

M. ERSOY

USING GEOGRAPHICAL INFORMATION SYSTEM
IN
EMERGENCY MANAGEMENT SYSTEMS

MAHMUT ERSOY

DECEMBER, 2011

ÇANKAYA UNIVERSITY

USING GEOGRAPHICAL INFORMATION SYSTEM
IN
EMERGENCY MANAGEMENT SYSTEMS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
ÇANKAYA UNIVERSITY

BY
MAHMUT ERSOY

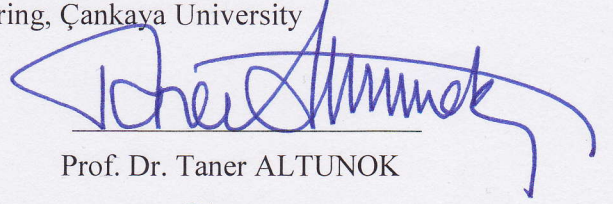
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
COMPUTER ENGINEERING

DECEMBER 2011

Title of the Thesis: **Using GIS in Emergency Aid Systems**

Submitted by **Mahmut ERSOY**

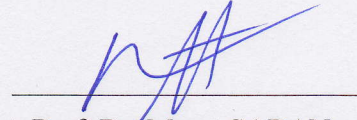
Approval of the Graduate School of Computer Engineering, Çankaya University



Prof. Dr. Taner ALTUNOK

Director

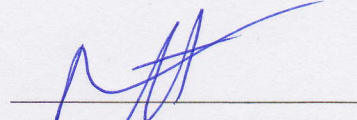
I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.



Asst. Prof. Dr. Murat SARAN

Acting Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.



Asst. Prof. Dr. Murat SARAN

Supervisor

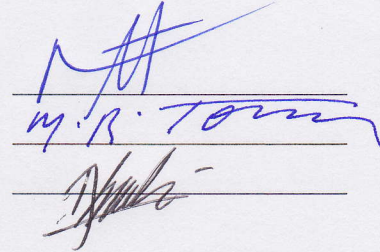
Examination Date: 29.12.2011

Examining Committee Members

Asst. Prof. Dr. Murat SARAN (Çankaya Univ.)


Prof. Dr. Mehmet R. TOLUN (TED Univ.)

Asst. Prof. Dr. Abdülkadir GÖRÜR (Çankaya Univ.)



STATEMENT OF NON-PLAGIARISM

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name : Mahmut ERSOY
Signature : 
Date : 29.12.2011

ACKNOWLEDGMENTS

I wish to express my deepest gratitude to my supervisor Asst. Prof. Dr. Murat SARAN for his guidance, advice, criticism, encouragements and insight throughout the research.

I would also like to thank to Başarsoft Family for their suggestions, commands, and technical supports.

ABSTRACT

USING GEOGRAPHICAL INFORMATION SYSTEM (GIS) IN EMERGENCY AID SYSTEMS

ERSOY, Mahmut

M.S.c., Department of Computer Engineering

Supervisor : Asst. Prof. Dr. Murat SARAN

December 2011, 46 pages

This study is designed to be a guide for Geographical Information System (GIS) about Emergency Management System (EMS) applications. The purpose of this study is to give background information about Geographic Information System (GIS), to show how to develop a GIS application step by step, and to analyze the benefits of performing GIS technology to emergency management in a general context. This study also provides an example application on how the Emergency Services can use GIS in emergency response. Moreover, in this study to find the shortest path between two points in a very short time Djikarta Algorithm, which is one of the most important algorithms in this field, was used.

Keywords: GIS, Emergency Management, Djikarta Algorithm

ÖZ

COĞRAFİ BİLGİ SİSTEMLERİNİN ACİL YARDIM SİSTEMLERİNDE KULLANILMASI

ERSOY, Mahmut

Yüksek Lisans, Bilgisayar Mühendisliği Anabilim Dalı

Tez Yöneticisi: Yrd. Doç. Dr. Murat SARAN

Aralık 2011, 46 sayfa

Bu çalışma, Coğrafi Bilgi Sistemleri'nin (CBS) Acil Yardım Sistemleri (AYS) uygulaması konusunda bir kılavuz olması için tasarlanmıştır. Bu çalışmanın temel amacı, Coğrafi Bilgi Sistemi (CBS) ile ilgili temel bilgileri sunmak ve acil durum yönetimi bağlamında bir CBS uygulaması geliştirme sürecini adım adım anlatmaktır. Bu amaçla acil servisler için acil müdahalede CBS'nin nasıl kullanılacağı konusunda örnek bir uygulama sunulmuştur. Bu çalışmada ayrıca acil durum yönetimi faaliyetleri tanıtılmış ve Coğrafi Bilgi Sistemleri teknolojisinin bu faaliyetlerde nasıl önemli bir rol oynadığı anlatılmıştır. Ayrıca bu çalışmada iki düğüm arasındaki en kısa yolu hızlı bir şekilde bulmakta kullanılan ve bu konuda en önemli algoritmalarından biri olarak kabul edilen Dijkstra Algoritması kullanılmıştır.

Anahtar Kelimeler: CBS, Acil Durum Yönetimi, Dijkstra Algoritması

TABLE OF CONTENTS

STATEMENT OF NON PLAGIARISM	iii
ACKNOWLEDGMENTS	iv
ABSTRACT	v
ÖZ	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF SYMBOLS/ABBREVIATIONS	x
CHAPTERS:	
1. INTRODUCTION	1
2. GEOGRAPHICAL INFORMATION SYSTEMS	4
2.1 What is GIS	4
2.2 Components of GIS	5
2.3 Major Application Areas of GIS	7
2.4 What is a Map in GIS	19
2.5 MAPINFO as Map Developer Program & MAPXTREME	22
3. IMPLEMENTATION	25
3.1 Hardware	25
3.1.1 Vehicle Tracking Devices	25
3.1.2 Server	27
3.2 Application	27
3.2.1 Listener	27
3.2.2 Web application	28
3.2.2.1 Part 1: Health care center finder	28
3.2.2.2 Part 2: Emergency service application	31
3.2.2.3 Part 3: Ambulance application	33
3.3 Dijkstra's Algorithm	37
3.3.1 Introduction to Dijkstra's Algorithm	37
3.3.2 Description of the algorithm	38
3.3.3 Pseudo-Code of the algorithm	39
3.3.4 Example of Dijkstra's Algorithm	40
3.3.5 Inserting Dijkstra's Algorithm into the system	43
4. CONCLUSION	45
REFERENCES	R1
APPENDICES:	
A.CURRICULUM VITAE	A1

LIST OF TABLES

TABLES

Table 2.1: Raster and Vector Model	22
---	----

LIST OF FIGURES

FIGURES

Figure 2.1 : Components of a GIS	5
Figure 2.2 : The Application Used by Colombian Coffee Growers Federation	8
Figure 2.3 : GIS in Electric Utilities	9
Figure 2.4 : GIS in the Environment	10
Figure 2.5 : GIS in Forestry	11
Figure 2.6 : GIS in Land Use Planning	12
Figure 2.7 : GIS in Local Government	13
Figure 2.8 : Sweeper Trucks	14
Figure 2.9 : GIS in Risk Management.....	15
Figure 2.10: GIS in Site Planning	16
Figure 2.11: GIS in Transportation	17
Figure 2.12: Vehicle Tracking System	18
Figure 2.13: All Rivers in Turkey	19
Figure 2.14: All Cities in Turkey	20
Figure 2.15: A Map Representing the Cities and Rivers in Turkey	20
Figure 2.16: Raster and Vector Models	21
Figure 2.17: Police Station Responsibility Areas in Ankara	23
Figure 3.1 : A GPS Device's Position	26
Figure 3.2 : The Shortest Path	29
Figure 3.3 : The Fastest Path	29
Figure 3.4 : The Shortest Path Route Description Table	30
Figure 3.5 : The Fastest Path Route Description Table	31
Figure 3.6 : Address Information of a Patient	32
Figure 3.7 : Giving Work to an Ambulance	32
Figure 3.8 : The Fastest Path between the Patient and the Ambulance	33
Figure 3.9 : Ambulance's Duty and Position	34
Figure 3.10: The Fastest Path between the Patient and the Ambulance	34
Figure 3.11: The Closest Hospitals to the Patient	35
Figure 3.12: The Fastest Path between the Patient and the Hospital	36
Figure 3.13: The Fastest Path between the Ambulance and the Hospital	36
Figure 3.14: Directed-Weighted Graph	38
Figure 3.15: Weighted-Directed Graph	40
Figure 3.16: Shortest Path to Vertices B, C from A	41
Figure 3.17: Shortest Path From B, D Using C as Intermediate Vertex	42
Figure 3.18: Shortest Path to E Using B as Intermediate Vertex	42
Figure 3.19: The Path Obtained Using Dijkstra's Algorithm	43
Figure 3.20: Nodes and Roads Tables	43

LIST OF SYMBOLS/ABBREVIATIONS

sDist[w] : The shortest distance
sDist[1]←0 : The distance to the source is zero

CBS : Coğrafi Bilgi Sistemleri [in Turkish]
GIS : Geographical Information System
VTD : Vehicle Tracking Device

CHAPTER 1

INTRODUCTION

Advances in the Geographic Information System (GIS) technology have led to a tremendous increase in the number and usage areas of GIS applications in our daily lives. A GIS is a system consisting of hardware, software, and a data which are used to link geospatial data with attribute data [1]. Geographic information is data about data objects and the location (spatial coordinates) on the Earth; and the attribute data is information describing the geographic data like name, characteristics, etc. A GIS provides the benefits of traditional maps and relational databases over the map in conjunction with the accompanying nongraphic attribute data query, analysis and presentation of geographic data.

GIS systems have wide application areas as a positional analysis tool in the present day [2]. For instance, vehicle navigation systems, vehicle tracking systems, environmental and natural resources management, defense and security purposes, disaster and emergency management, agriculture management, climate control, risk management, etc. In this study, we introduce the design and development of a GIS system which is used for emergency management.

Emergency management includes plans, structures and arrangements established to engage the normal endeavors of government, some voluntary agencies and some agencies which are aimed to effort emergency needs in an exhaustive and coordinated way to respond to the whole spectrum of emergency requirements [3]. This is also known as disaster management. Emergencies can happen because of natural events (e.g. earthquakes and floods), accidents (e.g. traffic accidents and hazardous material spills), or intentional attacks (e.g. terrorist bombings or release of chemical agents). The purpose of this study is to give background information about GIS, to show how to develop a GIS application step by step, and to analyze the benefits of performing GIS technology to emergency management in a general context. This study provides an example application on how the Emergency Services can use GIS in emergency response.

Before GIS applications were developed, no one can certainly know the certain destination or address of somewhere. Today special GIS applications are used as navigation aids to find and reach to the certain destination or address easily. Therefore, the importance of GIS is increasing day by day. On the other hand, there are not enough resources and specialists who are an expert person in GIS. This study also aims to fill this gap by providing a correct and enough information about GIS and a sample GIS application. This study is important because, this study can make a new view of GIS applications. The system does not only monitor the destination address on map, but also helps the ambulances, polices, firefighters reach the scene of the crime faster by presenting the fastest path. For example, for a firefighter team, it will be easy to reach the right scene of accident with having exact information and fastest path about the

destination. The police can also reach the scene of crime using the system in the same way. Examples can be redounded, but our application focused on GIS applications for the health care management.

Time is very important for health problems. Quick intervention can save life. In this study, we designed a system that finds and directs the closest ambulance to the patients. In this system, ambulance can reach to the patient in a short time by using the fastest path which can be seen by using mobile computer. Then, the system finds the closest hospital to the patient's address. (And) ambulance can also reach to this hospital by using the fastest path between the patient and the hospital. In each movement of the ambulance, the system saves time for the patient by finding the fastest path. As it is mentioned before, time is important for saving life, especially in bleeding accidents. This system may have a significant role to save people's life during emergencies.

In this study, we first present the theoretical information about GIS. Then, we introduce Dijkstra's Algorithm that we use to find the shortest and the fastest path in our application. We also give the details of the development process of GIS based emergency management system for health care. Finally, in the conclusion part, our recommendations for future studies are presented.

CHAPTER 2

GIS (GEOGRAPHICAL INFORMATION SYSTEMS)

2.1 What is GIS

GIS (Geographical Information Systems) has been generating huge interest worldwide. There are many definitions of GIS in the literature. However, their comparative innovation, rapid rate of development, commercial orientation and diversity have prevented to produce a clever and open definition of GIS [1]. We selected the following definitions of GIS in order to clarify its meaning.

- Any manual or computer based set of procedures used to store and manipulate geographically referenced data [4]
- An institutional entity reflecting an organizational structure that integrates technology with a database, expertise and continuing financial support over time [5]
- An information technology which stores, analyses, and displays both spatial and non-spatial data [6]

- A special case of information systems where the database consists of observations on spatially distributed features, activities, or events, which are definable in space as points, lines, or areas. A GIS manipulates data about these points, lines, and areas to retrieve data for ad hoc queries and analyses. [7]

Maras [8] gives a comprehensive definition of GIS in his GIS lecture notes as “A Geographical Information System is an integration of computer hardware, software, personnel, data and methods, which enables to capture, store, integrate, manipulate, manage, analyze, portray and to graphically render spatially referenced information so as to meet the user requirements.

2.2 Components of GIS

A GIS contains five key components. These are hardware, software, data, people, and methods [9, 10]. Figure 2.1 shows visually GIS components below.



Figure 2.1: Components of a GIS

Hardware

Hardware consists of the technical equipment which needed to run a GIS. The technical equipment includes a computer system with enough memory to store large amounts of data, enough power to run the software, and input and output devices such as scanners, digitizers, GPS data loggers, media disks, and printers.

Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. The most commonly used GIS software is MapInfo, ARC/Info, AutoCAD Map, etc. The best software is the one that is more specific for the application. MapInfo is the suitable option when the low cost GIS work is to be carried out desktop. It is easy to use and supports many GIS feature. If the user intends to carry out extensive analysis on GIS, ARC/Info is the best option. For the people using AutoCAD and willing to step into GIS, AutoCAD Map is a better option.

Data

Data is the most important component of a GIS. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. The digital map forms the basic data input for GIS. Tabular data related to the map objects can also be attached to the digital data. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organization to maintain

their data, to manage spatial data.

People

GIS technology has limited value without the people who manage and develop plans for applying it to real world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them to perform their everyday work. The people who use GIS can be extensively classified into two classes. The CAD/GIS operator, whose work is to vectorise the map objects. The use of this vectorised data to perform query, analysis or any other work is the responsibility of a GIS engineer/user.

Method

A successful GIS works according to a well-designed plan and business rules, that are the models and operating practices unique to each organization. There are various techniques used for map creation and future usage for any project. The map creation can be automated raster to vector creator or it can be manually vectorised using the scanned images. The source of these digital maps can be either map prepared by any survey agency or satellite imagery.

2.3 Major Application Areas of GIS

There are a variety of GIS application areas in use today. The most important areas with examples are listed below [2, 11]:

GIS in Agriculture

GIS is used in the solution of a variety of agricultural problems such as managing crop yields, monitoring crop rotation techniques, and projecting soil loss for individual farms or entire agricultural regions. For example; North Carolina uses GIS-Based agricultural model to help administer state, agricultural development and farmland preservation trust fund [12].

Another example is; Colombian Coffee Growers Federation's using ARCGIS Analytic Tools the design, formulation, and tracking of Colombian Coffee Farming [13] as it is illustrated in the Figure 2.2.



Figure 2.2: The Application Used by Colombian Coffee Growers Federation

GIS in Electric/Gas Utilities

GIS is used every day by Cities and utilities to help them map and inventory systems, track maintenance, monitor regulatory compliance, or model distribution

analysis, transformer analysis, and load analysis. For example: It is illustrated in the Figure 2.3, PPL Electric Utilities Manages Vegetation at NERC Standards [14].

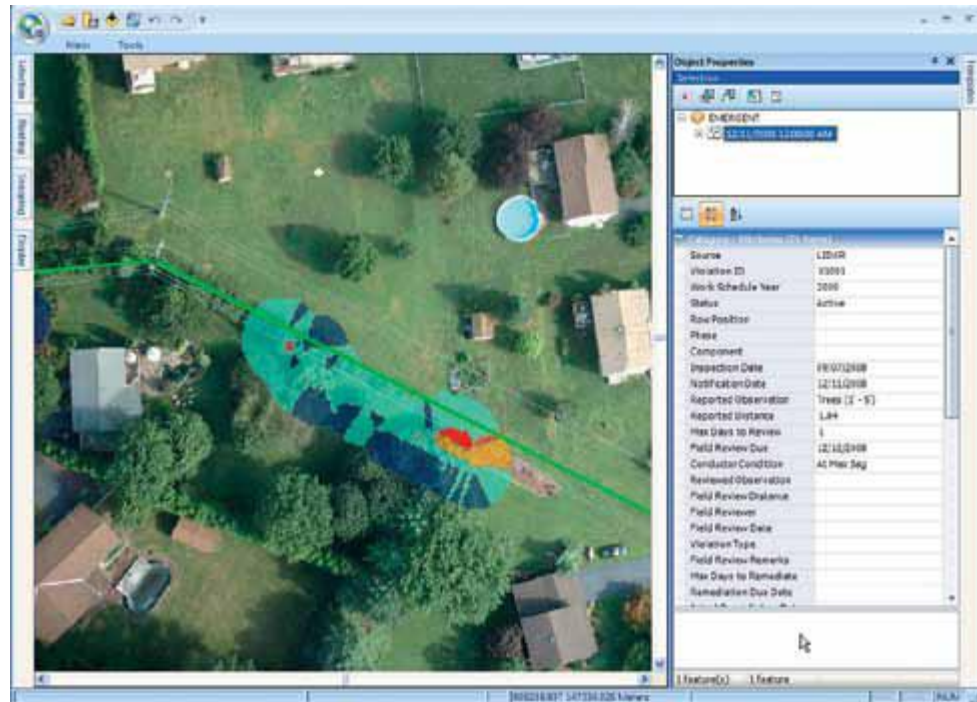


Figure 2.3: GIS in Electric Utilities

GIS in The Environment

GIS is used to protect the environment every day. GIS can be used to produce map, measure environmental impact, take inventory species; it can also be used to trace pollutants. There are lots of GIS applications for environment in use today and new applications are increasing day by day. It is almost endless. For example, Figure 2.4 illustrates that Lidar data showing the City of Darien, McIntosh County, Georgia, with one of many meandering rivers that converge on America's Eastern Seaboard.

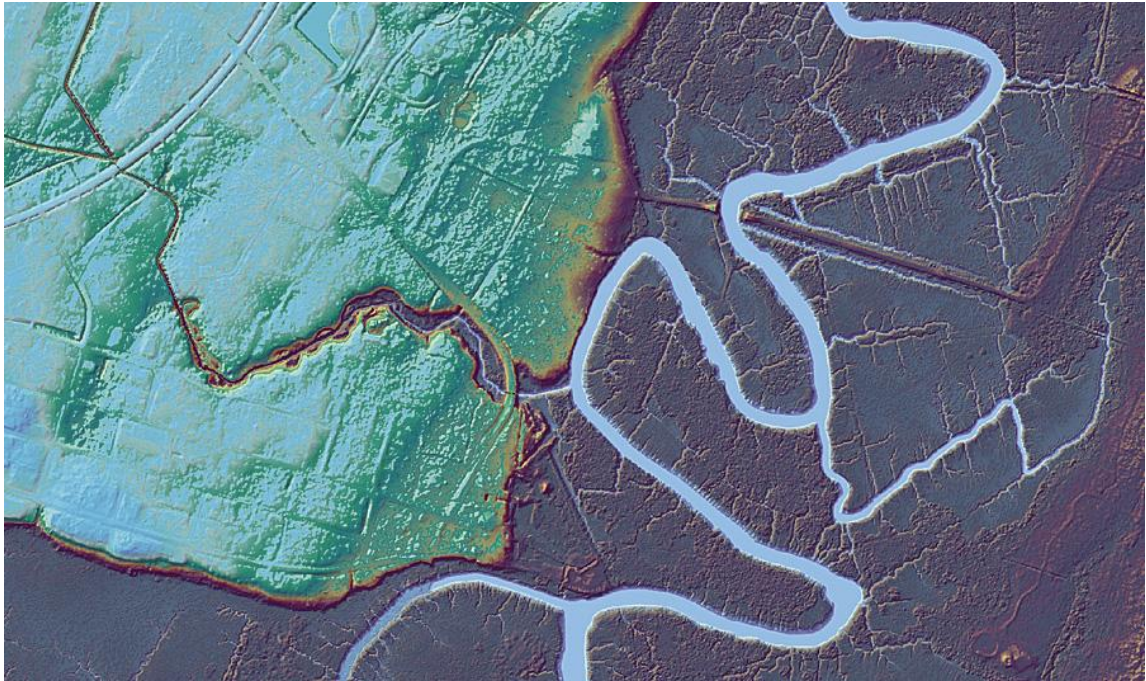


Figure 2.4: GIS in the Environment

The Coastal Regional Commission of Georgia (CRC) is working with multiple agencies to ensure that geospatial data is created in the area for current community planning and mitigation of any future natural disasters that may affect the area [15].

GIS in Forestry

Managing forests is turning into a more complex and exhaustive challenges nowadays. With the help of GIS, woodsman can easily see the forest as an ecosystem and they can manage it sensibly. Figure 2.5 shows redwood tree locations and provides specific species information.



Figure 2.5: GIS in Forestry.

GIS technology is helping community garden manager inventory, maintain and manage their plant collections [16].

GIS in Geology

GIS is used by geologists every day in lots of applications. Everybody can use GIS to search strata and soils, study geologic features, appraise seismic information. You can also create 3D exhibitions of geographic features. An example can be given as US National Park Service Geology Data Model. This data model is developed for implementation in the production of digital geologic-GIS data for parks with significant natural resources [17].

GIS in Hydrology

GIS can be used to evaluate groundwater, visualize watersheds, and, study

problems in daily life. For example, Figure 2.7 displays Automating Street Sign Maintenance in St. Johns County [19].

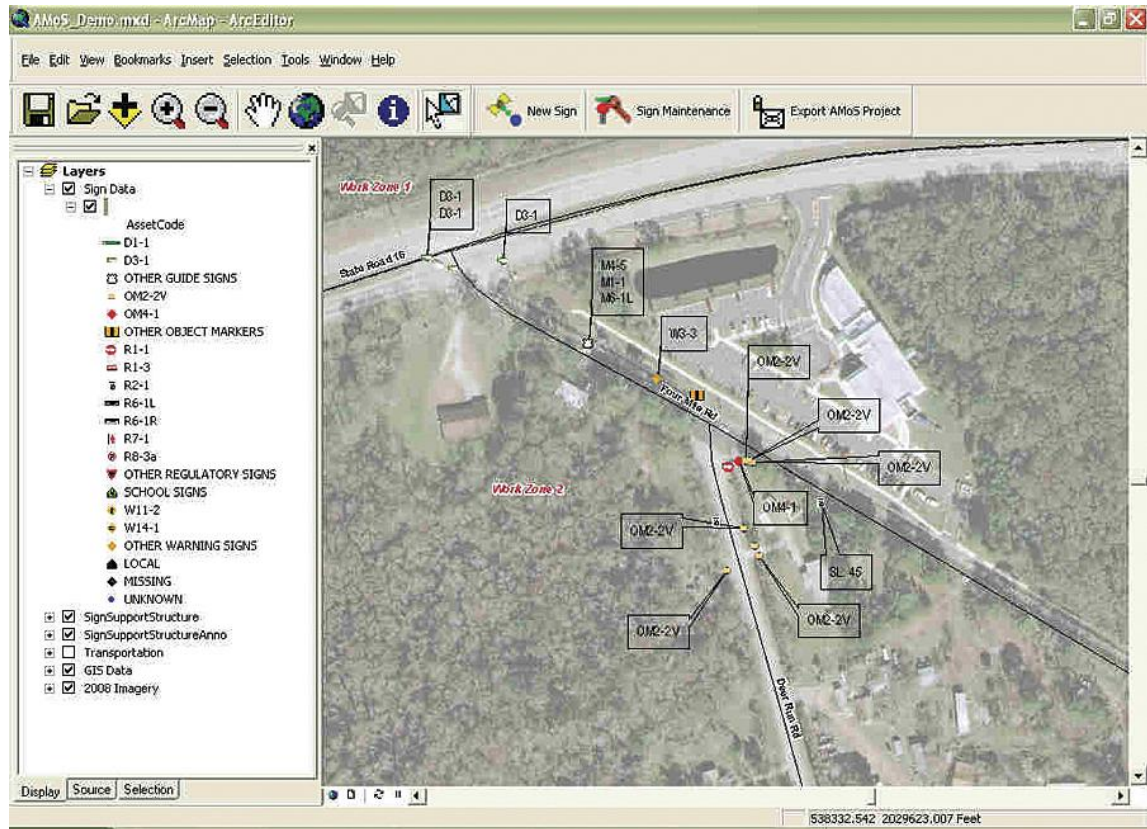


Figure 2.7: GIS in Local Government

The computerized maintenance management system helps St. Johns County easily locate and reference each street sign, determine the MUTCD code for that sign or group of signs, and review maintenance history.

Another example is shown in the Figure 2.8. Maricopa County Public Works GIS Division used a simple application to track speed compliance of its sweeper trucks [20].

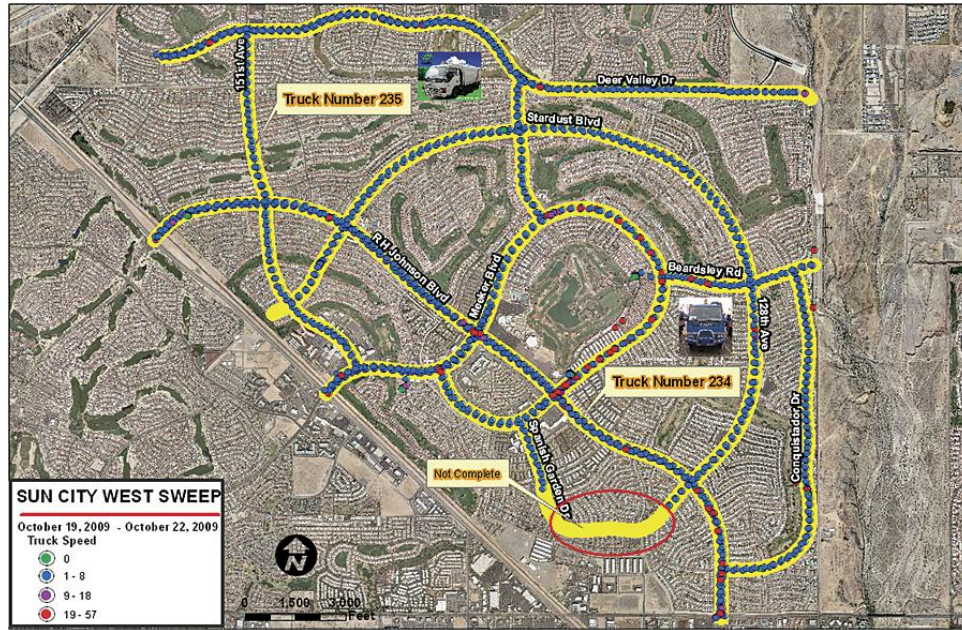


Figure 2.8: Sweeper Trucks

GIS in Mapping

Mapping is one of the major functions of a GIS. GIS is used by the people in lots of professions to help the other people understand geographic data. Nobody needs to be a professional to design a map with GIS.

GIS in The Military

Military is one of the most important are of GIS applications. Military cartographers and researchers use GIS in a lot of applications. For example: assessing land, helping in tactical decisions, and making basemaps. All intelligence services of all countries use GIS.

GIS in Risk Management

GIS shows people which areas will be in danger when a natural or human-made disaster exists. Risky areas can be found before a disaster happens. (And) it can be used in risk management to prevent human loss and material damages. As an example: To proactively assess and address flooding risks to the public, the U.S. Federal Emergency Management Agency (FEMA) has developed the National Flood Insurance Program (NFIP) [21]. Figure 2.9 shows that once the parcel is located, flood risk can be assessed.

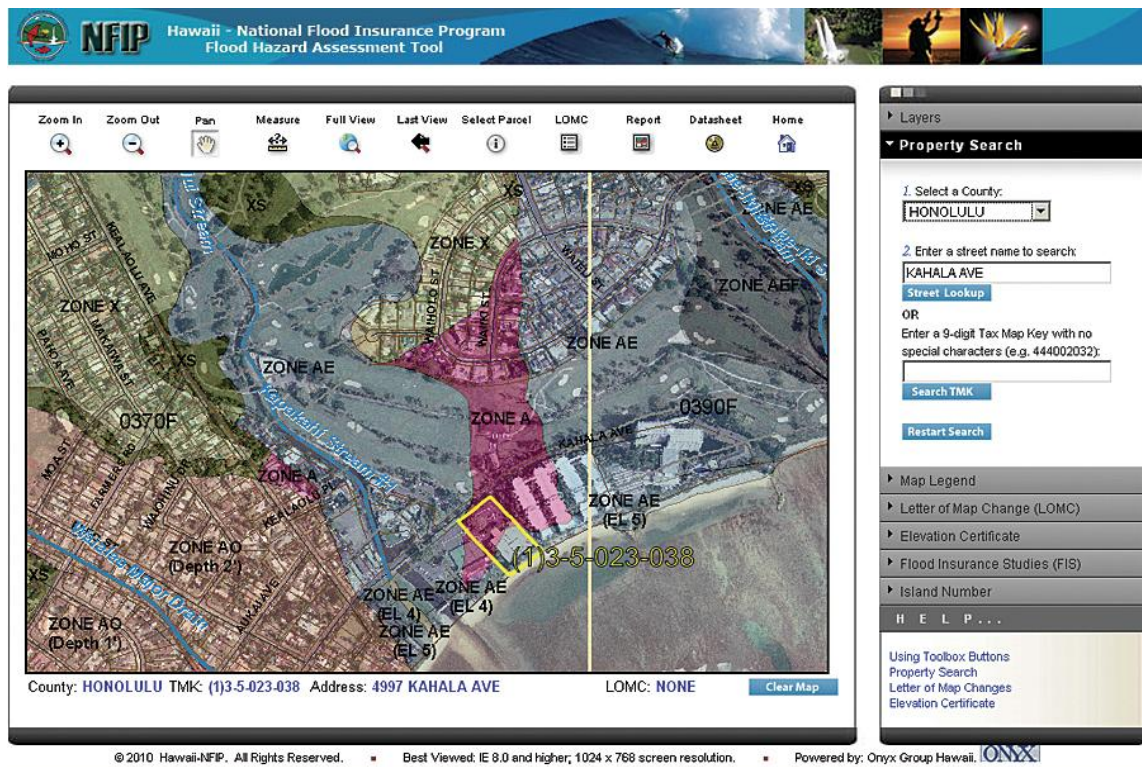


Figure 2.9: GIS in Risk Management.

GIS in Site Planning

GIS is used by people to help them locate places for new facilities or locate alternative places for existing facilities. Figure 2.10 shows the application focusing into a certain area of a city that could be re-planned or an area that is considered great for living [22].

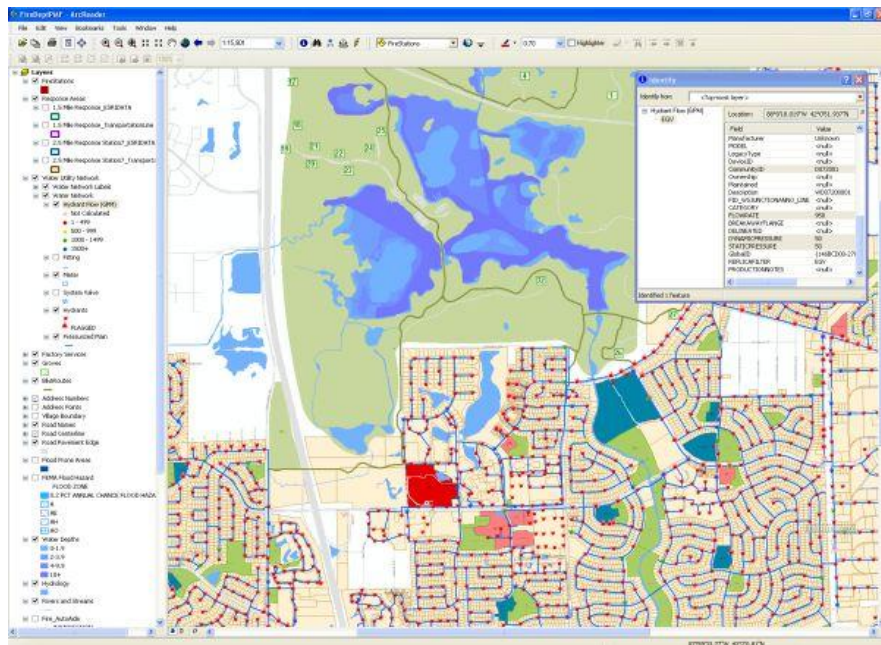


Figure 2.10: GIS in Site Planning.

GIS in Transportation

People use GIS in a variety of transportation applications. For example: you can use GIS to manage transportation infrastructure or it can be used to solve logistical problems. Also, GIS can help people find the shortest or fastest path which save time for transportation. Figure 2.11 illustrates a GIS application showing the location of trucks.

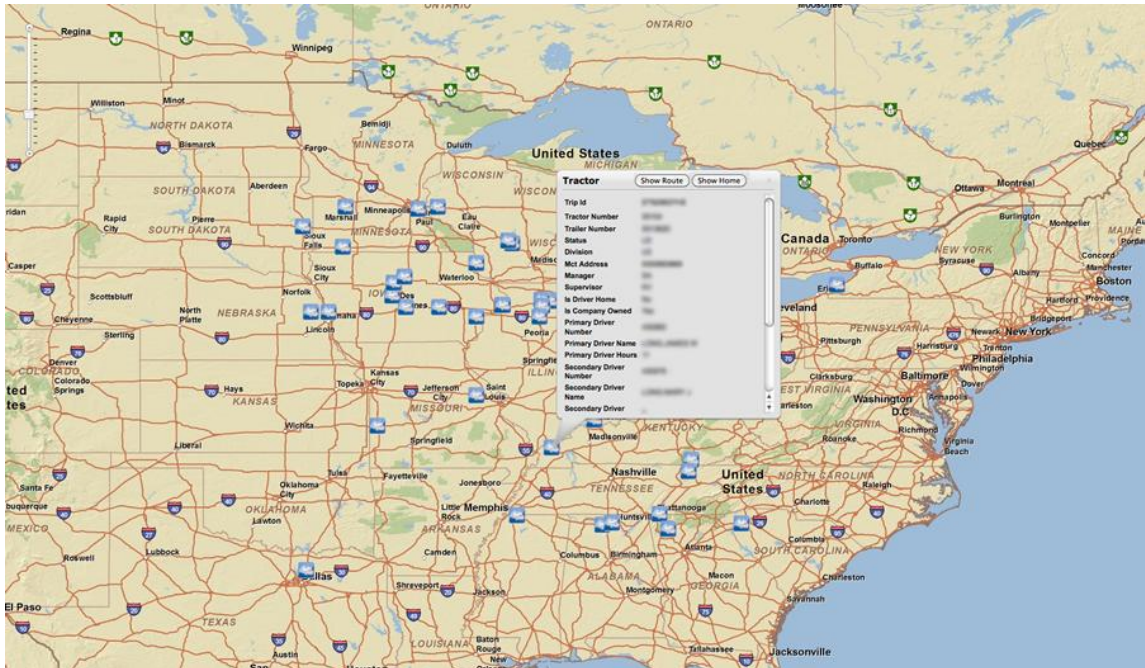


Figure 2.11: GIS in Transportation.

Using ArcGIS technology, Werner can see where the company's trucks are located anywhere and at any time by using the GIS technology [23].

A similar vehicle tracking system for Apsis Company is available in Turkey [24]. In this tracking system, companies can monitor their vehicles in real time as it is displayed in the Figure 2.12.

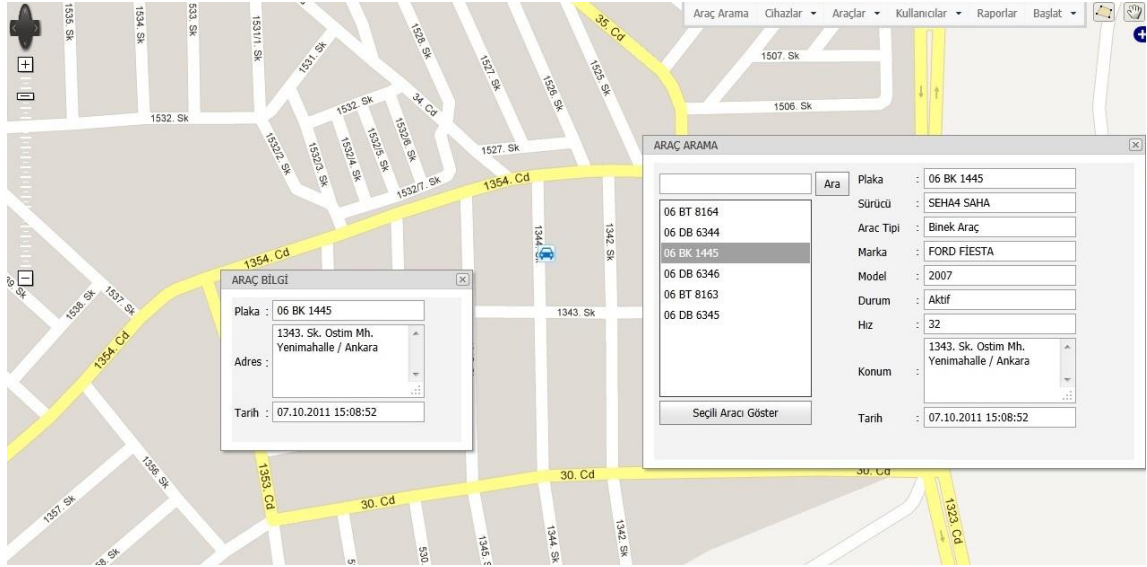


Figure 2.12: Vehicle Tracking System

The system enables users to define a zone to restrict the movement of the vehicle. If the vehicle enters or leaves this zone, a warning message is displayed on the screen and also this warning message is written to the log file. This system can be used by the student service companies. Parents can monitor the vehicle in real time, until the car reaches to the school or home. Company members give a corresponding vehicle id, a user id, and password to each parent to enter the web based vehicle tracking system. Also, they can see reports about the car whether the driver makes a breach or not. For example, s/he can see speed violations, zone violations, etc.

GIS in The Water/Wastewater Industry

GIS is used by the people in the water/wastewater industry with the planning, engineering, operations, maintenance, finance, and administration functions of their water / wastewater networks.

2.4 What is a Map in GIS

A Map shows geographic features and their attributes in an understandable view. Geographic information of an object describes the position on the Earth's surface. It is also known as spatial data. Attribute information describes descriptive information about the characteristics of spatial features. It is also known as non-spatial data.

A Map consists of the combination of different types of geographic feature. For example, all rivers in the Figure 2.13 are considered one type and roads or city areas in the Figure 2.14 are considered another. The combination of these different data types generates a map as is illustrated in the Figure 2.15.

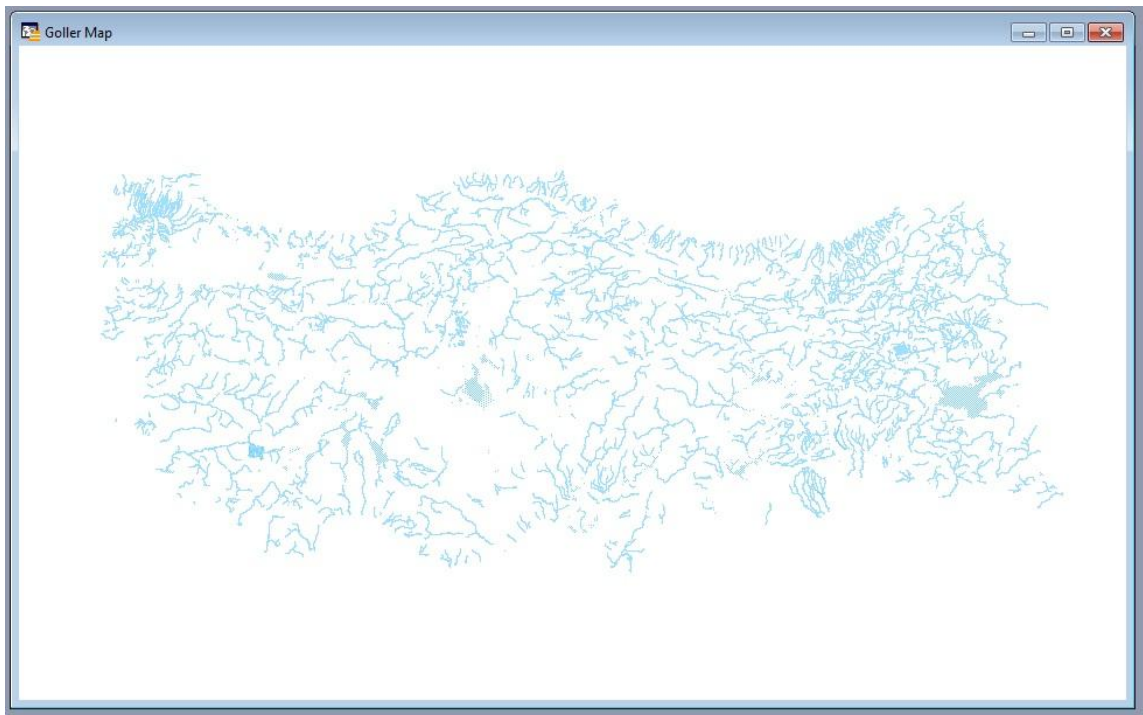


Figure 2.13: All Rivers in Turkey.

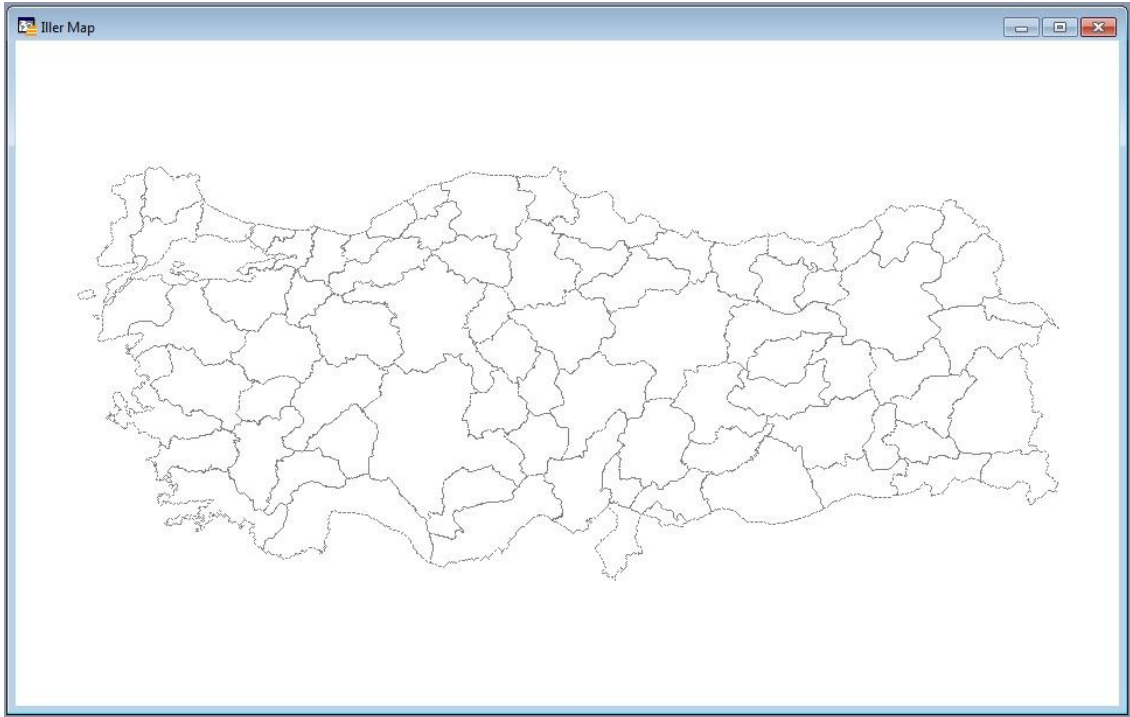


Figure 2.14: All Cities in Turkey.

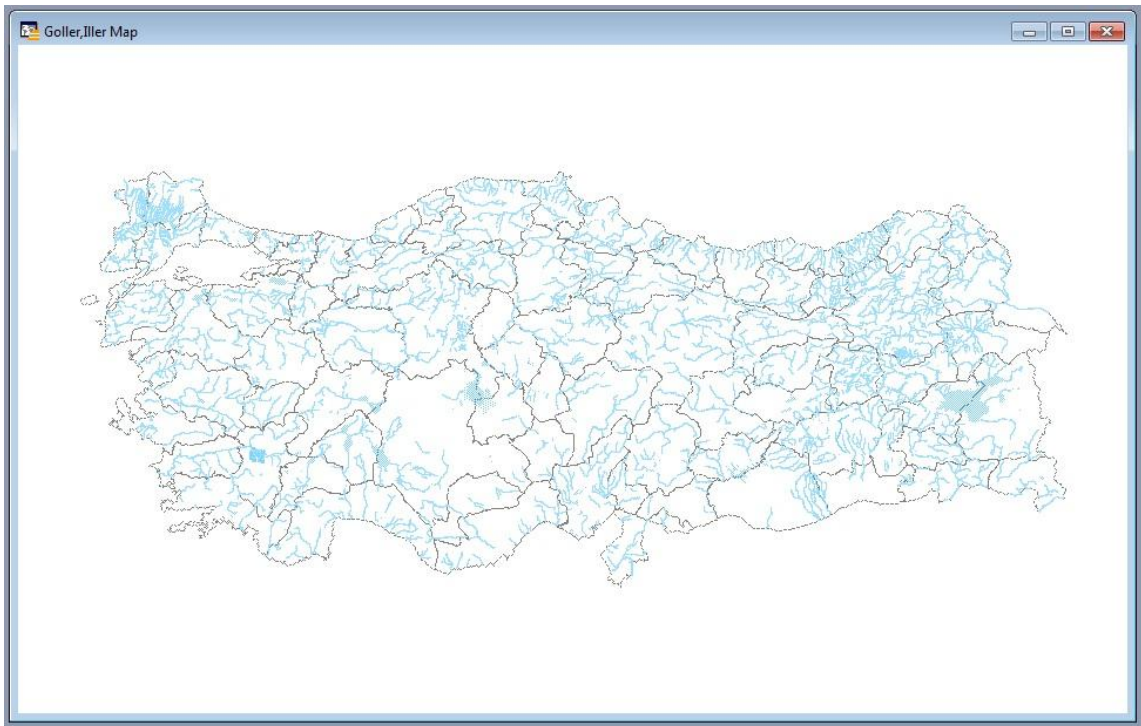


Figure 2.15: A Map Representing the Cities and Rivers in Turkey.

There are two basic ways of representing spatial data in digital form: vector and raster.

With **vector** representation, boundaries of a feature are defined by a series of points that represent the feature. Each point is coded with coordinate pairs that give the X and Y position in a reference system such as latitude/longitude. A unique ID is given to each feature. Attribute information of the feature is stored in database tables with its ID. Points, lines and polygons are the main types of feature represented in vector maps.

With **raster** representation, the map is divided into grid cells. These cells hold a numeric value according to attribute information. The numeric value may represent a qualitative attribute or quantitative attribute. Each numeric value has a color to display the layers.

Figure 2.16 illustrates raster and vector model and table 2.1 shows the difference between raster and vector model.

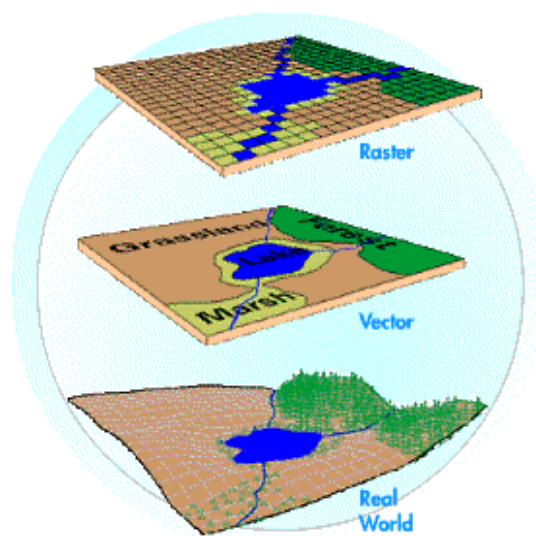


Figure 2.16: Raster and Vector Models

Table 2.1: Raster and Vector Model

Raster model	Vector model
Simple data structure	Complex data structure
Easy and efficient overlaying	Difficult to perform overlaying
Compatible with Remote Sensing imagery	Not compatible with RS imagery
High spatial variability is efficiently represented	Inefficient representation of high spatial variability
Simple for programming by user	
Same grid cell definition for various attributes	Compact data structure
	Efficient encoding of topology
Inefficient use of computer storage	Easy to perform network analysis
Errors in perimeter and shape	Highly accurate map output
Difficult to perform network analysis	
Inefficient projection transformations	
Loss of information when using large pixel sizes	
Less accurate and less appealing map output	

2.5 MapInfo as Map Developer Program & Mapxtreme

MapInfo [25] is a software tool which enables user to create GIS data. It is one of the most important software used by many companies today in the world. Data can be displayed as points, line or polygon, as thematically shaded regions, as bar or pie charts, as districts, etc. Geographic operations can be done such as splitting, redistricting and combining objects. Also queries can be made against the data.

For example, MapInfo can show you which Police Station is closest to your address. It can calculate the distance between the Police Station and your home. It can

show you the areas which Police Stations are responsible for by giving a color to each of the stations as it is displayed in the Figure 2.17.

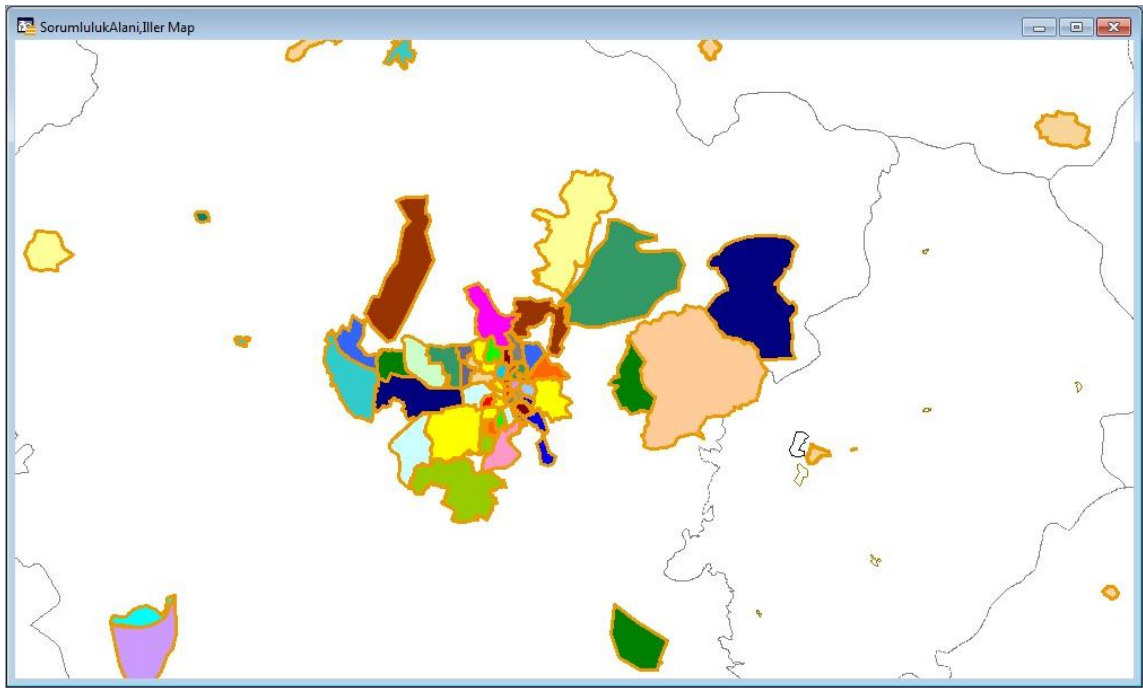


Figure 2.17: Police Station Responsibility Areas in Ankara

MapXtreme [26] is an application development tool which is used in .NET and java platforms to develop map applications. But it can give efficient solutions on .NET platforms. On the other hand, MapXtreme is used to organize data visualization and mapping applications. These applications can help you make better business decisions and manage property and operations more effectively. MapXtreme is dealing with organizations that need to incorporate location analysis or definition into desktop, at the same time client/server and web-based products. We can also use MapXtreme as a powerful analysis toolkit to make critical business decisions, or emergency decisions

such as ideal locations for sales offices, hospitals, and so on. By this way, we can figure out how to transport goods most powerfully, or how to manage and protect assets. MapXtreme can be used by Developers to shorten their development time and improve performance, reliability, and security.

CHAPTER 3

IMPLEMENTATION

A GIS application was developed in this study. In this section, implementation details will be explained in order to give guidance for the GIS programmers. Implementation can be divided into three parts as hardware, applications and Dijkstra's Algorithm. In this chapter we will explain each of them.

3.1 Hardware

Hardware is the system requirements used to work the system successfully. We need Vehicle Tracking Devices (VTD) and a server as hardware.

3.1.1 Vehicle Tracking Devices (VTD)

VTDs can be considered as GPS (Global Positioning System) devices. So, working style of a VTD is similar to a GPS device.

GPS satellites convey signals to the devices on the ground. GPS receivers take satellite signals passively. GPS operations depend on a very exact time reference provided by atomic clocks at the U.S. Naval Observatory. Each GPS satellite has atomic

clocks on board [27].

Each GPS satellite transmits data that point out the current time and its location. All GPS satellites synchronize operations to ensure these repeating signals' being transmitted at the same time. A GPS receiver receives the signals which are moving at the speed of light, at a little different time because of some satellites' being farther away according to others. The distance to the GPS satellites can be determined by forecasting the amount of time it takes for their signals to arrive the receiver. Receiver can calculate its position in three dimensions, when it estimates the distance to at least four GPS satellites.

To determine position; the location of the satellites is included in satellite transmissions, so a GPS receiver can understand the locations of satellites using this information. In addition, the receiver can realize that it is at the intersection point of the imaginary spheres whose centers are the satellites. It also determines the sizes of these spheres. Figure 3.1 shows how a GPS receiver can determine the position



Figure 3.1: A GPS Device's Position

There are lots of producers of these devices today in the world. The device's features depend on the used area of the device. For example in architecture, the length is very important. So, precision of the device is sensitive. It can show the position 100 divided by one millimeter accuracy. These devices are very expensive. In a Vehicle Tracking Device, the accuracy is important but not as it is in architecture. It works in 10 – 15 meter accuracy.

A VTD is a kind of GPS receiver, but it has more ability than a GPS receiver. VTD can also find speed, altitude, heading angle, coordinates, etc. of the car. After finding the information of the car, VTDs sends this data to the server.

3.1.2 Server

The server is a usual server which collects the information sent by VTDs. This server also publishes the main web application for the system.

3.2 Applications

The system consists of two different applications. First application is a listener program and the second application is the main web application.

3.2.1 Listener

Vehicle tracking devices (VTD) send the coordinates, speed, altitude, etc. of the

car to a port of a server. This program always listens to this port. With the help of this program, vehicle's necessary information for the tracking system is inserted into the database. The data coming from a VTD depends on the program which is installed in it.

3.2.2 Web application

The main web application consists of three parts. First one is public but the second and third one can be used by the people who are responsible for the system.

Part 1: Health care center finder

The first part is an application which can be used by the people who have internet connection. This part enables people to find the closest health care center to their street. First the people choose a health care center type, such as hospital, drugstore, veterinary, etc. After the choice, they enter their address information. First they choose the city, then county, then neighborhood, and finally street is chosen. After entering all address information, by clicking on the search button, system finds the closest health care centers according to chosen health care center type and address information. The centers are listed in a box. There are two options for routing. One of them is the shortest, and the other is the fastest path. After choosing one of the routing options and one of the health care centers, system draws a route from the street to the chosen health care center in the list. Figure 3.2 and Figure 3.4 illustrate an example for routing the ambulance with

the shortest and the fastest paths.

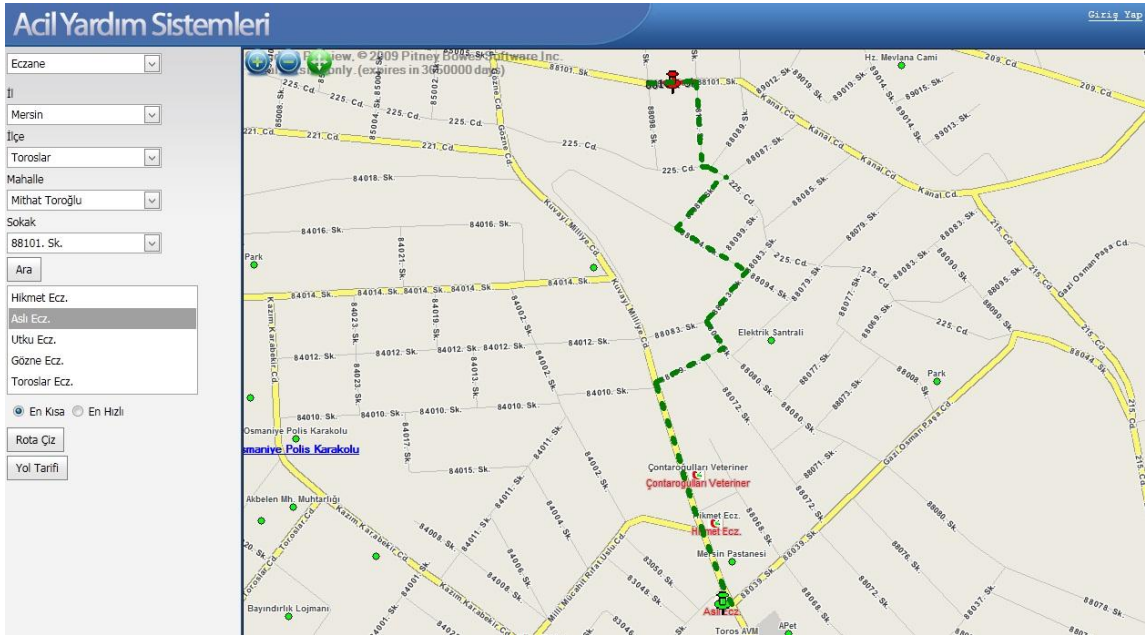


Figure 3.2: The Shortest Path

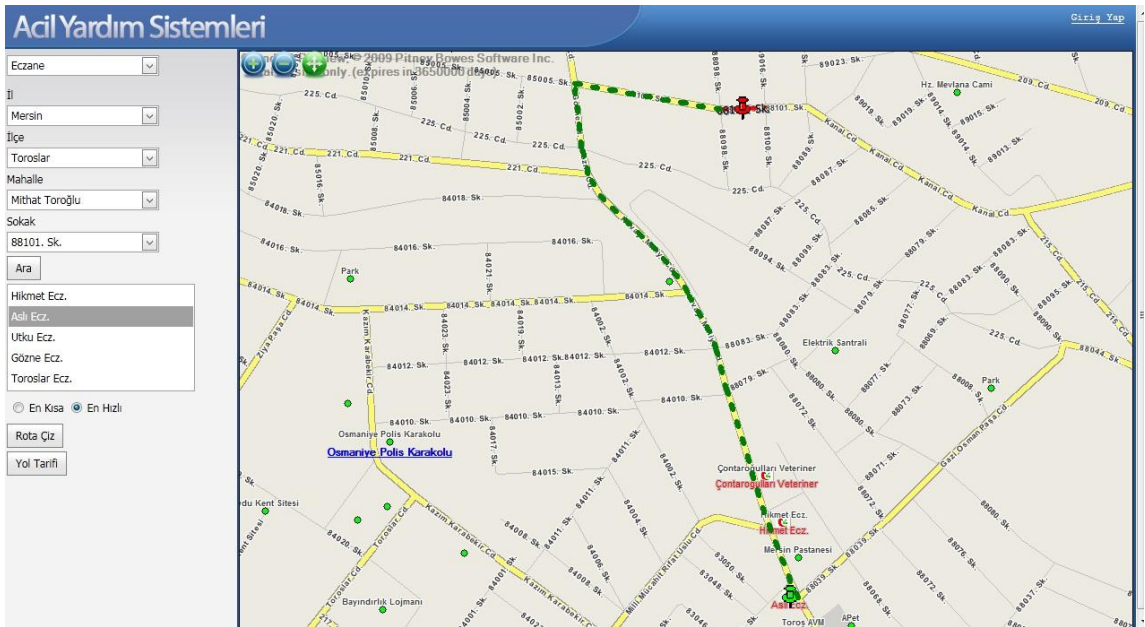


Figure 3.3: The Fastest Path

The system also enables users to see the directions by text. This text is a

description which tells user how to go to the destination in certain ways. Figure 3.3 shows the shortest path route description for the route in the Figure 3.2. And Figure 3.5 shows the fastest path route description for the route in the Figure 3.4.



YOL TARIFI
88080. Sk. üzerinden 25 metre giderek başlayınız. Sonra 88079. Sk. yönüne dönün.
88079. Sk. üzerinden 41 metre gidiniz, 88101. Sk. yönüne dönün.
88101. Sk. üzerinden 38 metre gidiniz, 88100. Sk. yönüne dönün.
88100. Sk. üzerinden 66 metre gidiniz, 88094. Sk. yönüne dönün.
88094. Sk. üzerinden 41 metre gidiniz, 88083. Sk. yönüne dönün.
88083. Sk. üzerinden 50 metre gidiniz, Kuvayi Milliye Cd. yönüne dönün.
Kuvayi Milliye Cd. üzerinden 184 metre gidiniz, 88087. Sk. yönüne dönün.
88087. Sk. üzerinden 56 metre gidiniz, 225. Cd. yönüne dönün.
225. Cd. üzerinden 20 metre gidiniz, 88094. Sk. yönüne dönün.

Page 1 of 2 (14 items) < [1] 2 >

Figure 3.4: The Shortest Path Route Description Table

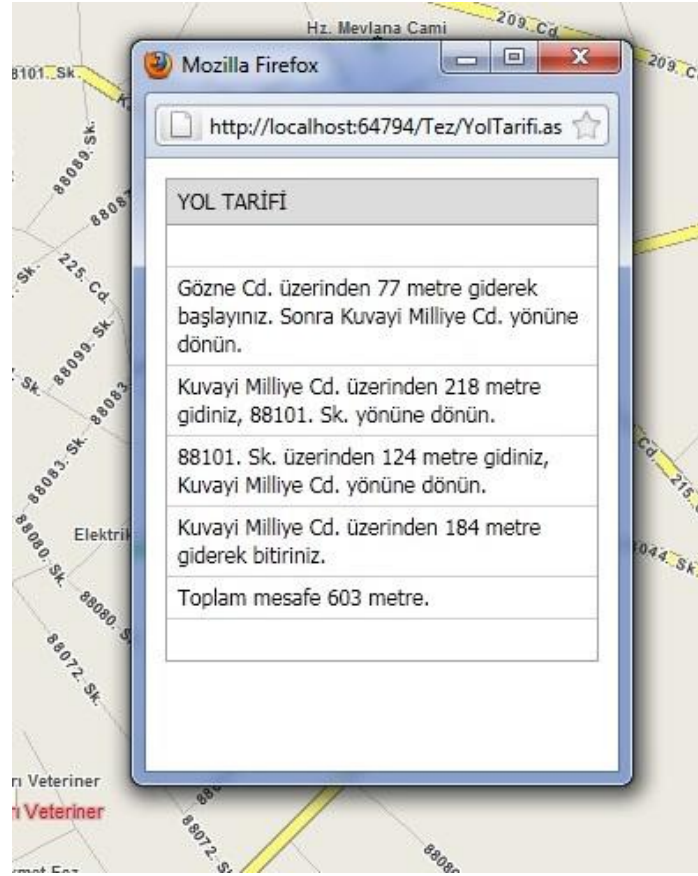


Figure 3.5: The Fastest Path Route Description Table

Part 2: Emergency service application

This part is used by emergency services to find the closest ambulances to a patient. Each emergency service has a user ID and a password to enter to the system. In this system each ambulance has a Vehicle Tracking Device (VTD). These devices send the coordinates of the ambulances instant by instant. So, the system knows all ambulances' positions.

When a call is come to emergency service number, the person who is responsible

for the system enters to the system. Then s/he enters the patient's address information beginning from the city to the street as it is shown in the Figure 3.6.

The screenshot shows a form for entering patient address information. It consists of several dropdown menus and one text input field. The labels and values are as follows:

Label	Value
İl	Adana
İlçe	Seyhan
Mahalle	Bahçelievler
Sokak	54001. Sk.
No	10

Below the form, there is a button labeled "Bul" and a label "En Yakın Ambulans".

Figure 3.6: Address Information of a Patient

After entering all address information, the user clicks to the search button. Then the system finds the closest ambulances to the patient's address, and shows these ambulances in a list as is displayed in the Figure 3.7. The user chooses one of the ambulances in the list. Then s/he gives this duty to this ambulance.

The screenshot shows a window titled "En Yakın Ambulans". It contains a search button labeled "Bul" and a list of four ambulance IDs: 01ABC01, 01ABC02, 01ABC03, and 01ABC04. At the bottom of the window, there is a button labeled "Görevlendir".

Figure 3.7: Giving Work to an Ambulance

After giving to work to an ambulance, the fastest path between the address and the chosen ambulance is seen on the map as it is illustrated in the Figure 3.8.

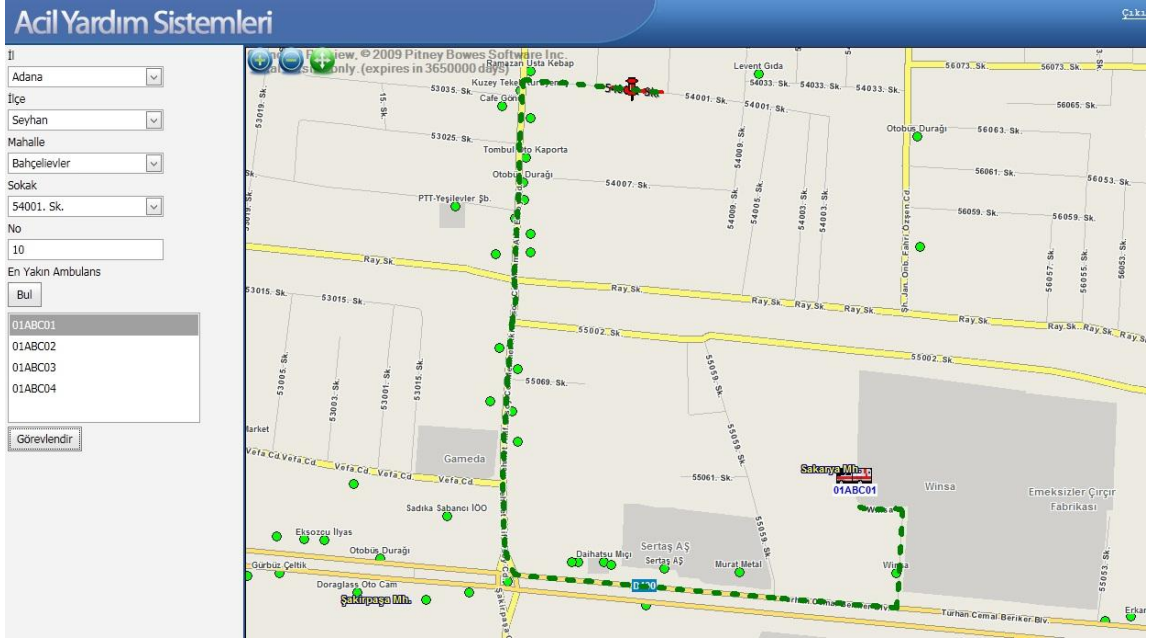


Figure 3.8: The Fastest Path between the Patient and the Ambulance

Part 3: Ambulance application

This part is used by the person who is responsible for the ambulance. Each ambulance user has a user ID and a password to enter the system. After an emergency service gives a duty to an ambulance, ambulance user enters to the system. When the user enters the system, s/he can see the duty in a box and current position of the ambulance as it is displayed in the Figure 3.9.

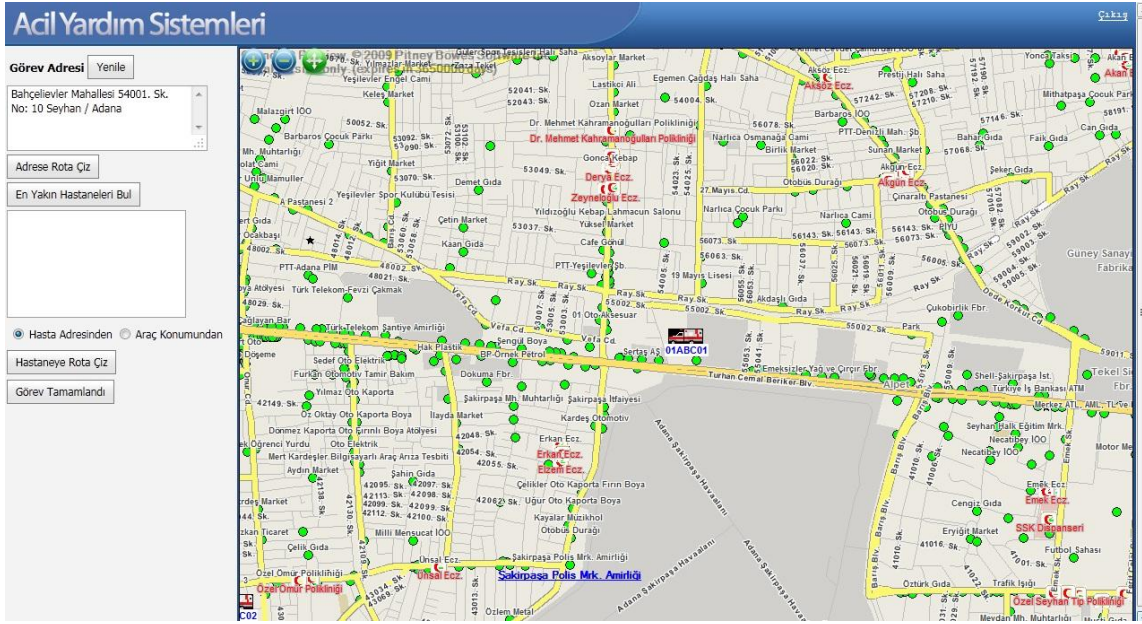


Figure 3.9: Ambulance's Duty and Position

The system enables ambulance user to see the route from the ambulance position to the patient's position as it is shown in the Figure 3.10. So, ambulance can reach to the patient faster by following the fastest path.

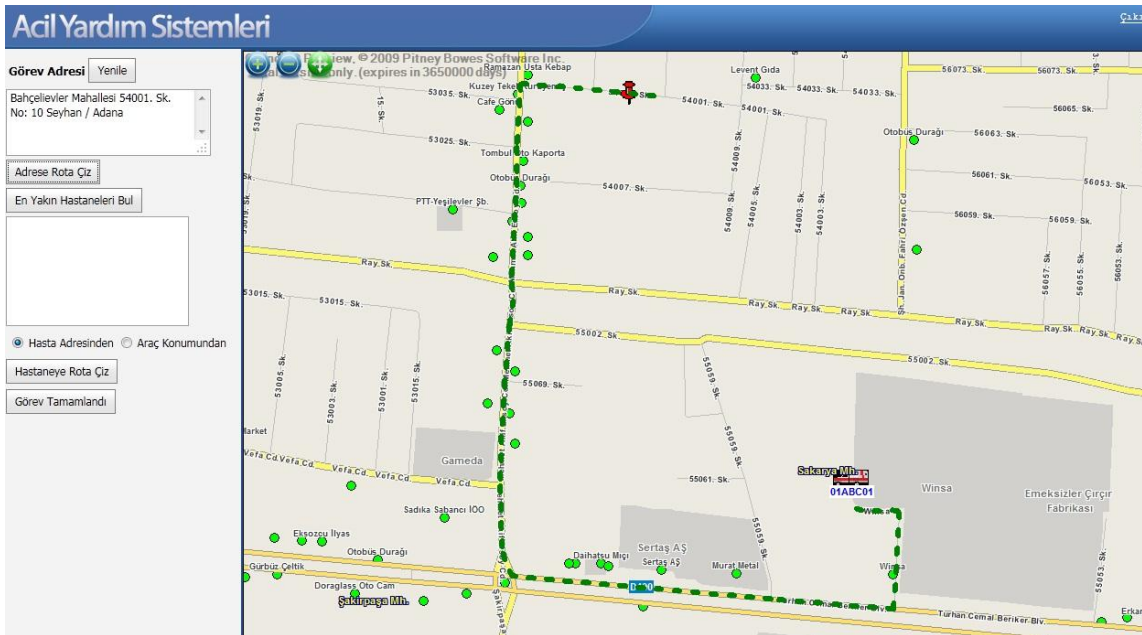


Figure 3.10: The Fastest Path between the Patient and the Ambulance

The system automatically finds the closest hospital to the patient's address as it is displayed in the Figure 3.11. After arriving to the patient's address, the user chooses one of the hospitals in the list. There are two options about routing. One of them is from the patient's address, and the other is from the ambulance's position.

En Yakın Hastaneleri Bul

Deva Polikliniği
Dr. Mehmet Kahramanoğulları Polikliniği
Özel Ömür Polikliniği
Safa Tıp Mrk.
Özel Biomed Tıp Mrk.

Hasta Adresinden Araç Konumundan

Hastaneye Rota Çiz

Görev Tamamlandı

Figure 3.11: The Closest Hospitals to the Patient

The system generates the fastest path from the ambulance's or patient's position to the chosen hospital in the list as it is illustrated in the Figure 3.12 and the Figure 3.13. So, the ambulance can bring the patient to the hospital faster by using the fastest path.

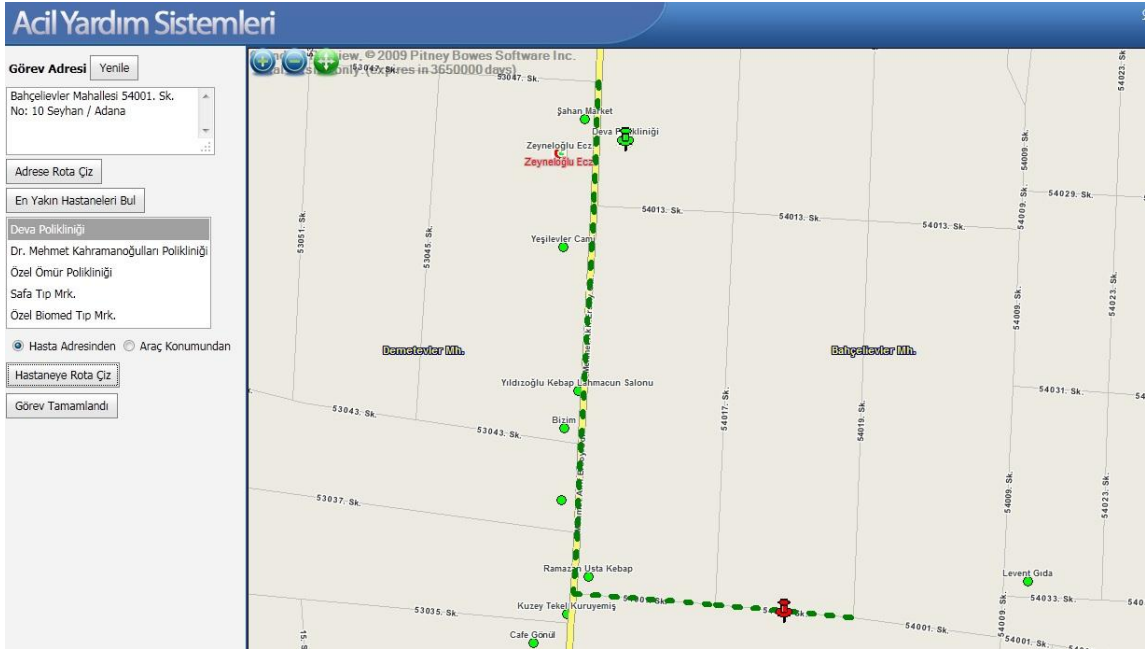


Figure 3.12: The Fastest Path between the Patient and the Hospital

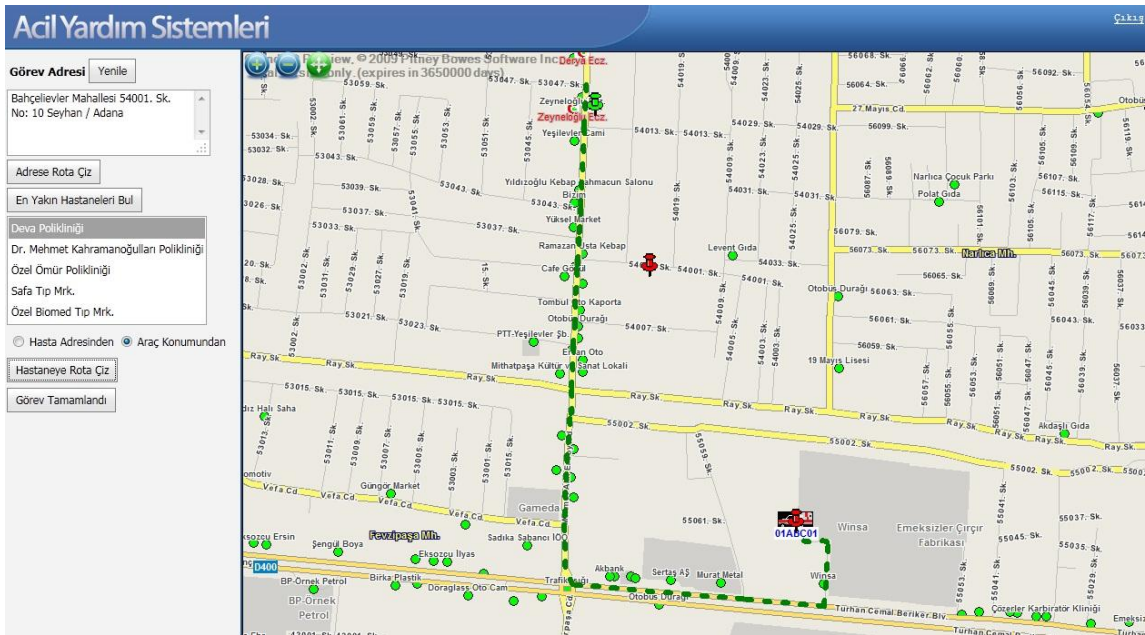


Figure 3.13: The Fastest Path between the Ambulance and the Hospital

3.3 Dijkstra's Algorithm

3.3.1 Introduction to Dijkstra's Algorithm

Dijkstra's Algorithm is considered as one of the most popular algorithms in computer science. It is also popular in operations research. In 1959, a paper which contains three pages named by “*A Note on Two Problems in Connexion with Graphs*” was published in the journal *Numerische Mathematik*. In this paper Edsger W. Dijkstra, who is a twenty-nine-year-old computer scientist, proposed algorithms for the solution of two main graph theoretic problems: the minimum weight spanning tree problem and the shortest path problem [28].

Dijkstra's algorithm is called the single-source shortest path. It is also known as the single source shortest path problem. It computes length of the shortest path from the source to each of the remaining vertices in the graph.

The single source shortest path problem can be explained as below:

Let $G = \{V, E\}$ be a directed weighted graph with V having the set of vertices. The special vertex s in V , where s is the source and let for any edge e in E , $\text{EdgeCost}(e)$ be the length of edge e . All the weights in the graph should be non-negative.

And what is directed graph? Directed graph can be defined as an ordered pair $G = (V, E)$ with V is a set, whose elements are called vertices or nodes and E is a set of ordered pairs of vertices, called directed edges, arcs, or arrows. Directed graphs are also known as digraph [29].

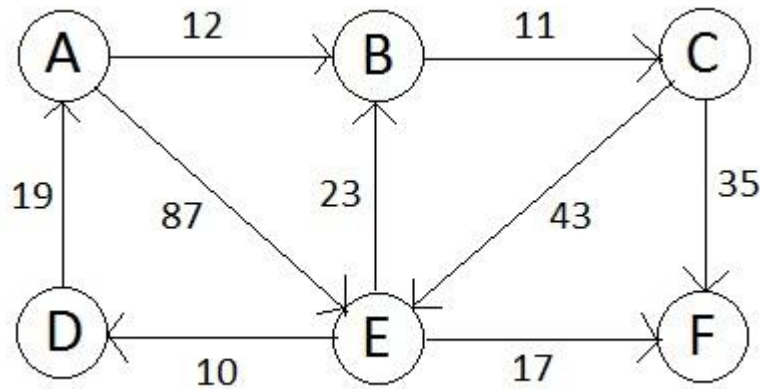


Figure 3.14: Directed-Weighted Graph

3.3.2 Description of the algorithm

Before focusing on the pseudo-code of the algorithm, it is important to know how the algorithm works to determine shortest path. Dijkstra's algorithm works by solving the subproblem k , which computes the shortest path from the source to vertices among the k closest vertices to the source. Dijkstra's algorithm has a necessity to work with a directed-weighted graph and the edges should be non-negative. If the edges are negative, it is impossible to find the actual shortest path problem [29].

At the k^{th} round, there will be a set called **Frontier of k** vertices which will consist of the vertices closest to the source, at the same time the vertices which lie outside frontier are computed and put into New Frontier. The shortest distance acquired is maintained in $sDist[w]$. It holds the approximation of the distance from s to w . Dijkstra's algorithm finds the next closest vertex by maintaining the New Frontier vertices in a priority-min queue.

The algorithm works by keeping the shortest distance of vertex v from the source in an array, $sDist$. The shortest distance of the source to itself is zero. Logically, $sDist$ for all other vertices is set to infinity to show that those vertices are not yet processed. After the algorithm finishes the processing of the vertices $sDist$ will have the shortest distance of vertex w to s . Those two sets are maintained Frontier and New Frontier which helps in the processing of the algorithm. Frontier has k vertices which are closest to the source, will have already computed shortest distances to these vertices, there is an obligation for paths must be up to k vertices. The vertex that lies outside of Frontier is put in a set called New Frontier.

3.3.3 Pseudo-Code of the algorithm

Pseudo-code in the below gives a short and clear explanation of the working of the Dijkstra's algorithm.

Procedure Dijkstra (V : set of vertices $1 \dots n$ *{Vertex 1 is the source}*
Adj[$1 \dots n$] of adjacency lists;
EdgeCost(u, w): edge – cost functions);
Var: $sDist[1 \dots n]$ of path costs from source (vertex 1); *{ $sDist[j]$ will be equal to the length of the shortest path to j }*

Begin:

Initialize

{Create a virtual set Frontier to store i where $sDist[i]$ is already fully solved}
Create empty Priority Queue New Frontier;
 $sDist[1] \leftarrow 0$; *{The distance to the source is zero}*
forall vertices w in $V - \{1\}$ **do** *{no edges have been explored yet}*
 $sDist[w] \leftarrow \infty$
end for;
Fill New Frontier with vertices w in V organized by priorities $sDist[w]$;
endInitialize;

repeat

$v \leftarrow \text{DeleteMin}\{\text{New Frontier}\}$; *{ v is the new closest; $sDist[v]$ is already correct}*

```

forall of the neighbors w in Adj[v] do
    if sDist[w]>sDist[v] +EdgeCost(v,w) then
        sDist[w]←sDist[v] +EdgeCost(v,w)
        update w in New Frontier {with new priority sDist[w]}
    endif
endfor
until New Frontier is empty
endDijkstra;

```

The algorithm exemplifies “Best-First-Breadth-First-Search”. It is the “Best-First” because the best vertex in “New Frontier” is selected to be processed next. The search used is “Breadth-First”, since “New Frontier” consists of vertices that can be tried next and these vertices are one edge away from the explored vertices.

3.3.4 Example of Dijkstra’s Algorithm

The Dijkstra’s Algorithm can be explained and understood better by exemplifying it. The example will shortly explain each step that is taken and how sDist is calculated.

Consider the following example:

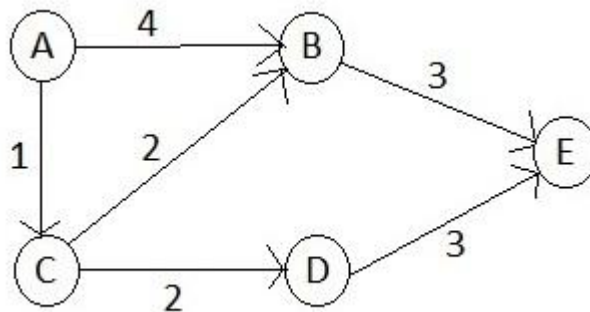


Figure 3.15: Weighted-Directed Graph

The above weighted graph has 5 vertices starting from A and ends with E. The

value between those two vertices is known as the edge cost between two vertices. As an example, the edge cost between A to C is 1. Using the above graph the Dijkstra's algorithm is used to determine the shortest path from the source A to the remaining vertices that lies on the graph.

The example is solved as follows:

- Initial step
 $sDist[A]=0$; *the value to the source itself*
 $sDist[B]=\infty$, $sDist[C]=\infty$, $sDist[D]=\infty$, $sDist[E]=\infty$; *the nodes not processed yet.*
- Step 1
 $Adj[A]=\{B,C\}$; *computing the value of the adjacent vertices of the graph*
 $sDist[B]=4$;
 $sDist[C]=2$;

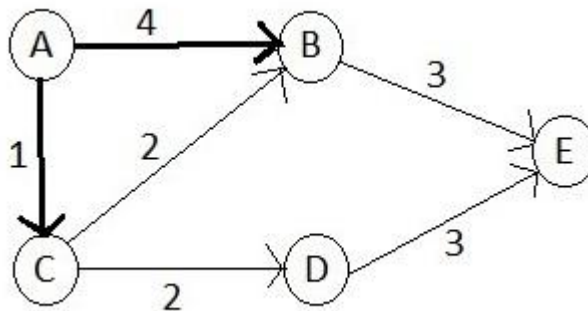


Figure 3.16: Shortest Path to Vertices B, C from A

- Step 2
Computation from vertex C
 $Adj[C] = \{B, D\}$;
 $sDist[B] > sDist[C] + EdgeCost[C,B]$
 $4 > 1 + 2$ (*True*)
 Therefore, $sDist[B]=3$;
 $sDist[D]=2$;

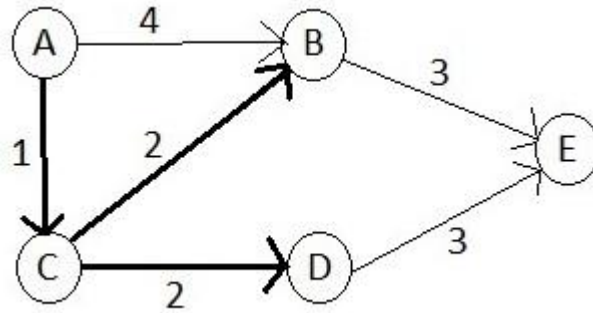


Figure 3.17: Shortest Path from B, D Using C as Intermediate Vertex

Adj[B]={E};
 $sDist[E]=sDist[B]+EdgeCost[B,E]$
 $=3+3=6;$

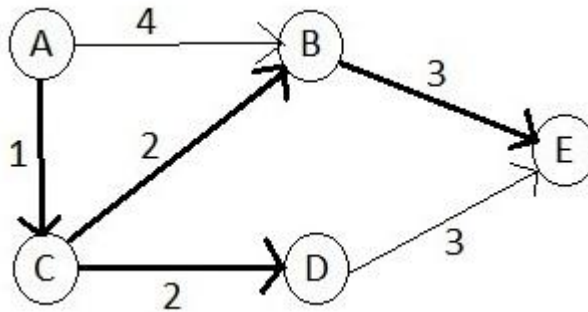


Figure 3.18: Shortest Path to E Using B as Intermediate Vertex

Adj[D]={E};
 $sDist[E]=sDist[D]+EdgeCost[D,E]$
 $=3+3=6$

This is same as the first value that was calculated so $sDist[E]$ value is not changed.

- Step 3

Adj[E]=0; means there is no outgoing edges from E
 And no more vertices, algorithm terminated. Hence the path which follows the algorithm is

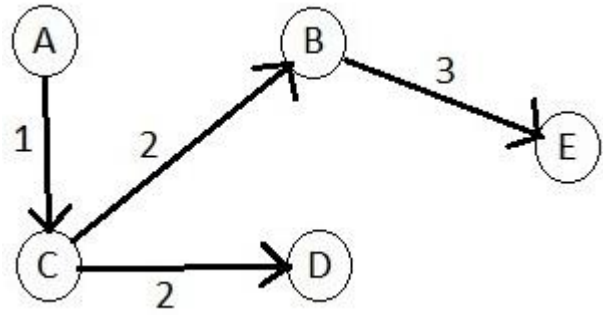


Figure 3.19: The Path Obtained Using Dijkstra’s Algorithm

3.3.5 Inserting Dijkstra’s Algorithm into the system

In the system, we have real roads to find the shortest path. The roads are in MapInfo tables. We have nodes at the intersection of the each road in the Node Table. The asterisks in the Figure 3.20 represent the nodes.

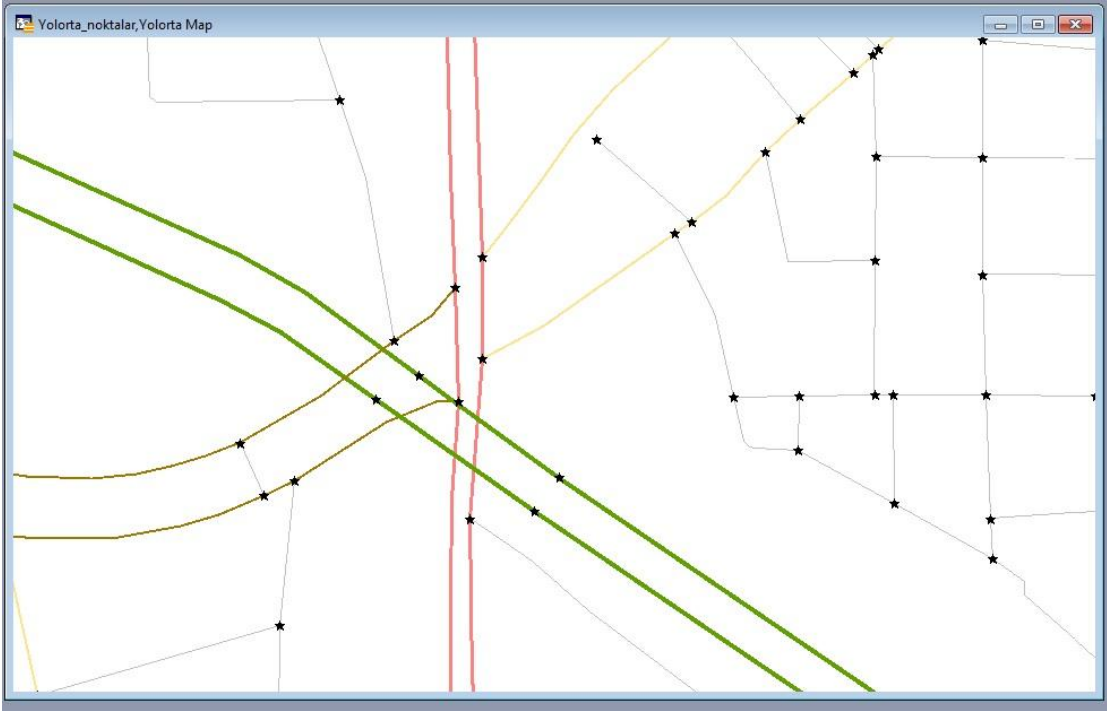


Figure 3.20: Nodes and Roads Tables

Each road and node in the figure is an object. MapInfo holds an object's text and geographic data in its tables. So, we know each road's weight according to its geographical information. Also, we can find nodes on a road from the intersections of two objects. Then it is easy to find the weight between the nodes on a road. The shortest path is found according to these nodes by using Dijkstra's algorithm.

The fastest path between two points is found by using the same algorithm. But it is a bit different from the shortest path. Moving from one point to another faster depends on some factors such as road quality, type, width, etc. So the algorithm must choose the best road to go faster. In our road table, each road has a quality and type. According to the weight, quality and type of the road, the system finds each road's value in time unit. We can think this value as weight in the algorithm. By using the same algorithm, system finds the fastest path.

CHAPTER 4

CONCLUSION

Time is the most important issue in an emergency situation. In this study, we designed a GIS system to use the time effectively in an emergency situation. The system enables users to find the closest ambulance to forward to a patient. While finding the closest ambulance, the system generates the fastest path between the ambulance and patient. When the ambulance reaches to the patient address, the system finds the closest health care centers according to the patient's position. After choosing one of the health care centers, the system generates the fastest path between the ambulance and the chosen health care center. In each step, beginning from finding the closest ambulance to the patient address to bringing the patient to the hospital, the system saves time by routing the ambulance how to move faster. By this system, we can save lots of time in emergency situations such as bleeding accidents or fire.

There are similar GIS systems in different countries [19, 20, 21, 23], but this system is developed by considering Turkey's conditions. This system has many applications in different areas. We used this system in emergency management in health care. The system helps the system users to reach to the nearest health care center easily in a short time. For the future studies, some improvements can be made in this system.

For example, emergency services enter the patient's address information manually in the current system when a call comes to emergency call center. Patient's address information can be obtained from national address information system or the telephone signals. Another addition can be a messaging system between the ambulance and the nearest medical center. By this way, hospital can make preparations about patient's situation before the patient being brought. Additions to the system can be redounded.

This study can be a model for GIS system developers to create similar applications. For example; a GIS application can be developed for firefighters in light of the methods used in this study. Fire engines can be directed to the fire faster by using fastest path. Also the similar application can be developed for police stations. Police can reach to the scene of crime faster in the same manner.

Today in Turkey, each emergency service has different telephone number. Such as emergency service telephone number is 112; police department telephone number is 155; fire-fighting service telephone number is 110. Nowadays governors are trying to design a system which enables people to reach all services with a single number, as it has been in USA. The system we developed may contribute to the system which the governors are willing to design. For example, with vehicle tracking device embedded into navigation systems, our system can direct the closest corresponding emergency vehicle (ambulance, police, firefighter, etc.) to the scene of emergency.

As a result, today GIS is getting an important role in human life. GIS applications make people life easier by providing visual maps. In the future, GIS and its applications will be indispensable for people.

REFERENCES

1. **Maguire, D. J.** (1991). *An Overview and Definition of GIS, Geographic Information Systems*, First Edition, pp. 9-20, Wiley.
2. **Nişancı, R., Yıldırım, V., and Çolak, H. E.** (2010). *Coğrafi Bilgi Sistem Uygulamaları*, Bilim ve Teknik, Eylül, pp. 59-63.
3. *What is Emergency Management?* (2011). Retrieved April 29, 2011, from http://www.sdcounty.ca.gov/oes/emergency_management/oes_jl_EM.html
4. **Aronoff** (1989). *Geographical Information Systems: A Management Perspective*. WDL Publication, Ottawa Canada.
5. **Carter J. R.** (1989). *On Defining The Geographic Information System*. In: Ripple W J (ed.) *Fundamentals of Geographical Information Systems: a compedium*. ASPRS/ACSM, Fall Chuch Virginia, pp. 3-7.
6. **Parker H. D.** (1988). *The Unique Qualities of a Geographic Information System: a commentary*. *Photogrametric Engineering and Remote Sensing* 54 (11), pp. 1547-49.
7. **Dueker** (1979). *Land Resource Information Systems: a review of fifteen year experience*. *Geo-Processing 1*, pp. 105-128.
8. **Maraş, H.** (2011). Çankaya University CENG 572 Introduction to Geographic Information Systems Lecture Notes.
9. *Components of GIS*. (2010). Retrieved May 1, 2011, from

<http://aboutgisinfo.blogspot.com/2010/07/components-of-gis.html>

10. *Components of GIS*. (1999). Retrieved May 1, 2011, from
<http://www.mapsofindia.com/gis/gis-components.html>
11. *GIS Applications*. (2011). Retrieved May 1, 2011, from
http://en.wikipedia.org/wiki/GIS_applications
12. *Agricultural GIS Aids Fund Management*. (2009). Retrieved May 4, 2011, from
http://www.geoconnexion.com/uploads/agriculturalGIS_intv9i5.pdf
13. *Crop Forecasting Improves with GIS*. (2010). Retrieved May 4, 2011, from
www.geoconnexion.com/uploads/cropforecasting_intv9i5.pdf
14. *Energy Currents*. (2011). Retrieved May 4, 2011, from
<http://www.esri.com/library/newsletters/energycurrents/energywinter2010-2011.pdf>
15. *What is Emergency Management?* (2011). Retrieved May 4, 2011, from
http://www.sdcounty.ca.gov/oes/emergency_management/oes_jl_EM.html
16. *Public Gardens Grow Research Capability with GIS*. (2010). Retrieved May 4, 2011, from <http://www.esri.com/news/arcwatch/0810/uc-davis.html>
17. *NPS GRI Geology-GIS Data Model Documents*. (2009).
<http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm>
18. *Planning and Development Specialist, Akron Metropolitan Housing Authority*. (2010). Retrieved May 4, 2011, from
<http://www.esri.com/library/newsletters/govmatters/govmatsum10.pdf#page=10>
19. *Automating Street Sign Maintenance in St. Johns County*. (2011). Retrieved May 4, 2011, from <http://www.esri.com/news/arcnews/spring11/articles/automating->

[street-sign-maintenance-in-st-johns-county.html](http://www.esri.com/news/arcnews/spring11/articles/better-street-sweeping-management.html)

20. *Better Street Sweeping Management*. (2011). Retrieved May 4, 2011, from <http://www.esri.com/news/arcnews/spring11/articles/better-street-sweeping-management.html>
21. *State of Hawaii Deploys Web-Based Flood Hazard Assessment Tool*. (2010). Retrieved May 4, 2011, from <http://www.esri.com/news/arcnews/summer10/articles/digital-flood-insurance.html>
22. *GIS Application: ESRI Solutions City Planning*. (2011). Retrieved May 4, 2011, from <http://sggage.wordpress.com/2011/01/12/gis-application-esri-solutions-city-planning>
23. *Werner Enterprises Keeps on Truckin' with GIS*. (2008). Retrieved May 4, 2011, from <http://www.esri.com/news/arcwatch/1110/feature.html>
24. *Apsis Araç Takip Sistemleri [in Turkish]* (2011). Retrieved May 4, 2011, from <http://www.apsisats.com>
25. *Pitney Bowes Software Inc.* (2010). MapInfo Professional 10.5 USER GUIDE.
26. *Pitney Bowes Software Inc.* (2009). MapXtreme 2008 V 7.0.0 DEVELOPER GUIDE.
27. *How Does GPS Work?* (1998). Retrieved May 4, 2011, from <http://www.nasm.si.edu/gps/work.html>
28. *Dijkstra's Algorithm Revisited: the OR/MS Connexion*. (2011). Retrieved May 4, 2011, from http://www.ifors.ms.unimelb.edu.au/tutorial/dijkstra_new/index.html
29. **P. E. Black**, "Dijkstra's algorithm", in *Dictionary of Algorithms and Data*

Structures, Paul E. Black, ed., U.S. National Institute of Standards and
Technology. 20 September 2006. Retrieved May 4, 2011, from:

<http://www.nist.gov/dads/HTML/dijkstraalgo.html>

Appendix A

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Ersoy, Mahmut

Nationality: Turkish (TC)

Date and Place of Birth: 17 May 1987, Mersin

Phone: +90 543 474 83 86 / +90 505 817 01 95

email: mahmut_ersoy33@hotmail.com

EDUCATION

Degree	Institution	Year of Graduation
BS	Çankaya Univ. Computer Engineering	2010
High School	Mersin 19 Mayıs Süper Lisesi	2005

WORK EXPERIENCE

Year	Place	Enrollment
2010 – 2011	Başarsoft	Computer Engineer