A Network Analyst Design For Providing The Shortest Intervention Time Of The Emergency Vehicles As Like Ambulance And Fire Fighting To The Emergency Events , A Case Study Konya

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SUMMARY

With the growing population in urban center traffic trouble is getting more important issue for human safety. Because of intensive traffic flow, problems about planning of the streets and wrong parked vehicles are causing delays when emergency situations as like fire, traffic accidents and ambulances. When emergency services are delayed, fatal results are occurs within seconds. This situation is shows that emergency vehicles must know all attribute information about road segments.

In this study for Konya province, a network analyst is created for determine shortest and most open ways. For providing this, there are some attribute information about road segments are integrated with the road vector data. In this project the aim is not only determine the shortest way to the emergency area, also determine the most open ways for intervention in the shortest time. For this purpose, narrow streets, car parking streets for both side, intensive traffic flow streets which can block the emergency vehicles way, are integrated into network analyst as an attribute. Therefore, the shortest and the most appropriate ways can be determined for the emergency vehicles. This study shows how these attribute information are gathered and integrated into network analyst. As a result with network analyst, address based emergency events can be used in this project in a few seconds. An example applied for Konya province to show the results and findings are shared.

1. INTRODUCTION

Due to the multi-objective nature of many optimization problems, mainly in the area of transportation planning, in recent years there has been an increase in research on multi-objective shortest path problem (SPs), with goals of relevant interest, like the minimization of cost, time, risk and unreliability. For a review of multi-objective SPs the reader is referred to (J. Current, 1986). When a budget of various resources is given, some objectives related to the corresponding resources can be treated as constraints for the problem, thus obtaining the Resource Constrained SP, for which an efficient algorithm is presented in (J.E. Beasley, 1989)(P.Modesti, 1998).

In urban transportation study, the urban region is divided into small, relatively homogeneous areas called zones. The zone size depends on the density of development, so that activity levels per zone are relatively similar. A journey between zones is called trip. The urban region thus can be represented as networks, where the term ‘‘network’’ is used to represent both a mathematical representation (known as a graph) and its physical structure. The definition of network is a set of nodes and a set of links connecting these nodes, where nodes are representation of centroids or intersections, and links are representation of centroid connectors or streets (Meng Xu,2009).

Most transportation systems are networks. They can range from the physical networks of highways and rail lines to the more ephemeral networks of sea-lanes and air routes. Regardless of their physical nature, all of these can be notionally represented as constellations of nodes and connecting links which can be analyzed by various techniques, including geographic information systems (GIS). However, while most transportation movements travel over some sort of network, many of these shipments are generated or received by sites that are not directly on the network itself. When analyzing a transportation network which features off-network locations for trip origins and destinations, it may be necessary to go beyond the network and directly examine these hinterlands. (C. Upchurch,2004).

Figure 1: Problems for the emergency vehicles

Networks are very important in determining routes in urban area. Especially in emergency events, it is vital to reach to the event area immediately. In urban area there are some obstacles which make vehicles slower as like traffic flow, street width, crossroads, and rail cross roads, speed limiters and street structure. Normally, it is impossible to change the structure of streets. Because of this, vehicles must find the fastest way to reach to the emergency event area.

For the purpose of predicting the obstacles and providing emergency vehicles to reach emergency area as soon as possible, in this study, a network analyst has realized by considering obstacles and reasons which makes vehicles slower.

2. MATERIAL METHOD

Application has been realized in Selcuklu district in Konya city. Selcuklu city has large urban and industry areas. Because of this, Selcuklu district has a densely population. This status has causing intensive traffic flow. In Konya city, most of the traffic accidents has occurs in Selcuklu district. Including industry area and hospitals, it needs to be configured for emergency events. Especially for fire-fighting cars and ambulances, intervention time is being most important object for urban safety and human life.

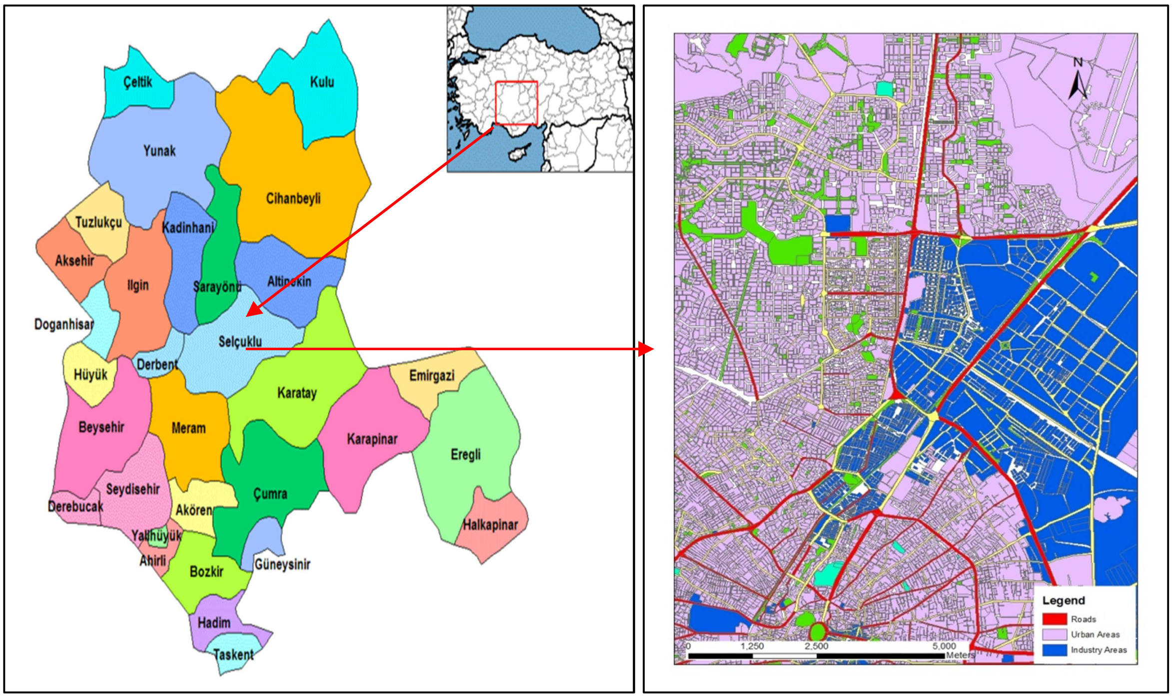


Figure 2: Study Area

Application has been realized with ArcGIS software Network Analyst tools. Network analyst tools provide users to define parameters for solving routes between destination and arrival points. Normally, these parameters are direction, distance and time units. Additionally, users can specify parameters for the aim of determining routes.

Using network analyst needs to line vector data. Thus, routes can be determined as a line vector. In this application, Selcuklu district roads are digitized from satellite images as a road map. In digitizing process, roads are digitized by considering the status of one-way and global turning parameters.

For providing shortest intervention time to emergency vehicles, additional parameters are used in network analyst processes. Considering the dimension of vehicles, sometimes it is being impossible to turn in narrow streets. Because o this, vehicles are losing time when trying to reach to the emergency area. Especially traffic density which roads have intensive traffic flow makes the vehicles slower. In the other hand, signalization, speed blockers and rail road crossings are extending the speed of vehicles. This situation causes longer intervention time to the emergency events. These situations are shown in Table 1.

Table 1: Parameters for network analyst

CRITERIAS	SPEED OF VEHİCLE	TURNİNG
Parking Status	Slower	More difficult in two-side parked streets
Width of Street	Slower in narrow streets	More difficult in narrow streets

Signalization	Slower	-
Crossroads	Slower	More difficult in crossroads
Speed Blockers	Slower	-
Pedestrian crossing	Slower	-
Rail road crossing	Slower	-
Traffic Density	Slower	More difficult in intensive traffic

- **Parking status** is affecting the ability of the vehicles. If parking status is two-sided, big vehicles are getting slower depends to the width of street.
- **Width of street** is affecting the traffic lane count. If traffic lane is more than two, this means traffic flow is lighter.
- **Signalization** is making vehicles slower. Although right of way is belonging to emergency vehicles, waiting cars in signalizations are effecting the intervention time.
- **Crossroads** are also making cars slower because of the road intersections.
- **Speed blockers** have a widely usage in Konya city. Because of Konya has a smooth terrain, it is possible to drive faster on roads. By using speed blockers, traffic flow is getting slower in specific places.
- **Pedestrian crossing** are one of the reason that emergency vehicles are getting slower.
- **Rail road crossing** is one of the reasons of losing time when train is passing.
- **Traffic density** is a real problem when intervention to the emergency events. Especially on specific times, roads are getting crowded.

3. APPLICATION

First step in the application is digitizing the roads from satellite images. To realize network analyst from digitized lines, some parameters must be considered as like way of road, length and turnings. These parameters will play important role in determining routes. Because route will follow the direction of line. In figure 3, digitizing process has shown on satellite image.

Figure 3: Digitizing process

In digitizing process, additional to specified parameters, for emergency vehicles, the parameters shown in Table1 has added. For example when digitizing a road segment, it is possible to see the parking status, width of street, crossroads and rail road crossing. Thus, while digitizing, it is possible to define additional parameters. In figure 4 it has shown clearly two side parked, crossroads and width of street.

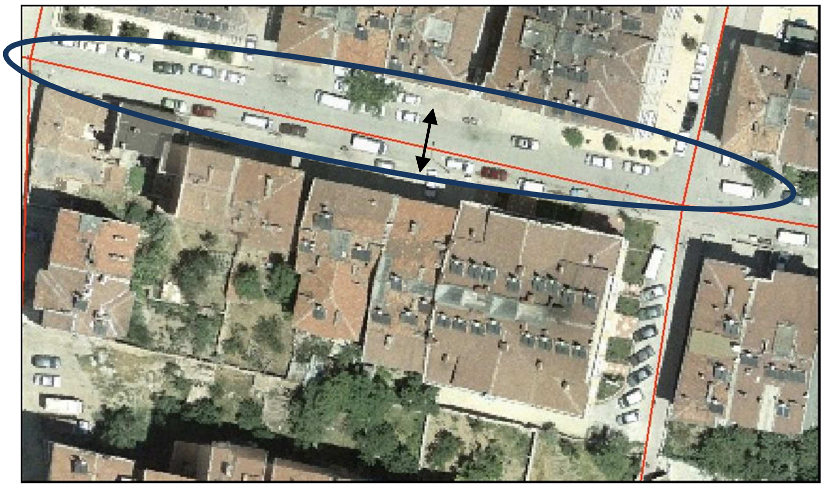


Figure 4: Two sided parking area and street width

After digitizing process, ArcGIS Feature class attribute Table has shown in figure 5. On columns, additional parameters seem and on rows road segments are shown. For the parameters, if the situation is true value is 1 and if the value is false the value is 0. These parameters will define the route according to 1and 0 values. After defining process, network analyst need to know the parameters as restricted or cost.

Table

merge

Shape *	ONEWAY	NAME	Shape_Length	PARK_STA	WIDTH_STRE	SIGNAL	CROSSROADS	SPEED_BLOCK	PEDESTRIAN	RAIL_ROAD	TRAFFIC_DENS
Polyline	0	GELINALAN_SOK	183.904008	1	1	0	0	1	1	1	0
Polyline	0	GULDERE_SOK	216.324955	1	1	0	1	0	0	1	1
Polyline	0	GOZLUCE_SOK	90.632468	1	1	0	1	0	0	1	1
Polyline	0	ATAKENT_SOK	323.458577	1	1	0	1	0	0	1	1
Polyline	1	PADISAH_SOK	63.064869	1	1	0	1	0	0	1	1
Polyline	1	ANBER_SOK	72.991074	1	1	0	0	0	0	0	0
Polyline	1	TEST_SOK	60.824732	1	0	0	1	0	1	0	0
Polyline	1	MURSEL_SOK	175.772416	1	0	1	1	1	0	0	0
Polyline	1	MURSEL_SOK	49.604205	1	0	1	1	1	0	0	0
Polyline	1	GOBEK	34.457456	1	0	1	1	0	0	0	0
Polyline	1	GOBEK	33.186128	1	0	0	1	0	0	0	0
Polyline	0	HAFIZ_AHMET_SOK	37.582071	1	0	0	1	1	0	0	1
Polyline	0	GOKDAG_SOK	142.92423	1	0	1	0	0	0	0	1
Polyline	0	HUSNA_SOK	37.796555	0	1	0	0	0	1	0	0
Polyline	0	BUZDAGI_SOK	65.627709	0	0	0	0	0	1	0	0
Polyline	0	ILGI_SOK	81.690605	0	0	0	0	1	1	0	0
Polyline	1	BUZDAGI_SOK	102.513017	0	0	0	0	1	1	0	0
Polyline	0	HUSNA_SOK	68.636203	0	0	0	0	1	1	0	0
Polyline	1	GULBAHCE_SOK	70.726572	0	0	1	1	0	0	0	0
Polyline	1	MEMLEKET_SOK	141.578447	0	1	0	1	1	0	0	1

15 (0 out of 4083 Selected)

merge

Figure 5: Table of Street vector data

ArcGIS network analyst has an interface to define the restrictions, costs and evaluators for determining routes. In this interface users can define the columns that parameters has deployed in tables and write scripts and define evaluators for a selected column. For this study, 8 parameter will be defined as a restriction. So, routes will be determined according to the values 0. In figure 6 interface has shown to define the restrictions.

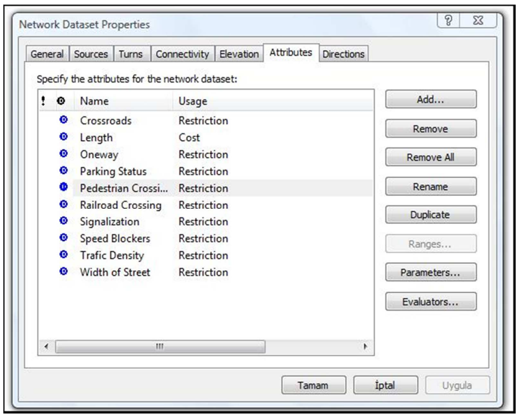
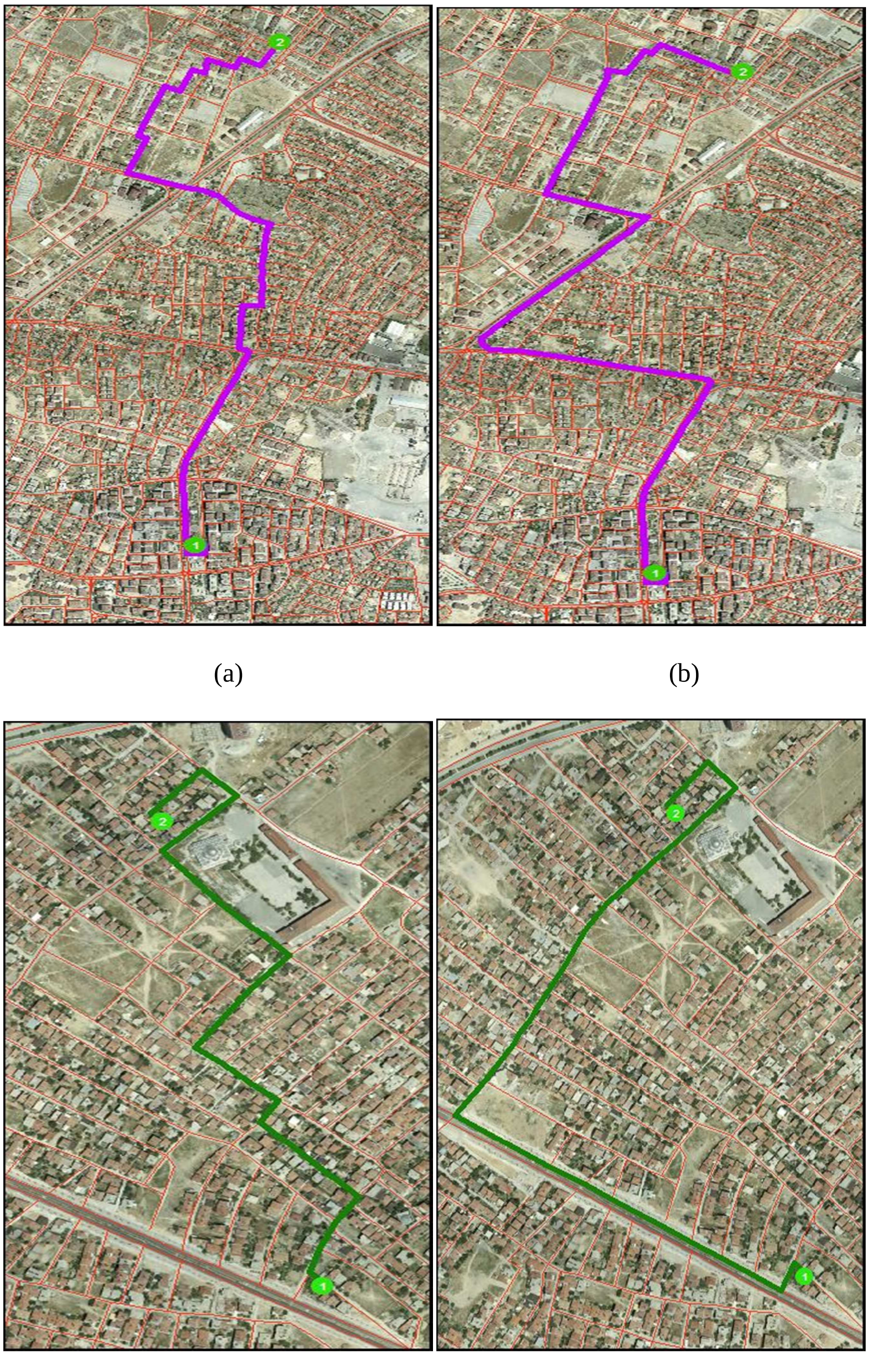


Figure 6: Specifying the parameters

With specified restrictions, by using ArcGIS Network Analyst, a network dataset has constituted for Study area. Totally, with 9 restrictions, 1 length and 1 time parameter network analyst will be determined the routes between destination and arrival locations. In figure 7, new route has shown with applied parameters and without.



(a) (b)

(c) (d)

Figure 7: Determined routes with parameters and without

As seeming in the figure “7a” the route has determined without any parameters. In figure b, the route has determined with specified parameters. As it seeming the parameters has affecting the route to follow main roads. Similarly, in figure “7c” and “7d”, route is following main roads. Thus, the parameters are providing the routes to follow main roads with minimum crossroads and from large streets. In Table 2, the results are shared for the routes which have showed in figure 7.

Table 2: Route information

ROUTE	Length	Time	Average Speed
Route A	2350 m	4 m 32 s	62 km/h
Route B	2752 m	3m 54 s	73 km/h
Route C	1486 m	2 m 41 s	53 km/h
Route D	1378 m	2 m 02 s	63 km/h

RESULTS

With this study, application result has showed that considering the obstacles make vehicles faster and make it easy to reach to emergency area. In some cases, however the route Distance is getting longer; the intervention time is getting shorter because of the increased speed. With this,

- Intervention time is getting shorter to the emergency events,
- Especially in vital accidents, losing human life will be decreased as well as possible,
- In fire status, rapid intervention is too much important to save human life and physical savings
- With analyzing the time of vehicles, it is possible to analyze the fire center and hospitals. Thus, new service area facility can be used to determine where new fire center and hospitals should be build.
- For urbanization planning, the roads status can be determined.
- Alternative routes can be determined with this application to find alternative routes in urban area.
- With analyzing most used routes, it is possible to put forward new needing of streets as like additional signalization or overpass buildings.

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