European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 152 No 2 March, 2019, pp. 128-135
http://www. europeanjournalofscientificresearch.com

Smart Accident Management in Jordan using Cup Carbon Simulation

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Abstract

Traffic congestion is a common transportation problem around the globe, especially in populated cities, which leads to the issues of traffic management and its safety. A major cause of accidental deaths on the road is due to either the absence of quick medical assistance or traffic-mismanagement. Traffic network management system aims to reduce traffic congestion, delay, and to improve the level of service (LOS) of the urban streets and intersections. Jordan as most of the growing countries has suffered from the impacts of highway mode of transportation. This paper discusses effects of using smart traffic station control in Jordan transportation system by testing different scenarios using Cupcarbon simulator, these scenarios are tested to utilize the benefits of IoT and smart cities applications. CupCarbon is a Wireless Sensor Network design and simulation tool. It is a discrete and multi-agent event Wireless Sensor Network (WSN) simulator. Networks can be designed and prototyped in an ergonomic user-friendly interface using the OpenStreetMap (OSM) framework by deploying sensors directly on the map. CupCarbon simulator is used to model various scenarios which show the actual roads and vehicles movements in the implementation. Two scenarios have been tested to select the optimum route from accident's position and the nearest available hospitals, in order to enhance the rescue time operations.

Keywords: Cupcarbon, IoT, LOS, SAM, Smart City, V2I, V2V

1. Introduction

Traffic congestion worldwide has a negative impact on our life, these negative effects can be presented by: loss of human lives due to failure in transporting accident victims, decrease of human productivity; due to nervous, loss of control for critical patients, and late of medical treatment (L. Sumia, V. Ranga, 2018). The number of cars is increased rapidly causing physical use of roads by vehicles, so traffic demand is great enough resulting in intersection between vehicles and slowing the speed of traffic; this results in some congestion. When vehicles are stopped for a period of time, this is informally known as a snarl-up or a traffic jam. World Health Organization (WHO) has reported the statistics of global road-safety in that showed over 3400 people die every day and tens of millions injure or become disable every year, around the globe (Global status report on road safety 2017, Global status report on road safety 2015).

Traffic congestion has not only resulted in wastage of time, property damage or environmental pollution, but also caused loss of lives as accident victims. Unguided accident management resulted from traffic congestion, and sometimes medical equipment, critical patients' necessary medicines are not transported in time. Controlling traffic congestion with traffic stations control is an important and integral part of any smart traffic management system. The important aspects to imagine the day when the vehicle itself can process road, weather, traffic, and engine information, to predict and avoid hazards and delays. Traffic accidents and jams would become a thing of the past. Connected car technology is rapidly advancing. With Vehicle-to-Vehicle (V2V) technology and Vehicle-to-Infrastructure (V2I), this may not be as far away as you think. With current technology, people can access the internet almost anywhere: at their home, office, cars, and many other places they visit (A. Kumar, M. Gupta, 2017). Now it's the car's turn. Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) will bring the internet into vehicles, for more intelligent navigation, and connecting with the grid and other vehicles for improved safety and convenience.

The Hashemite Kingdom like many other countries in the world is suffering from a great pressure on its roadways, facing many problems in traffic network system. It needs constantly to evaluate and identify existing problems and to find solutions to them (Great Amman Municipality 2013).This paper will propose solutions to reduce delay time for emergency vehicles and improve traffic congestion in Jordan by testing a prototype using Cupcarbon simulator which is a Wireless Sensor Network design and simulation tool.

2. Related Work

Many researchers have been taken place about improving the traffic network management system in Amman city or in other Jordanian cities or in other countries. All these researches aim to improve the existing traffic network to ensure that it will carry the future traffic demand.

(Al-Allaff, Basim Jrew, and Abojaradeh 2015), studied the evaluation and improvement of traffic flow and traffic network management system in Al-Shmesani -Amman / Jordan. The study focused on certain network in Al-Shmesani district to achieve the best results to solve such problems. The network is consisting of two main arterials with eight signalized intersections that are located at the selected network. The main objectives of this research study are: 1- To evaluate the existing and the future traffic conditions (year 2012 and year 2022) of the network system by using HCS2000 and Synchro-8 computer software. 2- To improve the traffic network management system by optimizing the existing and future traffic conditions by using Synchro-8 computer software. 3- To improve the traffic network management system by modifying the geometric and traffic signal for the existing and future traffic conditions by using Synchro-8 computer program.

(Djahel et al., 2014) presented an adaptive framework for an efficient traffic management of emergency vehicles that not only adjusts the traffic signals dynamically, but also recommend drivers required behavior changes, driving policy changes and exercise necessary security controls. Similarly, (Shekher et al., 2012) also introduced an efficient navigation system based on VANET for ambulances that addresses the problem of ascertaining the shortest path to the destination to get rid of unexpected congestions based on real time traffic information updates and historical data. Our proposed system does not depend on any historical data, it takes into consideration the moment data of roads between any expected accident position and state of hospital as it will be explained later. A dynamic routing system was suggested by integrating real time traffic scenario and Global Positioning System (GPS). The system also has a metro rail network with road transport system to guide ambulances in real time scenarios.

Abojaradeh et al. (2014), presented the operational analysis of Wadi-Saqra signalized intersection in Amman area. The intersection has high traffic volume, heavy congestion traffic and higher delay more than any other similar intersections in Amman. The intersection was analyzed as an isolated signalized intersection by using HCS (Highway Capacity Software) and HCM (Highway Capacity Manual). Synchro-6 computer program was also applied for the improvement through optimization process. The traffic, signalized data and geometric were collected during the morning and afternoon rush time periods. The results showed that the current delay was 473 sec/veh with Level of Service F (LOS-F). Four alternatives were recommended to fix the current and future problems. The suggested alternatives are prohibit left turning at all approaches, optimization of the existing traffic signals, construct one through overpass for one direction, and construct two overpass or one overpass and tunnel for two directions.

Karim Q. (2011) studied Al-Quds intersection in Baghdad. The intersection is a T-intersection with three (legs) main roads. The main objectives of the research are to evaluate traffic performance operation in Al-Quds signalized intersection, finding the Existing LOS, suggesting the best proposed geometric design at study area to fulfill a suitable LOS at the present time and future.

It is noted that all previous studies are concentrated on static solutions and in developing the street infrastructures which will have a large cost ignoring the benefits of applying new technologies related to Internet of Things (IoT) and smart cities applications which will a rise on the horizon within the coming years as a result of applying the fifth generations. The mainobjectives of this paper to find dynamic optimal solution.

3. Proposed Application Design and Implementation

In this research, the important aspects to assume the vehicle itself can process road, weather, traffic, and engine information, to predict and avoid hazards and delays by mimicking the real situations through using Cupcarbon simulator. Cubcarbon gives Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) technologies. With these current technologies, car and control traffic congestion can communicate together. This research aims to achieve the following objectives:

- To enhance rescue operation when accidents are occurred
- To reduce response time for accident management
- To avoid Emergency Room Occupied and to select the optimal route from accident to the available hospital.
- To enhance hospitals preparation for expected accidents.

3.1. Multi-agent Cars Simulation Environment using CupCarbon

Once the CupCarbon tool is started and a new project is created, it is possible to create a network of sensors directly on a geographical map which represents the main window of the software. It is possible to create routes to be assigned to mobiles that represent cars in routes. Once the network is developed, the different communication scripts must be created and assigned to each sensor. One script can be assigned to multiple sensors. Figure 1 represents the features and architecture of Cupcarbon simulator (Lounis et al.,2017)

Cupcarbon has the following characteristics:

- CupCarbon provides an environment for a multi-agent simulation.
- CupCarbon allows to run simulations and to monitor various events and changes over time.
- CupCarbon provides an integration of Open Street Map in the environment that gives an interface and a database of digitized data related to geo-locations such as roads, the positions of buildings, etc.
- CupCarbon allows to configure each agent of the simulated system without using low-level programming. Agents of the system can be linked to script files to program their communications.

3.2. Smart Accident Management Proposed Algorithm

Smart city applications and IoT sensors enhance traffic management and accelerate rescue operations. IoT will satisfy the internet users or world populations' expectations. The number of IP addresses will be increased, so IoT will use IPv6 to overcome the limitation exist in IPv4, since the number of connected devices will exceed 70 billion as this will be considered as the Second Economy or the Industrial Internet revolution, and it will produce a huge market with various services, and the size of this market is estimated in the trillions of dollars (Chris Folk et al., 2015). In this paper we developed a smart (SAM) accident management algorithm which relies on new sensors technology as depicted below.

Figure 1: The Architecture of Cupcarbon Simulator

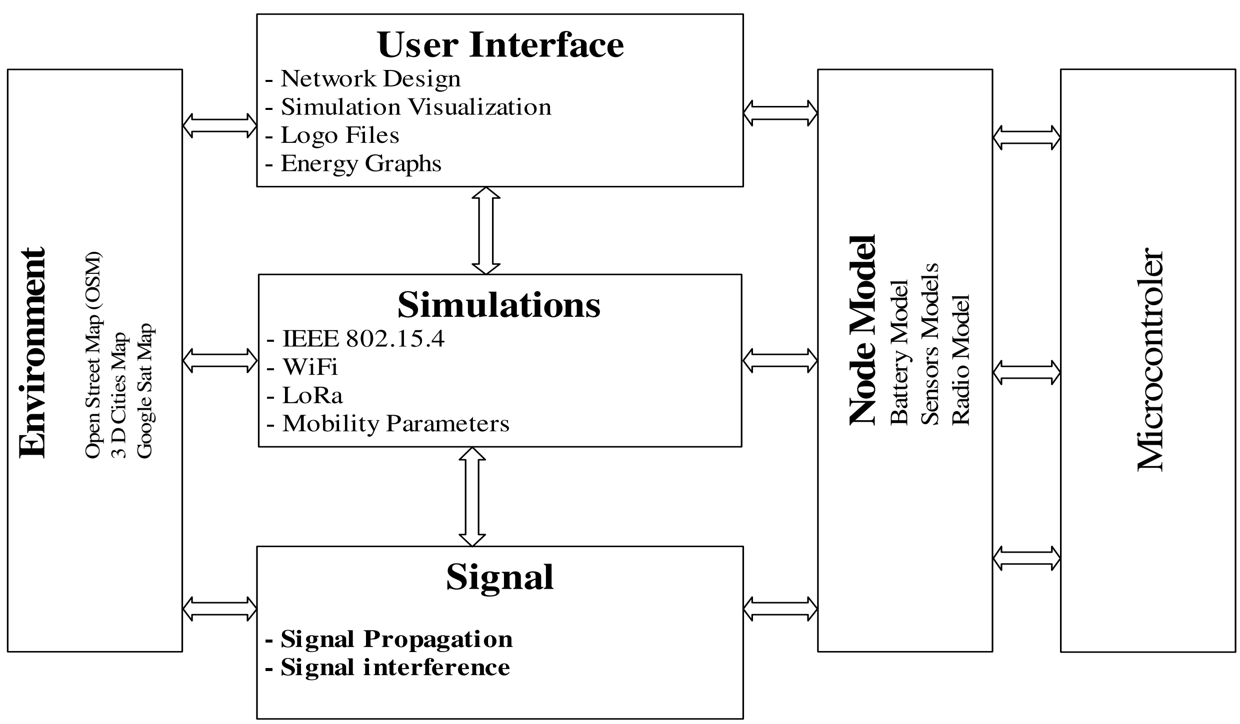
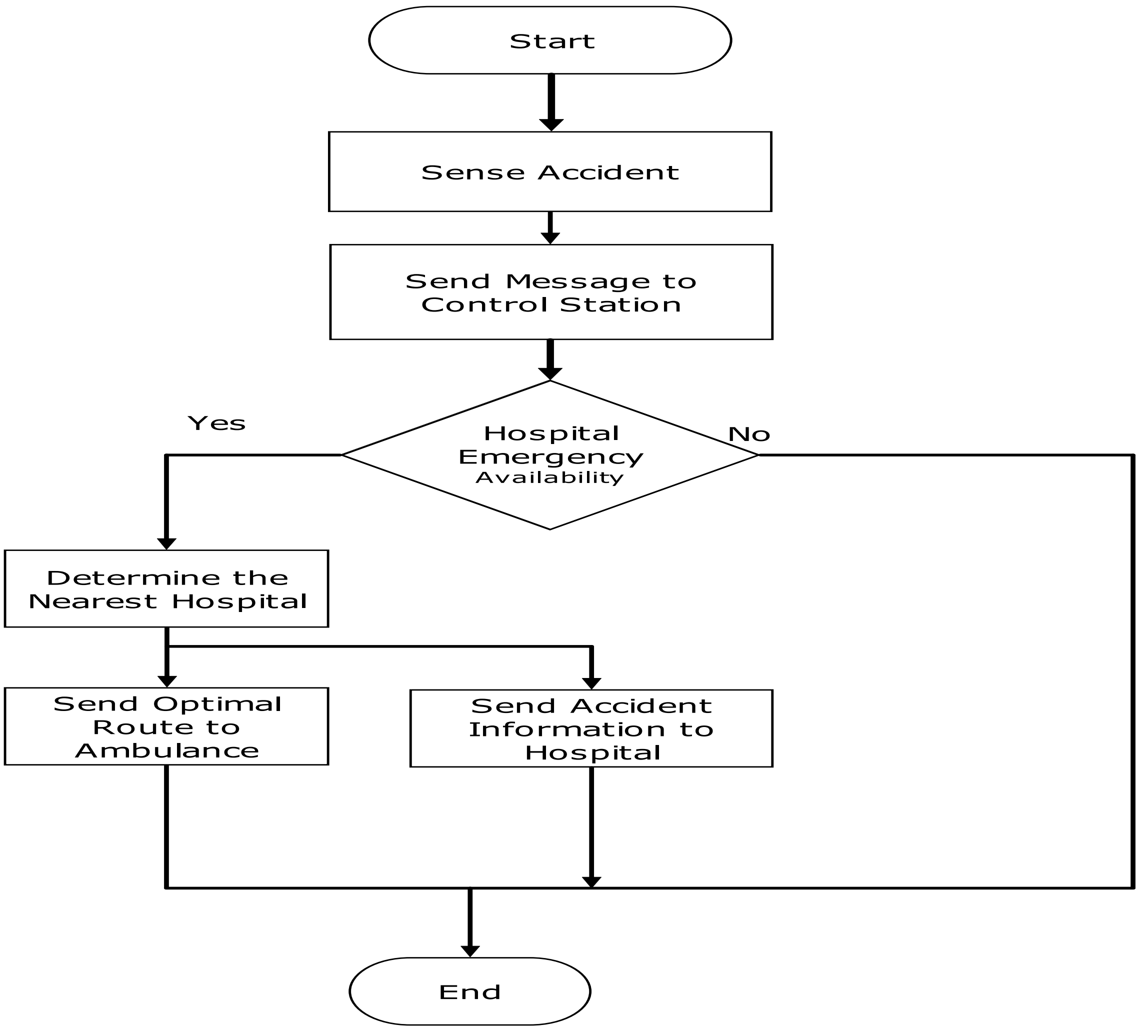


Figure 2 shows improving traffic management system algorithm (SAM) to manipulate rescue operations when accident has been occurred. Let us discuss how the smart traffic management system (SAM) will be improved using Cubcarbon simulator. When an accident is occurred, the sensors in the ambulance or rescue vehicle will sense it. Then, the sensor will communicate with the nearest control station, after that the nearest control station is connected to the rescue vehicle, the control stations will depend on the following sequential steps: the control station sends a message to the nearest hospitals which are saved in control station database to check the availability of hospital, After finding the available hospitals, the control station will determines the optimal route using two equations that will be discussed in the following subsections.

Figure 2: The Proposed Accident Management Algorithm



3.3. Determining the Distance and Availability of Hospital to Find Optimal Route

First to find optimal route for emergency car from the hospital to the accident, the control station does the following steps that are described in equation 1:

1. The control station Checks the availability of hospital:
   if the hospital is available, then go to step 2, else ignore this hospital.
2. If the hospital is available and there are more than one routes from accident to hospital, then the control station calculates the distance from the hospital to the accident for each route and send a message of the shortest route to the hospital.
   $F(n) = D(n) + \text{availability}(n)$ (1)

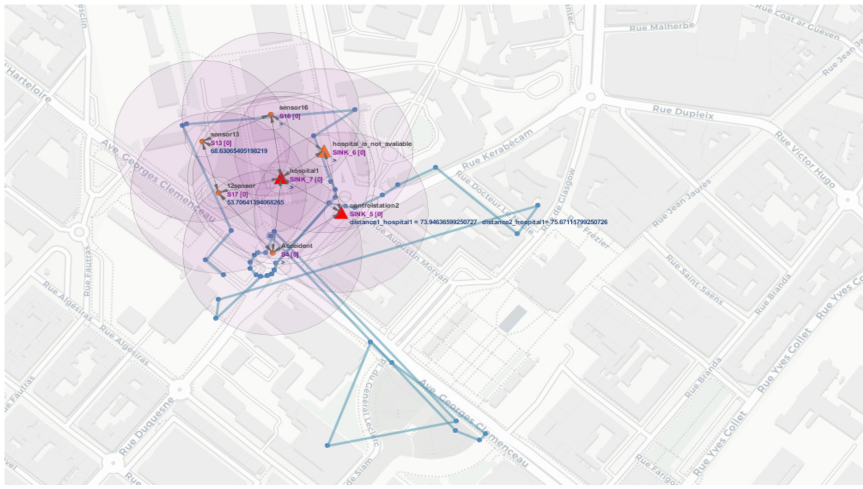
Where n is a specific route from accident to hospital, D(n) is the distance from accident place to the hospital, and availability (n) is a Boolean function has true and false values.

This scenario is tested using Cupcarbon simulator assuming the position of the accidents and the position of control station as depicted in Figure 3, the results show that there are two routes to the nearest hospital with different distance. The relative distance to each route is calculated using the following formula:

Relative percentage distance = (route distance / total route distance)* 100 % (2)

The relative percentage distance for the first route is equaled to 51%, while the relative percentage distance for the second route is equaled to 49 %, so the second route is selected and its information sent to rescue vehicle with the nearest hospital information guiding it to follow this path and at the same time the control station sends alert to the hospital informing it with the accident information.

Figure 3: Determining the Available Hospital and Shortest Distance Scenario



3.4. Determining the Optimal Route to Available Hospital with Respect to Traffic Congestion

In equation 1, optimum route is found depending on the shortest distance and availability of hospital without looking to the traffic congestion in the route. According to (Ogunrind R.B, Lebile Olayinka, 2015), traffic congestion can be resulted from increasing number of vehicles in the roads that leads to increase delay time for each vehicle in the route. The delay time for vehicles in route it is critical task for accident management system. Let us discuss a more realistic scenario. Assume there are two routes from the hospital to the accident place: one route is long with low traffic, and the second route is short with high traffic. In this case, the short route with high traffic may take more time from hospital to the accident place than the longer route that is critical point in accident management system. The control station uses Equation 2 which shows the second version for finding the optimal depending on the traffic congestion.

F(n) = Traffic(n)+ availability (n) (3)

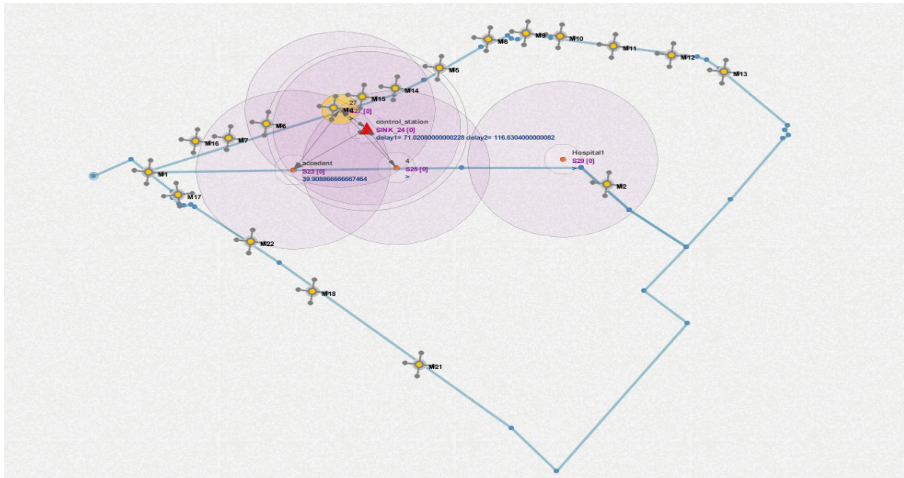
Where n is a specific route from accident to hospital, T(n) is the traffic congestion from accident place to the hospital in route n, and availability (n) is a Boolean function has true and false values.

Figure 4 describes the scenario that is tested assuming that there is a tow path from accident position to the nearest available hospital. One path is short with a high traffic load, the relative time percentage is calculated according to formula below.

Relative percentage time = (route time / total route time) *100 % (4)

While, the second path from accident is too long and has low traffic with respect to the first path, the relative time is found to be 38 %, so the control station will choose it to be the optimum route and will send all the route information to the rescue vehicle.

Figure 4: Determining the Available Hospital and Shortest Time Scenario



4. Conclusion and Future Work

It is noted the IoT will be the dominant technology for the future as it has two aspects of emerging: Brain-Body Merge in which everything in the world will be smart and intelligent, and Head in the Clouds in which everything in the world will be supported by cloud. An intelligent Transportation system (ITS) is a cost-efficient system, which requires a lot of requirements and experiences in new advanced technologies. Accident management is important aspect and mainly depend on the response time, as response time is low the rescue operation will be better. In this paper we take into consideration the use of IoT and intelligent transportation system to enhance rescue operations through applying Cupcarbon simulator. Two scenarios have been tested to enhance rescue operations and reducing response time, it is noted that the rescue time is dynamic and depends on the status of roads which is considered in the second scenario, also the hospital response time to handle injuries persons and patients can be enhanced by alerting the hospitals by the incoming cases, so this can develop rescue operation. In discussed two scenarios we do not show the effects of traffic control devices (traffic light signs) in the accident management system. More scenario and more sophisticated cases are going to be tested in the future relating disasters recovery and rescue operations.

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