

**WEB BASED MULTI PARTICIPANT
SPATIAL DATA ENTRY
IN CRIME MAPPING**

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ABSTRACT

WEB BASED MULTI PARTICIPANT SPATIAL DATA ENTRY IN CRIME MAPPING

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Geographic Information Systems (GIS) development in crime analyses encourages sustainable platforms within various types of users and decision makers. Since patterns of crime incidents are pinpointed and analyzed in crime mapping, accurate data acquisition must be considered as a key concept to construct a successful GIS application.

Ankara City Police Department utilizes a semi-automated geocoding interface in which crime incidents including offenders and victims are pinpointed. However, this system has some accuracy errors during geocoding, because in this process point based data are located in the center of street line

segments, and this may cause position errors up to 200 meters. Therefore, additional data editing must be done to reach a reasonable accuracy. In this context, real time data editing provides opportunity to gain time instead of expanding the GIS database within received hardcopy files from each police station. As the crime incidents occur daily, online editing must be used to maintain such an accurate and efficient spatial database.

In this study, for effective and accurate geocoding, a Web based data acquisition method is proposed. This online entry system enables real-time editing for GIS repository. In this way this study aims to provide a fast and reliable data acquisition system by constructing a multi participant platform enabling online data entry from each police station.

Keywords: Crime Mapping, Geographic Information Systems (GIS), Web based GIS, Geocoding

ÖZ

SUÇ HARİTALARINDA WEB TABANLI ÇOK KATILIMLI MEKANSAL VERİ GİRİŞ SİSTEMİ OLUŞTURMAK

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Yüksek Lisans, Jeodezi ve Coğrafi Bilgi Teknolojileri Bölümü

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Suç analizlerinde; Coğrafi Bilgi Sistemleri (CBS) oluşturulması kullanıcılar ve karar mekanizmaları için önemli avantajlar sağlar. Haritalarda suç olaylarının doğru işlenip hatasız saptanması ve bunun sürdürülebilir olması başarılı bir CBS kurulumunda anahtar rol oynar.

Ankara Emniyet Müdürlüğü suç olaylarının ve karışanların haritalara işlenmesi için yarı otomatik adreslendirme arayüzü kullanmaktadır. Fakat kullanılan bu sistemde adreslendirme esnasında bir takım hatalar ortaya çıkmaktadır. Çünkü bu süreç boyunca veriler olay mahaline birtakım konum hatalarıyla işlenmektedir. Bu da sokak uzunluğuna bağlı olarak 200 metreye

kadar pozisyon hatasına neden olmaktadır. Bu sebeple verilerin doğru işlenmesi için ilave düzenlenmeler yapılmalıdır. Bu noktada karakollardan ulaştırılan verilerin merkezde tek tek işlenmesi yerine, gerçek zamanlı veri düzenleme metoduyla hem zaman kazandıran hem de hassas veri elde edilmesini sağlayan bir alternatif sunulmaktadır. Suç olaylarının günlük gerçekleştiği düşünüldüğünde Web tabanlı CBS kullanımı, doğru ve verimli bir mekansal veritabanı oluşturulmasına katkı sağlar.

Bu çalışmada etkili ve konum hassasiyeti olan bir adreslendirme sistemi oluşturmak için Web tabanlı veri depolama metodu önerilmektedir. Bu sayede CBS veritabanına gerçek zamanlı veri girişi mümkün kılınır. Bu çalışma internet sayesinde karakollardan çok katılımlı bir şekilde hızlı ve güvenilir bir veri depolama sistemini gerçekleştirmeyi amaçlamıştır.

Anahtar Kelimeler: Suç Haritaları, Coğrafi Bilgi Sistemleri (CBS), Web Tabanlı CBS, Adreslendirme

To my father,

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TABLE OF CONTENTS

ABSTRACT	iv
ÖZ	vi
ACKNOWLEDGEMENTS	ix
LIST OF FIGURES	xii
LIST OF TABLES	xiv
CHAPTERS	
1. INTRODUCTION	1
1.1 Overview of the Study	1
1.2 Purpose and Declarations	3
1.3 Organization of the Study	5
2. CRIME MAPPING AND WEB BASED GIS	7
2.1. Concepts of Mapping Crime	8
2.2. Types of Crime Mapping and Analysis using GIS	13
2.3. Theoretical and Practical View of Web Based GIS	16
2.3.1. Architectures used in Web based GIS Applications	18
2.3.2. Online Spatial Database Editing Functions	24
2.3.3. Web based Crime Mapping	26
3. SYSTEM DESIGN PROCESS	32
3.1. Introduction	32
3.2. Requirement Analysis	34
3.3. System Development	45
3.3.1. System Components	47
3.3.2. Server Side Model	49
3.3.2.1. Map Server Application Development	50
3.3.2.2. Client Interface	52
3.3.3. Functions of the system	53
3.3.3.1. Map Generation and Display	54
3.3.3.2. Navigation	55

3.3.3.3. Incident Data Input.....	57
3.3.3.4. Offender and Victim Data Input.....	58
4. EVALUATION PROCESS OF MULTI PARTICIPANT ONLINE MAPPING.....	61
4.1. Description of the Study Area	62
4.2. Expanding the GIS Database	65
4.2.1. Performance Testing	66
4.2.2. Accuracy Testing.....	69
5. CONCLUSION AND RECOMMENDATIONS.....	74
REFERENCES	80
APPENDIX A	84
APPENDIX B	95

LIST OF FIGURES

Figure:

2.1: A Pinned Map. Baltimore Country, Baltimore Maryland	9
2.2: The Crime Analysis Process	12
2.3: Typical Web Mapping Application Model	19
2.4: Client Side Web based GIS Model	21
2.5: Server Side Web based GIS Model	22
2.6: Medium Client/Server Side Web based GIS Model	23
2.7: The Map-Survey Interface of the First Project: The 18th Street Commercial Corridor	25
2.8: Animated Crime Map of Redlands, California.....	27
2.9: Online Mapping Feature of crimeBase Application	28
2.10: Kansas, Overland Park Online Crime Mapping	29
3.1: Entity Relationship Diagram of Crime Database	43
3.2: System Overview	46
3.3: MapXtreme 2004 Architecture	48
3.4: Server Side Model	50
3.5: Web System Designed Interface	53
3.6: Initial Map Display with Layer Control and Toolbar	55
3.7: Precincts, Neighborhood and Street Selection Tool	56
3.8: Crime Incident Input Screen	58
3.9: Involved People Input Screen	59
4.1: Study Area Overview	62
4.2: Distribution of Incidents and Involved People Occurred in Some Precincts in the First Half of 2003 Year	65
4.3: Performance Testing Schema	67
4.4: Incident Accuracy Testing 1	70

4.5: Incident Accuracy Testing 2	71
4.6: Incident Accuracy Testing 3	71
4.7: Involved Accuracy Testing 1	72
4.8: Involved Accuracy Testing 2	72

LIST OF TABLES

Table:

2.1: Crime Analysis Types	14
3.1: Police Precincts Attribute Database Table	41
3.2: Crime Incidents Attribute Database Table	41
3.3: Involved People Attribute Database Table	41
4.1: Ankara City Police Department Districts	63

CHAPTER 1

INTRODUCTION

1.1 Overview of the Study

Human cognition in navigation, location analysis and cartographic map production has always been important for centuries. Knowing what is where must be the primary concern of analysts and decision makers dealing with spatial phenomena. In this frame of reference, Geographic Information Systems (GIS) has been created and used on a variety of applications. With the help of computer technology GIS has provided many tools enabling decision makers and end-users to analyze and manipulate spatial data (Campbell, 2001). As the computers and networks become widespread, GIS is now utilized by not only decision makers but also end-users that have basic knowledge of map interpretation. Crime mapping is one of the contemporary easy-to-use GIS applications that enable decision makers to track crime patterns by using these computer networks.

Every community dreams of living in a peaceful and stable environment. However, effort is required to build up such an environment. To start up this exertion, as a governmental level work, taking advantage of spatial information can help law enforcement agencies to fight with crime. In this

context, GIS may help crime analysis in data collection and spatial understanding of location and concentration of the incidents. This allows law enforcement agencies to understand where the crime occurs as well as to determine the specific patterns of crimes. Akpınar (2005) point out that there are several issues related to environmental criminology that identifies higher density of crime areas to be intervened by the local police authorities. It is obvious that the more concentrated problematic areas are the more dangerous places, and where require greater attention. In this context, the accuracy of a spatial database is a key factor to identify crime patterns effectively.

Goodchild (2002) mentions location of a feature does not mean in itself, but necessary in determining the relationship between features. The author underlines the fact that positional errors may mislead the eventual outcomes of GIS. At this viewpoint, decision-makers in police departments may intervene in such districts to manipulate crime. However, the solid way that these agencies should follow is to deem efficient and effective data acquisition methods to pinpoint crime occurrences. Among several choices of data collection methods, the selected system must use appropriate and efficient data input technique to reach essential positional accuracy for analyses. Considering time and accuracy, online mapping is one of the most useful choices. In this framework, each type of crime can be pinpointed by the local police officers via Internet or private intranet environment.

Recently, Web based GIS is used in publishing maps or much advanced level as a collaborative decision making process. Functions that are implemented in Internet mapping are numerous. Data collection and editing is one of the functions that can be conducted through Web browsers. This crucial advantage enables individuals to participate in the GIS platform and produce data instead of single user data production. Therefore, in different locations of

a computer network, data production is possible which could truly be achieved through Web browsers. Today Web based GIS platforms within diverse architecture options provide point, line, and polygon-based editing functions as well as tabular database operations that are conducted via Web browsers. In order to gather up-to-date data for analyses, a Web based system can answer the questions of accurate and real time data input for crime mapping applications.

1.2 Purpose and Declarations

Emphasizing the importance of time and accuracy, it is better to put forward the current situation of the law enforcement agencies that use GIS for crime analysis. Ankara Police Department has been using GIS for thematic mapping retrievals of each type of crime, ad-hoc database queries for victims and offenders for decision making process. However, it is important to consider the accuracy of the spatial database that is used for these types of analyses.

Tandoğan (2005), head of crime analysis department, mentions that they collect data via hardcopy materials including address, and associated information of incidents and offenders (Type, Date, Names, Geocoding information, and Persons Involved etc.). These data are then converted into digital maps with a semi-automated geocoding interface which is operated by the technicians in the general police department information services branch. According to the varying type of incident information, point based crime data are generated in the spatial database. In this system, geocoding of points, pinpointing the crime locations with appropriate accuracy, is directly involved with that semi-automated geocoding process success.

During the geocoding process, crime data are pinpointed in the center of street lines. This might cause position errors depending on the length of these lines, because by the time the length increases position error might be higher. Coincidentally, a crime occurrence can be pinpointed in the exact location. However, this geocoding process is still not reliable for a city road network with random lengths. In addition, although this semi-automated interface allows the user to enter building numbers as attribute information of crime, street centers may not be located in the actual building number. Obviously, to reach building level accuracy, these located crime incidents must be checked and edited in the digital map. This is why the system is called semi-automated geocoding process and it costs time and workforce to produce accurate data for GIS analysis.

Torun (2005), a technician using the system, mentions that each day regardless of how many crime incidents have happened all of them must be entered to the database in day time. This operator is the only responsible person for expanding the spatial database and states that there is no other staff for editing the crime locations for building level accuracy. In addition, geocoding of hardcopy information could be rather daunting for a person who does not know the exact location of crime. Instead, if the police officers are able to pinpoint the exact locations via online, then more accurate and efficient data production could be possible. Because in this way, police officers who report the crime in place, can interpret data from the Web map better than the technicians at the center of police department. Therefore, within this approach operator(s) in the center division might only ensure that whether spatial database is prepared for final GIS analysis.

There are two major aims of this study; the first one is to provide building level geocoding accuracy for spatially correct and up-to-date data collection. Second one is to achieve it by a multi-participant environment. Internet

mapping technology, in other words Web based GIS, can now meet this demand to produce and manipulate spatial data online. Therefore fast and reliable data collection can be achieved by this approach.

The system uses MapInfo MapXtreme as a Web mapping server and windows built in IIS (Internet Information Services) as a Web server. These two servers are in one single computer communicating each other for the browser side person (end-user) requests. As the processing requests are conducted in the server, the system uses a server-side GIS. In addition, to provide multi participant editing, the system uses Microsoft Access database to enter attribute information including geographic coordinates. In the Web interface users have constraints such as combo boxes to enter the consistent information. This allows both fast and reliable data production system.

1.3 Organization of the Study

This thesis is composed of five chapters. In the next chapter, literature review is given on the subject of crime mapping and Web based GIS. Main concepts of crime mapping and applications solutions in law enforcement agencies are mentioned. In addition, architectures and system components used of online and participatory mapping are described.

In the third chapter, system design process is thoroughly explained. Online mapping components and tools used for data entry process are discussed. In addition, interface design, functions and operations implemented via Web browsers are presented. In order to give some idea about the background, some essential parts of the programming development are explained.

In the fourth chapter, study area is explained. In addition distribution of crime incidents and involved people in the Police districts are evaluated. Proposed online geocoding system performance issues such as speed and positional accuracy are compared to the current semi-automated geocoding system.

In the final chapter of this thesis; with a brief summary of the results, conclusions and recommendations about the proposed study are given. Satisfaction of the results and contribution to Ankara City Police department are evaluated. Moreover, future directions and trend of Web based GIS in crime mapping technologies are discussed.

CHAPTER 2

CRIME MAPPING AND WEB BASED GIS

Today, evolving GIS technologies can make the building of various spatially associated applications possible. A wide range of applications ranging from diverse aggregation methods of geographic data to conducting numerous application specific analyses are now a standard GIS capability. Improvements in GIS technology can also meet the requirements of law enforcement agencies for crime mapping and analysis. Since the community requires a larger extent of a nonviolent environment, fighting with crime using GIS becomes a priority issue in both governmental and institutional level. From this point of view, numerous researches have been carried out for aggregation of spatial data, multi purpose publishing and statistical crime mapping and analysis. In this framework, this chapter discusses general view of crime mapping, and online participatory spatial data entry functions for pinpointing crime incidents, offenders and victims. Moreover, in this chapter, a crucial part of data acquisition process, accuracy of spatial databases within online mapping is discussed.

2.1. Concepts of Mapping Crime

Crime is violation of acts that are socially accepted. Crime may cover burglary, murder, sexual assault or any other criminal activity which are not authorized by regulations. Where crime incident happens is a spatial phenomenon but has diverse motives and factors in their occurrences. Osborne and Wernicke (2003) state that among several reasons, mostly, sociological and economic factors affect the execution of crime. More specifically, these causes could be explained by unemployment, educational level, race, ethnicity, and so forth. Why crime occurs and factors involved for criminal activity are beyond the scope of this study. However, fast and reliable aggregation of crime data is meeting point of this study.

Boba (2005) defines crime mapping as a procedure using GIS to conduct spatial analysis of crime problems and police-related issues. The author clarifies crime mapping as a subdiscipline of crime analysis which has three main functions. The first one is to facilitate visual and statistical analysis to unravel the spatial nature of crime. The second one is to provide a link to unlike data sources on common geographic variables (e.g. demographic information etc.). And the last one is to produce maps that help to communicate for analysis results.

Maps are the abstraction of true reality of surface. Geographic components and patterns may diverge on demanding mapping applications. When not cartographically represented, crime data only contain information about incident type, address, offender, and victim status. Generally, this information in hardcopy materials could be inadequate and misleading without location information. However, such data in maps can give the decision makers a definite advantage, that is- a spatial insight. Harries (1999) states that crime

maps were first used as pinned maps in New York City Police Department in the early 1900's (Figure 2.1). It is obvious that the decision makers in law enforcement agencies require location of the repeated crime incidents, and as a result crime maps are generated. Tandoğan (2005) mentions that they had encountered the same situation before the computer mapping technology was available for Ankara Police Department. At a glance, these pinned maps may appear functional to track crime occurrences; however, time and the quantity of pinpointed incidents become larger and can not be consequential when dispersed everywhere in the map.



Figure 2.1. A Pinned Map. Baltimore Country, Baltimore Maryland (Harries, 1999)

Effective map interpretation has always been a major aim of cartography. This state-of-the-art map making relies on several factors for mapping the crime data. It may not be useful when information overload maps serving decision makers as abstraction of reality. Geographic components, interacting with the user, must enforce the map interpreter to look for exact locations of incidents. Eck et al (2005) state that crime is not dispersed homogenously in the maps, but on the contrary, it piles in some areas and is not present in others. In addition, spotting different type of incidents ultimately leads to confusion for the map interpreter. For example, pinpointing burglary and murder incident must be differentiated for the user navigating in the map. In this context, decision makers must not be tackled by too much information; instead maps must facilitate them when analyzing criminal information. In this frame of reference, positional accuracy of point based data emerges as well, because the relationship between point features depends on how close they are. For this reason, realistic attention is needed when locating point based crime incidents in maps.

Eck et al (2005) also point out that visualization of crime patterns varies long with the underlying theories. It is quite acceptable that each type of crime incident requires a different theory. For example place, street and area theories of crime can be depicted by typical point, line or polygon features of GIS. This issue puts forward cartographic mapping principles to pinpoint numerous crime incidents types, because map interpreters must distinguish these patterns when navigating in a map. Therefore, a crime map with a well defined theory can help decision makers in the law enforcement agencies effectively. Creating cartographically appealing maps also needs accurately stored data.

In predictive and statistical level of crime mapping applications, accuracy and data preparation issues come forward as well. Corcoran and Ware (2002)

state that in order to meet the initial requirements of their neural network implementation called COPDAT, preprocessing of raw data must be accurate. Their artificial intelligence study looks for hidden places to generate future prediction of crime patterns. It is obvious that by using more accurate data the system can retrieve more consequential results. Therefore, it can be declared that not only governmental but also research levels of applications require accurate data in crime mapping.

Since crime incidents occur depending on time and space, and are dynamic, they should be mapped accordingly. Geographic profiling of crime incidents requires work and cost load for governmental and institutional levels. Helms (2002) mentions that not counting the prerequisite correctly formatted reference map, incident locations still entail spatially correct address matching. Moreover, producing crime maps in weekly, monthly or for a specific period of time requires a maintainable procedure. As can be observed, crime has a dynamic structure and requires mapping in specific time intervals. In this way, spatial movement of crime patterns can be correctly identified. While evaluating crime displacements in temporal intervals, decision makers can develop a knowledge base for certain jurisdictions.

In order to answer the mentioned statements, Boba (2005) proposes five steps in a typical crime analysis process (Figure 2.2). These are data collection, data collation, analysis, dissemination of results, and incorporation of feedbacks from users. The author emphasizes that data might come from many sources such as police officers, call-for-service dispatchers, community service officers, census workers and geographers. For example, Ankara Police Department, in most cases, collect their data from police officers. Tandoğan (2005) mentions that their basic data collection is to retrieve longhand materials which are written by clerks in each police station.

Inputting incidents reports directly to the computer is done by technician(s) in the main center. In this framework Boba (2005) argues that the officers dictating data entry procedures, as well as the care by taken individuals who implement the procedures, are crucial to crime analysis because they affect both the quantity and the quality of the data and subsequent analysis. In addition to providing consistency, data must be in electronic format and collected regularly, because paper copies are time consuming to crime analysts and are not useful for immediate results.

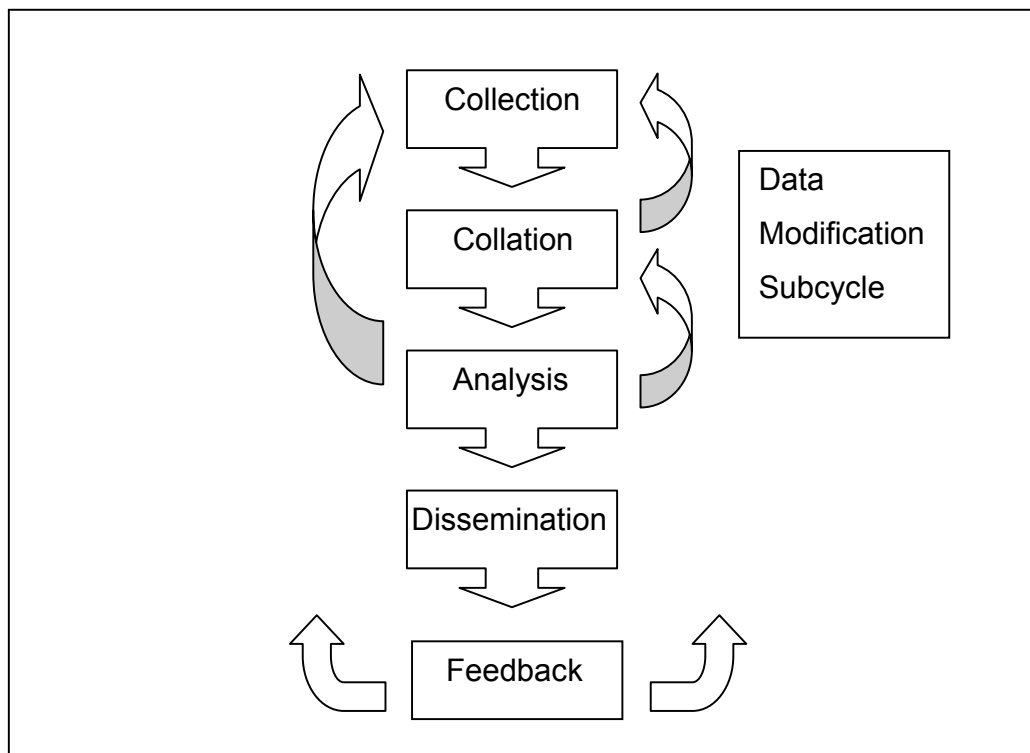


Figure 2.2. The Crime Analysis Process (Boba, 2005)

In the data collation process correction of inconsistent data is accomplished. In addition, geocoding of recent incidents are combined with the actual database. There are various statistical and visualization techniques performed in the analysis phase of the process. After retrieving results from analysis collation step might suggest new improvements for data collection step. These first three steps iteratively work with each other to retrieve results and may create new policies for crime mapping and analysis.

The fourth step dissemination is to communicate the results with various types of audiences. These reports could be paper reports maps, presentations, internet documents. Finally, in the feedback step the crime analysis process retrieves response from the audience of the usefulness of their analysis for decision making.

2.2. Types of Crime Mapping and Analysis using GIS

Geographic profiling of crime can now be accomplished with more robust digital maps together with advanced database functions. Within GIS not only can crime incidents, offender and victim status be digitally displayed, but also their attribute information can be aggregated for retrieval operations. Police departments use these features to determine the patterns of crime, analyze historical events, produce crime atlases, and also predict future events.

Crime mapping and analyses are distinguished as to where they are specifically used and to whom they serve for decision making. There can be several reasons behind this, because each law enforcement agency would have different approaches to command, control and prevent crime. According to Ahmadi (2003), who is inspired from Hirschfield and Bowers (2001), there are six types of crime analysis techniques. These are tactical, strategic,

investigative, operations, intelligence, and academic crime analysis. Each type has its own objectives and characteristics for crime mapping and analysis.

Table 2.1 displays the categories of crime analysis types that agencies and institutions use while fighting with crime. The first four type tactical, strategic, investigative, and operation analyses are mostly used in local law enforcement agencies such as city police departments. The fifth type is generally used in governmental and intelligence agencies' work area. Whereas, academic analysis category is expected to forecast crime movements by using exploratory data analysis and statistical methods.

Table 2.1: Crime Analysis Types (adapted from Ahmadi, 2003)

TYPE	PRACTICE
Tactical Analysis	Series, daily, weekly, monthly reports, hot spots for deployment and administrative reactions.
Strategic Analysis	Identification of long term pattern activity, causing socio-economic and demographic factors.
Investigative Analysis	Forensic analysis of serial and repetitive crime incidents
Operations Analysis	Monitoring patrolling activity and progress
Intelligence Analysis	Determining the relationship between crime organizations in a much broader level.
Academic Analysis	Generating statistical analysis and reports along with social and demographic factors

Putting more focus to accurate data acquisition techniques, this thesis study concentrates on improvements of tactical crime mapping and analysis. Oatley and Ewart (2003) outline crime analysis software capabilities by stating general demand on incident based crime maps. They point out the importance of quantitative methods while investigating crime movements by giving an example of vehicle theft displacements over time. In addition, the authors emphasize the importance of statistical summaries of time while defining the movements of crime. This example shows the basic structure of tactical crime analysis software that law enforcement agencies use.

Instead of scrutinizing the deeper meanings of each practice, it is better to determine the relationship between these analyses and GIS. Performing GIS operations apparently must have spatial data, and therefore, the question must be formulated as follows: How can crime incident data be obtained and how is it used for analysis? GIS can collect and manipulate spatial data as well as analyze them. From this definition, Osborne and Wernicke (2003) state that GIS can serve crime analysis in order to collect, edit and examine the crime information.

As GIS stores attribute data in point, line or polygon based forms, crime incident information can be pinpointed with these types of representations. Hirschfield and Bowers (2001) state that when it is polygon based it contains demographic information, such as census based data and neighborhood information in order to compare with land use, socio-demographic concerns and environmental criminology. Whereas, line data type could be used to gain information of distance between a specific crime incident and offenders and victims. Point based data is most effective when it is geocoded as incident data. In this way, they can be used for pattern analysis, hot spot and thematic mapping. In addition, points can be used for statistical and exploratory data analysis along with additional tools combined with GIS.

There are various ways in which GIS is used for data acquisition, manipulation and retrieval operations. Within the functionality of GIS, robust application specific platforms and interfaces can be constructed. In this way GIS can serve as a spatial decision making tool. In addition, for effective geocoding of incident data, web based data entry methods can be used for crime mapping. Because mainly point based data are used in tactical crime analysis in which dispersed incidents are displayed. In this context, both accurate and contemporary data aggregation can be accomplished by online mapping.

2.3. Theoretical and Practical View of Web Based GIS

Web-based GIS, in other words internet mapping, is the emerging technology of commercial and open (non-proprietary) GIS use. Recently, web-based GIS is applied in such issues as environmental monitoring, resource management, land information management, utility management, mobile applications and various Decision Support Systems (DSS) practices. As a generic approach, a web-based GIS serves spatial data to clients within a web browser. Green and Bossomaier (2002) point out that this data can be either static (i.e. texts, map images retrieval system) or dynamic that allows complex geographic analyses for decision making process. The system serves end-user requests interactively, which are implemented by click on operations.

Yet, web-based GIS are not capable of conducting every desktop GIS analysis; there are some basic operations that recent web technologies can achieve. These are map-rendering functions (e.g. zooming, panning, rotating, etc.), ad-hoc database queries (e.g. getting relevant tabular information related to geographic features on the map, searching the database to display a specific location, etc.), topological queries exploring which features reside

where, obtaining routing information by pinpointing locations, and receiving online information for vehicles with satellite transmissions to know where they are, called Automatic Vehicle Locator (AVL) technology. In addition to reaching desktop GIS capabilities, a web-based GIS would allow manipulation of data for public participation in collaborative community planning, or environmental decision-making processes (Al-Kodmany, 2001).

Implementations of Web based GIS in crime mapping have some crucial matters. Ratcliffe (2002) mentions ethics and mapping accuracies while displaying crime information of victims and offenders. He states that no one would want to know the distinctive information of a sexual offender living next door. This point of view clearly suggests that whether crime maps should be made available to public or not. He also points out accurate mapping of crime incidents, and declares that dispersion of many incidents in a web map might reflect wrong information in comparison to actual crime occurrence places.

Although Ratcliffe (2002) points out some fallacies in mapping and distributing crime information through web, accurate geocoding of incidents can be achieved by web-based GIS. Because, today's online mapping technology enables manipulating spatial data through browsers. So as to argue this issue in geocoding, crime incidents can be pinpointed along with users that know the exact location of crime, and accurate results can be gathered.

Just like all information systems projects and researches, a Web based GIS application requires a thorough requirement analysis, systems audience, and determining the capabilities of a system. Thereby, next section tries to give introductory information of web-based GIS architectures, techniques, and trends.

2.3.1. Architectures used in Web based GIS Applications

Internet mapping development strategies differ according to application issues, data structures, and analysis functions. Determining the system architecture of a web-based GIS must be a preliminary step for the required successful application. Since the user defined functions and the available datasets are determined, a web-based GIS demands an appropriate development platform. Peng (1998) states that there are two main approaches applied in internet mapping, which are client side and server side systems. Each type possesses different advantages and deficiencies. However, within advances of technology a hybrid system called mixed server-client side online mapping has emerged as well. Rinner (2003) states that along with additional plug-ins in the browsers mixed server-client systems can be proposed. Figure 2.3 illustrates a typical Web mapping application model.

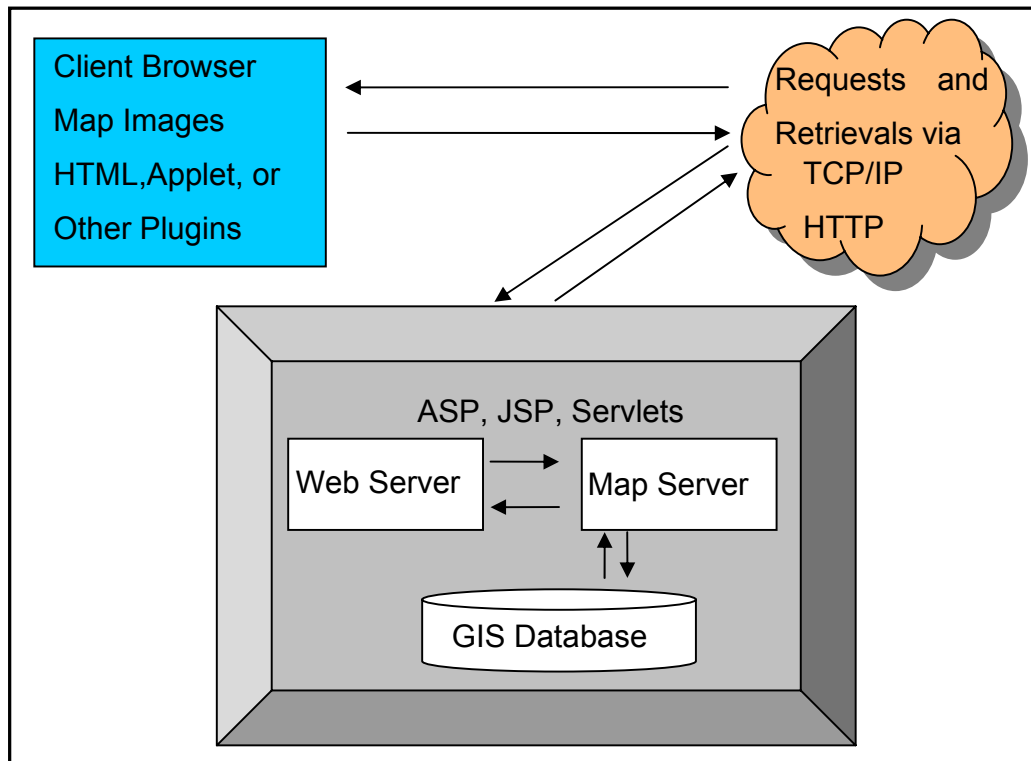


Figure 2.3: Typical Web Mapping Application Model
(Adapted from Alesheish et. al, 2002)

In this model processing of geographic queries and serving maps are conducted within three-tier architecture. These tiers are client, web server and map server. The client is used to retrieve maps as image or vector file formats through HTTP, TCP/IP requests and web server transmits client's requests to be processed in the map server tier. Web server mainly operates as a mediator that sends and receives client's requests to be processed by the map server. At a glance, it may be perceived as mixed-client server architecture; however, it covers all the architecture types inside. For instance, a client can either have HTML browser or applet/plugin installed one. To differentiate between these three types of systems architectures, each model is discussed below in detail.

Takatsuka and Gahegan (2001) state that in client-side Web-based GIS, spatial data and analysis tools are downloaded to the Web browser with plug-ins (e.g. Applet or an ActiveX component). The plug-in, used in the browser, enables GIS analysis in one single frame. Therefore, the application inherits every static or dynamic function of GIS with these components. As the vector data comes along through server, this data structure could be used in analysis like a regular GIS functionality. This advantage allows various geographic queries to be implemented in the component itself. Furthermore, vector data structure allows better visualization of features, which is extremely important to interpret digital maps with human perspective (Campbell, 2001). In order to apply these preferences in crime mapping, a more detailed map can be downloaded to the browser. Thereby the issue must be how effective a crime map can serve to the clients. As the incidents are pinned to the map as point based data in tactical crime approach, there is no need to have a complex data structure to conduct crime mapping and analysis. Although this capability is uniform and serves like a regular GIS application, it needs a strong bandwidth environment as well.

In addition to this vector data download capability; Green and Bossomaier (2002) also mention that there is no need to adhere to internet standards one of which is the data-exchange protocol. However, it requires the client to have a powerful computer to conduct spatial analyses. In addition to this disadvantage, since all the spatial data and the functions are downloaded, it would be a daunting task to acquire large amount of data in the low bandwidth environments (Figure 2.4). Furthermore, this independent development strategy requires a thorough software development process. Therefore, the system usability and convenience of operability are limited to the developer's knowledge and experience.

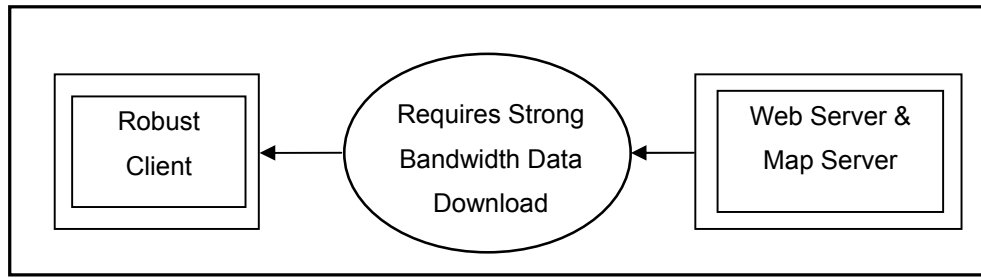


Figure 2.4: Client Side Web based GIS Model

On the other hand, in server-side internet GIS, a web server is used to execute all GIS analysis and map retrieval operations. Vatsavai et al. (2000) mention that tasks can be performed on either a Web server or a GIS server. The user executes commands with Hyper Text Markup Language (HTML) requests while the filtered data is delivered within appropriate communication protocols. As all the GIS analyses are conducted in the server, the system demands a strong server to cover several end-users submits at the same time. In addition to this disadvantage, the filtered data must be delivered as GIF, or JPEG images, common Web graphic formats, which has rather poor visual quality in comparison to vector file format in the client side model.

This inadequate visualization capability in the server-side model disallows users to interpret maps effectively. To overcome this problem Zaslavsky (2000) developed an XML-based 2D vector rendering application to address the problem of low graphic quality. Moreover, as long as the analyses are conducted in the server, each request must hold Internet standards (Figure 2.5), which is an important problem for data interoperability among different data formats (ESRI, 2002). However, there is no need to have a powerful client machine, because the client is only for displaying retrieved maps and have click on functions. In addition to this advantage, this rather simple client does not need extensive development strategy at the Web browser, which

allows the system to be developed and maintained easily. This server side web-based GIS can be applied to crime mapping for data mining with multi participant user environment, because point based crime data does not need extensive development strategy.

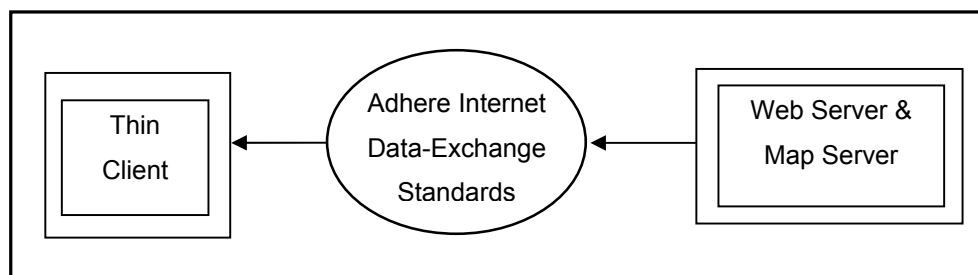


Figure 2.5: Server Side Web based GIS Model

Although researchers classified online mapping architectures mainly into two models, developing technologies have changed the view of these models by coming up a new approach called medium client/server side Web based GIS. Alesheish et al. (2002) describe this model to reduce both prior server and client side models' shortcomings. In this model, the system uses both server and client side functions. For instance, the client either has an Applet or ActiveX component in the browser or use HTML browser that displays and navigates in the map. In this way, the user can perform static Web mapping or much interactive level dynamic map display in the browsers. Figure 2.6 displays a general overview of the medium server/client side model.

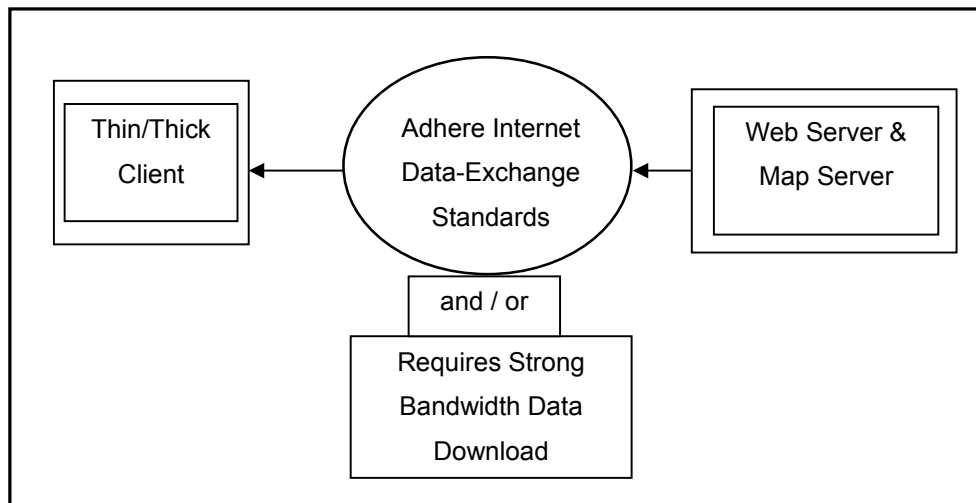


Figure 2.6: Medium Client/Server Side Web based GIS Model

In fact recent commercial Web based GIS vendors are now using this medium client/server side processing in their applications. For instance, MapXtreme Windows and Java allow the developers to build applications either HTML or applet form in the browser. Whereas, ESRI's ArcIMS application gives the programmer the chance to choose for specific types of developments as well. Among diverse application development environments, one issue must be concerned as a top priority. That is determination of the problem and systems audience and the final goal of the application. Although authors like Ratcliffe (2002), argues that whether or not crime information must be displayed and distributed to public, this study indicates how effective crime can be pinpointed by the police in their private intranet platform.

Summarizing the issues and models for a Web based GIS application, it can be argued that there are various Internet map servers operating for displaying, manipulating and retrieving information. Since the development platforms diverge, both open and proprietary platforms can be used to

establish an online GIS. However; the application developer must choose systems audience, required analysis, development cost and maintenance in order to develop a maintainable Web based GIS.

In order to scrutinize typical Web based GIS capabilities in participatory mapping, the spatial data editing functions that Web GIS should have must be discussed. The next section discusses potentials of interactive online mapping when serve as a crime mapping.

2.3.2. Online Spatial Database Editing Functions

Since one of the aims this study is to develop an online multi participant application, it is better to put forward the capabilities of online mapping. It was explained previously that if a web browser has a more complicated interface embedded with additional plug-ins, it is a client side or client/server (medium) side Web mapping. In these types, either vector or raster (actually vector data in the GIS database but displayed as raster in the browsers) data can be represented through browsers.

Point, line and polygon based editing can be functioned within online mapping. Tabular GIS database along with the digital maps can be manipulated as well. Researches indicated public participation could be implemented for numerous cases in Web based GIS. Kingston et al. (2000) compare traditional online mapping with participatory version. They state that if public joins in the planning process, it is much more applicable and effective for community planning. Instead of using server side environment, their approach is implemented using Java Applets and a set of Java bean tools called GeoTools for GIS based functions and internet mapping. While navigating in the map, text input can be done for the selected area. This

approach could be used in crime mapping as well, and when a user pins the digital map, a text input screen might come out in order to lead the user to enter crime incident information.

Because online mapping requires participation, and thus users employ editing functions, it would be better to give another subsequent example of public participation using the Web. Al-Kodmany (2001) proposes a participatory planning application in order to improve public attendance. In his research, the system expects community to participate as sharing ideas, comments and complaints. Figure 2.7 illustrates an example of public participation in which people use a web browser and enters text information for geographic components in the map. In this approach gathered data are used for analysis in the planning process. Just like this prototype, it could be implemented in other applications like entering point based information of crime incidents and their tabular attribute information.



Figure 2.7: The Map-Survey Interface of the First Project: The 18th Street Commercial Corridor, (Al-Kodmany, 2001)

As can be observed in Figure 2.7, users are expected to click on the specific geographic areas and to enter comments about the place. The system uses Oracle as a database and implements a client side online mapping using Java Applets. At the end of the study, Al-Kodmany (2001) states the survey results and information about the industrial area. As a result of that study, some improvements are achieved for community planning in controlling and regulations establishment. In contrast to that study, recent server side interactive online mapping applications allow the developers to build such an application as well. It is applicable for inputting text information for selected raster images with recent server side GIS development platforms.

To sum up the spatial database editing functions within the internet, it can be declared that maps in the browsers can be used for editing by point, line, polygon based data structures in GIS. In addition, by entering text data, attribute database can be expanded click on operations. Therefore, fundamental GIS database operations can be implemented in multi participant environment.

2.3.3. Web based Crime Mapping

Boba (2005) defines interactive crime mapping as a simplification of basic GIS capabilities that can be accessible for novice users over the Internet. This enables the users to facilitate a Web based GIS without having a spatial knowledgebase. The author mentions that many police departments have interactive Web sites where citizens or police officers can conduct basic crime mapping for themselves. These applications basically are not flexible or complicated enough for crime analysis, but rather useful for disseminating crime information via Web.

A typical example of interactive crime mapping is COMPASS (Community Mapping, Planning and Analysis for Safety Strategies) by Redlands, California, Police Department (Web 1). In this application standard GIS functionality, exploring crime patterns is achieved through Web browser. When the animations are created individual density maps are developed. Figure 2.8 displays a snapshot of animated traffic collisions for a specific time frame. The system also has an option for assault, burglary, auto theft, and all incidents animated maps so that the users can interact with various types of crime. It can be observed that this application is useful for increasing public awareness of several crime incidents.

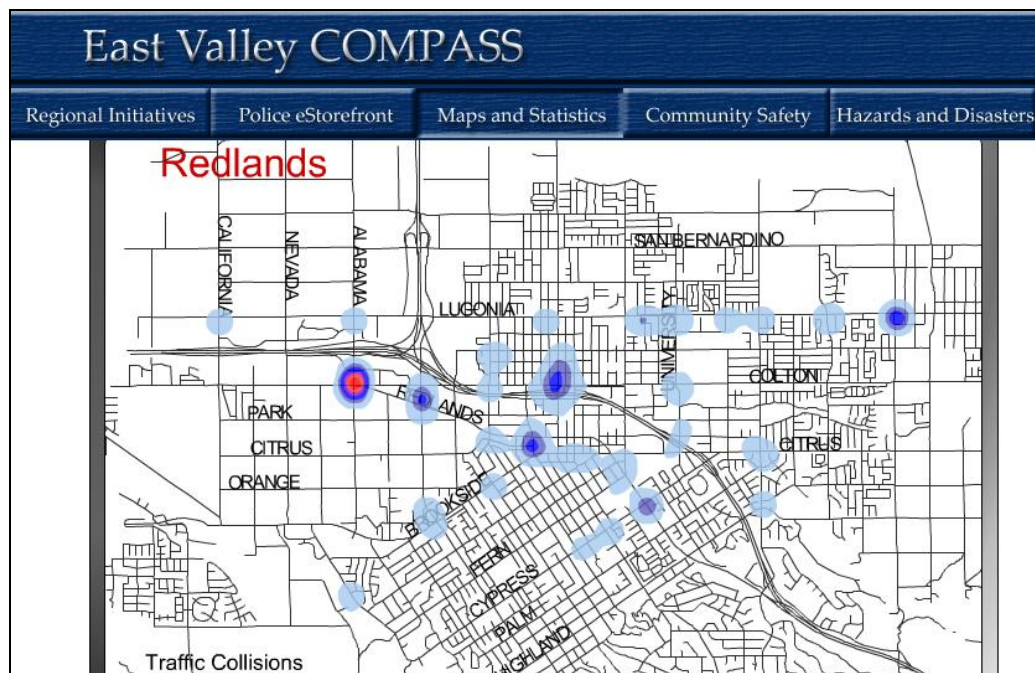


Figure 2.8: Animated Crime Map of Redlands, California (Web 1)

Another example of interactive crime mapping application is applied by Philadelphia Police Department (Web 2). Their system crimeBase is based on distributing meaningful information to the local community engaged in planning, public safety and polices. This online mapping application allows users to create maps, tables, charts, summary statistics, trends and crime movements. The application has remarkable features one of which is to provide creating user defined maps with color types, legends and statistical output. Figure 2.9 illustrates an example of a user defined quantile map of burglaries with 2000 census data. Such an application could be useful to local community for planning and strategy development. Although, this application provides geographic data analysis, it does not have data input capability.

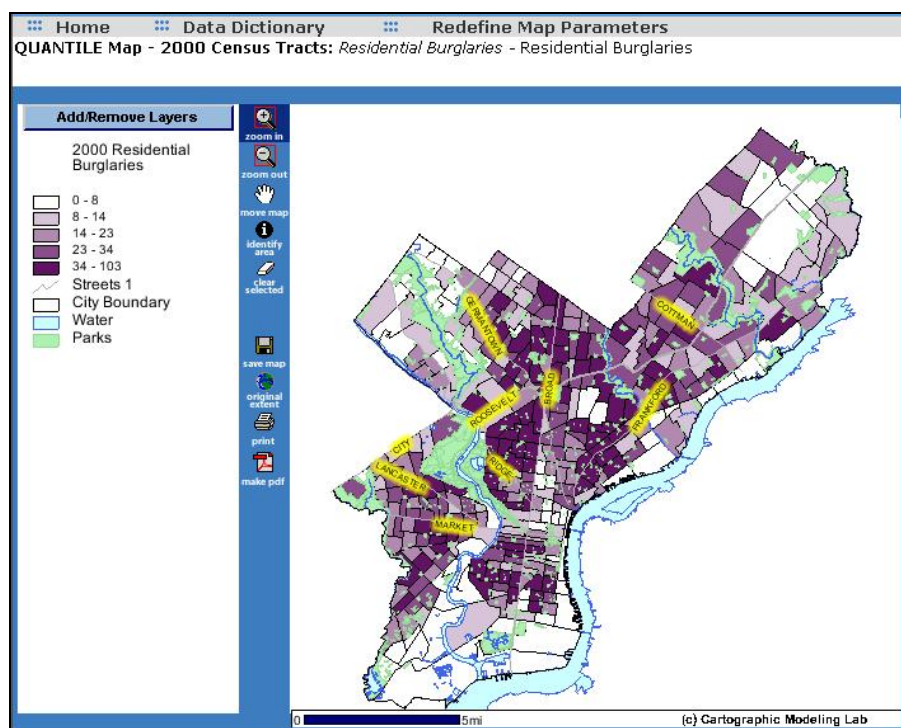


Figure 2.9: Online Mapping Feature of crimeBase Application (Web 2)

Examples can be expanded by pointing local authorities' works on Web based crime mapping. Kansas City, Overland Park neighborhood is one of such local communities that perform online mapping (Web4). Their approach is firstly giving some background information for interpreting crime maps over the Internet. Afterwards, their online system displays crime statistics and distribution of certain crimes which can be accessible to interested residents.

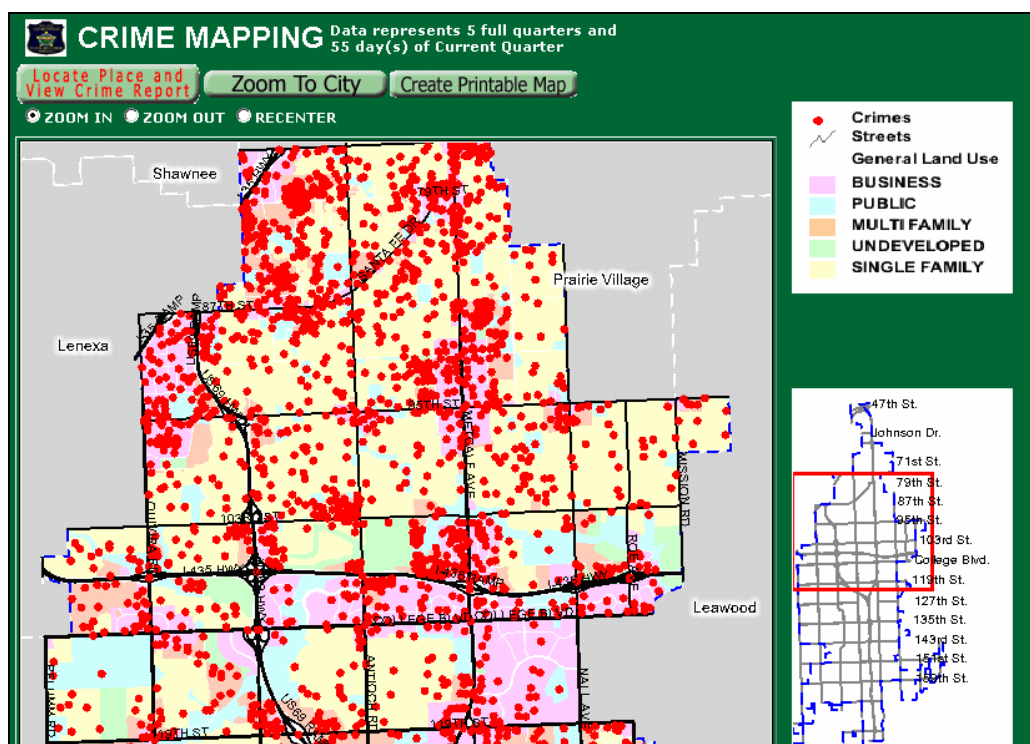


Figure 2.10: Kansas, Overland Park Online Crime Mapping (Web 3)

Ratcliffe (2002), in his article, tries to clarify the common problem of online mapping with a metaphor by saying “damned if you don’t and damned if you do” in the title of his paper. This argument has a crucial importance because it questions whether or not public has the right to be aware of what is going

on in the neighborhood. This study, however aims to construct a system that provides interactive mapping benefits to only law enforcement agencies themselves.

Unlike common public participatory methods, if crime incidents information is published, it could affect location choices of living. This revealing information might be useful when it is applied in community planning or site selection together with society. However, it would be unwise when individuals of society recognize a murder incident two blocks away from home. In the same way Ashby (2005) indicates several arguments affect crime when concerning population, demographics, urban-rural distribution, lifestyle of people, socioeconomic status. In research and security based applications, this information could reflect several useful feedbacks to prevent crime. However, it may not be meaningful when this information is distributed to public.

In order to construct a participatory crime mapping application for police departments, the applicability of spatial data editing functions must be taken into consideration. Instead of publishing crime maps to public, it would be better to distribute information throughout the agency itself. This can be accomplished by constructing a multi participant online mapping in a private intranet/internet platform. In this way, local police officers in Police stations can pinpoint crime occurrences and expand the database. (Web 4) gives a considerable example for online data entry of crime information. In this commercialized application, interactive system allows inputting customized Microsoft Excel and Access spreadsheets. However, this system is not involved with geographic profiling but a regular database entry application because there are no geographic components of this application for entering location information.

Ratcliffe (2004) points out the accuracy of spatial databases by putting forward the geocoding success of crime incidents. As the author defines geocoding is converting location information into grid coordinates, he argues the optimum hit rate of crime position accuracies. From this perspective of view, it can be declared that geocoding is excessively important for crime analysis. Instead of entering crime point information along with hardcopy materials into map by operators, pinpointing incident data with appropriate zoom level could increase the accuracy via online mapping.

To sum up, online crime mapping can meet the requirements of producing crime data in any time frame with appropriate accuracy. Users are able to enter both tabular and graphic information via web-based GIS. As this study aims to convey some improvements for accurate and real time data production, general demands for a successful tactical crime analysis application can be accomplished as well. Within building level accuracy and real time data editing of incidents, decision makers can conduct immediate and accurate crime analyses. Therefore, it could be declared that mapping crime with Web based approach could be time saving and cost effective in comparison to traditional methods.

CHAPTER 3

SYSTEM DESIGN PROCESS

In this chapter system designed process is evaluated. This study has two major phases to bear out online multi participant GIS and accurate geocoding of crime incidents, offenders and victims. These phases are (1) designing of an interactive Web based mapping system; and (2) evaluation of crime incidents, offenders and victims data entry. The Web application provides point based data entry along with tabular information. In this way, a single record of crime data with location and attribute information is added to the spatial database through a Web session. In this frame of reference, sections in this chapter revolve around discussing major development steps and database design and optimization of online mapping.

3.1. Introduction

Web application evaluates geocoding of crime incidents within interactive map navigation and data entry. Users are expected to attach point based graphic and tabular attribute information through Web browsers. These users are required to be police officers working as clerks in the local stations. Additionally, police officers working in the local police stations are more aware of incident locations than the operators in the Ankara City Police Department

information systems division. GIS technicians in this center division certainly can not be expected to be familiar with each street including precincts and neighborhoods. However, police officers in the local stations might be more responsive to these places, for the reason of being familiar with routine working area. Therefore, they are likely to enter crime information via Web much accurately.

Identical to most Internet mapping applications, the system also provides map navigation and display functions including zoom leveling, pan, selecting/deselecting the geographic components, information tool, measuring the distance between features and layer control options. Moreover, as a remarkable distinction of this study, the system includes point based incidents and involved people (victims and offenders) data entry.

As mentioned above the interactive online system provides dynamic map navigation and display. Users are either anticipated to select occurred incident streets by a drop down menu or by simple navigation tools zooming preferred street level. There are three sets of choices in this menu to zoom selected street level, which are police precincts, neighborhoods, and streets. After choosing the precinct, all related neighborhoods is appeared in the below list box menu. Respectively, streets belonging to the neighborhood are displayed as a final step to zoom into the crime incident place.

Major advantage of this selection method is providing dynamic segmentation of streets. As this road network may be very long in length in some places, the system zooms to covering neighborhood's streets. In this way, users can locate the crime incidents in a very short time. In addition, after selecting the required street, surrounding buildings appear with labeled numbers in the map. Therefore, users can easily reach the building level accuracy at the end of this map navigation process.

The system also provides incidents and involved people (offenders and victims) tabular database entry. After pinpointing the exact location of crime, an input screen appears in the Web page. This input panel contains text and combo boxes to enter the fields of the tabular data. The panel is also designed to be flexible and considered to enter accurate and non-redundant information entered into the spatial database.

Since the system provides some improvements for tactical crime mapping, and the reason that time and accuracy is important, real time data editing is one of the major achievements of this study. In addition, proposed online data entry process provides sustainable GIS platform. In this way, spatial database can stay up to date as long as the system is used.

3.2. Requirement Analysis

Law enforcement agencies develop similar tactics in crime mapping and analysis. As mentioned in the previous chapter, there are several crime analysis types that benefit from GIS. Since Ankara Police Department utilizes GIS for tactical crime mapping and analysis, accurate and consistent spatial database production is a vital claim in their applications. In this context, this law enforcement agency produces data for hot spot mapping and analysis to monitor temporal activity. Therefore, the spatial database must be carefully evaluated and designed. In this study, current spatial database of Ankara City Police Department is optimized for effective tactical crime mapping and analysis. Some of the redundant fields are removed from their previously designed system, because they are no longer needed for standard GIS retrieval operations. Further, optimized relational database tables are discussed for Ankara City Police Department.

Ankara City Police Department utilizes GIS database in 5 distinct layers. These are:

- Point based crime incidents
- Point based involved people
- Line based road network
- Polygon based precincts
- Polygon based buildings

The GIS dataset includes these layers in MapInfo Professional format. Each layer has distinct attribute information in which contains fields about crime incidents within appropriate data types. In police precincts (Mintika) layer, police station names are recorded as precinct names in the spatial database (Table 3.1). This layer is utilized as a base map for navigating and pinpointing crime incidents and involved people point based data. Whereas, in the crime incidents and involved people layers are used to fetch new attribution information of incident types, when it occurred, database unique identifiers and so forth. Detailed information about containing fields of each table is given in Table 3.1, Table 3.2 and Table 3.3.

Table 3.2 includes the following optimized fields:

- 1) OLAYNO** (Incident Number): This column records contain unique numbers that are automatically assigned by the developed system. Provided by this process, consistency of the spatial database is achieved.
- 2) BUROKOD** (Crime Branch): This field contains data about related crime branch's incidents. These are auto, missing, robbery, murder, morality, and usurp branches.
- 3) ILCE** (District): This field contains district information about where the incident in question takes place.

4) KARAKOL (Police Station): This column includes one of the 47 district names in which the crime incidents take place.

5) OLAY (Crime Incident): This field encloses crime incident information that is related to crime branch field. Each crime branch has its own crime type data entry. These are:

- Auto: Theft from car and car theft
- Missing: Missing person
- Robbery: robbery from spike, breach of trust, robbery from home, stealing animal, robbery, safe breaking, robbery from coalbunker, robbery from temple, robbery from official office and robbery from office.
- Murder: Self-inflicted wound, abduction, wound, carnal abuse, murder and suicide.
- Morality: Prostitution, solicitation of chastity and gambling.
- Usurp: strike, usurp, claim of usurp, resist officer in charge, insult and threat, harming, sabotage, kidnapping, constructive breaking into a house, auto shooting, indecent assault, threat, claim of distorting money, raise a stink and office shoot.

6) OLAYTAR (Incident Date): This field contains information about date of the incident.

7) OLAYGUN (Incident Day): This field contains information about which day the crime occurred.

8) OLAYSAAT (Incident Time): This field encloses information about when the crime occurred in a day time.

9) OLAYMAHAL (Crime Place): This column includes information about where the crime takes place such as construction yard, on the street, in home, main road, public place, official institution, mall, parking space, bar, (ATM) cash machine and club.

10) OLAYNEDEN (Crime Reason): This field includes information about the reason of crime. These are; argue bad language, alcohol, matrimonial affairs, pecuniary problems and enmity.

11) SUCYONTEM (Crime Method): This column contains information that is related to crime incident types. In this frame of reference, crime methods are defined as:

- Theft from car: By matching up a key to lock, from baggage, taking out window, stealing auto tire and tire rim, breaking window, using pallet, using screwdriver and other types.
- Car theft: By matching up a key to lock, entering open door, short circuit, breaking window and other types.
- Missing person: Male, female and teenagers.
- Robbery from spike: By matching up a key to lock and jimmying the door.
- Breach of trust: Other types.
- Robbery from home: By matching up a key to lock, breaking padlock, entering open window, entering balcony, breaking window, ripping out the window, jimmying, kicking and other types.
- Stealing animal: Other types.
- Robbery: Matching up a key to lock, jimmying the door, from construction yard and other types.
- Safe breaking: By jimmying and matching up a key to lock.
- Robbery from coalbunker: By jimmying and matching up a key to lock.
- Robbery from temple: By jimmying and matching up a key to lock.
- Robbery from official office: By jimmying and matching up a key to lock, breaking padlock, entering open window, and by taking out window bar.
- Robbery from office: By jimmying and matching up a key to lock, breaking padlock, and entering open window.
- Self-inflicted wound: By using cutters.
- Abduction: Other types.
- Wound: Other types.
- Carnal abuse: By striking and other types.
- Murder: By using a firearm, cutter and other types.
- Suicide: By grafting, other types.

- Prostitution: By arranging and other types.
- Solicitation of chastity: By arranging and other types.
- Gambling: Other types.
- Strike: By striking and other types.
- Usurp: By threatening with a knife, by threatening with a gun, by striking and other types.
- Claim of usurp: By using a fake gun, using spray, threatening with a gun and other types.
- Resist officer in charge: Threatening with a gun, threatening with a knife, striking and other types.
- Insult: Other types.
- Threat: By threatening with a gun, threatening with a knife, striking and other types.
- Harming: By striking and other types.
- Sabotage: Other types.
- Kidnapping: Other types.
- Constructive breaking into a house: Other types.
- Auto shooting: By a pistol, and other types.
- Claim of distorting money: By threatening with a gun, threatening with a knife, striking and other types.
- Raise a stink: Other types.
- Office shooting: By a pistol, and other types.

12) OLAYDUR (Crime Incident Situation): This field contains information of crime incident situation where is the suspect is known or not.

13) ADRESMAH (Neighborhood Name): This field includes neighborhood information where the occurred crime incident takes place.

14) ADRESSOK (Street Name): This field includes street information where the occurred crime incident takes place.

15) ADRESBIN (Building Number): This field includes building information where the occurred crime incident takes place.

16) ADRESDAI (Apartment Number): This field includes apartment number information where the occurred crime incident takes place.

Table 3.3 includes the following optimized fields:

1) OLAYNO (Incident Number): Unlike crime incidents attribute database table, OLAYNO field is not assigned as unique in involved people table. This time crime incident number column is expected to be entered manually to the spatial.

2) KARISANNO (Involved Number): This column records contain unique numbers that are automatically assigned by the developed system. Provided by this process, consistency of the spatial database is achieved for involved people numbers.

3) SAHISNO (Person Number): This column records contain unique person numbers that are automatically assigned by the developed system.

4) SAHISDUR (Person Status): This field gives information about whether the involved person is offender or victim.

5) UYRUK (Nationality): This field contains the nationality information.

6) ADI (Name): This field contains the name of the involved person.

7) SOYADI (Surname): This field contains the surname of the involved person.

8) BABAADI (Father's Name): This field contains the father's name of the involved person.

9) LAKAP (Nickname): This field contains the nickname of the involved person.

10) DOGYER (Place of Birth): This field contains the birth place of the involved person.

11) DOGTAR (Date of Birth): This field encloses the date of birth of the involved person.

- 12) NUFILI** (City of Birth Registration): This field encloses the city of birth registration information of the involved person.
- 15) NUFILCE** (District of Birth Registration): This field encloses the district of birth registration information of the involved person.
- 16) NUFKOY** (Neighborhood of Birth Registration): This field encloses the neighborhood of birth registration information of the involved person.
- 17) OGDUR** (Education): This field contains the education level of the involved person.
- 18) VATNO** (National ID number): This field contains the national identification number of the involved person.
- 19) CINSIYET** (Gender): This field contains the gender of the involved person.
- 20) ALISKANLIK** (Habit): This field contains information on whether the involved person has a bad habit or not.
- 21) SABIKA** (Previous Conviction): This field contains information on whether the involved person has previous convictions or not.
- 22) MESLEK** (Occupation): This field contains the occupational information of the involved person.
- 23) YAKTAR** (Date of Arrest): This field contains date information of arrest.
- 24) YAKYER** (Place of Arrest): This field contains place information of arrest.
- 25) TUTUKLAMA** (Arrest): This field contains date information of arrest.
- 26) YAKALANMA** (Capture): This field contains information of whether the involved person is currently free or under custody.
- 27) ALKOLDUR** (Alcohol Situation): This field contains information of whether the involved person is drunk or not in the incident time.
- 28) ADRESILCE** (District): This field includes district information about where the involved person stays.
- 29) ADRESMAH** (Neighborhood): This field includes neighborhood information about where the involved person stays.

30) ADRESSOK (Street): This field includes street information about where the involved person stays.

31) ADRESBIN (Building Number): This field includes building number of the involved person residence.

32) ADRESDAI (Apartment Number): This field includes apartment number of the involved person residence.

Table 3.1: Police Precincts Attribute Database Table (Mintika Layer)

ID	KARAKOL	ILCE	ALAN
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Table 3.2: Crime Incidents Attribute Database Table (Olay Layer)

OLAYNO	BUROKOD	ILCE	KARAKOL
OLAY	OLAYTAR	OLAYGUN	OLAYSAAT
OLAYMAHAL	OLAYNEDEN	SUCYONTEM	OLAYDUR
ADRESMAH	ADRESSOK	ADRESBIN	ADRESDAI

Table 3.3: Involved People Attribute Database Table (Kariřan Layer)

OLAYNO	KARISANNO	SAHISNO	SAHISDUR
UYRUK	ADI	SOYADI	BABAADI
LAKAP	DOGYER	DOGTAR	NUFILI
NUFILCE	NUFKOY	OGDUR	VATNO
CINSIYET	ALISKANLIK	SABIKA	MESLEK
YAKTAR	YAKYER	TUTUKLAMA	YAKALANMA
ALKOLDUR	ADRESILCE	ADRESMAH	ADRESSOK
ADRESBIN	ADRESDAI		

The information systems division in Police constructs database layers within a relational database model. However, there are some problems in this model. For instance, crime incidents and involved people tables contain redundant fields that must be repeatedly entered into the database. In addition, choosing some of the fields as the primary key for GIS analysis might lead to errors in the analysis step. In their system there is no consistent entity relationship (ER) diagram and it is the programmer's choice when developing a crime analysis system. Incidents and involved people tables contain several similar fields which could lead to redundancy in the analysis.

On the contrary, this study chose some of the fields as the primary key for relational model. Crime incidents table holds OLAYNO and KARAKOL for creating relation between involved people and district table because of the reason that involved people layer contains OLAYNO field in the table, whole relations can be constructed between, districts, incidents and involved people layers. Therefore, this system enables not only to construct a mapping system but a crime analysis application for the further step of this study.

Figure 3.1 illustrates a consistent database entity-relationship schema for effective database practice. In this diagram there is a one to one (1:1) relationship between crime incidents and district layer: Because each crime incident occurs in one district. Whereas, involved people layer contains at least two people for each crime incident and district, who are offenders and victims. However, it may contain more than one victim and offender as well. Therefore, there is one to many (1:M) relationship between crime incidents and involved people. In addition, involved people layer may contain more than one district, because there is no relationship between offenders and victims before the crime occurs. Thus, it can be declared that each involved person may overlap more than one district which provides a many to many (M:M) relationship in the entity relationship diagram.

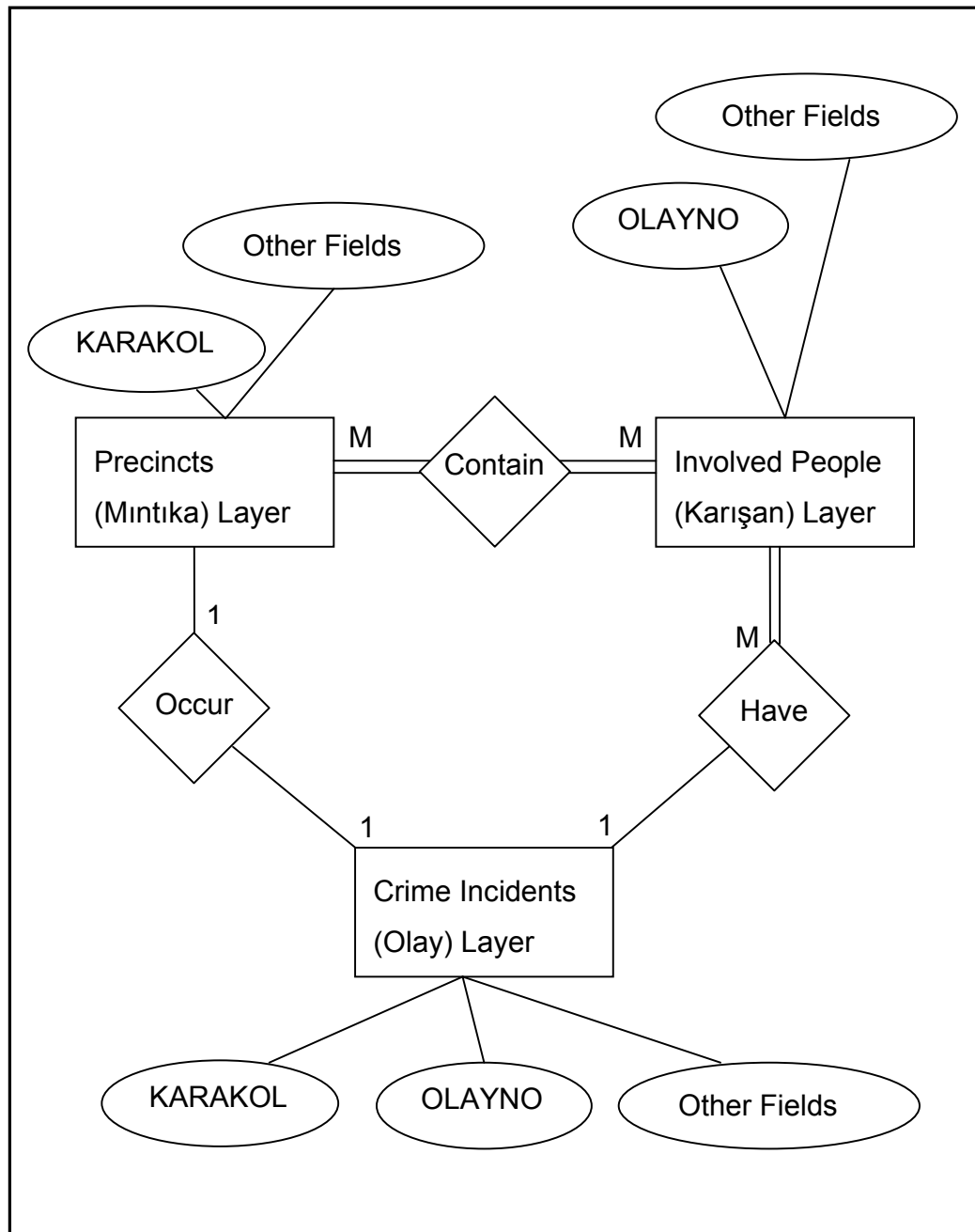


Figure 3.1: Entity Relationship Diagram of Crime Database

Spatial database tables cover up information regarding base map, crime incidents and involved people dataset layers. In the current system, incidents and involved datasets are expanded by the operators within a semi-automated geocoding interface in the center division of Ankara City Police Department. Hardcopy files are received by the center division periodically. A technician in that division produces this data into tables by entering each field. This is achieved by a tabular data screen interface in which semi-automated geocoding process is also conducted. The system pinpoints data without a mapping screen. As was mentioned previously, this geocoding interface inserts redundant fields because currently designed spatial database includes unnecessary location information fields, repetitive unique identifiers and so forth. Thus, this study eliminates this redundant information in order to facilitate and effective spatial database for crime mapping application.

In the current system, also geocoded data is pinned in the center of the street lines no matter the building number indicates at the end or start of the street line segments, because the semi-automated system cannot refer to the crime location with building information. Eventually, this shortcoming can lead to high positional errors for further tactical crime analysis step. However, on the contrary, this study's Web based data entry system locates the crime data by pinpointing in the exact place where the crime occurred. In this context, to evaluate this failure, accuracy testing of the geocoded data for the current and the proposed Web based system is compared in the next chapter of this study.

3.3. System Development

System development initiates with selecting appropriate hardware and software.

Hardware:

Pentium Intel® Centrino Mobile Notebook

512 Megabytes RAM

~ 1728 MHz Speed CPU

Software:

Windows XP Professional: Operating System

Internet Information Services (5.1): Web Server

MapXtreme 2004 Version 6.0: Application (Map) Server

Microsoft Visual Studio .NET 2003: Web Development

Microsoft Access: Relational Database Development for Initial Data Input

MapInfo Professional Version 6.0: Data Preparation and Evaluation

The application employs server side architecture with a proprietary GIS MapXtreme® 2004 as application (map) server and Microsoft® Internet Information Services (IIS) 5.1 as Web server together performing online mapping functions. Figure 3.2 displays organization schema of online crime mapping that is utilized for crime analysis and spatial decision making as the final step. Since the system provides a regular server side Internet GIS, Web and map servers work incorporated to supply the client requests. These requests are click on operations in the map for retrieval, ad hoc database query and insertion functions. When the client requests a HTTP course of action, the system first processes required task in the Web server, afterwards transmits it to map the server to render the final map.

Once the user enters geographically located tabular data, the system commits this as a new fetched record to the Microsoft Access database. Afterwards, recently added data can be imported to MapInfo Professional GIS database with geographic location components. This is achieved by storing X and Y geographical coordinates as column information in Microsoft Access Database. These coordinates are obtained from converted Web Map coordinates in to real geographic coordinates. In this way, produced data can be used for customized tactical crime analysis operations and spatial decision support. This organization schema is designed to serve as a spatial decision support for crime analysis in a law enforcement agency using GIS.

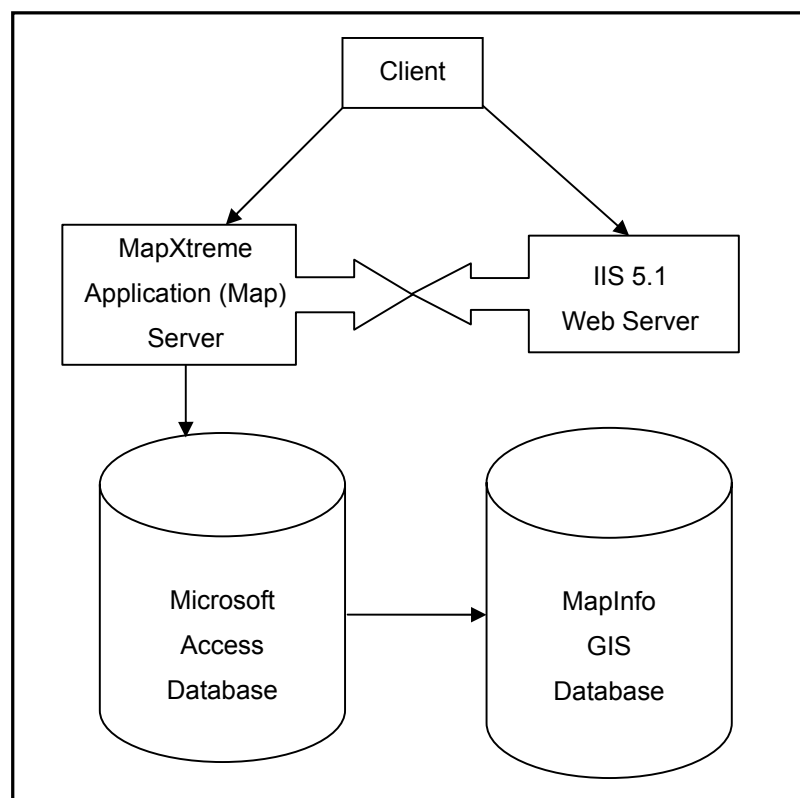


Figure 3.2: System Overview

3.3.1. System Components

MapXtreme 2004 version 6.0 as a proprietary MapInfo GIS vendor product contains object model for client/server and Web applications. This application development tool has core components working incorporated in Microsoft Visual Studio.NET platform. Within this flexible and scalable development, successful and powerful solutions can be created for visualization, mapping and location analysis. MapXtreme is built on top of .NET architecture and utilize the functionality of this infrastructure.

The object model contains a number of namespaces. Each namespace includes a set of related classes. Some of the more commonly used namespaces are (MapXtreme Developers Guide, 2004):

- MapInfo.Engine
- MapInfo.Mapping
- MapInfo.Data
- MapInfo.Geometry
- MapInfo.Styles
- Mapinfo.Tools
- MapInfo.Windows.Controls
- MapInfo.Web.Controls

Figure 3.3 illustrates the MapInfo MapXtreme 2004 architecture. The MapInfoCoreEngine.dll and MapInfo.CoreTypes.dll contain most of the core data visualization and access functionality. Controls and tools are built on top of the core engine for specific types of deployments. Any application can be created from the MapXtreme 2004 object model is built on top of the MapInfo.Windows or MapInfo.Web namespace.

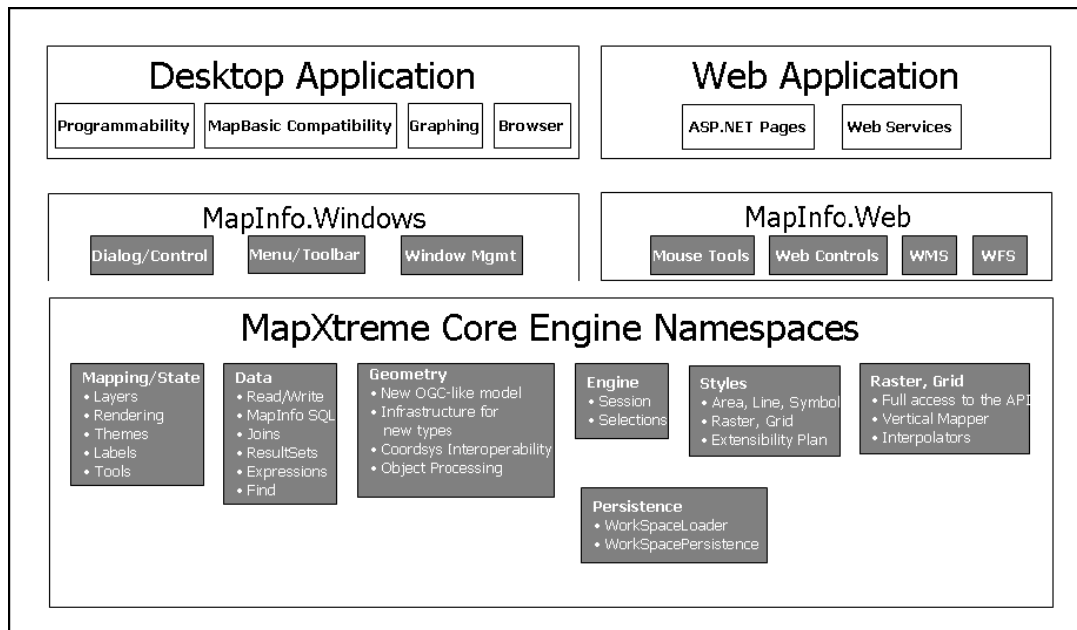


Figure 3.3: MapXtreme 2004 Architecture (MapXtreme Developers Guide, 2004)

The study utilizes MapInfo Web controls and components in .NET development. The solution is created under the name of CrimeXtreme project. It contains MapXtreme Web User Interface controls, Global ASP.NET session protocols and Web Config references. After choosing appropriate visual development within MapXtreme Web application, some of the files are generated by default in the Web root folder. Some of these are system runtime and others are design time components. In order to clarify the point based data entry process, this chapter mentions Web form and data entry functions.

3.3.2. Server Side Model

The system is designed to serve multi client network that utilizes Web browsers with HTML requests. These thin clients conduct basic click on and mouse over operations for interaction and data entry. In the server side processing, GIS vector database is converted into basic raster based images (e.g. Graphic Interchange Format) files to be displayed in the browser. Therefore, within low bandwidth environments users can send and retrieve maps easily. In fact, these raster based images are the representations of vector maps displayed in the browser. Original data are always kept in standard GIS vector format aside in the server.

The system is planned to serve multiple clients, clerks in the police stations, to work with one single database. In order to make session management easier, MapXtreme Web application provides several ASP.NET protocols running concurrently with pooling process. In this way, several requests running at the same time are controlled by MapInfo session engine instance which actually maximizes CPU utilization by reducing thread context switching.

Figure 3.4 illustrates a typical Web session practice during data entry process. When the user finalizes the map manipulation and pinpoint crime incident with tabular information, the features are inserted permanently in the Microsoft Access database. Herein, IIS Web server functions as a mediator between MapXtreme application server and the user's ASP.NET requests. In this way, MapXtreme provides the geographic components for a required level of mapping. MapXtreme application server; indices, binds, and displays features, and implements geographic functions as a mapping control working at the server side.

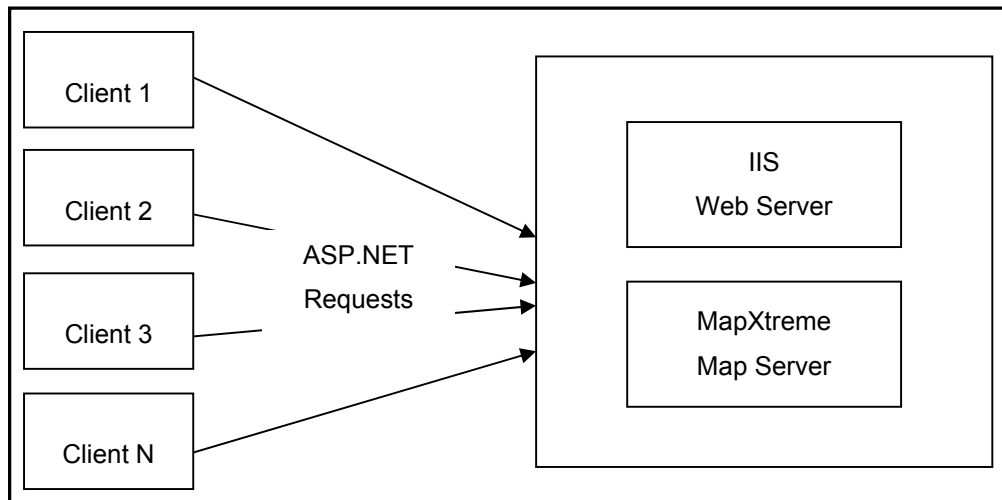


Figure 3.4: Server Side Model

3.3.2.1. Map Server Application Development

In this section application specific developed codes and instances are discussed. These are Web form and new incident tool files including procedures and functions. Codes are developed for session management and customization of system references for point based tabular data entry through Web. During the ASP.NET development, some of the files are modified and others are created for entering point based crime incidents, involved people (offenders and victims) including tabular attribute information. In order to give background information of map server development, customized files are explained briefly. However, so as to put some of the crucial file contents forward, source codes are given in appendices section. Code contained files have several repeated lines and routines so that they are summarized to give background information for map server application development. Moreover, point entry development process is the same for

incidents and involved people. Therefore, only incidents entry process related source codes are given in the appendices section.

In the Web form (WebForm1.aspx) file, crime map constants, user interface instances, styles, and map engine protocols are declared first (Appendix A.). Map control, toolbar, and layer control objects are inserted in the main Web page WebForm1.aspx file. Default zoom level and centric coordinates of crime map are defined for map control. It is important to display the map in predefined zoom level and coordinates to extent the entire map display in the browser. Toolbar definitions are declared to work incorporated with map tools, session variables, and menu items. In addition layer control functions including layer name, visibility and selection and label names are defined. This allows users to change the properties of the layers in the map (e.g. whether a layer is visible, labeled, etc.). Moreover, application paths of virtual directory and map image directory are defined within routines for tracking error codes and descriptions.

Toolbar functions are created to perform navigation, display and mapping operations. These tools are pan, zoom in, zoom out, add point incident, add point involved (offender and victim), clear selection, information and measurement tool. Each tool works in sequence with others, and therefore functions in the map with on mouse over, on mouse up, and on mouse down events.

New incident tool (NewOlayTool.aspx) file, commit and canceling functions of pinpointing operation are declared first (Appendix B.). Client side methods for mouse over operation instances are declared for user interaction. Working incorporated with WebForm1.aspx file, all purpose generalized HTML block structures are defined to enter both graphical and tabular information of crime

incidents. These procedures are created for offenders and victims with the same application development methods as incidents data entry file.

Designed application allows multi participant data editing for Ankara City Police Department intranet called POLNET. The system's concurrent access capability is limited with Microsoft Access and MapXtreme database management protocols. In this context, other database management systems can be used to constructs a multi participant platform.

3.3.2.2. Client Interface

Client interface is designed for interactive Web based map navigation and data entry through browsers. Like all HTML applications this interface executes user commands to perform online mapping. Figure 3.5 illustrates initial map interface of the application. This interface is developed to be utilized as a regular desktop GIS functionality for mapping point features. The initial mapping screen shows a tool bar for navigation, information gathering and pinpointing crime incidents and involved people buttons. This client interface is designed by considering human computer interaction shortcomings which are false data entry, lack of focus on the map and so forth. As the system proposes consistent and accurate data production, this Web interface has restrictions with combo and list boxes that provide precinct, neighborhood and street selection tools as well. Moreover, there is a layer control panel for layer visibility and user defined zoom level options.

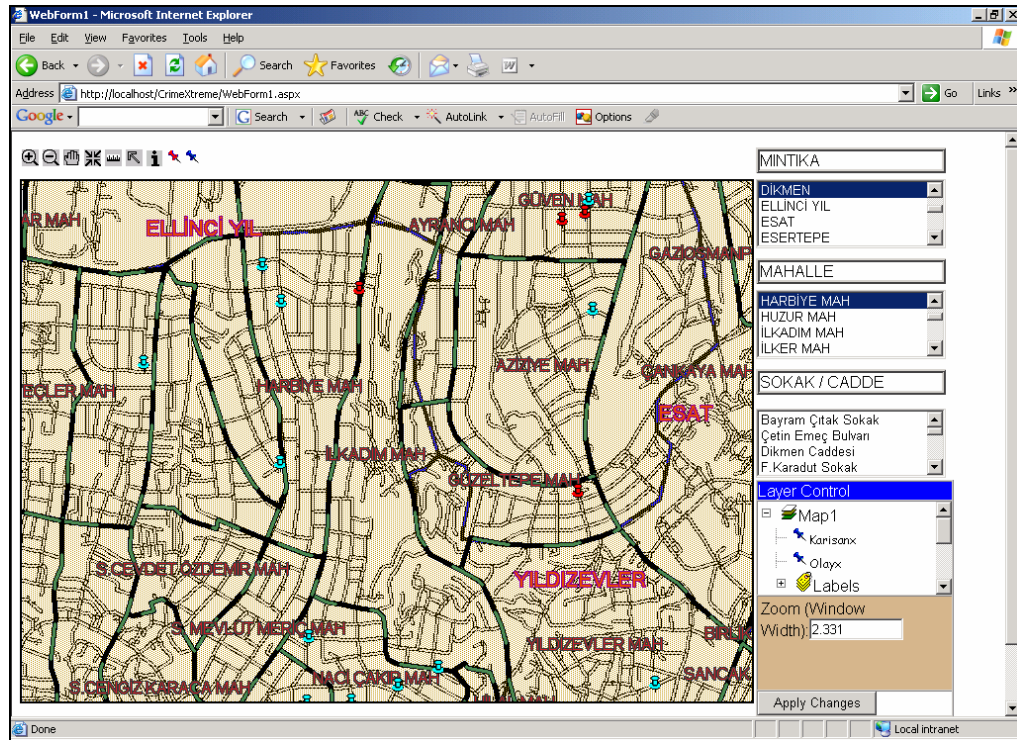


Figure: 3.5 Web System Designed Interface

3.3.3. Functions of the system

WebForm1.aspx operates main display page and all the operations are carried out through this file. There is a map control for displaying and providing mouse over interactivity. In addition, a drop down menu tool is near the map control on the condition of user to navigate in the map and locate the point data. Moreover, there is a layer control panel which allows users to display selected layers of crime incidents, involved people, districts, precincts, neighborhoods and roads selection to locate the exact position in the street. In order to constitute a flexible user interface, some constraints are provided to minimize the user's possible mistakes in graphical and tabular data

entrance. In this framework, users are restricted to enter accurate spatial data by locating the selected streets. In addition, the tabular data entry screen has some limitations to input consistent information. This is achieved by automatic numbering of incident numbers, and combo box constraints. Moreover, the location column names are generated from the pinned point location automatically. This process enables a time saving process to enter the location information to the spatial database.

Operations including map generation, display, navigation, and pinpointing incidents and involved people are discussed in the following sub-sections of this chapter. Provided with the illustrative figures of graphical user interface, general outlook of developed application is given for interactive online crime mapping.

3.3.3.1. Map Generation and Display

Human computer interaction initiates when the digital map first appears in the browser. In this frame of reference, it is important to consider user requirements during map generation and display. The initial interface is shown in Figure 3.6 in which users are allowed to interact with the components of the system. When the Web page initializes, complete map of the study area is displayed first. Users are expected to locate crime data with interactive tools provided by the system. This online crime mapping application is intended to be utilized by the officers working in the local police stations of Ankara. Thereby, it is designed to be user friendly and flexible while performing mapping operations.

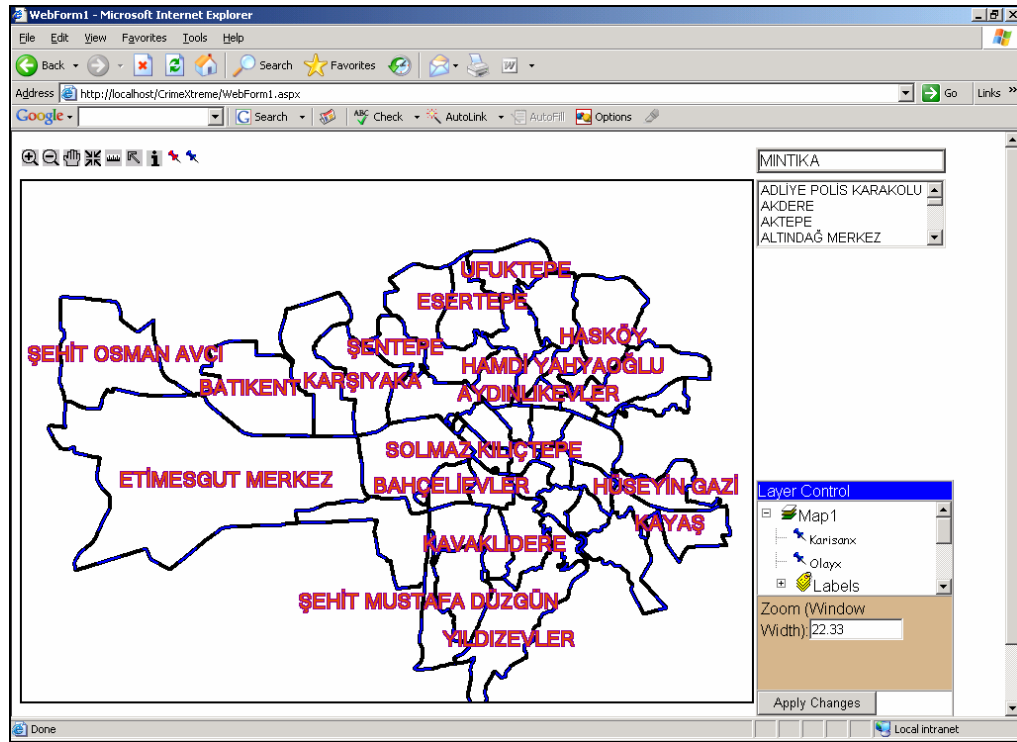


Figure: 3.6 Initial Map Display with Layer Control and Toolbar

3.3.3.2. Navigation

The drop down menu near the map control includes police precincts, neighborhoods and streets selection options that users locate to the required zoom level and pinpoint the crime data. Figure 3.7 illustrates precinct, neighborhood and street selection click on operation in which user is redirected to desired zoom level of streets. The advantage of dynamic segmentation process enables users to zoom into preferred streets in the covering neighborhood. In this way, users might not mix up different segments of the streets. Moreover, as the user zoom into desired street, buildings layer is appeared with labeling their number information.

In addition to this selection, users may pan, zoom in and out and re-center the map for required locations on the map. There is a measurement tool that provides point to point distance calculation as well. This tool might be useful while pinpointing crime incidents, because the user would want to pinpoint crime data from a specific location or a landmark. Moreover, it might be needed to locate a point in a place that the spatial database does not have building number information. Therefore, the system allows maximizing the location accuracy of pinpointed incidents.

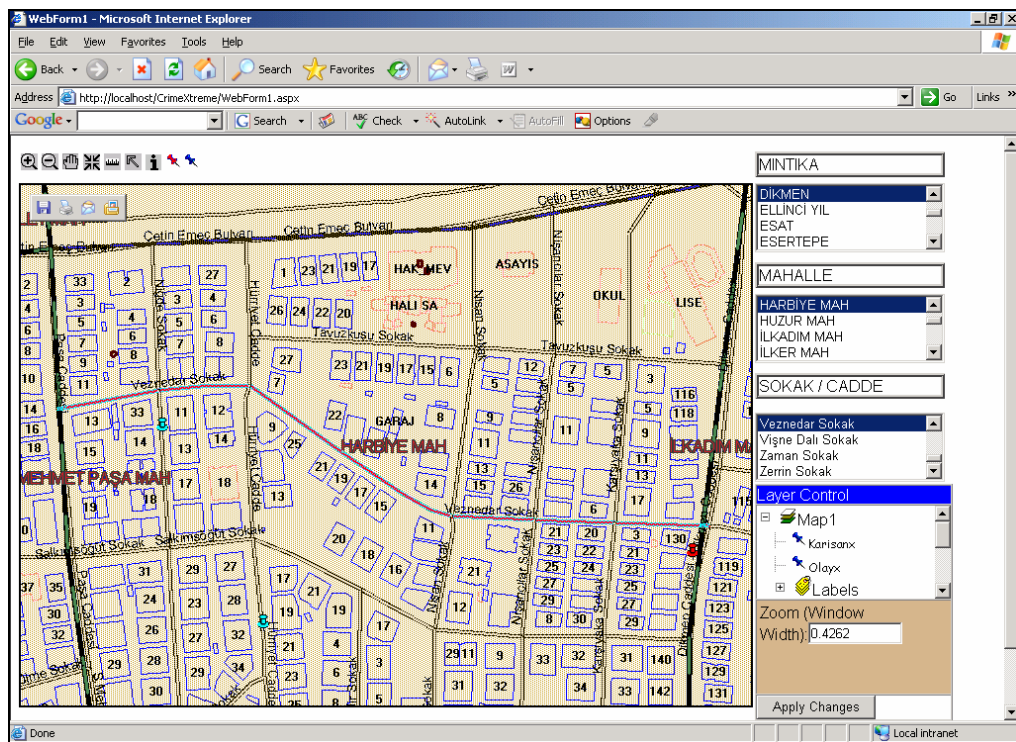


Figure: 3.7 Precincts, Neighborhood and Street Selection Tool

3.3.3.3. Incident Data Input

Main aim of the Web application is to enter crime information through multi participant user environment. As an alternative to the existing data production of Ankara City police department, it is intended for police officers using the Web and input crime information via browsers. Data entry process is conducted by using MapXtreme and Microsoft Access database connection. Points are inserted to the Microsoft Access with geographical coordinates. These are converted screen coordinates with Latitude and Longitude information. In this context, newly created points are added to the spatial database. In addition, they can be used in analysis by the time they are inserted. Therefore, real time data production is established within this application.

There are incident and offender-victim input buttons that a user clicks after pinning the point based crime data. After pinning operation, a tabular information entry screen appears including text, date and combo boxes for input process. In addition, it also has canceling and save options to finalize the entry. Some repetitive fields are saved as null while entered in the database. In order to improve flexibility and to enter crucial information for spatial decision making, this study uses limited number of data for entry.

Figure 3.8 displays tabular input panel for point incidents. As can be observed from the illustration some of the fields are generated automatically and others are entered iteratively from combo boxes. Fixed with selection of crime incidents, related crime methods appear in the following combo box. In addition, some spatial fields are generated automatically such as district, precinct and neighborhood. Since the user is redirected to the located crime incident, pinpointed data inherits spatial information from geographical

coordinates. In this way, a user is not required to enter spatial information of point based data.

The screenshot shows a web browser window titled "WebForm1 - Microsoft Internet Explorer". The address bar shows "http://localhost/CrimeXtreme/WebForm1.aspx". The form contains the following fields:

- OLAYNO: 34533
- BUROKOD: GASP
- OLAY: GASP İDDİASI
- OLAYTARİH: Mayıs 2006 (calendar view)
- SUÇ YÖNTEMİ: SPREY SIKARAK
- OLAY SAATİ: 11:11
- OLAY DURUMU: FB
- OLAY GÜN: SALI
- OLAY NEDEN: TARTIŞMA
- OLAY MAHAL: SOKAK
- İLÇE: ÇANKAYA
- KARAKOL: BAĞÇELİEVLER
- ADRES MAH: EMEK MAH
- ADRES SOKAK: 56. Sokak

The map shows a neighborhood with numbered houses and streets. The "Layer Control" panel on the right includes "Map1", "Kartısonx", "Olayx", and "Labels". The "Zoom (Window Width)" is set to 0.1954. The "Apply Changes" button is at the bottom right.

Figure: 3.8 Crime Incident Input Screen

3.3.3.4. Offender and Victim Data Input

Like crime incident data entry, involved people (offender and victim) input operation facilitates the similar functions. It has cancel, save and pin options as well. When the user clicks on pin tool and selects the involved people location in the map data input screen appears (Figure 3.9). This element contains field information of offenders and victims. As the system uses relational database management system, entered involved people point data

is related with the preceding incident input. Therefore some of the fields are generated automatically. Other ones are entered with text and combo boxes.

OLAYNO		ADLİYE POLİS KARAKOLU
KARIŞAN NO	350003	AKDERE
ŞAHIS NO	9979	AKTEPE
ŞAHIS DURUMU	MUŞTEKİ	ALTINDAĞ MERKEZ
UYRUK	T.C.	
VATANDAŞLIK NO		
ADI		
SOYADI		
BABA ADI		
LAKAÇ		
DOĞUM YERİ		
DOĞUM TARİHİ		
NÜFUSA KAYITLI OLDUĞU İL		
NÜFUSA KAYITLI OLDUĞU İLÇE		
NÜFUSA KAYITLI OLDUĞU KÖY		
MESLEK		
ÖĞRENİM DURUMU	İLKOKUL	
CİNSİYET	KADIN	
ALIŞKANLIK	UYUŞTURUCU	
SABİKA	YOK	
YAKALANMA TARİHİ		
YAKALANDIĞI YER	EV İÇİ	
ALKOL DURUMU	VAR	
TUTUKLAMA	TUTUKLU	
YAKALANMA	YAKALANDI	
ADRESİLÇE	KEÇİÖREN	
ADRES MAHALLE	ADNAN MENDERES MAI	
ADRES SOKAK		
BİNA NO		

Figure: 3.9 Involved People Input Screen

In this chapter system design process and functions of online mapping are discussed. As can be observed from the mainframe, a point based crime data can be inserted into the system to be used for crime analysis. This reflects the ability of real time data production along with online crime mapping. In this frame of reference, both crime incidents and involved people (offenders and victims) data can be entered into the server side system.

This chapter claims that the system design process brings solutions for establishment of a tactical crime analysis environment. In the next chapter, this system's capabilities are evaluated by giving examples on accuracy and performance testing of crime data input. Therefore, shortcomings and strengths of the system are discussed with comparing different situations of online crime mapping application.

CHAPTER 4

EVALUATION PROCESS OF MULTI PARTICIPANT ONLINE MAPPING

In this chapter firstly description of the case study area is given. In this framework, introductory view of defined police districts is discussed. Since the police district areas vary on size and covering neighborhood borders and Web system provides spatial data entry for each precinct, it is better to give some background information of the study area.

In addition to general view of Ankara City Police department borders, sections of this chapter include evaluation process of Web based geocoding process of crime incidents and involved people. Since this online system allows entry of point based features within user defined zoom level, accuracy testing of inserted data is also evaluated. In this context, comparison of actual data input methodology of Police and proposed study is conducted. In addition, performance issues are evaluated during point data entry session. Finally, online mapping capabilities are evaluated.

4.1. Description of the Study Area

The study area includes Ankara City Police department formerly defined precincts. These zones are created according to classified criteria's for the whole city handling. Figure 4.1 illustrates the zones that are located in the municipal part of Ankara. Unlike gendarme, police control areas covers metropolitan areas. These areas are actually created from central districts and neighborhoods' borders.

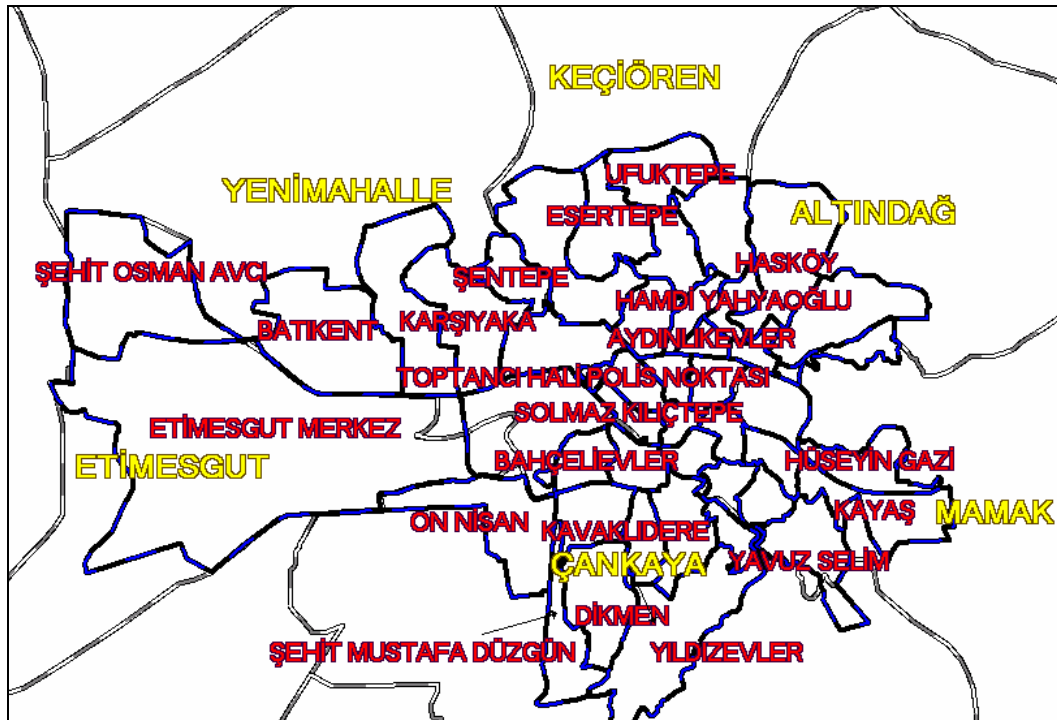


Figure 4.1: Study Area Overview

There are 47 precincts in Ankara City Police Department's jurisdiction area with an approximately total of 396 square kilometers. Table 4.1 indicates precincts including their area information. For the reason that, each precinct's area differs in extent, crime concentrations must be monitored in an appropriate zoom level. In addition, as the study underlines accurate mapping of point based data, building level accuracy is a demand to pinpoint crime data.

Table 4.1 Ankara City Police Department Districts

No	Name of the Precinct	Km ²	No	Name of the Precinct	Km ²
1	KAVAKLIDERE	4	25	ŞEHİT KADİR ÖZCAN	15
2	ELLİNCİ YIL	6	26	BATIKENT	18
3	ŞEHİT MUSTAFA DÜZGÜN	7	27	ŞEHİT İDRİS AYDIN	3
4	ON NİSAN	12	28	MAMAK MERKEZ	6
5	DİKMEN	9	29	HÜSEYİN GAZİ	6
6	YILDIZEVLER	19	30	KAYAŞ	9
7	ESAT	7	31	YAVUZ SELİM	8
8	CEBECİ	5	32	AKDERE	3
9	BAHÇELİEVLER	4	33	OTUZ AĞUSTOS	3
10	ÇANKAYA MERKEZ	4	34	TUZLUÇAYIR	3
11	SOLMAZ KILIÇTEPE	3	35	DEMİRLİBAHÇE	2
12	ANAFARTALAR	3	36	ETLİK	15
13	DEMİRFIRKA	2	37	ESERTEPE	9
14	ALTINDAĞ MERKEZ	2	38	KEÇİÖREN MERKEZ	5
15	SEĞMENLER	3	39	UFUKTEPE	8
16	AYDINLIKEVLER	2	40	AKTEPE	8
17	SİTELER	2	41	YÜZÜNCÜ YIL	5
18	SELAHATTİN DOĞAN	11	42	KAVACIK	3
19	HAMDİ YAHYAOĞLU	3	43	TERMİNAL	1
20	HASKÖY	14	44	ÇİFTLİK	16
21	ETİMESGUT MERKEZ	79	45	ŞEHİT OSMAN AVCI	22
22	YENİMAHALLE MERKEZ	8	46	TOPTANCI HALİ NOKTASI	1
23	KARŞIYAKA	12	47	ADLİYE POLİS KARAKOLU	1
24	ŞENTEPE	5			

Data used for the study are compiled from Ankara City Police Department's 2003 statistics containing from the beginning of February to the end of April. Due to classified information regulations, this study includes crucial components of database production. In this frame of reference, this study concentrates on crime incidents', victims and offender's visualization and mapping.

Figure 4.2 displays the distribution of crime incidents and involved people (offenders and victims) covering some precincts of Ankara Police Department. Red points indicate crime incidents, whereas blue spots are involved people. Whole data covering all the precincts contain totally 790 incidents and 1054 involved people in digital format. In addition to crime data, road network, neighborhood, districts and building layers of Ankara are used for Web based geocoding process of this study.

In Ankara Police Department, point based data are produced by a semi-automated geocoding interface. However, there are some question marks regarding the data accuracy while these point based data are located. It can be observed from the Figure 4.2 that the illustration contains overlapping features of incidents and involved people. Unlike this display, points should be rather dense when displayed in the map. The following sections discuss data accuracy with comparing the current status of data production techniques. In this context, location accuracies are evaluated by examining the pinpointed data and its real tabular geographic informative location.

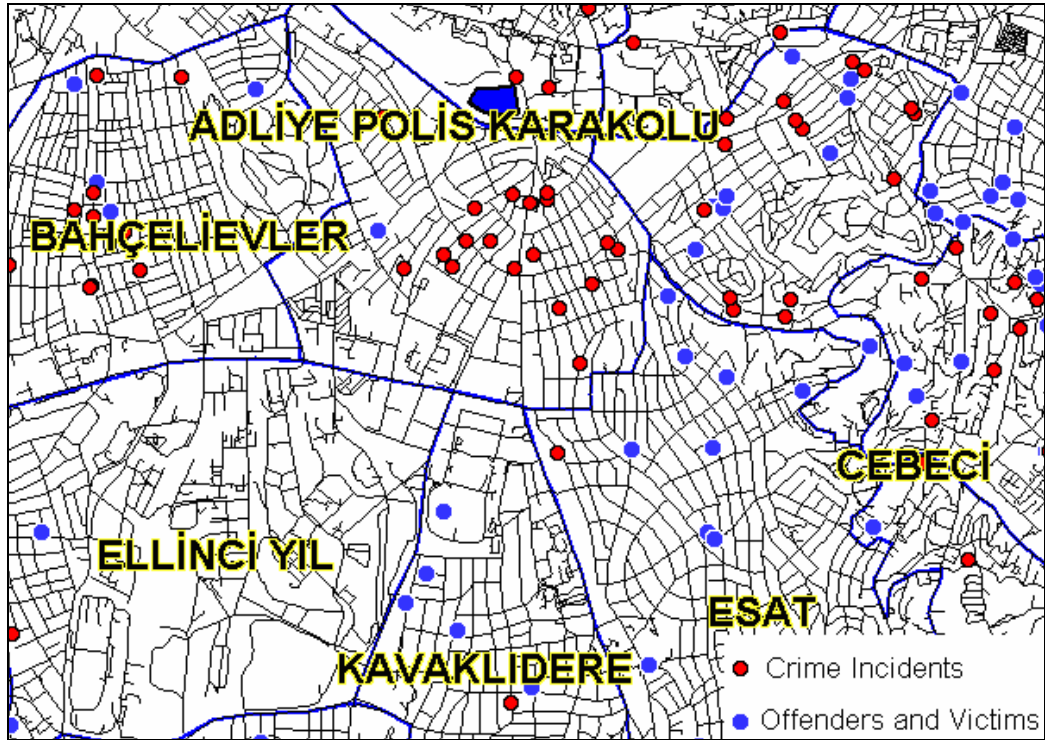


Figure: 4.2: Distribution of Incidents and Involved People Occurred in Some Precincts in the First Half of 2003 Year

4.2. Expanding the GIS Database

Designed system allows tabular information of crime incidents and involved people point based data entry into the GIS database. As can be observed in the ER diagram and database tables, there are some critical fields entered for incidents and involved people. These fields are explained in the previous section; however some are entered as null and considered to be useless for this study. Because, some of these futile fields are used for semi-automated geocoding system and are not appropriate for online mapping. For this reason, they are not included for data entry process.

As mentioned in the system design process, incident and involved people data entry is conducted by combo and text boxes. After navigating and pinning the incident or involved data, user is expected to enter tabular information. During crime data input, primary key field OLAYNO is generated automatically for incident entry. On the other hand primary fields KARISANNO and SAHISNO are generated automatically for involved people table too. Although this online crime mapping system constructs this relational database that is not used directly, the spatial database can be used for further crime analysis applications.

Since the study put forwards a Web based data entry system, accuracy and performance testing are performed to validate this application's capability. Test sections evaluate proposed system's shortcomings and strengths in the following sections.

4.2.1. Performance Testing

Online system provides multi participant access to the spatial database in the main server. As mentioned earlier, the system use Microsoft Access for holding incidents and involved layers including X and Y fields of geographic information. Therefore, after the entry process, data can be imported for any kind of integrated mapping crime analysis or spatial decision support application.

Performance testing process is conducted in the Middle East Technical University, Geodetic and Geographic Information Technologies lab. Since the proposed system can be used as a prototype for 47 stations of Ankara Police Department, and theoretically not all of them penetrate the Web server at the same time, this test is conducted with three user access for performance

evaluation. Therefore, multi participant platform is assumed to be created within these three clients. The users are decided as research assistants working in the department. In this state users are entering point based crime incidents and involved people data through Web.

In the testing process users are required to enter two crime incident and one involved people respectively. In addition, it is expected from the users that involved people OLAYNO is same with the first incident entry. In the scenario one incident has one involved people to be entered for the first crime incident. Since the system use relational model, it is expected from users to enter one related data on the map. Each user has different location to navigate and pinpoint the crime data. In this way, system's multi user server map rendering capability is also evaluated in the online mapping process.

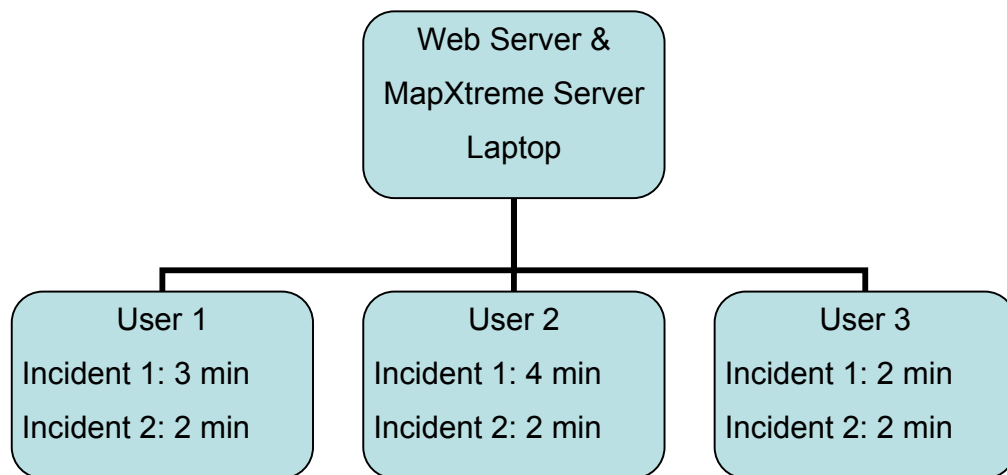


Figure 4.3: Performance Testing Schema

Figure 4.3 illustrates the users and performance results during online data entry process. This schema includes users' data entry timing of incidents and involved people. Timing process is comprised of navigating and locating the point data and input the field information. Users are expected to enter two different crime incident and one involved people data. Survey results show that users enter crime incident data faster than involved people layer. For the reason that involved people input screen has more database fields, and has less number of combo boxes, it takes more time to enter involved people data.

Timings are approximate rounded values that are gathered from users' forms. Forms also include user comments in which overall satisfaction of the system is evaluated. Users' common comment is that the system is satisfactory; however, they also underline that during the entry process, automatically generated fields may mislead the user. Because when a user commits a point to the database, other users' OLAYNO field change instantly. Theoretically, this response of the server is necessary, because the database keeps this field as a primary key to provide the consistency. However, users may miss the OLAYNO number after they pinpoint the data. Same situation happens in the involved people entry for KARISANNO and SAHISNO fields, because they are generated automatically as well.

To sum up, in the performance testing step multi users online access process is performed. Since the system is proposed to 47 stations of Ankara City Police Department, three users access can be good practice for it. The system facilitates a 1.7 MHz. laptop computer in the server side. Apparently, the better CPU and ram means the faster processing speed.

4.2.2. Accuracy Testing

The system proposes accurate geocoding of crime incidents and involved people into the spatial database. Unlike Ankara City Police Department's semi-automated geocoding interface, this Web based application is a mapping system. Users witness the actual crime place in the map, so that accuracy is achieved by pinpointing the crime information in building zoom level.

Accuracy testing section evaluates some sample incidents and involved people location information. Sample data are compared with Police's semi-automated geocoding interface and online mapping system. In fact, it is assumed that points are always entered in building zoom level in the online mapping approach. However to put forward the geocoding problems of semi-automated system, original data accuracy is evaluated with building number information.

Points are selected randomly from the spatial database and they are considered to reflect semi-automated system's accuracy success. Three different incidents and two involved people locations are selected for position assessment. They are evaluated with building number information and actual place of the pinpointed data. MapInfo Professional calculates the distance between located data and the real building with a measurement tool. The following representations illustrate pinned data with including building and street layers. Three of the following figures show incidents' and the rest two display involved people's positional accuracy in different level of map scales.

Figure 4.4 displays the first crime incident example occurred in Cebeci district. As can be observed from the illustration, there is 178 meters of

positional accuracy error. Although the Police semi-automated geocoding system enters the tabular information of building number as 5, it pinpoints data next to the building number 26. Figure 4.5 shows the same situation for the second crime incident example occurred in Altındağ. This time actual crime takes place in the building number 42 but pinpointed next to the building number 25, and there is a 95 meters of positional error. The next sample illustrates a 181 meters error in figure 4.6.

As the Police system utilizes the same method to geocode involved people layer, identical to crime incidents layer positional errors happen here as well. Figure 4.7 displays 204 meters error pinpointed in Aktepe neighborhood and finally Figure 4.8 illustrates 198 meters of positional error in Siteler neighborhood.

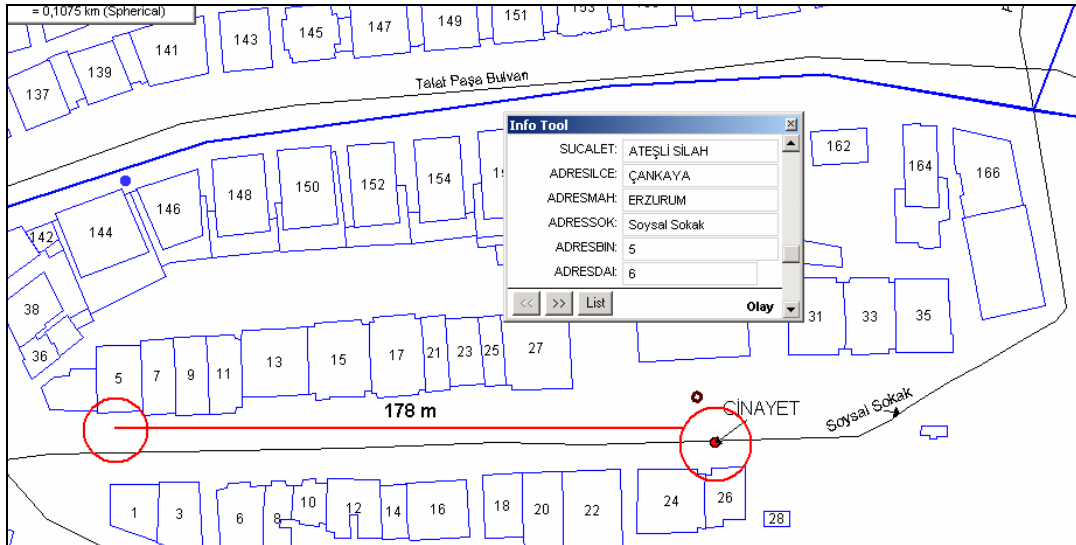


Figure 4.4: Incident Accuracy Testing 1

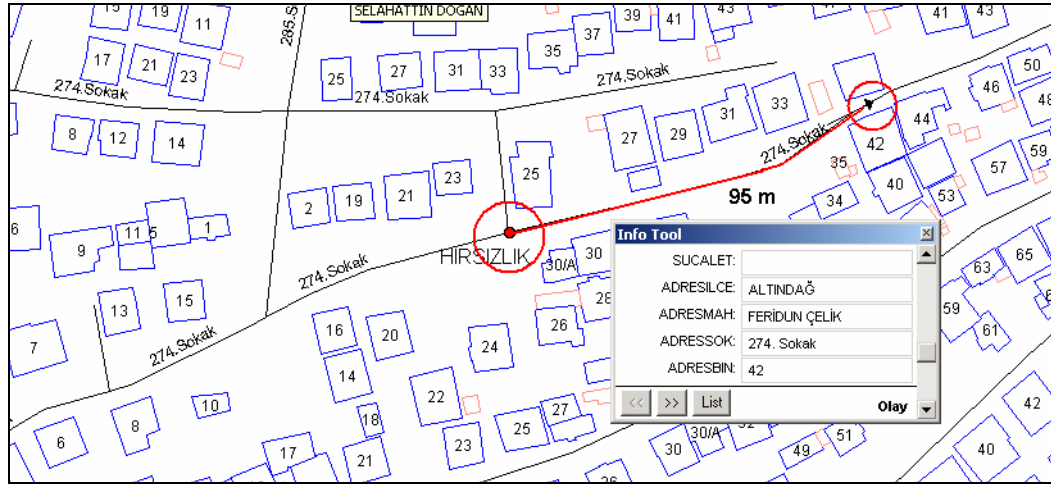


Figure 4.5: Incident Accuracy Testing 2

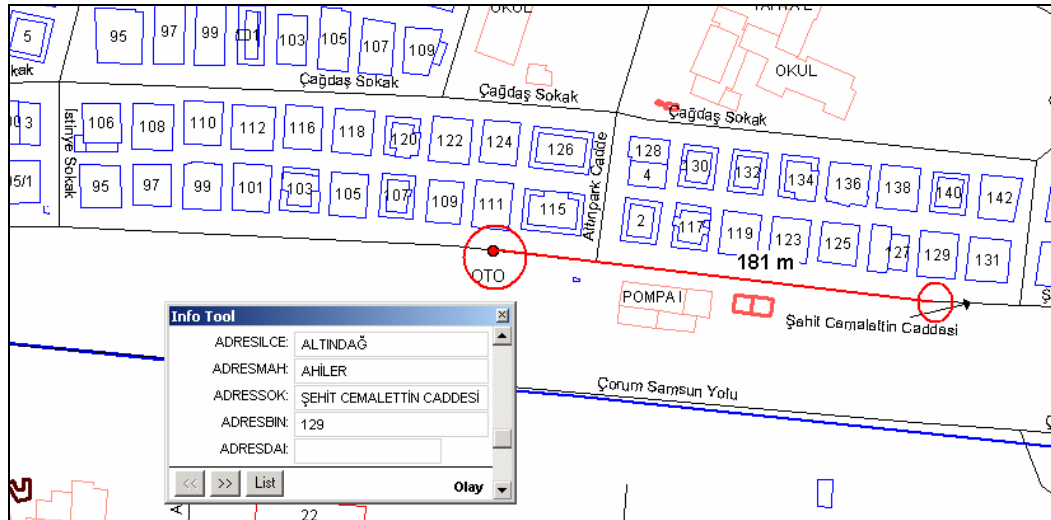


Figure 4.6: Incident Accuracy Testing 3

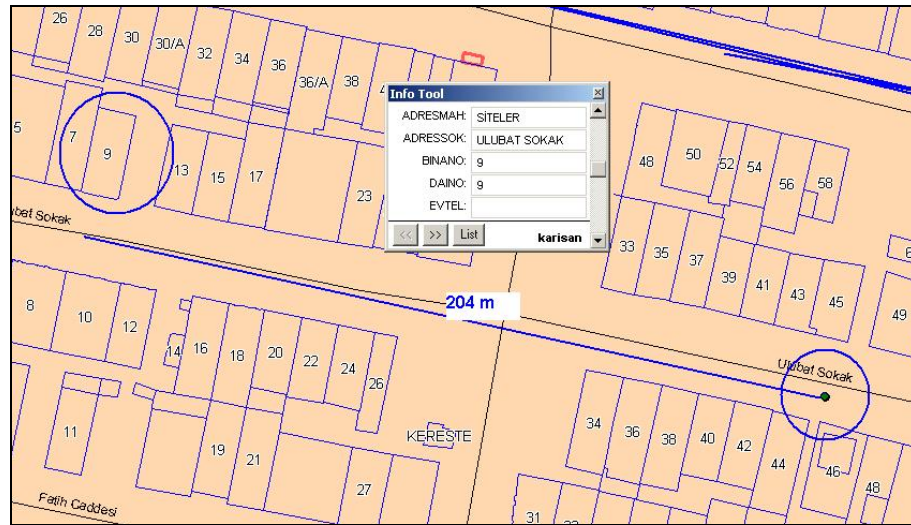


Figure 4.7: Involved Accuracy Testing 1

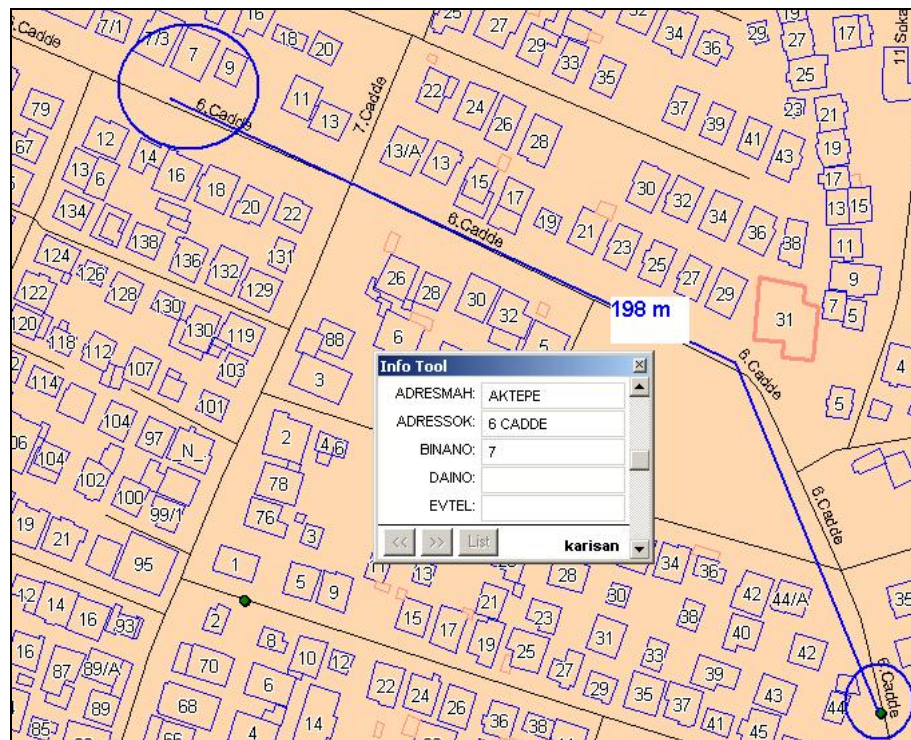


Figure 4.8: Involved Accuracy Testing 2

Unlike Police's geocoding system the Web based mapping application locates the incidents and involved people data to the actual place of buildings. Basic advantage of the system is to provide this geocoding process by navigating in the map. Therefore, users can aware of located points and finally appropriate positional accuracy level is achieved within this study's online mapping approach.

In this chapter, online system's capabilities are evaluated. In this context, performance and positional accuracy are considered as key factors in order to bring solutions for tactical crime mapping. It can be claimed that, when a user pinpoints crime data by utilizing a defined zoom level base map, convenient results can be achieved with this online mapping system. In addition, considering the importance of time to conduct up-to-date tactical crime analysis, this Web system enables real time data production.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

This thesis is designed to build a crime mapping system in order to produce data along with a Web based data entry methodology. The main emphasis in this study is to convey some new improvements for effective and accurate geocoding of point based crime incidents, offenders and victims' data. In this thesis, general requirements of Ankara City Police Department are examined for building a typical tactical crime mapping application. In this context, to accomplish an up-to-date and proper positional accuracy of these point based features, a Web based multi participant platform is constructed. Police stations of Ankara are considered as participants working interactively with the center division to enter crime data.

This study establishes a server side Web architecture that provides map visualization and point based data input to the current spatial database through Web browsers. Major advantage of this server side system is that the clients using the browsers do not need to install any additional plug in to conduct online mapping. Typical HTML operations in the browser such as clicking, selecting and typing text data are performed at some stage in this online crime mapping application. For this reason, user friendly map navigation and display functions are included to the client interface.

Online mapping has two distinct advantages including multi user access to the spatial database and accurate geocoding of point based geographic features. In this context, proposed system can be a good suggestion to the current database production of Ankara Police Department. Moreover, this system is able to produce data faster than the recent one, because it can be facilitated among the network of computers. Obviously, real time data input approach is faster than currently used semi-automated geocoding interface of the Ankara Police Department. Unlike their input process, there is no need to send hardcopy information from each station to the center division.

The fact that crime occurs heterogeneously, this proposed online system can work effectively for inserting new points into the spatial database. For the reason that users render the digital map in precinct, neighborhood, and street level; it is quite applicable to reach building level accuracy. In addition Web mapping application allows entering tabular attribute data of point features of crime incidents and involved people. In this context, the server side MapXtreme working together with IIS Web Server meets the data entry requirements.

Both incidents and involved people data contain several fields of tabular attribute information. The online mapping system facilitates some of these fields that are crucial for a tactical crime analysis or spatial decision support application. In this context, current relational database model is improved with automatic generation of primary fields of involved people and crime incidents layers. However, to keep up the actual database production of Ankara Police Department, other fields are input as null during the Web entry. Due to practiced redundant information in the actual spatial database of Police, the system must be rebuilt with consistent entity relationship diagram. Therefore, more efficient tabular database could be used for tactical crime analysis as a further step.

Layers including buildings, streets, neighborhoods and precincts are displayed within predefined zoom level intervals. In order to reduce server side processing tasks, this layer visibility range method assists for fast rendering of digital maps in the browsers. Since the system can be used at maximum of 47 users from each police station at the same time, this layer visibility option is necessary for performance considerations.

MapXtreme application server facilitates Microsoft Access database for crime incidents and involved people layer. The system stores the data in the Microsoft Access database including geographic location information. The reason of choosing an additional database management system is to provide multi user and session management. Moreover, Microsoft Access database is rather fast and simple compared to many advanced databases such as Oracle, SQL Server etc. Because advanced database management systems use more physical recourses, and therefore a high speed computer must be used at the server side.

Web based crime mapping application is proposed to Ankara City Police Department to be implemented in their private intranet platform called POLNET. They have 10 Mbit intranet bandwidth speed which means that they can easily establish such a platform to be used by 47 Police stations at the same time. In this context, as long as the server at the center division has more physical memory and CPU, the system performance can further be improved.

It is observed that crime incidents and involved people layers of containing year 2003, 3 months data have several positional errors. The semi-automated system used by the Ankara Police Department locates point based data every time in the same place of a street. Depending on the street lengths, their application always pins the data in the center of the roads and eventually this

misleading process may cause high positional errors. In addition, points are located each time in the same place of a street line segment, which grounds overlapping features in the map. On the contrary, online entry system enables navigating in the entire streets without considering the lengths. Because the system zooms into the containing precinct and neighborhood and point based data always entered into the right place. This is achieved by dynamic segmentation method and the users can easily switch to street segments for covering neighborhoods.

The system can be used by the officers working as clerks in each police station. As they write down crime information to the hardcopy papers as a regular working activity, they can use Web browsers to enter the same criminal activity. In order to make the tabular data input process easier for police officers, iteratively working combo boxes are used in this online mapping application. In this frame of reference consistent attribute information input is provided as well.

The entire system facilitates MapInfo Professional components and Microsoft Access as a relational database. The availability of recently inserted data usage provides a compact mapping application. Produced data with Access database can be imported to MapInfo Professional platform. Therefore, this crime mapping application can be also used for any type of customized crime analysis application for spatial decision support. Since a successful Spatial Decision Support system necessitates data production and analysis in one single frame, this proposed online application seems to fit well as a crime mapping part of any advanced system.

As long as this prototype facilitates the base map with unified building, street, neighborhood and district layers, this online crime mapping application can be used in other cities of Turkey. Because the system filters the database

dynamically, it can be used in other Police departments. More specifically, it depends on the spatial database used as base up for pinpointing crime data. Therefore, it can be claimed that as long as an up-to-date and reliable base map the city has, an online crime mapping application can be constructed for that city as well.

As for future work, users tracking capability can be included to this online mapping system. Users may have predefined username and passwords before they login to the system. This login information of users can be kept in any database management system as well. Therefore, in the session management users can also be monitored in cases about who entered which crime incident or involved people point data. Considering any data verification process, this method may enable communicating with the user who locates the data for verification.

In addition, considering the recent telecommunications network and satellite systems, GPS enabled palm computers could be a better practice for crime database production. These computers can transmit data to the center division by using this satellite networks. Thus, police officers may enter crime in their actual location with geographical coordinates and tabular attribute information. This implementation is obviously the most accurate positioning of crime data. However, it is required to put effort with a larger software development team. Because designing such a system could be practical but not easily developed.

In order to develop a Web based multi participant mapping application, an advanced level of software development experience is required. General requirements and system's audience must be identified clearly for such kind of applications. Mostly, these participatory systems can be used in AM/FM (Automated Mapping and Facilities Management), community planning and

so forth. However, for instance this online crime mapping application produces only point based features including their tabular attribute information. Therefore, it can be claimed that the more complicated features like line and polygon based data must be carefully designed and developed with choosing appropriate Web architecture and map server components.

As long as tactical crime analysis needs daily, weekly, monthly reports, and hot spot mapping for administrative reactions, this prototype of online mapping application seem to fit very well of these requirements. Because accurate data means efficient hot spot mapping and real time data entry signifies monitoring temporal activity whenever the analysts want. To sum up, this study can be a prototype for online crime mapping in tactical crime analysis. In addition, in this thesis a real time GIS data production is established which enables dynamic crime mapping. Considering the outcomes of this study, it can be claimed that fast and reliable data production is constructed within an online multi participant platform.

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APPENDIX A

WebForm1.aspx File

```
using System;
using System.Collections;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Web;
using System.Web.SessionState;
using System.Web.UI;
using System.Web.UI.WebControls;
using System.Web.UI.HtmlControls;
using MapInfo.Data;
using MapInfo.Styles;
using MapInfo.Engine;
using MapInfo.Mapping;
using System.Data.OleDb;

namespace crimeXtreme
{
    public class WebForm1 : System.Web.UI.Page
    {
        protected MapInfo.Web.UI.WebControls.ZoomInToolControl ZoomInToolControl1;
        protected MapInfo.Web.UI.WebControls.ZoomOutToolControl
ZoomOutToolControl1;
        protected MapInfo.Web.UI.WebControls.PanToolControl PanToolControl1;
        protected MapInfo.Web.UI.WebControls.CenterToolControl CenterToolControl1;
        protected MapInfo.Web.UI.WebControls.DistanceToolControl DistanceToolControl1;
        protected MapInfo.Web.UI.WebControls.ToolbarControl ToolbarControl1;
        protected MapInfo.Web.UI.WebControls.InfoToolControl InfoToolControl1;
        protected MapInfo.Web.UI.WebControls.DistanceToolControl DistanceToolControl2;
        protected MapInfo.Web.UI.WebControls.MapControl MapControl1;
        protected System.Web.UI.WebControls.ListBox ListMintika;
        protected System.Web.UI.WebControls.ListBox ListMahalle;
        protected System.Web.UI.WebControls.ListBox ListSokak;
        protected System.Web.UI.WebControls.Label Label1;
        protected System.Web.UI.WebControls.Label Label2;
        protected System.Web.UI.WebControls.Label Label3;
        protected MapInfo.Web.UI.WebControls.LayerControl LayerControl1;
        protected System.Web.UI.WebControls.Button Button1;
        protected System.Web.UI.WebControls.Panel Panel1;
        protected System.Web.UI.WebControls.Label Label4;
        protected System.Web.UI.HtmlControls.HtmlGenericControl P1;
        protected System.Web.UI.WebControls.Table Table1;
```

```

protected System.Web.UI.WebControls.Calendar Calendar1;
protected System.Web.UI.WebControls.DropDownList cmbburokod;
protected System.Web.UI.WebControls.DropDownList cmbolay;
protected System.Web.UI.WebControls.TextBox txtilce;
protected System.Web.UI.WebControls.TextBox txtkarakol;
protected System.Web.UI.WebControls.DropDownList cmbsuc;
protected System.Web.UI.WebControls.TextBox txtsaat;
protected System.Web.UI.WebControls.DropDownList cmbolaydur;
protected System.Web.UI.WebControls.TextBox txtadresmah;
protected System.Web.UI.WebControls.DropDownList cmbned;
protected System.Web.UI.WebControls.DropDownList cmbolaygun;
protected System.Web.UI.WebControls.TextBox txtadresdaire;
protected System.Web.UI.WebControls.TextBox txtolayno;
protected System.Web.UI.WebControls.Button butkaydet;
protected MapInfo.Web.UI.WebControls.PointSelectionToolControl
PointSelectionToolControl1;
private void Page_Load(object sender, System.EventArgs e)
{
    MapControl1.MapTools.Add(new newOlayTool(Page.Session,this));
    if (!Page.IsPostBack)
    {
        Catalog cg=MapInfo.Engine.Session.Current.Catalog;
        SearchInfo si=MapInfo.Data.SearchInfoFactory.SearchAll();
        si.QueryDefinition.Columns=null;
        IDynamicFeatureCollection fc=cg.Search("mintika",si);
        for (int i=0;i<fc.Count;i++)
        {
            ListMintika.Items.Add(fc[i]["KARAKOL"].ToString());
        }
        OleDbConnection conn;
        OleDbCommand comm;
        conn = new OleDbConnection("Provider = Microsoft.Jet.OLEDB.4.0; Data Source
=D:\\inetpub\\wwwroot\\crimextreme\\Olayx.mdb");
        comm = new OleDbCommand("Select * from Olayx",conn);
        conn.Open();
        OleDbDataAdapter dadap = new OleDbDataAdapter(comm);
        DataTable dt=new DataTable();
        dadap.Fill(dt);
        comm.Dispose();
        conn.Close();
        TableInfoAdoNet ti = new TableInfoAdoNet("Olayx", dt);
        ti.CacheSettings=new CacheParameters(CacheOption.Off);
        SpatialSchemaXY xy = new SpatialSchemaXY();
        xy.XColumn = "X";
        xy.YColumn = "Y";
        xy.NullPoint = "0.0, 0.0";
        BitmapPointStyle olaystil = new
        BitmapPointStyle("PIN232.BMP",BitmapStyles.None,Color.Red,24);
        xy.DefaultStyle = olaystil;
    }
}

```

```

xy.CoordSys =
MapInfo.Engine.Session.Current.CoordSysFactory.CreateFromMapBasicString
("Earth Projection 1,28");
ti.SpatialSchema = xy; //
try
{
MapInfo.Data.Table t= MapInfo.Engine.Session.Current.Catalog.OpenTable(ti);
FeatureLayer fl=new FeatureLayer(t);
MapControl1.Map.Layers.Insert(0,fl);
}
catch(Exception ex)
{
System.Diagnostics.Debug.WriteLine(ex.Message);
}
InitializeComponent();
base.OnInit(e);
}
private void InitializeComponent()
{
this.Button1.Click += new System.EventHandler(this.Button1_Click);
this.ListMintika.SelectedIndexChanged +=
newSystem.EventHandler(this.ListMintika_SelectedIndexChanged);
this.ListMahalle.SelectedIndexChanged += new
System.EventHandler(this.ListMahalle_SelectedIndexChanged);
this.ListSokak.SelectedIndexChanged += new
System.EventHandler(this.ListSokak_SelectedIndexChanged);
this.cmbburokod.SelectedIndexChanged += new
System.EventHandler(this.cmbburokod_SelectedIndexChanged);
this.cmbolay.SelectedIndexChanged += new
System.EventHandler(this.cmbolay_SelectedIndexChanged);
this.butkaydet.Click += new System.EventHandler(this.butkaydet_Click);
this.Load += new System.EventHandler(this.Page_Load);
}
#endregion
private void InfoToolControl1_InfoRetrieved(object sender,
MapInfo.Web.UI.WebControls.InfoToolEventArgs e)
{
Feature f=e.Features[0][0];
System.Diagnostics.Debug.WriteLine(f[0]);
}
public System.Web.UI.WebControls.Panel getolaypanel()
{
return this.Panel1;
}
private void ListMintika_SelectedIndexChanged(object sender, System.EventArgs e)
{
System.Diagnostics.Debug.WriteLine(ListMintika.Items[ListMintika.SelectedIndex].T
oString());
String ss=ListMintika.Items[ListMintika.SelectedIndex].ToString();

```

```

SearchInfo mintika = MapInfo.Data.SearchInfoFactory.SearchWhere("KARAKOL=" + s + s + "");
simintika.QueryDefinition.Columns = null;
MapInfo.Engine.Session.Current.Catalog.SearchForFeature("mintika", simintika);
MapControl1.Map.SetView(f);
MIDatabase miconn = new MIDatabase();
miconn.Open();
MIDatabaseCommand cmd = miconn.CreateCommand();
cmd.CommandText = "select * from mahalle where KARAKOL=" + ss + " order by mahalle_adi";
cmd.Prepare();
IDynamicFeatureCollection fcmah = cmd.ExecuteFeatureCollection();
cmd.Dispose();
miconn.Close();
ListMahalle.Items.Clear();
ListSokak.Items.Clear();
for (int i = 0; i < fcmah.Count; i++)
{
    ListMahalle.Items.Add(fcmah[i]["mahalle_adi"].ToString());
}
ListMahalle.Visible = true;
}

private void ListMahalle_SelectedIndexChanged(object sender, System.EventArgs)
{
    System.Diagnostics.Debug.WriteLine(ListMahalle.Items[ListMahalle.SelectedIndex].ToString());
    String ss = ListMahalle.Items[ListMahalle.SelectedIndex].ToString();
    SearchInfo
    simintika = MapInfo.Data.SearchInfoFactory.SearchWhere("mahalle_adi=" + ss + "");
    simintika.QueryDefinition.Columns = null;
    MapInfo.Engine.Session.Current.Catalog.SearchForFeature("mahalle", simintika);
    MapControl1.Map.SetView(f);
    MIDatabase miconn = new MIDatabase();
    miconn.Open();
    MIDatabaseCommand cmd = miconn.CreateCommand();
    cmd.CommandText = "select ADI from yol where MAHALLE=" + ss + " and (ADI <> ) group by ADI order by ADI";
    cmd.Prepare();
    ListSokak.Items.Clear();
    MIDatabaseDataReader dr = cmd.ExecuteReader();
    while (dr.Read())
    {
        Feature ff = dr.Current;
        ListSokak.Items.Add(ff["ADI"].ToString());
    }
    ListSokak.Visible = true;
    dr.Dispose();
    cmd.Dispose();
    miconn.Close();
}

```

```

}
private void ListSokak_SelectedIndexChanged(object sender, System.EventArgs e)
{
String ss=ListMahalle.Items[ListMahalle.SelectedIndex].ToString();
String yolstr=ListSokak.Items[ListSokak.SelectedIndex].ToString();
MIconn=miconn=new MIconn();
miconn.Open();
MIconn.CreateCommand();
cmd.CommandText="select * from yol where MAHALLE='"+ss+"' and
ADI='"+yolstr+"'";
cmd.Prepare();
IResultSetFeatureCollection fcyollar=cmd.ExecuteFeatureCollection();
cmd.Dispose();
miconn.Close();
MapControl1.Map.SetView(fcyollar);
MapInfo.Engine.Session.Current.Selections.DefaultSelection.Clear();
MapInfo.Engine.Session.Current.Selections.DefaultSelection.Add(fcyollar);
}
private void Button1_Click(object sender, System.EventArgs e)
{
MapControl1.MapTools.CurrentTool =new OlayTool.Toolname;
}
private void cmbburokod_SelectedIndexChanged(object sender, System.EventArgs)
{
cmbolay.Items.Clear();
switch (cmbburokod.SelectedIndex)
{
case 0:
cmbolay.Items.Add("OTO HIRSIZLIĞI");
cmbolay.Items.Add("OTODAN HIRSIZLIK");
break;
case 1:
cmbolay.Items.Add("KAYIP ŞAHIS");
break;
case 2:
cmbolay.Items.Add("AÇIKTAN HIRSIZLIK");
cmbolay.Items.Add("DEPODAN HIRSIZLIK");
cmbolay.Items.Add("EMNİYETİ SUİSTİMAL");
cmbolay.Items.Add("EVDEN HIRSIZLIK");
cmbolay.Items.Add("HAYVAN HIRSIZLIĞI");
cmbolay.Items.Add("HIRSIZLIK");
cmbolay.Items.Add("KASA HIRSIZLIĞI");
cmbolay.Items.Add("KÖMÜRLÜKTEN HIRSIZLIK");
cmbolay.Items.Add("MABETTEN HIRSIZLIK");
cmbolay.Items.Add("NİTELİKLİ HIRSIZLIK");
cmbolay.Items.Add("RESMİ DAİREDEN HIRSIZLIK");
cmbolay.Items.Add("İŞ YERİNDEN HIRSIZLIK");
break;
case 3:

```

```

cmbolay.Items.Add("4230 S.K.M.");
cmbolay.Items.Add("DİĞER SUÇLAR");
cmbolay.Items.Add("KENDİ KENDİNİ YARALAMA");
cmbolay.Items.Add("KIZ KADIN KAÇIRMA");
cmbolay.Items.Add("YARALAMA");
cmbolay.Items.Add("ZORLA IRZA GEÇME TASSADI");
cmbolay.Items.Add("ÖLDÜRME");
cmbolay.Items.Add("İNTİHAR");
break;
case 4:
cmbolay.Items.Add("FUHUŞ");
cmbolay.Items.Add("FUHUŞA ARACILIK");
cmbolay.Items.Add("FUHUŞA ARACILIK VE FUHUŞ");
cmbolay.Items.Add("KUMAR");
break;
case 5:
cmbolay.Items.Add("6136 S.K.M.");
cmbolay.Items.Add("DARP");
cmbolay.Items.Add("DİĞER SUÇLAR");
cmbolay.Items.Add("GASP");
cmbolay.Items.Add("GASP İDDİASI");
cmbolay.Items.Add("GÖREVLİ MEMURA MUKAVEMET");
cmbolay.Items.Add("HAKARET VE TEHDİT");
cmbolay.Items.Add("IZRAR");
cmbolay.Items.Add("KUNDAKLAMA");
cmbolay.Items.Add("KÜÇÜK YAŞTA KIZ KAÇIRMA");
cmbolay.Items.Add("MEMURİYET ÜNV.GASPI");
cmbolay.Items.Add("MESKEN MASUNİYETİNİ İHLAL");
cmbolay.Items.Add("OTO KURSUNLAMA");
cmbolay.Items.Add("POLİS SÜSÜ VERMEK");
cmbolay.Items.Add("SARKINTILIK");
cmbolay.Items.Add("TEHDİT");
cmbolay.Items.Add("ZORLA PARA ALMA İDDİASI");
cmbolay.Items.Add("İCRAİ REZALET ÇIKARMAK");
cmbolay.Items.Add("İŞYERİ KURŞUNLAMA");
break;
}
}
private void cmbolay_SelectedIndexChanged(object sender, System.EventArgs e)
{
cmbsuc.Items.Clear();
switch (cmbolay.SelectedValue)
{
case "4320 S.K.M.":
cmbsuc.Items.Add("DARP ETMEK SURETİYLE");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "6136 S.K.M.":
cmbsuc.Items.Add("ATEŞLİ SİLAHLA");

```

```

cmbsuc.Items.Add("BEYLİK TABANCASI İLE");
cmbsuc.Items.Add("DARP EDEREK");
cmbsuc.Items.Add("DİĞERLERİ");
cmbsuc.Items.Add("KURU SIKI TABANCA");
cmbsuc.Items.Add("UZUN NAMLULU SİLAH");
break;
case "AÇIKTAN HIRSIZLIK":
cmbsuc.Items.Add("İNŞAATTAN HIRSIZLIK");
cmbsuc.Items.Add("KALDIRIMCILIK SURETİYLE");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "DARP":
cmbsuc.Items.Add("DARP EDEREK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "DEPODAN HIRSIZLIK":
cmbsuc.Items.Add("ANAHTAR UYDURARAK");
cmbsuc.Items.Add("KAPI ZORLAYARAK");
break;
case "DOLANDIRICILIK":
cmbsuc.Items.Add("ÜÇKAĞITÇILIK");
cmbsuc.Items.Add("JOPÇULUK");
break;
case "DİĞER SUÇLAR":
cmbsuc.Items.Add("BANKA SOYGUNU");
cmbsuc.Items.Add("DARP ETMEK SURETİYLE");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "EMNİYETİ SUİSTİMAL":
cmbsuc.Items.Add("AÇKAPACILIK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "EVDEN HIRSIZLIK":
cmbsuc.Items.Add("ANAHTAR UYDURARAK");
cmbsuc.Items.Add("ASMA KİLİT KIRARAK");
cmbsuc.Items.Add("AÇIK CAMDAN GİREREK");
cmbsuc.Items.Add("BALKONCU");
cmbsuc.Items.Add("CAM KIRMAK SURETİYLE");
cmbsuc.Items.Add("CAM SÖKEREK");
cmbsuc.Items.Add("ELİYLE ZORLAYARAK AÇMAK");
cmbsuc.Items.Add("KAPI ZORLAYARAK");
cmbsuc.Items.Add("SERT BİR CİSİM İLE YÜKLENEREK");
cmbsuc.Items.Add("TEKME İLE KIRARAK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "FUHUŞ":
cmbsuc.Items.Add("ANLAŞMA USULÜ");
break;
case "FUHUŞA ARACILIK":

```



```

cmbsuc.Items.Add("ANLAŞMA USULÜ");
break;
case "FUHUŞA ARACILIK VE FUHUŞ":
cmbsuc.Items.Add("ANLAŞMA USULÜ");
break;
case "GASP":
cmbsuc.Items.Add("BIÇAK TEHDİDİ İLE");
cmbsuc.Items.Add("DARP EDEREK");
cmbsuc.Items.Add("SİLAH TEHDİDİ İLE");
cmbsuc.Items.Add("ŞAHISTAN GASP");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "GASP İDDİASI":
cmbsuc.Items.Add("KURU SIKI TABANCA");
cmbsuc.Items.Add("SPREY SIKARAK");
cmbsuc.Items.Add("SİLAH TEHDİDİ İLE");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "GÖREVLİ MEMURA MUKAVEMET":
cmbsuc.Items.Add("BIÇAK TEHDİDİ İLE");
cmbsuc.Items.Add("DARP EDEREK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "HAKARET VE TEHDİT":
cmbsuc.Items.Add("BIÇAK TEHDİDİ İLE");
cmbsuc.Items.Add("DARP EDEREK");
break;
case "HAYVAN HIRSIZLIĞI":
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "HIRSIZLIK":
cmbsuc.Items.Add("ANAHTAR UYDURARAK");
cmbsuc.Items.Add("KALDIRIMCILIK SURETİYLE");
cmbsuc.Items.Add("KAPI ZORLAYARAK");
cmbsuc.Items.Add("İNŞAATTAN HIRSIZLIKSIZLIK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "IZRAR":
cmbsuc.Items.Add("DARP EDEREK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "KALDIRIMCILIK":
cmbsuc.Items.Add("ÇANTACILIK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "KAPKAÇCILIK":
cmbsuc.Items.Add("AÇKAPACILIK");
cmbsuc.Items.Add("ÇANTACILIK");
cmbsuc.Items.Add("DİĞERLERİ");

```

```

break;
case "KASA HIRSIZLIĞI":
cmbsuc.Items.Add("İNŞAATTAN HIRSIZLIK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "KAYIP ŞAHIS":
cmbsuc.Items.Add("ERKEK");
cmbsuc.Items.Add("KADIN");
cmbsuc.Items.Add("ERKEK ÇOCUĞU");
cmbsuc.Items.Add("KIZ ÇOCUĞU");
break;
case "KENDİ KENDİNİ YARALAMA":
cmbsuc.Items.Add("KESİCİ DELİCİ ALETLE");
break;
case "KIZ KADIN KAÇIRMA":
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "KUMAR":
cmbsuc.Items.Add("ANLAŞMA USULÜ");
break;
case "KUNDAKLAMA":
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "KÖMÜRLÜKTEN HIRSIZLIK":
cmbsuc.Items.Add("ASMA KİLİT KIRARAK");
break;
case "KÜÇÜK YAŞTA KIZ KAÇIRMAK":
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "MABETTEN HIRSIZLIK":
cmbsuc.Items.Add("ANAHTAR UYDURARAK");
break;
case "MEMURİYET ÜNV.GASPI":
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "MESKEN MASUNİYETİNİ İHLAL":
cmbsuc.Items.Add("DARP EDEREK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "NİTELİKLİ HIRSIZLIK":
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "OTO HIRSIZLIĞI":
cmbsuc.Items.Add("ANAHTAR UYDURARAK");
cmbsuc.Items.Add("AÇIK KAPIDAN GİREREK");
cmbsuc.Items.Add("DÜZ KONTAK YAPARAK");
cmbsuc.Items.Add("OTO CAMINI KIRARAK");
cmbsuc.Items.Add("DİĞERLERİ");
break;

```

```

case "OTO KURSUNLAMA":
cmbsuc.Items.Add("BEYLİK TABANCASI İLE");
break;
case "OTODAN HIRSIZLIK":
cmbsuc.Items.Add("ANAHTAR UYDURARAK");
cmbsuc.Items.Add("BAGAJDAN HIRSIZLIKSIZLIK");
cmbsuc.Items.Add("CAM FİTİLİNİ SÖKEREK");
cmbsuc.Items.Add("LASTİK VE CANT ÇALARAK");
cmbsuc.Items.Add("OTO CAMINI KIRARAK");
cmbsuc.Items.Add("SPATULA KULLANARAK");
cmbsuc.Items.Add("TORNAVİDA KULLANARAK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "POLİS SÜSÜ VERMEK":
cmbsuc.Items.Add("POLİS SÜSÜ VERMEK");
break;
case "RESMİ DAİREDEN HIRSIZLIK":
cmbsuc.Items.Add("AÇIK CAMDAN GİREREK");
cmbsuc.Items.Add("AÇIK KAPIDAN");
cmbsuc.Items.Add("DİĞERLERİ");
cmbsuc.Items.Add("PENCERE DEMİRİNİ SÖKEREK");
cmbsuc.Items.Add("TEKME İLE KIRARAK");
break;
case "SAHTECİLİK":
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "SARKINTILIK":
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "TEHDİT":
cmbsuc.Items.Add("BIÇAK TEHDİDİ İLE");
cmbsuc.Items.Add("SİLAH TEHDİDİ İLE");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "YANKESİCİLİK":
cmbsuc.Items.Add("CEPÇİLİK");
cmbsuc.Items.Add("MUSLUKÇULUK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "YARALAMA":
cmbsuc.Items.Add("ATEŞLİ SİLAHLA");
cmbsuc.Items.Add("DARP ETMEK SURETİYLE");
cmbsuc.Items.Add("KESİCİ DELİCİ ALETLE");
cmbsuc.Items.Add("KÜT CİSİMLE VURARAK");
break;
case "ZORLA IRZA GEÇME TASADDİ":
cmbsuc.Items.Add("DARP ETMEK SURETİYLE");
cmbsuc.Items.Add("DİĞERLERİ");
break;

```

```

case "ZORLA PARA ALMA İDDİASI":
cmbsuc.Items.Add("BIÇAK TEHDİDİ İLE");
cmbsuc.Items.Add("SİLAH TEHDİDİ İLE");
cmbsuc.Items.Add("DARP EDEREK");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "ÖLDÜRME":
cmbsuc.Items.Add("ATEŞLİ SİLAHLA");
cmbsuc.Items.Add("KESİCİ DELİCİ ALETLE");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "İCRAİ REZALET ÇIKARMAK":
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "İNTİHAR":
cmbsuc.Items.Add("ASI SURETİYLE");
cmbsuc.Items.Add("DİĞERLERİ");
break;
case "İŞ YERİNDEN HIRSIZLIK":
cmbsuc.Items.Add("ANAHTAR UYDURARAK");
cmbsuc.Items.Add("ASMA KİLİT KIRARAK");
cmbsuc.Items.Add("AÇIK KAPIDAN");
cmbsuc.Items.Add("CAM KIRMAK SURETİYLE");
cmbsuc.Items.Add("CAM SÖKEREK");
cmbsuc.Items.Add("HAVALANDIRMA BOŞ. GİREREK");
cmbsuc.Items.Add("KALDIRIMCILIK SURETİYLE");
cmbsuc.Items.Add("KAPI ZORLAYARAK");
cmbsuc.Items.Add("PENCERE DEMİRİNİ SÖKEREK");
cmbsuc.Items.Add("SERT BİR CİSİM İLE YÜKLENEREK");
cmbsuc.Items.Add("TEKME İLE KIRARAK");
break;
case "İŞYERİ KURŞUNLAMA":
cmbsuc.Items.Add("BEYLİK TABANCASI İLE");
cmbsuc.Items.Add("DİĞERLERİ");
break;
}

```

APPENDIX B

NewOlayTool.aspx File:

```
using System;
using System.Web;
using MapInfo.Engine;
using MapInfo.Data;
using System.Data.OleDb;
using MapInfo.Mapping;
using MapInfo.Web.UI.WebControls;
using MapInfo.Geometry;
using System.Web.SessionState;
namespace crimeXtreme
{
    /// Summary description for newOlayTool.
    public class newOlayTool:MapTool
    {
        private string _clientStartMethod;
        private string _clientStopMethod;
        private string _clientCodeSource = null;
        private string _name;
        public static readonly string Toolname = "newOlayTool";
        public HttpSessionState sess;
        private WebForm1 parentfrm;
        public newOlayTool(HttpSessionState hsess,WebForm1 wf )
        {
            sess=hsess;
            parentfrm=wf;
            ClientStartMethod = "MapInfoWebRectangleStart";
            ClientStopMethod = "MapInfoWebRectangleStop";
        }
        {
            get { return _name; }
            set { _name = value; }
        }
        // Name of the client side method to set up mouse event handlers for drawing
        {
            get { return _clientStartMethod; }
            set { _clientStartMethod = value; }
        }
        // Name of the client side method to cancel the mouse event handlers
        public override string ClientStopMethod
        {
            get { return _clientStopMethod; }
            set { _clientStopMethod = value; }
        }
    }
}
```

```

public override string ClientCodeSource
{
    get { return _clientCodeSource; }
    set { _clientCodeSource = value; }
}
// Url of the cursor image when this tool is active public override string CursorUrl
{
    get {return ""; }
    set {; }
}
// This method sets the zoom value
public override void Execute(string dataString,
System.Collections.ArrayList arrayList,
MapInfo.Mapping.Map map)
{
    // Extract points from the string
    System.Drawing.Point [] points =
base.ExtractPoints(dataString);
    MapInfo.Geometry.DPoint from;
    map.DisplayTransform.FromDisplay(points[0], out from);
    CoordinateTransform ctrans=new
CoordinateTransform(map.GetDisplayCoordSys(),MapInfo.Engine.Session.Current.
CoordSysFactory.CreateFromMapBasicString("Earth Projection 1,28"));
    MapInfo.Geometry.DPoint to=ctrans.CoordSys1ToCoordSys2(from);
    System.Diagnostics.Debug.WriteLine(to.x+":"+to.y);
    sess.Add("olaykoor",to);
    parentfrm.getmc().Map.Invalidate();
    OleDbConnection conn;
    OleDbCommand comm;
    conn = new OleDbConnection("Provider = Microsoft.Jet.OLEDB.4.0; Data Source =
C:\\inetpub\\wwwroot\\crimextreme\\Olayx.mdb");
    comm = new OleDbCommand("insert into olayx (x,y) values
("+to.x.ToString().Replace(",",".")+"","+to.y.ToString().Replace(",",".")+"",conn);
    conn.Open();
    comm.ExecuteNonQuery();
    comm.Dispose();
    conn.Close();
}
}
}

```