Wireless GIS – Concept & Reality

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ABSTRACT

We are currently witnessing a renaissance in Geographical Information System (GIS) technology. With the emergence of new spatial database, web and wireless technology, ***GIS is merging with mainstream IT (Spatial IT),*** and is being called on to serve in increasingly critical enterprise-wide roles. Subsequently, many Information System Executives and Senior Managers are realizing that in order to meet the increasing demand for this information, and to take full advantage of emerging spatial technologies, their spatial data holdings must be fully integrated and managed together with other enterprise information.

Recent advances in GIS, GPS, Personal Digital Assistant (PDA) and wireless technology in particular are fuelling the rapid growth of a new industry known as Location Based Services (LBS). This paper addresses the current state of the emerging technologies underlying LBS, and provides a pragmatic view on the practical challenges and limitations of implementing LBS in North America.

This paper concludes that, although promising, implementation of LBS applications is still only practical on a limited basis in North America. The main barriers preventing LBS from reaching its full potential in North America include; limited wireless coverage; narrow band width for wireless transmission of data; lack of current and reliable base map, road centreline and street address information; and a cost barrier to this information when it is available (particularly in Canada).

Key words: Wireless GIS, LBS, GPS, Spatial IT.

1 GIS Industry Trends – From GIS to Spatial IT

We are currently witnessing a renaissance in Geographical Information System (GIS) technology. With the emergence of new spatial database, web and wireless technology, ***GIS is merging with mainstream IT,*** and it is being called on to serve in increasingly critical enterprise-wide roles.

Spatial IT

New terminology that better describes the assimilation of GIS into mainstream IT is introduced in this paper. Spatial Information Technology, or Spatial IT, is used throughout this paper in place of the usual term "GIS". Spatial IT is intended to be a much broader and more descriptive term than GIS. GIS refers to a "Geographic Information System", and is usually associated with vendor products used to perform analysis using geographically based spatial (geo-spatial) data. Spatial IT, on the other hand, encompasses all aspects of collection, management and use of spatial information. This includes not only (GIS) systems and technology, but also the modeling, collection, management, analysis and use of spatial information throughout the enterprise. Spatial IT is also not restricted to geographic information, but can include engineering and mechanical drawings and any spatial information about objects that can be captured and stored digitally.

From an information resource management perspective, the assimilation of GIS into mainstream IT is a positive development. The integration of spatial systems and data with enterprise systems provides opportunities to unify systems management and technology, which should result in significant cost reductions and improved spatial information through the adoption of better spatial information resource management practises. Hopefully, by treating spatial information as just another enterprise data set, the control of this valuable information will be wrestled from the hands of the GIS "experts", who have long confused and mystified laypersons and Information Technology professionals alike with GIS acronyms, terminology and techno-babble, and perpetuated the myth that Geographic Information Systems are completely different from other information systems.

Other relevant Spatial IT Industry Trends include:

Emerging Standards
On its Web site at www.OpenGIS.org, the **Open GIS Consortium** (OGC) describes itself as:

"An international industry consortium of more than 220 companies, government agencies and universities participating in a consensus process to develop publicly available geoprocessing specifications. Open interfaces and protocols defined by OpenGIS® Specifications support interoperable solutions that "geo-enable" the Web, wireless and location-based services, and mainstream IT, and empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications."

It is the author's opinion that the number and stature of OGC's membership organizations, and its formal affiliation and cooperation with other standards bodies such as ISO TC 211 geographic information committee (http://www.isotc211.org/), and US Federal Geographic Data Committee (http://fgdc.er.usgs.gov/) provides OGC with the "critical mass" of support and industry buy-in necessary to finally define fully open interoperability standards for spatial information that will be adopted worldwide.

New Database Products
All major database vendors have "spatially enabled" their database products to allow for storage, management and query of spatial information.

New GIS Products
All major GIS vendors have released software products for Web-based visualization and analysis of spatial information. These same vendors have also released software products for use on Personal Digital Assistant (PDA) devices running Windows CE.

New GPS Technology & Services
The cost of GPS hardware has fallen dramatically over the past few years. GPS units that sell for as little as $300 today, provide the same level of accuracy and functionality as units that cost in the tens of thousands of dollars just a few years ago.

In conjunction with this dramatic decrease in GPS hardware cost, the accuracy of GPS technology has actually improved significantly due to two main factors. The first is the US military's decision to drop "selective availability" degradation of GPS signals. The second is new technology for broadcasting real time correction information through services such as the US FAA Wide Area Augmentation Systems (WAAS) that has been operational since 1999, and the Canadian Differential GPS systems (CDGPS) which is scheduled to be operational the summer of 2002. The WAAS system provides real time positioning information accurate to 7 metres across North America, and is available at no cost for users with newer GPS units that support the WAAS protocol. The CDGPS system is expected to provide real time correction information that will improve the positional accuracy of GPS units to the sub-metre level.

New Wireless Communication Technology & Services
New wireless communication infrastructure, technology and services are rapidly improving to provide remote access to the Web and the back office via cell phones and PDAs.

New 3G cellular standards and infrastructure (i.e. towers, etc) are being implemented in North America by the major telephone companies and Internet service providers. This new standard provides wider bandwidth and the transmittal of larger data packets. It has been operational in Europe and elsewhere for some time, where the population density supports the additional cost of the infrastructure.

Advances in PDA technology
Significant improvements in the storage capacity, processing speed and functionality of PDA hardware over the past few years, coupled with a corresponding drop in price, has resulted in a greater distribution of these devices as well as an increase in the cost benefit of utilizing these devices for enterprise wide applications. The increased performance means that processes previously requiring desktop computers can now be preformed on PDAs. The introduction of a Windows

based operating system for the PDA (Windows CE) and emerging standards for wireless communication protocols have also improved the interoperability between PDA applications and applications running on the desktop and the web.

Emerging Location Based Services
Lastly, the technology trends mentioned above have given birth to an entirely new industry – Location Based Services (LBS).

2 Taking "IT" to the Streets – LBS & Wireless GIS

This section of the paper provides a definition of Location Based Services (LBS), and discusses applications areas, business drivers, and two operational modes for LBS – connected and disconnected.

What are Location Based Services?
LBS is anywhere, anytime mobile computing. In practical terms, it represents the merger of 4 new technologies mentioned in the previous section, namely:

- Personal Digital Assistant (PDA) – handheld PCs.
- GIS for PDAs, including; ArcPad from ESRI; OnDemand and IntelliWhere from Intergraph; and Onsite from AutoDesk.
- Real-time GPS positioning
- Wireless internet technology and infrastructure

Business Drivers for LBS
One of the major business drivers for LBS in North America is the implementation of the Automatic Location Identification (ALI) under Phase II of the E911 mandate governed by the US Federal Communication Committee (FCC). This mandate supports the E911 emergency response call centres across the US that receive up to 100,000 calls per day – 50% of which are from cell phones. The mandate, effective in December 2002, specifies that all new cellular phones sold in the US must have the ability to transmit their position to within 100 metres (300 feet) along with a 911 call. Several Telco companies and service providers have already released products and services compliant with this mandate.

Application Areas for LBS
There are 4 basic application areas for LBS technology. They are:

- Finding things – E911, travel directions, etc.
- Customer Relationship Management (CRM) – sales and service calls, etc.
- Asset Use Management – fleet management, work permitting, field based infrastructure inspection, etc.
- Field Force Automation – meter reading, delivery services, etc.

LBS Operational Modes
In ***connected mode***, direct wireless connection is maintained to the enterprise spatial and attribute database and server application during operation via the Internet. This mode requires a PDA with a wireless communication card. This allows real-time updates to the data through the wireless connection.

In the ***disconnected mode***, the spatial data and application is cached and processed directly on the PDA device. There is no need to maintain a wireless connection to the Internet. The field-captured information is downloaded and integrated (synced) to the enterprise database back at the office, or when a wireless connection is made via the Internet.

A GPS card for real-time positioning of the user can benefit either mode of LBS operation. Alternatively, existing map features accessed via the Web for the connected mode, or stored and displayed on the PDA for the disconnected mode can be used to position the operator if real-time GPS positioning is not available.

3 Reality – What a Concept

Although LBS and wireless GIS holds great promise for the future, there are a number of challenges and limitations that must be overcome before the full potential of this technology can be realized – especially in North America. These challenges and limitations include the following:

Wireless Coverage & Staying Connected
With the exception of a few small geographic areas, the new G3 cellular standards have yet to be implemented in North America. The current G2 and G2.5 cellular standards are very restrictive in the amount of information (data packet size) that can be transmitted. Also, digital signal coverage is typically only available within urban areas, and quickly drops off in sub-urban and rural areas.

GPS Coverage & Staying Connected
For LBS applications that require real-time positioning, maintaining adequate satellite links can present a problem. To receive an accurate "position fix", the GPS antenna must maintain a link to at least 4 or 5 GPS satellites simultaneously. This is not always possible in urban areas due to tall buildings or in forested areas due to tree canopy.

Disconnected Mode & Re-syncing
Although the disconnect mode of operation can solve some of the limitations and challenges of staying connected, re-syncing (long transaction) of spatial data collected in "redline" files during the field sortie is not straight forward and can present a major challenge for this mode of operation. The re-syncing of "redline" attribute data from field collection and update is less problematic, but can still present a challenge.

Lack of Base Map, Road & Street Address Information
The lack of current, accurate, reliable and standardized base map, road and street address information that must be in place for many LBS applications is a particular problem in Canada, where practically all geo-spatial information is owned and managed by some level of Government. This information was typically "born" out of the planning, engineering or mapping departments of these organizations – initially as a by-product of automating drafting or cartography (CAD). For this reason, this vast information asset – representing multi-millions of dollars of investment – has usually not been subjected to the same rigorous information resource management principles applied to most other enterprise information.

Considering the legacy of most geo-spatial data (i.e. from automated drafting and cartography), meeting the demand for current, accurate, reliable and standardized base map, road and street address information is indeed a challenge that many geo-spatial data owners (mostly Government agencies) have recently started to address – at great expense.

For example, in British Columbia, where the author has considerable first hand experience, it is estimated that the provincial government has expended in excess of a $250 million in the past 15 years in the collection, conversion, cleansing and updating of geo-spatial base, resource, thematic and cadastral parcel information. Although ahead of many of their federal, provincial and local Government counterparts across Canada in this regard, much of the geo-spatial information is still not adequate to meet the ever-increasing demand.

Another example is in Ontario, where more than $1 billion has been expended in the past several years to create a cadastral parcel geo-spatial database and the TerraNet system. Much of this cost was for conversion, cleansing and updating of cadastral geo-spatial information for the Province.

The sheer magnitude of data conversion, and cleansing cost for geo-spatial information is usually surprising to most mainstream IT professionals and Spatial IT neophytes. In fact, this is one of the major differences between geo-spatial information and non-spatial information. For non-spatial information databases, migrating to a new systems or database architecture involves a mostly automated process for data conversion and cleansing or "data scrubbing". Geo-spatial data cleansing and conversion can usually only be partly automated, and can involve hours of interactive user intervention – particularly when the original source data comes from CAD files or GIS map tiles that have not been "edge tied".

Common problems with much of the existing geo-spatial information in Canada (and elsewhere in North America and the World, for that matter) include; multiple copies and sources of information throughout the enterprise, multiple standards and formats, topology errors (i.e. not analysis ready), insufficient or non-existent metadata, no links to associated attribute information, inconsistent and / or sub-standard data quality, poor positional accuracy, information not readily available (i.e. it is on CDs or local hard drives), and information is tile based and not "seamless". These common data problems, combined with different and often incompatible GIS and CAD systems and their proprietary data formats deployed throughout the various departments of many Government agencies can create information "silos" and significant MIS and data interpretation problems – and a major hurdle to realizing the potential benefits LBS offers.

4 Summary

In summary, implementation of LBS is still only practical on a limited bases in North America. The main barriers preventing LBS from reaching it's full potential in North America include; limited wireless coverage; narrow band width for wireless transmission of data; lack of current and reliable base map, road centreline and street address information; and a cost barrier to this information when it is available (particularly in Canada).

5 The Future Looks Bright

Even with the many challenges and limitations to wireless GIS and LBS in North America, this emerging market is expected to grow to over $32B by 2004 (Gartner Group), including infrastructure and services.

LBS and wireless GIS holds great promise for increasing personal and organizational productivity. With the continuing decrease in cost of mobile computing, communication and GPS technology, the market for LBS and (Spatial IT) is going mainstream. For example, according to a recent article in the Globe and Mail, the HP research lab in Brisbane is currently testing what they refer to as "Space Messaging" – where email messages can be left at a "location in space". The way this works is that the message is "tagged" with the location from where it was sent, and this information is stored on a Web message server. The receivers' device is constantly polling this Web site, and receives the message when he or she arrives within a predetermined radius of the broadcast location. It is easy to see how this type of application will catch on within the mass mainstream market of the general public.

One unexpected benefit of LBS and wireless GIS that is encouraging, is that the increase demand for current, accurate, reliable and standardized base map, road and street address information will hopefully result in adequate funding for clean up, update and improved management of this valuable spatial information – which is long overdue.