The problem of traffic congestion in Saudi Arabia

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Abstract— The emergence of traffic and subsequently traffic congestion in urban road networks are increasing worldwide with the growing number of vehicles, which results in excess delays, and reduced safety. The aim of this paper is to use many GIS functions (network analyst, shortest path) in evaluating traffic congestions point during working day hours according to roads directions. The study area is a residential area of Jeddah city, Saudi Arabia. A geo-database is designed that includes the road network with their directions that located in Jeddah city. Several GIS functions are used in this paper including network analyst and overlay analysis using ArcGIS 10.2. The priority results are utilized in evaluating congestion points according to roads direction, which can help planner in re- assigning roads directions to mitigate congestion points at all parts of Jeddah city..

Index Terms— jeddah , traffic.

1 INTRODUCTION

Geographic information system (GIS) is widely being used in many applications as it developed to be with no-limit. Generally, in planning applications and specifically in transportation, both are benefited from this powerful and efficient technology. These applications of GIS in transportation include for example; road design, highway mapping, analysis of accident data and traffic volumes [1]. GIS are used today in several planning applications including land use planning, health care planning, and transportation planning. Evaluation of congestion road points is considered as one of the planning fields that could benefit from using this novel technology. Planners are faced today with many issues that can be better handled with GIS. These include constructing demographic, and finding the best locations for new services, in correlation congestion points [2]. Traffic flow analysis, visualization, traffic flow environmental impact and decision making from the point of GIS view. Therefore, it is necessary to provide decision-makers with up to-date traffic flow information in an easily understandable form. To achieve this goal traffic flow measurement systems are integrating with software which has graphical user interface, which includes a GIS [3].Nowadays GIS has obtained immense amount of traffic road network information due to advanced technologies which is necessary for the traffic simulation and has been regarded as the potential foundational data platform of traffic simulation [4].The rapid growth of urban traffic requires efficient control methods. Traffic congestion appears when too many vehicles attempt to use a common transportation infrastructure, and services points, with limited capacity. It leads to a degraded use of the available infrastructure, thus contributing to an accelerated congestion in crease, which leads to further infrastructure degradation, and so forth.

The analysis on transport infrastructure expansion has considered three categories of transportation infrastructure: highways, primary roads and secondary roads. The studies indicate that Jeddah underwent tremendous transportation infrastructure expansion from 1964 to 2007 [5]. Transportation infrastructure increased rapidly from 136 km to 435 km in 1970 to 1980, with a change of 69% and an annual growth of 6.9% respectively. Most of the transportation infrastructure in Jeddah was constructed during this period [5].

The main objectives of this paper are:

Demonstrate the importance of GIS in the analysis of the traffic network;

Refer different types of analysis tools;

Evaluating roads directions.

2 LITERATURE REVIEW

GIS technology is appropriate for a variety of usages including resource management, land surveying, and traffic planning. Traffic use GIS technology to solve problems, find solutions for traffic congestion [6].

Traffic congestion is the phenomenon of increased disruption of traffic movement on an element of the transport system, observed in terms of delays and queuing, that is generated by the interactions amongst the flow units in a traffic stream or in intersecting traffic streams. The phenomenon is most visible when the level of demand for movement approaches or exceeds the present capacity of the element and the best indicator of the occurrence of congestion is the presence of queues [7].

Traffic congestion is aggravating due to increased

growth rate, population, modernization and improved lifestyle.
Not only do traffic bottlenecks increase due to these factors but weather conditions also intensify the situation.
Transportation professionals use traffic analysis tools to find the best transportation solutions for their regions. However, as transportation solutions become more sophisticated and complex, so do traffic analysis tools [8].

The simplest GIS tools that can be used for traffic congestion GIS application is related to displaying and querying spatial and attribute data. For example, ArcGIS software has several functions that can be used for data query and display. This software can display attributes in relation to points, lines or polygons, otherwise known as thematic mapping [9].
Shortest path analysis is an essential precursor to many GIS traffic applications. [10] Has worked on this and explored the use of fast shortest path algorithm on extensive road networks. [11] Has evaluated the possibilities of optimization, in which the optimum routes, travel time, travel distance and cost for defined paths and for the optimum paths was determined for few transport services.
Another study relied on GIS to identify deficient facilities (i.e., tolerable, moderate, moderate to heavy and heavy road deficiencies) in the vital area within Riyadh ring road by incorporating the link volumes resulting from the travel demand forecasting into the network attribute table in GIS. Shortest path and travel time allocation of major activity centers analyses are also investigated [12].
Also [13] demonstrate the importance of Geographic Information System (GIS) as a support tool in developing policies for the organization, management and promotion of transport efficiency in Almada, a Portuguese city.

3 STUDY AREA: JEDDAH CITY

Jeddah city is the second largest city in Saudi Arabia. Jeddah
city has witnessed a remarkably rapid urban growth rate during the past four decades. Jeddah has witnessed a dramatic increase in population primarily due to out-migration from villages and from suburbs to the city by individuals in search of jobs and better living. Historically, traffic grows by 3.5% to 4% annually in a city [14]. With population and economic development keeping pace, the pressure on the traffic system has been tremendous. Up until now the road network is not stable and has been witnessing changes or amendments in lanes and roads, which put pressure on vehicle users because they need to constantly find easier ways to get to their destinations.

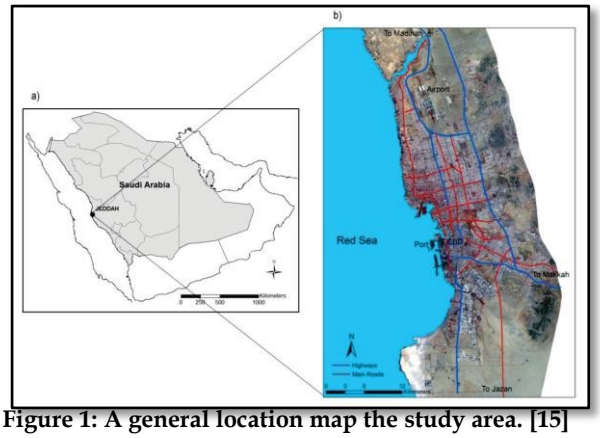

Figure 1: A general location map the study area. [15]

Land use in Jeddah went through remarkable changes during the period of 1964 to 2014. Although all land uses changed from 1964 to 2014, five significant land use classes have rapidly and actively changed: residential, commercial, industrial, informal settlements and public places. Residential development in Jeddah city has dramatically, notably catalyzed by the constructed transportation infrastructure, the new airport location and the government development policies, such as land grants and interest-free loans [15].

Although road length in all road infrastructure categories continually expanded after 1980, only the secondary road category increased significantly. Highways and primary roads remained steady from 1980, with only minor changes in 1993 and 2007.

The literature review indicates that secondary roads expanded in different parts of Jeddah. Most of these secondary roads serve as main access points for residential development [16] but with good connectivity with the highways and primary roads. The secondary roads in Jeddah are predominantly laid out in a grid pattern. Notably, the transportation infrastructure expansion in Jeddah has thus followed the proposed locations by Jeddah Municipality master plans of 1962, 1973, 1981,1987 and 2004. The literature reviews indicate that road density in relation with the urban area changed from 0.005 km/ha in 1964 to 0.015 km/ha in 2007. The most significant changes occurred between 1970 and 1980, when the road density increased from 0.0072 km/ha in 1970 to 0.013 km/ha in 1980. Thus, in this period greater accessibility to different land uses was provided.
Conversely, the road density in comparison with the population of Jeddah was reduced from 0.00068 km/person in 1964 to 0.00025 m/person in 2007. Although it slightly increased from 0.00035 km/person in 1970 to 0.00047 km/person in 1980 due to the rapid increase in transportation infrastructure at the time, it decreased considerably to 0.00027 km/person in 1993. This change reflects the rapid increase of Jeddah population growth since 1964.

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On the basis of this indicator can conclude that the speed of road infrastructure provision has not coincided with population growth. In fact, during the last forty years, the population of Jeddah has grown rapidly, with a 6.3% average annual growth [17]. Accordingly, demand has increased for public services, infrastructure (including transportation) and utilities.

4 GEO-DATABASE DESIGN

As a feature of the calculated stage, a percentage of the strides
utilized "information outline designs". Information plan examples are generally reoccurring connections among information components that show up so as often as possible, it depends on their presence for understanding of information. The results of a calculated configuration stage in database outline will complete a discourse about what is the goal and significance of the information that is expected to determine data, putting that data in the connection of proof and knowledge.
Identifying the thematic layers which are needed for the application is the first step, then, deeply defines each of these layers in more details. The characterization of these layers will result in geo-database which takes different types of data elements, such as feature classes, tables, relationship classes, raster datasets, subtypes, topologies, domains, and so on. As shown in Table (1).

Table 1: Geo-Databases Themes

layer Name	Layer descriptio n	Feature type	Source	Resolutio n
Land _use	Building and blocks	Vector/polyg on	Esri Imagery	60 cm
Roads	All Road network	Vector/line	Esri Imagery	60 cm
Traffic directi ons	Road direction	Network dataset	Jeddah municipalit y Reports	60 cm

The purpose of this paper is to discuss a GIS application for evaluation of traffic congestion at Jeddah city (Rawda Residential area case study) during working day hours the created application covers congestion road points In order to build this application, several data sets were captured and built using ArcGIS software, as the following:
Polygon and line data. In addition to services features, the present application created polygon features showing city district boundaries (figure 2 shows land use include residential areas as parcels) as well as line features showing city road network (figure 3 shows road network). These two basic GIS features were used with point data to define and model the service area of Rawda Residential centers at Jeddah city. For each of these features the relevant attributes were linked at the feature attribute table.
The data for application of network analysis tool box was available on ArcGIS, for different analysis purposes used Jeddah city.

Figure (2) Land use of Jeddah

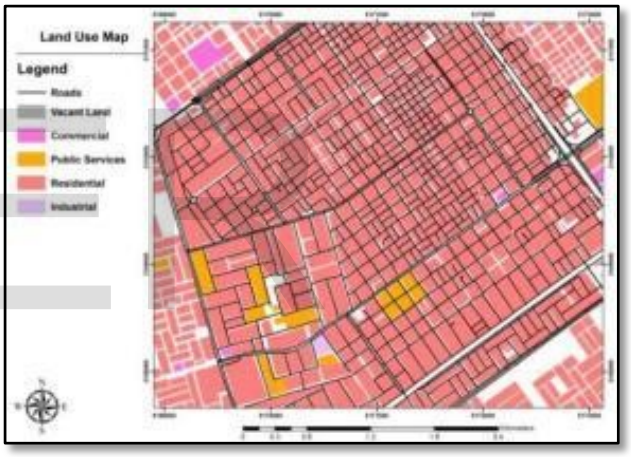

Figure (3) Road network in Jeddah city

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5 ANALYSIS

5.1 Shortest Path Model Analysis

A shortest path problem is to find a path with minimum travel directions from one or more origins to one or more destinations through a network [18, 19]. Shortest path analysis is important because of its wide range of applications in transportation [18]. [20] Stated that the shortest path helps calculate the most optimal route, and optimal routing is the process of defining the best route to get from one location to another. The best route could be the shortest or fastest depending on how it is defined. The shortest path can be computed either for a given start direction or to find the start point and the path that leads to best direction for the journeys.

As part of the ranking process, road directions were identified for roads. The road directions were used to define the congestion point at the end of the road, with the distribution of the services for the proposed project. Path Finding Module of Arc/info can be used to generate the shortest route between

points of the proposed project interactively. This can be a done using the link impedance attribute table which contains link's. GIS is used to identify links for projects where service areas are used as variable for analysis. (Figure 4 shows the shortest Path Model Directions)

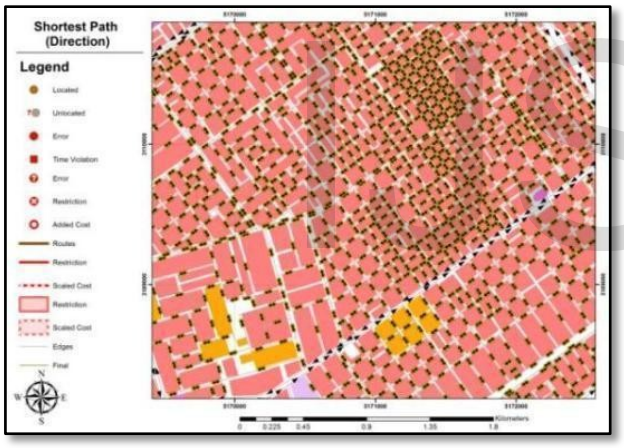

Figure (4) shows the shortest Path Model Directions

6 RESULTS

6.1 Congestion areas definition

The first step to produce this output was to plot and map the locations of congestion points according to roads directions and working day hours starts from 9 a.m. to 3 p.m. that were interviewed in the course of this study. One of the useful GIS functions to be used for this purpose is known as shortest path. It refers to the process of creating map of the shortest path from one point to another. In order to use this function, ArcGIS software requires that the user should have road direction table containing a list of directions stored as a database table as well as a set of reference data such as roads on which the addresses can be located. Using city-district shape file as a reference data and road direction, this application produced point features describing the spatial distribution of congestion points at different working day hours in Rawda residential area, Jeddah city (Figures.5, 6, 7, 8, and 9).

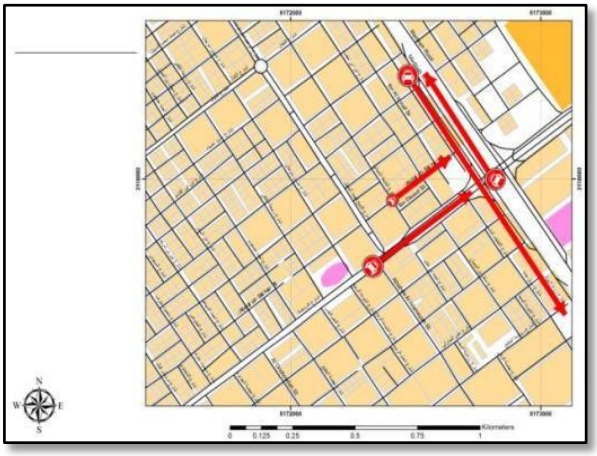

Figure (5) Main congestion point at 9 a.m.

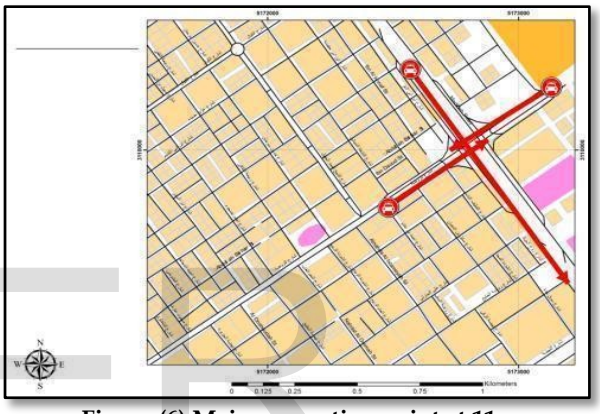

Figure (6) Main congestion point at 11 a.m.

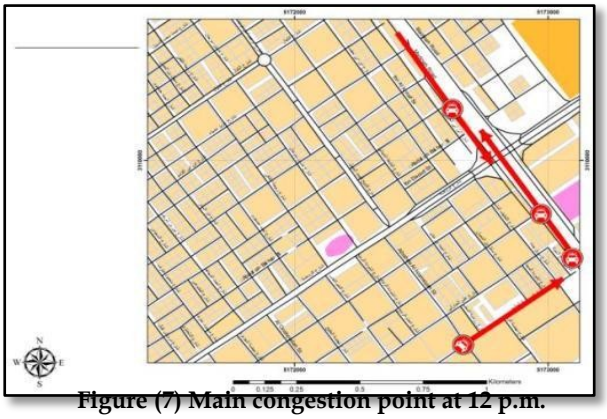

Figure (7) Main congestion point at 12 p.m.

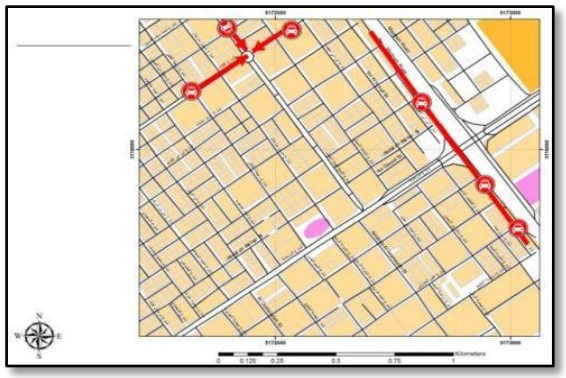

Figure (8) Main congestion point at 1p.m.

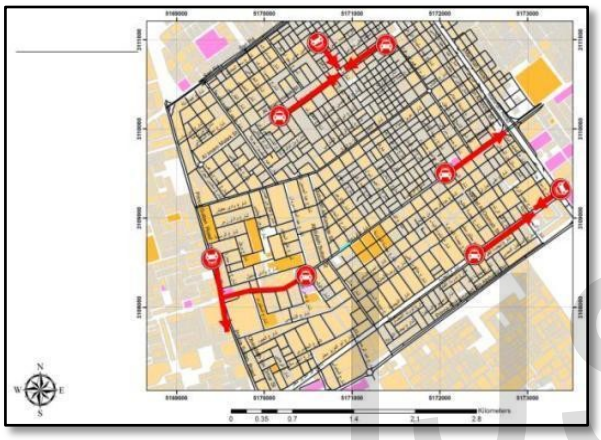

Figure (9) Main congestion point at 3p.m.

From the previous analysis the main 2 traffic congestion points in Rawda residential area as the follows:

Those areas at the intersections of Prince Mohammed bin Abdul Aziz Street, where it observed a repeat of the traffic congestion throughout the day.

For example, the intersection of AlSemat Taybah street "two-way street " which lead to Madina high way road, with Prince Mohammed bin Abdul Aziz Street.

So through using the shortest path model we suggest converting AlSemat Taybah Street to one Way Street, as it is possible to find other subsidiary path to go to Madina high way road.

Also Other area located in the right area of Rawda residential area, in the intersection of Ibn Zydon Street with the end of the bridge of Madina high way road.

As it is end of bridge the traffic congestion is expected to occur, it suggested using divider at the bridge to separate between the cars coming down from the bridge and cars coming from Ibn Zaidoun Street.

For the rest of the traffic congestion point in Rawda residential area, they are not repeated throughout the day, and it may be temporary and only during peak time or may be sites for the organization of the passage of the movement signals.

But with an overview of the causes of traffic congestion point repeated in this area is the presence of the narrow streets work as two-way which lead to traffic congestion when the intersection with the main roads occurs.

7 Engineering solutions to solve the problem of traffic congestion in Saudi Arabia

The problem of traffic jams is not a new phenomenon that appeared only recently; it has been a problem for many years. But as Jeddah's population grows along with its number of automobiles, the traffic is backing up.

Officials in Jeddah have not found any real solution to the traffic problem because the current road grid is old and has not been expanded to accommodate the growing number of cars.

Always ready to help, Arab News filled up the car and hit the roads to find out what people in the backups had to say — provided they would stop honking their horns long enough to talk to us.

And area residents have as many suggestions about how to fix the problem as there are cars stopped in front of you on your way home from work.

"The traffic jam problem didn't exist in the past," said Muhammad Al-Balawi. "It started to grow after they allowed these limousine cars to operate. The construction of new bridges in Jeddah is essential to ease up transportation problems — especially now that the population is increasing."

One visitor thought it was basically a design problem.

"When I visited Jeddah, I noticed that there's street traffic everywhere," said Saeed Al-Omari, a visitor from Taif. "I think that the reason is because all the important buildings, such as universities and companies, are located in the middle of the neighborhoods."

He said we should learn some lesson from abroad.

"Industrial and residential areas are located next to each other in contrast to the advanced countries that tend to establish their important buildings, like universities and the industrial projects, far from the big cities. They locate them in the countryside to reduce traffic jams," Al-Omari said. "I hope they do something like that here and move traffic away from Jeddah."

Why not just build a bunch of new streets?

"The problem resides in the street design that was drawn many years ago when population density wasn't as big as it is nowadays," said Saleh Al-Otaibi, a Jeddah resident. "Today our streets cannot accommodate this large number of cars. Sometimes I wait for more than an hour at the traffic lights."

He said he is pleased with the improvements on some Jeddah streets, such as the Prince Abdullah Bridge Project, which means that officials are trying to do something to fix the problem.

There seems to be some support for that position among the idling cars.

"Most of Jeddah's streets suffer from traffic jams, especially on the main roads," said Ali Al-Kaabi. "The best solution is to design new projects, such as bridges and exit ways, for cars on the crowded streets. I consider the Prince Abdullah Bridge Project an important step toward a solution. I'd recommend more similar projects to be started."

Why not just get rid of cars?

"Jeddah streets can't tolerate any more cars," said Hamed Al-Muzainy. "The layers of asphalt have started to crumble quickly from the large number of cars using it every day. New bridges must be installed and some roads redesigned to make them wider by reducing the shoulders."

Traffic engineers have some ideas to solve the problem.

"We conducted studies in the municipality to establish an experimental road project and to remove some terminal stations in the pathway," said Mifreh Al-Zahrani of the Makkah Roads and Transportation Department. "In addition, we will establish a highway by using King Fahd Road as starting point to the airport. We will also provide well-equipped buses for public transportation to limit the spread of cars and taxicabs, but it is still in process."

The traffic jam is a big problem for everyone in Jeddah, and some say it will just get bigger — and the backups longer.

"If they don't come up with any plan to solve it, an enormous disaster will occur in the coming years," said Dr. Hamed Al-Baar, associate professor of the transport and traffic engineering in King Abdul Aziz University's Engineering Department.

He notes that a shortterm solution is already in place, but Jeddah also needs a long-term solution.

He suggested redesigning and organizing crossways by establishing double streets or bridges and tunnels to reduce traffic jams.

Besides that the traffic lights are isolated from each other and have become useless. What worked before now makes motorists wait along time at the traffic lights. "That's why they have to reorganize them and provide new stoplights that work by sensors that change the duration of the light according to the traffic density."

Why not just a bullet train or two?

Dr. Al-Baar said the best long-term solution is to plan for modern transportation projects, such as subways and express trains that are used in developed countries.

There may not be light at the end of the tunnel, seeing as it hasn't been built yet, but there is hope that an end to traffic jams is on the way. Hopefully you'll get out of the one in which you are now stuck before then.

8 CONCLUSION

Methodology for traffic congestion solutions in the paper includes the various steps and use of GIS technology. It integrates the geo-database, network analyst tool, and field experiment. The priority results are utilized in evaluating congestion points according to roads direction. Results obtained from these tools compare alternate improvement strategies, and solutions thus giving the best possible solution.

ArcGIS is a collaborative that allows using, creating, and sharing maps, apps, and data, including authoritative base maps. Finally, a service area investigation has been performed based on GIS buffer analysis technique and by using GIS overlay analysis function it could define the congestion points according to roads direction. This methodology could help planners in managing the distribution of the future services, and re-assigning roads directions to mitigate congestion points at all parts of Jeddah city.

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To Sindhi in the life of my beloved brothers, to the dream of life and the ambition of tomorrow and the daily brilliance of Laura and Lara

REFERENCES

[1] Antenucci J., Brown K., Croswell P. Kevany M., with Archer H., (1991) Geographic Information System: A Guide to the Technology.

[2] Olson, D, Chae, B, and Sheu, C (2005) „ Issues in multinational ERP implementation" Int. J. of Services and Operations Management 2005 - Vol. 1, No.1 pp. 7 -21.

[3] Gulliver, J.; Hoogh, K.; Fecht, D.; Vienneau, D.; Briggs, D. 2011. Comparative assessment of GIS-based methods and metrics for estimating long-term exposures to air pollution, Atmospheric Environment 45(39): 70727080.http://dx.doi.org/10.1016/j.atmosenv.2011.09.042.

[4] Tazin Malgundkar et. Al., "GIS DRIVEN URBAN TRAFFIC ANALYSIS BASED ON ONTOLOGY", International Journal of Managing Information Technology (IJMIT)Vol.4, No.1, February 2012.

[5] Al Ahmadi, K, See, L.M., Heppenstall, A.J., and Hogg, J. (2009). Calibration of a fuzzy cellular automata model of urban dynamics in SaudiArabia. Ecological Complexity, 6(2), 80-101.

[6] Cheng, E, and Ling Yu, H, (2007) „ A GIS approach to shoppingmall location selection Building and Environment" Vol. 42, pp. 884–892.

[7] Taylor, MAP., Woolley, JE., and Zito, R. (2000). Integration of the global positioning system and geographical information systems for traffic congestion studies. In ThillJ.C. (ed.) Geographic Information Systems in Transportation Research (1st ed). Elsevier Science Limited, Amsterdam, the Netherlands.

[8] Gang Cheng, Qingyun Du, Hongli Ma, (2008) "The Design and Implementation of Rules Based Knowledge Base for Transportation", IEEE International Conference on Computer Science and Software Engineering, Vol. 3, pp 1035 – 1038.

[9] Grimshaw D., (2000) Bringing Geographical Information Systems into Business, Wiley, New York.

[10] Zhan, F. B. and Noon, C. E. (1996) Shortest Path Algorithms: An Evaluation using Real Road Transportation Science vol. 32, no. 1, pp. 65-73.

[11] Pathan (1994), „Optimization of Transportation Routes using GIS techniques".

[12] Alterkawi M. (2001). Application of GIS in Transportation Planning:The Case of Riyadh, the Kingdom of Saudi Arabia. GBER Vol. 1 No. 2 2001 pp38-46.

[13] Leite, and FERREIRA (2011). Application of GIS in Public Transportation. Proceedings of 7VCT, Lisbon, Portugal- pp.439-446.

[14] IBI, G. (2007). Jeddah Public Transportation Study. Ministry of Transportation, Saudi Arabia.

[15] Aljoufie, M., Zuidgeest, M.H.P., Brussel, M.J.G., and van Maarseveen, M.F.A.M. (2011). Urban growth and transport understanding the spatial temporal relationship, in: Pratelli, A.,Brebbia, C.A. (Eds.), Urban transport XVII : urban transport and the environment in the 21st Century. WIT press, Southampton, pp. 315-328.

[16] Daghistani, A. (1993). A case study in planning implementation. Working paper no. 32. University of Newcastle upon Tyne.

[17] Jeddah Municipality (2004). Jeddah Structure Plan, Jeddah Municipality, Saudi Arabia.

[18] Lim, Y. and Kim, H., 2005. A shortest path algorithm for real road network based on path overlap. Journal of the Eastern Asia Society for Transportation Studies, 6 (1), 1426-1438.

[19] Panahi, S. and Delavar, M., 2008. A GIS-based dynamic shortest path determination in emergency vehicles. World Applied Sciences Journal, 3 (1), 88-94.

[20] Naqi, A., Akhter, N., and Ali, N., 2010. Developing components of web GIS for shortest path analysis "Find Shortest Route": A geographical explanation for SSGC, Pakistan. Sindh University Research Journal, 42 (1), 23-30.

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