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AN EXPLORATORY STUDY: THE ROLE OF THE INTERNET OF THINGS (IOT) IN REDUCING TRAFFIC CONGESTION IN MUSCAT GOVERNORATE

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ABSTRACT

Traffic congestion is considered as an escalating problem in Muscat governorate which has resulted from the increase of vehicles on the road and growth of population and other reasons which have negative impacts on people, environment, and business .Subsequently, this research study includes the analysis of the current traffic status where the researcher study mainly the causes of traffic congestion in Muscat, find and know the real role of the internet of things technology in reducing traffic congestion by having comprehensive details and information about the IoT technology with its related technologies and devices which can be used in traffic management. And based on analysis, the researcher set a group of recommendations in regard to the utilization of the IoT to know its real role in reducing this issue and to enhance the road infrastructure. The prompt and magnificent development of implementing the advanced technologies in information and communication technologies domain has become the main interest for many researchers nowadays that promotes to present many modern chances to retain the business continuity. The internet of things mainly aims to assemble the necessary information from many IoT devices and technologies. IoT is mainly dependent on the internet, wireless, and the technologies of detecting and sensing which utilized to understand any smart recognition of the tagged things by observing, tracking, processing, controlling all data in an automatic way.

In addition, the research was conducted using explanatory/descriptive analysis through the random sample size which been selected for the purpose of the study. The results of the analysis revealed that the main causes of traffic congestion in Muscat were because of the increasing number of cars, secondly due to population growth. The rest of the reasons were between the centralization of institutions and shopping centers in Muscat, road repairing and construction, and the behaviors of drivers who driving reckless and their unobligation to traffic rules. The recommendations decreed that, to take advantage of using the internet of things technologies, placing the smart traffic lights, deploying the smart signs. In addition, one of the recommendations is to link all of these suggested solutions with the traffic application of Royal Oman Police.

Keywords: IoT,ICT, traffic congestion,Technologies, traffic,4IR.

1. Introduction

Now day's traffic congestion is considered a major issue in many countries. And this is comparatively true in case of increasing traffic congestions in Muscat governorate in the Sultanate of Oman. Traffic congestion is a global phenomenon caused by the rapid urbanization of countries. There are many reasons for traffic congestion for instance; population growth, conditions of road (including repairing and maintenance), and the increasing number of cars in the road. In the current time, there is imposing attention from many researchers and scientists in regard to the fourth industrial revolution (4IR) including IoT. Where these technologies aim to make human life better and smarter.Taking the advantage of the IoT solutions will assist the operation teams in traffic management to manage and minimize the issue of congestion in a better way. where IoT and the integrated technologies with IoT provide many advantages for example; cost management and traffic safety.

1.1 Statement of the Problem

Oman has good Road infrastructures and the number of vehicles keeps increasing yearly. Many motorists face traffic congestions on the road and this can lead to many issues. Some motorists before reaching their destination, they keep on checking Google maps to know if there is a traffic congestions in road and which route they can use. National center for statistics and information (NCSI) stated that "the total population of Sultanate of Oman has reached four million and six hundred and sixty-four thousand and seven hundred and ninety (4,646,790) people until the beginning of January 2020"(Atheer 2020). In addition, according to statistics published by the national center for statistics and information that "the number of vehicles traveling on the roads in Sultanate of Oman by the end of January 2020, reached one million and five hundred and fifty thousand and ninety-four vehicles with an increasing of 3.4 % compared to the end of January 2019" (AL-Omania-Atheer 2020). Increasing populations and the number of vehicles in the streets have driven traffic congestions in the last few years and other reasons for traffic congestion. In addition, if traffic congestion happens suddenly in road even, there isn't any notifications or dashboard in streets to alarm motorists to reduce their speed. Royal Oman police only notify motorists in social media accounts and on specific radio channels and this is not enough. If drivers do not reduce their speed, an accident may happen. In addition, drivers are not routed to use another road.

2. Objective of the Study

- To study and review the literature regarding the importance of the Internet of things (IOT) in traffic management.

- To explore and identify the causes of traffic congestion in Muscat city
- To study and review IOT devices and Architecture for managing traffic congestions.
- To suggest new solutions to reduce traffic congestion using the internet of Thing.

3. Literature Review

A. Internet of Things (IOT) overview and background

The concept of the internet of things has been extensively addressed since the 1990s. According to Atzori, et al. (2010), the IOT is new paradigm has become widely circulated in the world of modern communications that envision everything in life are interconnected with each other and able to interact and communicate with

devices and users to achieve a common goal, becoming an integral part of the internet in which new paradigm will play important role in new coming future. All in all, IOT is about connecting many different devices to-gether and with the internet. The main characteristics of the internet of things are as follow; Heterogeneous,

Unobtrusive, Connectivity, Reliability, Flexible, Economical. Overall, the main concept of the internet of things is based on the premise of connecting devices to other devices via the internet in order to exchange the

necessary information. The below figure explains the common applications of the IoT in different fields.

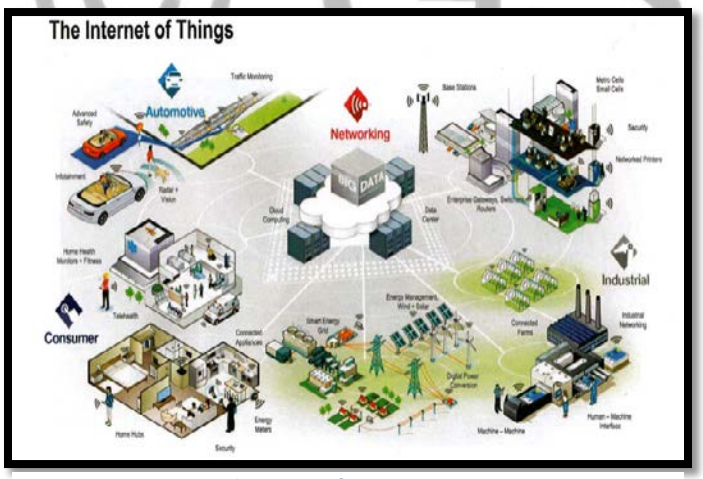


Figure 1: common applications of IoT

B. Key Technologies of the Internet of Things (IOT)

The Internet of things technology consisting of many technologies with a variety of hardware and software. The main technologies are explained below.

a. RFID Technology

It is an acronym for "Radio Frequency Identification" and refers to technology for automatic identification used

to identify devices or objects in IOT.

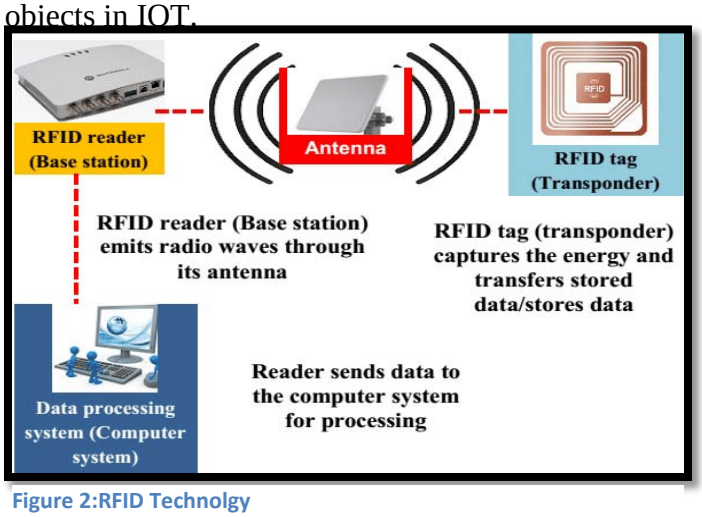


Figure 2:RFID Technolgy

b. WSN Technology

It stands for "Wireless Sensor Network" and indicates a network of nodes that contain a huge number of sensor nods. Each node contains sensors to discover any physical phenomena as shown in below figure.

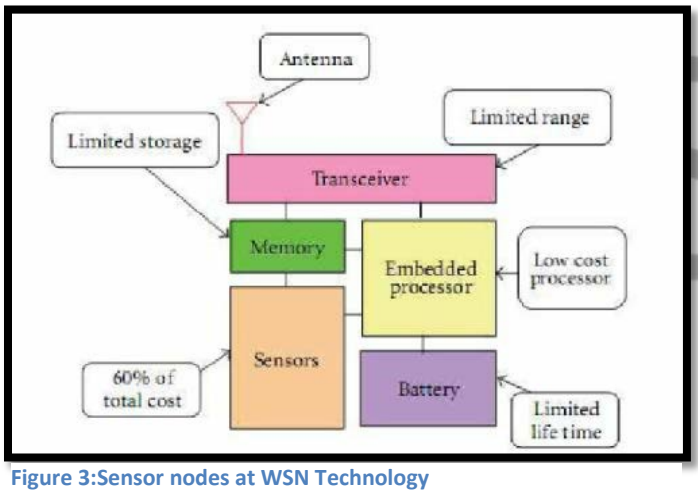


Figure 3:Sensor nodes at WSN Technology

c. Cloud Computing Technology

Cloud computing is a group of technologies that enable users to use different software to process and store data through the internet. However, cloud computing is a combination of network technology and computer technology to provide services over the internet in a visualized way (Rui et al. 2015).

d. NFC Technology

It stands for near field communication and has been found in many mobile devices allowing the formation of peer-to-peer connections and passing data from one device to another device by touching them or placing them close to each other. The Figure(4) presents the NFC diagram which is based on sensor system.

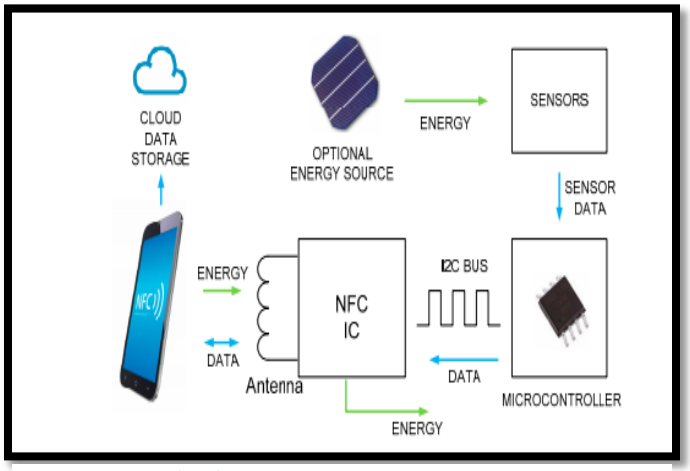


Figure 4:NFC Technology

e. Bluetooth Low Energy (BLE) Technology

The energy of Bluetooth is more efficient and consider as an appropriate option for the IOT. Which used for short communication range to enable foe exchanging data between different devices. (Collotta and Pau 2015) discuss that Bluetooth technology is reliable technology located in personal computers and mobile phones with low cost and less energy which can provide a user interface for IOT applications.

f. Network Communication Technologies

There are many communications technologies use on the internet of things applications, for instance, 2G, 3G, 4G, WSN, and RFID. The new next generation of the network is 5G which provide high range for transferring data. (Vargas et al. 2020) indicate that the internet of things systems and applications have unique

characteristics and requirements such as security, high data rate, operations, and quality of services which are supported by 5G communications.5G network is like network technologies with 2G/3G/4G.

Moreover, the major projects for 5G applications and systems contain a higher rate for data transfer to reach up to (10Gbps), have extra users(0.5M users/km2), provide more interactive services, and make a high and flexible network.

4. Research Methdology

The two main approaches used in the study of the role of IoT to reduce traffic congestion in Muscat were quantitative and qualitative methodologies. In addition, the literature review offered comprehensive information in regard to the concept and overview of IoT, the importance of IoT, and main technologies of IoT. Furthermore,

the survey questions were designed and distributed randomly among the participants on the research study.

The results of both approaches will be written in the section of findings and discussion.

5. Summary of Research Results

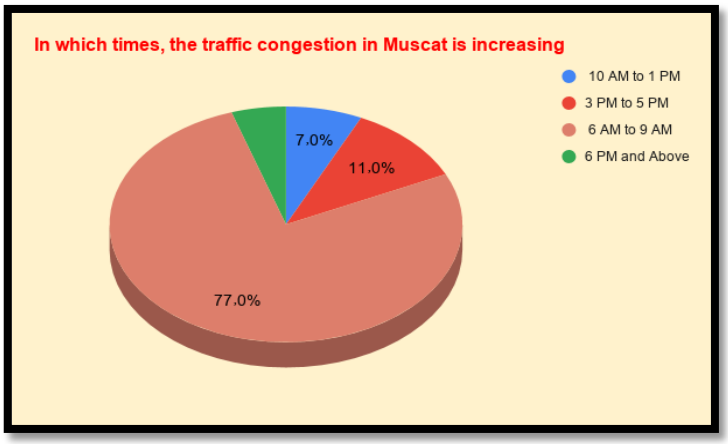
Based on findings, the researcher recap the results as below.

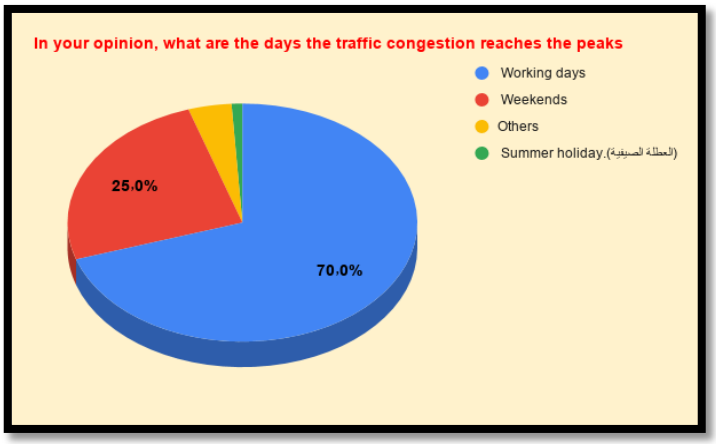
i. The peak and days of traffic congestion

- **(In which times, the traffic congestion in Muscat is increasing?) and (What are the days the traffic congestion reaches the peaks).**

The finding presents that the common reponse on the time and days where traffic is increasing and reached to the paek. Specifically, Most of the participants by **(77%)** out of **100** pointed out that during the morning period between **6 AM** and **9 AM** the traffic congestion is increasing, and by **(11%)** stated that the time where traffic congestion is increasing between **3 PM** and **5 PM**. Furthermore, **70%** of respondents confirmed that the traffic reaches the peak during the working days while **25%** of participants indicated that during the weekends the traffic congestion reached to the peak.

In general, it can be seen that during the morning period between **6 AM** and **9 AM** contained the most cases of traffic congestion during the working days where these days considered are the peak days where the congestion is increasing. The below figures recapped the results.





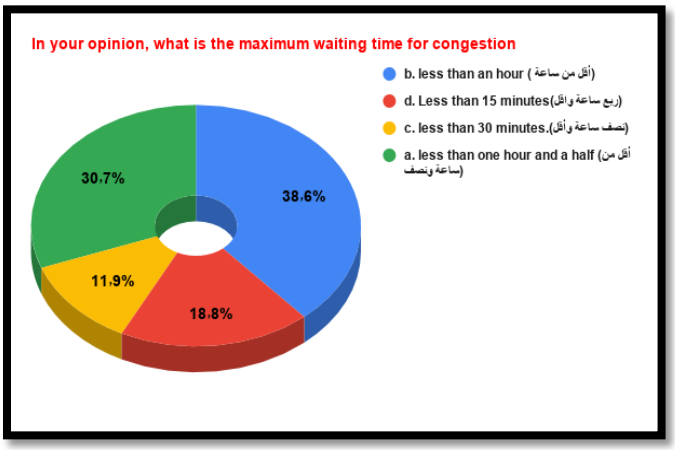
ii. Maximum waiting time for congestion.

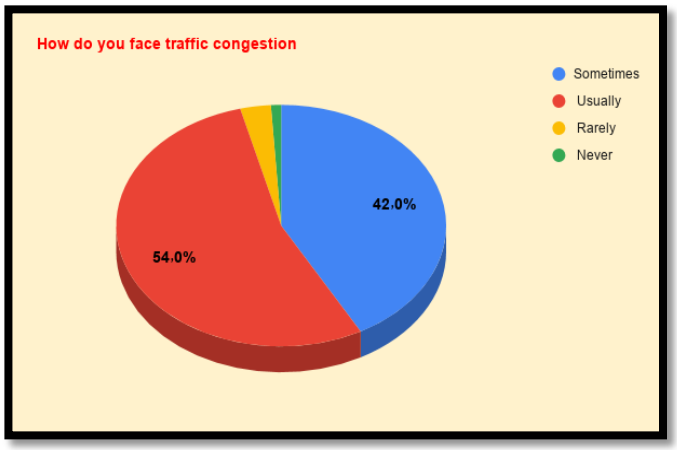
- (**what is the maximum waiting time for congestion**?)

The results revealed that the majority of participants by **(39%)** pointed out that the maximum waiting time at congestion needs to be less than an hour. And by **(31%)** of respondents indicated that the maximum waiting

time in congestion needs to be between not more than one hour and a half. In addition, the participants were been asked about how they faced traffic congestion whether it is usually, sometimes, rarely, or never and the results discovered that many participants indicated that they face usually traffic congestion.

According to (Muwatin 2013) stated that in all cases of traffic congestion the drivers preoccupied this period by listening to the radio, using a mobile phone, and pay attention to vehicles. Below figures summarize the results





iii. Causes of traffic congestion

- **(What are the main causes of traffic congestion in Muscat?)**

The results to these question showed that the main causes of traffic congestion in Muscat were due to the the increasing number of cars on roads, where around **(73%)**of participants stated that the main causes of congestion in Muscat was because of this. (Revenio and Amalinda 2015) mentioned that this is because of the increasing number of car licenses in recent times which lead to an increase in the number of vehicles. However, **20%** of respondents said that population growth in recent years in Oman also a reason for traffic congestion in Muscat. Moreover, **5%** states that motorists behaviors where many of them driving reckless and this is due to their un obligation to traffic rule even if they have knowledge but they do not follow it. Also, **2%** mentioned road repairing and maintenance causing congestion in many areas.

- **(Centralization of Ministries and other organizations and shopping centers is a key factor for traffic congestion in Muscat?)**

In order to find more reasons for the traffic jam in Muscat governorate, this question has been asked among Participants, the findings showed that **(63%) out of (100)** were strongly agree that the distribution and centralization of institutions in the Capital city and shopping centers have led to congestion in the past and current

years. Where many residents and citizens resort to Muscat because of their daily works and finishing their own business.

- **(Some car accidents are caused by traffic congestion?)**

The results revealed that **(41)** of (100) of participants were agreed that some car accidents can occur because of traffic congestion, and by **(37%)** were strongly agreed on that reason. However, one reason of causing accidents during traffic congestion is because of many drivers get busy with their cell phones and they do not care about other cars in road.

- **(How do you think about the quality of Muscat roads?)**

To line and find if there is a relation between the road quality and traffic jams, the results showed that the majority by **(46%)** stated that the road quality in the capital city is good, while**(36%)** pointed that the quality of the road is excellent. To confirm the revealed opinions of participants who stated that the road quality in the capital city is excellent and good, according to Global Competitiveness Report for 2018 the Sultanate of Oman as the Sultanate ranked eighth globally and the first Arab in the road quality index.

iv. The IoT Architecture to manage traffic congestion

Upon the literature review conducted by the researcher, the researcher founded that current research study adopting six-layered architecture which includes the below layers and their main functions:

- **Coding layer**: this layer will offer a foundation to define any objects by assigning a unique identifier to distinguish the objects easily.
- **Physical/Perception**: this layer contains the IoT devices like sensors to gather the necessary information from various resources utilizing different technologies like; RFID, IR and network sensors which realize the speed and location of things and transmit the hardware data into digital signals to pass them to the following layer for different actions such as; sensors which installed in many places as radars, traffic signals.
- **Layer of Network**: the data which had been received will be transmitted to the system of processing which is in the following layer using different transmission devices such as; 5G, 4G, WIFI. For the current research study, the information has been transmitted using 5G network and WIFI.

- **Middleware Layer:** it triggers data which has been coming from the sensors including some technologies for example; Cloud computing which provides instant access to the database in order to store the necessary data. In the current study, cloud computing can be utilized to automate all processing.
- **Application:** this layer identifies different applications of the IoT, based on the processed data. For this research study, the ROP application has been considered.
- **The business layer:** this layer identifies different applications of the IoT, based on the processed data. For this research study, the ROP application has been considered.

v. IoT and solutions

❖ **Do you agree to use the technologies of the fourth industrial revolution (4IR) including the internet of things (IoT) to reduce traffic congestion?**

The question aims to measure research objectives 1 and 4. In this regard, the majority of the participants by **(51%)** were strongly agreed on that, and about **(43%)** were agreed. upon these results, the researcher believed that the usage of technologies involving the IoT will make big changes in people's lives as it plays a great role in making quantum leaps in various fields.

In addition, Mr.Wadih AL-Lawati (Professor at Sultan Qaboos University) explained that the IoT is important in collecting the necessary data for many organizations and then analyzing this data and use it in several aspects for instance; providing new services, enacting new laws and legislations or changing the existing, and the initiative in providing services for beneficiary before requesting. AL-lawati stressed that all these and other matters are in the interest of the country developments and prosperity and facilitate the performance of the organization's works (Oman daily 2017).

o **Solutions to minimize traffic congestion**

❖ **Smart road signs used to inform drivers about different road conditions and traffic status. Do you agree to place them on our roads?**

Upon the survey results to this question, it showed that **(57%)** had been strongly agree on this sloution, and by **(39%)** had agreed on that.The smart signs works to notify drivers about the road conditions and traffic status which enable to make drivers to drive in a safe ways, and assist to minimize the congestion in raod. Moreover, Many features can be added with this smart signs, for instance, adding alerting about construction sites, notifying about weather conditions, and alerting about speed limitation.

❖ **Smart traffic lights gather information sensors to detect congestion, Do you agree to**

implement this feature in Oman Roads?

To find more solutions that assist in traffic management which works based on the advanced technologies like the IoT, the researcher finds that by **(57%)** of participants were totally strongly agreed to this option, and by **(40%)** of them were also agreed.

6. Conclusion and Recommendations

Overall, it is clear that traffic congestion considered one of the major problems in many countries that needed instant and long term solutions. Accumulation of traffic congestion daily has effects on the environment,

business, and individuals, though the effects are more widespread on the people. In order to meet the research objective number 2 and based on the collected information from the quantitative and qualitative

methodologies,the researcher found that there were diverse reasons for traffic congestion in Muscat that was totally obvious in this study**.** Firstly, the increasing number of vehicles which considerd as the main reason for congestion, as such the National Center for Statistics and information indicated that the total number of cars in Oman at the beginning of 2020 reached **1,5M**. Secondly, the increase of population in the Sultanate of Oman, where the population reached **(4,646,790)** in the first quarter of 2020.Finally, the work repairing and

construction of road, and centralization of institutions and malls in Muscat lead to congestion.

Furthermore, the researcher studied different IoT architecture which was based on prior literature studies to meet the study objective three. Upon that, the researcher knew that the best architecture for the current study adopted with six-layers where several technologies and devices of IoT can be embedded on those layers which improve the efficiency of performance as well as can enhance the security.

To line all of the above and upon the researcher's findings to meet the study objective number 4, it is clear that usage of ICT and 4IR which include the IoT will assist in minimizing the current issue with its relevant effects.

The researcher knew that there was great interest from participants to implement like these solutions which will be based on the advanced technologies unlike the traditional solutions that were not helping too much in

reducing the effect of the problem and the phenomenon of congestion still exists.Furthermore, a group of

recommendations can be presented for example; Utilization of the IoT where it assists in collecting the necessary data and required information from the sources adopted with IoT. So, in case there is traffic congestion, sensors will send alerts to the concerned team and they will analyze data and provide proper actions based on. Moreover, implementing smart traffic signals that can analyze the current and expected traffic situation, and

collects information from the grounded sensors to detect congestion, and change their time based on real-time traffic congestion situation. In addition, using smart road signs (smart dashboards) to inform drivers about road and traffic conditions, weather conditions, speed limitations with changing time, which help in traffic

management and reduce congestion. Also, linking all of these recommended solutions with traffic application of Royal Oman police in order to get a notification and alert in case traffic congestion happens in a specific area and guidance to use the alternative routes by using interactive road maps.

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