ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

VEHICLE REWARDING FOR VIDEO TRANSMISSION OVER VANETS USING REAL NEIGHBORHOOD AND RELATIVE VELOCITY (RNRV)

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ABSTRACT

Video transmission is a critical issue in VANETs. The main problem is how to extend the lifetime of video streaming in order to overcome routing overhead in the high mobility environment of VANET highways using the concept of rewarding vehicles in reliable zones/clusters with the long lifetime. This paper conducts a novel model based on the assumption that the relative velocity should essentially affect the dynamic topology and network lifetime, especially in high mobility environment, which is a vital property of VANETs. In this paper, a mathematical model named Vehicle Rewarding for Video Transmission over VANETs Using **R**eal **N**eighborhood and **R**elative **V**elocity (RNRV) has been developed to optimize video transmission by the concept of real neighborhood of the rewarded vehicle. The idea behind the proposed model is to maximize VANET lifetime and minimize routing overhead of the network using the concept of relative velocity of neighbors within the transmission range of a rewarded vehicle. The concept of real neighborhood introduced by the proposed model decreases the impact of high mobility in VANET highways because it maximizes the dynamic topology of a VANET zone/cluster, which, consequently, leads to better routing path and link durations. The proposed model has been implemented and examined using MATLAB. Results show that number of real neighbors is critically influenced by the factors of relative velocity and distance of vehicles within the transmission range of the rewarded vehicle.
Keywords: *Relative Velocity, distance, Throughput, Delay, VANET, RNRV.*

1. INTRODUCTION

In recent decades, the field of wireless communication has grown dramatically in both industrial research and commercial applications. Progress in this area has significantly changed the daily life of people around the world [1]. Wireless technologies such as Wi-MAX, 802.11/Wi-Fi and Bluetooth [2] assist in exchanging information between mobile devices with different ranges of radio broadcasting. Networks that contain mobile devices should consider the lack of infrastructure, which can be used to support wireless connections. Consequently, a new area of portable communications has surfaced to provide self-configuring network infrastructure-less, specifically MANET [3], [4]. It consists of movable nodes, which can act as routers, clients and servers [3]. Due to the current growth of computer and wireless communication technology, the moving vehicles such as motorcycles, cars, and buses communicate with each other without developing any fixed infrastructure [5]. These types of networks are called Vehicular Ad-hoc Networks (VANETs).

Research area of VANET has increased rapidly in recent years. To support the quick growth of VANETs, standard protocols such as IEEE P1609, IEEE 802.11p and DSRC have been designed to adapt to the requirements of VANET [6]. Moreover, several applications have used the intelligent idea in the transportation systems. Typically, VANETs' applications can be divided into three categories: (1) infotainment, (2) transportation efficiency, and (3) safety [7].

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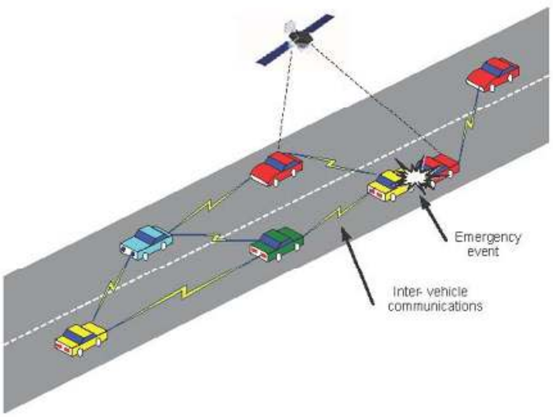

Fig. 1: Vehicle To Vehicle Communication In VANET

VANETs have several challenges due to their special properties such as high dynamic topology and high mobility. For network connectivity, the standards provide VANETs with sufficient range of communication and bandwidth. Additionally, using vehicle technology as a node to transmit video content, a number of difficult challenges will occur due to highly dynamic network topology. Moreover, to decrease routing overhead, many methods in VANETs are proposed to extend the lifetime of the network by gathering the requirements for network efficiency. To emphasize a good contribution of a proposed model is to maximize the lifetime of VANET zone/cluster and consequently routing path. A mathematical model proposed in this paper aims at maximizing the lifetime of VANET zone/cluster and improving routing performance in terms of routing overhead for video transmission over VANET. The concept of real neighborhood introduced by the proposed model decreases the impact of high mobility in VANET highways because it maximizes the dynamic topology of a VANET zone/cluster, which consequently leads to better routing path and link durations. The mathematical model called Vehicle Rewarding for Video Transmission over VANETs Using Real Neighborhood and Relative Velocity (RNRV) has been developed for vehicle rewarding with maximizing VANET zone/cluster lifetime and consequently routing path duration in a high mobility environment, which essentially affect network performance in terms of routing overhead. A vehicle in a VANET zone is rewarded based on the concept of real neighborhood, which is defined as a novelty of this paper. Number of real neighbors for a candidate vehicle for rewarding is derived under a condition of relative velocity factor and a relative distance within transmission range of the candidate vehicle for rewarding in a zone/cluster. The proposed model has been implemented using MATLAB and results show that relative velocity and distance within transmission range of the candidate vehicle for rewarding in a zone/cluster in VANETs have a crucial impact on the number of real neighbors and consequently a vital effect on routing overhead because of the enhancement in zone/cluster lifetime.

Recently, VANET has gained much attention, increased largely by the growth of interest in Intelligent Transportation Systems (ITS). The VANETs' environment as well as the strict Quality of Service (QoS) requirements represent challenge on video transmission over VANETs. The most challenging issue in conjunction with VANETs is reliable routing that determines the path of packets traveling over the network [8]. The following subsections present the full details regarding the research methodology steps included in this study. The proposed framework is divided into three main components: Rewarded Vehicle Estimation in Camera zone, Proposed Mathematical Model, and Real Neighbors Estimation.

Video Streaming has an assortment of promising applications in VANETs such as road safety, traffic, efficiency and infotainment. Thankfully, it is also possible to stream video over vehicles. The overflowing electricity provided by vehicle engines can supply plenty energy for video transmission and playback. Furthermore, there is a large amount of space available inside the vehicle to house large onboard computational devices and to keep for encoding and decoding.

2. RELATED WORK

In recent years, many related work about the high mobility issue have been conducted. Moreover, several approaches and models are suggested for routing enhancement of the VANET. The selection of the rewarded vehicle for video transmission in VANETs is proposed using several analytical and theoretical models. The proposed idea using relative velocity for determining real neighbors is critical parameter to get stable transmission in the zone/cluster and improved performance and routing decision in VANET.

Thus, VANETs have recently become a smart field for scholarly research and have received quite a bit attention from the manufacturing [9]. Interestingly VANETs are significant technology that support intelligent transport systems, driver assistant, and

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

safe routing at the sea, as well as help to increase in marketing of entertainment applications [10]. By comparing MANETs to VANETs, VANETs have a more dynamic environment, leading generally high failure rate due to the large number of link break and changes in topology [10]. On the positive side, however, vehicles have unlimited power and computing resources. Including CPU, memory and storage capacity, vehicles are as good as the best options available in the market [9].

Authors in [24] suggested a cluster based multi-channel c scheme that may support a wide range of future multimedia and data applications and public safety message delivery. They proposed scheme merges clustering with contention-free and/or -based medium access control (MAC) protocols. The selected cluster-head vehicle functions as the coordinator to deliver real-time safety messages within its own cluster and forward the consolidated safety messages to the neighboring cluster-heads.

The scenario of cognitive radio enabled vehicles communications freeway mobility model is discussed by authors in [23]. The vehicles as secondary users (SUs) that the behaviors of PUs follow the call-based model, when these channels are not engaged can access the licensed channels of primary users (PUs). In the EPDM-R algorithm, the estimated link duration for each link is computed. Then, the max-bottleneck algorithm is used to solve for the route achieving the longest estimated path duration. Theoretic analysis verifies the optimality of suggested EPDM-R algorithm in terms of maximizing EPD. Simulation results show that suggested algorithm has larger average path-duration than the Dijkstra based scheme and the scheme that does not consider the PUs behaviors. They are not considering the interference among them in the scenario extended by incorporating multiple source-destination pairs for the EPDM-R algorithm in CR-VANETs.

Authors in [22] proposed an analytical model to estimate path duration in a MANET using the random way point mobility model. The main feature of the proposed model is that it establishes a relationship between path duration and MANET design parameters including node density, transmission range, number of hops, and velocity of nodes. The model could be extended to include protocol dependent factors that contribute to path duration. This would help in the accurate prediction of average path duration for various routing protocols. They are not also focus on mobility model dependent factors that contribute to average path duration. The model also provides an insight into the impact of mobility on routing protocols. It also points out that routing protocol should be equipped with the functionality of choosing paths with higher duration, in order to improve the network performance.

Authors in [21] proposed RVVR (Relative Vehicle Velocity Routing) algorithm which to solve the local maximum and the link breakage problems by taking into account the density, the speed of neighbor nodes and the relative speeds between the transmitting node and its neighbor nodes to select a relay node. However, they need to use more efficient routing algorithm that can handle the case of the intersection in which the prediction of node moving direction is not possible should be focused. They are not use GPS. While driving in tunnel and parking building, the routing protocol using geographic information cannot construct the typical VANET communication, because vehicles cannot receive the signal from satellites for GPS system. In this environment, proposed routing protocol can be helpful to provide more reliable non-real and/or real time services.

Authors in [20] considered a high-speed highway mobility scenario, where the available knowledge about the network's topology is used to improve the routing path duration. The improvement is mainly due to the use of a topology control algorithm, which increases the path duration by decreasing the probability of path breaks. They integrate topology control scheme in the Optimized Link-State Routing Protocol (OLSR). They compare the performance of their approach with other routing protocols for different values of vehicles density. The comparison includes end-to-end path delay, path availability and path length (in number of hops).

Authors in [11] introduced a new routing protocol supporting high mobility over VANET, which is using hop counts and relative velocity between vehicles to find the best routing transmission path. By exchanging relative velocities, the more stable and reliable paths are searched as compared to traditional MANET protocols using only hop count information at the time of routing path setup.

Authors in [12] proposed a model to calculate the reliable link between the nodes and reliable path for the purpose of communication. They also evaluates and compares the performance of Ad-hoc On-demand Distance Vector (AODV), Fish-eye State Routing (FSR) and Optimized Link State Routing (OLSR) routing protocols with different number of nodes, mobilities and speeds in MANETs and VANETs using Packet Delivery Ratio (PDR), Normalized Routing Overhead (NRO), End-to-End Delay (E2ED), Average Link Duration (ALD) and

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Average Path Duration (APD). They observe that AODV is more efficient than both FSR and OLSR at the cost of delay but the ALD and APD of FSR and OLSR are greater as compared to AODV. Moreover, these protocols perform better in MANETs as compared to VANETs. They do not introduce multiple QoS path parameters, energy efficient MAC protocols, sink mobility and heterogeneity in their work.

Authors in [13] have derived a mathematical model to estimate path duration using border node-based most forward progress within radius (B-MFR), a position based routing protocol. The mathematical model for estimation of path duration consists of probability of finding next-hop node in forwarding region, estimation of expected number of hops, probability distribution of velocity of nodes, and link duration between each intermediate pair of nodes. Each of the analytical results has been verified through respective simulation results. The result analysis clearly reveals that path duration increases with the increase in transmission range and node density and decreases with the increase in the number of hops in the path and velocity of the nodes.

Authors in [14] analyzed various challenges and existing solutions used for clustering in VANETs. Their contribution is a comprehensive analysis of all the existing proposals in literature is provided with respect to various parameters such as topology selected, additional infrastructure requirements, road scenario, node mobility, data handled, and relative direction, density of the nodes, relative speed, communication mode, and communication overhead. The analysis provided for various existing proposals allows different users working in this domain to select one of the proposals with respect to its merits over the others.

Authors in [15] proposed a vehicular routing scheme in which the available channels are managed for optimizing a considered composite metric for multi-channel transmissions, which takes into account different parameters (multi-objective). Network Simulator 2 (NS2) has been employed to validate the Multi-Channel Multi-Objective Distance Vector (MCMO-DV), showing how it outperforms classical approaches in terms of throughput, packet delivery ratio, and overhead.

Authors in [16] represented a simple and robust dissemination technique that efficiently deals with data dissemination where the density of roadside base stations and vehicles distribution are both high. This technique divides the users in two categories premium user as well as free users. They illustrate three schemes such as fuzzy inference system, genetic algorithm scheme and hybrid of fuzzy inference and genetic algorithm.

Authors in [17] introduced a novel multi-hop clustering scheme for VANETs, which generates cluster heads (CHs) via neighborhood follow relationship between vehicles is proposed. The scheme is based on a reasonable assumption that a vehicle cannot certainly identify which vehicle in its multi-hop neighbors is the most suitable to be its CH, but it can easily grasp which vehicle in one-hop distance is the most stable and similar with it, and thus, they most likely belong to the same cluster. Consequently, a vehicle can choose its CH by following the most stable vehicle. The relative mobility between two vehicles combining the gains based on the followed number and the historical following information enables a vehicle to select which target to follow. Extensive simulation experiments are conducted to validate the performance of the proposed clustering scheme.

Authors in [18] have proposed a multi-metric next hop vehicle selection algorithm for geocasting in VANETs. Link and node based metrics have been identified and used in the proposed algorithm. Mathematical formulation for each of the identified metric are provided. The working of the proposed algorithm has been shown using a case study. The algorithm has been evaluated by empirical study.

Authors in [19] proposed a practical model which considers the distribution of relative velocity, inter vehicle distance, and impact of traffic lights to estimate the expected link duration between any pair of connected vehicles. Such is implemented on each vehicle along with (1) a relative velocity estimation approach and (2) an exponential moving average (EMA) based data processing procedure. Furthermore, the proposed model assumes that the events of two consecutive vehicles encountering traffic lights combination are dependent, which make the model more practical. To avoid the influence of sudden velocity changes, they applied EMA on collected velocity samples to filter outliers. They plan to further validate the LDP model by real-world dataset and extend the model by considering vehicles turning at intersections.

3. PROPOSED FRAMEWORK

The methodology of the framework composes several systematic stages to enhance video transmission in VANET. The framework is significant in VANET due to its importance for helping drivers in the road. The estimation of the vehicles relative speeds in the road identifying the neighbors and calculating distance for destination of

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

each vehicle in the zone are provided by the mathematical model of the framework for selecting the rewarded vehicle. Figure 2 demonstrates the proposed framework that contains three components: The mathematical model, which is the core part of the framework, GPS system, and routing protocol, used to transmit video. The proposed model will be presented in details later in this section. In the rest of the study, the researcher will highlight only the model not the framework because the model is the core part of the framework.

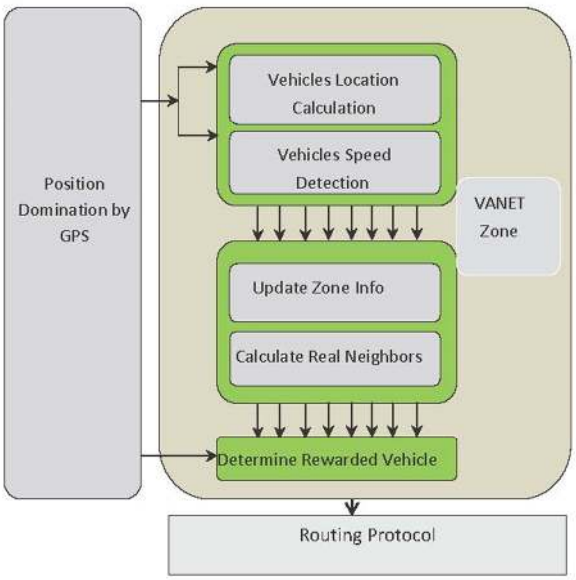

Fig. 2: The Proposed Framework.

3.1 Vehicles Location Calculation

The needed information of vehicles' locations is assumed here to be created using GPS by the vehicle itself. According to [25], GPS is consisting of 24 satellites and ground support. GPS provides users with accurate information about their positions, as well as the time, anywhere in the world and in all weather conditions. GPS formally known as the Navstar Global Positioning System was initiated in 1973 to reduce the proliferation of navigation aids. GPS is operated and maintained by the United States Department of Defense. By creating a system that overcame the limitations of many existing navigation systems, GPS became attractive to a broad spectrum of users. GPS has been successful in classical navigation applications, and due to its capabilities are accessible by small, inexpensive equipment, GPS has been also used in many new applications.

In order to determine the locations, GPS satellites orbit high above the surface of earth at precise locations. They allow a user with a GPS receiver to determine latitude, longitude, and altitude. As illustrated in figure 3.2, the receiver measures the time it takes for signals sent from the satellite to reach the receiver.

GPS determines the location by computing the difference between the time that a signal is sent and the time it is received. GPS satellite carries atomic clocks that provide extremely accurate time [25]. The time information is placed in the codes broadcast by the satellite so that a receiver can continuously determine the time the signal was broadcast. The signal contains data that a receiver uses to compute the locations of the satellite and to make other adjustments needed for accurate positioning. The receiver uses the time difference between the time of signal reception Tsreceipt and the broadcast time Tbroadcast to compute the distance, or range, from the receiver to the satellite. Therefore, the time of determining the location using GPS is computed using equation 1:

$$T_{location} = T_{sreceipt} - T_{broadcast} \qquad (1)$$

where $T_{sreceipt}$ is the time of receipt the signal and $T_{Broadcast}$ are the time of sending that signal.

The receiver must account for propagation delays, or decreases in the signal's speed caused by the ionosphere and the troposphere. Figure 3 shows the process of requesting the positions and determining the vehicles' locations.

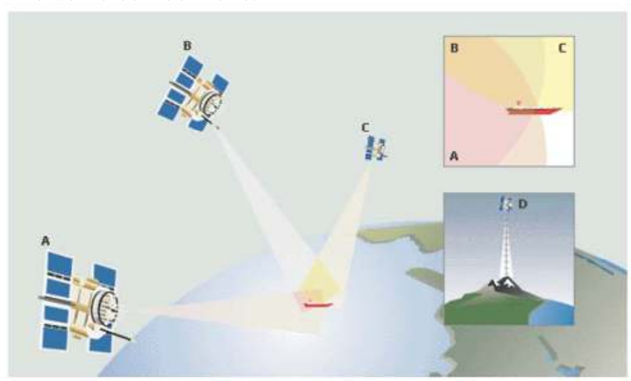

Fig. 3: Process Of Requesting The Positions

The GPS receiver computes position information by comparing the time taken by signals from GPS satellite to reach the receiver. The process of determining vehicles locations is shown in Figure 4. Mathematical model can be responsible for estimate

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relative speed of vehicles in the road, which will be described in the next section.

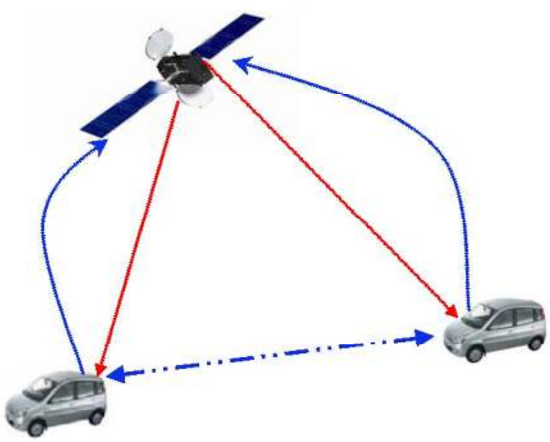

Fig. 4: Process Of Determining Vehicles Locations

3.2 Rewarded Vehicle Estimation In Camera Zone

In this study, the distance from the destination is needed for each vehicle in the zone and predication for vehicles and estimation for vehicle neighbors' relative speeds is another requirement at the same zone. The Rewarded Vehicle Estimation is consisting of vehicles location calculation stage and vehicle relative speed calculation stage.

1) Vehicles Relative Speed estimation: In this study, mathematical model estimates the needed information of vehicles' features such as relative speed. The vehicle speed is one of the traffic parameters, which is widely used in road traffic planning, so it is vital that model must be developed to estimate relative speed for all neighbors of each candidate vehicle for rewording.

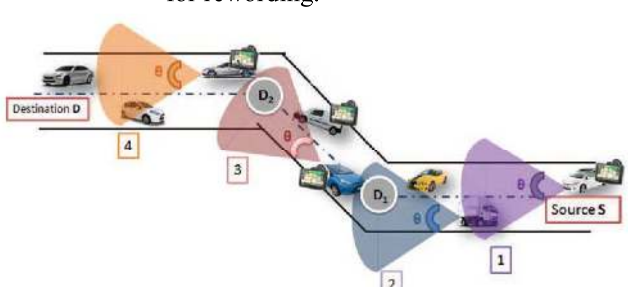

Fig. 5: Creating Rewarded Node Toward The Destination

This stage aims on improving transmission over VANET through utilization various scenarios and optimizations. The focus is on different VANET challenging domain called video transmission. The proposal is based on a mathematical model by which a reward vehicle is determined. The delay and number of packets aggregations are taking into account as a performance metrics and thus makes the collection process more reactive to topology changes and nodes' mobility. The algorithm functionality of proposed technique is presented after describing specifications of the system to examine in details the different steps in the process of proposed model. As mentioned in the preceding section that GPS used and every communicating vehicle knows its current position, and each vehicle itself provides speeds. In addition, two kinds of messages: beacons and event-driven messages are supposed exchanging by vehicles, where the previous aims at improving driver awareness of surrounding environment by exchanging information about position, velocity, and direction. The latter is triggered when a vehicle needs to collect traffic data toward a control center. Aggregations adapt, and the forwarding policies of the network status are required due to the frequent topology changes over vehicular networks. Hence, there are difficulties to predict in advance the set of rules that will adjust the actions of each vehicle when the vehicular environment's variables are changing.

The key challenge to successfully achieve the efficiency of relay node selection is to define the various features of the reward. In fact, the vehicles will use this function to update their strategy to transfer the video. The next section describes the features of the rewards and defines the variables that play an effective role on the reward function.

2) *Rewarded Vehicle:* Selecting the relay node from the candidate's nodes is the important criteria to ensure video packets transmission and achieve the potential routing in VANET. Thus, determining equation for reward is depending on the vehicles' relative speed, number of neighbors and distance from the distention. These parameters define the best node to be selected for forwarding the packet in the zone. In other word, if the reward for any candidate node in the zone has

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

the highest reward value, it leads to consider it as a rewarded node.

3) *Distance Computation Stage*: This study assumes that source is far from destination about 900 meters as a scenario. The whole distance is divided into several forwarding zones where each zone has a length of 300 meters. The last hop will be as forwarding node and has forward in zone with 1500m and so on. Figure 6 demonstrates the setting and characteristics of the forwarding zone

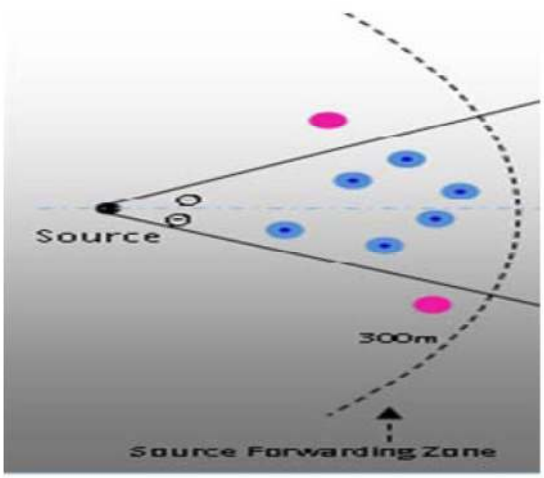

Fig. 6: Characteristics Of The Forwarding Zone

Each candidate node is responsible for calculating the distance with respect to the destination and broadcasts its reward to the other nodes in the zone. Therefore, the receivers follow the receiving-based approach in the transmission process. Figure 7 shows the transmission process between vehicles through different zones. This model is a receiver based forwarding solution designed to fulfill video unicast over vehicular networks. A destination node starts a video streaming by sending a video request to the source. As soon as the source hears the request, it will transmit video to the destination. The video content and request packets are forwarded to the next nearest neighbors within the zone. The last forwarder node broadcasts packets to all neighbors in its communication zone. Then the nodes inside the forwarding zone will report their reward to all neighbor nodes. After receiving the packet, the candidate node with high reward within the forwarding zone of the last forwarder will be selected to be in the wanted path that leads to the destination node.

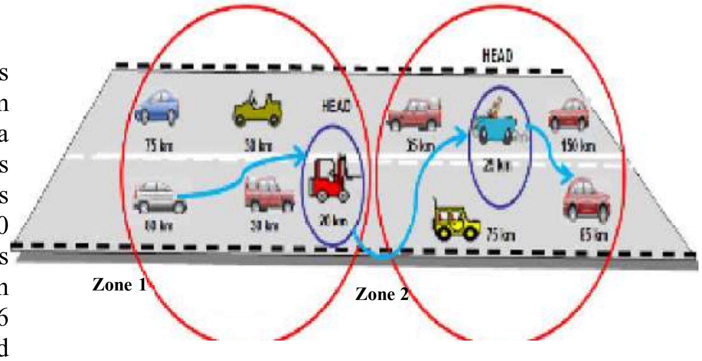

Fig. 7: The Transmission Process In VANET Through Different Zones

As shown in Figure 8, the forwarding zones of the last hop can be defined as a sector of its communication range. The forwarding zone is directed towards the location of the destination node. The prerequisite for this step is to determine the location of vehicle in term of x and y coordinates. This computation is important for calculating the distance between the neighbors and destination. This distance can be calculated based on the values of coordinates for the receiving vehicle and destination as follows:

To do this, it is important to compute the change in the x-axis movement ΔX, and the changes in the y coordinate ΔY as shown in Equations 2 and 3:

$$\Delta X = X_2 - X_1 \quad (2)$$

$$\Delta Y = Y_2 - Y_1 \quad (3)$$

The slope is calculated based on the change in Y and X. Therefore to compute the distance between the two points (x1, y1) and (x2, y2) by the Equations 4 and 5:

$$D^2 = \Delta X^2 + \Delta Y^2 \quad (4)$$

$$D = \sqrt{(\Delta X^2 + \Delta Y^2)} \quad (5)$$

Then, the distance between each of neighbors and destination is also calculated in order to formulate the needed data set. For the vehicle movement, Figure 9 and Figure 10 illustrates the coordinates and distance between the source and distention. If T is the transiting vehicle with coordinates T(x,y) and R is the receiving vehicle with coordinates R(x,y). Then the distance can be calculated by equation 5.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4. PROPOSED MATHEMATICAL MODEL

Real neighbor for a candidate vehicle in a VANET is defined in this study as group of vehicles that are very close to rewarded vehicle in the zone. It is derived under the condition shown by Equation 6. It can be represented also by Equation 6, which have been derived in this study to determine the reward function:

$$RN = \frac{\propto}{\Delta S} + \frac{\beta}{\Delta d} + K \quad (6)$$

where α is related to relative distance, β is related to relative distance with respect to the candidate vehicle for rewarding, and k is constant (can be +ve or −ve). The rewarded vehicle is then determined by applying the function MAX(RN(i)) where i=0, 1, 2, ⋯,n and n is number of candidate vehicles for rewarding.

4.1 Relative Velocity and Relative Distance Estimation

As shown by Equation 6, and because of the effect of the mobility, the number of real neighbors can be affected by relative speed and relative distance of the neighbors in a zone with respect to a particular candidate vehicle for rewarding. As shown earlier in this paper, mobility is a crucial parameter that dramatically affects the VANET performance in terms of routing overhead, throughput, and end-to-end delay. It is assumed that the mobility should be essentially affected by relative speed and relative distance of the neighbors. Thus, the neighbors could be not real for a while because it might be shortly out of the coverage of the candidate vehicle. Therefore, the real neighbor should be in the zone for enough time so that it can receive the data (video) from the source (rewarded vehicle). A mathematical model for number of real neighbor is derivation in a VANET zone. The rewarded vehicle is that has maximum number of real neighbors. It is assumed that sending video to only real neighbors (not all neighbors) will dramatically affects the performance of routing protocols in VANET. In this section, we try to prove our assumptions regarding to the effect of number of real neighbors on VANET performance.

Assumptions:

There are some assumptions that are very important to be in consideration for this work as the following:

1. The Camera is stable and has GPS system to determine its location.
2. The zone that Camera can broadcast is 300m.
3. The vehicles in deferent speeds and every vehicle contains GPS system and simple database to save the basic information that are x,y positions , speed, Wi-Fi system, and IP6 address.
4. Only one reward vehicle will be selected in every zone.

4.2 Mathematical Model

Suppose that stable Camera C, Vi is the vehicle (candidate vehicles), where i=0,⋯, $m-1$, where m is the number of the candidates vehicles in the zone (C zone) , and j=0 ,⋯, $n-1$, where n is the number of neighbors vehicles, and V_k is the rewarded vehicle. In this thesis, the definition of a real neighbor is as follows: for V_{ij} to be a real neighbor to vehicle V_i, it should meet two conditions:

1. The distance d_{ij} of the neighbor $V_{ij} \leq$ where R_i is the zone radios of vehicle i.

2. The relative speed of V_{ij} is ±20% with regard to Vi speed, i.e $S_{ij} = S_i \pm \alpha S_i$.

The contribution of this definition is to minimize the number of neighbors, so that only the real neighbors, which are near to the rewarded vehicle will be involved in the process of video transmission. This will lead to affecting the performance of network dramatically in terms of routing overhead and end-to-end delay, which are significant parameters in VANETs for real time system. Let us suppose that Camera captures the important video and wants to broadcast it to many vehicles in the road, this will happen by the following steps:

- C sends request message (which is a specific packet) to all vehicles in C zone. This packet includes C location (x,y), its IP address, and a request for each vehicle in the C zone to send some information that contents the following:
  - The vehicle location: (xi,yi) of Vi, where $i= 0, \cdots, m-1$ and m is the number of candidate vehicles in C zone.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

- Number of neighbors *RNi*, where *N* represents the real number of *Vi* based on our definition for real neighbors.
- IP address of *Vi*

➢ *C* performs some calculations to select the rewarded vehicle among all candidates in the zone *C*.

➢ *C* computes the Euclidean distance, *dci*, *C* vector for all nodes (vehicle) in the zone *C*. This is performed as in Equations 7 and 8:

$$\Delta dci = (xc - xi)^2 + (yc - yi)^2 \quad (7)$$

$$\Delta dci = \Delta xci^2 + \Delta yci^2 \quad (8)$$

➢ The result is a distance vector $\Delta di\,j$ that looks as in Equation 9:

$$\Delta d_{ij} = \begin{bmatrix} \sqrt{\Delta d_{i0}} \\ \sqrt{\Delta d_{i0}} \\ \sqrt{\Delta d_{i0}} \\ . \\ . \\ . \\ \sqrt{\Delta d_{i_{m-1}}} \end{bmatrix} = \begin{bmatrix} \sqrt{(d_i - d_0)^2} \\ \sqrt{(d_i - d_1)^2} \\ \sqrt{(d_i - d_2)^2} \\ . \\ . \\ . \\ \sqrt{(d_i - d_{m-1})^2} \end{bmatrix} \quad (9)$$

where Δxc_i the deference in x-axis between the Camera C and vehicle i and Δyc_i is the deference in y-axis. The distance of the reward vehicle dci should be between Rc/2 and R.

i.e. $\frac{R_c}{2} \leq \Delta dc_i < R_c$ where i = 0,…,m

This means the rewarded vehicle should not be much closer to the Camera C as the vehicle is moving toward the camera. It would be better if it is in the second half of the zone to give it enough time for communication with the Camera before being much closer and may succeed it.

➢ C selects the rewarded vehicle based on the following:

Rewarded C is the vehicle that have Max (Ni) AND $\frac{R_c}{2} \leq \Delta dc_i < R_c$ where i= 0,1,…,m.

3. C transmits the video to rewarded vehicle V_0 directly as between a source C (the Camera) and distention D (the vehicle V_0) using a routing where V_0 is the rewarded of the first zone (Camera zone).

4. V_0 in turn transmits the video to a list of destinations (its real neighbors list) using a routing protocol (AODV, DSR or OLSR).

4.3 Real Neighbors Estimation

Let us estimate number of real neighbors for a particular V_i located in C zone. The real neighbor of *Vi* should not be far from it and has a speed not that much far from *Vi* speed and a relative speed factor α between 0 and 0.5 to maximize the lifetime of the the neighborhood. This means that *Vi* neighbor has a distance *di j* to *Vi*. The following calculations should be updated by each vehicle *Vi* in *C* zone periodically (say every 5 or 10 seconds which is determined up to the administration of the VANET). *Vi* first computes Δdij vector for all neighbors in its zone as shown in Equations 3.12 and 3.13.

$$\Delta d_{ij} = \sqrt{\left(x_i - x_j\right)^2 + (y_i - y_j)^2} \quad (12)$$

$$\Delta d_{ij} = \sqrt{\Delta x_{Ci}{}^2 + \Delta y_{ci}{}^2} \quad (13)$$

where Δx_{ci} is the deference between the awarded vehicle and all vehicles in its zone on x positions and Δyci is the deference between the awarded vehicle and all vehicles in its zone on *y* positions.
The result is a distance vector *di j*, where *j* = 0,1,...,*m*. Here *m* is the number of all vehicles in the same zone.
Then *Vi* computes the relative speed for all vehicles in *Vi* zone as shown in Equation 3.14.

$$\Delta S_{ij} = \sqrt{\left(S_i - S_j\right)^2} \quad (14)$$

$$\Delta S_{ij} = \sqrt{\Delta S_{ij}{}^2} \quad (15)$$

where ΔS_{ij} is relative speed between Si and Sj.

Thus, the result is a speed vector ΔS_{ij} that looks as in Equation 16.

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$$\Delta S_{ij} = \begin{bmatrix} \sqrt{\Delta S_{i0}} \\ \sqrt{\Delta S_{i1}} \\ \sqrt{\Delta S_{i2}} \\ . \\ . \\ . \\ \sqrt{\Delta S_{i(n-1)}} \end{bmatrix} = \begin{bmatrix} \sqrt{(S_i - S_0)^2} \\ \sqrt{(S_i - S_1)^2} \\ \sqrt{(S_i - S_2)^2} \\ . \\ . \\ . \\ \sqrt{(S_i - S_{n-1})^2} \end{bmatrix} \quad (16)$$

where n is number of all neighbors in Vi zone.

Now, how to select the real neighbors from the distance vector dij and speed vector Sij.

Number of Real Neighbors = RN, and first condition in 17 should be met.

$$\Delta dVij \leq \alpha Ri \quad (17)$$

where Ri is the zone radios of a particular vehicle Vi and j= 0,…,n and n is the number of neighbors in the whole zone.
AND the second condition in 18 should be met as well.

$$\Delta Sij \leq \alpha Si \quad (18)$$

This can be performed by applying a 1-D loop to the vector Δdij and ΔSij using j counter j=0 to n.
The result is the vector shown in equation 19.

$$RN_{List} = [IP_0 \ \ IP_1 \ IP_2 \ . \ . \ . IP_{k(r-1)} \ \ ] \quad (19)$$

Where r is the real number of neighbors in the zone $r = N_i$
The count of this vector is *r* thus, *RNi* = *r*, where *r* is estimated number of real neighbors for a particular vehicle *Vi* in C zone. The vector *RNListi* and the value of *RNi* will be stored in the database of *Vi* and they should be updated periodically. Once the Camera C requests the information from the vehicle *Vi*, it only replies the value of *RNi* along with its location (*xi*,*yi*) and its IP address. The vector *RNListi* will not be sent to the Camera C. Instead, it will be stored in the database of the vehicle V_i for the future use (for video transmission if this node is selected as a rewarded vehicle).

4.3.1 Generalization of the Mathematical Model

Suppose that the first-rewarded vehicle is called V_0, which is rewarded by the Camera C among all vehicles located in the Camera zone. *V*0 should have a subroutine that can select the next rewarded vehicle among all vehicles in its zone (next zone), so that they should be located in the forward direction of the Camera.

Assumptions

All assumptions mentioned above for the Camera zone will be applied here in addition to the following:

1. The Camera is stable and has a GPS system to determine its location.
2. The zone that Camera can broadcast is 300m.
3. The vehicles in deferent speeds and every vehicle contains a GPS system and simple database to save the basic information that are x,y positions, speed, wireless system, and IP6 address.
4. Select a rewarded vehicle in every zone.
   To generalize the case; let us denote V_k as the rewarded vehicle where k=0,1,2⋯, $z - 1$, where z is number of reworded vehicles (no. of zones) V_0 is the first zone (C zone) where k=0 and so on.

4.3.2 Determining reward vehicle in next Zones

The reward V_k should select the next rewarded V_{k+1} based on the assumptions mentioned above.
The following steps will be applied to determine V_{k+1}:

1. V_{ki} sends request message, which is a specific packet to all vehicles in zone k. This packet includes V_{Ki} location (x,y), its IP address, and a request for each vehicle in the k zone to send some information that contains the following:
   - The vehicle location: (x_{ki}, y_{ki}) of V_i where i= 0,⋯, $m - 1$ and m is number of candidate vehicles in k zone.
   - *RNki* is number of real neighbors of V_{ki} based on our definition for real neighbors in the paper.
   - IP address of V_{ki}

2. V_k performs some calculations to select the next rewarded vehicle among all candidates in zone *k*.
   - V_k computes Euclidean distance, Δd_{ki}, *k* vector for all nodes (vehicles) in the zone *k*. This is performed as in Equation 20 :

$$\Delta dk_i = \sqrt{(x_k - x_i)^2 + (y_k - y_i)^2} \quad (20)$$

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The result is a distance vector Δd_{kij} shown in Equation 21.

$$\Delta d_{kij} = \begin{bmatrix} \sqrt{\Delta d_{ki0}} \\ \sqrt{\Delta d_{ki0}} \\ \sqrt{\Delta d_{ki0}} \\ . \\ . \\ . \\ \sqrt{\Delta d_{ki_{n-1}}} \end{bmatrix} = \begin{bmatrix} \sqrt{(d_{ki} - d_{k0})^2} \\ \sqrt{(d_{ki} - d_{k1})^2} \\ \sqrt{(d_{ki} - d_{k2})^2} \\ . \\ . \\ . \\ \sqrt{(d_{ki} - d_{k(n-1)})^2} \end{bmatrix} \quad (21)$$

where ΔX_{ki} the difference in x-axis between the vehicle k and vehicle i and Δy_{ki} is the difference in y-axis. The distance of the reward vehicle d_{ki} should be between $R_k/2$ and R.

i.e. $\frac{R_k}{2} \leq \Delta d_{ki} < R_k$ where i = 0,…,m

This means the rewards vehicle should not be closer to the vehicle K. As the vehicle is moving toward the vehicle k so that, we can maximize its lifetime in the zone k. It would be better if it is being in the second half of the zone to have enough time for communication with vehicle k before being much closed to the last rewarded vehicle or may succeed it.

- V_{ki} selects the rewarded vehicle based on the following: Rewarded V_{ki} is the vehicle that have Max(Ni) AND

$$\frac{R_k}{2} \leq \Delta d_{ki} < R \quad (23)$$

where i= 0,1,…,m.

3. V_k transmits the video to the rewarded vehicle V_{k+1} directly as between a source k (the forwarded vehicle) and distention D (the vehicle V_{k+1} using a routing protocol of VANET.

4. V_{k+1} transmits the video to a list of destinations (the real neighbors) using a routing protocol.

4.3.3 Real Neighbors Estimation in the next Zones

Let us estimate a number of real neighbors for a particular V_i located in k zone.
The real neighbor of V_k should be not far from the vehicle and have a relative speed between 0 and 0.5 with respect to V_{ki} speed. This means that V_{ki} neighbor has a distance $\Delta d_{ki\,j}$ to V_{ki}. Each vehicle V_{ki} in k zone should update the following calculations periodically (say every c second, which is determined up to the administration of the VANET).
V_{ki} first computes $\Delta d_{ki\,j}$ vector for all (vehicles) neighbors in its zone as shown in Equations 25 and 24.

$$\Delta d_{kij} = \sqrt{(x_{ki} - x_{kj})^2 + (y_{ki} - y_{kj})^2} \quad (24)$$

$$\Delta d_{kij} = \sqrt{\Delta x_{kij}^{\ 2} + \Delta y_{kij}^{\ 2}} \quad (25)$$

where Δx_{kij} is the difference between the awarded vehicle and all vehicles in its zone on x positions and Δy_{kij} is the difference between the awarded vehicle and all vehicles in its zone on y positions.
The result is a distance vector d_{kij} as shown in Equations 26 where j = 0,1,...,n. Here n is the number of all vehicles in the same zone and n is number of all neighbors in V_{ki} zone.

$$\Delta d_{kij} = \begin{bmatrix} \sqrt{\Delta d_{ki0}^{\ 2}} \\ \sqrt{\Delta\Delta d_{ki1}^{\ 2}} \\ \sqrt{\Delta d_{ki2}^{\ 2}} \\ . \\ . \\ . \\ \sqrt{\Delta d_{ki(m-1)}^{\ 2}} \end{bmatrix} = \begin{bmatrix} \sqrt{(d_{ki} - d_{k0})^2} \\ \sqrt{(d_{ki} - d_{k1})^2} \\ \sqrt{(d_{ki} - d_{k2})^2} \\ . \\ . \\ . \\ \sqrt{(d_{ki} - d_{m-1})^2} \end{bmatrix} \quad (26)$$

Then V_{ki} computes the relative speed for all neighbors in zone V_{ki} as shown in Equations 27 and 28.

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$$\Delta S_{kij} = \sqrt{(S_{ki} - S_{kj})^2} \quad (27)$$

$$\Delta S_{kij} = \sqrt{\Delta S_{kij}{}^2} \quad (28)$$

Where ΔS_{kij} relative speed between S_{ki} and S_{kj} and thus, the result is a speed vector ΔS_{kij} as shown in Equation 29.

$$\Delta S_{kij} = \begin{bmatrix} S_{ki0} \\ S_{ki1} \\ S_{ki2} \\ . \\ . \\ . \\ S_{ki_{n-1}} \end{bmatrix} = \begin{bmatrix} \sqrt{(S_{ki} - S_{k0})^2} \\ \sqrt{(S_{ki} - S_{k1})^2} \\ \sqrt{(S_{ki} - S_{k2})^2} \\ . \\ . \\ . \\ \sqrt{(S_{ki} - S_{k(n-1)})^2} \end{bmatrix} = \begin{bmatrix} \sqrt{\Delta S_{ki0}{}^2} \\ \sqrt{\Delta S_{ki1}{}^2} \\ \sqrt{\Delta S_{ki2}{}^2} \\ . \\ . \\ . \\ \sqrt{\Delta S_{ki(n-1)}} \end{bmatrix} \quad (29)$$

Where n is the number of neighbor's vehicles. Now, how to select the real neighbors from the distance vector $\delta d_{ki\,j}$ and speed vector S_{ki}. The Real Neighbors = RN_{ki}, and a real neighbor should have meet the conditions:

$$\Delta d_{kij} \leq \alpha * \frac{R_k}{2} \quad (30)$$

where R_k is the zone radios of a particular vehicle V_{ki} and $j = 0,...,n$ where n is the number of neighbors in the whole zone.
And:

$$\Delta S_{ki\,j} \leq \alpha S_i \quad (31)$$

This can be performed by applying a 1-D loop to the vector $\Delta d_{ki\,j}$ and $\Delta S_{ki\,j}$ using j counter from $j = 0$ to n. The result of the selection is a new vector called $RNList_{ki}$ as shown in Equation 32.

$$RN_{kir} = \quad [IP_{k0} \;\; IP_{k1} \, IP_{k1} \, . \, . \, . IP_{k(r-1)} \;\;] \quad (32)$$

where r is the real number of neighbors in the zone which is the count of the vector $RNList_{ki}$, $RN_{Ki} = r$, the real number of neighbors for a particular vehicle V_{ki} in zone k. The vector $RNList_{ki}$ and the value of RN_{ki} will be stored in the database of V_{ki} and they should be updated periodically. Once the rewarded vehicle request the information from the vehicle V_{ki}, it replies only the value of RN_{ki} along with its location (x_{ki},y_{ki}) and its IP address. The vector $RNList_{ki}$ will not be sent to the rewarded vehicle in zone k. Instead, it will be stored in the database of the vehicle V_{ki} for the future use (for video transmission if this node is selected as a rewarded vehicle).

Rewarded vehicle V_k sends request packet to ask the nodes in its zone to send the required information including the request packet contains IP_k address and its location (x_{ki},y_{ki}) and the location of rewarded vehicle (xk,yk) to filter the nodes in the opposite direction to the vehicle V_k as follows: V_{k+1} should be located in a location beyond V_{ki}. i.e.

$$(x_{k+1},y_{k+1}) > (x_k,x_k) \quad (33)$$

With respect to (x_c,y_c) , (the original coordinate)

$$(x_{k+1} - x_k \,,\, y_{k+1} - y_k) > (x_c - x_k,\, y_c - y_k) \quad (34)$$

i.e.

$$\Delta d_{k+1} > \Delta d_k \quad (35)$$

$$(x_c - x_{k+1})^2 + (y_c - y_{k+1})^2 > (x_c - x_k)^2 + (y_c - y_k)^2 \quad (36)$$

AND

$$x_{k+1} - x_k \geq 0 \quad (37)$$

AND

$$y_{k+1} - y_k \geq 0 \quad (38)$$

Reply packet contains:
-Location (X_{ki},y_{ki})
-IP address of V_{ki}

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-RN_{ki}, number of real neighbors
-Ack (+ve or -ve); 1 or 0 to indicate that the node V_{ki} already have the video or not. If the node is next rewarded by V_k and Ack = 1, the video will not be resent to it, else the video should be sent by V_k.

How to select the new reward vehicle V_{k+1}:
In addition to conditions mentioned above, calculate MAX(N_{ki}) which is the largest number of real neighbors among all candidates in zone k. Then, we should verify the condition is $\frac{R_k}{2} \leq \Delta d_{ki} < R_k$. The algorithm 1 describe the rewarded technique.

Algorithm 1: Rewarding Algorithm

```
begin
  Global Variables:
  IPList;
  RN;
  RNList;
  R_c;
  LocationofC;
  for k = 1 to number_of_zones do
    Update Zone Info. ;
    for i = 1 to number_of_vehicle_in_zone do
      Reply packet contains:
      Location (X_ki,y_ki);
      IP address of Vki;
      RN_ki; number of real neighbors;
      Ack (+ve or -ve); indicates that the node V_ki already has the video
      or not.
      Compute the Euclidean distance between V_k and V_i; for j = 1 to
      Number_of_all_Vi_neighbors do
        Compute the Euclidean distance between V_i and V_j;
        Compute the relative speed ΔS_ij for all vehicles in V_i coverage
        area;
        Compute list and number of real neighbors of V_i (RNList_i,RN_i);
    Compute Max(RN_i);
    Find the next rewarded V_k+1:
    If Ack = +ve
    Vk will not resent the video to Vk+1
    Else
    Vk will resend the video to Vk+1
    V_k sends data to V_k+1;
    V_k+1 sends data to its RNList;
```

5. MATHEMATICAL MODEL IMPLEMENTATION AND RESULTS STUDY

The proposed mathematical model has been implemented using MATLAB and the results will be introduced later to show the relationship between the average number of real neighbors and relative speed and distance of the neighbors in a zone.

Real neighbor for a candidate vehicle in a VANET is defined in this study as group of vehicles that are very close to rewarded vehicle in the zone. It is derived under the condition shown by Equation 6 in the mathematical model. It can be represented also by Equation 7 which have been derived in this study to determine the reward function, where α is related to relative distance, β is related to relative distance with respect to the candidate vehicle for rewarding, and k is constant (can be +ve or −ve). The rewarded vehicle is then determined by applying the function MAX(RN(i)) where i=0, 1, 2,⋯,n, and n is number of candidate vehicles for rewarding.

As shown by Equation 6, and because of the effect of the mobility, the number of real neighbors can be affected by relative speed and relative distance of the neighbors in a zone with respect to a particular candidate vehicle for rewarding. As shown earlier in this section, the mobility is a crucial parameter that dramatically affects the VANET performance in terms of routing overhead, throughput, and end-to-end delay. In this study, the researcher assumed that the mobility should be essentially affected by relative speed and relative distance of the neighbors. Thus, the neighbors could be not real for a while due to it might be shortly out of the coverage of the candidate vehicle. Therefore, the real neighbor should be in the zone for enough time so that it can receive the data (video) from the source (rewarded vehicle). In this study, the researcher has developed a mathematical model for number of real neighbor's derivation in a VANET zone. The rewarded vehicle is that has maximum number of real neighbors. The researcher assumed that sending video to only real neighbors (not all neighbors) will dramatically affects the performance of routing protocols in VANET. In this section, the researcher try to prove the assumptions regarding to the effect of number of real neighbors on VANET performance.

Assumptions

There are some assumptions that are very important to be in consideration for this work as the following:

1) The Camera is stable and has GPS system to determine its location.
2) The zone that Camera can broadcast is 300m.
3) The vehicles in different speeds and every vehicle con
tains GPS system and simple database to save the basic information that are x,y positions , speed, Wi-Fi system, and IP6 address.
4) Only one reward vehicle will be selected in every zone.

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Figure 11 shows that regardless the relative speed factor α, the average number of real neighbors for five candidate vehicles for rewarding (vehicles) in a VANET increases with an increase of the factor of coverage distance β (related to the zone radios). The worst case has been recorded at β = 100 which is 3.87 and the best case has been appeared at β = 300 which is 13.33 neighbors. However, the relative speed factor α has its own effect on the number of real neighbors in a VANET regardless the factor of coverage distance β. Figure 12 shows that average number of real neighbors for five candidate vehicles for rewarding which increases with an increase of relative speed factor α . The worst case has been remarked at α = 0.2 which is 7.32 while the best case has been remarked at α = 0.4 which is 12.36.

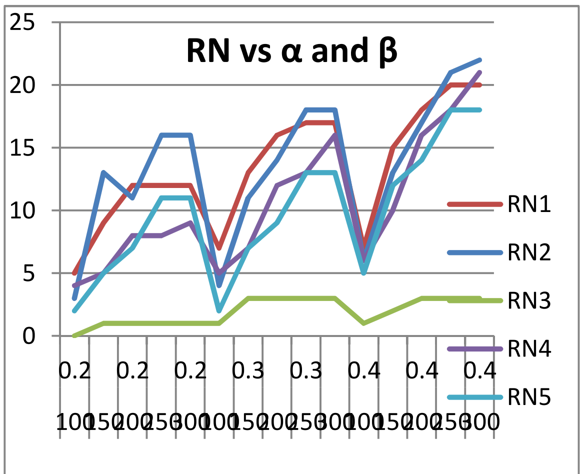

Fig. 11: RN against β

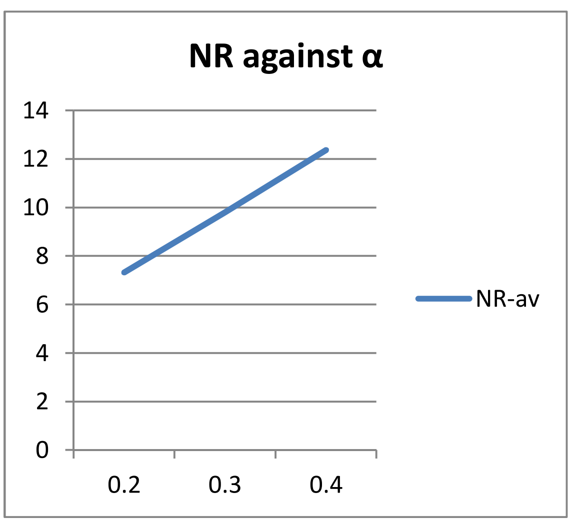

Fig. 12: RN-av against

On the other hand, increasing α and β do not make a sense for a VANET to decide which vehicle is a real neighbor to a particular candidate vehicle for rewarding. This is due to the far vehicles that move with high relative speed with respect to the candidate vehicle for rewarding can lead to high mobility in the zone so that the candidate vehicle for rewarding may lose the connection with such vehicles. Thus, there should be a compromise between the relative speed factor α and the distance factor β. Figure 13 shows the behavior of real number of neighbors against different scenarios of β and β work together as AND condition for a real neighbors. As shown by Figure 13, for all candidates vehicles for rewarding, the local minimum v alue almost occurred at distance 100 even though it slightly increases when the factor α increases. These occurred at points (0.2, 100), (0.3, 100), and (0.4, 100). This can be also noticed in Figure 11 and 12 for the average number of the real neighbors. On the other hand, the beak values (local maximum values) almost occurred at distance 300 even though it slightly increases when the factor α increases. These occurred at points (0.2, 300), (0.3, 300), and (0.4, 300). This can be also noticed in Figure 11 and 12 for the average number of the real neighbors. Absolutely, the worst case shown by Figure 13 has occurred with vehicle 3 which has very low speed (13). This can be justified by the large deviation of the speed of this node from the mean speed of all vehicles in the Camera zone (mean speed =63). We use two factor called δS and δd to reflect this deviation and consequently affect the value of number of real neighbors. As shown by Equation 3.1 Figure 6 shows the effect of δS on the number of real neighbors for five candidate vehicles for rewarding. RN decreases with an increase of δS. As shown by Figure 6, the worst case occurred at δS = 4.12 (node 3). On the other hand, Figure 17 shows the effect of δd on the number of real neighbors for five candidate vehicles for rewarding. RN decreases with an increase of δd. As shown by Figure 17, the worst case occurred at δd = 0.3789 (node 3). Finally, the average number of real neighbors against different scenarios of α and β work together as AND condition for Figure 18, which represents the average results of Figure 5.15, shows a real neighbor.

Journal of Theoretical and Applied Information Technology
31st January 2017. Vol.95. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

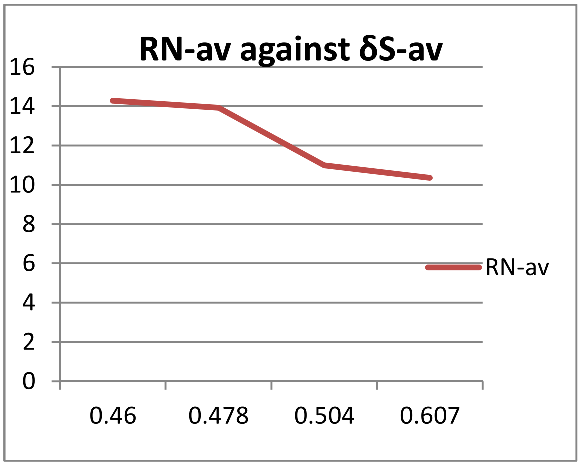

Fig 17: RN vs δS-av

Table 1 shows the rewarded vehicle for each scenario, which are signed as bold in table.

6. CONCLUSION

An analytical model has been conducted in this study within a framework applied to routing protocols in VANET. The model has been developed in mathematical approach to enhance video transmission over VANET with the concept of real neighbors, which is a novel contribution of this study. The research model maximize VANET lifetime and minimize end-to-end delay of the network. It has been implemented and evaluated, and results show good conclusion regarding the success of the idea of real neighbor that enhances critically the performance of routing protocol AODV for video transmission in VANET. The factors of relative speed and distance of vehicles within the transmission range of the rewarded vehicle have played a vital role in enhancing the performance in high mobility and dynamic topology environment. Moreover, a validation study has been executed prior to the design and implementation of the research model to examine theperformance of AODV, DSR, and OLSR routing protocols in VANETs against mobility and traffic to determine which protocol is more suitable to apply to research model. This is performed by analyzing their nature and behavior in different levels of mobility and traffic with respect to performance metrics such as routing traffic received, throughput, network load, and network delay. The existence comparisons between single path and multipath are not enough, so the researcher introduced a more holistic comparison. Theoretical evidences on the efficiency of multipath are provided in the critical analysis. However, the experimental testing of multipath protocols will be conducted in the next publication. Simulation results show that OLSR outperforms others in both network delay and throughput. OLSR has the lowest delay in all situations and levels of mobility and traffic, which is useful for limiting the capacity of the environment using data streaming. It is

B	*α*	*RN1*	*RN2*	*RN3*	*RN4*	*RN5*
100	0.2	**5**	3	0	4	2
150	0.2	9	**13**	1	5	5
200	0.2	**12**	11	1	8	7
250	0.2	12	**16**	1	8	11
300	0.2	12	**16**	1	9	11
100	0.3	**7**	4	1	5	2
150	0.3	**13**	11	3	7	7
200	0.3	**16**	14	3	12	9
250	0.3	17	**18**	3	13	13
300	0.3	17	**18**	3	16	13
100	0.4	**7**	6	1	6	5
150	0.4	**15**	13	2	10	12
200	0.4	**18**	17	3	16	14
250	0.4	20	**21**	3	18	18
300	0.4	20	**22**	3	21	18

Table 1: Rewarded Vehicles

found that in OLSR, routing traffic received a constant value during the entire time of simulation and in all cases. The study of these routing protocols demonstrates that the OLSR is better in VANETs based on our simulation results in high mobility and high density, but it is not always necessary that it outperform AODV in terms of delay in medium and high mobility. Even though OLSR has better performance, the researcher

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

selected AODV for applying proposed model because OLSR has high change in the neighbors, which is not suitable for this study.

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