NEAR-REAL-TIME GIS DATABASE UPDATING SYSTEM USING GPS AND TELECOMMUNICATION TECHNOLOGIES

Abdullah Hisam Omar and Ruzaimi Abdul Mukhshin

Department of Geomatic Engineering, Faculty of Geoinformation Science and Engineering
Universiti Teknologi Malaysia, 81310 Skudai , Johor.
Tel: 607-5530945
Fax: 607-5566163
E-Mail: elsevier77@hotmail.com, a.hisham@fksg.utm.my

Abstract

The need for real-time data acquisition and maintaining process in Geographic Information System(GIS) technology was one of important aspect to ensure that there will be no double dipping of data, a very fast an accurate field data collecting and significantly help to save time and cost in maintaining GIS database. Apart from that, an off-site manager or decision makers can make rapid evaluation of progress and preliminary results while maintaining GIS database. The method of gathering field data in maintaining GIS database typically a time-consuming task due to the need for measurement and attributes of data often in remote regions. To be worthwhile a very fast and accurate field data collecting system that significantly help to save time and cost in updating GIS database should be develop to allowing the GIS field data being transmit in real-time to headquarters. The recent advance in mobile information technology and wireless data communications have created opportunities for developing tools that bring computing power to field worker. Based on available coverage in the region, an integration of Global Positioning System Bluetooth receiver, Personal Digital Assistant and General Packet Radio Service enable mobile phone will be used for enable real-time streaming of field data by Short Message Service (SMS), Email or Internet. Wireless transmission of the data contents is periodically made to an Email Server where it is will transfer the data into off-site manager database at headquarters. The field data then will be process and automatically updating the GIS database.

Keywords: *GIS database, mobile GIS, GPRS mobile access network.*

1.0   INTRODUCTION

Over the past few years the world has seen an explosion of new wireless device and capabilities such as Personal Digital Assistant (PDA) and smartphone, which enables user to browse internet from any location. The evolution of wireless technology has growing rapidly through the Global System for Mobile Communication (GSM) platform such as General Packet Radio Services (GPRS), Enhanced Data rates for GSM Evolution (EDGE) and Third Generation (3G). Therefore, there is a need for GIS developer to getting involved in creating new capabilities to make full use of this telecommunications technology to support a vast of application in GIS.

Global Positioning System (GPS) has been widely used for the purpose of navigation, surveying and GIS. This day GPS is widely use for GIS field data capture because of its well arranged orbital position to ensure continuous worldwide coverage under any weather condition. Also, enormous advances have taken place in GPS technology in the past years: GPS accuracy has improved, the receivers have become smaller and cheaper and the GPS integration with mobile device as PDA has been made possible. For this, the integration of GPS/GIS into the mobile devices system provides a cost-effective, efficient and accurate tool for creating maps and GIS database. Furthermore with the support from telecommunication

technology such as GPRS, near-real-time system for updating GIS database can be developed by software capable of running on mobile devices and interoperating it with desktop-based program.

Currently, GIS data capture process use GPS handheld equipment to collect the data and the field worker must get back to the office to download the data.This method of data gathering is time consuming especially when the GIS data capture tasks being made in the remote region and due to the emerging applications that needs near-real-time data support such as emergency management, web GIS and service routing and law enforcement. With the advancement and convergence of GPS, Internet, and wireless communication technologies, mobile GIS has a great potential to play an important role in field of data acquisition and validation (Pundt, 2002). As we can seen, the current of mobile computing can improve the field work of capturing GIS data for reducing a gap in time and space between the outdoor environment and office, which can leads to more efficiency GIS data management

Due to the growing interest in wireless application, this article will present the near-real-time system for updating GIS database. The advantages from this system are as follows; i) it will make the task of collecting GIS data for updating database is faster, reliable and to ensure that there will be no double dipping of data in anytime and anywhere in the region as long as there is a wireless access network and ii) as the growing interest in cartographic market through GIS application, this system is critical to support any map modification on the GIS web application such as emergency management, transportation and services routing and law enforcement.

2.0   GIS, GPS AND TELECOMMUNICATION TECHNOLOGIES

This project will integrate GIS, GPS and telecommunications technologies such as GPRS to bring information in near-real-time to any database. Many approaches we see in making this task a reality.

2.1   Geography Information System

GIS is a tool for decision making. GIS allows user to manage, view and perform a series of analyses to different data types that linked to geographic. With this ability GIS gives us a better decision platform to solved everyday real world problem. GIS technology includes a database management system, input tools, analysis feature, queries feature, visualization tools and a graphical user interface. At present the there are many software systems claim to have mapping and GIS capabilities.

2.2   The Global Positioning System

GPS is a collection of 24 satellite-based navigation systems that was developed by the U.S. Department of Defense in the early 1970s. Positioning derived from GPS is on the basis of determined the distance from a point on earth to three satellites. Basically by applying resection method a coordinate can be derived when we know the distance to each satellite and its coordinated. In recent years GPS has revolutionized GIS data capture techniques. With just only using standard GPS receivers, GIS field data collection can collect the data with 5 – 10 m accuracies. Based on this characteristic GPS is very useful for GIS data capture project.

2.3   Telecommunication Technology

Telecommunication technology has long been identified as key factor for potential impact on productivity and competitiveness of the firms. Telecommunications can be referring as a process of transmitting or receiving information by any electrical or electromagnetic medium. The information that would be transfer may take the form of voice, video or data. The elements of telecommunications systems are a transmitter, a medium (line), a channel assign for those medium and finally a receiver.

Nowadays, the rapid development on telecommunication has been evolved from wired transferred medium to wireless transferred medium. Wireless telecommunication technology offered us possibilities for mobile connection with a technology such as Internet to keep growing in the world of mobility. The enhancement of such a technology for Local Area Network (LAN) to Wireless Local Area Network (WLAN) and Wide Area Network (AN) to Wireless Wide Area Network (WWAN) has create a greater in sharing information from one building to one building without wired and cable. This technology make further impact on mobile Global System for Mobile Communication (GSM) user that need Internet access whether to access data or transfer data for their business demanding when they entered global world, so an impressive evolution of mobile access network such as GPRS ,EDGE and 3G has dictate the future of trends of wireless world. So it is now we can see so many possibilities and development in GIS to create what we call a wireless network of GIS world.

2.4   General Methodology of The System

The major goal of this prototype was to demonstrate the functionality of near-real-time wireless data update and GPS/GIS integration. In general this system prototype will help to utilize field GIS data streaming from remote area to GIS database by using wireless network connectivity that available in the region. It will provide an automation of near-real-time updating GIS database by plotting the GIS data and keep the attributes of new detail in the layer. An interfacing program will be created in wireless mobile GIS platform and GIS workstation. There are two main parts; i) to design a software by customizing the commercial mobile GIS software on wireless GIS platform using a developer tools for collecting the GIS data and automatically send the data via wireless network using GPRS connection (GIS Field Data Capture Software) and ii) to develop software for near-real-time task of updating GIS database (Near Real-Time GIS Database Updating Software). The general methodology of the system is shown in Figure 1.

3.0   PROTOTYPE OF THE SYSTEM

The technique for near-real-time GIS data streaming on this study is to use email technology. The prototype of the system consists of three elements. The first element is on Wireless Mobile GIS platform, where it was an integration of four components; (i) Bluetooth GPS receiver; (ii) PDA; (iii) Mobile E-mail Client (iv) Mobile GIS Software; and (v) Wireless Access Network. The second element is Central Server mainly from Internet Service Provider (ISP) to provide fully support on E-mail Server. Finally the third elements, was GIS Workstation: (1) E-mail Client; and (2) GIS Software (fully developed software for the purpose of updating GIS database).
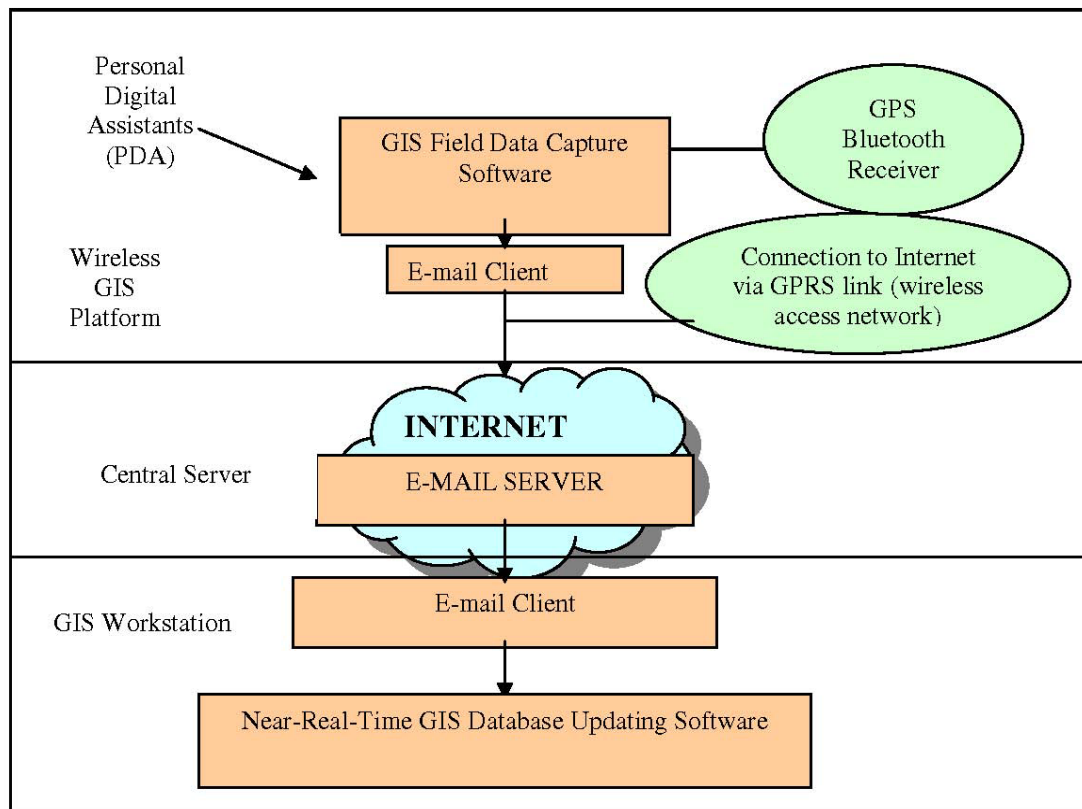
Figure 1: General Methodology of The System

3.1   Mobile GIS Platform

Mobile platform is required for integration of Geographic Information System Software, Global Positioning System and mobile computing devices such as PDA. A mobile GIS allow the process of information visualization in a digital map, collect information, and interact directly world wide, while improving productivity and data accuracy. With further enhancement by using PDA phone enable connection using GPRS, GIS data can be sending to Internet and any web server. This platform with combining from GPS receiver, GIS software and wireless network will create a new system, classified as wireless mobile GIS.

3.2   Bluetooth GPS Receiver

Total mobility of field data capture process is depends on how convenient GPS equipment in the development of the system. As a result, Bluetooth GPS receiver HI 303E multi-mode foldable GPS receiver model (refer Figure. 2) was used in this study. HI 303E developed by Haicom Inc is well suited for developer to develop integration system for user who used mobiles devices such as PDA, laptop PC and Tablet PC. The accuracy of the receiver satisfy a wide variety of applications such as GIS data capture process, personal navigation or touring devices, tracking and marines navigation purposes.

Figure 2: Bluetooth PDA (HI-303E (Multi-Mode Foldable) GPS Receiver User

3.3   Personal Digital Assistants

Personal Digital Assistants (PDA) is a handheld computer that was originally designed as personal organizers. The basic features of any PDA are a calendar, address book and task list. PDA have many capabilities similar to desktop computers, such as an Internet browser, e-mail client, word processor, spreadsheet and else.

PDA has been develop as a phone based PDA, which can runs an Internet browser that been used to access email through wireless network such as GPRS. The enhance feature on such PDA can make wireless streaming of data in near-real-time a reality as one important requirement for this project. This means that if an important message is sent, it can be reviewed and a reply even though the user is in a mobile environment.

For the purpose of this project the PDA manufactured by HP model HX2110 run on Windows Mobile 2003 (Figure. 3) has been used. The PDA utilize Bluetooth data connection technology with GPS receiver. This connectivity can provides Internet connection using GPRS connectivity.

Figure 3: PDA model HX 2110 from Hewlett Packard

3.4   Mobile Email-Client

The use of desktop PC for e-mail client on everyday messaging tasks over the Internet is a typical method. Internet user use well-known stand-alone clients like Microsoft Outlook, Outlook Express, Eudora, Pegasus, Yahoo, Hotmail, to name a few. If we are a mobile user such as PDA, there is also an e-mail client known as Outlook E-mail. E-mail can be send and receive when synchronizing is made via Internet connection with e-mail server.

3.5   Mobile GIS Software

Mobile GIS software refers to the specialized GIS software that reliable in the market to support mobile GIS and field mapping application. Based on that, our system is supported by ESRI ARCPAD 6.0.3 mobile GIS software. Arcpad is software that design to accomplished field-based personnel tasks with the ability to capture, analyze, and display geographic information. Field data collection with ArcPad is efficient and accurate and can integrate input from GPS receivers, rangefinders, and digital cameras. Furthermore with Arcpad we can perform reliable, accurate, and validated field data collection, integrated GPS, share enterprise data with field workers for updating and decision making, and improved productivity of GIS data collection.

Arcpad offers many basic functions for GIS field data capture mission. By using Arcpad, GIS file format associate with shapefile can be created and automatically stored from GPS coordinates tracking. From Arcpad also we can accomplished mission on capture GIS data such as building polygon, polyline and stored the GPS tracklog on shapefile format. Moreover, this data can be send through wireless connectivity by configured this software to do a connecting to IP (Internet Protocol) -based Internet Map Server or e-mail server as purpose for this project. With this ability by near-real-time, field workers can send data via GPRS connectivity to web server or e-mail server (refer Figure. 4).

This software also comes with a development platform for advanced user for building custom Arcpad application for mobile GIS. This developer software known as Arcpad Application Builder version 6.0.1. It has a support for developer to built custom built-in function using Microsoft® VBscripts® scripts language. For this project, this customization software is important in order to customize Arcpad to suit our advance user needs on the full part of capturing the data for GIS data streaming via email.
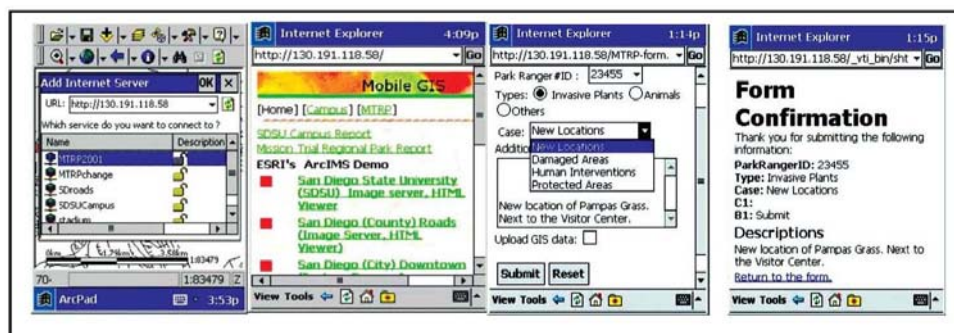

Figure 4: Internet connection to Map Server and web sites (Tsou, M. H., 2004)

3.6   Wireless Access Network

In order to send the data via email to the e-mail server, a mobile device must connect to a wireless access

network available in the region. Based on the network coverage on Malaysia region, GPRS connectivity has been choose for wireless internet roaming in this study. Through out the world GPRS service connectivity has been launch on 2001 and in 2002 GPRS is routinely incorporated into GSM mobile phone and has reached critical mass in terms of usage. GPRS is the first system offering instants connections or "always connected" whereby information can be sent or receive immediately without any user interaction. Theoretically, data rates of up to 170Kbps can be reached, although a more realistic limit is 115Kbps (Casademont et al, 2004).

3.7   Central Server

The server system is to support data exchange over the Internet. Internet is a collection of computer networks run cooperatively over the globe of information superhighway. Server support the Internet relay by runs server software on the main computer, this software run a process on a host that relays information to a client upon the client it a request. Servers come in many forms: application servers, web servers, database servers, email servers and so forth.

3.7.1   E-mail Server

Email-server is an application that receives email from e-mail clients (such as Microsoft Outlook) or other e-mail server. It is the workhorse of the e-mail. Each e-mail server usually consists of a storage area, a set of user definable rules, a list of users and a series of communication modules.

All the messages that been send be will handled by this e-mail server. The normal protocols which a user at a remote computer (usually a desktop PC or laptop) can access the messages that have been collected by mail server and stored in user's mail box known as POP3 and IMAP. POP3 stands for Post Office Protocol-version 3 and is the simpler of two. Using POP3 a user can transfer (download) messages to his or her local computer where they can be read, stored in various folder, edited and manipulated for various user desires. IMAP, which stands for Internet Mail Access Protocol, allows a user to create folders and organize messages on the same machine as the e-mail server. In this manner, a user who must access must access his or her email from different computers can maintain mail records that are accessible from any remote computer from which the user may have access. But, for handles outgoing mail, SMTP server is need. SMTP is stand for Simple Mail Transfer Protocol.

The e-mail server available from Server Administrator of Faculty of Engineering and Geoinformation Science, University Technology of Malaysia was used for a testing process. This server will handled all the GIS data that will be send as text file and shape file. This file consists of coordinates of the data and its attributes.

3.8   GIS Workstation

GIS workstation will plays an important part of updating the GIS database. The interfacing program will be fully developed on this workstation to retrieve GIS data that has been send from e-mail server. This software will work by connecting with e-mail client. The data then will update the database by create new spatial data and attribute data.

3.8.1   E-mail Client

E-mail client is a simply computer program that is used to manage e-mail. User can read and send e-mail by make some setting to this program. Protocols supported by e-mail clients include POP3, IMAP and SMTP. An e-mail program, typically use by many organization and individual such as Outlook Express and Microsoft Outlook puts the world of online communication on our desktop and every workstation in our every day life. The functions of the E-mail are listed as follows;

  i.   Shows a list of all messages in your mailbox by displaying who sent the mail, the subject of the mail and show you the time and date of the message.
 ii.   Lets you select messages and reads message
iii.   Help you create new messages and send.
 iv.   Add attachments to messages you send and save an attachment from the receive messages.

For this study, e-mail client such as Microsoft Outlook will plays an important part on connecting to the e-mail server. All the GIS data that been stored on the e-mail server will be receiving upon synchronizing between e-mail client and e-mail server. So when to field mission of collecting GIS data been made, this e-mail client on GIS workstation will 'always on' for receiving any data in near-real-time or when the field workers send the data via GPRS to e-mail server.

3.8.2   Near-Real-Time GIS Updating Software

This software will handle all the tasks of updating the GIS database. This software will be developed using Microsoft® Visual Basic .NET 2003. The developer tool known as ESRI MapObjects was used to integrate with VB.Net 2003. The tool provides powerful mapping components that plug into many standard development environments.

4.0   SOFTWARE DEVELOPMENT

The software development stage consists of two tasks: (i) field data capture for near-real-time GIS data streaming; and (ii) near-real-time updating GIS database.

4.1   Near-Real-Time GIS Data Capture Software

This software is a customization software build on ESRI Arcpad environment. By using its developer application tools (Arcpad Application Builder), the software will be design and customized for building custom field task Arcpad application. New toolbar and custom forms will be designed for specific field task and for GIS data captured and sending the data via e-mail.

The custom tools and new toolbars will perform automated tasks for field data capture and near-real-time streaming via e-mail. The program created in Arcpad will make a connection directly to e-mail client in PDA after its collect a specific amount of data. The program will ask the user whether the user want to send the data or not. If the field workers decide to send the data, the program will interact with e-mail client and send the data via GPRS. During this field job is done, the GPRS can be 'always on' while collecting the data, and with this feature the user can send automatically without a need to reconnect to GPRS network. If there is no GPRS coverage in the area the data will be send when the user arrive in the area where there is GPRS coverage and the data will be send again from e-mail client outbox (refer Figure 5).

4.2 Near-Real-Time GIS Database Updating Software.

The software will be developed using Microsoft® Visual Basic .NET 2003 with an add-on of ESRI MapObjects developers tools. This software will acts as a user interface for updating GIS database in near-real-time.
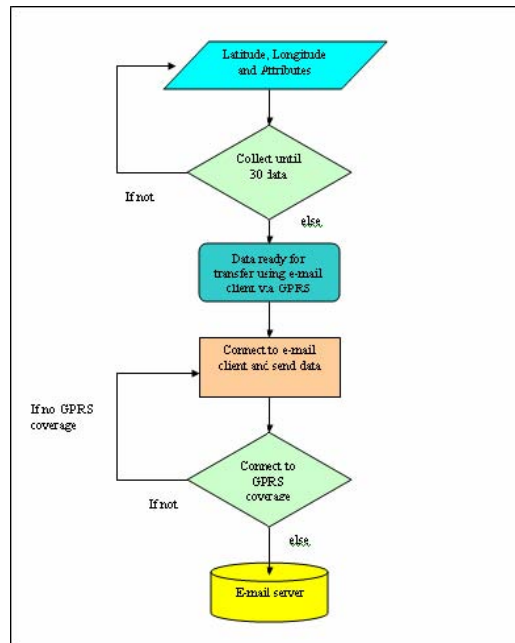

Figure 5: Near-Real-Time GIS Field Data Capture Software

The tools that will be created consist of toolbars and menus consisting editing, data displays, query, wizards and dialog box functions. For near-real-time updating GIS database, the toolbar for alerting the user on the incoming emails be created. This program then will ask users whether the user want to extract the data to database or ignore the incoming email. If users proceed for extracting the data, the program will convert the data to .dbf file format. From this format the program will create ESRI® Shapefile that will be stored on GIS database (refer Fig. 6).
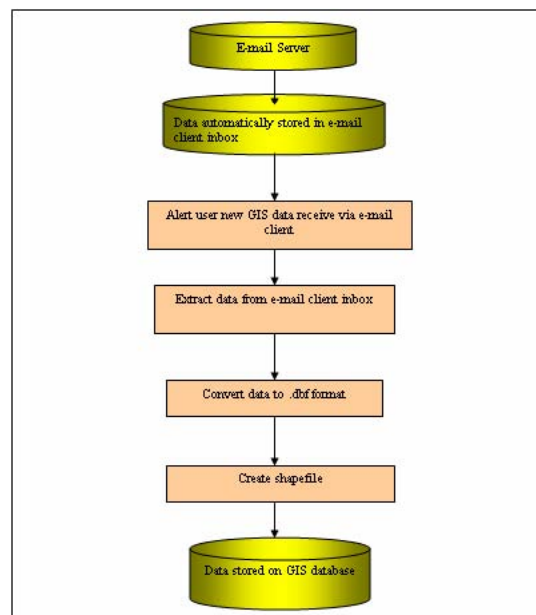

Figure 6: Near-Real-Time GIS Database Updating Software

4.3 Prototype Testing

A prototype test has been conducted in Johor Bahru, Johor area in order to evaluate the system configuration and setting. Communication between Bluetooth GPS and PDA shows a good compatibility between both hardware. As a result, the accuracy obtained from the test is ranging from 3 – 4 meters. Few data streaming interruptions occurred during data transfer from the system to central processing office. This are due to some technical in-agreements between data capture software and email-client configurations. Figure 7 shows the new updated features on the base map and database. The GIS database updating program will receive an email from field containing an attachment file which is consist of feature identity, coordinate in WGS 84 and its attributes. The attachment file will be read and the GIS base map and database will be updated automatically based on the features coordinates and attributes.
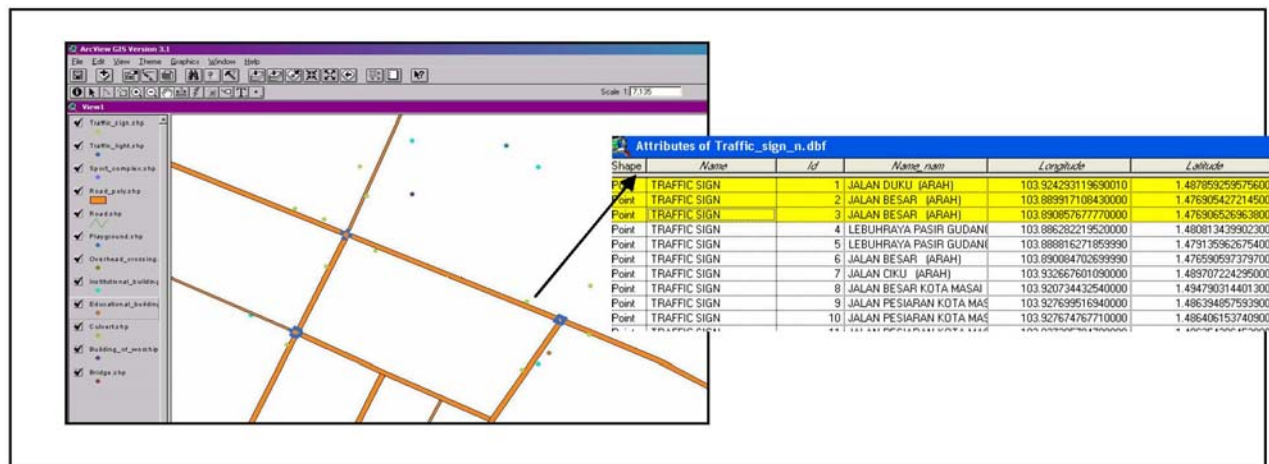

Figure 7: Updating GIS Base Map Using Prototype System

6.0 CONCLUSION

The discovery and harnessing of wireless telecommunication technology has introduced many possibilities for GIS field. Moreover with the growth of web-based GIS for supporting near-real-time data query and analysis in many organizations has made the need for near-real-time data very important. With the integration of GIS, GPS and Telecommunication technology later we can see the benefit of it as it will grow with the user needs for near-real-time data.

Moreover with the growth of web-based GIS and location based service for supporting near-real-time data query and analysis in many organizations has made the need for near-real-time data very important. The data for this application was need to be update every time based on their need, so this system of updating GIS database is a must in every organization that run GIS database in dynamic GIS environment. The prototype system has been developed and still need further technical modification, enhancement and refinement in order to be operational.

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