SEARCHING THE NEW LOCATIONS AND DETERMINING THE LATEST STATUS OF FIRE STATIONS WITH GIS IN ISTANBUL

Turan Erden and Mehmet Zeki Coşkun
Istanbul Technical University[1]

Key words: *GIS, location-allocation problem, fire stations, point locations, arc-node data model.*

Abstract

Coverage problems find applications in the location of emergency facilities, such as fire stations, where it is desirable that every possible emergency must be covered within a fixed number of minutes of response times, or when the objective is to minimize the worst-case response time, to the furthest possible point. These problems are referred to as *location-allocation* problems, because two types of decisions: where to locate, and how to allocate demand for service to the central facilities. This typical location-allocation problem might involve the selection of location for fire stations. Here GIS can be used to find locations for fire stations that result in better response times to emergencies.

The main mission of fire department of Istanbul is to reach to the disaster point within less than five minutes. Fire department execute its mission with 59 fire stations, 2724 personnel, and 310 vehicles now. The fire stations are too insufficient by thinking of the city of Istanbul with the population of the 15 million people over. It has to be searched new locations for the fire stations in Istanbul. Exploring the appropriate locations (i.e. fire stations) is the problem of finding appropriate point location.

In this study, firstly, the map of Istanbul which is 1/5000 scale is arranged in point of our analyzing. Secondly, data are prepared for a GIS program by leaving the unnecassary data. Road information (highways, main roads, emergency road) and existing fire stations will be pointed out on a digital map on the computer. Arc-node topology on ArcGIS software will be constructed with above mentioned data. This is an obligatory for making the network analysis.

In the scope of this study, moreover, a survey which is called *fire service survey form* is being conducted. The existing fire stations in Istanbul in the point of existing status of view are being investigated with this survey. Data of survey are stored in the ArcGIS software. This survey is very important because of giving the latest status of fire stations for emergency management activities of Istanbul.

Finally, in the selected part of İstanbul city, new locations of fire stations are investigated for giving the best service to the domination area. Moreover, the latest status of fire department

[1] Istanbul Technical University, Civil Engineering Faculty, Geodesy and Photogrammetry Engineering Department, 34469 Maslak-ISTANBUL-TURKEY

of Istanbul is being determined. This is an inevitable for emergency planning activities in the point of view of city of Istanbul.

Introduction

The effective use of information is getting importance because our age is information age. The information in our environment are increasing very rapidly. Due to the size and intensity of information, they become excessive and complex. These information must be managed by organizing carefully. The consept of Information System appear as the result of this need. A kind of Information Systems which have wide area applications is Geographic Information System. It is provided for the best product from information by Geographic Information System (GIS) (Davis, 1996; Star and Estes, 1990).

Healhty, culture, environment, life, and security procedures which everybody can meet can be performed by GIS. For instance, at the fire cases, reaching by an fire brigade to fire case area at the shortest time and making the first aid depend on a lot of parameters. To reach fire case area, precautions which take into consideration for transportation network, road information, the traffic intensity, the location of the hospital, and life safety must be organised efficiently. The more important thing than the above information is to best evaluate the 'time' information. GIS can help gathering these types of information. (Yomralıoglu, 2006).

Fire risks in urban areas have undoubtedly increased over the years and the rising cost of fire losses would seem to indicate that they are increasing at a greate rate. With the cities growing in size and complexity day by day need to be managed more and more efficiently. The above intances require for decision making rapidly and vigorously (Erden, 2001).

In this study, with over 15 billion inhabitans, the city of Istanbul is taken into consideration (Figure 1).

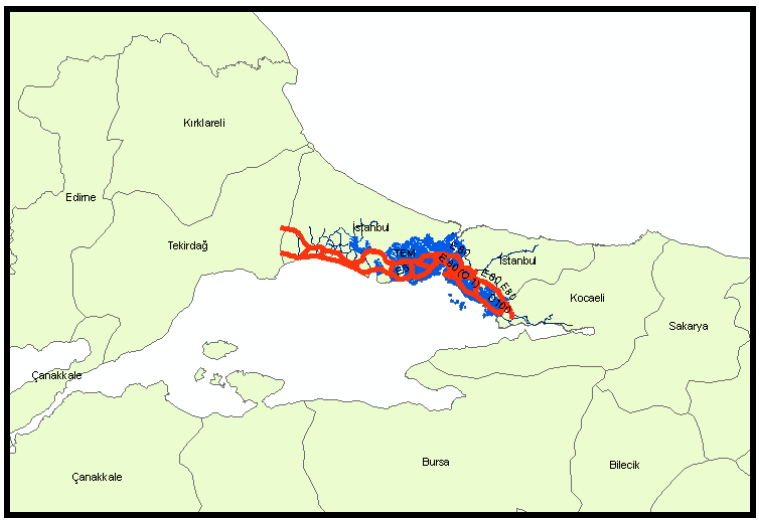

Figure 1. Study Area

The Information of Fire Cases in Istanbul

From 1994 to 2005 the number of fire cases is increased very rapidly in Istanbul (Table 1). Especially it is unavoidable with expanding the settlement area of it. This requires becoming well-prepared against fire cases in Istanbul (Fire Statistics, 2005).

Table 1. The Fire Cases in Istanbul

Years	The Number of Fire Cases
1994	12769
1995	14788
1996	15308
1997	15940
1998	19210
1999	19567
2000	20608
2001	20647
2002	18108
2003	21697
2004	22386
2005	22176

The Latest Status of Fire Brigade of Istanbul

The Information About Fire Brigade of Istanbul

Fire brigade of Istanbul was founded in 1774 based on the valuntary organization. In 1997, fire brigade was changed into fire brigade department of Istanbul. The fire brigade of Istanbul is one of the five oldest fire brigades in the world based on founded dates.

Istanbul fire brigade has the diffuculties because of the fact that Istanbul is the trade, industry and tourism center; it has transportation diffuculties and narrow streets, because of the strategical location of Boshphorus, and excessive immigration. Istanbul fire brigade makes an effort to reach the number of personel in the world standards. The Department of Fire Brigade of Istanbul is divided into five directorate, which is named are:

- Center Brigade
- The District of Istanbul Brigade
- The District of Anatolian Brigade
- The District of Bosphorus Brigade
- The Disaster Coordination Center of Istanbul

The main mission of fire department of Istanbul is to reach to the disaster point within less than five minutes. Fire department execute its mission with 59 fire stations, 2724 personnel, and 322 vehicles now (Table 2, 3, and 4). The fire stations are too insufficient by thinking of the city of Istanbul with the population of the 15 million people over (Fire Statistics, 2005).

Table 2. The Personnel Information of Fire Brigade

Directorate	**Official**	**Worker**	**Temporary Worker**	**Contr Pers.**	**Repr. official**	**Duty service**	**Overall**
Center Brigade	127	52		5	2	17	203
The District of Istanbul	532	602	170			180	1484
The District of Anatolian	404	354	81			134	973
The Disaster Coordination Center	6	1				57	64
Overall	1069	1009	251	5	2	388	2724

Table 3. The Vehicle Information of Fire Brigade

	Official Stock Vehicles															
Directorate	Shaft	Otomobile	Multi-purpose	Emergency vehicle	Mobile tube vehicle	Mobile lubrication vehicle	Van	Rescue Truck	Ladder	Minibus	Forest Vehicle	Water Tank	Truck with crane	Foam tower	Vehicle with air-bag	Live-broadcast vehicle	Total
Center Brigade		10				1	3			6							20
The District of Istanbul	23	2	17	6	1		7	4	20	2	4	70	1	1	2		160
The District of Anatolian	12	2	13	4			5	2	13	3	10	32	1	1			98
The Disaster Coordination Center		1														1	
Overall	35	15	30	10	1	1	15	6	33	11	14	102	2	2	2	1	280

Table 4. The Vehicle Information of Fire Brigade (cont.)

	Hired Vehicles					
Directorate	Otomobile	Van	Minibus	Water Tank	Total	Overall
Center Brigade	3	4	3		10	30
The District of Istanbul	6	11	1	4	22	182
The District of Anatolian	3	4	1	1	9	107
The Disaster		1				

Coordination Center						
Overall	12	20	5	5	42	322

In this study, 39 fire stations are taken into consideration and all analysis performed based on this information (Figure 2).

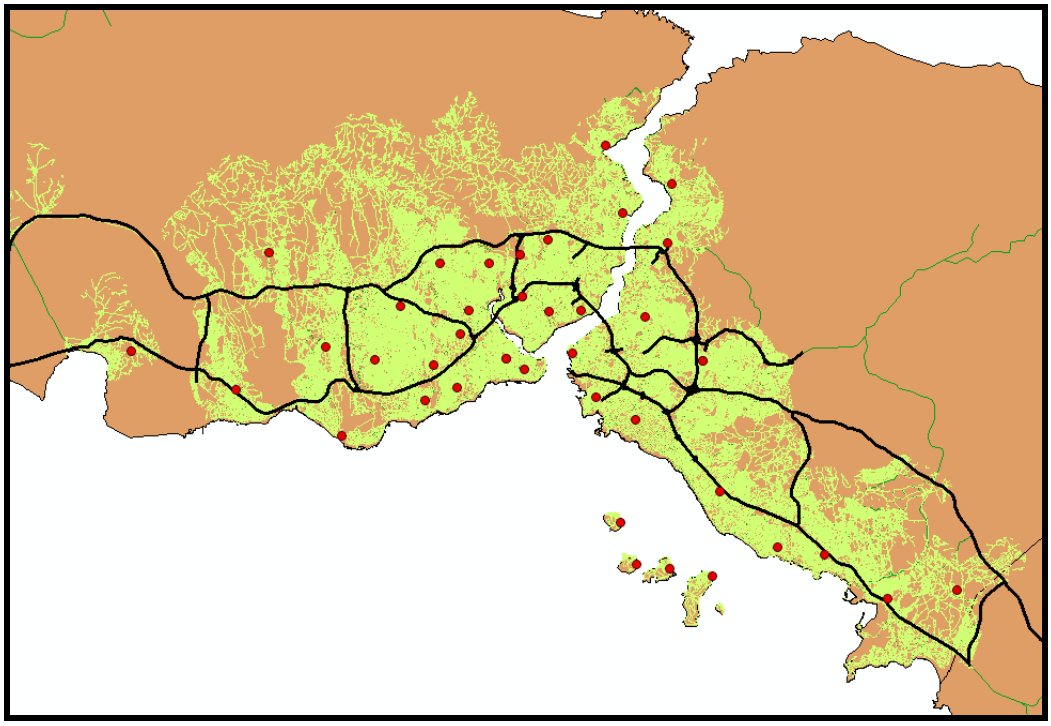

Figure 2. Fire Brigades in Study Area

Point Location Finding

Coverage problems find applications in the location of emergency facilities, such as fire stations, where it is desirable that every possible emergency must be covered within a fixed number of minutes of response times, or when the objective is to minimize the worst-case response time, to the furthest possible point. These problems are referred to as *location-allocation* problems, because two types of decisions: where to locate, and how to allocate demand for service to the central facilities. This typical location-allocation problem might involve the selection of location for fire stations. Here GIS can be used to find locations for fire stations that result in better response times to emergencies (Longley et al, 2001)

Preparing Road Data for Analysis

In this study, firstly, the map of Istanbul which is 1/5000 scale is arranged in point of our analyzing. Secondly, data are prepared for a GIS program by leaving the unnecassary data. Road information (local roads, main roads, highways) and existing fire stations will be pointed out on a digital map on the computer. Arc-node topology on ArcGIS software will be constructed with above mentioned data. This is an obligatory for making the network analysis.

Road data are constituted as vertex and edge data for performing network analysis correctly. Especially polylines are divided into vertices from one node to another node. Arc-Node data model is formed by performing it.

Analysis data are formed as personel geodatabase with the name of fire brigade analysis. And under this there is a personel geodatabase feature dataset with feature classes for using this analysis (Figure 3).

Figure 3. Geodatabase structure

Road types are categorized with three groups: local roads, main roads and highways. After that; road data are assigned to certain speed values in order to obtain the realistic results (Table 5). The road speeds of 20, 40 and 80 km/h are assigned to local roads, main roads and highways respectively.

Table 5. The Relation Between Road Types and Their Speeds

Road Types	Road Speeds (km/h)
Local Roads	20
Main Roads	40
Highways	80

In addition to road types and their speeds data, roads also have information with ID, Name, Shape Length, Width, FT_Minutes and TF_Minutes (Figure 4).

Attributes of local_roads

OBJECTID*	Shape*	ID	NAME	LENGTH	TYPE	WIDTH	WIDTH_CATE	TYPE_WIDTH	Shape_Length	FT_MINUTES	TF_MINUTES
120	Polyline	13517	18.Sokak	269	1	9	7-15	1_7-15	9.973756	0.029921	0.029921
121	Polyline	13517	18.Sokak	269	1	9	7-15	1_7-15	3.276886	0.009831	0.009831
122	Polyline	13517	18.Sokak	269	1	9	7-15	1_7-15	32.522745	0.097568	0.097568
123	Polyline	13517	18.Sokak	269	1	9	7-15	1_7-15	27.919180	0.083758	0.083758
124	Polyline	13517	18.Sokak	269	1	9	7-15	1_7-15	37.474016	0.112422	0.112422
125	Polyline	13517	18.Sokak	269	1	9	7-15	1_7-15	38.334053	0.115002	0.115002
126	Polyline	13517	18.Sokak	269	1	9	7-15	1_7-15	40.387868	0.121164	0.121164
127	Polyline	13517	18.Sokak	269	1	9	7-15	1_7-15	19.880454	0.059641	0.059641
128	Polyline	13517	18.Sokak	269	1	9	7-15	1_7-15	26.536496	0.079609	0.079609
129	Polyline	16646	Kirserdar Sok	2019	1	8	7-15	1_7-15	28.543267	0.085630	0.085630
130	Polyline	16646	Kirserdar Sok	2019	1	8	7-15	1_7-15	102.848641	0.308546	0.308546
131	Polyline	16646	Kirserdar Sok	2019	1	8	7-15	1_7-15	26.503800	0.079511	0.079511
132	Polyline	16646	Kirserdar Sok	2019	1	8	7-15	1_7-15	184.600508	0.553802	0.553802
133	Polyline	16646	Kirserdar Sok	2019	1	8	7-15	1_7-15	28.319430	0.084958	0.084958
134	Polyline	16646	Kirserdar Sok	2019	1	8	7-15	1_7-15	76.910522	0.230732	0.230732
135	Polyline	16646	Kirserdar Sok	2019	1	8	7-15	1_7-15	30.304368	0.090913	0.090913
136	Polyline	16646	Kirserdar Sok	2019	1	8	7-15	1_7-15	38.828012	0.116484	0.116484

Record: 1 Show: All Selected Records (0 out of *2000 Selected.) Options

Figure 4. Attributes of local_roads

Constituting Network Dataset Based on Road Data

A network is a set of features that participate in a linear system such as a utility network, stream network or road network. Network are well-suited for tracing analysis (Zeiler, 1999). Constituting the Network Dataset is necessary for analysing network issues.

Local roads, main roads and highways are chosen for constituting the Network Dataset in ArcGIS environment. End-point connectivity are used in analysis procedure. Global turns are taken into consideration for turn data. Drivetime is used for impedance for the Network Dataset according to FT_Minutes and TF_Minutes which are determined for every road types. Drivetime impedances are specified the attributes for the Network Dataset. In this study, road directions are not taken into account.

Performing Analysis

With ArcGIS Network Analyst, service areas which are required are found around any location on a network. A network service area is a region that encompasses all accessible streets (that is, streets that are within a specified impedance). For instance, the 7.5-minute service area for a point includes all the streets that can be reached within 7.5 minutes from that point (ArcGIS Help, 2006).

Service areas created by Network Analyst also help evaluate accessibility. Concentric service areas show how accessibility varies with impedance. Once built, service areas can be used to identify how many people, land, or anything else is within the neighborhood.

In this study, Service areas are determined for 39 fire stations. Service area regions are obtained for every fire station with 2.5, 5 and 7.5-minute drive times respectively. All road networks, settlement area of city, the locations of fire stations are taken into consideration in analysis (Figure 5)

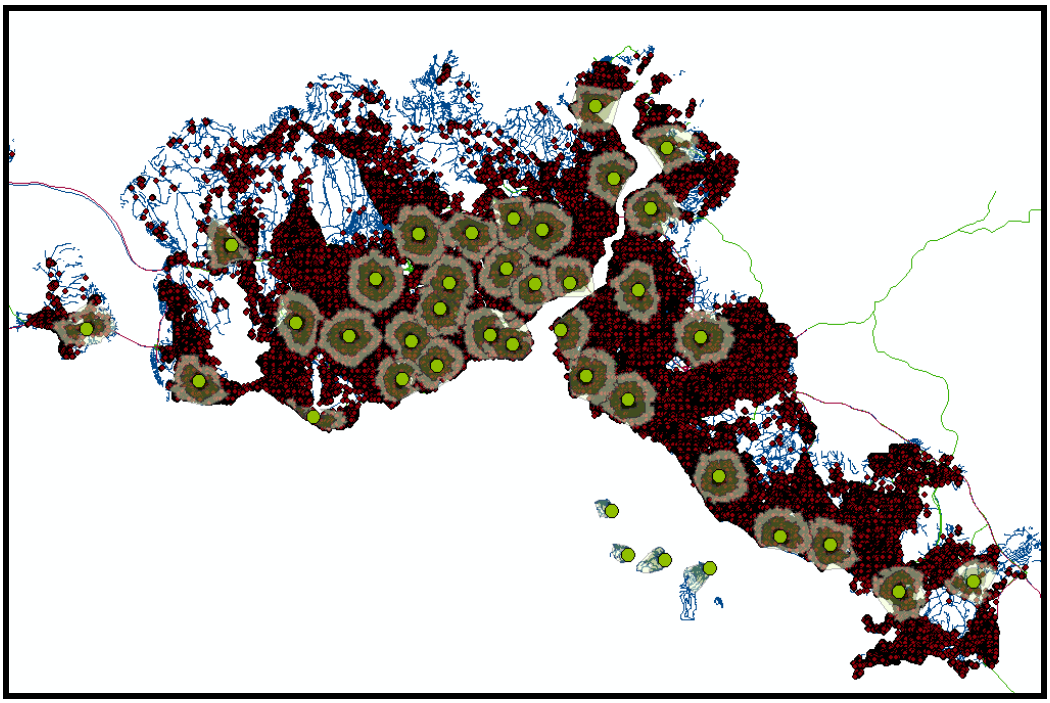

Figure 5. Service Area Determination for Existing Fire Stations

It is showed that fire stations is insufficient acording to settlement area of the city. Searching new locations for fire stations are unavoidable. For this purpose, according to 2.5, 5 and 7.5-minute drive times, new locations of fire stations are located based on existing locations of fire stations (Figure 6). In this study, the domination areas of new locations of fire stations are determined by making total drive times minimum.

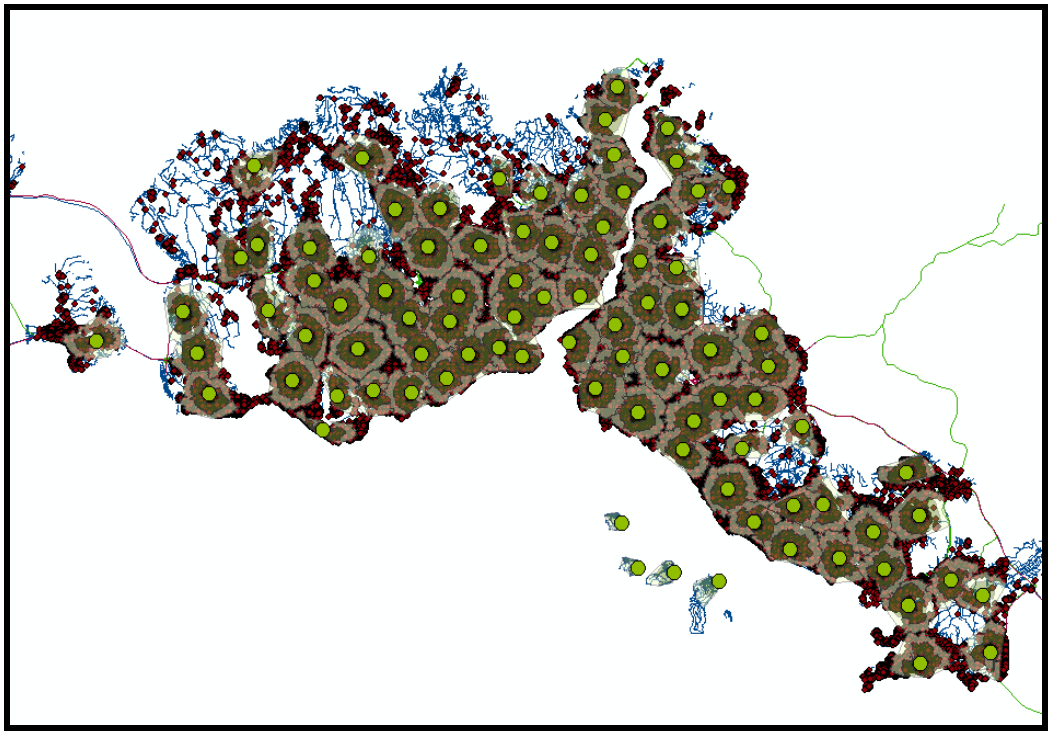

Figure 6. Domination Areas of Old and New Locations of Fire Stations

Conclusion

In this study, firstly, the latest information about fire birigades are given. In addition to this, rapid increasing in fire cases from 1994 to 2005 shows the seriousness of the situation. Moreover, expanding the settlement area of Istanbul year by year show the necessity of determining the new locations of fire stations. In this study new locations of fire stations are investigated for giving the best service to the domination area in settlement area of Istanbul. It is clear that the number of fire stations is too insufficient. It is seen that the necessity of adding 39 new fire station to existing 39 fire stations. This is an inevitable for emergency planning activities in the point of view of city of Istanbul.

Refernces

ArcGIS Desktop Help, 2006. http://webhelp.esri.com/arcgisdesktop/9.1/

Davis, B, 1996. *GIS: A Visual Approach*. OnWord Press. Santa Fe. USA.

Erden, T, 2001. *Emergency Planning in Metropolitan Cities by GIS*, Master Thesis, I.T.U. Institute of Science and Technology, Istanbul.

Fire Statistics, 2005. *Istanbul Metropolitan Municipality Department of Fire Brigade Press*, Istanbul

Longley, P., A., Goodchild, M., F., Magure, D., J., Rhind, D., W., (2001). *Geographic Information System and Sciences*, John Wiley &Sons, LTD.

Star., J., Estes, J. 1990. *Geographical Information Systems: An Introduction*, Printice Hall, New Jersey.

Yomralıoglu, T. 2000. *GIS: Fundamental Terms and Applications.* Istanbul.

Zeiler, M., 1999. *Modeling Our World*, The ESRI Guide to Geodatabase Design, 380 New York Street, Redlands, California.

Author Biography

Turan Erden was born in Tekirdağ in 1977. He is graduated from ITU-Geodesy and Photogrammetry Engineering in 1998, then took the MsC degree in 2001. He has been working as a research assistant in Surveying Techniques Division in Geodesy and Photogrammetry Engineering Department since 1999. He is a doctorate student now. He is interested in GIS, Emergency Planning and related subjects.

Mehmet Zeki Coşkun was born in Malatya in 1964. He is graduated from ITU-Geodesy and Photogrammetry Engineering Department, then took his MsC degree in 1992, and took PhD degree in 1998. He has been an assistant professor in Surveying Tecniques Division since 2000. He is interested in GPS, GIS, Mobile GIS, Emergency Planning, and software development.