A Solution For The Data Collection in The Field Survey Based on Mobile And Wireless GIS

Haidong ZHONG[1], Ping LI[2], Yingjie HU[1]
1 Key Laboratory of Geographic Information Science, Ministry of Education, East China Normal University, 3663 North Zhongshan Road, Shanghai, 200062, P.R.China

Zhenhua LV[1], Jie YIN[1], Bailang YU[1], Jianping WU[1,*]
2 Department of Environmental Science, East China Normal University, 3663 North Zhongshan Road, Shanghai, 200062, P.R.China
* Corresponding author, email: jpwu@geo.ecnu.edu.cn

Abstract—**Traditional data collection methods for geological investigation, profile measurement, and other field survey in the research community of geosciences are generally based on the manual measuring and recording by the investigators. The most popular "instruments" used in the traditional survey are pencils as well as printed hard copy charts. The methods are obviously complicated and inefficient, at the same time the collected data are always inaccurate and not compatible with the digital process in computer. For these reasons, a solution for the data collection in the field survey based on Mobile and Wireless GIS is proposed in this study. Key technologies involved in the solution are reviewed at first. Then, a prototype of mobile GIS with basic GIS functions is designed and implemented based on independent development. Important technologies of implementation some basic GIS services for data collection in mobile environment introduced and many key challenges related, which are overcome in the process of the system development, are studied in detail.**

Keywords-Data collection;Mobile GIS; Wireless

I. INTRODUCTION

Field work is very important in many scientific disciplines, such as surveying and environmental monitoring [1]. Environmental and socio-economic investigations often needs large amount of data. Apart from existing data that can be acquired using data mining technologies, the data are often collected during field surveys. Traditionally, data collection methods for geological investigation, profile measurement, and other field survey in the research community of geosciences are generally based on the manual measurements and records by the investigators. In conventional field survey or data collection process, investigators mostly use pencils as well as printed hard copy charts. The methods are obviously complicated and inefficient. And what is more, it is always makes us not confident enough to trust the accuracy of our collected data, due to bad environment in the wild and uncertain human factors.

With the rapid development of computer science and technology, embedded devices, such as mobile pocket computer or PDA, are more and more widely used in our daily life for their light weight, small size, and portability. Mobile Geographic Information System (Mobile GIS), which integrates the advantages of mobile devices and basic data process and analysis functionalities of desktop GIS [2], is more and more popular in outdoor data collections. The usage of mobile GIS, combined with measuring equipment and desktop GIS environment, can obviously make data collection more efficient and accurate [3].

There are many mature commercial mobile GIS products, such as ArcGIS Mobile. However, there also many defects using the existing mobile GIS software in field data collection: different from desktop PC, using a real, large-scale wireless network can imply a high cost in wireless communications (such as, GSM or GPRS) [4]; The network instability of mobile devices makes data transmission unstable; Also memory capacity in mobile device is far less than that of common desktop computer and its computing ability is somehow limited. Now many researchers in the computer science community focus on new technologies to improve web performance or upgrade mobile hardware with more powerful computing ability, although the methods can just take temporary solution.

To make use of the advantages, but avoid shortcomings of Mobile GIS in field data collection, a mobile and wireless GIS is designed and implemented based on independent development. In our system we try to minimize wireless large size data transmission. Also collected data in mobile devices is temporarily stored in SQL Mobile. We make sure the data in mobile device can be directly used in desktop computer to accomplish more complicated and useful analysis. This can makes up the disadvantages of mobile GIS in data collection.

The rest of this paper is organized as follows: In section II, mobile GIS supported field collection workflow is explained. In section III, both software and hardware environment of the pocket PC and desktop PC is introduced. Section IV presents some key technologies in our field collection oriented system. Section V introduces the whole architecture and some implemented functions in our Mobile GIS, and section VI prospects for the future work and some conclusions are given.

II. MOBILE GIS SUPPORTED FIELD DATA GATHERING MECHANISM

In our DIY style Mobile GIS, the General Packet Radio (GPRS) is used as the wireless communication mode. We try to change the situation of multifarious and error prone in traditional field data gathering. The workflow of data collection, supported by the system, is shown in Figure 1.

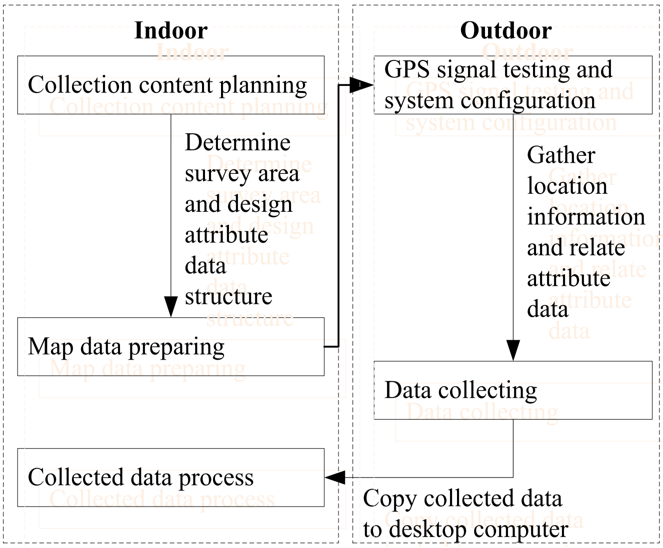


Figure 1. Data collection workflow

Data is the core of the collection application in Mobile GIS. All stages designed in Figure 1 take the data as their center. The methodology discussed here consists of five main phases: initial planning, data preparing, system setting, data collecting and collected data processing. Collection content planning and data preparing phases are the basis of the whole process, which can make a clear goal of what information, is to be collected and what kind of supplementary data is needed.

System setting phase must be accomplished outdoor. Because, GPS signal intensity in open country various greatly, although global positioning systems have high positional accuracy and ability to log "real-time" to a computer and great potential in many application areas [5]. Making out the GPS signal situation, and set a proper location information record and show time gap is very important to improve data gather efficiency. The main mission of the system setting phase is to ensure GPS availability and set an appropriate location information gathering interval.

Outdoor data collection is the most important phase, which involves a combination of GPS data and digital camera data. In this stage the image of surveyed area is loaded in mobile client, and the location information can be shown on map in real-time. During data collection process investigators can take a photo of a certain place or add some relevant attribute information, and then relate them to the location. For example, in wild tree inspection, operators can take a photo of a tree and write some descriptive message in the place, and then all the information can be stored as attribute data at the location of where GPS indicates.

Collected data processing is the last stage of field data collection. In this phase the investigator just need to copy collected data from PDA to a desktop computer and the data can be opened in ArcGIS directly to do some advanced spatial or statistical analysis if necessary.

III. SYSTEM DEVELOPMENT ENVIROMENT

Our mobile GIS design and implementation involves hardware and software configuration in both mobile terminal and desktop client.

A. Mobile Device (PDA)

- Hardware: Dop696 with Sirf 3 GPS receiver chip, 128M memory; + 64M Flash ROM.
- Operating System: Microsoft Windows Mobile 6.1 Professional for Pocket PC.
- Database: Microsoft SQL Server Mobile 2005

B. External GPS Receiver

- Columbus V-900

C. Desktop PC

- Hardware: Inter(R) Core(TM) 2 CPU 1.86G, 2G RAM.
- Operating System: Microsoft Windows Server 2003 Professional Service Pack 2.
- Development Platform: Microsoft Visual Studio 2008
- Development Library: .NET Compact Framework 3.5
- Software Development Kit: Microsoft Windows Mobile 6 Professional SDK
- Development Language: C#
- Database: Microsoft SQL Server 2005

D. Communication Software Between PDA and Desktop PC

- Microsoft ActiveSync 4.5

IV. KEY TECHONLOGIES IN SYSTEM IMPLEMENTATION

Developing general GIS functions, which are very commonly used in desktop computer, in mobile environment based on independent research and development is not easy. Complicated factors, such as wireless communication stability, limited computational storage capabilities of mobile devices, and map displaying in small screen, are all challenges need to be overcome. Key technologies related are discussed below.

A. Data Model Implementation

Data model is very important in our system, which should be well integrated with application in mobile field data collection. According to the usage of data, two kind of data model have been used: raster data, and vector data.

JPEG format is a kind of raster dataset support by Window Mobile. Location information acquired by GPS can be added into EXIF [6] file of the JPEG format images, which can bring great convenience in location information storage; Shapefile is a kind of widely used data structure in most commercial GIS software. Base on the consideration of universality, our system choose the shapefile as vector data model, and it has been implemented in our system according to ESRI shapefile technical description [7].

B. .NET Compact Framework

The Microsoft .NET Compact Framework (.NET CF) is a version of the .NET Framework that is designed to run on Windows CE based mobile/embedded devices such as PDAs, mobile phones, factory controllers, set-top boxes, etc. It uses some of the same class libraries as the full .NET Framework and also a few libraries designed specifically for mobile devices such as Windows CE Input Panel. However, the libraries are not exact copies of the .NET Framework. The ones in the .NET Compact Framework are scaled down to take up less space, and some new features are added to meet the requirement of limited memory and computing capability in mobile device.

It is possible to develop applications which use the .NET Compact Framework in Visual Studio.NET 2003, in Visual Studio 2005 and in Visual Studio 2008, in C# or Visual Basic.NET [8].

C. Coordinate System Conversion and Data Representation

GPS signal is received with WGS-84 geographical coordinate in “degree, minute, second” format. In order to make a better user of GPS, all the maps in our system use the same geographical coordinate system as received GPS. However, the GDI graphic canvas uses the Cartesian coordinate system measured in integer pixel of the screen. And in all graphic related operation transformation between the two coordinate systems is needed.

To draw real-time position on the screen of PDA, the system needs to update and redraw location information continually at a user set interval, which can cause serious screen flicker in limited memory of PDA. In our system we adopt double-buffering technology to solve the problem.

D. Bluetooth Communications

Bluetooth, which is originally conceived as a wireless alternative to RS-232 data cables, is a radio technology for Wireless Personal Area Networking (WPAN) operating in the 2.4GHz ISM frequency band, and allows devices to be connected into short-range ad hoc networks to exchange data (using short length radio waves) from fixed and mobile devices [9]. It can connect several devices, overcoming problems of synchronization. In our system Bluetooth is used to connect external GPS receiver.

E. GPRS

General packet radio service (GPRS) is the most common mobile phone system in the world. It a packet oriented mobile data service available to users of the 2G cellular communication systems, global system for mobile (GSM) communications, as well as in the 3G systems. It provides both packet-switched and circuit-switched services [10].

GPRS data transfer is typically charged per megabyte of traffic transferred, while data communication via traditional circuit switching is billed per minute of connection time, independent of whether the user actually is using the capacity or is in an idle state. GPRS is a best-effort packet switched service, as opposed to circuit switching, where a certain quality of service (QoS) is guaranteed during the connection for non-mobile users. Any service that is used on the fixed internet today will also be able to be used over GPRS.

In our system, GPRS is used as the communication mode between PDA and web image server to download customized-size map.

V. FIELD DATA COLLECTION MOBILE GIS IMPLEMENTATION

Functions implemented in our system can be divided into four main modules: basic GIS function module, data collection module, system setting module and wireless data communication module, according to their functionality. Figure 2 shows the whole framework of our system.

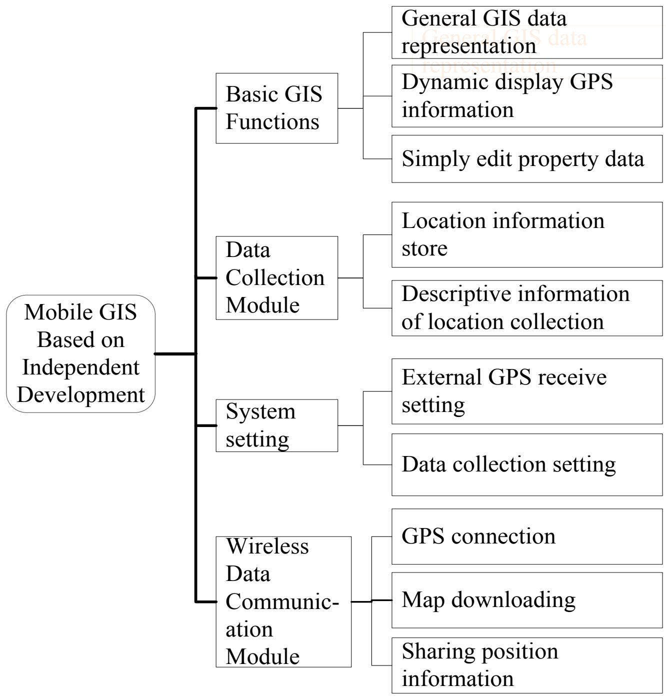


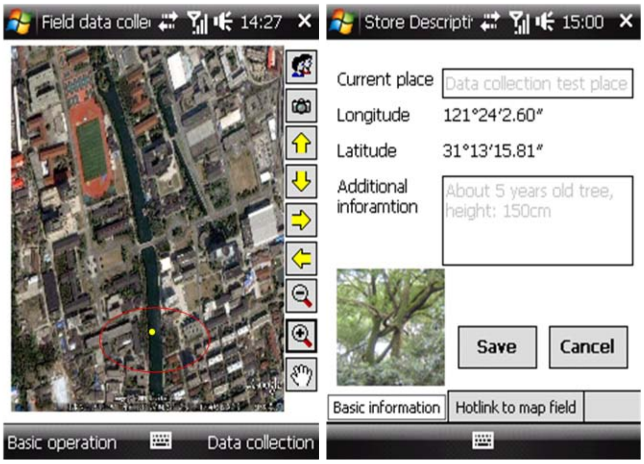
Figure 2. System framework

A. Basic GIS Function Module

In this module general GIS functions used in desktop GIS software, such as digital map representation, dynamically show the received GPS location information on loaded map, zoom in, zoom out and panning of a map, are implemented in mobile environment. Location information and location image are stored as attribute data of a map, and can be edited.

B. Data Collection Module

Data collection module is the core of the whole system. It is responsible for gathering GPS information and related data. Before any collection operation, the system must ensure GPS connection is established and location information can be read from serial port stably. At a place, where we investigate, the system will record its latitude and longitude information automatically when an image is taken (See Figure 3). The name of the image and its saving location will be saved in Microsoft Mobile database in PDA.

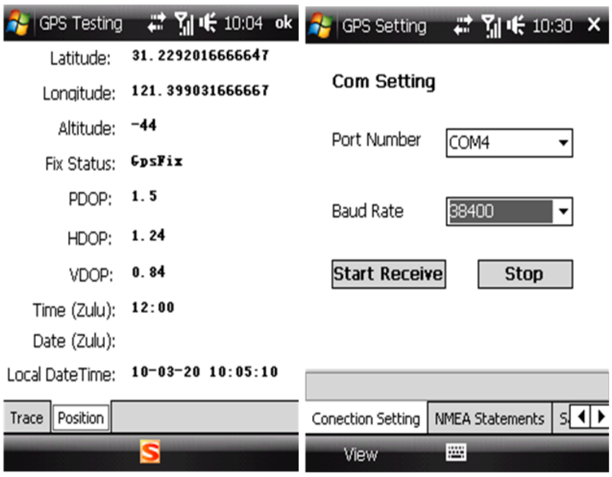


(a) (b)

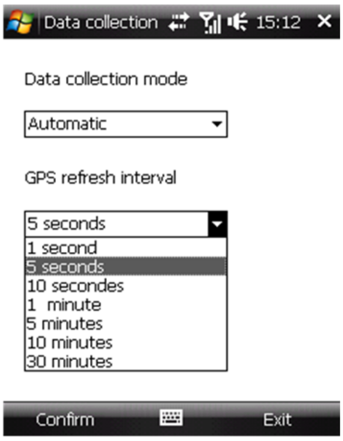
Figure 3. Data collection services. (a) draw GPS information on map (b) location image and descriptive information stored

C. System Setting Module

System setting must be accomplished at data collection target place. It mainly test GPS signal intensity and then set a proper location information acquisition interval. The process of system setting is generally shown in Figure 4.



(a) (b)



(c)

Figure 4. System setting (a) GPS signal testing (b) GPS port setting (c) GPS collection interval setting

D. Wireless Data Communication Module

Wireless data communication module including external GPS data receiving through Bluetooth (there is no inner GPS receiver in our PDA), map downloading and sharing location information by GPRS. Here we want to introduce the latter two services in detail.

By GPRS connection, investigators can send a map download request, which contain a longitude and attitude pair of the map center, to map server, for example 76800(240×320) square meter area centered with current GPS position as we designed in our system, then the map server will clips a image and responses the clipped map to the mobile client. The whole process can be described in Figure 5.

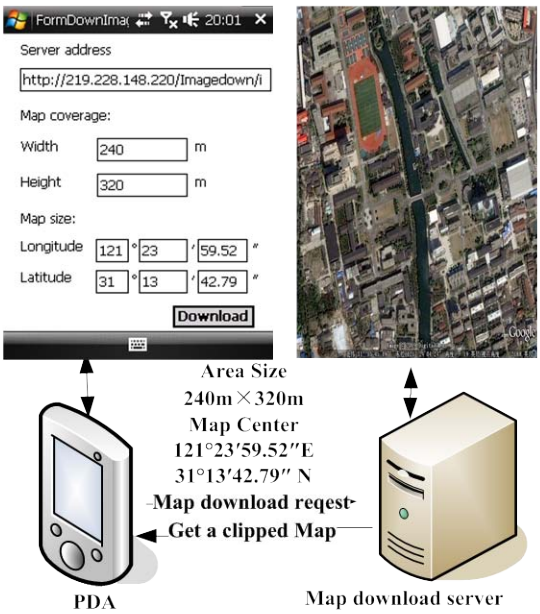


Figure 5. The process of map download

Location sharing service is designed for investigators to share their locations and communicate with each other in data collection process. The service can be divided into two parts, one is sender side, and the other is receiver side. Generally the sender use a touch-pen to write some message, then location information, read from serial port, will be added to the message and automatically converted into a short message format. The sender just need to choose a contact person from telephone book of PDA, then the short message can be sent to the recipient through GPRS. The receiver PDA will extract the location information when it receives a short message. And then the sender's location can be drawn on map using GDI methods. The whole process of place sharing can be described in Figure 6, and the implemented location information sharing service in our system is shown in Figure 7.

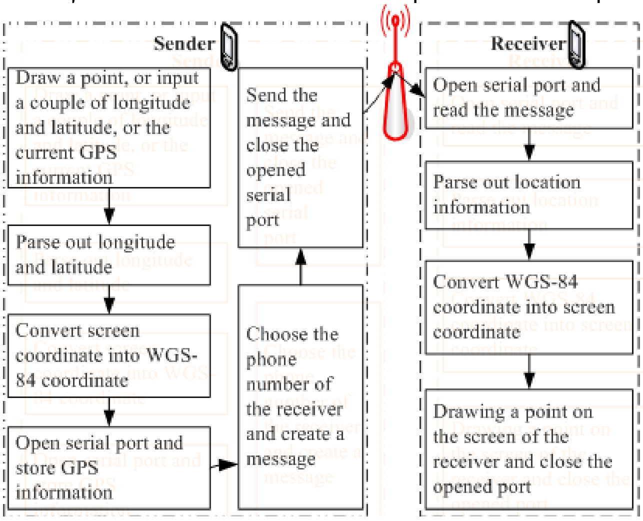


Figure 6. The process of place sharing

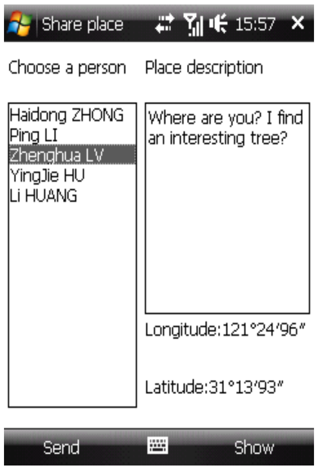


Figure 7. Send GPS information with additional message

VI. CONCLUSION

In this paper, a field collection oriented Mobile GIS solution based on independent R&D is presented. In the process of system development many difficulties have been overcome. And what is more, we find an efficient and useful way in Mobile GIS implementation, which can be used as an example for other mobile GIS design.

Compared with desktop GIS development, many more complicated factors need to take into consideration in mobile environment. Only some basic functions and services, which are very common in desktop GIS, are implemented in our system, we still have a long way to go.

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