Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 8 (18): 3279-3283, 2008
ISSN 1812-5654

Developing a Mobile GIS for Field Geospatial Data Acquisition

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Abstract: Field based and GPS assisted GIS are frequently used in various geoscience applications. Such systems deliver more advanced, time and cost effective tools than traditional field forms for information collection. At the same time, different systems are on the market. These systems mostly enable users to determine positions of geo-objects by GPS and maintain functionalities to gather and analyze geometric information. The digital obtaining of the application's specific information is often underrepresented within these kinds of systems. This study attempted to develop a system for gathering, integrating, analyzing and visualizing spatial and aspatial information in electrical industry facilities. A PDA based GIS is extended to collect information in a beneficial manner, thus, adequately supporting the requirements of its users. Mobile GIS architectures, the components of a mobile GIS and their impacts on gathering data are examined. The steps followed to design and develop a system for the electricity Transmission and Distribution Company are demonstrated. The results are presented and discussed in details in the study.

Key words: Mobile GIS, GPS, PDA, spatial information, aspatial data

INTRODUCTION

GIS databases, used by government agencies and private organizations, must be kept up-to-data to inform decision makers about proper management of resources (Alesheikh and Fard, 2007; Longley *et al*., 2005). Data gathering is a time and money consuming task (Hosseinali and Alesheikh, 2008). The recent evolutions in Mobile GIS caused the possibility to cost effectively gather and manage GIS data (Amirian and Alesheikh, 2008a).

Mobile GIS is the accessing, using and storing 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 need timely access to GIS data in the field (McLarin, 2004).
Mobile GIS is evolved with developments in:

- Global positioning system (GPS) technology
- Rugged handheld computing technologies
- Wireless communications and
- GIS software for mobile platforms

Mobile GIS depends heavily on high quality data in the GIS database. However, in many organizations this data can be obsolete or even non-existent.

GIS data collection is the process of populating a GIS with data on the properties, including position and attribute information, of interest to the organization.

Until recently, collecting and using information in the field was a paper-based process with multiple points of data entry without accessing to real-time information or the ability to accurately communicate field observations back to the central stations. The recent developments in mobile GIS technologies have benefited many field-based information gathering. Information collection can now be performed more accurately with higher efficiency (ESRI.com, 2004).

Mobile GIS can facilitate the following field processes:

- Asset inventory-recording the location and attribute information of an asset on a digital map
- Asset maintenance-managing asset location, condition and maintenance schedules in the field
- Inspections-maintaining digital records of field assets for legal code compliance
- Incident reporting-spatially recording accidents or events

The process of decoding field notes, entering valid information into the geodatabase and redistributing new

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study maps is time-consuming, expensive and at risk for errors. However, what is routine and necessary is to maintain geodatabases (Wilke, 2003). Mobile GIS has made it possible to digitally view and edit spatial data in the field. It overcomes the shortcomings of study maps and provides real benefits to field-workers as well as cost benefits for the utility.

A GPS data collection system has the same basic components as a Mobile GIS system. It requires the user 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-optimized software allow the user to efficiently record feature and attribute data (McLarin, 2004). During the past years, tremendous advances have taken place in GPS technology (receivers), data collection hardware and field data collection software. Not only has the autonomous GPS accuracy improved, but the data collectors have become smaller, lighter and less expensive. The software has become cheaper and easier to learn (Wadhwani, 2001).

With the introduction of Palm Pilots followed by Microsoft's launch of a pocket PC operating system, a new generation of handheld Personal Digital Assistants (PDA's) have swamped the market. It is now possible to use these lightweight handheld PDA's, with GPS/GIS data collection software, for field applications.

Onboard digital cameras allow users to include a visual record as part of the field data collection process. An application can automatically control the camera, preview an image and finally take a proper photo for possible inspections. The photo can then be linked to its real world location where it was taken and associated with descriptive attribute information.

In this study a system is developed to assist operators in data collection for electrical power industries.

MOBILE GIS ARCHITECTURES

Mobile GIS is based on mobile computing and mobile Internet. It is an extension of Web GIS to mobile Internet including wireless Internet/Intranet and mobile communication network (Fangxiong and Zhiyong, 2004). Mobile GIS have several restrictions due to the limited capabilities of both hand-held hardware and the network data transfer speeds and bandwidth (Drummond *et al*., 2006). The diversity of mobile devices, the limitation in processing power and screen display and the diversity of mobile system platforms are examples of hand-held challenges. Various architectures have been proposed for mobile GIS implementation, namely; Stand-Alone, Client-Server, Distributed, Services and Peer-to-peer (Bryan, 2001).

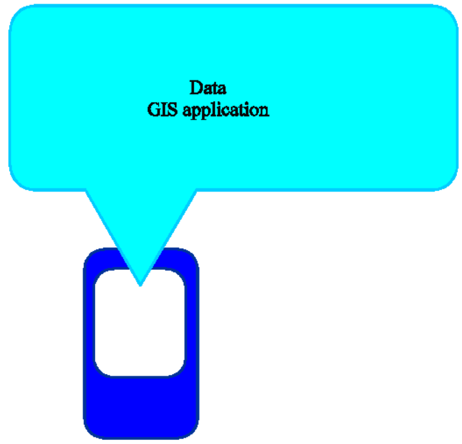

Fig. 1: The stand-alone client architecture

Fig. 2: The client-server architecture

The simplest Mobile GIS architecture is the stand-alone client. In this architecture the application and spatial data reside entirely on the mobile device (Fig. 1). Although, some applications may profit from this approach, such settings have major drawbacks. First, the hardware resources of the mobile device restrict the amount of spatial data the application can support. Second, this architecture does not allow for communication with any other applications.

To address the above challenges, client-server architecture can be adopted. As Fig. 2 presents, spatial data is moved to a separate computer and served to the client by GIS server software. The GIS applications can still be in the mobile device searching for data in data servers. Depending on the GIS applications, the location of the servers and the network constraints, thin, thick or medium clients may be adopted (Alesheikh and Helali, 2002). In such architecture, the spatial data is constrained by the resources of an enterprise server. Moreover, multiple mobile devices running the same application can access the server concurrently, making this a potentially multi-user architecture. However, the architecture poses a new constraint: Communication. If the mobile cannot establish communication to the data server, the GIS applications are useless and the architecture losses its versatility. Due to range and interferences, inconsistent communication occurs frequently in mobile applications.

In order to overcome the inconsistent connectivity, two challenges must be addressed: Persistence and

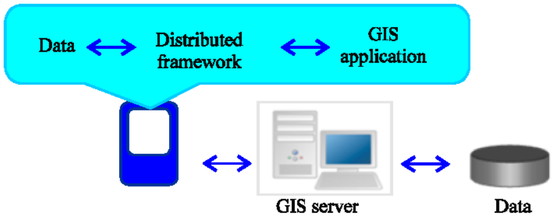

Fig. 3: The distributed client-server architecture

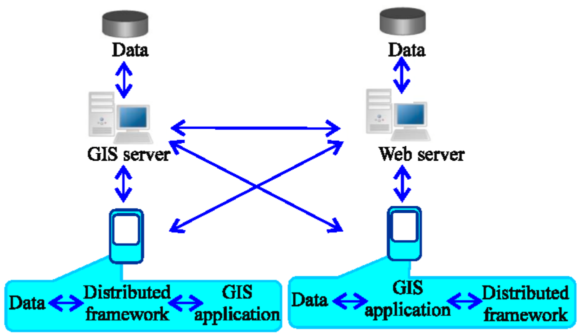

Fig. 4: The services architecture

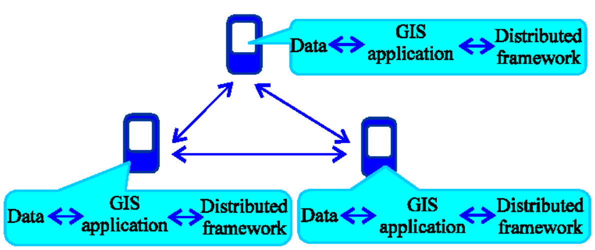

Fig. 5: The peer-to-peer architecture

resource management. A distributed framework can handle the logic for persistence and resource management (Fig. 3).

To further extend the back-end functionality of mobile GIS, applications can view the GIS server as a web service and allow for other web services to be part of the application (Fig. 4). Since the web services use similar communications protocol, all mobile devices can communicate with each other. In addition, the web services can also communicate between themselves using SOAP XML, the industry standard for passing messages between software components (Alesheikh *et al*., 2005). Once employed, this architecture can support robust communication between any number of mobile devices and web services. Unfortunately, it might not be the best for some applications, such as those designed for collaboration in remote areas where connectivity to servers is unavailable.

In a peer-to-peer architecture a server is no longer available to keep spatial data; the data must be stored on the mobile devices themselves as seen in Fig. 5. However, if each mobile device stores 100% of the data, then the architecture is restricted in the same manner as the Stand-Alone Client.

To allow for more data storage throughout the application, each mobile device keeps just a subset of the data. When Mobile Device A needs data, it relies on its distributed framework's resource management to know if it has that data locally. If it does not, the distributed framework must know how to access that data on Mobile Device B (Kalantari *et al*., 2003b).

MOBILE GIS COMPONENTS

The core components of a mobile GIS are the same as generic mobile business systems. A mobile GIS has three fundamental components: Hardware, software and the wireless network, which connects the mobile device to a data repository.

The hardware component consists of the mobile device; a suitably configured wireless modem; a Web Server with wireless support, i.e., a wap gateway, a communications server and/or a mobile communications server switch so that the mobile device can communicate with the internet or an intranet and an application or database server that contains the application's logic and databases (Amirian and Alesheikh, 2008b).

The software component includes the mobile device operating system (Windows 98/2000/NT, PalmOS, Win CE, EPOC, etc.); the mobile application user interface, which may run through an Internet browser; application server and/or database server software; application middleware if the mobile device needs to communicate with legacy (predecessor) systems or web-based application servers and wireless middleware that links multiple types of wireless networks to application servers (Malek *et al*., 2007).

The wireless network component may be either a private network such as that used by law enforcement or emergency services or a public shared network. Connectivity to wired networks or wireless LANs may also be included depending on the requirements of the mobile application.

CASE STUDY

Since many organizations' activities are based on spatial information, collecting spatial data has become outstandingly as one of the organizations target. Electricity Transmission and Distribution companies are among the companies that require spatial data and need a spatial information system with an up-to-date database of the conditions of the transmission lines, distribution lines, posts and other spatial features. By considering the importance and the role of a spatial information system in the electrical industry (production, outfitting and maintenance parts), a system for collecting spatial data related to transmission and distribution posts was designed. A user-friendly system was developed to enable operators to gather and save descriptive information, the feature's position by GPS and the feature's picture. The system is designed to work off-line (Stand-Alone Client Architecture) as well as online (Distributed Architecture).

In this project a HP iPAQ hw 6945 was used to collect data. The device was equipped with an internal GPS receiver and a 1.3 mega pixel camera. The device has also the features of a cell phone in addition to the ability to communicate via infrared, Bluetooth and Wi-Fi technology. The mobile is integrated with a high sensitivity GPS receiver and HP iPAQ Quick GPS Connection technology. Quick GPS Connection technology is a software application residing on the device that enables a faster connection for enhanced GPS performance.

The operating system of the device is Windows Mobile and has the ability of programming (Application programming) using .Net technology. The system's software is consisted of two parts: The database and the user interface.

The needed information contents for collecting geodata were extracted from the related data models and the database was designed in SQL Server CE (Compact Edition).

The user interface was designed based on .Net compact framework using Window Mobile APIs. A connection between the program and the database was established and the program was setup for use in Pocket PC.

By using the designed software the ability to insert, edit and search information, to register the position and the picture of the feature is provided; in such a manner that the information will be saved in the database and its' transmission and retrieval in the central database will be easily done. Figure 6 presents the several user interfaces for data entry and capturing photos.

The system has been set up for practical uses in Tehran Regional Power Company. The initial results are promising as it populates the database in real time. The deployed system has several practical features. The most compelling are:

- Access to data in the field (where, it is often needed the most)
- Capture data in the field and in real-time (it includes photos)
- Append positional information to data capture
- Run GIS functionality in the field, (where, again it is often needed the most)

Further, GIS applications are requested to guide the maintenance crew to the needed utilities locations.

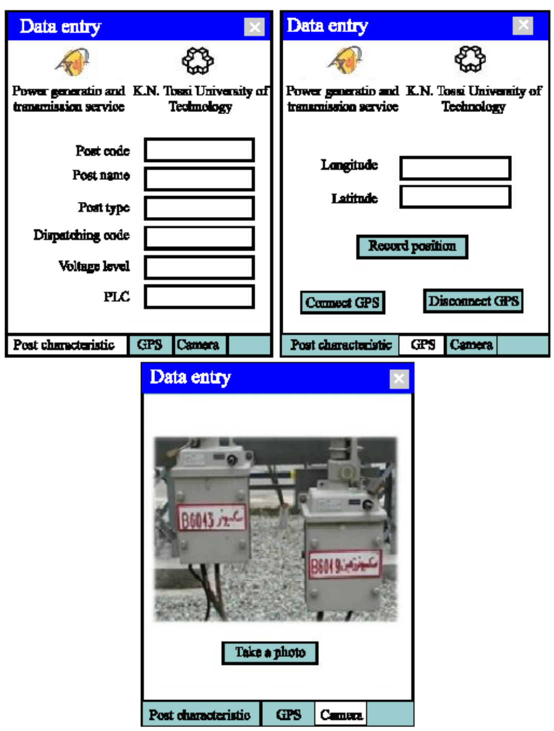

Fig. 6: The user interfaces of the developed system

CONCLUSION

Both the hardware and software available for digital data acquisition have advanced considerably in recent years. Professional clients look towards mobile platforms to increase productivity through efficient information handling, resulting In cost reduction, as well as a well-informed mobile workforce.

This study analyzed mobile GIS architectures and its components. The study also presented a mobile GIS for power industry users. The ability of the system to capture positional data through its GPS receiver, gather descriptive information using its API and take photo made the system cost effective.

With mobile GIS, data is always in a digital format, making it easy and efficient to transfer from the field to the office without introducing interpretive errors. Checks and balances are still required, of course, but many of these can be automated so, those carrying out the checks can focus on the real errors.

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