Collision Prevention In Internet Of Things Enabled VANET Using Big Data Analysis On Traffic Distribution

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Abstract- *The rapid emergence of Internet of Vehicles (IoV),involving numerous cars generates enormous amount of data. Huge volume of gathered data would fetch abundant information such as the vehicles present condition and various traffic distribution. Offloading of VANET (Vehicular ad hoc network) is one of the promising solution to eradicate the problem of big data collection as cellular network has limited storage capacity. The paper proposes an intelligent network recommended system that supports big data analysis of traffic. It is also used to make the roads a safer place as it consists of Internet of Things(IoT) enabled vehicles, which deals with the trust levels every vehicle and various behavioral patterns of the car driver. Mobile Agent(MA) is used in the proposed approach to detect the misbehaving nodes in the IoT enabled VANET.*

Keywords- Trust, Behavior, Mobile Agent, Collision, IoT, VANET, Big Data

I. INTRODUCTION

The rapid growth of IoT has begun to emerge as all the devices around us are getting connected. Internet of Things has also accelerated the expansion of Internet of Vehicles (IoV)[1] where the presence of mobile operating systems are becoming common. Thus, the future vehicles would have the presence of Internet access as a standard feature. Cellular-based access[2] technologies is one of the main way to provide ubiquitous and reliable Internet access needed in the vehicles[3]. Usage of cellular infrastructure for Internet in vehicle could result in overloading issues[4]. Inorder to offload the cellular network, many countries have developed city-wide WLANs[5]. Wireless Access in a Vehicular Environment (WAVE) uses IEEE802.11p standard that is used to extend the service provided to the vehicular users [6]. This leads to the formation of various heterogeneous networks which includes the cellular network and VANET[7][8][9].

VANETS are becoming an extensive area of study and research for its numerous applications and various technical challenges involved within it for implementation[10]. VANETs are actually Mobile Adhoc Networks (MANETs)[11] which are generally wireless, self-organized and are autonomous[12]. Taken a scenario where all the vehicles in a VANET are equipped with sensors that communicate with the sensors present in other vehicles enabling the formation of IoT enabled VANET. In this case, IoT involves huge amount of information payload. These payloads are used to determine the various behaviors of the devices as well as the users. There are some issues relating to the Quality of Service[13][14] provided to the vehicular users when they are roaming[15]. Many research studies have proposed various methods to overcome the challenges on network selection[16]. A mathematical model was used for a network selection in [17]. Network selection was also done based on vehicular communications by some researchers. In [18] a self-selection mechanism was developed which was made use of decision trees. The paper proposes the solutions for the following objectives: 1) Designing the traffic distribution model used in network recommendation; 2) Based on real-time traffic environment a network selection algorithm is proposed; 3) A low computational complexity involved network selection approach provided to all the available wireless technologies. The proposed method also provides a solution of determining the trustworthiness of various nodes in a VANET. This is done to relay on the messages that are broadcasted to various vehicles in the VANET[19].

One of the major issues faced by all the recent technologies is the security issue. VANET is not an exception in this case. The biggest challenge that this technology faces is the reliability of the information that is being sent across all the vehicles in the network. As the data that is being exchanged is very sensitive it is very important that lot of care is taken when these data are exchanged. Many researchers are trying to provide solution to this problem. By making use of the government organizations, YeongkwuKim[20] et.al has proposed an effective trust system that is employed considering a hybrid scheme. Usage of Trust Third Parties (TTP)[21] were used for generating various security keys and certifications which could be majorly used for dealing with trust management. Hind Al Falasi[22], assigned various trust rating to all the vehicles present inside the VANET and then these ratings were used to identify the misbehaving or abnormal vehicles. The vehicles in the network are always in the listening state where it listens to the beacons that are sent by any other vehicle in the network. The information that was listened by the listening vehicle would be stored in the receiving vehicle so that it could be used for some other future purpose. The information is only received from the vehicles in the VANET when same speed is maintained. In order to calculate the trust rating of the neighbor vehicles in the VANET, the similarity ratingwas forwarded to the Decision Maker Module. One of the major challenges faced by this approach was that it considered speed as the major factor to calculate the similarity rating of various vehicles present in the VANET.

A real time system was designed by Alexandra Rivero-Garcia et.al.[23] in order to improve the road safety by making use of event alerts[24]. The event alerts were generated based on various factors such as the verification votes of the users, user profilesand also included the trust levels of the users. The system was designed to run on the mobile device of the drivers. Three user actions were available on the mobile device which were i) Generate- where an event could be generated by the user, ii)Verify- where a user can verify if the event received by him was true and iii) Deny- where a user could deny an event if it is not needed by him. A feedback form option could be added as a further study to enhance the application. Wejia Li et.al.[25] proposed an attack-resistant trust management approach which was named as ART. ART evaluated the trustworthiness of the data that was received both from the traffic data and also the vehicle nodes in the VANETs. Functional trust[26] and node trust[27] were other to trust factors that were considered to evaluate the trustworthiness of the users. A Cosine based similarity metric[28] was used to measure the similarity of two vectors in the VANETs where no additional overhead occurs inside the VANET.

without loss of generality and to make the model simplified, we have made the following assumptions:

Statement1: The geographic area which is considered for modeling is segregated into grid-like street layout. The street pattern which is modeledconsists of a set of M vertical roads. These roads are intersected with a set of M horizontal roads in which each road segment is marked as road segment, from horizontal roads to vertical roads.

Statement2:We have considered two types of networks, cellular network and VANET. Cellular network is used to cover the entire region, whereas VANET covers partially. In addition, the vehicle-to-vehicle communication is also not considered.

Statement3:The criteria that is considereddistinguishesamong the critical factor and the factors influencing it. The Traffic Densityis considered as a critical factor and influencing factors includes Bandwidth, Cost and Delay.

Statement4:Many types of real-time services are present which is extracted from two types of services representative namely voice and video communications.

The paper will discuss about a IoT enabled VANET model which could be used for safer roads. Safer roads are built by priory detecting collision on the roads and taking an alternate one. This is donethrough optimum network selection algorithm. The basic steps followedwhile choosing the optimum network is discussed and results are shown using MATLAB graphical view. The results discusses about the performance of QoS for various network selection schemes for various service times.

II. NETWORK ARCHITECTURE

VANETs are ad-hoc nodes that are present in every vehicle and form a network.. The network consists of three layers which are as follow: i) Network Access Layer[29] where the data is collected and disseminated. The vehicles in the network connect with the various Cellular base station (eNB)[30] and Road side units (RSUs)[31][32]. ii) Data Aggregation Layer[33] where the data is connected to the central controller and is accessed for Internet. iii) The Application layer[34] is used to provide the traffic related information to all the vehicles present in the VANET from the data that is stored in the cloud.

The Data collection unit collects the data from the GPS that is located in each and every vehicle[35][36]. From the GPS location we can easily trace out the velocity of the vehicle as well as the direction in which the vehicle is moving. The data that is collected from this passed on to the next phase that is the Data Aggregation. The information is gathered and is sent to the Access recommender (AHP) where the Internet access is provided to the user in the vehicle[37].

The network selection is done in a secure way and passed on to the next phase that is the Access Execution. When an access is provided to the user he has the rights to use the information and take necessary actions. Various options are available to the users through a mobile application. The application also provides the information of the user and their generated events to all the other users in the VANETs.

III. IoT SYSTEM BASED ON TRUST AND BEHAVIOR

A novel approach is designed based on the behavior of each and every node in the VANET. The description of the proposed model is as follows:

A. Architecture

The IoT based system consists of the following components for vehicle-to-vehicle communication and for Vehicle-to-Infrastructure communication.

- Traffic Signals - The traffic signal is considered as a Base Transceiver Signal Station (BTSS) which plays a major role in transferring the information form/to the IoT enabled vehicles.
- IoT Enabled Vehicles - All the vehicles in the VANET should be IoT enabled which is necessary for continuous transmission and reception of information.
- Speed Detectors - The speed of each and every vehicle is detected and the information is passed to all the other vehicles in the network about the over speeding vehicles.

All the vehicles must be equipped with Collision Detection sensors and Transceivers. This is used to sense the vehicle during collision and transmit the information to all the other vehicles in the VANET.

B. Behavior based on Trust

The proposed model has a principle of collecting information about the vehicles on road to generate the trust rating for each and every vehicle in VANET. The major factors that are used for calculating the trust level are:

- Review - where a vehicle can gather data on traffic status of the route and if any accidents are reported in the route. In case of any accidents what are the alternate routes available and what would be the expected travel time of the route.
- Sensory Data - Speed sensors are deployed in all the vehicles which gather information about the speed of the vehicles passing by every other vehicle. It is useful to collect the information of the vehicles that are crossing the speed limit. This help to identify the possible vehicles that are dangerous on the route and could engage in collision[38].
- Mobile Agents (MA) - The mobile agent is used to verify incase of any collision claimed by any other vehicle. This is done to calculate the trustworthiness of a vehicle time-to-time. Any node could be appointed as a MA. It could be a vehicle passing the route or an Insurance agent that is present on the site or a nearby police node[39][40].

C. Reporting of Collision

The collision detector node that is equipped in each and every vehicle could report a collision. By passing this information it would helpful for all the other nodes who are passing through the route to take an alternate route.

D. Zonal Agents (ZA)

Zonal Agents could be elected by the network to verify the claims that are made by the nodes in the VANET. These agents are also used to monitor the Mobile Agents. ZA can be any random node which have highly available resources.

IV. PROBLEM DESIGN

A. VALUE FUNCTION

QoS is the Quality of Service which refers to the satisfaction of the users by the service providers. Several attributes are considered in providing Quality of Service to the users such as data rate, cost_delay and cost_make should be provided to the users in our problem. When an attribute is taken, its utility can be expressed in terms of its utility function. Many researchers have analyzed various utility functions on various attributes[41][42].

B. NETWORK REFERENCE

The recommendation of an "optimal network" that should be incorporated in the vehicles should satisfy various criteria during various conditions. Some of the steps that needs to be followed are as follows :

*STEP 1:*In order to select an optimum network, there are several factors to be considered. Figure 1. shows the hierarchy for the optimal network selection. In the hierarchy "Optimal Network" is considered as the highest level and it the goal to be achieved. To achieve that various factors such as traffic density, communication delay, bandwidth and cost needs to be considered. There are additional triggering factors also that determine the optimal network like RSS and some application changes.

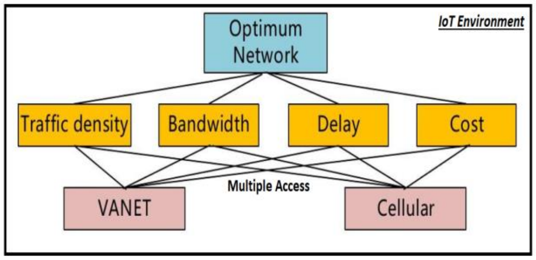

Figure 1. "Optimum network" selectionhierarchy

*STEP 2:*Pair-wise comparisons are performed on various elements in the hierarchy which are done by making a series of judgments. A specific level in the hierarchy is compared with a higher level hierarchy for establishing the priorities. A pair-wise comparison matrix is constructed based on a standard comparison. A pair-wise comparison matrix is constructed for first level. The criteria set for second level is $C = \{Cj| j = 1, 2, . . .,NC\}$.

*STEP 3:*The comparison matrixis designed in such a way that it satisfies the transitive preference and strength of the relations. IT is also very much essential to check for the consistency. When the matrix is passed through a consistency test it should be accepted otherwise it should be again revised. The test consists of two important calculations:Consistency Index (Ci) and Consistency Ratio (CR), whose formulae are discussed in the following equation:

$$Ci = (\lambda_m - N)/(N - 1);$$

$$CR = Ci / RD$$

where, N- Size of the pair-wise comparison matrix

RD- Random Index.

λ_m - Maximum Eigen value of thematrix.

Step-4: The priority vector should be ranked at each level's alternatives. The priority Vector (V) can be calculated when the constructed matrix passes the consistency test. V can be gained by normalizing various eigen vectors which are corresponding to the maximum eigen values

$$AV = \lambda_m V, V = [V_1, V_2, . . . , V_n]$$

*Step-5:*The priority vectors are synthesized based on the overall priority vector. The final goal could be reached only when (Vi) are determined. This is done by multiplying the priority vector with the first level AHP matrix.Synthesize these priority vectors to construct anoverall priority vector, and the final priorities of the alternativesfor the goal can be yield.The final priorities of alternative networks can be obtained through the above five steps for an "Optimum Network".

V. EVALUATION AND RESULTS

The performance of the optimum network selectionis done through simulation using MATLAB. The traffic distribution is modeled as scalable grids. 20,000 vehicles were taken in an area and the area is of 10*10km size. 20 horizontal and vertical streets are taken as the bottom of the X-Y layer in Figure 2.

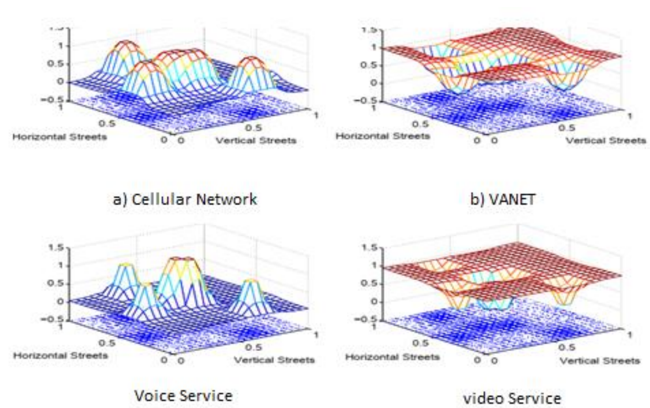

Figure 2. Recommendation index

The simulation has considered various voice and video service applications[9] that are available to the users. The average time neededfor a vehicle on voice service was 3minutes and for video service 5minutes. The data rate of the services provided are 0.6Kb/s for voice and 5Mb/s for video. Figure 2. shows the recommendation index of VANET vs. Cellular network for voice and video services which was used for selecting an optimumnetwork selection.

While consideringthe voice service and video service applications[14], the total time that the vehicle spends on voice service is 3minutes and for video service is 5 minutes. The rate at which the data flows is 0.6kb/s for voice and 5 Mb/s forvideo service. AHP method is used to solve the network recommendation problem. This is done by comparing pair-wise matrices.

TABLE I: Comparison Matrix

(a)VOICE SERVICE and (b)VIDEO SERVICE					
Optimum Network	**Traffic Density**	**Bandwidth**	**Delay**	**cost**	**Priority**
Voice Service	1	5	1	3	0.5
Video Service	1	0.2	2	2	0.01
Voice Service	1/5	2	1	2	0.1
Video Service	5	1	0.1	1	0.2
Voice Service	1/3	4	1	2	0.1
Video Service	3	0.1	1	1	0.21
Voice Service	1/7	1/3	1/3	1	0.02
Video Service	1	0.5	0.23	1	0.11

The First level of AHP comparison matrixis shown in TABLE I. It is used for making decisions on priority among various criteria to advise each and every vehicle with a network to access. The matrices for voice and video applications are presented in TABLE I, (a) and (b). We have defined the traffic density as one of the most importance factor among all the four criteria. Voice communication delay should be very short. Video communicationpays attention to bandwidth and delay when compared to cost. The value of R is less than 0.1for boththe two services. This means that the pair-wise comparison matrices which have been constructed has passed the consistency test.

The different proportion that are involved in each type of scheme is shown in Fig. 3. It is the sum of three types of network selection schemes. “All cellular” means all vehicles that are assessed to the cellular networks to gain services. “Random”scheme is used to select the vehicles in a network randomly. “INAS” is the scheme proposed by this paper. Fig. 3(a) and Fig. 3(b) shows the comparison between the proportion of each and every type of schemesduring the time when vehicles have one time service requirement and when it has 30 times service requirement, respectively. For Fig. 3(a), the proportion of QoS of “Random” is very much less when compared to “All cellular”, as many vehicles have noaccess to VANET. In spite of large data rate of “Random”, its QoS is minimum as there are too many vehicles with voice services which are connected to the VANET. This large data rate can be improved by the QoS of voice service. The advantage of the application of VANET is reflected when the amount of service requirements is greater as shown in Fig. 3(b), and hence it is shown that INAS has the best QoS performance.

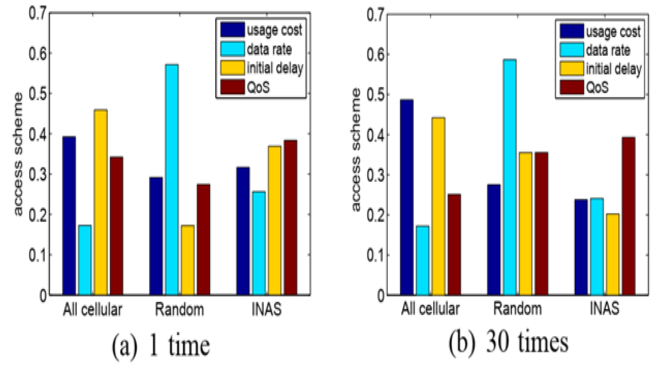

Figure 3. QoSforvarious network selection schemesfor different service times.

VI. CONCLUSION AND FUTURE WORKS

This paper proposes a model where an IoT enabled VANET is used for safer roads. This is done to detect the collision on the roads and the user can get to know the alternate route. The model also helps the user to find misbehaving nodes on the route so that he could be safe while driving. The learning about one vehicle is used by other vehicles to form an intelligent model. An intelligent network selection recommender was designed using the big data analysis on traffic distribution. The future work could include a secure communication between several VANETs. The user information is passed to all the vehicles in the VANETS, hence a secured protocol could be used to ensure the security of the user information.

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