



A Multi-Modal Journey Planner to Manage Transportation in Jeddah

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Abstract: *The concept of the smart city is about using smart computing technologies to create a convenient environment for the residence and to improve the quality of living. Mobility and transportation are one of the major characteristics of the smart city, especially for fast growing population cities. Our study focuses on Jeddah city as it's the second large city in Saudi Arabia with more than 3.5 million populations. An investigation for the current transportation system in Jeddah was conducted to outline the issues that cause traffic and congestion. A multi-modal journey planner (MMJP) was proposed based on the requirements specified from the analysis phase. A demo application named (smartITS) was developed to illustrate the proposed solution interface, functions, and features.*

Keywords: *Smart city, Transportation, smart transportation system, Multi-modal Journey planner*

I. Introduction.

A smart city concerns concepts that uses technology to improve the quality of life for the residence by improving the infrastructure and the delivered services. Smart cities appear as the next stage of urbanization. Since 2005 Saudi Arabia has shown strong initiatives toward the urbanization and the modernization of the kingdom. Many new economic cities "Greenfield" have been established like King Abdullah Economic City, Prince Abdul-Aziz Bin Mousaed Economic city, Tabuk City, and others. One of the main characteristics of a smart city is having smart mobility/ intelligent transportation system. Transportation systems are very important in modern life. Effective transportation systems can significantly enhance the efficiency of travel, reduce traffic incidents and improve safety, alleviate the impact of congestion.

Jeddah is the second largest city in Saudi Arabia with rapidly growing population rates. The population projection is estimated to exceed 5.6 million by 2030 [1]. This significant growth will require doubling the roads space and the services to serve the growth rate. Having a smart public transportation system and smart parking facilities would not just decrease the amount of streets space needed, it will preserve the character of the city. This will offer economic benefits and it will increase the mobility for residents.

This focuses on the field of intelligent transportation systemic in Jeddah city. It aims to encourage the smart development to provide the citizens with better mobility in term of quality and options. This is achieved by demonstrating the current condition of Jeddah to propose a Multi-modal solution that is tailored to the need and infrastructure of Jeddah city.

II. Smart City Concept.

The concept of smart cities assumes that the functions and the services provided to the citizen are delivered in a smart way "using computing technology" [2]. It thrives on giving a high-quality level of living to their residence through a clean and sustainable environment and application of 'Smart' Solutions. The mission promoted by smart cities is to drive economic growth and improve the employment opportunity in different socio-economic of the developing world [3]. There is no specific definition for smart city, many researchers have come up with a various definition. The author in [4] defined smart city as: "the use of smart computing technologies to make the critical infrastructure components and services of a city- which include city administration, education, healthcare, public safety, transportation, and utilities more intelligent, interconnected, and efficient".

III. Intelligent Transportation Systems /Smart mobility.

Smart Cities aims to improve the overall quality of life by using interconnected smart devices and the Internet of Thing (IoT) to understand citizens' needs, and this must incorporate ITS. Intelligent Transportation Systems (ITS) is one of the main characteristics of the smart city, it has emerged over the past 15 years as a crucial part of any smart city concept providing an important means of managing road transport. It is the application that use technology to provide innovative services related to the efficient use of the transportation infrastructure. It aims to enhance the management and the information capabilities for various transport and traffic modes. It enables the user to be informed and updated, thus perform better, safer, and smarter decisions related to transport network [5]. To start constructing smart transportation, the city sectors should be integrated with smart transportation systems within sectors of the city. The main purpose to apply smart transportation is to increase the number of the users include commuters, travelers, and tourists and this will mainly focus to help people who cannot pay for private transportation, on the other hand, this will help to reduce the traffic during rush hours [3]. To this end,

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this paper will investigate the current transportation system in Jeddah thus, to evaluate the potential and the challenges to enhance the Transportation system in Jeddah city.

IV. Jeddah Transportation system – Case Analysis of the Current Situation.

4.1 Background

Saudi Arabia suffers hugely from traffic issues. Jeddah is the commercial capital and the portal of the two Islamic holiest city mecca and Madinah and the second large city in Saudi Arabia with rapidly growing population rates. Many studies have found that the population of Jeddah has grown in short period of time from about 147,900 in 1964 to more than 3.5 million nowadays [6]. The reasons behind the significant rapid urban incensement rate during the previous four decades was because of the incoming migration rate from villages in Saudi Arabia and from other countries, during the last four decades where the population grown for 6.3% average annual growth which indicates to the demand for public services, infrastructure, transportation and utilities [7]. Additionally, in 2030 the number of people in Jeddah will be increasing by 2 million which will cause more traffic congestion [8]. Furthermore, Jeddah has continuous development according to the networks changes and the planned expansion which disable the traffic movement in the rush hours [3]. On the other hand, some studies have shown that the traffic has an annual increase of 3.5% to 4%, and that is the reason why the transportation should be reliable with the population and economic development but till now the road network is not stable and has been witnessing main and minor changes, which in turn dissatisfy the vehicle users because they cannot arrive at their destinations in the estimated time [7]. Thus, indicates that there is an urgent need for a reliable transportation system which can be implemented by hybrid technologies to improve the transportation efficiency to match the user's needs. The road length in Jeddah expanded after 1980, but unfortunately not all roads because the high and the primary roads did not change. In comparison, in 2007 the road consistency compared to the population of Jeddah was reduced for 0.00043 km/person. The road consistency percentage shows the fast increase of Jeddah's population growth from 1964. Thus, the road infrastructure improvement doesn't meet the population growth needs.

According to [7], from 1964 till 2014, lands and roads in Jeddah have a momentous change, there are five significant land use classes that changed which include: residential, commercial, industrial, informal settlements and public places. Constructed transportation infrastructure in Jeddah city has a residential change which includes the location of the new airport and the government's development policies. Some of the changes that didn't meet the population's needs are the road length expansion which started after 1980, but only the secondary road category increased significantly which serve with good connectivity with the highways and primary roads, while other road types have a minor expansion. In our opinion, this road development considered as one of the main challenges that prevent or terminate applying a smart solution. In 2007 the road density in relation with the urban area increasingly changed for 0.01km/ha, which means that in this period higher accessibility to different land uses was provided. Thus, due to the rapid increase in transportation infrastructure during the previous years, the road density got improvement in the population of Jeddah in 2007 for 0.00043 m/person. One of the main challenges that terminate the improvement of Jeddah infrastructure was that the speed of road infrastructure provision has not coincided with population growth which was equal to 6.3 annual growth in the last forty years which indicated to the demand has increased for public services, infrastructure includes transportation and utilities.

4.2 Jeddah's Transportation Problem

Jeddah's transport is car dominant wherein 93% of daily trips done by car [9]. Public transportation is deficient and shares a very low percentage of daily trips. Thus, one of the problems will be the lack of adequate public transportation. The road infrastructure improvement doesn't meet the population growth needs and that leads us to the second problem which is the limitation of the road capacity. Also, Jeddah suffers from the lack of adequate parking facilities that led drivers to park their car on the main road which causes more traffic congestion.

4.3 Analysis

4.3.1 The lack of public transportation

The Two current systems supporting the public transport in Jeddah are, firstly, Saudi Arabian Public Transport Company (SAPTCO), which operates the regulated bus systems and covered 150 km. Secondly, Unregulated Coaster buses which are a bus system consists of approximately 90 buses that cover a distance of 160 km. there are lots of problems with regards to these services such as the bad buses conditions, Low accessibility, deficient infrastructure and unscheduled services [6]. Recently, the ministerial gave the approval to start implementation of Jeddah Public Transportation Program (JPTP), it should provide facilities such as metro trains, a bus network, a Corniche tram, sea ferries and an Abhur suspended bridge, which will provide quality of public transportation and places [22].

4.3.1.1 Challenges:

One of the main obstacles is the cheap oil which poses the use of the private car over the public transportation. Another reason, based on the examination of the current situation is the need for covering more distance area of the city, it has to be more appealing than cars, and it should incorporate more advanced technology. Such as Smart bus stop system (Intelligent public transportation system) that uses the GPS and GIS technologies. Also, the development of public

transportation in Jeddah acquire the improvement of the existing roads circulation. Indeed, the construction of the bus transportation system will be on road network. Thus, Jeddah needs to increase the road network and transportation capacity [10].

4.3.1.2 Opportunity:

Accordingly, as city expands over the time it can create more public transportation in new areas and connect it with old one, for example, connecting the bus services to new transportations facilities. Also, it will provide a convenient solution for women and children, as we know that women cannot drive according to the Saudi laws. Thus, this will increase the opportunity for the success and the need of such a system for the citizens. Indeed, the financing for such projects is highly supported by the government.

4.3.2 The Parking Facility

Jeddah city is experiencing parking problems where car parking provision is not compatible with land use and differences in density. There are several factors the contribute to the act of illegal parking, for example, lack of policies and regulations, increase of economic growth, social and cultural unpleasant habits, inadequate parking facilities and parking management techniques [11]. According to [6], illegal parking increase during weekend compared to weekdays. However, there are some initiatives to enhance the parking facility although, they are not implicitly considering solving the problem.

4.3.2.1 Challenges:

Provide an effectively parking space, control the limited of high demand capacity areas, and put parking sign and arranging times. Indeed, Jeddah needs to deploy and incorporate smart parking system, and that requires data standardization and management, mobile phone integration, hardware and software innovation, and the collaboration of different involved stakeholders.

4.3.2.2 Opportunity:

The Emerging technologies now as a result of the transformation from the traditional system to smart intelligent systems, has affected the way to solve this kind of challenges with high advance technology. Many companies now are providing techniques that can be implemented and integrated with the old systems if any or in this case to replace it.

4.3.3 The Road Capacity

The limited capacity of roads and highways caused traffic congestion. As a consequence, of bad urban planning, the road capacity is minimum compared with the population increase.

4.3.3.1 Challenges:

New infrastructural projects and dealing with congestion problem.

4.3.3.2 Opportunity:

The municipality is paying more attention to this problem, a lot of expanding projects are now taking place. Additionally, the vision of 2030 emphasizes the establishment of a plan for ease traffic congestion in Jeddah. One of it will focus on the main roads and the arrangement of the street by moving cars from Congestion Street to another direction [22].

V. Analysis Results.

Improving an existing transportation network is different than constructing a new one from scratch. The previous analysis explored the current situation of Jeddah transportation system from three basic interrelated transportation aspect (the lack of public transportation, the parking facilities, and the road capacity). For the road capacity problem caused by bad urban planning and the rapid population growth, the municipality of transport has established a plan for infrastructure and expanding projects. At the meantime, this will cause more traffic because of the undergoing construction work but it will decrease the traffic congestion in the future.

The public transportation issues are still encountering difficulties that preventing it from being efficiently functioning or even exist. In the case of Jeddah city, there is obviously a desperate need for an intelligent or smart transportation system to overcome the traffic congestion by decreasing the use of private vehicles, to provide a convenient transportation options to the residence especially for moderate and low-income class, and to offer a secure and safe transport alternative for Saudi women, since females cannot drive yet in Saudi Arabia. As for parking, which plays a major role in the transportation system. The parking facility in Jeddah is creating part of the traffic congestion with 30% [6].

Many factors have contributed to Parking issues such as the lack of policies and regulations, the population growth, the social and cultural unpleasant habits toward illegal parking, and the inadequate parking facilities (building and locations). Deploying a smart solution to deal with this parking issue will be a smart move and it will decrease the traffic and enhance the mobility. Furthermore, this will require the integration of Information and Communication Technology (ICT) infrastructure, and that is always challenging work to design and improve an existing system.

VI. The Proposed Solution: Multi-modal solution.

6.1 Multi-modal intelligent transportation system components:

Our multi-modal transportation system consists of two main basic components:

- Smart public transportation system.
- Smart Parking system.

Smart public transportation can be developed in multi-modal transportation system for Jeddah which can be a catalyst for Jeddah's broader transformation into a smart city. Metro Jeddah Company (MJC) has been established to connect all public transportations together in a smart way. MJC focuses on three main levels, first the network level with four lines to link which include King Abdul-Aziz International Airport, Abhur suspension bridge, and downtown area and connect King Abdullah Stadium. Second, the station level which integrates multi-modal that provides commuters to access several public transportations. Third, the fare structure level by integrating ticketing system e.g. smart cards [14]. Buses considered as one of the suitable solutions for the traffic cognition in Jeddah, it helps to free up the roads from the huge number of vehicles by providing safe and secure trip. Also, Busses need to keep up with the customers' expectations such as availability of buses at a time and anywhere within the region. The Project for smart busses has been studied which provides easy access for users to track their bus through the application. The system provided services; GPS and GSM/GPRS which allow users to use it while online or offline. Moreover, GPS-GSM model which that sends to the server the dynamic location for the vehicle to it users so they can access it online [15]. Connecting the entire system will be a new smart system and real-time travel information systems. Furthermore, a multi-modal can be used for journey planning, Multi-Modal Journey Planner (MMJP), which was adapted in a way which satisfies Jeddah's citizens' needs. MMJP categorized as smartphone application software. We consider that MMJP has availability to collect and provide information from another public transportation to provide a full data about the transportation services in an area and to suggest a journey for the users. Evidently, MMJP services enable commuters to set up a trip and guide commuters from point to another, also help in the search for a destination, to configure departure, calculate the easiest and shortest time between public transportations and to help in choosing between them and incorporate the current plan to upcoming one [12]. In other words, multi-modal transportation system integrates smart technologies into infrastructure developments and new services will be key to developing a successful smart city strategy. These integrated solutions can be any suitable solution that fit Jeddah current infrastructure, and that is the reason why some of the needed environment objectives should be applied first. The multi-modal for Jeddah transportation system is described in the following in the following section as illustrated in Figure (1). The name of the MMJP application is smart Intelligent Transportation Systems (smart ITS), check figure 2.

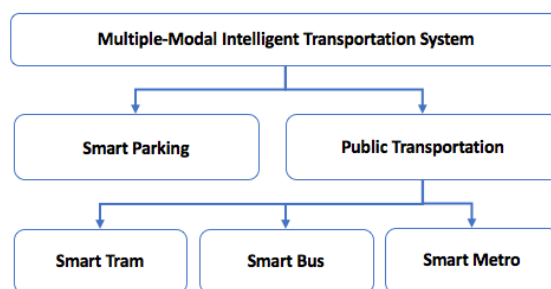


Figure (1): Multi-Modal Intelligent Transportation System Components

There is only one storyboard we used to design the layout of the app screens, where we can easily change the image of each service such as Bus, Tram, Metro, and Parking (check figure 2). Thus, we used the mapkit framework which is built in Apple Map that is similar to Google Map for all iOS devices. We used Google Map in the browser to find out latitude and longitude of various places near Jeddah. All images have been tested by using simulator before the final implementation in the app. The metro considered as the fastest facility with its high efficiency, and thus it became the first choice for a lot of people. The application allows users to view all available bus stations on the map (figures 3 and 4). It also allows the user to view the nearest station by finding the nearest Bus, Tram, Metro, and Parking (figures 5). The application also supports the booking function where the user can book a trip by Book Bus, Tram, and Metro through the app. The user can see all the schedules (figure 6).

VII. Discussion.

This App was just a demo with fake data to just illustrate how we can make an app with all the solutions we had proposed. Below are the features which can be implemented in actual real life smart ITS App beside the aforementioned features:

- Login/Register feature for members.
- Pay using PayPal or Saddam.
- Add balance and use it anytime, so the user doesn't have to go through the payment process each time.

- Check previous tour history.

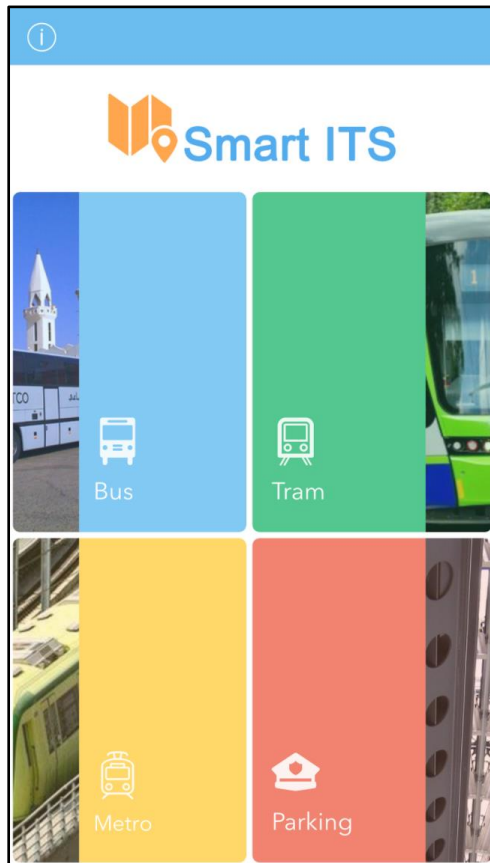


Figure (2): Application Interface

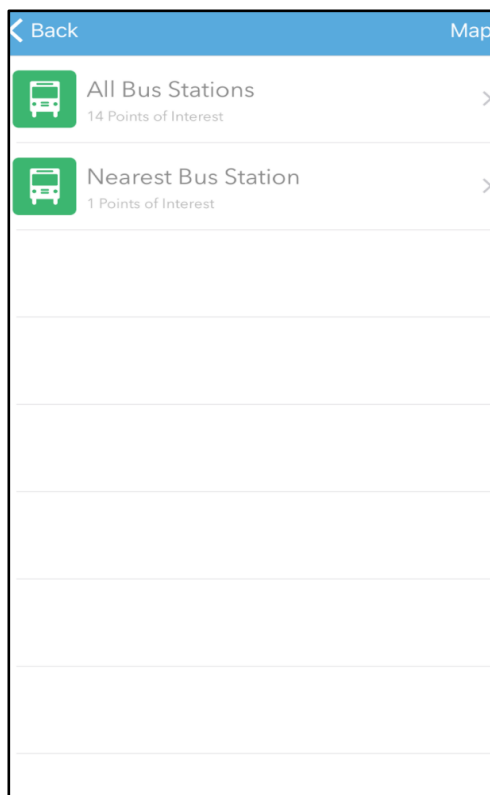


Figure (3): Available Station (ex: Bus).

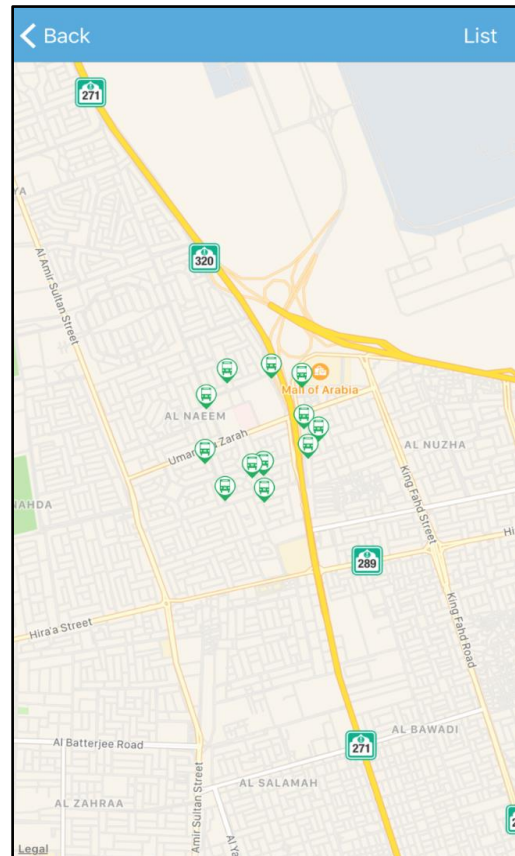


Figure (4): All Available Bus Station in the City

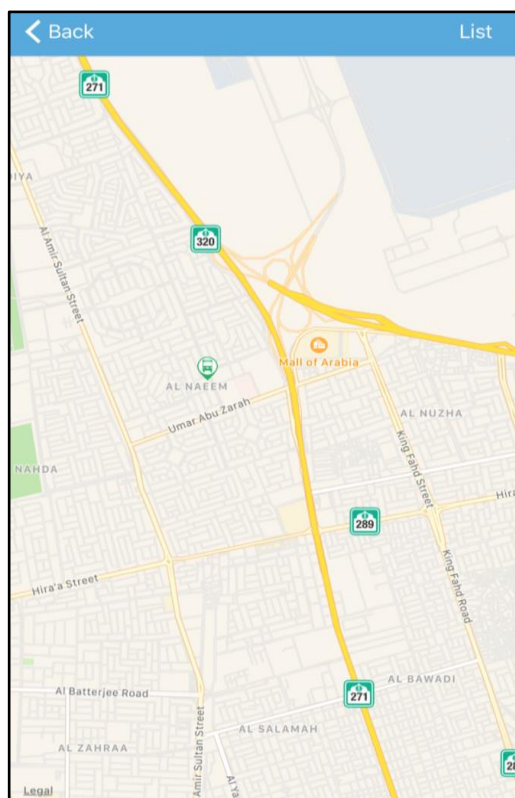


Figure (5): Only the Nearest Bus Station Base on the User Location.

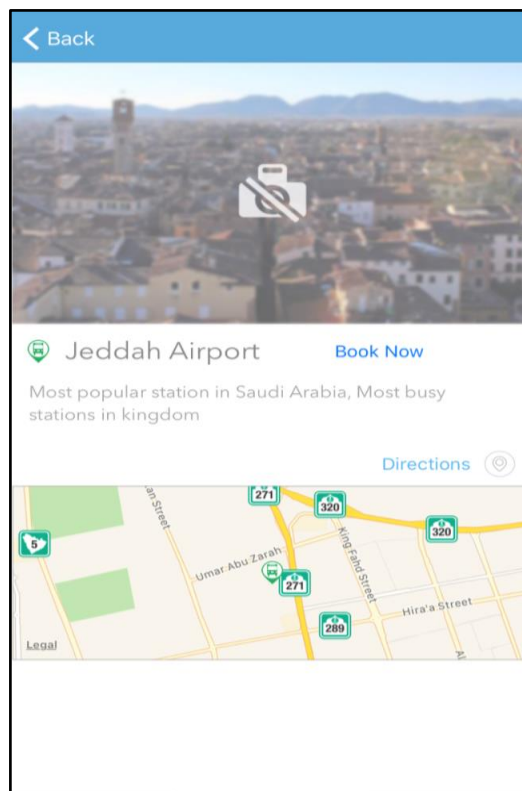


Figure (6): The App Allows the User to Book for a Trip.

VIII. Conclusion.

Intelligent transportation systems are considered one of the main characteristics of a smart city. Providing the residences with convenience and smart mobility as it became a must in a modern and urbanization city. Jeddah is one of the important and the rapidly growing city in the Kingdom, and it suffers from the lack of sufficient public transportation and the smart parking facility. Thus, the city is facing a high rate of traffic hours and congestion, indeed the trail of improvements especially in the road capacity is not coping with population growth rate. This work was conducted to investigate the issues that cause the travel congestion as well as to improve the mobility services provided to the residents as a form toward the movements for intelligent and smart solutions. We proposed a multimodal intelligent transportation system that facilitates the options of mobility around Jeddah city. The proposed system is a unified system which has been implemented as an application for smartphones that allow the user to select the transportation method, check the location and the availability, view the schedule, and book for a trip. It connects all form of possible solution to solve the transportations issue that Jeddah city is facing by integrating all the transportation components into a single mobile application.

In the next phase, the system would be tested with real data and to provide it for other operating systems other than iOS. Also, we would like to add more enhancement features to enrich and improve the services provided to meet and obtain convenience, usability, and quality service for the residence. These would include login/Register feature for members, online payment as well as personalized features and the ability to check the users' history.

References

- [1] Municipality, J., 2009. Jeddah strategic plan. Saudi Arabia.
- [2] Schlingensiepen, J., Mehmood, R. and Nemtanu, F.C., 2015. "Framework for an autonomic transport system in smart cities". *Cybernetics and Information Technologies*, 15(5), pp.50-62.
- [3] Al Dewaik, M. and Nayer, A., 2016, June. "Initiating a smart Transportation system in Jeddah". In *REAL CORP 2016–SMART ME UP! How to become and how to stay a Smart City, and does this improve quality of life? Proceedings of 21st International Conference on Urban Planning, Regional Development and Information Society* (pp. 891-897). CORP–Competence Center of Urban and Regional Planning.
- [4] Washburn, D., Sindhu, U., Balaouras, S., Dines, R.A., Hayes, N. and Nelson, L.E., 2009. "Helping CIOs understand "smart city" initiatives". *Growth*, 17(2), pp.1-17.
- [5] Barmounakis, E.N., Vlahogianni, E.I. and Golias, J.C., 2016. "Intelligent Transportation Systems and Powered Two Wheelers Traffic". *IEEE Transactions on Intelligent Transportation Systems*, 17(4), pp.908-916.
- [6] Aljoufie, M., 2016. "Exploring the determinants of public transport system planning in car-dependent cities". *Procedia-Social and Behavioral Sciences*, 216, pp.535-544.
- [7] Al-Enazi, M., 2016. "Traffic Congestion Evaluation using GIS Case Study: Jeddah City". *Traffic*, 138(1).

- [8] Kala, B. and Martin, P., 2015. "Comprehensive Complete Streets Planning Approach". In Transportation Research Board 94th Annual Meeting (No. 15-1177).
- [9] Ibi, G., 2007. "Jeddah public transportation study". Ministry of Transportation, Saudi Arabia.
- [10] SHAKKER, A., 2014. "The Feasibility of Implementing Public Transportation in Jeddah (Doctoral dissertation, BALL STATE UNIVERSITY)".
- [11] Al-Fouzan, S.A., 2012. "Using car parking requirements to promote sustainable transport development in the Kingdom of Saudi Arabia". *Cities*, 29(3), pp.201-211.
- [12] Rahman, M. S., & Kiyomoto, S. (2016, October). "Secure Bike Sharing System for Multi-Modal Journey". In Big Data and Cloud Computing (BDCloud), Social Computing and Networking (SocialCom), Sustainable Computing and Communications (SustainCom)(BDCloud-SocialCom-SustainCom), 2016 IEEE International Conferences on (pp. 437-444). IEEE.
- [13] Warhurst C., "Developing Students' Critical Thinking: the Use of Debates," in Walker M. (Ed), *Reconstructing Professionalism in University Teaching*, Open University Press, 2001.
- [14] "150 properties in Jeddah to be acquired for metro". (2015, September 8). Retrieved from <http://www.arabnews.com/saudi-arabia/news/803181>
- [15] Rathod, R., & Khot, S. T. (2016, August). "Smart assistance for public transport system". In *Inventive Computation Technologies (ICICT)*, International Conference on (Vol. 3, pp. 1-5). IEEE.
- [16] Shingare, A., Pendole, A., Chaudhari, N., Deshpande, P., & Sonavane, S. (2015, October). "GPS supported city bus tracking & smart ticketing system". In *Green Computing and Internet of Things (ICGCIoT)*, 2015 International Conference on (pp. 93-98). IEEE.
- [17] "Appycity - Ios City Guide Map App". CodeCanyon. N.p., 2017. Web. 5 May 2017.
- [18] "Iconfinder - 1,675,000+ Free And Premium Icons". Iconfinder. N.p., 2017. Web. 8 May 2017.
- [19] "Upload Your App - Diawi - Development And In-House Apps Wireless Installation". Diawi.com. N.p., 2017. Web. 13 May 2017.
- [20] "Apple Developer". Developer.apple.com. N.p., 2017. Web. 7 May 2017.
- [21] DeNicola, E., Aburizaize, O.S., Siddique, A., Khwaja, H. and Carpenter, D.O., 2016. "Road traffic injury as a major public health issue in the Kingdom of Saudi Arabia: a review". *Frontiers in public health*, 4.
- [22] Aljoufie, M., Zuidgeest, M., Brussel, M. and Van Maarseveen, M., 2013. "Spatial-temporal analysis of urban growth and transportation in Jeddah City, Saudi Arabia". *Cities*, 31, pp.57-68.