Mobile GIS for Homeland Security

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Executive Summary

Whether the mission is homeland security or public safety, remote access to information is absolutely essential and critical. The ability to provide location-based services (LBS) in a mobile environment requires a subsystem of device interfaces, location-enabled hardware such as GPS chips, software applications, and application servers designed to capture, store, mine, and consume spatially referenced data including telemetry and radio-frequency identification (RFID) technologies.

A complete end-to-end location-based mobility solution involves three elements: geographic information system (GIS) technology, position tracking, and visualization. The combination of all three elements is the chemistry for situational awareness.

GIS provides specialized processing power for the acquisition, retention, access, and analysis of geographic and spatially referenced data. GIS is the core of knowledge for a location-based service solution because it manages and serves data relative to the surrounding environment such as addresses, streets, areas of interest, risks, and hazards.

Position tracking is a critical element in LBS. A basic element of intelligence is the knowledge or awareness of location, and knowing where you are is the basis of understanding your surroundings. In a mobile environment there are essentially two forms of location tracking, automatic and manual. Automatic location tracking is a systematic process of the mobile device and the wireless network using either GPS or cellular tower triangulation. Position tracking also includes RFID and telemetry technologies. RFID is often used to track information on objects, such as shipping containers, hazardous materials, or sensitive cargo, and their whereabouts. Telemetry provides the ability to track position as well as package data from I/O sources such as vehicle computer buses to monitor critical sensors including emergency lights, fuel levels and consumption, security systems, or engine functions.

The value of GIS and position reporting is not fully realized without a visualization tool such as a mapping application. Mapping applications and tools furnish information to the user in a geographic context. Mapping applications also provide users with the ability to interact with data through point-and-click interfaces.

Mobile GIS means more than accessing and using GIS data in a wireless environment. Mobile GIS will become the key to device intelligence, providing the user with greater ability to communicate and manage information. In the future, users will be able to create profiles, and the device will understand how to apply those profiles to the user's current environment, equipping the user with new knowledge of their surroundings and even automatically responding to conditions with alerting, workflow processing, or information management.

Introduction

The association between a handheld mobile device and a wireless network is driven by protocols unique to each respective system or network. As such, each device/subscriber should have the necessary software configuration to operate on a specific network. The software in question is provided by the device manufacturer and is typically installed during the manufacturing process.

GIS software is independent of any device and network relationship, meaning GIS is a system that functions outside the communication protocols required for interoperability. However, GIS can and should be an integral component of any communication system. Today, many device manufacturers and/or network providers are providing location tracking services either through GPS chips embedded in the device or services provided by the network such as device location tracking and/or presence notification.

Therefore, it is highly recommended that any wireless (radio or cellular) network deployed for the purpose of providing public safety should incorporate GIS server technology. Location-based solutions developed on GIS server technology can process any geospatial data transported across the network for the purpose of tracking the location of the device or being consumed by other applications that provide situational awareness to the user. If a homeland security or public safety agency wants to have location intelligence in a mobile device, it needs to know where the device is and who is using it; GIS can provide this information.

This paper will discuss the fundamentals of GIS functioning within mobile devices, applications, and wireless networks in the context of homeland security and public safety.

GIS Fundamentals in the Mobile Environment

There are four basic components to any information technology system: hardware, software, network, and data. How each of these components is designed and configured determines the effectiveness of the overall system. Not enough hardware processing power, and the system functions very slowly. Not enough network bandwidth, and the flow of information grinds. If software applications do not provide the right features, workflow is inefficient. Finally, if data can't be accessed and shared, the information is usually of little value.

The term *mobility* in relation to information technology, is simply defined as the ability to access, acquire, and/or process data anytime, anywhere. As such, homeland security or public safety solutions should be designed to support mobility.

From data acquisition to situational awareness, GIS plays a significant role with homeland security and public safety in the mobile environment. In fact, GIS functionality can be found in each of the four basic system components.

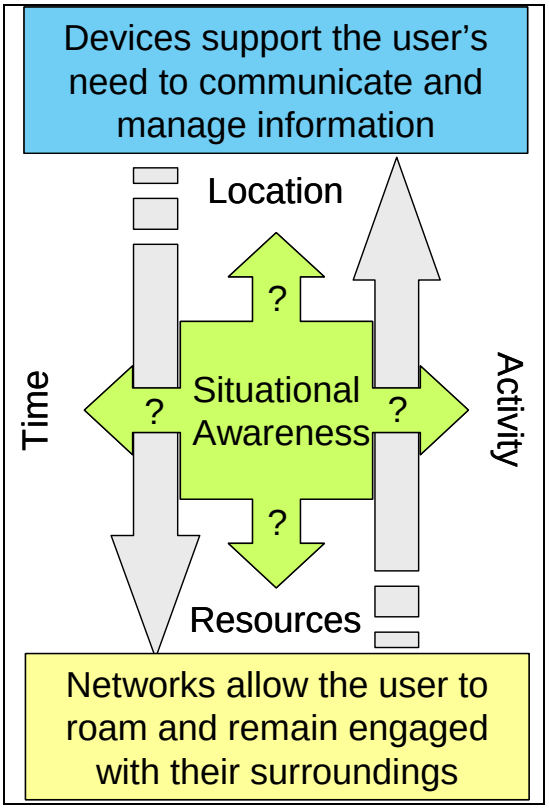
The device is the hardware component the user interacts with. Today, nearly every adult in society carries some type of device to facilitate mobile communication or to access and manage information in a mobile environment.

Software applications on the device help the user understand data such as location, time, resource availability, and desired activity. In a nutshell, the user understands where they are and where they are going, how to more efficiently arrive at their destination, what they need to know about the place they are going to, what they will need to do when they get there, and how their surroundings relate to their given situation.

Wireless networks provide the mobile user with connectivity and access to information anywhere and at any time.

The resulting interaction and collaboration of all four components creates situational awareness.

Figure 1
Mobile Situational Awareness



Hardware Devices

Mobility in the context of hardware means much more than portability. In this paper, *hardware mobility* will be referred to as the device's capability to connect to a network to exchange data or communicate while roaming.

Portable laptops, cell phones, handheld radios, tracking devices (GPS units), PDAs, and numerous others meet the hardware mobility definition. Mobile hardware devices should be light enough to carry and rugged enough to withstand heavy use. They should also be feature rich enough to be multifunctional (e.g., handle voice communicating, text communicating, and data processing) as well as "intelligent" enough to know where they are.

GIS from a hardware mobility perspective has three dimensions: data acquisition, data presentation, and position reporting.

Acquiring data can be accomplished in many ways such as key pads, function keys, touch screens, sensors/scanning (RFID, bar coding, magnetic coding), or a series of algorithms automatically processed by the device. Of course, data acquisition is also largely the function of a software application user interface.

When engaged in either a response or recovery mission, the user may have physical barriers, such as protective clothing and gloves or inability to hold the device while also performing a physical activity, making it difficult to enter data. Therefore, from the standpoint of many homeland security missions and particularly emergency response, the device should provide the simplest method of entering data.

Data presentation is mainly the function of the software application. However, the device plays a critical role, and screen display size may present limits to work within. As such, the software application should be designed for compatibility with the device to be used. For example, a user is not going to be able to do much typing on a small two-inch LCD screen on a portable radio with a 10-key pad. So it is important to select a device that provides display capabilities commensurate with the desired software and tasks to be performed.

Many manufacturers are building devices with GPS chips built into the device itself. This feature allows the device to report its position to a central server or back to itself through a user interface. When interfaced with a software application, the device essentially becomes spatially intelligent and can alert the user of events, workflow triggers, and other critical information relative to the user's surroundings. These functions are important to creating situational awareness.

The mobile device is a strategic element in creating situational awareness because it is the object users interact with. Therefore, the device's ability to run sophisticated applications and perform multiple functions, such as communication and data acquisition/ management, is extremely important to situational awareness. However, the device and software applications resident on the device are not enough to create situational awareness. Another component is connectivity to a central server where there is significant processing power to handle complex transactions and dissemination of information. The interaction between the user, the device, the software, and the server is what creates situational awareness.

However, situational awareness is not the only objective when selecting mobile hardware. In many cases, it is more important for a device to perform a specialized function and do it well.

When selecting a mobile device, follow these simple rules to ensure GIS enablement:

- The device should have the capability of reporting its position or being enhanced through accessorizing to perform this function.
- The device should provide display resolution commensurate with the application being used.
- The device should be rugged enough to withstand heavy wear and tear.

- Choose the right device for the right job. Don't buy a cell phone if the biggest part of the job is to collect GPS points.

Software Applications

Software in the mobile environment is divided into two categories: embedded software and loaded applications. Embedded software functions exactly like loaded applications except for two differences. First, embedded software is loaded during the manufacturing process and is part of the device's operating functions, whereas loaded applications are typically distributed after the device is purchased and provide task-specific functionality. Second, embedded software is rarely updated throughout the life of the device, whereas loaded applications are frequently updated when new releases are available.

Loaded applications can be divided into two classes: customized and commercial off-the-shelf (COTS). Customized applications are generally designed to meet the user's specific requirements and provide specific functionality unique to the user's business process. In some instances, a customized application is COTS software with additional user-specific code. In these situations, the customization effort is either performed by the user, a systems integrator, contract developer, or third-party solution provider.

Because it is nearly impossible to develop software that meets every user need, some COTS software also offers functionality similar to customization called configurability. Depending on the application solution and the way the user performs a generic function, configurability can be complex, offering numerous options from which to choose. Configurability is often limited to field label nomenclature, field values, screen display orientation, or font colors and styles.

Many device manufacturers are beginning to offer devices with preloaded COTS-type applications as a value-added feature. In fact, some cell phone manufacturers are forming agreements with third-party solution providers to provide additional services that add value to a component option on the cell phone. For example, a cell phone manufacturer that is providing GPS chips in the phone will also install COTS mapping software, creating an integrated device. The manufacturer does this in hopes that the market will buy more cell phones with GPS chips.

It is important to note that the COTS mapping application may not completely fulfill commercial needs but may be tailored more to the average consumer that is simply looking for directions. Therefore, the commercial user may be paying extra for software that is of little value for their particular needs.

Beyond the functionality and display requirements for an application on a mobile device, when selecting a GIS solution in the mobile environment, it is also important to understand four user profiles:

1. **Data Administrator—**Typically requires very robust features/functionality to ensure that all desired configurations and provisioning are set and maintained properly and efficiently. Often Web applications enable mobility for the data administrator versus a mobile device application.

2. **Data Collector—**Any user who has a primary purpose to collect and enter data into a system.

3. **Data Quality Assurance Technician—**Typically needs to have administrator or full access rights to a data repository to ensure the data is accurate.

4. **Data Consumer**—Any user that will use data for informational or transactional purposes.

Networks

There are two primary types of wireless networks: private and public. Private networks are owned and operated by a private entity such as a public safety or government agency. Private networks tend to offer better security than public networks because the network owner has control over who is granted access. Still, it is often recommended by many IT professionals to secure data, not the network.

There are three essentials when deciding which type of wireless network is best for a particular deployment:

1. **Bandwidth—**The amount of data traffic the network can facilitate. Typical data transactions require large bandwidth networks.

2. **Coverage Area—**The ability to remain connected to the network when roaming. Coverage tends to weaken as a device travels away from the farthest network access node.

3. **Compatibility—**Many networks allow a device to navigate from one network to another without losing a connection. This feature is important in public safety since some personnel may be in a remote area, operating on a narrow bandwidth network, then travel to an area with a broadband network.

Public network providers are increasingly becoming the choice solution for public safety agencies because of available coverage and bandwidth. In addition, public networks are often more affordable because the maintenance of the network is performed by the public carriers.

Public and private networks are essentially built on the same hardware and software, so there is little difference in performance between the two. However, public carriers are motivated by profit, so they continually upgrade their networks to meet market demand for high-speed data and broadband solutions.

Wireless network technology is becoming more sophisticated, providing the ability to "self-heal" should an access node become incapacitated and provide presence notification or device tracking as part of the network.

Presence notification when combined with GIS is a valuable solution in tracking mobile devices indoors or outdoors. The network's ability to provide presence information adds to situational awareness when GIS servers are used to process spatial data associated with device location.

Data Repositories

This is a broad topic that could require an entire paper on its own. The important point is that there needs to be an understanding of how data is accessed and shared. Often custom interfaces need to be developed to access data because the repository schema may be complex and require intimate knowledge of how to decipher the records.

In a mobile environment, data access can be the long pole in any deployment project. Large data repositories often impact mobile performance because of the time required to search through data stores to obtain the desired records.

As such, when building a mobile solution, it is imperative to consider data access in evaluating performance. Factors such as frequency of data access, data transference volumes, data versioning control, and data security should be well defined in a mobile project. In defining data repository interfaces in a mobile environment, it is equally important to understand the desired and optimum workflow. Workflow will determine whether or not data access is required immediately during a mobile connection, or if a user can initiate a data query, disconnect from the network, and return later to retrieve the results. Often, it makes more sense to do the latter to maximize bandwidth and reduce costs associated with wireless access.

Conclusion

There are four key components to any internal technology solution: hardware, software, networks, and data repositories. GIS tools today are increasingly adding value in the desktop and mobile environments by presenting information in the context of its location. Everything that occurs happens at a specific point on earth. Geoanalysis using GIS technology provides the ability to understand potential relationships between data. Spatially enabled devices, networks, and applications provide a higher degree of intelligence and capability to the system because of the fundamental understanding of how location impacts business and process decisions.

Whether the homeland security need is in the Emergency Operations Center solving complex problems, in the intelligence center analyzing threats and risks, in an administration office creating strategic plans, or in the field coordinating multiagency response and recovery efforts, GIS is sure to add value by giving geographic insight to those who need to make tough decisions regarding a secure homeland.