Smart Transportation for Smart Oman: An Enquiry into its Potentials and Implications

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The concept of smart city has recently gained popularity both among policy makers and academic researchers. Despite the importance of smart city, there is still confusion regarding its meaning as many terms associated with it is often used interchangeably. Many countries around the globe have developed various smart city initiatives to help solve the problems associated with traffic congestion. This paper explores smart city initiatives that are currently being implemented in Muscat. The paper provides the need for the development of smart city initiative in Muscat. Muscat city has been experiencing heavy traffic congestion especially during the morning and evening hours when people are travelling to and from their workplaces. The increase in traffic congestion in Muscat is occasioned by an increase in population in the city and poor traffic management to cope with increase in population and number of vehicles in the town. The study provides analysis of the current situation of public transport in the Sultanate, particularly in Muscat. There is a need to find suitable mechanisms for solving the city's traffic problems. Every problem has various solutions, and enhancing public transport will be explored as part of a comprehensive solution for Muscat city traffic problem. Thus, the study presents the solutions for growing traffic congestions in a smart city and public transportation perspectives. While addressing the traffic problems and extent of public transportation in Oman, the researchers used primary data collected form 80 respondents to know their perception of traffic issues and user acceptability of public transportation initiatives in Oman. The study, while exploring available smart city initiatives in Oman provides further recommendations that can be implemented in order to solve the problems related to traffic congestion, and further recommendations are placed for enhancing the public transportation systems in Oman.

Keywords: Oman; smart city; smart transportation; traffic congestion

Introduction

The past decade has witnessed a growing interest in the concept of smart city in most of the countries around the world. Nations today are competing and striving through the optimal use of information and communication technology to make their cities smart. The smart city concept has multiple definitions which differ from country to country depending on how each country is integrating the information and communication technologies to create smart environments in their cities (Cocchia 2014). Therefore, until today there is no specific or universal definition for smart city, as the meaning depends on the city's level of development and its effort and willingness to change and reform its resources. However, many scholars have come to an agreement that smart cities should be achieved through the implementation of sustainable infrastructures and other facilities within the cities. This means that the development of cities across the globe should be in such a way that ensures the maximum protection of the social, economic and environmental welfare (Leung et al. 2011). Por (2016) provided a definition of smart cities that is based on the following six dimensions:

- Smart Government: It involves private and public organizations. The government is making solid efforts to enable the use of applications (hardware and software) for the purpose of decision making and providing electronic public services.
- Smart Economy: It includes processes of ecommerce as well as business to support the sustainability and development of productivity.
- Smart People: Promoting people's critical thinking and inspirations along with making efforts to foster their innovations.
- Smart Mobility: Mainly focusing on the logistic and transportations sector and including the integration of both the intelligent use of technology to develop smart mobility with clean energy.
- Smart Living: It includes the safe use of applications and technology that allow an independent style of living and behavior.
- Smart Environment: Focusing on having a clean, energetic environment controlled and managed by technology, as well as the mechanisms to reduce pollution and adverse weather impact.

Al Shidhani (2016) from the Research Council of Oman has stated that "Smart city is enabling the characteristics of smart people, smart environment, smart living, smart economy and absolutely smart governance to bring society, government and technology together.

Recently, new technologies have encouraged the development of smart city initiatives. These initiatives are comprised of different transport systems, ICT, social

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participation, economic growth, city services and energy efficiency (Bifulco & Tregua 2013). According to Handy (2005), smart technologies are concerned with the provision of the solution of the current challenges without interfering with the future needs of the society. In other instances smart technologies are referred to as the implementation of technology that is considered as socially, environmentally and economically sustainable (Neirotti et al. 2014). Smart technology encompasses various sectors such as transport, building and construction sectors. In many countries, transportation has been considered as one major sector that can help facilitate green technology. Smart transportation refers to the development of appropriate transport system that is energy efficient, environmental friendly, time efficient and cost effective (Neirotti et al. 2014). The aim of smart transportation technology is to come up with appropriate technologies to solve various transportation problems in urban centers such as parking problems and traffic congestion among others.

The main purpose of this research is to analyze the recent research trends in the smart transportation systems in Singapore and Dubai. In addition, the study aims to draw inferences that can be applied in Oman to find remedies for its traffic congestion and parking issues and to enhance the use of public transport in Muscat.

Among the different aspects covered in the research, attention will centre particularly on the role played by smart transport projects in the chosen cities. The first of these, is Singapore which is one of the world's most active and successful cities in exploring ways to optimize smart city development by integration of policies, intelligent use of ICT and focusing on helping people to live happily (May 2004). The second chosen city is Dubai, which is an ideal example of a smart city in the GCC countries (Tok, et al. 2014). It has been already developed in the Dubai Health City as well as making successful use of technology in different types of transportation, such as Metro Dubai, private taxis working by distance based fare. It has also applied smart technologies for monitoring traffic congestion, analyzing traffic data and using detection cameras to avoid incidents and to quickly identify congestion hotspots. Further information on the chosen cities will be provided in the coming chapters of the research.

This research conducts a study on Smart Transportation for Smart Oman and an Inquiry into its Potentials and Implications. First, the purpose and main objectives, background and rationale of the study will be explained. The expected outcomes of this study will also be discussed. Then a review of relevant literature will be conducted in order to develop the theoretical framework as a basis for the study.

Problem Statement and Objectives

Most of the population in Muscat are adversely affected by traffic and parking issues, which cause a lot of disruption and delay in their daily work. This therefore impacts on their productivity and affects the economic development in the country. Expansion of the roads is not the only or necessarily the best solution for these traffic issues. Instead, a mechanism is needed for applying suitable technology to make the movement of traffic easier and also relieve parking issues.

Recently, London has introduced congestion charging for the central area, in an effort to reduce central London's congestion levels. Following on the heels of that initiative, many other cities around the world are now seriously considering similar measures for dealing with congestion (Handy 2005). This is because congestion in major cities is a major source of transportation problems which eventually slows economic growth in countries. Some of the challenges that are caused by the congestion problems include traffic problems, pollution, and high consumption of energy and to some case accidents. This makes it appropriate for other countries including Oman to implement some of the efficient transportation systems

Muscat, as the capital of Sultanate of Oman, has seen a rapid increase in car ownership among its households. In 1999, the number of passenger cars in Muscat was estimated at 174 per 1000 people, whereas the corresponding figure for wealthy Asian cities was 123 per 1000 people (Low & Gleeson, 2015).

These figures indicate that car ownership in Muscat is 42 percent higher than in wealthy Asian cities, while at the same time Muscat has a much smaller population than any of these Asian cities. It is consequently unsurprising that Muscat is a city that is suffering from serious congestion problems (Low & Gleeson, 2015).

The study will provide analysis of the current situation of public transport in the Sultanate, particularly in Muscat. There is a need to find suitable mechanisms for solving the city's traffic and parking issues, especially during the rush hours and at the weekends. Every problem has various solutions, and enhancing public transport will be explored as part of a comprehensive solution for Muscat city traffic problem.

This study aims to investigate recent trends on the Smart Transportation systems and conduct a comparative analysis in order to draw inferences that can be applied to addressing Oman's traffic congestion problems.

This study will pursue the following aims:

1. Analyze the perceptions of residents of Muscat towards traffic congestion and parking issues.
2. Analyze the user acceptability of public transportation initiatives in Muscat.
3. Explore the possibilities and potentials of smart transportation projects in Oman and to suggest smart transportation as a mechanism to eradicate traffic congestion and parking issues. Maintaining the Integrity of the Specifications

Review of Literature

Traffic congestion simply is the increase use of vehicles on the road which results in a difficult movement on the roads where one vehicle blocks another for long period. Therefore, traffic flow had become a major issue in most cities and that there are many reasons behind the traffic congestion in major cities. The rapid increase in population can be considered as the key factor for the increase in the traffic congestion as this means that there is an increase in the number of vehicles to cater for the needs of the grown population.

According to last updated information regarding population growth rate in largest cities around the world, the big cities are dealing with huge numbers of car every day. For example Tokyo in Japan with a population of about 37843000, Jakarta with a population of 30539000, New York with 20630000 populations, Paris 10858000, Delhi 24998000, Singapore 5624000, UK of 10236000 population, and other big cities all are dealing with huge number of cars on their roads every day (Tsekeris & Geroliminis 2013). Hence, traffic congestion can be considered as a big problem for everyone within these cities. The main reasons for the occurrence of traffic congestion can be explained in terms of the increase in the number of the cars, different types of vehicles and the poor management of roads (WorldMap, 2016).

Although there is a use of public buses to manage the traffic, the traffic congestion is still increasing because of lack in optimal use of roads infrastructure. The optimal use of road infrastructure should include a range of activities such as management of the traffic flow, parking facilities and highway traffic movement among others. This means that relying solely on the introduction public transport system is not effective.

In addition, employees in both government as well as private sectors can take a part of measures aimed at getting rid of traffic congestion problems. Traffic congestion often happens when people are going to work and also when they are coming back from their work. This occurs every day and at the same fixed time which normally ranges from 7:30 am to 2:30 pm or 4:30 pm for the private sector. This time interval is normally considered as the rush hours in Muscat city.

Another problem for the traffic congestion is lesser use of public transport. In first quarter of 2016, Mwasalat Company had launched the new public transport buses, 40 buses are designed for the passengers in the governorate of Muscat and 17 trips departs daily outside Muscat with luxury buses operated in Marmul lines for those who are working in Oil and Gas Companies, Salalah and Dubai. The company is intended to have a capacity of about 4 to 5 million passengers by the end of 2016 (GULF DIGITAL NEWS, 2016).

The lack use of public transport absolutely will have an effect on traffic and if there is no other option for using public transport the traffic problem will not be solved. If there are no adequate trains, metro and buses for people to use for their daily tours, people will use their own cars for work and other purpose. The number of travelers on automobiles will decrease if they could take the buses or other public transport choices and this will also lead to a decrease in the number of driven cars.

According to Downs (2010), traffic congestion is getting worse every year in America comparing to five years ago. He was pointed the reasons behind the traffic congestion in Metropolitan Areas, due to the growth of jobs as well as population. The same study mentioned that traffic congestion are affected by the structure of society itself and more intensive use vehicles including cars, trucks and others with the number of these vehicles increased by around 50% comparing to previous years especially in rush hours. Hence, the study mainly focuses on the growth of population and increase in the employment as the main cause of traffic congestion. This makes it fails to address other notable causes of traffic congestion such as ineffective parking systems and inefficient traffic control system.

Another study conducted by Elizabeth (2010), proposed solutions to traffic congestion in Boston. She emphasized that congestion would grow worse unless there is a mechanism to mitigate and manage it. Therefore, a subway as well as railway could contribute significantly to reduce congestion. Especially, this should be implemented in downtown where most residents are focusing there for doing their daily works, business and as a result the expanding of modern building will be expanded as well. In addition, increasing in the number of vehicles, and peak times (going and back to work, schools and other colleges and universities) and faults and design of roads such as a large roundabout, narrow roads among other factors can lead to traffic congestion in Muscat and other regions of Oman.

To conclude all mentioned studies in traffic congestion, if the government invests more in public transportation, encourage people and force them to use affordable and cheap public transport that will result in less traffic congestion and could be one of the solutions. This is besides the optimal use of road infrastructure and supporting the public transport with technology.

Public Transportation

According to Handy (2005), public transport refers to the shared transport system primarily for the use of public. Public transport is significantly different from other modes of transport that include taxicabs, hired buses, and carpooling which are not shared by the strangers without prior private arrangement. The public transport can include mode of transport such as city buses, trams, passenger trains, trolley buses, ferries, airlines and rapid transit. Within the cities, public transport is dominated by buses which have the ability to carry passengers from different locations within the city. Passenger train is also another common public transport that operates within cities in different countries.

According to Handy (2005), transportation and mobility are some of the key challenges that face a number of cities globally. Residents of different cities rely on transportation systems to travel, commute and transport some of the essential goods. Cities also face numerous challenges that are related to transportation. The growing cities encounter congestion and the long trip times that is caused by the overloaded infrastructure while some of the older cities suffer from the ageing infrastructure (Tsekeris & Geroliminis 2013). It is also worth to note that transportation infrastructure is normally capital intensive and thus requires several years to build.

As many countries are in the process of developing smart cities, one major area that has been considered as important towards meeting the goals of smart cities is the public transport system. In many countries around the world, the state of public transport has been a major hindrance towards meeting the objective of smart city (Pacione 2014). To ensure that the goals and objectives of smart cities is realized it is important that there is the development of appropriate and efficient public transport system. Different transportation system initiatives have been implemented to help meet the objective of smart cities in various countries. This initiative differs from one country to another and can differ based on the level of technology and technical expertise that is applied. Some of the initiatives that are aimed at reforming public transport system include construction of efficient parking system, improvement of road and railway networks and the design of appropriate smart public transport system (May 2004).

Different countries have introduced various initiative aimed at ensuring that the goals of smart transportation is achieved. The initiatives to meet smart transportation have been different from one country to another. Some of the initiatives of smart transportation that are common in a number of countries include smart traffic rooting, smart parking, smart infrastructure planning, and smart public service vehicles. The smart traffic rooting is an initiative that is established to help control the flow of traffic within cities in different country. The initiative takes different dimension based on the unique requirement of country. In most cases it involves the control of traffic flow using some advance technologies such as placing of sensors at various strategic places to help control the flow of traffics (Neirotti et al. 2014). Such sensors automatically detect traffic congestion and control traffic flows without necessary involving the use of traffic personnel. Smart parking is also another initiative that is instrumental towards development of smart transport system. Smart parking initiatives are normally concerned with the development of efficient and effective parking lots that can help to effectively control the rate of traffic flow. This includes programs that ensure those motorists are aware of the availability of the parking lots at different spaces designated for parking. In this case, the wireless sensors are placed in the parking spots and are aimed at detecting whether or not the parking areas are available or occupied. The data is then transmitted to the central system which is then sent to the respective Smartphone of the users that are searching for the parking spots.

Smart Transportation

The idea of smart transportation has been defined in various countries around the globe. The concept of smart transportation was primarily initiated due to the environmental problems and concerns in various countries around the globe. Currently, every city across the globe has embarked on the initiative to ensure that there is the development and implementation of the sustainable transport system (Taniguchi et al. 2001). Although there is no universally accepted definition of sustainable transport, it is however generally accepted that sustainable transport refers to the proper balance between the current and the future social, environmental and economic qualities. This means that sustainable transport should satisfies the current transport need without interfering with the ability of the future generations to meet their needs.

In United States sustainable transport system has been achieved through the implementation of the intelligent transport system. The intelligent transport system which is commonly referred to as ITS include a variety of technology solutions that help provide and manage

information as well as improve the efficiency, safety and the performance of the transportation network (Mimbela et al. 2000). The technology to achieve the intelligent transport system in the United States includes the electric tags that enable motorist and other road users to pay the tolls without necessary slowing down. It also provide the real time travel information to travelers with an of improving the management of traffic congestion and enable the provision of the travel equipment, choices on the vehicles that can alert drivers and other travelers to issues such as dangerous situations.

In United Kingdom, the initiative oneTRANSPORT is being implemented across various cities to help solve the problems associated with the current road transport. The goal of oneTRANSPORT is to help deliver the travel experience that is superior as well as facilitates the exploration of the new incomes and revenues for the local authorities (Bach et al. 2010). OneTRANSPORT is considered as a major future proof strategy that can be play significant role towards transforming the transport industry to become sustainable.

GCC is an acronym for the Gulf Cooperation Council and is composed of countries such as Kuwait, Oman, Qatar, UAE and Saudi Arabia. The GCC countries have come up with a common initiative for smart transport system aimed at improving the efficiency of transport services in the country. As the future of the transport system relies on the smart transportation, many of the GCC are beginning to implement integrated and intelligent transport system. As the countries of the GCC continue to flourish, the numbers of individuals entering the country are increasing and this condition has led to a situation where there is strain the transport network and other infrastructural facilities (Leung et al. 2011). This has necessitated the need to develop transport system that can cope with growing need of these nations.

There are various efforts that have been taken by the GCC member countries to help improve the current status of their infrastructures. The new urban challenge in that are facing cities within the GCC regions can be argued to be the major reason towards the investment in the Smart Transport solutions. In these countries, smart transport solution is composed of various components that should be included. The major components of Smart Transport Solutions in GCC countries can be argued to be car sharing, advanced public transportation, bike sharing, tolling, congestion charging, and smart parking and traveler information systems.

Oman has also embarked at initiatives that are aimed at implementing smart transport network in its major cities. In Muscat there are several elements of smart cities that are evident and this shows the desire of the country to solve the issues associated with its transportation problems (Yigitcanlar et al. 2008). One area in which Muscat has invested towards improving its transport network can be argued to be the mode of public transport. Over the present periods Muscat introduced some of the smart buses named Mwasalat. The Mwasalat project is aimed at improving the efficiency of the public transport in the city as well as helps achieve the smart transport objectives. The Mwasalat buses are fitted with technologically advanced gadgets that include Wi-Fi service, tourism information facilities and real time tracking and online ticketing application (Cuddy et al. 2014). The project also allows individuals to book parking spaces using their Smartphone, send complaints and feedbacks and monitor service request. There is also free Wi-Fi and some of the selected parking lots. Another key component of the smart transport system in Muscat is the installation of the intelligent traffic light control and smart parking devices.

Data analysis and findings

There were total of 80 participants in the study; 48 males and 32 females. Questionnaire was mainly designed to get the user acceptability of public transportation systems in Oman and to analyse the participants' perception of traffic problems.

Public Transportation in Oman

The participants were asked a number of questions regarding the transport that they use in a regular basis. The result of the study indicated that majority of them use own cars while a few others use Minibus. The individuals with own cars were 80 %, followed by those who travel by minibus (7.5 %). There were no individuals who indicated that they were sharing cars. It was also interesting to find out that only 5 % use Mwasalat and 2.5 % use private taxi. This clearly gives us an idea that the number of people who prefer and use private transportation is considerably high in Oman that adds to the problems if traffic congestion. However, 93.75% of the participants have used the public transportation system offered by Mwasalat. This gives an insight that, if planned well and if the services are enhanced, people will be interested to use the public transport facilities in their daily commute. This must also be read along with the response of the participants to the question on the potential of Mwasalat in enhancing public transportation facilities in Oman. 95% of the participants agree that Mwasalt will improve the public transportation system of the country.

A question was asked to participants to know their level of satisfaction with Mwasalath services. When 47.5% of the participants expressed their satisfaction, 10% of the participants are dissatisfied with the service, and another

36.25% of the respondents are feeling that there is still room for further improvement.

In an attempt to know the factors that make the Mwasalat a preferable transportation system, majority of the participants indicated that they prefer Mwasalat because of its punctuality (40 %). 30% of the participants prefer Mwasalat because of its convenience, 10% due to its cleanliness, and 5% due to its price. Although the majority of the participants indicated that they are happy about the services of Mwasalat, there is a need to improve certain areas such as safety, affordability and cleanliness. Improvement in these areas can help satisfy the needs of all the residents of Muscat and there can have a positive growth in the number of people using public transportation.

Traffic Congestion

The participants were asked certain questions to know their perception of traffic congestions in Oman. The result indicates that 97.5 % (65 % males and 35 % females) feel that there is a serious traffic problem in Muscat and majority of the participants admit that the problem is worse during the morning hours. When majority of the participants (65%) face the traffic problem on a daily basis, 25% face the same few times a week and remaining 15% of the participants encounter the traffic problems few times a month. Similarly, 85% of the responses show that traffic congestion has recently got more aggravated comparing to past five years.

In an attempt to know the reasons behind traffic congestion, majority of the respondents (50%) indicated that it is caused by increasing number of vehicles, 23.75% attribute population growth as the cause and 11.25% of the respondents feel that the accidents cause traffic congestion. Other reasons identified include bad weather (5%), use of mobile phones while driving (5%), special events (2.5%) and 4% opine that the traffic is caused by all of these factors.

Conclusion and recommendations

The findings of the study addressed all the objectives and research questions that were developed for the study.

The study developed four main objectives that were as follows.

1. To analyze the perceptions of residents of Muscat towards traffic congestion and parking issues.
2. To analyze the user acceptability of public transportation initiatives in Muscat.
3. To conduct a comparative study on smart transportation initiatives in Oman, Dubai and Singapore.
4. To explore the possibilities and potentials of smart transportation projects in Oman and to suggest smart transportation as a mechanism to eradicate traffic congestion and parking issues.

Based on the findings of the study, it is recommended that Muscat develop effective traffic management system aimed at controlling traffic flow in the city. The development traffic management system such as the use of Smart transport system is suitable means for solving the traffic problems in the country. Besides, it is appropriate for the government to increase the awareness of its Mwasalat program to help in the management of traffic flow. It was evident that there is lack of awareness of the Mwasalat Bus Services as majority of the residents of Muscat have not previously used the bus service. This implies that the residents of the city should be made aware of the traffic system and encouraged to use it so as to avoid the unnecessary traffic congestion and other related problems in the city. Major highways in the city should also be installed with efficient traffic management systems such as cameras and other technological devices that provide regular updates on traffic flows and movements.

As majority of the people feel that public transport will ease the traffic, authorities must enhance it with more good facilities.

Muscat should ensure that it solves the challenges associated with traffic congestion by considering Smart Transport System that has been developed by several countries across the globe. Such Smart Transport System should consider improving parking spaces, increasing traffic surveillance and introducing public transport system in the city.

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