure by integrating/linking spatial and attribute data in stage II, (3) service provider strategy utilizing integrated spatial data infrastructure in stage III, (4) the strategy sharing integrated spatial data infrastructure from the public and private sides.

Second, with recognition of the importance of advancement of system quality provided by local e-government, we need to differentiate the implementation strategy of local e-government by domain, because users and characteristics of the system in each promotion domain are not same, and for this reason, the system quality for each domain should be differentiated. In order to do it, we need the strategy of introducing 'Department GIS' for utilizing spatial information by department in stage I, and the strategy of 'Enterprise GIS' for sharing all information of the integrated spatial data infrastructure within a local government in stage II.

In stage III, the strategy of constructing spatial information service network by introducing 'Web GIS' will be needed in order to share and send/receive spatial information at anywhere and anytime. In stage IV, the strategy of introducing 'Mobile GIS' and '3D GIS' will be needed for various kinds of information with advanced visualization techniques services anywhere.

Third, enhancement of the quality of human resources should be needed for development of e-government, and it is closely related to get GIS human resources for constructing, operating and managing a GIS-based local e-government. The strategy of utilizing human resources outside the organization, because there will be limitation to use appropriate human resources with specialized techniques, knowledges, and various kinds of experiences inside the organization, with the changing environment such as fast changes in information

technology, complicated situation inside/outside the local government. In order to do it, we need to get specialized human resources for the system development in stage I, and for the system integration in stage II. In stage III, the specialized human resources for providing the established information services and responding the related situations will be needed, and in stage IV, we need the human resources for more various kinds of tailored services.

6. Conclusion

This research proposes a framework and strategy for utilizing GIS in order to realize a local e-government. For it, I propose a fundamental framework that represents what an electric government aims for and how to advance it and a series of development stages with regard to its strategy. The proposed model with development stages for an electric local government enables us not only to identify the development level for a government at a certain time, but also to estimate which direction the local e-government will and should go for. From it, we can expect it will have a role as the road map of local e-government development.

This research can be differentiated from other research by two points. First, the research proposes the development stages of the local e-government by categorizing implementation domains in terms of its purposes and objects, and by considering the relationships among the implementation domains, while others did not show explicit criteria to define development stages, rather usually applied by researchers' subjective decisions.

Second, the research applies the strategy of utilizing GIS to the development stages in order to improve the quality of information and systems for a successful local e-government. We will expect it to reduce some trial and errors that may occur during the implementation of local e-government. With regard to it, the previous research could not propose the systematic GIS utilization plan for developing local e-government.

This research has the limitation in that it could not verify the development stages of local e-government empirically; it established the development stages logically, with the background of GIS application system experiences such as Integrated Land Management Information System, Underground utilities management systems, but with a limited verification procedure.

With regard to it, the future research need to verify the framework, development stages and their strategies proposed here empirically. In addition, we need to find where a specific local e-government is in terms of the development stages, what is the problem of a

government at a certain stage in the future research.

REFERENCES

Accenture, 2001, *Governments Closing Gap Between Political Rhetoric and e-Government Reality.*

Atkinson, Robert and Jacob Ulevich, 2000, *Digital government: The next step to reengineering the federal government.*

Baum A. Di Maio, 2000, *Gartner's Four Phases of E-Government Model*, GartnerGroup Research Note.

CITU, 2000, *e-Government: A strategy framework for public service in the information age.*

DeLone, W. & MacLean, E., 2001, "Information Systems Success: The Quest for the Dependent Variable," *Information Systems Research*, Vol. 3. No. 1. 2001

Deloitte & Touche Study, 2001, *At the Dawn of e-Government: The Citizen as Customer.*

ESRI, 2003, *Enterprise GIS for Municipal Government,* ESRI: New York

Kauver, G., 1998, "Electronic Government: Concept, Visions, and Strategies", *Proceedings of International Symposium on Electronic Government*, Seoul: Korean Association for Public Administration: 276-286.

Landrum, T. B., 2001, "Enterprise GIS - Building a Strong Foundation", *Geospatial Information & Technology Association's 24th Annual Conference and Exhibition Proceedings*, San Diego, CA, March 4-7, 2001.

NAPA, 1998, Geographic Information for the 21st Century: Building a Strategy for the Nation, NAPA: Washington

Pitt, Leyland et al, 1995, "Service Quality: A Measure of Information Systems Effectiveness", MIS Quarterly, June 1995.

Sood, R., 2000, *State and Local E-Government Business Models*, Gartner Group Research Brief

OMB, 2002, *e-Government strategy*, OMB: Washington

UN, 2002, *Benchmarking E-government*: A Global Perspective, New York: UN

Current Policies & Challenges of NaGIS in Korea

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1. Backgrounds and Objectives

Advanced foreign countries have set up Geographic Information System (GIS) since 1970's in order to efficiently resolve such problems as environment pollution and disasters, and effectively manage and use maps and geographic information. As there is a rising demand and need for space information which use drawings and maps in the fields including space planning, resources, environment and anti-disaster, the GIS based on computer technologies has steadily widened its range of application, and seen its importance growing. The Korean government was also aware that the national GIS needed to be built in the 21C advanced-level informatization society, it introduced and started to set up the GIS centering on local governments and public institutions since 1995. However, since individual GIS project had been conducted independently on a public institution unit basis, it caused several issues including a lack of compatibility between developed database, and ineffective cost spending due to redundant investments across public institutions.

Therefore, the Korean government formulated 'the 1st national GIS master plan' which is purposed to establish a national space information base in a systematic and consistent way, and began the national GIS project as of May 1995. The master plan has key objectives as follow: to consistently push forward with the GIS project, curb redundant investments through a cooperation system between related parties, and systematically build and use national geographic information. Also, the plan has the following topics: national GIS policy direction, the establishment and management of basic geographic information, standardization, GIS application, distribution, technology development, human resources

training, and investment plans. Based on such a national master plan, Korea has systematically pushed ahead with the National GIS project under a leadership of the Government.

The establishment of National GIS NGIS) has an objective to effectively build a base for national space information, and provide various range of geographic information for the people. By doing so, the NGIS could help realize the efficient use of national lands and resources, and contribute to the development of national economy, in the end. Compared with foreign cases, Korean GIS policy has a distinctive feature which is the Government-led project in order to systematically implement the GIS project based on the national master plan.

2. The 1st NGIS Mater Plan (1995-2000)

'The 1st NGIS Project' aimed to lay a foundation for geographic information system under a key plan of 'the establishment of national space information for stronger national competitiveness and higher execution productivity.' During the 1st NGIS project period, the data including paper topographic and cadastral maps were uploaded onto the IT system. Also, a land use status map and other subject maps were drawn on a priority basis. As for paper topographic maps, they were drawn on a scale of 1 to 5,000.

During the period, the project focused on digitalizing national master maps, which is the backbone of national space information. Also, the project set out standards required for the database and developed related technologies. In addition, 「Act on the establishment & use of NGIS」 was enacted and enforced in 2000, which marked the completed construction of a foundation for NGIS.

During the 1st NGIS master plan, total GIS expenses including national and local expenses amounted to 278.7 billion won. About 46% of the total budget was spent for the establishment of GIS application system, and 42% for the establishment of basic geographic database.

3. The 2nd NGIS master plan (2001-2005)

The 2nd NGIS project (2001-2005) put its focus on the distribution network setup, standardization and human resources training as well as the expansion of space information

base under a key plan of 'Digital national land establishment.' Also, during the 2nd project the basic geographic database has been continuously set up, and the GIS application system has been established. The basic geographic database means the backbone of national geographic information including administrative district, transportation, maritime & water resources, cadastral, measurement standard level, topography, facilities, satellite picture, and aerial photo. As for the setup of basic geographic data, it focused on the improvement of national standard level, transportation & water resources, maritime basic geographic data. Also, each government body has pushed for the establishment of GIS application system based on the previously completed basic geographic database. In addition, NGIS distribution network was set up so as to share information among public institutions and provide an easy access to geographic information for people. The following table shows the summary of the 1st & 2nd NGIS projects:

<Table 1> The results of 1st & 2nd NGIS projects

Category	The 1st NGIS project	The 2nd NGIS project
Basic geographic database	• Digitalization of topographic, cadastral maps • National subject maps database such as landuse	• Framework database for each sector such as road, river, building and cultural asset
GIS application system	• Underground utilities maps	• GIS application system setup for landuse, underground, environment, agriculture, and marine.
Standardization	• GIS standardization for national basic maps, subject maps, underground facilities • Standardization for geographic info exchanges and distribution	• Standardization for basic geographic data, distribution, and application system
Tech. Develop	• mapping tech, DB Tool, GIS S/W tech development	• 3D GIS, high-precision satellite picture tech development
Distribution	• Initiation of national geographic info network pilot project	• Setup of national geographic information distribution network. total 139 types, about 700,000 cases registered
HR training	• training through informatization service business • Offline GIS training	• Online, offline GIS training • Training materials and practice program development

During the 2nd NGIS master plan period, total expenses are expected to amount to 498.7 billion won including actual exp. until 2004 at 388.3 billion won and 2005 budget at 110.4 billion won. To break it down, 56% of the total budget for the 2nd NGIS project was alloted to the establishment of GIS application system, and the 2nd biggest budget item is the establishment of geographic database which takes up about 31% of the total budget.

The investment result during the 1st & 2nd NGIS projects is as follow:

<Table 2> NGIS investment result

Category	The 1st NGIS project (1995~2000)	The 2nd NGIS project (2001~2005)
Basic geographic database	1,166	1,558
GIS application system	1,287	2,796
Distribution	-	221
Tech Develop	204	232
Standardization	14	45
HR training	76	81
Research	40	55
total (100 mil won)	2,787	4,987

4. Change in GIS condition and policy direction in the future

4.1.   Change in GIS condition and its prospect

The condition of GIS is rapidly changing with the technological development. The GIS condition is expected to change in the future as follows.

First, a wide range of government ministries in Korea are pursuing powerfully national information project to be developed as advanced information nation in the 21st century. Korean government is laying out the blue print to grow as knowledge and information powerhouse through 'e-KOREA VISION 2006' Ministry of information and communication establishes information infrastructure through IT83 strategy and Ministry of Administration government administration and home affairsis seeking for information advancement in

administration. GeographicInformation System (GIS), the core technology to realize e-government along with the newly introduced service and new growth engine promotion, is expected to develop as the main pillar in the national information.

Second, as the importance of geographical information is increasing everyday, the various socioeconomic activities in information will require more advanced use of GIS and its service. Its original simple function such as data establishment and management will be improved more state-of-the-art GIS which supports job process and decision-making. Currently, the application of GIS is expanding from the public sector including both central and local government to the various classes like general citizens and enterprises. Also more advanced applications will be available by connecting and converging each individual GIS to enhance the synergy effect.

Third, to improve the value of GIS applications, the establishment of demand-side GIS will be accelerated. Korea is driving forward e-government to improve the efficiency of public administration as well as service provided to the public. To that end, more evolving development of GIS is required in the public sector. In addition, geographical information service to satisfy various service needs such as the safety, health, welfare of the citizens and in particular, the application of location-based service will rapidly increasing.

Forth, to prevent mass production and redundancy of geographical information producedin both public and private institutions, the importance of reinforcing and guiding national geographical information infrastructure will be increasingly highlighted. In order to produce and manage the geographical information in every sector such as economy, society, and culture etc., with the widespread applications of geographical information and to efficiently utilize the geographical information established in different settings, the role of the nation like interoperability security will be more and more significant.

Fifth, the development of GIS which responds to the ubiquitous computing environmentwill be required, enabling the computing process anytime, anywhere by integrating the real and virtual space. As the technologies in information and communication, GIS, GPS and Sensor converges each other, the environment will be developed into the space where information exchanges between person and person, person and object, object and object are available. In addition, GIS, as the core element of ubiquitous technology, should be more state-of-the-art as opposed to the present.

4.2. policy direction of future GIS in Korea: the third phase of national GIS basic framework

The vision on the third phase national GIS (2006-2010) is "to create the infrastructure to realize ubiquitous land."During the first level of national GIS basic framework, the government focused on building the information infrastructure of national space, during the second phase, it aimed to set up the digital land by securing national space information. The third level of national GIS basic framework plans to build the necessary national information needed in one step higher ubiquitous computing environment. The land of ubiquitous is, by converging information technology centered on GIS, to integrate real and virtual space, on which public administration, civic service and new business activities will be created.

The strategies of the third phase national GIS is largely to expand and add substance of national GIS infrastructure, to maximize the application value, to build up user-oriented national space information, and to establish cooperation with national information business.

The national GIS infrastructure is the foundation necessary to build national GIS, such as basic geographical information, standard, education, promotion, institution etc. The foundation here should be maintained, managed and improved continuously according to the changing condition. In particular, global standard needs to be set, so that national standard is able to be registered as global standard befitting the changing global landscape and the level of technology. To further develop the national GIS infrastructure, the structure system should maintain itself to efficiently promote the national GIS, enhance the interoperability and the quality of geographical information and enforce the system maintenance and policy development.

The purpose of maximizing the value of national GIS application lies in raising the application value of the already established national space information to the highest level. The integration and convergence of various kinds of data or system creates the application value of national geographical informationand raise the synergy effect of application. More advanced system will be pursued to assist from the initial simple tasks to policy and decision-making. In addition, it is planned to proactively utilizeGIS in setting up the various space plans such as national plan, metropolitan plan, basic urban plan, in an effort to facilitate the existing achievement of GIS.

So far, he national GIS has been operated centering on suppliers. In the future, the national GIS is needed to shift from the current supplier- to demand-oriented. To enhance

the application value of geographical information, demand-sided GIS led by the public and the citizens and private enterprises etc. would be established and actively provided.

So far, the national GIS did not positively consider the close links with other sectors at the level of securing the national space information infrastructure. However, the national GIS application should promote the cooperative development with the related GIS technology and the relevant information policies. AS we've mentioned above shortly, in terms of more advanced national information, it tries to develop in connection with national information policies suchas IT839, Ministry of information and communication is seeking for, e-government establishment project and comprehensive administrative information of local government, Ministry of Administration government administration and home affairs is implementing. To achieve that goal, more close partnership through the divided role among ministries needs to be built.

There is the future primary project which will be pursued with top priories for the next five years starting the year of 2006, according to the third phase national GIS planning basis.

First, establishment, expansion and materialization of geographical information. Building the geographical information framework which was started in earnest since 2000 is planning to be finished by 2010, pursuing efforts for renovation project of basic geographical information will be continued and at the same time, the quality standard will be arranged.

Second, By expanding the establishment of GIS application system to maximize GIS application, the synergy effect of utilization, connecting the already established system, will be enhanced. In addition, for more smooth distribution and utilization of GIS data, one-stop integrated portal plans to be established.

Third, the development of GIS core technology befitting ubiquitous computing environment will be pursued. It is planned to develop the next-generation core GIS technology such as national information processing technology, national information maintenance technology, land information distribution technology etc. and through those technologies, the GIS application plans to be more sophisticated and to generate added value further.

Forth, to enhance the interoperability of national space information, national standard of GIS infrastructure will be secured by 2010 and the promotion activities will be empowered to institutionalize the national GIS standard and to raise the application.

Lastly, the promotion of more advanced national GIS policies. The assistant efforts to nurture GIS industry, GIS expertise will be enforced, and also promotion efforts of national

GIS importance and usefulness of application will be carried out. In addition, The materialization of national GIS business will be promoted throughthe evaluation of national GIS building project and feedback system.

5. Closing remark

The upcoming 10 years down the road is expected to be the most ciritical period in the information age in the 21stcentury. Recently, the ubiquitous computing environment is newly emerging as the mantra defining the informatization in the 21st century. The space information in the ubiquitous landscape is the critical part and one cannot image the ubiquitous setting without the space information. GIS opens the new chapter and the cyber land will be the container embracing the such a ubiquitous environment.

The US National Spatial Data Infrastructure: Why Is It Important? What Is New?

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ABSTRACT

Initially the major development focus of US Federal Geographic Data Committee (FGDC) and the National Spatial Data Infrastructure (NSDI) has been almost completely at the federal level. With time and much promotion, FGDC's vision has found its way into states and local governments. The central focus of the NSDI is carried into the current political administration through the President's management agenda consisting of 25 major programs with a vision to improve the federal government's value to the citizen by an order of magnitude. The challenge is to make information, data and decisions available in minutes or hours, not weeks or months to other government agencies and the general public. This e government (E gov) is focused on using digital technologies to transform government operations in order to improve effectiveness, efficiency, and service delivery. Geospatial One Stop (GOS) grew from this vision and raises the visibility of the strategic value of geographic information. It is another mechanism to accelerate the NSDI development in the US. Specifically it is to build framework data standards, breathe life into portal development, accelerate data inventory, and promote data and its application throughout the marketplace.

Concurrently, the FGDC, the NSDI and GOS began to look strategically at the next steps in the evolution of the NSDI. International examples of infrastructure development have

been examined and the strategy has been formulated with three principal goals: creating partnerships with purpose, making framework real, and communicating the message. The major message is that in order to create a truly national spatial data infrastructure, one needs to involve the people and data at the day ‑ to ‑ day working level ‑ cities, counties, and utilities. New and different policies and partnerships need to be developed before all meaningful data can be made available for critical decision making. This massive effort involves components of the US Federal Government as well as State, County, City, and community Governments. The team also has considerable input from NGOs and the private sector. Early findings indicate that it is critical to build a formal national council involving all potential generators, users, and distributors in the public and private sectors. This plan is being reviewed at the current time and will yield a completely new approach to building the US NSDI.

BACKGROUND

The world is quickly becoming knowledgeable on the application of Geographic Information Systems (GIS.) GIS will help all communities make better decisions more efficiently and effectively. These decisions are not just for scientists and engineers but for those dealing with social, health, demographic, emergency, disaster, and many related issues. A common reference system, common standards, and a common language ‑ a spatial data infrastructure (SDI) ‑ is essential for better governance and business advantages.

The SDI message is simple and over arching .... **GISs will not work unless the data fits together horizontally and vertically, ... and there are more chances that it will not fit together under most conditions today.** If one takes road center line files from federal, state, county, city, utility and other sources, the chances of them not matching by 1, 5, 10, 30, 50 or 100 meters or more are a very realistic. Then how do property boundaries; sewer, water, electric, and gas lines; subway tunnels; building foot prints; zoning boundaries; watersheds, land use; water, gas, and oil wells; land fills, and related phenomena fit and to which road network? When things do not fit, the user must either convert or even re collect the same data at great additional time and expense ... often time and money we do not have, particularly in emergency situations.

The answer is to encourage organizations that collect, process, archive, distribute, and use geographic data and information to do **so using common standards and interoperable systems and processes**. *Common data standards* means that one can easily convert data files

from one source to fit with data from other sources. *Interoperable systems and processes* means that users can collect data using one hardware system, and the resultant data can be used in another provider's software. Typically the data obtained from FGDC registered clearinghouses have met accepted standards and have been collected by interoperable systems and techniques. Some do not, but you can find that out in the metadata records without going through time consuming trials of analyzing full data sets. Clearinghouses can be found globally on the FGDC site. http://registry.gsdi.org/

There are many organizations promoting these values, but the three organizations devote full time and effort to the promoting and promulgating common standards and interoperability are: The Federal Geographic Data Committee (FGDC) charged with building a US National Spatial Data Infrastructure (NSDI) focusing on (among other things) on common data and metadata standards and policy barriers to data sharing; the Open Geospatial Consortium (OGC) is a group of principally (but by no means exclusively) commercial participants focusing on building system software and hardware interoperability specifications such that different hardware and software can work together; and the Global Spatial Data Infrastructure (GSDI) Association promoting building regional, national, and sub national SDIs around the world. Their message is crucial to those who want to use GIS as a decision making tool.

Why is this message critical? Let me give a simple example. My family and I recently traveled to state of Florida in the US for a short holiday. I used a common web mapping service to generate a map to use to get from the airport to the place we were renting on the beach.

The exit I wanted from the expressway to the bridge to the shore was not completely clear. It could have been 69, 68, 69A, 69B or 70. However, for the purposes intended, this was just fine. It really did not matter if I spent another 2 or 5 or 10 minutes on side streets trying to get to the bridge to the island. The reason for this apparent confusion and inconsistency with the exits and the street map is that the data may have come from at least two different sources. The Interstate Highway system (red) was probably collected by either the State of Florida or the federal government. The street maps were probably generated by the city or county. Both did their jobs well, and the products met their intended needs. Government managers met their mission and managed the taxpayer's money efficiently. However, each data set was probably developed using different standards. The two did not match exactly. Again, for my purposes they were fine.

Change the situation. Let us assume that it is an emergency vehicle trying to get to a hospital, and a few minutes could mean the difference between life or death to a patient. What if this was a hurricane, tsunami, or a just a flood, and we need to find a gas shut off valve, fire hydrant, electrical substation, subway air vent or exit, and time is critical to save many lives. It is essential that the data from multiple different organizations fit horizontally and vertically or we have another disaster piled on top of the original one.

Policy and business decisions based on the application of geographic data and information may not be as time sensitive. However, having timely, current, and relevant integrateable data is critical to good governance and business advantages. Consider two companies bidding on the same job. The one with the clear advantage will be the one that can apply data to the solutions quickly and effectively. The other company will experience delays and additional costs for modifying data to fit and/or completely recollecting it at greater expense.

Realities of data:

There are some basis realities about geospatial information that are disturbing and best and unacceptable at worst.

- Relevant data is often hard to find
- Frequently the data will be in incompatible forms
- Information describing data is often non existent

- Framework data does not exist for broad geographic areas
- Data sharing across organizations is inconsistent at best

A common framework is critical. Agreements are critical among those that collect, process, archive, and distribute disparate geospatial information do so using *common standards and interoperable systems and techniques…and share as much as possible via the web*. Without a common framework there is no way to quickly tie together the essential information used to coordinate any unified response. A unified framework and base information have been and will continue to be critical to emergency managers and government officials responsible for response and recovery efforts regardless of the type of disaster. This common framework is a spatial data infrastructure (SDI.)

Spatial Data Infrastructure (SDI) – what is it?

The single most important element to the success of decision making in good governance as well as any emergency response operation is the human contribution. Beyond that, standards for data quality and access become critical. What are these critical ingredients to a successful emergency operation requiring geospatial data and information? They correspond to the components of a National Spatial Data Infrastructure (NSDI.)

GEODATA — the actual geospatial data and information collected, processed, archived and potentially distributed by multiple agencies/organizations to meet disparate mission needs. It can be property ownership, political boundaries, land use/land cover, transmission lines, transportation/energy grids, geology, soils, surface and groundwater hydrology, demography, disease vectors, economic service areas, and many more.

META DATA — standardized data elements that describe the data (content, quality, condition, resolution, scale, time of collection, other times it was collected, areas of coverage, ownership, and other characteristics of the actual data)

FRAMEWORK — The most commonly used base layers of data. Frequently these base layers will most likely be different from location to location, and nation to nation.

Framework also identify the data features, updating processes, and data exchanging mechanisms.

CLEARINGHOUSE — A place for users to go to find out who has what data. Each Ministry may have their own clearinghouse or they may choose to contribute their metadata to another clearinghouse. The clearinghouse will also direct users to other sources of data.

STANDARDS — Most important to agree to use those standards promulgated by the International Standards Organization (ISO.) However ministries/nations are encouraged to contribute to national standards building and promulgate those standards to the ISO.

PARTNERSHIPS — fabric that allows all of this to happen efficiently and effectively. Collaboration to identify policy barriers and recommend practices and policies to overcome these barriers; to reach agreements as to who is the best data stewards for the principal data sets; promote data sharing; reduce duplication costs of collecting the same data several times; and extend local/national/global capabilities in technology, skills, and sharing.

What if ………..?

It is bad enough to have to deal with one disaster. Not having access to data and information that can be fully and rapidly integrated is another disaster.

Without common standards and interoperable practices, many of the emergency services, relief ministries, media, NGOs, academia, and private companies would have to generate their own views of the effected area(s) to remediate the effects of any disaster and its aftermath. The goal of a National Spatial Data infrastructure (NSDI) is to allow these groups to communicate, collaborate and leverage disparate assets and specialists in real time with a maximum of efficiency and effectiveness.

One Model

The United States has one model for the building of a National Spatial Data Infrastructure (NSDI), but it is only one model. This model works fairly well in the US,

but it may not work in other nations. There are several success stories, but there are lessons to be learned from those things that need improvement in the US model.

In the early 1990s the USA established a Federal Geographic Data Committee (FGDC.) Its goal is to promote and establish an NSDI. The responsibility was assigned to the Secretary of the Department of the Interior. In the US the Department of the Interior is responsible largely for managing the public lands of the federal government. It is not similar to many nations in which the Ministry of the Interior means the federal police. The FGDC is administratively assigned to the US Geological Survey (USGS), but it facilitates the work of the Secretary of the Interior.

The FGDC is an intergovernmental committee made up of 20 federal agencies who have come together to build the NSDI. The reader will note that the Office of Management and Budget (OMB) is not only a participant on the FGDC, but it is also a co chair or the Committee. The OMB is part of the President's Office that prepares and administers the annual budget for all US Federal agencies. This is not an accident. It makes good business sense to, not only involve this budget/policy making bureau, but to give them a leadership role in building the NSDI as well.

- ○ Department of the Interior (co chair)
- ○ Office of Management and Budget (Co chair)
- ○ Department of Agriculture
- ○ Department of Defense
- ○ Department of Energy
- ○ Health and Human Services
- ○ Housing and Urban Development
- ○ Department of Justice
- ○ Department of State
- ○ Department of Transportation
- ○ Environmental Protection Agency
- ○ Federal Communications Commission
- ○ Federal Emergency Management Agency
- ○ Library of Congress

○ NASA

○ Archives

○ Department of Commerce

○ National Science Foundation

○ Tennessee Valley Authority

○ General Services Administration

A staff of about 20 people have been assigned as the FGDC Secretariat . Their full time job is to support the Secretary of the Interior in building an NSDI through the FGDC. This staff is housed within the U.S. Geological Survey.

Functions of the FGDC

Over the years and currently, FGDC's mission includes collaboration to identify institutional barriers for the components of the NSDI eg. Policies that inhibit sharing data and identifying one ministry to be responsible for a data type. After identifying the barriers, the committee works to recommend policies that will remove these barriers and facilitate the building of an NSDI.

The FGDC also discusses, evaluates, and recommends the most effective ways to collect, process, archive, and distribute geospatial data and information. Ideally this leads to recommending data stewards the one best agency/ministry to collect, process and archive a given data theme. It makes little business sense for several ministries to collect the same data. It is duplicative and wasteful, particularly when governments have limited resources to support critical programs.

Another major task is to reach consensus on base framework data and mechanisms for update. The US has agreed on 7 framework data layers.

○ Transportation

○ Hydrography

○ Elevation

○ Cadastral

○ Political boundaries

○ Geodetic control

○ Ortho imagery

For good reasons, it is unlikely that all nations or governmental components will agree on one set of base framework data layers. Framework data is often considered that data commonly found on maps. It is only important that your NSDI body reach consensus as to the base data layers and which organizations will maintain the respective data themes.

Framework does not stop at identifying the base data layers. It involves a feature based model; permanent and unique feature identification codes; reference to modern horizontal and vertical geodetic datum(s); seamless integrated data for adjacent or overlapping geographic areas; and it reaches into the development of the metadata model. It also has operational aspects to include transactional changes; access to previous data versions; and allows for location of data from and through the Geospatial One Stop portal.

Agreement of metadata development and standards is another critical component of the NSDI mission. Metadata is really data about the data. It typically tells one something about the data scale, resolution, time of collection, coverage, other times the steward collected the same data, etc. It allows a user to quickly review multiple sources of data and decide which data set best fits his or her application without having to spend considerable time reviewing each data set. The metadata standard, among other things, identifies the number and types of data fields to be included in the metadata. Frequently, data providers balk at having to fill in all data fields because of the alleged amount of time required. The US metadata model calls for 22 data fields. However, it allows data stewards to fill in 8 critical fields for it to be considered fully metadata compliant.

Yet another task assigned to the NSDI is promoting clearinghouse development. The clearinghouse is a decentralized system of servers located on the internet that contain field level descriptions of available digital spatial data. The metadata facilitate query and consistent presentation across multiple participating sites. The Clearinghouse functions as a detailed catalog service with support for links to spatial data and browse graphics. Clearinghouse sites are encouraged to provide hypertext linkages within their metadata entries that enable users to directly download the digital data set in one or more formats. Where digital data are too large to be made available through the Internet or the data products are made available for sale, linkage to an order form can be provided in lieu of a

data set. Through this model, clearinghouse metadata provides low cost advertising for providers of spatial data, both non commercial and commercial, to potential customers via the Internet.

The Portal is an outgrowth of the clearinghouse concept. It is a super clearinghouse. Conceptually it is one place in any one given nation where anyone can go to learn what data exists nationally, its associated metadata, and how to get it. Additionally, the portal will provide web services such mechanisms to view the data form many sources, integration and analysis models, and other capabilities.

Incentives

Providing new policies to reduce or remove barriers is important. Frequently, however, using policy is viewed by participants as forcing compliance. Another route is to cajole others into compliance by providing incentives for their full participation. The US model has developed the Community Agreements Program (CAP) Grants. The CAP provides seed funds to engage organizations in building components of the NSDI, which can include metadata documentation, national standards development and implementation, clearinghouse and web mapping, and framework development, and collaboration. The CAP is open to all U. S. organizations and seeks new participants annually. With the goal of GIS infrastructure development, the CAP program does not support GIS startups, data collection, or data purchases. Annually the NSDI allocates between $300,000 to $1,500,000 USD toward the program.

Policy support:

As mentioned earlier, policies issued from the highest levels frequently aid in building a NSDI. The US model has several policies that help in this.

First, the US government has a long standing policy that the taxpayer has already paid for the data collection, archive, and processing. As such, the data can be provided free to other agencies, commercial sector, and citizens except for the cost of reproduction and distribution. This policy was issued as the Office of Management and Budget (OMB) Circular A 130 and is a major contributor to the concept of open sharing that the US enjoys. This is an OMB directive. It is not a public law that was passed by congress.

However, OMB has the political clout to enforce these rules, because it controls the budgets of all of the federal agencies.

Another policy that was enacted many years ago – well before the FGDC was institutionalized – is the OMB Circular A 16. In its original form, the circular assigns the all responsibility for geographic data collection and coordination to the Department of the Interior (DOI). This does not mean that it is the only agency that can collect geospatial data. However, the DOI must know about it and agree that the effort is not duplicative and wasteful.

In 2002 the FGDC and the OMB published an upgraded version of the A 16 circular that assigns greater enforcement authority to the FGDC regarding geospatial data collection, archive and update. This newer version requires every agency that has geographic data responsibilities to report on the level of effort associated with their collection, archive and update activities as well as the measures the agency is taking to meet the NSDI component expectations. Such activities as: metadata development, populating their clearinghouse or providing their metadata to another clearinghouse, complying with or contributing to data standards and interoperability specifications, and the like. The A 16 is considered the backbone of the FGDC.

http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html

OMB Circular A 119 authorizes and encourages federal agency participation in the development and use of voluntary consensus standards in conformant assessment activities.

In 1994 President Clinton signed Executive Order 12906 recognizing the need for improved means for finding and sharing geographic data and information. This order called for the establishment of a coordinated National Spatial Data Infrastructure supporting public and private sector applications of geospatial data in such areas transportation, community development, agriculture, emergency response, environmental management, information technology, and related fields. Essentially this executive order laid out activities promoting data sharing among federal, state, and local governments, citizens, private sector, NGOs, and academia. The purpose was to make accurate and timely geographic data readily available to support sound decisions over a geographic area to do so with minimal duplication and at a reasonable cost.

http://www.fgdc.gov/publications/documents/geninfo/execord.html

At the start of the current administration, President Bush called for the building of a Presidential Management Agenda that asks policy makers to focus on several critical areas.

One of these areas was to implement e gov and e com programs. This is another case of policy driven from the highest levels benefited the creation of an NSDI. This generated the Geospatial One Stop program that will be covered later in this paper.

   A list of all of the policies supporting the creation of the US FGDC can be found in the booklet on the OBM Circular A 16 titled "Coordination of Geographic Information and related Spatial Data Activities" and published by the FGDC.

<div align="center">http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html</div>

Where is the US NSDI currently?

Since it started the NSDI has been successful in:

- Gathering high level support through three completely different political administrations
- Recommending and receiving policy encouragement
- Building an elaborate network of partnerships reaching beyond the purely federal structure into states, NGO, academia, the private sector, and communities
- Major player in the national and international standards organizations for data standards development
- A partner with the Open GIS Consortium (OGC) and the private sector in interoperability specifications promulgation
- An interrelated global network of 277 clearinghouse nodes is available for users
- Open policy for federal spatial data sharing
- Major contributions to the development of a Global Spatial Data Infrastructure
- Many more noteworthy accomplishments

WHAT'S NEW?

While it is clear that the FGDC and NSDI have come a long way in the last 14 years, there is still much to do. If the goal is to build a truly national spatial data infrastructure, it not sufficient to have federal stakeholders exclusively in the decision making positions. Typically, when a disaster hits a region, resource and emergency managers want working level data. It is not sufficient to have fully integrated data at the federal and state level only. It is essential to have city/community scale information fully integrated as well.

Geospatial One Stop

Geospatial Information One Stop was instituted as a part of the President's Management Agenda under the heading of Expanding E Government. It focuses on moving to a citizen centered way of providing information and services to constituents. Geospatial Information One Stop will provide a geographic component for use in all E Government activities. Geographic Information (GI) is a national asset, an essential requirement for just about every program at every level of government, and one of the key elements underlying the President's Management Reform Agenda.

The Geospatial One Stop is an important element in the overall national effort of achieving a common vision of accurate, accessible geospatial information for the nation that will transform the way government at all levels addresses the increasingly complex issues of the 21st century by using geographic information to:

- Simplify and unify business processes
- Respond to the information needs of citizens, producers and users of GI everywhere
- Integrate and engage the coordinated effort of government at all levels, and the private sector
- Align resources and foster co investment in GI among all levels of government
- Collect data once and uses it many times
- Provide easy and secure access 24/7 to current, accurate GI
- Enable timely and improved decision making for Homeland Security

These actions seem much like some of the original actions of building the NSDI. Essentially that is true. It is actually a mechanism to keep the pressure on – to keep the principals of building a NSDI in front of policy makers.
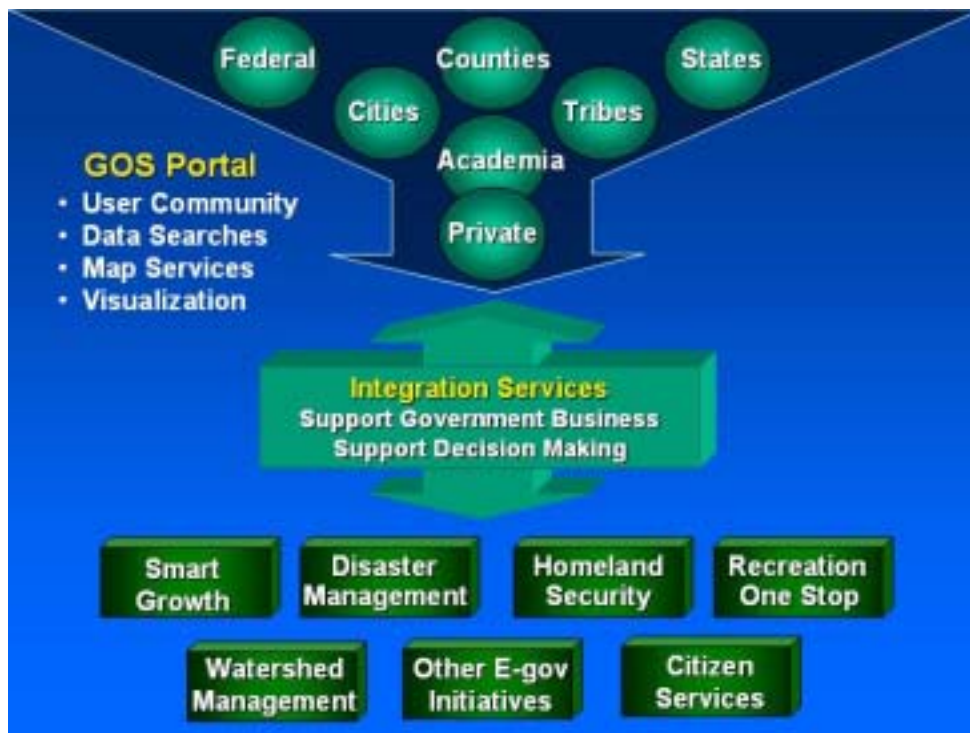
The Portal

A central point of the Geospatial One Stop program is building a portal. The portal is essentially a window or funnel to locate and view distributed geospatial data holdings from key communities or stakeholders such as the federal, state, local, tribal, acedemic and private sectors. This data coupled with geospatial data integration and services can be used to support the businesss of government with enhanced decesion making tools.

The centerpiece of the Geospatial One Stop strategy is geodata.gov. The initial implementation of the Portal designed is to facilitate publishing and searching of metadata, and enable viewing live web mapping services, is known as GeoData.Gov, and will feature intergovernmental and private sector collaboration. The National Map, led by the U.S. Geological Survey, as a starting point. It will allow easy searches for existing and planned data with a goal of "two clicks to content."

The portal is based on a distributed architecture allowing all the data to remain with the data owner. However, metadata from NSDI Clearinghouse Nodes will be harvested and copied to a centralized database for faster search and retrival. In addition a central inventory of live web map services will be published in the portal and made available for viewing.

The portal is an Internet based organizational umbrella for federal agency data categories or channels addressing geospatial activities. Data Category teams or 'stewards' from the communities of interest are forming to actively seek and monitor available thematic geospatial data products and services, assess and promote premier thematic data products, and showcase real success stories.

FUTURE DIRECTIONS

It is clear that the NSDI has come a long way in forging partnerships and streamlining mechanisms for data availability. However, one of the serious shortcomings has been that federal stakeholders exercise principal management and control. Others like states, counties, communities, NGOs, the private sector, etc. are encouraged to play significant roles. None the less, the federal establishment controls the vote.

If one is to build a truly national spatial data infrastructure, one needs to provide fully integrated geospatial data all the way to the ground and under it. It is critical to involve all those that collect, process, archive, use, and distribute such data in the decision making process.

Ideas and perspectives for the Future Directions Initiative were solicited and collected through interviews, Coordination Group meetings, workshops, forums, staff meetings, and conferences held between December 2003 and April 2004. Out of this a vision was formulated.

Vision - Current and accurate geospatial data will be available to contribute locally, nationally,

and globally to economic growth, environmental quality, sustainability, and social progress.

Three key actions were articulated repeatedly - Forging Partnerships with Purpose, Making Framework Real, and Communicating the Message   providing the structure for the goals, objectives and the strategic action plans of this initiative.

Forging Partnerships with Purpose — It is critical to engage people that deal with digital data at all levels from the smallest to largest scales. Mechanisms need to be developed to put city/county/utility practitioners on the FGDC Steering Committee with a full voting rights. Their concerns for things like policy barriers, and intellectual property rights need to be treated along with the concerns for those that deal with smaller scale data. A new governance model needs to be developed.

Making Framework Real — As in forging new partnerships, data managers from states, communities, utilities need to be involved in day to day decision making for building a truly national SDI. Framework categories defined by the federal sector at scales of 1:25,000 and smaller, probably have little meaning to public and private utilities. Similarly, data standards defined by the federal sector probably do not co line with cities and counties/provinces. Accordingly if the US is to build a NSDI truly to the ground, definitions for standards and framework need to be reconsidered.

Communicating the Message — To become recognized across the nation as the primary source for the availability and use of reliable spatial data.

The future directions plan:

Toward the vision and these goals, in 2004, the Federal Geographic Data Committee (FGDC) and the U.S. Geological Survey's National Geospatial Programs Office (NGPO) jointly established an action team to develop recommendations for the future governance of the National Spatial Data Infrastructure (NSDI). The team included broad representation from federal, state, and local governments, from the private and non profit sectors, and from academia. They reviewed reports and recommendations on the NSDI and examined effective cross jurisdictional governance models that oversee geospatial data. They also conducted focus group discussions and interviewed key stakeholders to gather input and

recommendations.

Findings:

Geospatial data and information has been identified as a useful asset in conducting the business of government, and in the post 9/11 era there is a heightened appreciation for the importance of geospatial data to support homeland security needs and other critical requirements.   The team witnessed continued frustration among users of geospatial information over unresolved issues relating to data production and access.   There is a clear sense of urgency that these problems need to be resolved in a timely and comprehensive manner.   Several consistent themes emerged from the team's outreach and consultation process.   There is wide agreement that NSDI governance requires strong national leadership, that all sectors should be represented in the governance process, that stable funding and political support are required, and that an effective NSDI requires a clear national strategy to complete and maintain the base framework layers.   They found a broad consensus that a strong and renewed national focus is needed to drive the nation toward production of highly accessible, accurate, and reliable geospatial data.

Recommendations:

Consensus was reached on the following recommendations:

- **The FGDC should make immediate improvements to its policies and business practices.**

These improvements include development of a revised NSDI strategic plan and accountability measures, closer coordination of subcommittees and working groups, and implementation of the new "Fifty States Initiative."   The FGDC should establish more formal relationships with the Federal and State Chief Information Officers Councils and with the Office of Management and Budget's (OMB) Federal Enterprise Architecture office.   In addition, there is a critical need for the FGDC to ensure that member agencies avoid duplication of effort and maximize the benefits from state, local, and tribal grant programs to support the development of the NSDI. To provide this level of oversight FGDC should

improve coordination, support training, and disseminate best practices for its member agencies.

- **A National Geospatial Coordination Council (NGCC) should be established to provide national leadership in the development of the NSDI.**

The purpose of the NGCC will be to ensure the development and coordination of the nation's geospatial resources to provide accurate and reliable data for decisions regarding the security, health and welfare, and prosperity of our citizens. It should also include appropriate levels of representation from all stakeholder groups involved in the NSDI, including federal, state, local, and tribal governments; private and non profit groups; and professional and academic organizations. Specifically, the Council should develop the linkages among the FGDC and the state and local jurisdictions. It should also develop a means to grow the NSDI with data most commonly needed for emergency responses as well as day to day decision making. The NGCC should be created initially by administrative action – either through Executive Order or through creation of a Federal Advisory Committee Act (FACA) organization. Ultimately it should be permanently authorized through statute. The team also recommends the creation of a significant grants program, to be administered through the NGCC or other appropriate mechanism, to promote the further development of the NSDI.

- **The Federal Government should improve its oversight and management of federal geospatial programs and investments**

A new investment analysis function should be created within the FGDC to provide assistance to OMB in the analysis of federal geospatial investments, portfolio management, and assessment of return on investment. In addition, a strong geospatial leadership function should be reestablished within OMB to provide support and guidance for NSDI implementation.

● **Implementation:**

   The team proposed a phased implementation strategy for these recommendations, with implementation to be staged over the next several years. The FGDC Steering Committee, in consultation with stakeholders, will consider the recommendations in this report, modify the recommendations as appropriate, and take action to pursue their implementation. As of this writing the Steering Committee is populating the working group with people from the Steering Committee and a few others from NGOs to review the Future Directions report recommendations and suggest a model to follow and build a plan for implementation.

Conclusion

   The US Federal Geographic Data Committee and the National Spatial Data Infrastructure have evolved for the last 14 years. The movement has lived through three completely different political administrations because it promotes better governance – doing things better, faster, cheaper. 'Collect it once; use it many times.' Making data available in a usable form to governments and the public. To live through three different administrations, is not an accident. The right policy makers needed to play leadership roles in NSDI development. The over arching message stays the same, but the focus changes slightly to meet the needs of policy makers of the day.

   This is just the US model. It is only one example. What works here may not work in other nations. The goal of the NSDI plan for any nation needs to fit the needs of the respective nation. In convincing Ministry level officials, however, I am certain that they will resonate with making government more efficient and effective.

References

Future Directions – Governance of the National Spatial Data Infrastructure; Final Draft Report of the NSDI Future Directions Governance Action Team, May 31, 2005; http://www.fgdc.gov/FutureDirections/Final%20Draft%20FD GOV%20Report%205 31 05.doc

U.S. Presidential Executive Order 12906 of 1994;
    http://www.fgdc.gov/publications/documents/geninfo/execord.html
U.S. Office of Management and Budget Circular A 16
    http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html

NGIS Related Activities In Japan and It's Future

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1. INTRODUCTION

With the dawn of post industrial society in the true sense, our society is rapidly turning into an information based society. Advances in science and technology propel digitization at a great speed, enabling us to capture a wide variety of information, to create a processing model of phenomena, and to simulate various models ranging from microcosmic environment exposure assessment to macrocosmic climate change on a global scale. As a result, our recognition of the real world has vastly changed. NSDIs (National Spatial Data Infrastructures) that facilitate the more effective use of national geographic information resources are core contents from the above viewpoints and require governments to take a much more proactive role. This view is evident in the Executive Order signed by U.S. President Clinton entitled "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure" (Executive Office of the President). This gives a good overview of the driving forces that lay behind the U.S. government's thinking with respect to the need for an NSDI.

----Geographic information is critical to promote economic development, improve our stewardship of natural resources, and to protect the environment. Modern technology now permits improved acquisition, distribution, and utilization of geographic (or geospatial) data and mapping. The National Performance Review has recommended that the Executive Branch develop, in cooperation with state, local and tribal governments and the private sector, a coordinated National Spatial Data Infrastructure to support public and private

sector applications of geospatial data in such areas as transportation, community development, agriculture, emergency response, environmental management, and information technology (Executive Office of the President 1994).

Since this publication, many countries throughout the world have taken steps to establish NSDIs. Liaison Committee of Ministries and Agencies Concerned with GIS, established in 1995, has an actual function of discussing NSDI in the government of Japan. In this paper, Japan's recent GIS and NSDI related activities are described in its entirety. The paper covers four topics. The first topic is **digital map preparation**, which was introduced about 25 years ago. At that time, there was no such concept as spatial database, and efficient map digitization was the main research problem. The second topic is a **study for the promotion and dissemination of GIS** in Japan. Two reports were published in this study and the summaries of the reports are provided. The third topic is about the **NSDI and Spatial Data Framework**, which was developed under the new concept of spatial database. The fourth topic is **recent GIS and NSDI related activities in the age of ubiquitous computing environment** by the Japanese government. Information on current activities and the policy of Japanese government are presented in this section. In the conclusion, discussion about where lies the future of geospatial sciences and geospatial market in Japan are provided.

2. DEVELOPMENT AND PUBLICATION OF MAP DATA

2.1. Outline

The development process of GIS infrastructure in Japan can be explained in four phases. Phase I began in the middle of the 1970s when the government started preparation of digital geographic data for only limited users such as central and local governmental organizations and researchers at universities. Phase II arrived when the Geographical Survey Institute (GSI), Ministry of Land, Infrastructure and transport (MLIT) began to publish digital cartographic data sets in 1993. Phase III started in 1995 when the government reached a consensus that the active encouragement of GIS development was necessary. At present, Phase IV is approaching when the preparation of spatial database in accordance with a standard is important. In this section, phases I and II are explained. Phase III and IV are described in the following sections .

2.2. Development of Digital National Land Information

The Japanese government has been developing digital geographic information since the mid 1970s. As its initial activity, GSI began to develop the "Digital National Land Information" in 1974 in cooperation with the National Land Agency, and was nearly

completed in 1980. Its accuracy corresponds to approximately 1:200,000 paper maps. It consists of DEM, land use data, boundaries of local governments, major roads, railways, rivers, coastal lines, public facilities, etc. The purpose of this project was to supply basic digital geographic data necessary for national land development planning and regional planning by the central governmental agencies and local governments. It has also prepared the "Detailed Digital Land Use Data" to support the policy making of building land administration in collaboration with the Economic Affairs Bureau of MOC since 1981. It is a data set of grid cells for land use (10m square on the ground) for three major metropolitan areas (Tokyo area, Osaka area, and Nagoya area), and each area is surveyed repeatedly every 5 years. These data sets have been highly reputed for they have enabled quantitative analysis of national land. However, they have been specially prepared for administrative purposes, therefore they have not been disclosed to the public but used only by administrators within the central and local governments and researchers at universities.

2.3. Publication of Digital Geographic Information

In June 1993, GSI launched into the publication of digital cartographic data sets called the "Digital Map Series". It was extremely epoch making. Since then, the variation and number of published digital cartographic data and software that apply those data have increased, and as a result, people have gradually come to recognize the benefits of geographic information. Nine kinds of "Digital Map Series" are available at present. They are "Digital Map 10000 (total)," "Digital Map 25000 (shore lines and administrative boundaries)," "50 m mesh (elevation)," "250 m mesh (elevation)," "1 km mesh (elevation)," "1 km mesh (average elevation)," "Digital Map 25000(Map Image)," "Digital Map 2500(Spatial Data Framework)," and "Digital Map 200000 (shore lines and administrative boundaries)". They are text files and distributed via CD ROM with simple software for quick browsing of the image of inside data.

3. STUDY FOR THE PROMOTION AND DISSEMINATION OF GIS

Today, the Japanese government is making great efforts towards the development and utilization of GIS, recognizing the necessity and important role of GIS in this highly advanced communications oriented society. In order to establish new strategies related to GIS, during 1995 96, the headquarters of MOC (Ministry of Construction) and GSI have jointly organized the GIS Research Committee.

3.1. First Report

The First Report by the Committee was presented on February 2, 1996. The title of the report is "Plans for the Development of National Spatial Data Framework throughout Japan". Its contents are summarized as follows.

3.1.1. Urgent need for preparation of a National Spatial Data Framework

The growth of the "Information Highway" makes it all but impossible to ignore the fact that we have truly entered the computer age, or age of information. Aside from the novel aspects of the information highway, this era offers an unprecedented opportunity to maximize efficiency in social areas. Yet most attention has been focused on the popular aspects of the highway. An equally important factor is the "National Spatial Data Framework". The Spatial Data Framework, which uses geographic information as a base, deals in all data that can be classified geographically.

3.1.2. Spatial Data Framework needs to be standardized

It is essential to standardize the Spatial Data Framework in order to ensure efficiency and accessibility in the following three areas.

a) Standardization of the National Spatial Data Framework

As some public organizations have already made electronic maps, it is highly likely that some will prepare the Spatial Data Framework suited to their unique needs. It is needed to standardize Metadata, which indicates Spatial Data specifications in detail. This standardization, which will be easily referred to, will make it possible for users to judge whether or not it meets their unique needs.

b) Standardization of Geo reference

In order to correspond Spatial Data to geographic locations, it is necessary to give precise axis coordinates of latitude and longitude. Most Spatial Data indicates addresses in conventional form. Therefore, it is necessary to shift to geo reference standards, using an address matching system which replaces conventional addresses with coordinates.

c) Standardization of Software

In GIS, which processes Spatial Data, there are various systems at work; these systems are developed to meet individual user needs. However, certain basic functions are used in all systems in common, regardless of user interest. In all probability, standardizing these basic

functions would help to broaden the appeal of GIS, thereby promoting its use.

3.1.3. Spatial Data Framework promotion policy

a) Sponsorship of the Spatial Data Framework

MOC(Ministry of Construction) is expected to take a leading role in promoting the preparation and standardization of the Spatial Data Framework. GSI, which is under MOC jurisdiction, is responsible for the country's basic map information, as well as public facilities, such as the nation's roads and rivers. In this endeavor, the Ministry of Construction should work closely with a team of other government agencies. Support will also be offered to regional public offices which, in order to improve their administrative services, will be called upon to prepare minute Spatial Data Framework. To lighten the financial burden of these offices, there will be cost sharing plans among Spatial Data Framework users, along with financial support from the government.

b) Building a system of information exchange

A system of information exchange, which will link users and data suppliers in one network, is a viable method with which to address user inquiries. Such a system, referred to as "Clearinghouse," enables users to properly locate and utilize the Spatial Data Framework.

c) Renewal of the Spatial Data Framework

If the Spatial Data Framework is to be effective in the long run, it will need to be modified or renovated as the need arises. This and other options will require a new framework for the maintenance and administration of the Spatial Data Framework.

d) Financing the preparation of the Spatial Data Framework

Apart from the initial large investment of money, the Spatial Data Framework will also require funding for management, maintenance, and ongoing modifications. The government should ensure that funds are allocated not only in this endeavor, but also in the basic promotion of the Spatial Data Framework throughout the country.

e) International standard

As the growth of information systems or the worldwide web is creating a new era in which people can access information in real time regardless of distance, an international standard on geographic information must be sought. To this end, Japan is participating in the international standardization activity of the ISO (International Organization for

Standardization) on GIS. Such participation in international standardization projects, as well as close cooperation with domestic fields such as business and academia, should be supported and encouraged continuously.

f) Conversion of accomplished concept

The Spatial Data Framework will, in the foreseeable future, eliminate the need for paper to be used to transmit information formally; instead, information, such as maps or any paper documents, will be transmitted electronically. Aside from being more efficient, such changes will serve to promote the use of Spatial Data Framework.

g) Preparation of an information communication network

In order to expand the utilization of GIS, there is a pressing need for the preparation of a high capacity information communication network, such as the optical fiber network.

3.2. Second Report

The Second Report was disclosed on May 30 the same year, which states:

3.2.1. Need for GIS introduction

GIS is the most important information system that utilizes the rapidly developing Information Highway. It is indispensable for executing high quality administrative services in diverse fields such as registration affairs, supplying administrative information to the citizens, information exchange among administrative organizations and regional inhabitants, and crisis management in the case of a disaster. In order to guarantee a rich and comfortable social life, and to realize effective and highly transparent administration, administrative organizations should immediately establish Spatial Data Infrastructure and tackle appropriate measures for the importation of GIS.

3.2.2. Administrative measures to be taken place

Spatial Data Infrastructure is so important in the era of the Information Highway that official bodies, such as GSI, facility administrators, local governments, and public utility enterprises, should take the lead to develop it. It is necessary for the central and local governments to discuss the establishment of a new framework for the effective revision of Spatial Data Infrastructure that can be achieved automatically through their respective routine activities, so as to assure the mutual utilization of revised information. Besides, in

order to secure mutual and flexible use of various information, it is essential to standardize metadata and location referencing by liaison with international standardizing activities.

Government, local governments, and the private sector should widely recognize that spatial data, which are prepared by themselves under the proper standards, have important meaning as infrastructure, and should open it to the public. In order to obtain information on the existence of these data and share their benefits, a system that connects data creators, managers, and users via network, namely a clearinghouse, should be established. Measures for the accelerating the positive utilization of GIS by administrative organizations, development of a high speed communication network, and necessary legal institutions should be discussed. It is desirable that GSI, together with other governmental organizations, local governments, and facility administrators, promote the preparation of the Spatial Data Framework, and complete it for the most part by the beginning of the 21st century.

3.2.3. Immediate actions for the promotion of the above mentioned measures

In order to promote the policy so that it can be dealt with smoothly, it is necessary to start a model pilot project to encourage the understanding and popularization of GIS and Spatial Data Infrastructure, clarify institutional and technical issues for the promotion of mutual utilization of Spatial Data Infrastructure, and take measures to solve those issues. Through these reports, the Committee clearly indicated the importance of GIS for the development of society, and the government was requested to make increased efforts towards the development of Spatial Data Infrastructure and standardization of spatial data for GIS.

4. RECENT GIS RELATED ACTIVITIES BY THE JAPANESE GOVERNMENT

Liaison Committee of Ministries and Agencies Concerned with GIS, established in 1995 to promote the efficient development and based on the above reports, effective utilization of GIS within the Government and has an actual function of discussing NSDI.

4.1. First Long term Plan for the Development of NSDI in Japan

The Liaison Committee developed a first Long term Plan in 1996 for the development of

NSDI in Japan. The Plan specifies actions to be taken by the Government during a two phase period starting in 1996 up to the beginning of the 21st century. The first phase focuses on the definition of NSDI in Japan as well as standardization of metadata and clarifying the roles of the central government, local governments, and the private sector, rather than actual spatial data development. The implementation of NSDI including spatial data development for NSDI is expected to take place in the second phase. Approximately three years have been designated for each phase, i.e., first phase (1996 99) and second phase (1999 2001).

4.2. Pilot Study by Local Governments for the Implementation of the Long term Plan

The definition of NSDI, one of the main subjects of the first phase of the Long term Plan, requires intensive research on the availability, utilization, restriction and distribution of maps and spatial data in local governments, because they develop and maintain most of spatial data sets in Japan. GSI and NLA are conducting a collaborative pilot study in fiscal year(FY) 1997 with four local governments to do such research. The main topics of the pilot study include: which spatial data item should be included in the Spatial Data Framework of the Japanese SDI; who should develop and maintain such data items; and which information would be most suitable for indirect geo referencing. The result of this pilot study was summarized in Interim Report of the Long term Plan at the end of FY 1997. Additional Ministries, i.e., the Ministry of International Trade and Industry (MITI), the Ministry of Posts and Telecommunications (MPT), and the Ministry of Home Affairs (MHA) joined the pilot study in FY 1998 starting in April 1998. The research topics of these Ministries in the pilot study are as follows: MITI will develop new information systems with GIS and foster related industries; MPT will focus on the development of a spatial data search engine through computer networks, spatial data encryption methods to protect private information, and spatial data compression for efficient data distribution; and MHA will investigate technological and institutional issues of local governments related to NSDI development. The results of these pilot studies were incorporated into the final report of the first phase of the Long term Plan, which will direct the implementation of NSDI during the second phase.

4.3. Final Report of the First Phase

The Committee adopted the Final Report of the First Phase of the Long term Plan on March 30, 1999. The Final Report entitled "Standards and Development Plan of National Spatial Data Infrastructure" includes two standards of Japanese NSDI (i.e., a technical standard that is based on ISO/TC211 standard drafts, and a list of data items adopted as the framework data) and a development plan for the second phase of the Long term Plan.

Table 1 shows the list of data items for the Japanese framework data.

Table 1. List of Data Items for Spatial Data Framework

Geodetic Control Points	National and Public GCPs
Elevation	DEMs
Transportation	Road Network, Road Boundary, Railroad Network
Rivers, Coastlines	River Network, River Boundary, Coastlines, Low Tide
Land	Parcel Boundary, Forest Boundary
Building	Public Building, Privately Owned Building
Georeference	Geographic Names, Address, Administration Boundary, Census Boundary, Standard Cells

4.4. Interim Agreement of Implementation of Second Phase

The Liaison Committee agreed upon its targets and specific action to facilitated development and utilization of GIS. The first target is a digitalization of geographic information and its provision service through internet. GSI has prepared a new type of digital cartographic data sets called a Spatial Data Framework (SDF). There are two types of SDF. One is SDF2500 (Digital Map 2500) which is for city planning area for all of Japan, the other is SDF25000 (Digital Map 25000) which is for whole Japan. GSI develops SDF2500 by FY 2000 and SDF25000 by FY 2001. NLA develops geo referencing data for districts. The target year for starting internet service is, FY 2000 for geo referencing data, FY 2001 for SDF2500, and FY 2002 for SDF25000. Table 2 indicates the content of SDF2500.

The second goal is development of metadata, the one whose digitization is delayed, in parallel with basic geographic information and establishment of clearinghouse for data sharing within the government to minimize redundancy and also to enable an easy access from private sectors. The governmental clearinghouse started in March, 2001. The third point agreed upon is standardization of geographic information developed by GSI and private sector in accordance with the Japanese Industrial Standard. In January 2001, National Land

Agency was integrated into the Ministry of Land, Infrastructure and Transport by the recent government restructuring.

Table 2. Contents of the Spatial Data Framework 2500

Item	Data structure	Attribute
Administrative boundary and coastline ('Cho-Chomoku' and 'O_Aza' (municipal section) as the minimum area units	Polygon, arc, point	Administrative code, name of each municipality
Block	Polygon, arc	Block code ('Ban')
Road line network	Vector, network	Name of each road
Road center line, boundary of road and sidewalk, boundary of road site (national highways only)	Vector	Name of each road
River center line, boundary of each river site (only for major rivers)	Vector, polygon	Name of each river
Railways and stations	Vector, point	Name of each railway and station
Inland water area, other specific area (park, airport)	Polygon	Name of each area
Buildings (only for central districts)	Raster image, polygons of public buildings	Code and name of each public building

These data sets have been published from April 1997 for the use of unspecified individuals at an appropriate price, just as the Digital Map Series. They are also distributed free of charge to every local government that provided data sources. The whole planned area was covered in March 2001.

4.5. Standardization of GIS DATA

Japan participated in ISO/TC211 from the beginning of this activity and contributed to the development of standards. Based on the need to develop a GIS standard for Japan, which is in accordance with that of ISO/TC211, GSI started research on Japan's GIS standard in 1996. This research was also intended to provide a technical backbone for the Japanese SDI standard discussed by the Liaison Committee of the Government. Fifty three private companies joined this three year research project funded by the Ministry of Construction as one of the projects of the collaborative research program with the private sector. Two kinds of standards were developed through this research: spatial data exchange standard and spatial data development standard. Six working groups were established for the exchange standard to discuss 8 work items including data structure, data quality, geo referencing, metadata, and cataloguing. The final draft of the standard was developed at the end of FY 1998 and adopted as part of the NSDI Standards by the Government Liaison Committee. After completion of the final draft in FY 1998, GSI and thirty three private

companies entered into the second stage of this research activity. The goal of second stage is to refine the draft produced in FY 1998 and make it available in practical use. The guideline for a product specification of GIS data is also being developed in this second stage. The G XML project to develop a protocol for spatial data exchange is also started at 2000 by the Database Promotion Center which is under the auspices of the Japanese government's Ministry of Economy, Trade and Industry (METI).

4.6. Geographic Information Directory Database (GIDD) and Geographic Clearinghouse

The Long term Plan developed by the Government pointed out the necessity for NSDI and specifies the need to establish a clearinghouse system for spatial data. GSI has been developing a Geographic Information Directory Database (GIDD) as a five year research project since April 1994. This database is designed to provide directory information (i.e., metadata) of spatial data through computer networks, and to become a clearinghouse node by developing a search environment of distributed databases. The metadata standard, which is currently used in the GIDD, can be considered as the Japanese localization of ISO/TC211 15046 15115 Metadata by making modifications on, for example, spatial reference, addressing, and language. This standard was determined as Japan Metadata Profile (JMP) after additional necessary modifications. GSI added a clearinghouse ISO23950 node server to the international geographic clearinghouse coordinated by the Federal Geographic Data Committee (FGDC). In addition, GSI asked the other Ministries and Agencies concerned with geographic information to prepare metadata and clearinghouse node server. As a result, government geographic information search service is available to the public. The URL of this clearinghouse gateway is http://zgate.gsi.go.jp/. A Clearinghouse is one of important tool for finding and using of geographic data. In Japan several organizations are developing their clearing house. GSI has developed its clearing house and opened it March 2000. The clearing house adopts Z39.50, so we can retrieve geographic data from sites located in many countries through this clearinghouse.

4.7. GIS ACTION PROGRAM 2002 2005

The "Liaison Committee of Ministries and Agencies Concerned with Geographic Information System" adopted the GIS Action Program 2002 2005 as the program that would ensure development and propagation of GIS in Japan from fiscal 2002 to fiscal 2005.

4.7.1. Key Measures to be Implemented by the Government

Measures were selected from the perspective of consistency with the "e Japan Priority Policy Program", avoidance of duplication between various measures, etc. Since these measures are crucial in realizing the intended outcomes of this program, these measures will be implemented with priority taking into consideration the state of national finances in the future. The key measures are as follows.

1)Promotion of Standardization concerning National Spatial Data Infrastructure and Promotion of Improved Administrative Efficiency through Governmental Lead in Using GIS

2)Development of Systems and Guidelines from the Perspective of Promoting Digitization and Distribution of Geographic Information

3)Promotion of Digitization and Provision of Geographic Information

4)Provision of Support for Full Scale Propagation of GIS

5)Realization of Efficient Administration and High Quality Administrative Services using GIS

6)Others, such as Program Following UP on Programs

5. Summary of the Activities related GIS and NSDI

5.1 Key concepts for SDIs

The starting point for the Japanese NSDI initiative was the government's reaction to the Kobe earthquake of January 1995. This led to a major review of emergency management services and their related data needs. A Liaison Committee of Ministries and Agencies concerned with GIS was set up as part of these developments in September 1995 under the supervision of the cabinet. In December 1996, the Liaison Committee published its plan of action up the beginning of the twenty first century. They envisaged that the first phase of this plan would last until 1999 and include the standardization of metadata, clarifying the roles of government, local governments, and the private sector and promoting the establishment of the NSDI. NSDI Promotion Association with a membership of more than 100 private sector companies was also set up to support these activities. The GIS Action

Program 2002 2005 was also adopted as the program that would ensure development and propagation of GIS in Japan. These activities show that some key concepts underpin all SDIs:

1) The overriding objective of an SDI is to maximize the use of geographic information. This requires ready access to the geographic information assets held by a wide range of stakeholders in both the public and the private sector. SDIs cannot be realized without coordinated action on the part of governments as well as private sectors.

2) SDIs must be user driven and assist the human activities with levels of details. Their primary purpose is to develop infrastructure environment to enable the usage of GIS that realize affluent national living through GIS. In order for GIS technology to become so widely accepted, GIS technology would need to follow an acceptance/growth model similar to that of the Internet.

3) SDI implementation involves a wide range of activities. These include not only technical matters such as data, technologies, standards, and delivery mechanisms, but also institutional matters related to organizational responsibilities and overall national information policies, as well as questions relating to the availability of the financial and human resources needed for this task.

5.2. The main stakeholders in SDIs

It is important to identify some key players or stakeholders with interests in geographic information and spatial data infrastructure field from the viewpoint of both producers and consumers side. The following players are listed: Central government organization, Local government organization, Commercial Sector (Information traders and publishers, Hardware/Software vendors, etc.), Not for profit or nongovernmental organizations (NGOs), Academics and Individual citizens. These include many different kinds of organization with many different demands for geographic products and services. They wish to use geographic information to enhance their personal skills and knowledge development or to participate in decision making at the local or national levels.

5.3. Current trends in SDI development

The shift in technological emphasis is due to the opportunities opened by the development of the Internet and the World Wide Web. This shift is said that "the WWW

has added an new and radically different dimension to its earlier conception of the NSDI, one that is much more user oriented, much more effective in maximizing the added value of the nation's geo information assets, and much more cost effective as a data dissemination mechanism. There is a shift that has taken place form the product model to a process model of an SDI, i.e. from data producers to data users, from database creation to data sharing, and from centralized to decentralized structure. There is also a shift in emphasis from SDI formulation to implementation overtime, i.e. from coordination to governance, from single level to multilevel participation, and from existing to new organizational structure. As for as diffusion of SDI, the most obvious SDI success can be measured in the establishment of clearinghouses and the Geospatial One Stop portals to disseminate metadata.

5.4. Final remarks

In the last decade, Japan has developed GIS based NSDI to promote economic development, good governance, and livable and sustainable development. We need also the Digital Earth which is a virtual representation of the planet, encompassing all its systems, and life forms, including human societies. It is designed as a multi dimensional, multi scale, multi temporal, and multi layer information facility. The Digital Earth vision incorporates a computerized Earth, as its interface, whereby a corresponding virtual body of knowledge, or global encyclopaedia of the real Earth and its digital representation for understanding the oneness of the Earth and its relevant phenomena. The GSDI(Global Spatial Data Infrastructure) is the means to assemble geographic information that describes the arrangement and attributes of features and phenomena on the earth. Digital Earth and GSDI are wide concepts that include the data, materials, technology, and people necessary to acquire, process, and distribute such information to meet a wide variety of needs. One of the outcomes of these activities, at the present, Location Based Service (LBS) and Web Mapping are the real application domain of the most active GIS community in Japan.

A ubiquitous computing system is regarded as an ideal information system of the future and it has drawn great attention in Japan. Computers have already changed their forms from desktop to mobile devices. What comes next will be the wide and in depth penetration of the benefits of IT through the network where all objects load computers and the objects are linked together. In other words, an age, when an information system that is accessible at "anytime and anywhere" penetrates into our society, is expected to come. On the other hand, GIS is changing from a tool for specialists to an infrastructure & tool used

in a wide range of domains and applications using NSDIs. This is the vision of ubiquitous computing and "Ubiquitous GI Services and Geo information Society".

Mobile phones in Japan at least are already equipped with broadband networks, positioning systems, high resolution display devices, large memory and high processing capacities, and it is believed that they already fulfill the required processing and communication capacity as terminal devices of such an age. In the world of ubiquitous computing, computers that have been mainly processing cyberspace information must now process real world information in real time. It is clear from the keyword of ubiquitous, "anytime and anywhere", "where", namely location information is necessary for real world information. For this reason, location information based on NSDIs processed by a ubiquitous computing system will be basic information such as ID and URL. In this way, most information systems and services that process location information have aspects as LBS in e-Society.

Through seamless visualization of location information and information linkage ranging from the global to the local level and an easily understandable overall representation of global issues, we can expect a formation of "knowledge of the global community" based upon shared sympathy of the majority of the global population. The potential of the GSDI and Digital Earth as a media to nurture a tactile sense of being part of one connected planet and one humankind is enormous. We have strong expectations that building such world will further enrich us and realize concepts such as "global citizenship" and "global society."

REFERENCES

Ian Masser (2005) GIS Worlds ‐Creating Spatial Data Infrastructures, ESRI Press
Satoru Takagi et al. (2004) goSVG   Standardization and promotion activity for LBS by SVG, SVG open conferencence.
Resources papers in Liaison Committee of Ministries and Agencies Concerned with GIS in Japan.

Comparative Analysis of NSDI Characteristics for the NGIS Directions in Korea

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1. Introduction

In the digital knowledge society, GIS technology is recognized as an essential tool to solve various human problems on the earth. With increasing importance of spatial information, most nations have developed their own implementation strategies for the National Spatial Data Infrastructure(NSDI). By facilitating better access and wider use of data, the NSDI provide a common framework for various and creative applications.

While the NSDI was initially established as a separate entity, recently more attention has been given to the SDI hierarchy, from a local level to a global level. In addition, integration of the NSDI with e-Government becomes an important policy to meet the citizens' expectations. As an advanced NSDI, the USA, the UK and Canada emphasize more on better citizen services through an e-Government GIS portal such as the USA's Geospatial One-Stop.

This study hypothesizes that the characteristics of NSDIs can be different from each nation in terms of vision, structure, evolution stages and a degree of integration with the e-Government. Rather than to describe differences just for comparison, more characteristics of NSDIs are identified and the comparisons are developed as recommendations for the future NGIS(National Geographic Information System) in Korea.

2. Comparison of NSDI Characteristics

The NSDI concept has changed with the development of the NSDI. According to the comparative analysis of NSDI development(Williamson, 2003), two generations are

introduced. In the first generation, data is the key issue for the NSDI development and the main focus is on techno-centric spatial data community. The second generation includes more socio-technical issues and focuses on the people as well as the data. Usage of the data and users' needs are driving forces for the NSDIs development. Although the development of SDIs is explicitly at a national level, the second generation of the NSDI requires a collaboration model that facilitates greater inter-jurisdictional information exchange from a local level, through to a state, a national, a regional and a global level. The relationship between the different levels of SDIs is complex and dynamic and the NSDI has an important effect on the upper and lower levels of the SDI hierarchy. <Figure 1>

<Figure 1> SDI hierarchy (Williamson, 2003)

2.1. Characteristics of the advanced NSDIs

2.1.1. The NSDI in the USA

Since the launch of the NSDI initiative in 1994, the NSDI has been reorganized and transformed to reflect technological changes and to focus on matters and places of national importance with an enterprise architecture for the Nation. Circular A-16, which describes the structures of NSDI and establishes the FGDC, has been revised from the 1990 version to the 2002. The revised Circular calls for continuing improvement in sharing and using geographical data. The revision proposes an integrated infrastructure system approach to provide multiple geospatial services for the e-Government[1].

For strategic consolidation of national geospatial programs, the USGS created the National Geospatial Programs Office (NGPO) in 2004 to lead the programs[2]. The NGPO will manage the essential components of the NSDI as a unified portfolio that can benefit the entire geospatial community. The goal of "bold step" of reorganization is to align national geospatial activities and responsibilities including the FGDC, Geospatial One-Stop (GOS), The National Map (TNM) and Interior Enterprise GIS. The geospatial profile will be added by the NGPO to the Federal Enterprise Architecture(FEA). The efforts imply that geographic information can be a major asset for most organizations in e-Government.

<Table 15> Characteristics of the NSDI in the USA

Component	Characteristics
Vision	• Current and accurate geospatial data will be readily available on a local, national and global basis to contribute to economic growth, environmental quality and stability and social progress.
Data	• Making Framework Real • The National Map
Metatdata and access service	• GOS Version 2 –"Two clicks to content" • Complete intelligent access to metadata with no license and restrictions
Partnership	• Clearly define agencies' role and FGDC responsibilities • Expand partnership into the public and private sectors • Creation of the NPGO as a unified portfolio
Integration with e-government	• Geospatial One-Stop is one of 24 E-Government initiatives. GOS Version 2 of the popular portal will be easier to use. • Geospatial profile for the Federal Enterprise Architecture

2.2.2. The NGDF in the UK

The objective of the NGDF(National Geographic Data Framework) is to facilitate and to encourage efficient access and widespread use of geospatial data. Despite that high quality geospatial data were already available, the national initiative of NGDF was established in 1997, which is much later than the USA's NSDI.

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1) http://www.whitehouse.gov/omb/circulars/a016/a016_rev.htm

2) http://www.usgs.gov/ngpo/

GIgateway is a free web service to increase awareness of and accessible chance to geospatial information in the UK[3]. This service is funded by the National Interest Mapping Services Agreement (NIMSA) and managed by the Association for Geographic Information(AGI) representing the interests of the UK's GI industry and playing an important role in the NGDF[4]. The NGDF tries to encourage direct private sector involvement and a market-oriented approach rather than a government-oriented approach in other countries. The characteristics of the NGDF can be summarized as follows:

① Intelligent geospatial information : For the 21st century, Ordnance Survey, Britain's national mapping agency and a market-leader in geographical information, has produced MasterMap. OS MasterMap contains more than 450 millions topographical objects(TOID) with unique IDs that can make daily-update possible[5].

② Integration of geospatial service with the e-Government : The UK's local e-governments define GIS as an enabler to implement the e-government[6] and the e-GIF (e-Government Interoperability Framework) includes spatial data as one of the e-government businesses[7]. The significant national e-government initiatives, such as the National Land and Property Gazetteer(NLPG), National Land Information Service(NLIS), and National Land Use Data(NLUD) are cooperated with the local governments. The UK's ODPM(Office of the Deputy Prime Ministers) formed the Geographic Information Panel in 2005, to take an advice on geographic information issues of national importance.

③ Partnership with the public and private sectors : As a cross-sectoral and mixed public-private body, the AGI(Association for Geographic Information) plays an important role in the NGDF.

2.2.3. The CGDI in Canada

To develop the Canadian Geospatial Data Infrastructure (CGDI), the Government of Canada funded the GeoConnections program with the objective of harmonizing Canada's

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3) http://www.gigateway.org.uk/
4) http://www.agi.org.uk/
5) http://www.ordnancesurvey.co.uk/
6) Office of the Deputy Prime Minister, "e-gov@local Towards a national strategy for local e-government," 2002. 4
   http://www.egovernment-uk.com/
7) Cabinet Office, "e-Government Interoperability Framework v.6.1," 2005.

geospatial databases and making them accessible on the Internet. Through partnerships with federal, provincial, local governments, and the private and academic sector, the GeoConnections program promotes the use of standards and protocols to facilitate access to Canadian geospatial data.

① Access : Provide the public with access to geospatial data and services in the GeoConnections Discovery Portal.

② Framework data: Seamless and fully integrated geospatial data that provides context and reference information for the country.

③ Standard : To ensure that the CGDI is compatible with activities at a global level, stakeholders in Canada have agreed to take advantage of international GIS standards for the CGDI.

④ Partnership : To strengthen a national partnership initiative, the CGDI involves the public and private sectors, academia and non-governmental organizations.

⑤ Policy : The objectives of the CGDI policy are to foster increased access to and use of geospatial data in the public and private sectors, to resolve licensing and distribution issues in supporting data-sharing and use, to facilitate inter-agency geospatial data-sharing arrangements, to expand partnerships, and to reduce the cost of the collection, maintenance and distribution of geospatial data.

To ensure that government information is managed effectively and efficiently the Government of Canada ratified the Management of Government Information Policy in 2003. The policy provides direction on how governmental institutions, departments and agencies should create, use, manage and preserve information in a comprehensive and strategic manner.

On June 15, 2005, the Government of Canada announced to fund $60 million for renewal of the five-year GeoConnections program[8]. While the first phase of GeoConnections focused on developing policies, standards, technologies and partnerships required to build a Canadian Geospatial Data Infrastructure (CGDI), the second phase aims to ensure more Canadians can actively adopt, use and benefit from the CGDI. From 2005 to 2010, the renewed GeoConnections program will work with its existing partners to ensure that CGDI technologies remain current, but will also pursue partnerships with new end-user

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8) http://www.geoconnections.org/

communities of practice. Specifically, GeoConnections will seek to understand the needs of users better in four key areas: sustainable development and the environment, aboriginal issues, public health, and public safety.

The first phase of GeoConnections was recognized internationally as a model partnership, and its success was attributed to its governance approach. The new GeoConnections program will operate in the almost same way: it will be led by Natural Resources Canada and be governed by a management board and several advisory boards; and it will undertake cost-shared partnership projects with the public and private sectors and other organizations in support of the CGDI.

2.2. Lessons learned form the compared characteristics

The fore-mentioned NSDI cases for the USA, the UK and Canada have proved that the emphasis of NSDIs can be different to reflect their own situations. While the USA can have more political and governmental support with Executive Order 12906, the UK has more market-orientated strategies. The Canada's Geoconnections can be characterized as an exemplary partnership with the public sector, the private and academic sector.

Lessons learned from the comparisons can be summarized as follows: ① The main direction of the NSDI is intelligent geospatial information and service, ② Much efforts are being made for the integration of NSDIs with the e-Government ③ Collaborative partnership with the public and private sectors is considered the most efficient way of implementing the NSDIs ④ Geospatial portals play a key role for easy access and wide use of geosptial information and services ⑤ Future directions for NSDI implementation: interoperability with NII and within the NSDI, expansion of the NSDI, and support to the GSDI.

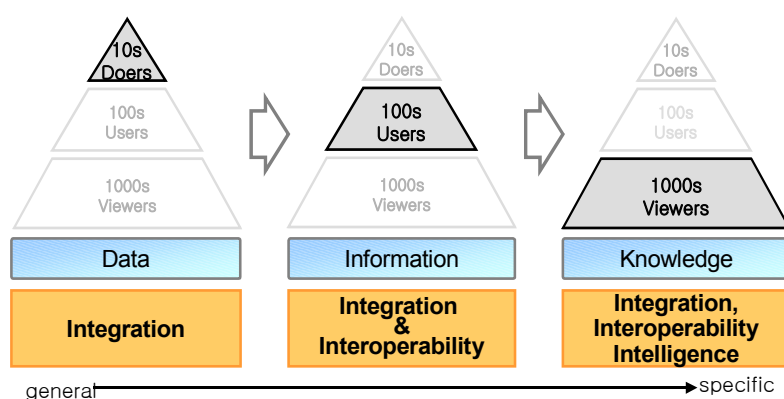<Table 16> The comparisons of the advanced NSDIs

	USA	UK	Canada
Intelligent geospatial information and service	• The National Map • Complete intelligent access to metadata with no license and restriction	• OS MasterMap • Knowledge based search for metadata	• Seamless geospatial data integration and access • Web-based geospatial service and access
Much effort for the integration of the NSDI with e-Government	• GOS Version 2 -"Two clicks to content" • Disaster preparedness service using geospatial data • Geospatial profile for the Federal Enterprise Architecture	• GIS as an enabler to implement local e-government • Spatial data as one of the e-government businesses in e-GIF • Formation of Geographic Information Panel, to take an advice on geographic information issues of national importance	• Focused on citizen-centered service • Life cycle event service integrated with geospatial data • Geoconnections portal integrated with the e-Government portal
Collaborative partnership with the public and private sector	• Clear definition of agencies' role and FGDC responsibilities • Expand partnerships to the public and private sectors • Creation of NPGO as a unified portfolio	• Improvement of partnership with the federal and local governments • Partnership into the public and private sectors	• Improvement of partnership with the federal and local governments
Geospatial portals for easy access and wide use of geosptial information and services	• GOS Version 2	• GIgateway	• Geoconnections
The future directions of NSDI implementation	• Interoperability with NII and within NSDI • Expansion of NSDI • Support to GSDI	• Interoperability • Intelligent geoaptial service	• Partnerships with new end-user communities • Better understanding users' need in four key areas: sustainable development and the environment, aboriginal issues, public health, and public safety

3. Possible directions for the NGIS in Korea

From the lessons mentioned, several directions can be suggested for the NGIS in Korea.
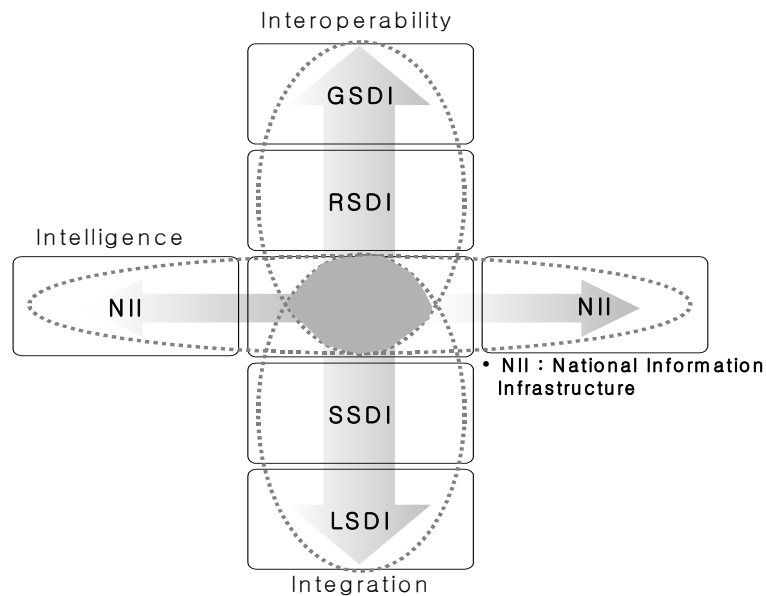
3.1. 3Is for the Ubiquitous NSDI

As a NSDI develops, it becomes more important to utilize and expand the existing the NSDI for the problem-solving purpose. As a GIS paradigm shifts, the NSDI evolves to require more geospatial data, information and knowledge.

<Figure 2> Future directions of NSDI according to GIS paradigm shifts

The <Figure 2> shows the evolution from the data(suppler)-centered NSDI to the user-centered NSDI with a more socio-technical viewpoint. The GIS paradigm shift requires new ideas, new services, and more creative applications of the NSDI. The advanced NSDI can provide seamless 24/7 data for citizens and interoperability within the e-Government for geospatial services. Furthermore, a degree of integration, interoperability, and intelligence can determine maturity and effectiveness of the NSDI in an e-Government perspective.

As mentioned, the NSDI has an important effect on the upper and lower levels of the SDI hierarchy<Figure 3>. Vertical and horizontal expansion of the NSDI in the hierarchy can provide a basis for integration strategies for the future. The integrated NSDI with e-Government means harmonization of the NSDI and the NII(National Information Infrastructure) with a more emphasis on geospatial information than ever.

<Figure 3> The NSDI in SDI hierarchy

Additionally, ubiquitous technology has emerged as a more powerful integration tool for another stage of the NSDI evolution. Ubiquitous service with 5As(Anytime, Anywhere, Anyservice, Anydevice, Anynetwork) will impact the future NSDI for government administration and citizen services. Especially, "context aware," an important characteristic of the ubiquitous technology, will contribute to the future intelligent NSDI. The three key concepts of integration, interoperability and intelligence will be a basis for the ubiquitous NSDI. The following table shows reorganization of the lessons in terms of 3Is and provides practical examples for the future NSDI.

<Table 4> The advanced NSDI in terms of NSDI future direction

	USA	UK	Canada
Integration	• Bluebook for NSDI Stewardship Guidance • Creation of NPGO as a unified portfolio		• Seamless geospatial data integration and access
Interoperability	• Geospatial profile for Federal Enterprise Architecture	• Partnership with the public and private sectors • Significant national e-government initiatives, such as NLPG, NLIS, and NLUD with the cooperation of the local governments	• Life cycle event service integrated with geospatial data • Geoconnections portal integrated with e-Government portal
Intelligence	• The National Map • Complete intelligent access to metadata with no license and restrictions' • GOS Version 2 –"Two clicks to content"	• OS MasterMap • Knowledge based search for metadata	• Web-based geospatial service and access • Focused on citizen-centered service

3.2. Possible Directions for the future NGIS in Korea

The future directions of the NGIS can be summarized in terms of 6 NSDI components: data, access and metadata, standard, technology, partnership, and law/regulations and institutional policy. Each component is analyzed in the perspective of integration, interoperability and intelligence.

☐ **Data**

• **NGIS Data specifications for framework data:** Arrangement of data model and specifications for framework data will provide the vertical integration with the central and local governments and horizontal interoperability for the NGIS such as the USA bluebook.

• **Data currency and intelligence with UFID:** The UFID(Unique Feature IDentification) are very useful to adding intelligence to data and real-time update. As seen in the UK's mastermap, the definition and assignment of the UFID will be needed for NGIS.

□ **Access and metadata**

• **Evolution of the Korean geospatial clearinghouse:** The current the national geospatial clearinghouse provide limited services, it needs to expand and provide more improved geospatial services such as Geospatial One-Stop in the USA case.

• **More recognition of importance of metatdata :** Metadata is a key for data access, distribution, and the intelligent NGIS. It is necessary to have more informative metadata in a GIS portal with "2 clicks to context".

□ **Standard**

• Standard for geospatial interoperability in e-Government: More international GIS standards need to be profiled for interoperability, but inconsistency and incomparability can be founded.

□ **Technology**

• **Geospatial profile for the Korean e-Government Enterprise Architecture :** Integration of NGIS with e-Government will require geospatial profiles for e-Government.

□ **Partnership**

• **Enhance collaborative partnership :** Central-central, central-local and local-local government partnerships are essential for the establishment of seamless geospatial integration.

• **NGIS as a unified portfolio : more control and guidance on NGIS projects:** As seen in the USA's NGPO, more top down guidance for NGIS is needed to improve integration, interoperability and intelligence of the NGIS.

□ **Law/ Regulations and institutional policy**

• **More practical and feasible vision statement in the NGIS master plan:** The NGIS needs to have more focus matters and places of national importance, such as national security.

• **Adaptation of existing regulations for fitness for use of geospatial information :**

Existing regulations need to be expanded for data custody, data security and privacy, and to be improved for wider use of the NGIS.

• **Harmonized integration of the NGIS law with the e-Government law :** Separation of the two laws in terms of geospatial information predicts less efficiency and effectiveness of the future e-Government implementation.

4. Conclusion

With the increase of population and continuing quality improvement of life, development will happen continuously on the earth and increase complexity of our spatial problems. To solve the emerging spatial problems, more creative and effective solutions are required. The NSDI can serve as a useful integration vehicle for matters and places of national importance, such as national security and emergency prevention and management. In the USA, the 911 accident provided a momentum to recognize importance of geospatial data and transformed the existing NSDI to a more integrated and problem-solving structure. To meet the emerging requirements properly, more specific data at the level of local government and the broader range of existing framework data are needed. Initially, the bottom-up approach of the NSDI in the USA now phases into a compromized stage with the top-down approach exemplified in geospatial profile in the Federal Enterprise Architecture.

It might be a proper time to accept good ideas for the future NGIS in Korea to the degree that can deal with complex spatial problems of national importance and utilize the NGIS in a citizen perspective. Shortage of resources and funds, as opposed to increasing citizens' needs, will require more capabilities of integration, interoperability and intelligence in NGIS. In addition to the capabilities, matured culture of better communication, cooperation and collaboration will be mandatory for the ubiquitous NGIS.

References

Cabinet Office, 2005, *e-Government Interoperability Framework v.6.1*, UK

Executive Order, 1994, Coordinating geographic data acquisiton and access, the National Spatial Data Infrastructure, *Executive Order 12906*, USA

Masser, Ian, 1998, *Governments and Geographic Information*, Taylor & Francis Ltd., UK

Office of the Deputy Prime Minister, 2002, "e-gov@local Towards a national strategy for local e-government," http://www.egovernment-uk.com/

USGS, 2005, *Bluebook for NSDI Stewardship Guidance Draft*

Williamson, Ian, Abbas Rajabifard and Mary-Ellen F. Feeney, 2003, *Developing Spatial Data Infrastructures: From concept to reality*, Taylor & Francis Ltd., UK

http://www.whitehouse.gov/omb/circulars/a016/a016_rev.htm

http://www.usgs.gov/ngpo/

http://www.geo-one-stop.gov/

http://www.gigateway.org.uk/

http://www.agi.org.uk/

http://www.ordnancesurvey.co.uk/

http://www.egovernment-uk.com/

http://www.geoconnections.org/english/index.html