A study to Integrate VANET and ArcGIS for Civil Defense Services in Urban areas

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ABSTRACT

When a car accident happens either on urban roads or highways the main consideration is how to provide first aids to the sufferer citizens as quickly as possible. Health organizations declared that the quick the help reaches the injured persons at the accident location, the more the lives saved. The main problem facing civil defense vehicles is the blocking roads due to the increasing in cars density in the neighboring area, which may cause delays in first aid services. Vehicular ad hoc network (VANET) systems are proposed to support transportation with real time safety information by using vehicles communication with each other or by infrastructure connecting to take the privilege of the cloud network traffic services. Moreover, geographic information system GIS is a business information management system that helps in capturing, analyzing, and presenting special geographic information. Using GIS can be useful in making better decisions for an everyday life living. In this study, we present the first steps of a new method that can combine the real time information coming from vehicles with the abilities of GIS in geographic analyzing to decide the shortest and the spare path to the accident location that civil defense vehicles can use to reach and help in saving lives. The contribution of this study is the use of the SignalR library with GIS services to give a safety real time support. Our study goal is to enhance the responding of civil defense vehicles to the emergency calls by leading the ambulance and fire cars from where they are to the accident location then to the nearest health center quickly through the shortest and sparse paths.

Keywords

VANET, ArcGIS, SignalR library

1. INTRODUCTION

Recently with the wide expansion of the transportation system, a high number of vehicles reside on the roads almost all the time. An abnormal situation may suddenly occur and cause an increasing in the road density because of the irritable in vehicle movement. Thus, civil defense vehicles will face difficulty to reach the accident location in a suitable time to give help and try rescues human lives. This is a huge problem which engorges the vehicle industries to participate in the research field to solve road density problem to give humanity better services. The main issue here is saving human lives, where, according to the statistic of the association for safe international road travel (ASIRT) web site, globally about 1.3 million people die in road crashes each year and an additional of 20-30 million injured. The solution for minimizing road crash risks is mainly depend on providing travelers with information.

In 2001 a project was presented and funded by the Greek Secretariat of Research and Technology to coordinate and lead ambulance vehicles to appropriate hospitals. This study depends on GIS, GPS, and global system for mobile communication GSM technologies [1]. Although it is possible to use cellular networks, but these networks may suffer from messages congestion that causes service delay. In 2005 a suggested work of five phases was presented for accident diagnosis based on GIS technology and Road Accident View system RAV. The work has described a framework for prototype in establishment a GIS-RAV System for traffic accident application [2]. In our knowledge the system did not deploy in a real-life environment. In 2013, distinct GIS has been designed to present all types of geographic data, to acquire flow intensities of roads in a city for map services. Maps on the internet have application programming interface (API) that support the GIS applications. Figure 1 shows the work's idea of traffic flow acquisition processing. The method procedure starts by map service API, and then a bash script was designed for traffic flow image collecting. Moreover the authors used image processing software to extract road intensity and saved it to a specific date and time into the traffic flow acquisition [3]. The work is not designed for real time processing.

In our study we concentrate on developing a method that can provide the civil defense vehicles such as ambulance and fire vehicles with real roads information to help them reach their destination through shortest and spare part, so to give their helping services to reduce accident effects.

2. VEHICULAR NETWORKS and CLOUD PROTOCOLS

VANETs are self-organized networks that support intelligent transportation with information through wireless communications among vehicles on the road. The protocol wireless access vehicular environment (WAVE) has introduced to the transportation community to enable vehicular communication using detected short-range communication (DSRC) frequencies. WAVE allows safety-related and non-safety related vehicular applications over single-radio using multi-channel operations defined in the IEEE 1609.4 protocol [4]. The goal for creating such network is to improve traffic safety by supplementing different services to the drivers. To establish vehicular communications, vehicles' are equipped with sensors, antennas, and on-board unit device OBU. Moreover, road side units RSUs are placed on fixed places on the roads to help vehicles to communicate with the infrastructure [5]. On August 2010 Prof. Olariu and his co-workers had promoted the vision of vehicular clouds (VCs), where the cloud computing (CC) technique used to help with vehicle service applications. The National Institute of Standards and Technology (NIST), gives a formal definition of **CC** as: “a model for enabling convenient, on demand network access to a shared pool of configurable computing resources (e.g., Networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” [6]. While The Vehicular Cloud Computing **VCC**, (or might be called autonomous vehicle cloud **AVC**) defined by Olariu S. As “A group of largely autonomous vehicles whose corporate computing, sensing, communication and physical resources can be coordinated and dynamically allocated to authorized users.” [7]. The authors suggested to start creating a new scenario using AVC facilities to help in enhancing the vehicle environment. Hussain *et al*. In 2012 proposed three kinds of architectural framework for VANET-based clouds, Vehicular Clouds (**VC**), Vehicles using Clouds (**VuC**), and Hybrid Clouds (**HC**) [8]. Services offered by **VuC** include the CAA (Cooperative Awareness Applications), real-time traffic information, warning messages, and infotainment. From the VANET application standpoint, CAA is of prime importance. Keeping in mind the size and frequency of data generated by CAA, authors of reference [9] indicates that **VuC** would be the ideal framework for providing services to VANET as illustrated in figure 2.

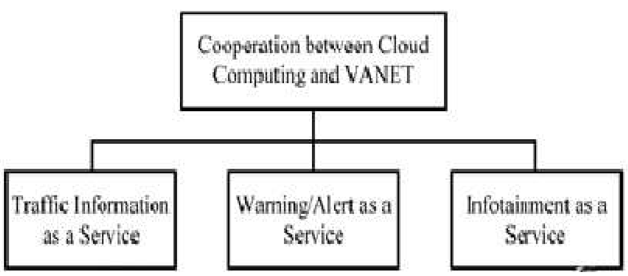

Fig. 2: VANET using Clouds (VuC) Framework [9]

In [10, 11] three level of cloud computing services was, defined as; Infrastructure as a Service (**IaaS**) that provide users with storage, processors and network resources, Platform as a Service (**PaaS**) provides users with development tools, and Software as a Service (**SaaS**) provides customers with application services. In [12] a proposed algorithm is presented where IaaS can get up to date information from the wireless sensor network and electronic equipment connected to the cars and collect the in-car information, traffic and road information. This information is then passed to SaaS through PaaS. This kind of system will communicate with the users within the cloud, process all information and give useful services, as figured in figure 3. This method can be useful to propagate an emergency message to the GIS system to create the final report that helps the civil defense vehicles with the needed information about road situation.

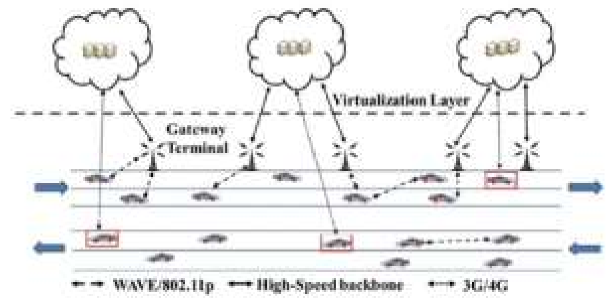

Fig. 3: Schematic diagram of cloud architecture which included VANET as IaaS [12]

3. Esri ArcGIS SERVER

By using public published maps and Geo-processing services created by the GIS team, a user application can be built to help in supporting multiple services that must react in real time. One of the best servers, used is the Esri ArcGIS Server supported by API, which is used together to create and manage GIS Web services, applications, and data [13]. GIS with the new SignalR library is used to develop high-frequency messaging and real-time web functionality easy. The signalR library allows bi-directional communication between server and client and its main goal is to deliver a real-time experience over HTTP. This library also lets you broadcast messages to all connected clients simultaneously or to specific clients [14].

4. THE MODEL STRUCTURE

Our goal is to support civil defense vehicles with important information about the road situation by following the decision that is made after analyzing the incoming data from cooperative V2V networks. Throughout the coming subsections we are going to review our assumptions and scheme algorithm briefly.

4.1 Assumptions and Problem Statements

We based our study on a suggested model with four fundamentals:

- *Platform*: The platform is the urban roads, where every vehicle can be connected at least one time to one of the available RSU during its journey; this connection helps to exchange and update the traffic database information in the VuC frequently. This is done by feeding both; the vehicle and the database with the latest road situations. We assumed that the digital road map is divided into segments with fixed sized depending on the GPS information, where each segment assigns with a unique (SID).
- *Dissemination mechanism*: Our concentration is about propagating the warning message between vehicles (V2V). Then the message will transfer to VuC database, and GIS center. This mechanism can provide helpful information to the civil defense vehicles considering the short and the spare path to the accident location. Many methods are presented for safety messages dissemination to alert all the neighboring vehicles [3]. A dissemination method for safety messages (DMSM) is addressed in a previous work by two of the authors of this study, which we suggested to be adopted [15].
- *Beacon and warning message structure*: Vehicles which are connected to each other (V2V) continue exchanging packets. A beacon is sent in a particular interval of time, and carries the

vehicle's status, (e.g. Vehicle identity, location, time, direction, velocity, neighboring vehicles aggregates to it, and road segment identity). There is no problem with storage space on vehicles OBU, so we based our idea on creating a table stored in each vehicle contains all the neighboring node status. Figure 4, shows our suggested packet's structure created from a pair of two values; the beacon and the warning message, which will remain empty until sensing an abnormal situation ahead.

- *Warning message data*: Messages can be classified into many kinds based on their information [16]. We suggest adding a filed in the message structure that states the priority value to each message kind depending on how important to be first processed. Fig. 4 illustrates the five fields of the warning message structure; the tag that indicates weather the node is a source node of the warning message, the time the message created, the forwarder node identity that the source node waits for its acknowledgement of receiving, message codes, and the priority value to help in filtering the incoming messages as shown in figure 5.

< (ID, time, position, direction, velocity, counter, SID), M>

Fig. 4: Beacon information fields paired with M, where the counter refers to the aggregating number of nodes connected to the node at a unit of time and M is empty in the normal case.

Warning info.				
Tag	Time stamp	F_ID	Code	Priority

Fig. 5: Message M fields, where tag =1 refers to the source vehicle, F_ID is the nearest unit identity, and code is the message kind

4.2 Proposed Scheme Algorithm

As clarified in figure 6, there are V2V and V2I communications that can handle any alert messages of an abnormal event to the VuC database, which in return transmit ArcGIS server to make a decision about the clearest road's path to be sent to the civil defense center within a real time action. Our suggested scheme starts when an accident occurs and a near intelligent vehicle senses this abnormal situation, the source node will immediately create a warning message and start sending it backward. The event source vehicle will keep resending its emergency message to the chosen forwarder node from the same area until receiving an ACK reply. Likewise, every forwarder will rebroadcast the message further through multi-hop until receiving a positive ACK from the nearest RSU. At this point the roads, traffic database stored in the VuC will be updated and immediately inform the GIS center with the new situation to start analyzing and preparing the information on the shortest path to be sent to the civil defense center.

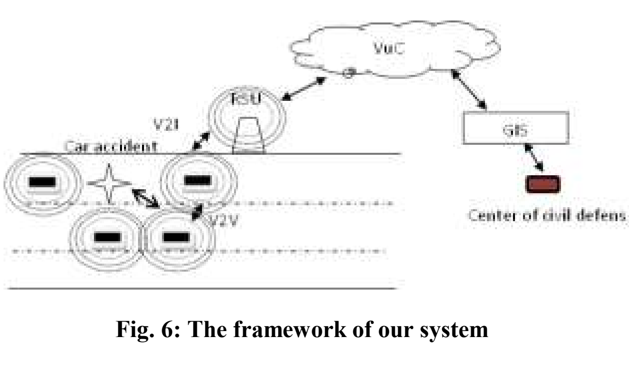

Fig. 6: The framework of our system

For more details we are going to review our study algorithm through three main phases; phase 1 represents the mechanism of data collection in normal situation and repeated at every time interval, phase 2 presents node action when it senses an abnormal situation where the nearest node (source node) starts creating the alert message and send it to VuC through RSU, while phase 3 start when the alert message reaches the GIS center to create the final report to be sent to the civil defense center, so their vehicles start their rescue journey using the most suitable path. The phases were named as follows:

1- Data collection phase
2- Creating and propagating alert message phase
3- ArcGIS server decision phase

Phase 1 and 2 subsections show the V2V ability of dissemination the warning message, while phases 3 subsections show the contribution of our work in improving the rescue procedure of the ambulance and fire vehicles by using the GIS technology.

Phase1: Data collection

With the help of OBU device, sensors, and GPS device any intelligent vehicle can exchange hello beacon with the neighboring vehicles to prepare its communication. Each beacon contains the vehicle status and is stored in a list in all connected nodes. The list of the status in any vehicle is updated every interval of time. Moreover the vehicles on the urban roads can have a connection with one of the RSUs every now and then. With RSU’s connection a vehicle can be informed with the latest road traffic situation and at the same time, the vehicle can update the traffic database in the VuC with its carrying road information. Our suggestion is based on adopting the dissemination method (DMSM) of reference [15], thus the pack format consists of a pair of data <B, M>; where B represents the beacon data, and (M) refers to the warning message type, which will remain empty during normal situation. Authors of reference [17] mentioned that the vehicle collision avoidance (VCA) latency has the long-run average time elapsed between sending and receiving VCA packet successfully and should be less than 100 msec. Thus we assumed that each vehicle placed in front of other vehicles sends its hello beacon backward every 50msec time interval and waited for another 50msec for a reply.

Phase2: Creating and propagating the alert message

When an abnormal situation such as car accident sensed by neighboring vehicles, the nearest one with less distance away is considered as the source node and starts to create immediately the alert message and keep resending it every time period. With the GPS device's help, the source node already knows the position of the nearest RSU, thus it starts disseminating the emergency message through a set of intermediate nodes until reaching a final destination which is the nearest RSU. We are suggesting that the adopted method DMSM must be modified to let the source node stop sending immediately after receiving acknowledgement (ACK) from the chosen forwarder which receives an ACK from RSU simultaneously. Meanwhile RSU sends the message information to the VuC traffic database, to start updating it with the new data to begin phase 3. Figure 7 shows the algorithm steps of phase 2.

1 Event: disseminating safety message

2 A source node sends M backward to the forwarder every time interval

2.1 Check: if the source node receives an ACK from the forwarder the stop sending and go to step 3 otherwise go to step 2

3 The forwarder rebroadcast M every 50 msec through multi-hops

3.1 Check: if the forwarder receives an ACK from RSU then stop rebroadcasting and go to step 4, otherwise go to step 3

4 RSU handle M to VuC traffic data base

5 start phase 3

6 end

Fig. 7: Algorithm steps for disseminating the safety message M until reaching the infrastructure

Phase3: ArcGIS server decision

When the method reaches this phase, vehicles handle the responsibility to the GIS to analyze the incoming data and make a path decision. We suggest using the SignalR library to create real-time, bidirectional, and asynchronous admin applications, which is based on standard web technologies. The application's output can alert the center of defense to lead their vehicles during this emergency situation in an efficient way. The algorithm steps of making the decision are illustrated in figure 8 and for more clarification figure 9 demonstrated the sequence stages of the idea.

1 Event: making a decision

2 The traffic database using SQL server transmit the new information to GIS server

3 ArcGIS API supporting by signalR library process a real time decision and choose the suitable roads path

4 Civil defense center receives the information and propagate it to lead all the civil defense vehicles in the area through the suggested path

5 end

Fig. 8: Algorithm steps of making real time decision

Fig. 9: collecting, and analyzing data to make a real time decision

5. CONCLUSION

Combining ArcGIS server services with VANET safety services to predict road traffic densities is not a new idea, but using ArcGIS with SignalR library to create real time decision for the wireless vehicular networks is totally new. This study produces a simple and new generation of real time services that can support moving objects like vehicles with information all the time in the daily life. Our aspirations are to enhance and implement this study to reach the optimal level of application performance that is used for social purposes. We intend to implement the idea of this study to be the starting point for a future project to be applied in practice.

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