TRAFFIC MANAGEMENT SYSTEM BASED ON WSN IN KUWAIT: AN INITIAL DESIGN

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Abstract- This paper discusses traffic problems in the world and emphasizes on Kuwait city as case study. Many of these problems can be solve by building a Traffic Management System based on a Wireless Sensor Network (WSN). TMS is an innovative design for the road that saves time and money for the driver. This solution creates a city of intelligence, which can be control automatically through sensors. Some of the sensor nodes were portable and fixed that spread in buildings, streets, cars and traffic signals. We use two kinds of WSN motion sensors and physical sensors. We also use two kinds of WSN nodes: special-purpose sensor nodes and generic sensor nodes. Zigbee platform use to communicate between nodes in short speed and reduce energy consumption. The Database Management Systems (DBMS) supports a geospatial database by offering the GIS services such as fingerprints, photos and videos. The functionality of Network Operation Center (NOC) to supervise, maintains, and monitors the wireless network. GPS/routing protocols use to detect the location with longitude and latitude date information with Geographic information system (GIS) to discover geographic location for the city maps. The routing protocols were cheaper and provide same functionality as GPS. Our initial design describes the physical layer to explain the connectivity path from (NOC) to vehicle then network layer depending on routing protocols lastly, application layer shows the dashboard monitor system that controlled by (NOC) and how it solve a different issues in traffic problems.

Index Terms—wireless sensor network (WSN), Traffic Management System (TMS)

1. INTRODUCTION

In recent years, technology has developed whether in connections, mobile phones and private networks in WLAN. Services and devices continued to improve in using energy, reprogramming, lower cost, more capabilities, and more wireless quality. New services in health, transportation and urban environments are the main developments. [18]

Smart City is a system of the city and is characterized by the interaction among the infrastructure, capital, behaviours and cultures and achieved through interdependence among them. It uses more Information and Communication Technology (ICT) for the analysis and integration of basic information in the cities and makes them able to respond to various needs, including ways of daily living, environmental protection, public safety, services, industries and commercial activities. Smart City has smart meters, smart networks, smart buildings, and smart transportation to facilitate people to live in a more comfortable and safe environment. [8]

The aim of Smart City is to use technology, while depending on less energy and using wireless radio wave IEEE 802.15.4c and to improve the quality of life by using wireless sensor networks and sensor platforms. The aim of development in the Smart City is clear, but it needs a big footprint. Some governments are developing the Smart City because they would appreciate the benefit of using this technology to bridge the growing gap in demand and supply. [3]

Intelligent Transport Systems (ITS) is part of digital and intelligence cities and vehicular ICT is changing people’s behaviour in their use of cars that become easy and efficient transport. Many devices are strengthening information, management and scientific decisions of city traffic which become the hotspot of the traffic department and the city emergency command department. The technologies that help are Radio
Frequency Identification (RFID), Global Positioning Systems (GPS), and Geographic Information Systems (GIS). These offer the necessary conditions for navigation, positioning and real-time monitoring of vehicles and Wireless Sensor Network (WSN). [18]

WSN is a network with sensor nodes (SN) that are deploying in certain shape depending on different factors such as: size of area, coverage, power consumption, number of data transfer, type of platform and node...etc. Also, it is nodes with computations and measurements that communicate among them via radio connection in order to sense the physical world by monitoring temperature, pressure, movement and sound. It has specialized protocols built into its design. It deploys the sensors on the highway and roads to provide detection for traffic observing and controlling.

Traffic Management system (TMS) is an innovative design for the road with efficient and accurate information. It includes many advantages that save time and money for the driver. It requires special elements that we discuss in this paper. [4]
The TMS is the most important part of a Smart City. TMS can save human lives, save time in finding parking for cars, and reduce traffic collisions and traffic chaos.

The next parts of this paper are ordered as follows. Section 2 briefly describes the related works. Section 3 presents the problem statements. Section 4 overviews the propose design of our system included physical layer, network layer and application layer. Finally, Section 5 concludes the paper with future works.

2. RELATED WORK

This research helps us in collecting data and information to solve traffic and vehicular problems by using WSN. Each research helps us in identifying certain information that relates to WSN and TMS to build our TMS system.

The municipalities develop parking systems by using a new smart technology. In St. Petersburg, Florida, the Smart meters are powered by solar energy systems by Cale. In St. Bruno, Quebec, Canada, the driver was allowed to pay for parking his car with coins or credit card or a Smart card.

The machine connects wirelessly with the central server wireless handheld General Packet Radio Service (GPRS) and devices for the car's agent. The agent uses this device to get information such as that the parking lot should be empty because of expiration time to the driver or the driver didn’t pay for his parking. Then the driver pays the time and marks his car on the dashboard. In Israel, the driver enters the payment card and begins to calculate the distance to the parking automatically. The Acme/Parking Carma's provided a test in Smart parking to allow the driver to enter the website and book in advance for parking his car for several hours or even days. Finland allows the driver to use a pre-pay service to pay for parking the car by making a phone call. When the time has expired, the service alerts the driver by sending a text message allowing him to reconnect and pay for more time. This has succeeded in Dubai since 2005. [10]

The Virginia Smart Road is part of public road. The advantages of this road are weather controlling snow or rain, a query system about weather, GPS and lightning road. A controlling room is prepared to observe movement performance. They also prepared a controlling tower for weather; each tower can rotate 360 degrees and tilt up or down and change the condition of weather. The road can upgrade the light about 95%. The road has electronic sensors and WSN. It is connected wirelessly with a lot of database systems.

We found solutions to the problems of traffic congestion and major accidents by building in small nodes wireless and lightweight processors. It's equipped to send and receive information and build a wireless network through the deployment of these nodes to monitor environmental conditions and track the movement of traffic. Intelligent Transportation Systems (ITS) are a benefit in the capacity of wireless sensor networks and support the transport infrastructure to find solutions to these problems by constantly monitoring them. This can also be used for parking management, to avoid collisions and to enhance the safety of drivers. These solutions have been applied in many countries such as: Canada,
the United States, and Japan and in Europe and Australia. [11]

Because humans are unable to use traditional methods to monitor environmental changes in inaccessible places such as in a desert, forest or mountains, a solution has been provided to them by using a wireless sensor network and distributing a sensor in many places because of their small size and low cost and accuracy. It can also monitor by controlling the dimension across the websites or applications in the console. [5]

They are used in Malaysia with multiple-VSCS software to picture the traffic from many sources. They execute this by using a 5.8GHz OFDM LAN wireless network. There are experiments to analyse effectiveness with better flow rates from a low of 50 Kbps and an increased rate 1800:1 and video formatting. They can also analyse the video flow rate and compare that with different formats. They are studying increasing the bandwidth. [2]

They used WSN in car parking. To spread WSN devices in car parking areas, every car prepared one node sensor to reveal whether the parking space is empty or not. They then sent the report to the database by WSN and gateway. The database system is only for management to find the busy parking areas, monitor management security and build statics. This was implemented by executed crossbow motes. [17]

The Vehicular Sensor Networks (VSNs) are a new type of technology for sensors that are available in new vehicles to collect information from the driver's environment such as speed and temperature. They can also lead to drivers being more comfortable and safe. They operated a wireless network and service provider wimax access point 2.5 3G to collect information about roads and traffic density. VSN is used for downloading traffic on a private Internet network by using IEEE 802.11p. For doing that, they suggested Clustered Gathering Protocol (CGP) and transit layer protocols to collect pyramid and geography information. They were also analysing the performance of CGP by using real dynamic samples without weighting the network. Network was used to reduce the cost and collect information from the vehicles. Now they expand the scope of this work. [14]

Parking Guidance System (PGS) is a system to detect available parking based on wireless sensor networks. The system consists of VDS (vehicle detection sub-system), which provides information on available parking spaces and directs drivers to available parking using control system monitoring. It has been testing the system on several types of cars and the results showed the success of the system and battery life will be over in five years. [15]

3. Problem Statement

Every day, citizens die in accidents on the road and every day we lose many hours in traffic congestion during the day and night. The Ministry of Interior in Kuwait has prepared statistics for the number of deaths in traffic accidents; there were approximately 370 deaths during the year 2010. It is an important problem facing society. There are several key factors involved, such as traffic collisions, wasted time, fuel consumption and pollution. [6]

These problems have implications, including damage to public and private property. From a health perspective, there are a total of infections ranging between superficial, medium and severe. Psychologically, one of the most significant effects on a driver who is in a traffic accident, is a lack of confidence in his or her ability or feeling fear of the road, which can cause confusion. Finally, there are social effects; accidents can lead to dismantling the family structure through the loss of a family member. [6]

Kuwait faced a problem of the mentality of drivers and their commitment to traffic rules and ethics that causes traffic chaos and many accidents. Traffic signals, traffic collisions and difficulties in monitoring are some of the worst problems. There are also parking problems in malls. Traffic problems have been discussed in the world and specifically in the State of Kuwait. This paper gives solutions to these problems using a traffic management system. [6]
4. THE PROPOSE DESIGN OF TRAFFIC MANAGEMENT SYSTEM

To implement this TMS system requires some special elements. WSN is a number of heterogeneous sensors devices spanning a large field that can sense the environment and communicate the information gathered from the monitored field through wireless links. In our system use two kinds of wireless sensors. The first includes a motion sensor (acceleration and position) that is used for GPS, contact sensor, optical fibre, optoelectronic and optical encoder. Secondly, we have physical sensors (pressure, temperature, humidity and flow) that are used for capacitive pressure change, thermo-mechanical and thermocouple resistive. We use two kinds of WSN nodes, special-purpose sensor nodes (spec 2003) because they are covered with silicon, saving energy and providing a high level of tag radio frequency, and generic sensor nodes (mica-z 2004) because they support IEEE wave 802.15. Both of them are charged by solar cell energy. Zigbee platform used to communicate between nodes in short speed and reduce energy consumption. [19] We also have a Network Operation Centre (NOC) for supervision, maintenance, monitoring the wireless sensor network by a dashboard.

4.1. Physical Layer

The physical layer work on different functionality such as: Hardware Specifications, Encoding and Signalling, Data Transmission and Reception and Topology and Physical Network Design. It contains of communication media, hardware and software interface to the physical medium. It gives the process of the signals send/receive from/to the vehicles wirelessly via WSN using routing protocols or GPS discussed in network layer and the Network Operation Centre (NOC).

Figure 1 is rep TMS Architecture system to solve traffic problems previously discussed. The system has two types of sensor nodes: sensor node (SN) and cluster head (CH). Sensor nodes represent to feeling and transfer the data to its cluster head. Also we divide each SN to portable tag SN and fixed SN. The cloud computing explains the GPS/routing protocols and GIS. GPS/routing protocols are used to detect the location with longitude and latitude data information. GIS is used for geographic location for the city maps. The portable tag SN collect information from cars sends/receives the request to/from fixed SN via wifi, wimax, 3G or IEEE 802.15.4c. The fixed SN connects wirelessly between each other. Then the fixed SN is linked directly to its cluster head. All SN here are charged by solar cell for saving energy. The CH is connected to the database. Every database has multi information and data. The Database Management Systems (DBMS) supports the geospatial database by offering the GIS services such as fingerprints, photos and videos. The geospatial database analyzes by Object Relational Database Management System (ORDBMS) because it supports the object-oriented data model and the relational database model. The main server controls the information from/to database. The NOC room maintains the system if it has any problems. The database administrator is allowed to
access the database and takes whatever gathered information he or she wants to enhance or reorganize the Key Performance Indicators (KPIs). All these processes show on the dashboard placed in the data services location via wireless connection. A GPS is very expensive and difficult to provide in Kuwait; therefore, the routing protocols do the same functions.

4.2. Network Layer

The network layer work on the remote and data path in the interconnected networks. It has a responsibility such as: Logical Addressing, Fragmentation, Reassembly, Routing, Datagram Encapsulation, Error Handling and Diagnostics. The task for routing protocol to know the address of the neighbor nodes, selecting routes and quality of service (QoS) in the WSN.

Figure 2 explains two types of routing protocols algorithm. This system has three components: Mobile Sink (MS), Vice Sink (VS) and Sink Node (SN). MS is reorganizing the field in remote sensing; therefore, GPS is obtainable so movement information is available. The GPS expected the path of the car move in little time. VS is reorganizing in light sensor so this is unrestricted energy and it's sending the data to MS. SN is spread in each field sensor and restricted energy. The algorithm 2 shows how the SN sends the data to the car. We observe that the SN sends data in a slow path and consumes more energy. But algorithm 1 sends data in a faster path than algorithm 2 and uses energy efficiently. [20] Most of the traffic roads using Link State Routing Protocol to compute the route based on the information of the topology. Specially using Open Shortest Path First (OSPF), which has two primary characteristics. The first is that the protocol is open, which means that its specification is in the public domain. The second principal characteristic is that OSPF is based on the SPF algorithm to calculate the shortest path to each node.

4.3. Application Layer

The application layer explains the whole network into a friendly user interface by implement a software application deal with communicating component and network resources. It is used to monitor the WSN and produce an alarm if it exceeds the threshold. Also, control the WSN area automatically to facilitate and solve the problems before occur.

Figure 3 is displaying the Monitoring System in a driver's car, which displays the list of buttons that helped the driver to find solutions to avoid traffic chaos and traffic collisions. Each button discussed in the next paragraph. The SN spread on the road is shown. All SN here are charged by solar cell for saving energy. SN displays the number of cars for calculating. We have calculations to determine red, yellow and green colours. The calculation is the number of cars in the road added to the size of the road (number of lines (width) + long). For example, assume the road lengths are same; the first road has 30 cars with 2 lines, which equals to 15 car rows; the second road has 60 cars with 2 lines, so the total is 30 car rows; and the third road has 15 cars and
with 3 lines, which equals to 5 car rows. The first road represented in yellow, the second road represented in red and the third road represented in green.

To solve traffic problems, we put the portable tag SN in cars and fixed SN in building, roads, parking areas and trees. In this way, we solve parking problems in malls by WSN. To help the drivers, we put sensors in each parking area and tag SN in each car. The driver sends his request to find which parking space is empty and which parking spaces are busy. His request is transferred to the database. Then he delivers the request to the car’s Monitor System. [17] Our system has new services in Figure 3 that show the best path to the driver and the right way to park his car represented in green and the busy parking areas represented in red.

Finding tags in cars and SNs spread on the roads and buildings helps the Ministry of Interior in knowing where there is traffic chaos and men wanted by the law. The warning messages shows in the dashboard to tell drivers about traffic chaos. If the traffic chaos is caused by an accident it gives a message to the NOC, so they send a police and ambulance also, it can appear on the drivers this area has a problem to avoid the path using best way. If it is caused by traffic lights, they open the signals by taking the number of cars on all the roads in this traffic light and making a calculation depending on the time and ratio of vehicles per path. For example, if the traffic signal has four roads crossover R1 to R4 where R is number of stopping vehicles: \( t = \sum_{i=1}^{n} R_i \), then divide the time for each road depending on: \( R_x/R_t \) that minimized the traffic chaos in the traffic light automatically via WSN and closes others.

Our system also helps on bridges. We put sensors before a bridge to alert drivers to what is happening after the bridge. A message appears on his Monitor System to change his direction and the system suggests an alternate road by using special calculations that we discussed before in Figure 3. Moreover, WSN helps by using the same technique on the main roads and fuel station. Navigation connecting to GIS shows the geographic location for the city maps.

5. Conclusion And Future Work

The TMS is the most important part of a Smart City. Solving traffic problems that are based on WSN, especially in Kuwait City by using our TMS system can help the citizens and Ministry of Interior. It can also save human lives and save time in finding parking spaces. To achieve this system, there must be cooperation among all stakeholders. Our initial design covers many issues to be fixed and gives appropriate solution for different areas on the traffic problems. This work will be continued by studying the problem statements for each situation and how to solve them by simulating different projects for each one of them.

References


