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Traffic congestion control using Smartphone sensors based on IoT Technology

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***Abstract* —Traffic congestion in road networks is one of the main issues to be addressed, also vehicle traffic congestion and monitoring has become one of the critical issues in road transport. With the help of Intelligent Transportation System (ITS), current information of traffic can be used by control room to improve the traffic efficiency. The suggested system utilize technologies for real-time collection, organization and transmission of information to provide an efficient and accurate estimation of traffic density which can be exploited by traffic-aware applications. So, the proposed architecture of Vehicle Traffic Congestion Control & Monitoring System in IoT would perform well. A short overview of the main currently used traffic control methods for freeways will be explained. The tangible Internet of Things (IoT) based service models which are helpful to academic and industrial world to understand IoT business will be discussed.**

***Index Terms* — ITS, IoT, Model Predictive Control (MPC), GPS/GSM, Smart City, and Smart Analytics.**

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I. INTRODUCTION

DUE to the ever-increasing traffic demand, modern societies with well-planned road management systems, and sufficient infrastructures for transportation still face the problem of traffic congestion. This results in loss of travel time, and huge societal and economic costs. Constructing new roads could be one of the solutions for handling the traffic congestion problem, but it is often less feasible due to political and environmental concerns. An alternative would be to make more efficient use of the existing infrastructure. The Internet of Things (IoT) is a growing technological trend in recent years that has gained significant attention in academia and computing industry during the past decade. [1] and [2]

ITS is one of the most important application of IoT. Now, it is a very serious problem because on road, more number of vehicles are present and due to that the congestion in traffic increased along with the increase in pollution and more time is waste on road traffic every day. Therefore, traffic state estimation is one of the most recent issue in ITS which plays a major role to reduce the travel time, improve the traffic efficiency, etc. Various sensors are available in the market which are useful for the ITS. The sensors which already exist in all types of smart phone like: GPS sensor, accelerometer sensor, and also the GSM module which is the core of any smart phone will be used. Figure 1. shows the comparative analysis of registered number of cars overall the world and a curve tendency for the expected numbers of vehicles next years (http://www.capmas.gov.eg/Pages/IndicatorsPage.aspx?Ind_id=5704). [3] and [4]

Fig. 1. Total number of registered vehicles, according to the type of license on the level of the Republic.

From the given data in fig. 1. we can predict that, in future as the number of cars (vehicle) will increases the traffic on the road will also increases along with the pollution. Thus the system of vehicle traffic monitoring and control system using IoT was introduced to avoid the traffic congestion, and to monitor the traffic density.

The suggested system will measure the real-time traffic density, and controls the traffic congestion on road using dynamic management of traffic signals. For understanding, let us consider an example: A vehicle wants to go from any source to a destination then, the user will login into proposed android app with the login details and it will be able to find out the real-time traffic density also user can able to find out optional routs to go to destination to avoid road traffic (As in **Uber** Application).

So, efficiency of congestion in traffic will improve. We can also manage the traffic signals by monitoring the traffic density to avoid traffic congestion on road using network communication between the server and smart phone sensors. It will be used for counting number of vehicles crossing the road. A sensor array is a group/ collection of sensors, usually it is deployed in a certain geometry pattern. [5]

II. WHY ANDROID SYSTEM

Mobile applications often stand in contrast to desktop applications that run on desktop computers, and with web applications which run in mobile web browsers rather than directly on the mobile device.

The term “app” is a shortening of the term “software application”. It has become very popular, and in 2010 was listed as “Word of the Year” by the American Dialect Society. In 2009, technology columnist David Pogue said that newer smartphones could be nicknamed “app phones” to distinguish them from earlier less-sophisticated smartphones.

Developing apps for mobile devices requires considering the constraints and features of these devices. Mobile devices run on battery and have less powerful processors than personal computers and also have more features such as location detection and cameras. Developers also have to consider a wide array of screen sizes, hardware specifications and configurations because of intense competition in mobile software and changes within each of the platforms (although these issues can be overcome with mobile device detection).

Android powers hundreds of millions of mobile devices in more than 190 countries around the world. It’s the largest installed base of any mobile platform and growing fast—every day another million users power up their Android devices for the first time and start looking for apps, games, and other digital content.

Android gives you a world-class platform for creating apps and games for Android users everywhere, as well as an open marketplace for distributing to them instantly. Apple’s devices might get more of the spotlight, but when it comes to market share, there’s no denying Android’s dominance.

According to the IDC Quarterly Mobile Phone Tracker, phone companies shipped a total of 344.3 million smartphones worldwide in the first quarter of 2017 (1Q17). In light of what might seem like a slowing market, consumers continue to show demand for smartphones and OEM flagship hype seems strong as ever. Worldwide smartphone shipments grew 3.4% in 1Q17 year over year, which was slightly lower than IDC’s previous forecast of 3.6% growth which is viewed in figure 2 and figure 3. [23]

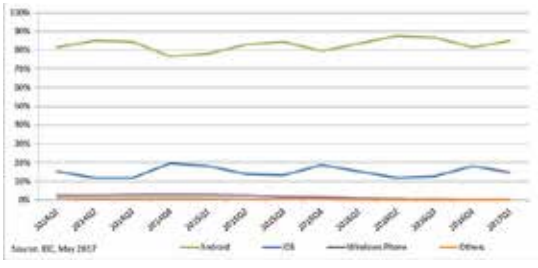

Fig. 2. Worldwide Smartphone OS Market Share

Period	Android	iOS	Windows Phone	Others
2016Q1	83.4%	15.4%	0.8%	0.4%
2016Q2	87.6%	11.7%	0.4%	0.3%
2016Q3	86.8%	12.5%	0.3%	0.4%
2016Q4	81.4%	18.2%	0.2%	0.2%
2017Q1	85.0%	14.7%	0.1%	0.1%

Fig. 3. Demand for smartphones using systems as IDC, May 2017

III. CONTROL DESIGN METHODS

In the literature different control methodologies have been presented for controlling and managing a traffic network in which vehicles are driven by humans. The control design methodologies for freeway traffic control that are currently most often used in practice such as: (Static feedback control, Optimal control and model predictive control (MPC), and Artificial intelligence (AI) techniques). These methodologies are different in directions like: (Computational complexity, Inclusion of hard constraints, Inclusion of future inputs, Model-based or not, and Scalability. The results of differences are shown in Table 1. [9]

Table 1. Comparison of control design methods

Control method	Computational complexity	Constraints (hard)	Future inputs	Model-based	Scalability
Static feedback	Low	No	No	Not explicitly	Localized
Optimal control and MPC	High	Yes	Yes	Model-based	System-wide
AI-based	Medium	No	No	Not explicitly	localized

IV. INTERNET OF THINGS (IOT)

The rapid development of information technology (IT) has brought forward a hyper connected society in which objects are connected to mobile devices and the Internet and communicate with one another. In the close future the technology will be as we could be connected with anything anytime and anywhere. The core component of this hyper connected society is IoT, which is also referred to as Machine to Machine (M2M) communication or Internet of Everything (IoE). [9] and [19]

A. Smart City Implementation Models based on IoT

sRecently, many local governments have been succeeded in implementing an IoT based smart city through the construction of a test bed for IoT verification and an integrated infrastructure [4]. This movement also corresponds to the creative economy that is emphasized by the Egyptian government Special in the great project "New Capital of Egypt". Smart City models are characterized in six major aspects: Smart Economy, Smart Mobility, Smart Governance, Smart Environment, Smart Living, and Smart People.

As an important component of Smart Cities, transportation network plays a critical role to address the urbanization, competitiveness, sustainability, and mobility issues. Developing better operation and management strategies is of practical importance to improve city-scale transportation system operations under the above Smart City research initiatives. [9] and [10]

Though we have been referring to Smart Cities and communities for some time now, let us look at how use of Information and data available to us can be used to really create some smart services, which in a true sense provide us with better living. Let us look at a key case, which impacts us almost daily: traffic management. Use of technology and real time analysis can actually lead to a smooth traffic management.

Connecting Traffic Management System (Traffic signals and Traffic Command centers) with a GIS enabled digital road map of the city and using the power of analytics is a key to smooth traffic management. Using real time analytics of data from these sources and linking them to some trends, we can manage traffic flow much better. Imagine a car driver getting an SMS when he is driving towards the City Center, guiding him to roads which are less congested and helping to identify a parking slot. [11]

Finally, using of technology in Traffic management is a known thing. However, it is the use of data from different sources in real-time and processing information to take immediate decisions that is the key to a successful traffic management in our cities. It is the need of the hour to leverage enormous amount of data around us and create a more meaningful and smooth living for us. [12]

V. DESIGN AND METHODOLOGY

The design process consists of selecting the technologies and software to implement these requirements, and to identify locations for deployment. Traffic signal control systems are usually based, in large measure, on existing software that may be provided by a number of suppliers. These software functions may be modified or augmented by the specifications resulting from the design process.

Agencies responsible for operation of traffic control systems often have standards for commonly employed field equipment. It may be necessary for compatibility and to simplify logistics to employ these standards for new systems to the extent possible. [13] and [20]

The ITS website provides current status on the ITS Standards Program. It also contains resource documents, fact sheets, testing, deployment contact, training and application area information as well as an interactive ITS Standards Forum. See Fig. 4, and Fig. 5.

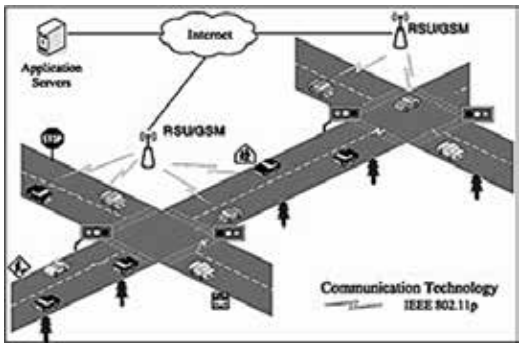

Fig. 4. Network model.

Fig. 5. Illustration of networking protocols for the suggested system.

The design phase consists of two sub-phases, high level design which provides the transition between requirements and detailed design and detailed design which completes the description of the system at the component level.

A. Traffic Light system

The aim of the measure is to design and implement an Urban Traffic Control (UTC) system that contributes to optimizing the flow of traffic through the city.

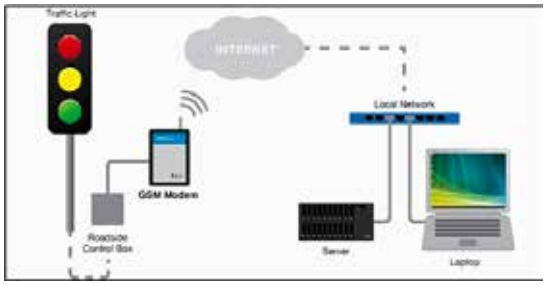

Fig. 6. Traffic Light system control management.

The use of real time location information gathered by the automatic vehicle location and monitoring system is fundamental to increase the service level provided by the urban public transport as in fig. 6. [14] and [21]

B. Software Specification

Software module we are going to use the android application at end-user, web server, database and data mining techniques. In the suggested system, sensors will send all the sensor information/values to a microcontroller. After that, android device (which is located in hardware module) will send all the collected information to the server via internet over the web server and store it in database. In database, Also traffic signals will be manage dynamically according to traffic density. [15] and [22]

When user needs a real-time traffic data or weather condition then, user will login to the android application, then android application will request to the web server for the user requirement and server will get back to end user with require results and user will now able to see the traffic data, traffic density, traffic condition and pollution/ weather condition. This introduced system can be useful for particular/any geographical areas (Vehicle 1, Vehicle 2, .. etc.) as shown in fig. 7. Smart Phone/Device. It will be useful to read the real time sensor values to know the current status of traffic density and weather condition. [16]

It is intended to develop and use various software tools and techniques for the introduced system, also, data mining/clustering technique

will used to sort out and mining the received big amount of data/information in a specific manner using the KNN, Naive Bayes and ID3 algorithms. [17] and [18]

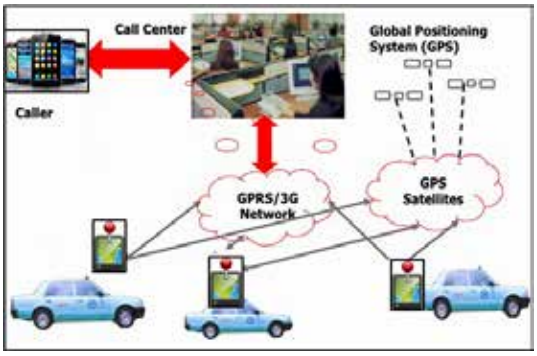

Fig. 7. Vehicle/Smart Phone accessing system using IoT

Perhaps the greatest promise of the internet of things is the insights to be gained from a flood of data provided by ubiquitous, wirelessly connected sensors. On January 9, this promise came closer to reality when Uber announced the launch of a new website that will display traffic data in the cities where it operates. The new website, Uber Movement, will display traffic volumes in different city zones based on anonymized data from Uber drivers' smartphone applications. This website aims to make urban transportation more efficient by providing current data on traffic patterns. Ultimately, this practice could expand beyond the transportation sector and lead to both greater private sector data sharing along with greater data-driven policymaking.

Reaping the full benefits of the internet of things will require novel agreements between the private sector companies that collect data and public sector agencies that can use it shape policy. However, this data sharing must also include the customer. Publishing aggregate data on a website for everyone to see is one way to ensure that customers know exactly how their data is being used in a public sector context. There are certainly some privacy concerns with making this data public, but as long as steps are taken to remove any identifying information, personal data can serve the public interest. Furthermore, relieving traffic congestion is only the beginning of using sensor data to solve policy issues. While more data cannot solve every problem, greater availability can lead to more precise policy solutions. [24]

VI. CONCLUSION

An overview of traffic management and control frameworks based on IoT have been presented. A short survey of the main control design methods currently used for freeway traffic control have been stated. Then the vehicle traffic congestion control and monitoring system in IoT to develop a real-time software for tracking and managing traffic have been presented. The introduced suggested system contains a server and an Android client application for reporting and displaying traffic related events (traffic condition, traffic jams, traffic density). It also includes a web application for the system administrators, data management and analysis. The interface of client application is intuitive and it is easy and safe to use while driving. Also the traffic signal depending on traffic density can dynamically managed. A limitation of this work, however, is the lack of available data in Egypt that hinders the required empirical analysis on the benefits of IoT technology. In the close future, a dedicated encryption algorithm for vehicle data and network security methods to support the reliable/trusted communication between the vehicle and Road side systems which is related to GSM network will be carried out.

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