Mobile Geographic Information Services (M-GIS): Technology That Changes the Way We Navigate Our World

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Abstract:

The convergence of a number of technologies including Geographical Information Systems (GIS), Internet, Global Positioning Systems (GPS), wireless communication and truly portable computing solutions enabled an exciting new field of informatics to develop, namely Mobile Geographic Information Services (M-GIS). M-GIS, is putting spatial information into the dashboards of vehicles and the hands of those in the street or carrying out fieldwork, it is giving service providers and emergency responders real-time location information that enables them to offer rapid response, targeted, relevant assistance and better services. This paper introduces the components of the technology involved, and the position of GIS and GIS service providers within this. It then discusses some applications to which this technology is being applied, and goes on to explore the growth factors and potential M-GIS holds both globally and within the context of China and the Asian Region.

1 A definition of Mobile Geographic Information Services (M-GIS)

Location is fundamental to the way we as humans understand and operate in this world (Tang, 2002). Whether it is understanding where we are in relation to where we want to go and the most efficient way of achieving this; or selecting suitable sites for houses, crops or businesses and understanding the factors that make these flourish in one place, but not in the next - 'Location' is crucial. Traditionally we have held location information either in our heads, or in graphical sketches and maps (there is evidence, in fact to suggest that the drawing of maps often predates the development of a written language in many primitive societies (Harley and Woodward, 1987). From the latter half of the C20th maps and spatial information have increasingly been stored, analysed and referenced in computerized systems.

Geographical Information Systems (GIS) developed as a distinct science in the late 1960's and early 1970's when concentration in mainstream computing world was on numeric computation and textual data storage. Storage of spatial data and spatial analysis, which could not be made to fit easily within the confines of the available database technology, developed as a separate science. This exclusivity has now definitely disappeared – most leading database and Operating System providers now recognize the importance given to location and spatial information by their clients, and most are now providing tools to facilitate the storage, retrieval and analysis of it. The tools and formats used for this are being standardized and integrated on the basis of common open standards and in many ways GIS can no longer be considered a separate and distinct science, but has been welcomed into the wider computerized information world.

What then are Mobile Geographic Information Services (M-GIS), and why are they important? First, traditionally we record and present location on static maps – fixed images that show a snap shot state in time. This by-enlarge has continued in the way we have implemented many of our GIS systems. However, many of the items we want to locate are far from static – they move – and there is significant value in knowing when, how and how quickly they move, and the direction and route taken. Delivery vehicles, emergency service patrols, weather fronts, trains, buses, taxis, wild animals, diseases – they all move, and being able to track them in real time is valuable. Secondly, often it is when we are on the move ourselves that we are most in need of location information. To be warned of traffic accidents and congestion, and be given driving instructions for a suitable alternative route is far more useful if it can be delivered to your car rather than be waiting for you

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on your computer at the end of your (delayed) journey. For asset service personnel to be guided to a faulty appliance whilst they are still in the field is far more useful than having to drop back to the office to pick this information up from a map or computer in headquarters (see Figure 1).

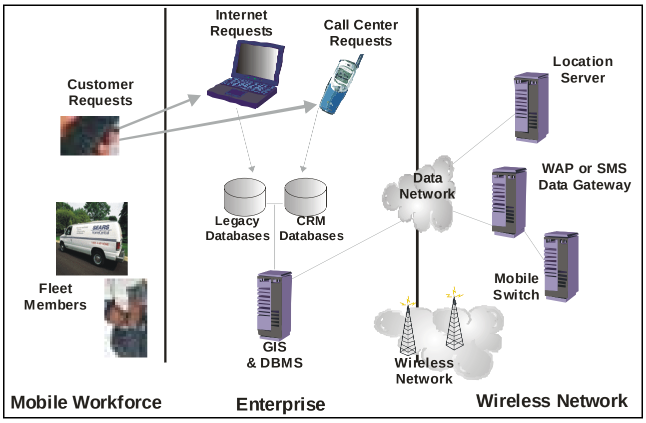

Figure 1. M-GIS - Making a different in the dispatch industry

This demands the ability to capture location information on moving objects and events, and to transmit this, in real-time, to recipients who may themselves be moving. This, simply put, is what M-GIS does. M-GIS provides the tools and services to capture, format, extract and stream location information that permits this to happen. As such it is a key contributor in the overall development and expansion of what is now termed 'mobile computing', providing both services and 'content'. In time M-GIS and indeed, the whole 'mobile computing' industry will, like GIS itself, enter the mainstream of services and facilities that are expected as standard. At present, however, the advanced nature of the technology and complexity of some of the issues that are being addressed warrants the definition of M-GIS as a separate field.

2 Complimentary Components

The development of M-GIS has been made possible by the convergence of a number of key technologies including those of:

a) wireless mobile communications;
b) mobile, handheld hardware;
c) network computing and the Internet;
d) terrestrial position definition; and
e) spatial processing.

The rapid development of the mobile communications industry over the last five years is a direct result of increasingly sophisticated wireless communications technology and rampant demand for mobile connectivity. These have together ensured that global coverage by wireless communication services is now a very real prospect. Whilst there remains substantial differences in the communication standards adopted throughout the world, a fact that stands in the way of truly global connectivity, this rapid expansion has been largely due to widespread regional adoption of a few key communication protocols such as GSM, GPRS, CDMA.

Mobile communication devices have evolved rapidly to take advantage of the expanding network bandwidth and meet the rising expectations of a rapidly growing user community. The Yankee Group has forecast that there will be 1 billion Web-enabled mobile devices in the world by the end of 2003. Of these at least 80 million of them will have some form of location capability. Nowhere is this more noticeable than in China which now boasts the world's largest mobile user community, 150 million cell phones in circulation as at May 2002, and a dramatic rate of uptake (3.6% in six months from November 2001) (IBC Asia Ltd, 2002).

Developments in size, weight, robustness and usability of mobile devices have been critical to their popularity. Demand driven development has lead to increasing sophistication in a full range of mobile devices from simple pagers and cell phones to PDAs and ruggedised notebooks. Increasing adoption of mobile OS standards such as CE, Symbium, WAP have opened up an rich collection of application development environments including XML, HTML, XHTML, WML and COM that revolutionize mobile interface development.

The development of Internet and remote computing technologies have been central to the expansion of the range of services offered to mobile devices users. New server and client side technology facilitate operation on very thin networks, and increasing adoption of optimized data transfer standards were initiated largely by the Internet boom over the last ten years. Mobile communications are now able to take advantage of such developments to leverage the range and nature of functions offered. Many of the standards adopted by mobile communications industry (XML, Java, J2ME, HTML) are growing out of standards developed for thin client Web solutions.

Positioning technologies, technology that identifies location on the earth's surface, have been essential to the development of mobile telecommunications as a means of tracking mobile units and ensuring they are effectively allocated within the network. Increased precision now offered by the development of certain positioning technologies provides the opportunity for offering location-based services to customers. Commonly used positioning technologies are described in Table 1.

Table 1. Positioning Technologies

Technique	Method and strengths	Examples
Data-based	Location calculated with reference to a single base station. Fast and cheap but reliant on density of base station distribution and provide limited accuracy	Cell-ID, Time Advance, MAHO/NMR.
Network-based	Location calculated based on triangulation of three base stations. Fast and accurate, but increased overheads	TOA, TDOA, AOA
Handset-based	Location calculated by handset based GPS receiver or packet switching capabilities. Very accurate position fix, increasingly affordable and GPS technology costs drop	GPS, A-GPS, E-OTD

For a position fix to be useful however, it must be related to geographic information and have a set of geographic tools through which it can be analyzed and presented. Spatial processing technologies, or GIS technologies, provide this. These include technologies to store, analyze and integrate data, undertake very rapid geo-coding, reverse geo-coding and routing functionality, and the ability to compress and stream, either as images or features, large quantities of spatial data across thin network connections to a variety of receiving platforms. This has been the focus of GIS development over the last thirty years, and it is due to advancements in spatial data storage, data transmission and Internet mapping that M-GIS has been made possible. As with other components, key to the recent development of GIS technology has been standards and compatibility. The definition of data standards through Open GIS Consortium (OGC), and the development of platform independent spatial data warehousing capabilities such as ArcSDE have been essential in opening access to large quantities of spatial data. The OGC has spawned a separate group the Open Locations Services (OpenLS) group which is working on integration of standards for LBS including: WAP, WML and WBMP, Mobile Location Protocol (MLP).

As is clear from the above, standards have been the facilitator in bringing these components together. There is certainly more work to be done on standards and integration, however, sufficient progress has been made for real, workable components to be established.

3 Where and how does M-GIS fit into Network Operators' Environment

The M-GIS components are implemented as server side operations within the network operators systems and as light applications that are downloaded or pre-loaded on wireless devices themselves. On the server side, components include: spatial datasets, data translators, projection engines, fast spatial search and analysis tools, compression and image rendering/streaming features. These communicate with other elements of the wireless system through LIF and OGC standards. On the device side are a range of tools enabling simple powerful interface development in standard languages such as Java, COM, HTML and XML.

There are two basic approaches available to network operators in developing the server side location services. The first sees the development of an internally hosted and managed Geospatial platform behind the operator's firewall that will handle all server-side location operations. The second permits the wireless operator to take advantage of externally hosted location solutions via Web-based External Geospatial platforms.

3.1 Internally Hosted Geospatial Platforms

This enables wireless network operators to host and manage their own spatial processing capabilities within the architecture of the wireless network (Figure 2). All spatial data content, applications and services can be developed and managed in house. Internally hosted Geospatial platform typically consists of: a spatially enabled RDBMS, a web based spatial interface, a routing engine, interfacing tool kit and geographic data.

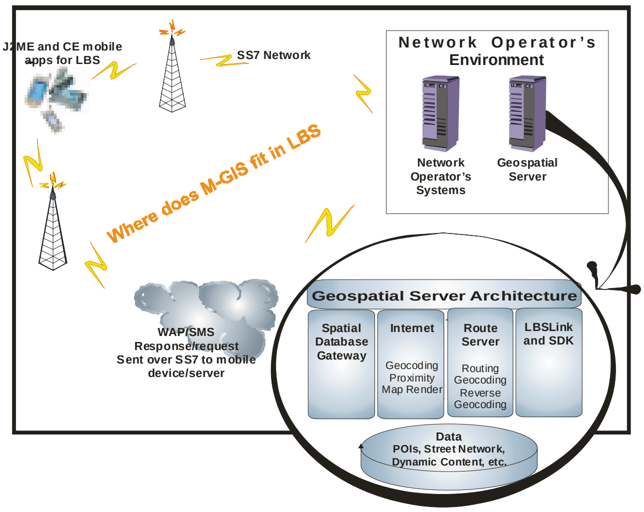

Figure 2. Internal GeoSpatial Server Network

The spatially enabled RDBMS acts as the location application server and the gateway between spatial and textual datasets. It is responsible for delivering data to Internet and wireless Internet based clients. The RDBMS should also enable efficient spatial indexing and searching as well as execution of basic geographic operators such as addition, deletion and merging of spatial data. If routing functionality is required, the spatial RDBMS must support the storage and maintenance of route network data structure. Examples of such spatially enabled RDBMS include Oracle Spatial or IBM DB2 Spatial Extender and ESRI's platform independent ArcSDE. Of these only ESRI's ArcSDE currently supports route networks.

The Web based spatial interface (e.g. ArcIMS) draws data from the RDBMS and presents it to Web and wireless clients. These packages provide a suite of tools for customizing user environment and functionality. Most are based on industry standard ASP, Cold Fusion, Java, HTML and XML standards. They enable the integration of data from many different sources and handle image rendering and feature streaming to thin and wireless clients. An interface module or standalone package should sit between the web based spatial interface and the wireless network to handle chaining requests to and from the wireless device and spatial server. These support a range of WAP, RIM or CE clients and are capable of interpreting XML through wireless messaging protocols (e.g. OpenLS and SOAP).

In addition to the server capabilities of the spatially enabled RDBMS and the Web-based interface, advanced location services wishing to take advantage of routing capability will need some form of routing engine. This will interface with network data stored in the RDBMS and will enable point-to-point and route search functionality. It should enable routing preferences to be set including, solving 'find shortest/fastest/cheapest path' algorithms and the allocation and maintenance of impedance. Finally, spatial content must be maintained and loaded. The range of spatial data now readily available is huge. Suitable datasets may include standard base maps at a variety of scales, road networks, business and tourist Point Of Interest (POI) layers, demographic and economic information as well as real-time data feeds such as weather, traffic conditions, etc. Custom layers providing tracking of other mobile users or assets may also be provided.

The advantage of an internally hosted Geospatial Platform is that the network provider has complete control over the content and services provided and can make use of elements of an existing GIS installation within their systems. The disadvantage is that the responsibility for content/service development and maintenance falls entirely on the provider and may demand an additional skills and tool set.

3.2 External Web Based GeoSpatial Services

External Web based GeoSpatial Service centers (Figure 3) are essentially built on the same kind of technology as an internally hosted platform, but they are developed and managed by an independent third party. This is a rapidly growing service sector. The wireless operator simply contracts a spatial service centre to provide data or functionality which are made available through standard XML or SOAP interfaces.

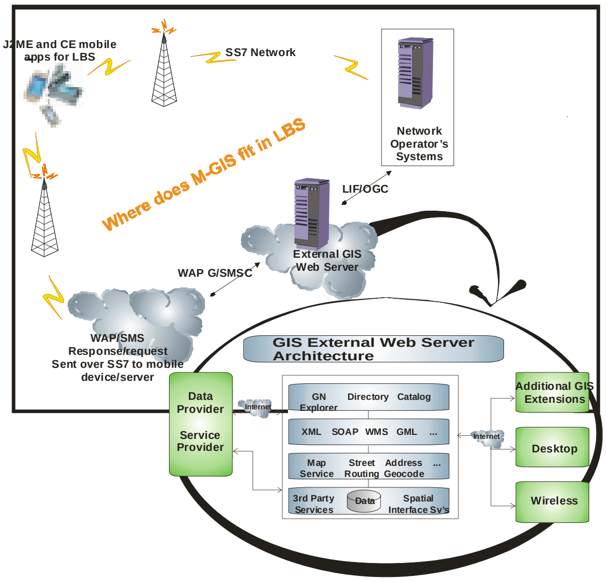

Figure 3. External GIS Web Server Platform

As External Web Based GeoSpatial Service providers concentrate purely on this market segment, they are able of offer a wide range of data and sophisticated applications. They provide access to a range of spatial datasets throughout the world, as well as advanced map rendering and compression which can reduce download times and enhance performance. They also are developing a range of standard tools such as address and place locators, simple location query, driving direction instruction servers and proximity/buddy searches. These services can be customized to conform to the image and style of the individual network provider.

Designed as robust multi-user service centers, external Web-based GeoSpatial servers are secure, and generally provide necessary billing, failsafe and load-balancing functionality. They offer a relatively cheap and simple way for wireless operators to extend their services into the location field without having to invest heavily in additional systems, datasets and skills.

4 Application examples – potential and benefits

Traditionally GIS has been used in telecommunications industry to support backend processes and logistics. GIS is a central tool for managing network assets, planning and rolling out network coverage, and managing customer relations and market analysis. M-GIS however expands this by enabling network operators to provide product differentiating location-based functionality as real time services delivered to their customers.

The scope of location services is wide and rapidly expanding. Many depend on spatial processing within a central server and do not require particularly sophisticated graphical visualization or functionality within the mobile units. Examples of these services include the increasingly important area of unit tracking, both for emergency response (automatically identify the location of a cell phone caller for dispatch of 991 services), and for fleet management. 991 services have been supported by legislation by the US Federal Communications Commission (FCC) that has made the ability to locate a cellphone users to within a certain radius a statutory requirement (currently 100m for 67% of all calls and 300m for 95% of all calls, (Francica, 2002)). Dedicated companies such as Intrado have developed to support network providers in meeting these requirements. Intrado claims 22 wireless and 52 wireline carriers as users – supporting daily services in excess of 67 million subscribers. Some providers are using the spatial information gained to offer basic search facilities which can return textual POI or addresses to mobile cells that are not graphically enabled. These are being used for business/leisure audiences to provide targeted directory services providing lists of restaurants, banks, shops that are within a certain radius of the user's current location.

Increasingly, however, network providers are realizing that knowing where their users are offers opportunities for tuning and refining their own networks or service packages. Organisations such as SignalSoft in the US and KLN in Netherlands, for example track the location of each outgoing call and record this in their internal geospatial databases. Internally this has a number of advantages as it enables them to study in detail network loading patterns and to arrange the density and distribution of their receivers accordingly. Better coverage, translates to more reliable service and more efficient network load balance, both key user demands.

In addition, SignalSoft has extended this proactively to offer location sensitive rates zones. As location of calls is known these are tailored to the individual subscriber rather than broad regional definitions – so for example you pay one charge for calls originating from your 'home' zone, another from your 'work' zone, another from your 'shopping' zone (Godin, 2001). The service also offers the ability to track mobile users, not just for emergency responders, but also for those involved in caring for the young, ill or aged whose movements may for their own safety need to be monitored. Companies such as Pinpoint are exploiting this technology to offer services to track people and even pets.

More sophisticated handheld units and networks allow digital map graphics to be sent and displayed. This permits complex spatial data to be graphically displayed, including presentation of route or pathfinding requests and 'buddie' tracking facilities (the ability to display the location of other mobile cell units within your current vicinity). This greatly enhances the range and usability of spatial information presented.

Demand for such services in general consumer information provision is evident. MTel's MobileSurf package permits display and analysis of graphical information and maps showing dining, entertainment, traffic and other data on handheld Pocket PC units. It has been estimated that there some 25% of all new cars sold in 2003 will have some form of online routing facility (Koeppell, 2001), and increasingly location based services are being found in the dashboards of cars and delivery vehicles. This is certainly appealing to the consumer market, as is evidenced by the widespread adoption of on-board car navigation systems in Japan.

It is also significant for distribution operators and the corporate market. On-board tracking and navigation facilities are permitting better routing decisions to be made by drivers, and allowing office staff to keep track of where their vehicles are at any one time. Evidence from organizations such as Cloudberry, that manages tracking services for a range of private and public companies suggest that there are substantial. Vehicle tracking not only helps to reduce down time and unscheduled trips, but enables better, more flexible allocation of vehicle resources. Cloudberry notes clients report 30% increases in average load per vehicle and 18% reduction in the total number of vehicles after installation of vehicle tracking services.

Enhanced mobile units permitting update and edit of spatial data are being increasingly used within incident response systems and onsite asset inspections. These offer the potential for keeping mobile maintenance crews in the field longer, reducing turnaround time for incident response and resultant cost efficiencies. Handheld PDA asset update systems are becoming commonplace particularly in the asset maintenance departments of utility companies and public authorities. The ability to download location plans and asset details, make and post back necessary amendments and updates, all whilst operating in the field has significantly increased efficiency.

Organizations such as PortaTrak are taking this a step further. In order to keep track of mobile assets (site or industrial plant) or multiple features in a large and complex facility, PortaTrak has developed cheap, robust wireless devices that can be place on the assets themselves. These are capable of reporting both location and asset status. In this way, maintenance teams equipped with wireless spatially enabled receivers can not only be immediately alerted of asset status and location, but can be guided to it as well (Godin, 2001).

5 The Market in Asia

The market for mobile services in China and Asia is recognized as one of the most significant in the world at present. China already has the world's greatest number of users, and the potential for expansion is still vast. In Hong Kong, Japan and Singapore mobile technology has been hugely successful – in Hong Kong there are 5.7 million registered users in a population of 6.7 million and Japan is an acknowledge global leader in wireless technology and services. Countries like Indonesia, Malaysia and China are set to see massive expansion of wireless usage as coverage is extended into rural areas where the cost of fixed line connections are prohibitive. Such extension will be able to take full advantage of cutting-edge technologies that are currently under trial or development. Such network technologies as smart antennas and mesh networks (both of which depend heavily on knowledge of location) and ad hoc architectures and ultra-wide band transmission, offer the potential for broadband wireless transmission at a fraction of the cost of 3G (The Economist, 2002).

In terms of commercial application of location services, Japan leads the world in the supply and take up of inboard car navigation systems. Such systems not only provide up-to-date traffic, accident and routing information, but are being used to integrate with traffic management systems, delivery of emergency response, and local service directories. NTT's DoCoMo and J-Phone along with service companies such as SECOM are both offering services such as location based directory searches, user tracking and localized 'buddy' finding.

Directory services are also provided to users in Hong Kong through PCCW's Yellow Page service, which is available on PDA and WAP phone as well as fixed link Internet (Figure 4). This permits searching for key public facilities and transportation options as well as a range of consumer POI such as chemists, restaurants and sports facilities. A joint venture between Shell HK Ltd, Sunday Communications Ltd and Webraska Inc. is also provide a comprehensive road routing service throughout Hong Kong and use of mobile asset maintenance is being investigated or actively used by a number of different Government Departments (Environmental Protection Department, Civil Engineering Department) and utility companies (China Light and Power).

Figure 4. Hong Kong's yp Map available to mobile and fixed line users

The US company SignalSoft mentioned above, has recently announced the extension of its SafetyFirst location to China, providing nation-wide location facility for tracking emergency calls and assisting with the allocation of first responders. Finally in Singapore, the network operator Orange is working with ESRI SE Asia to develop local External GeoSpatial Server hub which can be used to support wireless location services throughout Thailand.

6 Conclusion

Whether enabling spatial data and route finding to be streamed to users mobile cells, or enabling service providers to add additional services such as emergency response, direction finding or buddy tracking, M-GIS is playing a major role in the provision of mobile services. Technology and standards that support this are evolving, and have not yet been fully finalized. However, what is clear is that there is both market demand and technology available in Asia that will ensure that this region continues to be at the forefront of exploring and benefiting from the potential offered.

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