Mobile GIS technology update

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Abstract

Governmental organizations and private companies are deploying handheld computing technologies and appropriate software in the field to allow them to fully leverage the GIS data they have collected. By allowing field workers to have access to GIS data improves in-field decision making capabilities, and allows for more timely response to problems.

The technologies that allow mobile applications, including handheld computers, wireless technology and GPS positioning solutions, are continuing to improve and evolve. This paper will give an update on the latest advancements in this field, and provide some examples of organizations successfully deploying mobile applications today.

Introduction

The way we work and play is being continually reshaped by technological development. This is especially true in Asia where the mobile revolution has driven trends in modern urban culture. Being able to communicate with anyone, anywhere, any time is now taken for granted, for example in Singapore 85% of people own a mobile phone and many use Short Message Services (SMS)[1]. With mobile communications, we are more adaptive and flexible as we go about the business of our everyday lives. In Hong Kong 72% of businesses now use mobile phones for more than just voice calls[2] as wireless Internet and transfer of data using mobile phones increases.

While technology changes how we behave, the fast rate of urban and infrastructure development in Asia means that our landscape is also constantly changing. The roading and infrastructure in Beijing, for example, is being transformed in preparation for the 2008 Olympic Games.

GIS databases, used by government agencies and private organisations, must keep up with this changing world to ensure best management of development and resources. Fortunately for the industry, recent advancements in Mobile GIS technology mean that it is possible to cost effectively collect, manage and use GIS data.

Mobile GIS and GIS Data Collection

Mobile GIS is the accessing, using, and maintaining of geospatial data directly in the field. Mobile GIS addresses the needs not only of GIS managers, but also of field inspectors, maintenance teams, utility crews, emergency repair workers, and other field workers who require timely access to GIS data in the field. Field crews with access to enterprise GIS data can better target their actions with the latest information,

and they are perfectly positioned to maintain the GIS database as they maintain physical assets.
Mobile GIS is made possible with developments in;

- Global Positioning System (GPS) technology
- Rugged handheld computing technologies
- Wireless communications
- GIS software for mobile platforms

Mobile GIS relies on having high quality data in the GIS database. However, in many organisations this data can be out-dated or even non-existent. Typically the only means to getting the accurate information required is to collect it yourself. GIS data collection is the process of populating a GIS with data on the features, including position and attribute information, of interest to the organisation. Methods to do this range from manually entering coordinates transcribed from pen and paper, to digitising aerial photographs or paper plans, to GPS data collection.
A GPS data collection system has the same basic components as a Mobile GIS system. It requires the user to be able to locate and then record position and attribute information about the features of interest. GPS technology provides the obvious choice for recording reliable position information, while handheld computer platforms running field-optimised software allow the user to efficiently record feature and attribute data.
GIS data collection and Mobile GIS are intrinsically linked, firstly because they have similar technology requirements, but more importantly because the data generated by the former is critical to the latter. As a result, many organisations are choosing to deploy data collection systems that can expand to meet their Mobile GIS needs or Mobile GIS solutions that also provide GIS data collection capabilities.

GPS and Mobile GIS

GPS is now a standard and widely accepted method of providing position information for a wide variety of user applications, including Mobile GIS. In some locations GPS is the only effective way to map assets in the field. In Japan, for example, GPS-based systems have been used to quickly and accurately define private versus public forestry lands in difficult terrain with few landmarks. The use of GPS in this application allowed the user to achieve the level of accuracy required for the project, within their cost constraints.

Figure 1. GPS mapping of private forestry boundaries in Senbuko East Forest, Japan. Rugged GPS systems provided quick, reliable and accurate performance in extremely harsh conditions.

The key development in GPS technology for Mobile GIS is the integration of a high quality, sub-metre GPS receiver with Microsoft Windows Mobile 2003 software for Pocket PCs, in rugged and cable-free handhelds. This is particularly important for utility companies, where GPS positions must be accurate to within one metre so that field crews can locate manholes, valves, and meters. Accuracy requirements demand the use of professional GPS systems, while field procedures where workers are frequently in and out of vehicles and climbing down manholes, demand the convenience of a handheld, integrated solution.

The quality of a GPS receiver is determined by the architecture of the GPS antenna and receiver hardware, as well as the processing algorithms that operate on the signal. For example, how the receiver design handles electromagnetic interference (EMI) can affect GPS accuracy. All electronic devices emit EMI, which can be thought of as "noise" that "deafens" the GPS receiver. The effect of EMI can be reduced by:

- locating the GPS antenna away from the source of EMI
- shielding the GPS antenna and/or the EMI source directly, and
- using a dual feed antenna and data processing techniques.

Figure 2 illustrates the importance of GPS receiver design, by comparing the performance of a traditional handheld GPS receiver (Trimble GeoExplorer® 3) which does not benefit from advanced antenna design and shielding and a modern professional GPS receiver (Trimble GeoXT™) built using the latest technology

advancements. While 80% of positions from the traditional receiver were within 4 metres of truth, 80% of positions from the professional receiver were within 80 centimetres of truth.

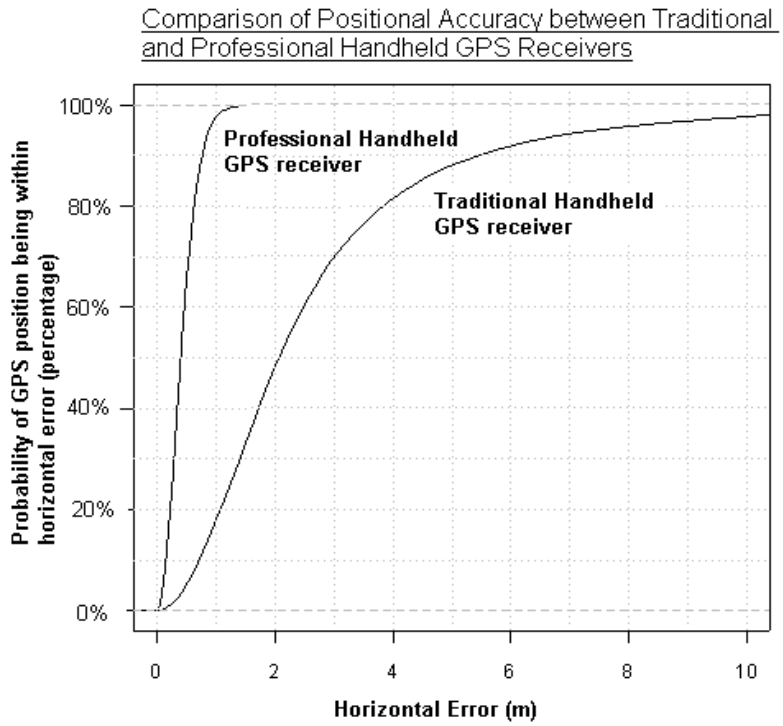

Figure 2. Comparison of positional accuracy between traditional and modern professional handheld GPS receivers.

China Unicom, a state-owned corporation tasked with the accelerated development of China's telecommunication industry, has successfully used the advances in handheld GPS to accurately map cell phone towers. Doing this allows mobile phone users more accurate position information directly on their cell phone handsets, supporting the quality location-based services that China Unicom offers customers.

Figure 3. Accuracy testing of Handheld GPS on cell phone towers, downtown Nanjing, China.

The convenience of the handhelds makes it is possible for workers to climb the towers, while the GPS accuracy ensures that China Unicom add only the very best information to their GIS database.

GPS is subject to a number of errors most of which can be removed through a process known as differential correction. Differential correction can be applied to GPS positions as they are recorded in a process known as real-time differential correction. For Mobile GIS applications obtaining accuracy in real-time is valuable for reliable navigation and spatial queries. A new Satellite Based Augmentation system (SBAS) is being developed for Japan and Eastern China that will provide free real-time accuracy to SBAS capable GPS systems. The satellite, named MTSAT (multi-functional transport satellite), is expected to launch in November 2004 with first operation in January 2005.

SBAS is already well established in the United States (WAAS) and Europe (EGNOS). In the United States American Electric Power's (AEP) has a Mobile GIS system that incorporates a convenient form-factor, a high quality GPS solution and an open Windows Mobile software system. AEP requires real-time sub-metre accurate positioning to stake-out lines of power poles across vast featureless areas of the southern United States. GPS supplemented with SBAS is the most cost-effective way to achieve this. The open operating system allows AEP to run custom Pocket Designer software. Pocket Designer was built for AEP by GeoSpatial Innovations, a

software development firm specialising in mobile solutions for Utility companies. Pocket Designer allows AEP workers to lay out poles productively. Real-time GPS allows AEP to stake a pole line through brush much faster than they could with traditional methods. Carl Livingood, President of Geospatial Innovations states that using this Mobile GIS system "they have recorded field savings as high as 75%" over traditional methods.

Rugged and portable computers

Mobile computing has advanced considerably in the last decade with Personal Digital Assistants (PDAs) becoming functionality-rich to the point where operating systems such as Windows Mobile software provide many of the features of their desktop counterparts. In addition, the low cost and high portability of PDA-style devices makes them the preferred option for most mobile workers. There has been some convergence between PDA's and mobile phones, with the introduction of the Smartphone, but while such devices are highly portable and optimised for wireless communications, they typically lack the rugged specification necessary for Mobile GIS applications.

One feature that distinguishes Mobile GIS from other mobile applications is that workers are always outdoors, and can be exposed to harsh elements. Another often overlooked requirement when assessing hardware is the ability to read a display in bright sunlight. Field computers that can be thrown around in the back of a vehicle, survive heavy rain or operate in sub-zero or desert-like temperatures and continue to operate, are critical for mobile GIS.

Figure 4. The Rugged GeoXT handheld is used to monitor the spread of Schistosomiasis by the National Institute of Infectious Disease (NIID) in Japan. The often wet conditions required a rugged and waterproof computing platform.

Ruggedness tends to add to the cost of a field computer. However, this is offset by reduced downtime, fewer return visits due to field failures or bad weather, and increased security of data. Also, in contrast to low-cost PDAs, ruggedised systems designed for Mobile GIS work, typically have sufficient battery-life for a full-day's work in the field.

In the past, the only mobile computers that could withstand the rigours of field use were heavy, power hungry and cumbersome. The offerings were typically customised for a specific application and often used a proprietary operating system. The convergence of PDA functionality and tough environmental specifications, coupled with improvements in battery performance, has allowed the development of field computers ideally suited for Mobile GIS.

Wireless technology for mobile GIS

Wireless data networks are a key requirement for Mobile GIS applications. Services such as GPRS provide a per-byte rather than per-minute rate, meaning that you pay only when data is transferred. This is ideal for mobile GIS applications as you may wish to be constantly connected to the enterprise data source, but only pull/push data over the network on an intermittent basis.

Mobile phone network coverage, including 3G CDMA, GSM and GPRS data services, are now widespread in Asia. Figure 5 illustrates the level of GSM coverage in North East China. Note that high quality coverage is predominant.

Figure 5. GSM coverage in North East China[3]

Mobile phones have become a consumer commodity and are becoming increasingly "smarter" with PDA-style functions such as email built in. While an excellent platform for the delivery of data over a wireless network, Smartphones typically lack the durability, or battery life of today's rugged handheld computers, making them less suitable for GIS data collection or Mobile GIS applications. Another option for wireless data transfer between the field and the office is using a standard mobile phone in conjunction with a rugged handheld. With this method there is the added advantage of being able to change your phone without changing your whole computing platform.

Bluetooth technology, increasingly standard in mobile phones, provides the ideal solution for cable-free communications between the mobile phone and the field computer. Bluetooth is a short-range wireless protocol for communication between mobile devices, replacing serial cables. In this setup, the field computer communicates with the mobile phone over the Bluetooth connection and the mobile phone communicates with a central server or Internet portal to access enterprise data.

Mobile GIS software

Access to enterprise data is governed largely by the GIS software solution. Today, every major GIS company has a mobile application for taking GIS data into the field. Functions most commonly provided in Mobile GIS software include the ability to:

- display GIS layers in their native format
- query attribute information for geographical features
- edit positional and attribute data, and add GPS data
- navigate using GPS
- use Web interfaces to access central data servers, and
- "check out" blocks of GIS data for field use and data maintenance.

Environment Canterbury (ECan), a regional government authority in New Zealand's South Island, has adopted a mobile GIS workflow with positive results. ECan uses ESRI's ArcPad mobile GIS software to maintain GIS data in the field. Monitoring officers have found the ability to request location-specific information while in the field especially useful, allowing them to instantly respond to customer queries. Figure 6 shows ECan's Mobile GIS architecture. The monitoring officer uses a high-speed wireless connection to access an ArcIMS server, so they can download a snapshot of the relevant GIS layers for viewing in the field. They can query the data to get attribute information back from the server—when and where they want it.

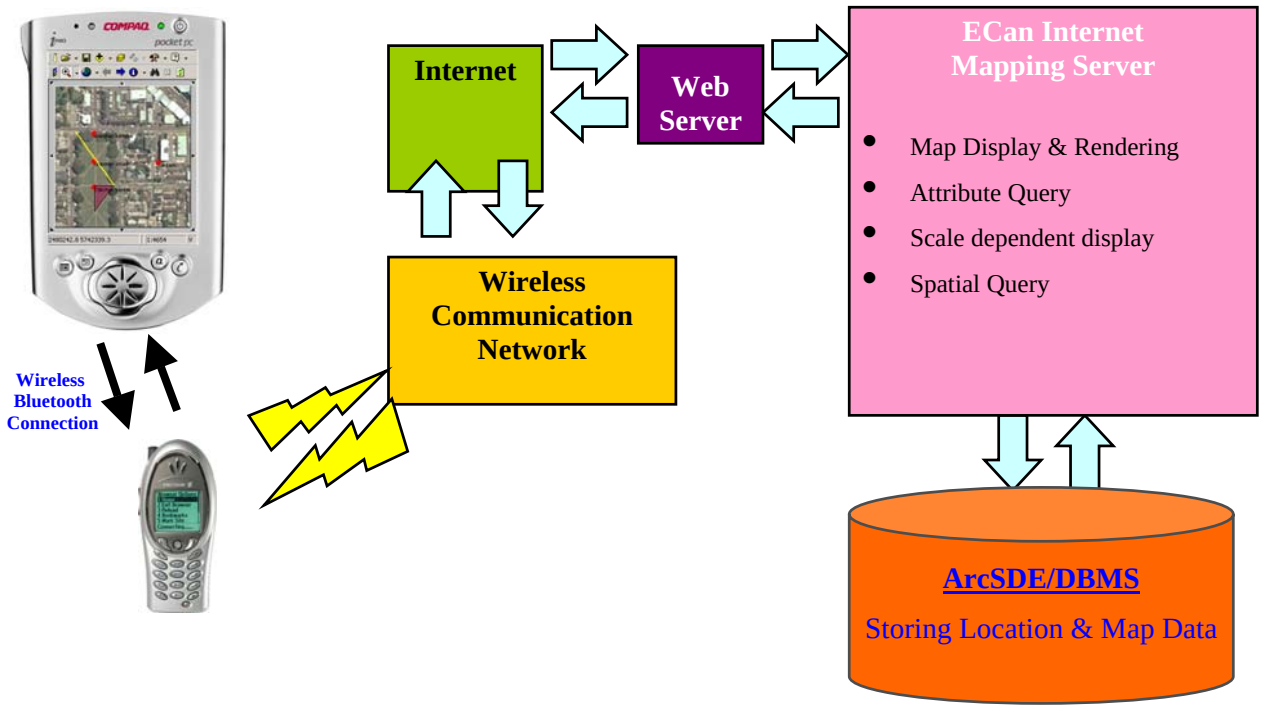

Figure 6. Environment Canterbury mobile GIS architecture.

CONCLUSION

Mobile technology uptake in Asia is expanding exponentially with more and more people increasing productivity by working wirelessly. The emerging trend is towards using data services and wireless Internet connections to access enterprise data. As technology advancements, such as wireless network services, enable more organisations to take advantage of Mobile GIS, it is clear that the deficiency in enterprise geographical data is hindering development.

To remedy this a system that can provide both GIS data collection and Mobile GIS capabilities is an attractive way forward for many companies. Rugged and portable computers with integrated high quality GPS are now available running the industry standard Windows Mobile 2003 operating system. That convergence of technologies allows companies to deploy their workers with GIS data collection or mobile GIS capabilities, with enterprise data being delivered over mobile phone with Bluetooth connectivity to the handheld. Once fully operational Mobile GIS provides a competitive edge to service provision to customers, increases productivity and ensures that data is always up to date for critical decision-making.

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