SOME ASPECTS OF MOBILE GIS

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Abstract: *In the future, many computer applications will be inherently mobile, and rely on seamless wireless networking. Although the desktop computer will still exist and be used for many tasks, the majority of tomorrow's computer applications will be accessed on other devices. A mobile GIS enables field-based personnel to capture, store, update, manipulate, analyze, and display geographic information. Mobile GIS is the use of geographic data in the field on mobile devices. It's an evolution of how the enterprise database is used and managed within an organization. Mobile GIS integrates three essential components: Global Positioning System (GPS), rugged handheld computers, and GIS software. Bringing these technologies together makes the enterprise database directly accessible to field based personnel—whenever and wherever it is required.*

Keywords: *GIS, Mobile GIS*

1. Introduction

A Geographic Information System (GIS) is a technological tool for comprehending geography and making intelligent decisions. A good GIS program is able to process geographic data from a variety of sources and integrate it into a map project. Many countries have an abundance of geographic data for analysis, and governments often make GIS datasets publicly available. Map file databases often come included with GIS packages; others can be obtained from both commercial vendors and government agencies. Some data is gathered in the field by global positioning units that attach a location coordinate (latitude and longitude) to a feature such as a pump station. From routinely performing work-related tasks to scientifically exploring the complexities of our world, GIS gives people the geographic advantage to become more productive, more aware, and more responsive citizens of planet Earth. In recent years, GISystems and GIScience have started to make the jump first from 2D to 3D and most recently from 3D to 4D, that is, from static to dynamic systems that incorporate a temporal element. GIS are also becoming increasingly distributed and mobile. Goodchild offers an interesting perspective on the implications of GIS becoming more distributed. He suggests that there are four distinct locations of significant 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.

Mobile GIS is the expansion of GIS technology from the office into the field. A mobile GIS enables field-based personnel to capture, store, update, manipulate, analyze, and display geographic information. Traditionally, the processes of field data collection and editing have been time consuming and error prone. Geographic data has traveled into the field in the form of paper maps. Field edits were performed using sketches and notes on paper maps and forms. Once back in the office, these field edits were deciphered and manually entered into the GIS database. The result has been that GIS data has often not been as up-to-date or accurate as it could have been.

Firefighters, police officers, engineering crews, surveyors, utility workers, soldiers, census workers, field biologists, and others, use mobile GIS to complete the following tasks:

- **Field Mapping** - Create, edit, and use GIS maps in the field (figure 1).
- **Asset Inventories** -Create and maintain an inventory of asset locations and attribute information.
- **Asset Maintenance** - Update asset location and condition and schedule maintenance.
- **Inspections** -Maintain digital records and locations of fi eld assets for legal code compliance and ticketing.
- **Incident Reporting—**Document the location and circumstances of incidents and events for further action or reporting.
- **GIS Analysis and Decision Making—**Perform measuring, buffering, geoprocessing, and other GIS analysis while in the field.

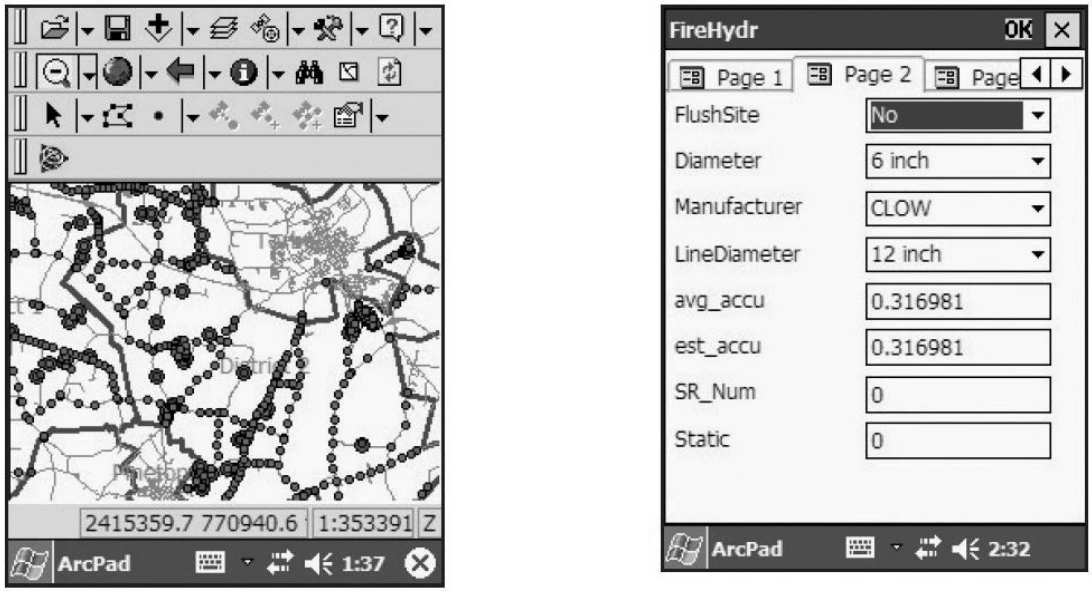

Fig. 1. Collect water and sewer infrastructure information

2. Mobile GIS

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 a 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 that in its most complete form comprises the following key elements (Figure 2):

- 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);
- a wireless / wire-line network for device-server communication.

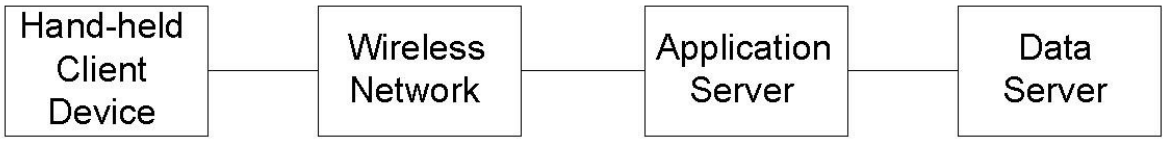

Fig. 2. Mobile GIS Platform

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 processors 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. 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 work orders with 'as-built' information or dynamic fleet-vehicle routing).

Fig. 3. Hand-held GIS software solution

PDAs - 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,

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 (Figure 3).

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.

An interesting trend is 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 ¼ VGA 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.

Wireless Communication Network. Mobile communication is set to be one of the key technologies of the 21st century. Mobile phones have not only gained currency and acceptance worldwide, but did so with a speed that outstrips many other technical innovations at any point in history.

As shown in Figure 4, one of the key 3G technologies is *GPRS (General Packet Radio Services)*. It is an "always on" communication service that transfers information in the same way that Internet does by breaking data up into 'packets' that each follow their own, shortest available route to their destination, where they are reassembled at the receiving end. GPRS currently supports an average data rate of 115 kb/sec, but this speed is only achieved by dedicating all eight time slots to GPRS (the GPRS maximum theoretical data rate under perfect radio conditions is 171 kb/sec).

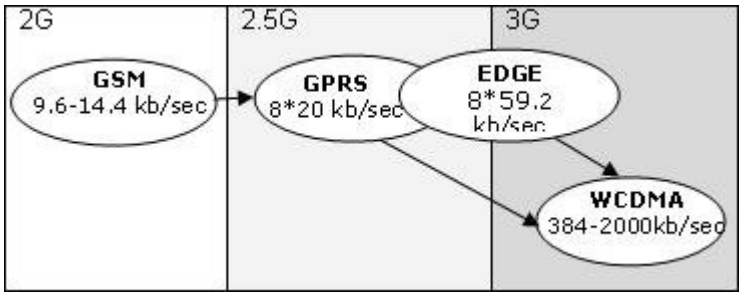

Fig. 4. Wide Area Mobile Network Evolution to 3G Time Division Multiple Access

EDGE (Enhanced Data rates for Global Evolution) is a 3G wireless technology that is capable of handling high-speed data. EDGE occasionally is called "E-GPRS" because it is an enhancement of the GPRS network.EDGE cannot be deployed by itself, it must be added to an existing GPRS network.EDGE's real world data rates are far lower than its theoretical peaks of 473 kb/sec.

WCDMA (Wideband Code Division Multiple Access) is a high speed 3G mobile technology adopted as a standard by the International Telecommunications Union.WCDMA can reach speeds from 384kb/sec to 2Mb/sec.

The basic functions of GIS system are: (i) storage; (ii) processing; (iii) management; (iv) analysis; and (v) displaying spatial information by involving computer-assisted cartography and a spatial database. Considering the requirements in application fields such as urban planning and management, transportation management and environment monitoring, GIS provides the powerful functionality of spatial analysis and decision support. Early applications of GIS in these fields were limited and simple, however, mobile GIS changes the application pattern of GIS so that users can free themselves from desktop computers via mobile terminals. It therefore shortens the distance between GIS applications and users, and, based on the above list of functions, mobile GIS can provide very many more services than static GIS, even when considering the limitations of data volume and unstable communication.

Summarising, the characteristics of mobile GIS applications:

1. Reduced hardware configuration requirements of terminal devices. Usually an embedded processor has a small volume memory and low CPU frequency, and supports 'mini' peripheral equipment at the mobile terminal device. Compared with desktop computers, the performance of the hardware configuration is much lower, but mobile GIS can still execute the basic GIS functions.

2. Wireless networks as carriers. At present, though the wireless network is used to carry spatial information under conditions of unstable communication and considerable expense, it can be improved with the developing wireless communication systems.

3. It is easy for traditional GIS to manage distributed spatial data via the Internet/Intranet while, for mobile GIS, the management of massive data sets is difficult. As mobile GIS needs real-time information about location, spatial data management should be improved in distributed and dynamic computing environments.

4. Mobile GIS relies on real-time position information. High-quality mobile GIS services can be offered only when the terminals are supported with location information, because most spatial information provided by Mobile GIS relates to users' current locations.

5. The User Interface must be very user friendly in mobile GIS. Traditional GIS software is designed for professionals, and its operation and interface can be complex. But mobile GIS is oriented to the public, so the operations should be necessarily simpler and with simpler interfaces than traditional GIS because of small display screen of mobile terminals.

6. Location based services (LBS) emerge as pivotal in converting GIS from a professional application to a public service industry. LBS mean easy information provision on the basis of location defined by different kinds of indexing and navigation systems. For example, location based services can be provided using the location data of a mobile phone as the search criterion (Jensen et al., 2003).

3. Standards

The following standards are associated with mobile GIS (Qingquan Li, 2006):

1. GSM, widely used and important standards, presented by the European Telecommunications Standards Institute (ETSI) Special Mobile Group (SMG) in 1990;

2. CDMA/W-CDMA specifications (the third-generation partnership project, 3GPP) (Adams et al., 2004);

3. UMTS (Universal Mobile Telecommunications System) technical specifications (which include standards for the 3G mobile Internet);

4. OpenGIS specifications of OGC;

5. GML(Geography Markup Language, developed by Open GIS Consortium) incorporated with SVG(Scalable Vector Graphics);

6. Simple Object Access Protocol (SOAP), one of a handful of standards behind the industry move toward building Web services software, published by World Wide Web Consortium (W3C);

7. Mobile Location Protocol Specification (Location Interoperability Forum (LIF) within the OMA Location Working Group);

8. Mobile Web Initiative (making Web access from a mobile device as simple, easy and convenient as Web access from a desktop device);

9. Wireless application protocol (WAP), etc.

All these specifications can be modified and developed to meet GIS service requirements in the mobile environment in terms of spatial information abstraction, spatial data compression, mobile positioning and data transformation, etc.

4. Conclusion

Mobile GIS is the expansion of GIS technology from the office into the field. A mobile GIS enables field-based personnel to capture, store, update, manipulate, analyze, and display geographic information. It is clear that enormous progress has been made in building and applying mobile GIS is the last years. There have been significant advances in computer hardware, networks and especially software. The functions and advantages of mobile GIS can be extended to almost all fields of human endeavour, but particularly including government agencies, intelligent transportation systems, emergency response, tourism, planning, real estate, resource inventory, environment protection, oceanography, field surveying and information update, utilities management, enterprise publicity and vehicle navigation.

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