Latency-Aware Load Distribution Model for Vehicular Adhoc Networks (VANETS)

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Abstract:- Vehicular Adhoc Network (VANET) is a network which prominent and fluid features have helped in drawing contiguous attention by researchers for more than thirty years. More often than none, routing and securing the network are of utmost priority to researchers while little focus is given to ensuring the effective distribution of load in Vehicular communications in order to ensure an infinitesimal experience of latency. However, with the advent of Intelligent Transport System (ITS) in pair with the possibility of cloud and Internet of Things (IoT) in VANET that support a mickle spectrum of mobile distributed software, there is need for a system that will evenly distribute load in the network. This study thereby introduces a latency-aware model via a 3-tier load distribution mechanism that reduces delay in message transmission and also helps in addressing traffic congestion faster.

Keywords:- *Load distribution; Latency; Latency-aware; RSUs; network; VANET; ITS.*

I. INTRODUCTION

Vehicular Adhoc Network (VANET) belongs to the “child-class” of Mobile Ad hoc Networks (MANETs). MANET is a type of Adhoc network that has a dynamic topology. Its topology is set up on a fly. A VANET is however a high speed and fluid topology MANET that is configured in vehicular terrains with infrastructures and roadside implements linked uniquely. Vehicular communications today still uses the IEEE standard of 802.11p for wireless admission in vehicular terrains as amended. This standard explore 5.9 Ghz or more licensed ITS bandwidth for communication between vehicles, infrastructure and road side units [1], [2], [3]. Due to the importance of safety and security of human parties involved in vehicular communications, VANET avail information about accidents or uncertainty conditions and traffic data to VANET users. Individual vehicles represent a node in VANET terrain and it is arrayed with VANET peripherals. These moving vehicles configure an Adhoc network at an instant in order for them to receive and disseminate all obligatory messages through the Wireless Access Point (WAP).

However, providing QoS in Adhoc network therefore became a necessity to maintain best-effort-of service [4]. In Adhoc networks, the peer-to-peer channel quality may alter rapidly. So, the link quality may affect the peer-to-peer QoS metrics in the multi-hop path [5]. There is therefore a pressing need to keep up to date the QoS metrics (latency in particular) of the system and maintain a secured communication network via a robust authentication. This research work is much more concern about load distribution in VANETs. Load distribution or balancing is best described as a process of dividing and distributing jobs among more than one server, more jobs can be served accordingly and the entire system would perform more efficiently according to Camellia and Hamid in [6]. The main aim of load distribution is to reduce execution time of the load and to ascertain that all resources present in the system are utilized optimally. Magade in [7], noted that load distribution involves load unit migration from one processing element to another when load is light on some processing element and heavy on other processing element. This work thereby considers developing a latency-aware model for load distribution in this regards.

II. REVIEW OF RELATED WORKS

In their work “Co-operative Load Balancing in Multiple Road Side Units (RSUs)-based Vehicular Ad Hoc Networks”, [8], developed a model using DSIN (Deadline Size Inverse Number on pending request) algorithm as a scheduler. DSIN calculates the DSIN_Value of all the received requests and chooses one which has the lowest DSIN_Value. Also in [9], a substantial result was achieved by the combination of the Wireless Mesh Network (WMN) and the Adhoc network. With the use of point information, congestion monitoring and routing switch, a geographic load balancing routing in hybrid VANETs, namely GLRV was designed. GLRV was designed using the mesh routers which were deployed to provide backbone supports. Data packets are transmitted in the form of forwarding set to provide multiple forwarding candidates. Although simulation results show that GLRV can reduce the transmission latency and increase network delivery ratio in hybrid VANET architecture yet it lacks the tracking of dropped packets in highly congested highway.

In [10], “Performance of new Load Balancing protocol for VANET using AODV (LBV_AODV)” was presented. A new protocol which happens to be an extension of conventional AODV – Adhoc on demand distance vector routing was defined and updated according to VANET parameters. The protocol was modeled using Ns2.34 and the performance analysis shows that the new protocol is preferred to AODV in terms of Packet Delivery Ratio. “A Cluster–on–Demand Algorithm with Load Balancing for VANET” was presented in [11] where urban vehicles were featured by unpredictable moving direction. These challenges were initially solved with the Lowest ID (LID) and Mobility based on clustering (MOBIC) algorithm which does not address the issue of completeness, contradictory packet delivery and end to end delay.

III. LATENCY–AWARE LOAD DISTRIBUTION CONSTRUCTION

It is important to note that a vehicle can only generate requests within time range. That is, the network life time of a request between an RSU and a vehicle is defined by the radius of the transmission range between them. Consider an RSU's transmission range measured in meters and an average speed measurement of a vehicle (measured in velocity meter per seconds) such that the vehicle reaches the transmission range of an RSU at a given initial time, and generates the first request at the same time, then the average deadline of the first request of the vehicle is the rate at which the transmission range is measured over the velocity of the vehicle. However, there's a limit to the number of connection and bandwidth the RSU can handle for an Internet Service Provider (ISP). Therefore, when the number of VANET users trying to connect to the internet or access information via a RSU is surplus, then, there is need for fairness in the sharing of resources in the RSU.

In this work, a standard 3-teir architecture pattern is adopted for the purpose of modularity and scalability. In order to check for unsuccessful Admission Controllers (AC) in a VANET cloud site, an Entry Point (EP) is set up with a time period specification. Once the responses from the AC are positive, the EP selects the most qualified VANET cloud site, for data transfer; that is, the one which offers the lowest network latency. Thus, a utility which asses and calculate the network latency between the VANET end-user and a VANET cloud site is designed. The model is designed in such a way that a Road Side Unit (RSU) would store and share periodic information with vehicles in the VANET cloud site and another RSU and all vehicles connected to it in a geospatial space via the internet. Two approaches are considered in this regards. First, with the aid of the database, the exact point and coordinate (longitude and latitude) of each IP addresses are ascertain. Secondly, once the coordinates are determined, to constantly update the records of network constituents such as round trip time, network life time among hundreds of vehicles and more, an Internet Performance Monitoring Service (IEPM) is adopted. The points (longitude and latitude) of each vehicular node are provided as well.

Vincenty's formula is used in computing the distance between any two geospatial coordinate for the RSUs. To calculate the latency between the coordinates (IP addresses), whose positions have already been resolved; this research uses the network latencies between any three geometrically closest pairs of vehicular nodes. For each pair of vector nodes (n_{i1}, n_{i2}), distance to the points of the target pair of IP addresses (t_1, t_2) *is given* as:

$$distance(d_i = \min\{v(n_{i1}, t1) + v(n_{i2}, t2), v(n_{i1}, t2) + v(n_{i2}, t1)\} \quad (1)$$

where v is the well-known "Vincenty's function" for computing the distance between two geographical points specified by their coordinates.

A three (3) pairs of vector nodes (n_{11}, n_{12}), (n_{21}, n_{22}), (n_{31}, n_{32}), which minimizes the *distance* function for the targeted t_1 and t_2 are selected. Hence, the Internet latency between t_1 and t_2 is approximated as the following weighted sum:

$$\text{Latency } (t_1, t_2) = \frac{\sum_{i}^{n} \left(\frac{d_{min} \cdot l_i}{d_i} \right)}{\sum_{i}^{n} \left(\frac{d_{min}}{d_i} \right)} \quad (2)$$

where d_i is the *distance* $(n_{i1}, n_{i2}, t_1, t_2)$, $d_{\min}$ is the smallest distance among d_1, d_2, d_3 and l_i is the Ping latency between n_{i1} and n_{i2}. In Eq. (2), a weighted sum of the network latencies between the three geometrically closest pairs of nodes is fundamentally specified. The weights are defined proportionally to each pair of vector's nodes combined with distance to the target locations.

Conclusively, to improve the performance of the network latency estimation, this work store and update in-memory, least-recently-used (LRU) caches of: the network link between IP addresses and their coordinates, the distances between geospatial points and the already resolved latencies. With these, the system addresses traffic congestion faster and could predict available routes for moving vehicles. This work again adopts a method of sending messages time or size smaller to the conventional VANET. It checks more important messages, let them go once. It also stops repetition of messages in order for it not to choke the band width.

A. Load Distribution Algorithm

```
START
Step 1:  for all discovered nodes Nij (shortest path);
         if (Nij>= L); where  L = Latency
                 ADD Nij to the qualified list, List [ ]
                 of paths, for data transfer in RSU(
                 using LRU queue mechanism);
Step 2:  else if RSU (AC buffer full){
                 redirect;
Step 3:  else if (path failed)
         assign failed data chunk as new message;
         Goto Step 1 five times;
Step 4:  else
         Exit (1)
                 }
END
```

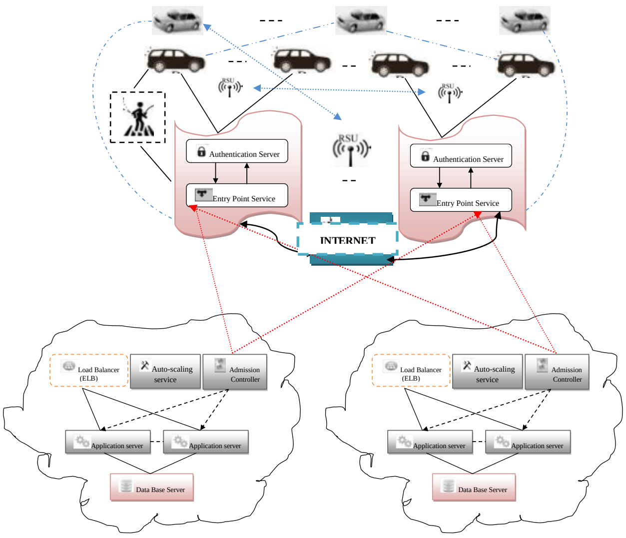


Fig. 1: System Architecture

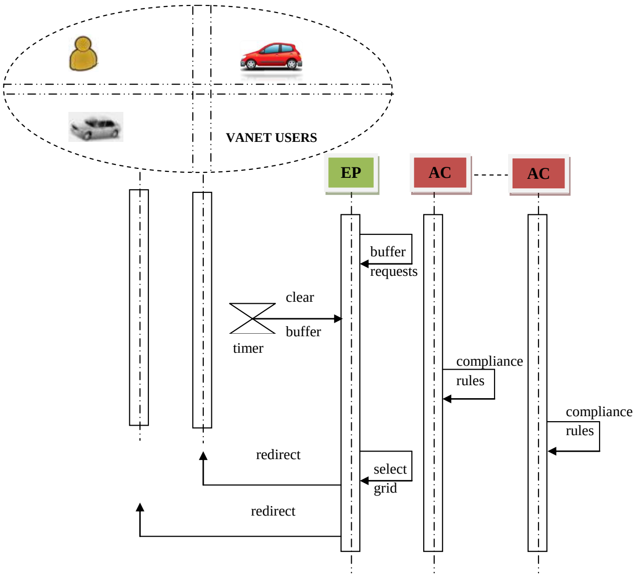


Fig. 2: System Sequence Diagram

The Entry Point (EP) redirects users (Vehicle, Infrastructure or human agent) among a set of cluster locations. So, within each target clustered or VANET cloud site there is an additional Admission Controller (AC) component adopted for the sole purpose of redirection. There may be more than one EP in a cluster but definitely, there are several admission controllers in the site. Thus, the EP interacts with the AC in order to determine the suitability of the respective VANET cloud sites and then redirect the users accordingly. The redirection is made easy since an RSU is servicing one or two VANET cloud site. When a VANET user arrives at the site, the VANET user is authenticated so that regulatory requirements can be upheld. Authentication is application specific according to the application developer involved. A custom username and password implementation is adopted here. A unique user identifier is passed to the EP once the authentication is complete.

B. *Simulation Technique*

Each component of the analyzed system is structured in programmable codes for scalability and modularity objectives. Each program module is also subjected to testing in isolation to ensure that the program is bug free. The system developed is simulated using MATLAB and the performance is evaluated by comparing it with an existing conventional VANET that uses a reactive protocol known as Adhoc on Demand Distant Vector (AODV).

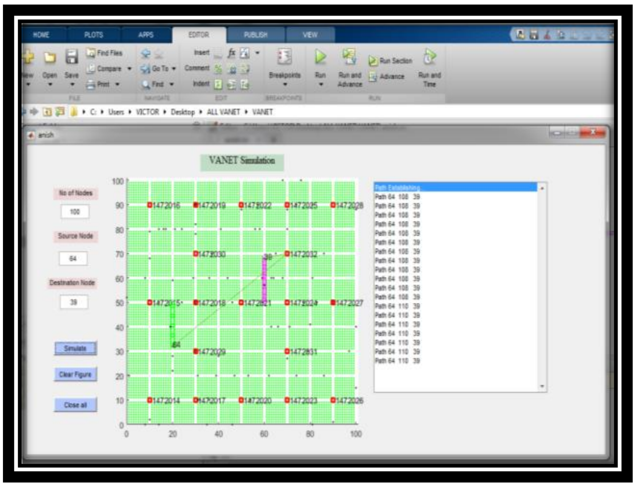


Fig. 3: Simulation Initial State

The black dotted line in Fig. 3 represents the moving and dynamic VANET users. The reddish square boxes modeled the RSUs and their IDs. The IDs are linked on a long range with one another via the internet. The city size is 100, the source node is 64 and it's trying to relay message to its destination node, 39. At the right hand side of the GUI are the paths the nodes are establishing for smooth communication between them.

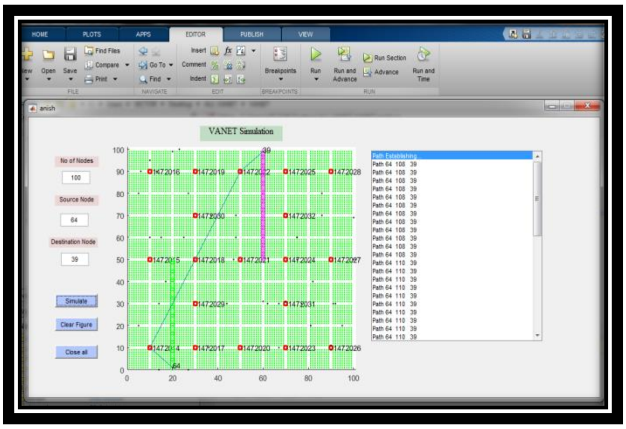
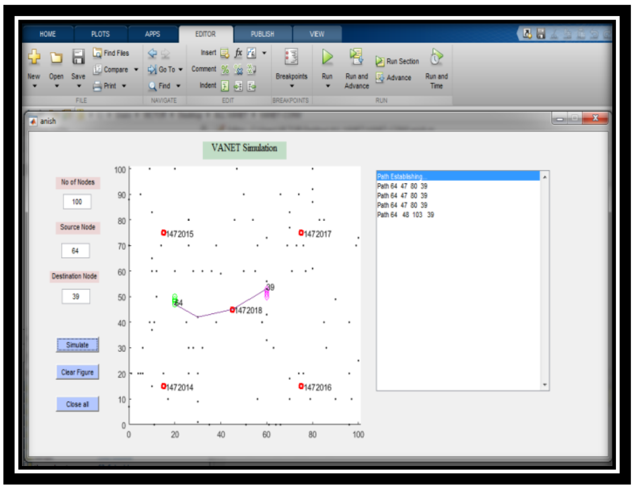


Fig. 4: Simulation approaching tail end

As the simulation approaches finish in Fig. 4, it is deduced that more paths were created due to the fact that the RSUs are connected in long range and were also positioned to man a cluster grid compared to the conventional VANET. Fig. 5 and Fig. 6 show the outcome of a conventional VANET during simulation.

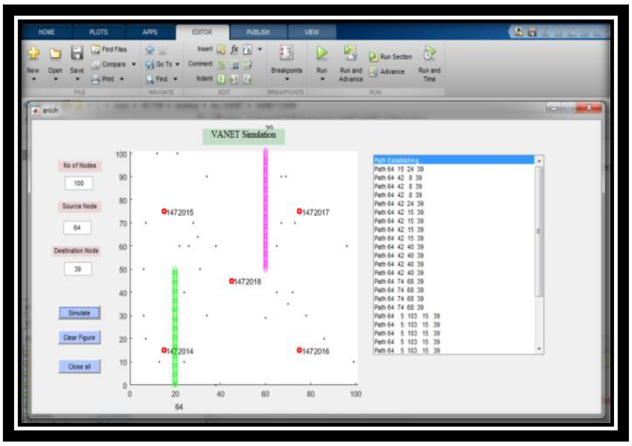


No of Nodes
100
Source Node
64
Destination Node
39

```
Path Establishing...
Path 64  47  80  39
Path 64  47  80  39
Path 64  47  80  39
Path 64   48  103   39
```

Fig. 5: Simulation of the Conventional VANET at the Initial Stage

RSUs were not linked with one another and were not in grid. So, the nodes try to establish a longer path which eventually increases latency.

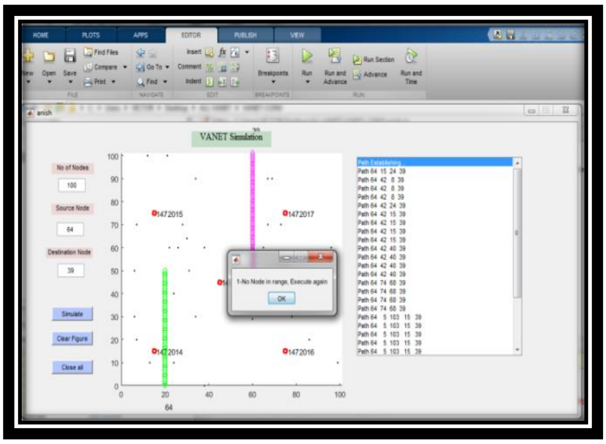


No of Nodes
100
Source Node
64
Destination Node
39

```
Path Establishing...
Path 64  15  24  39
Path 64  42   8  39
Path 64  42   8  39
Path 64  42   8  39
Path 64  42  24  39
Path 64  42  15  39
Path 64  42  15  39
Path 64  42  15  39
Path 64  42  15  39
Path 64  42  40  39
Path 64  42  40  39
Path 64  42  40  39
Path 64  42  40  39
Path 64  74  68  39
Path 64  74  68  39
Path 64  74  68  39
Path 64  74  68  39
Path 64    5  103   15   39
Path 64    5  103   15   39
Path 64    5  103   15   39
Path 64    5  103   15   39
Path 64    5  103   15   39
```

Fig. 6: Simulation approaching tail end in Conventional VANET

Longer paths are established just to service the message been sent. It got to a juncture that the source node and the destination node were far apart and could not communicate any longer; thus, it gave the error message “No Node in range” as shown in Fig 7.



No of Nodes
100
Source Node
64
Destination Node
39

1-No Node in range, Execute again

```
Path Establishing...
Path 64  15  24  39
Path 64  42   8  39
Path 64  42   8  39
Path 64  42   8  39
Path 64  42  24  39
Path 64  42  15  39
Path 64  42  15  39
Path 64  42  15  39
Path 64  42  15  39
Path 64  42  40  39
Path 64  42  40  39
Path 64  42  40  39
Path 64  42  40  39
Path 64  74  68  39
Path 64  74  68  39
Path 64  74  68  39
Path 64  74  68  39
Path 64    5  103   15   39
Path 64    5  103   15   39
Path 64    5  103   15   39
Path 64    5  103   15   39
Path 64    5  103   15   39
```

Fig. 7: Simulation Outcome when there’s no node in range.

C. Results

The results are displayed in pairs below. All figures ‘a’ are the result for the newly developed system while all figure ‘b’ are the results for the Conventional VANET

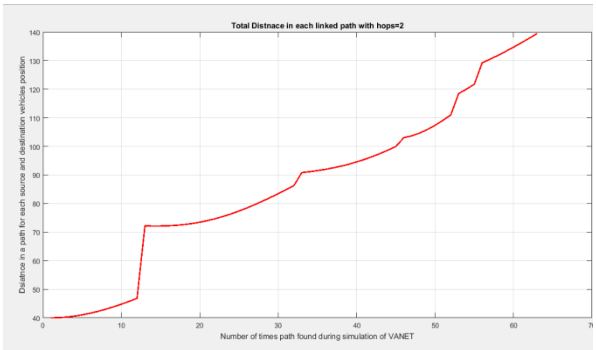


Fig. 8(a): Longer distance covered

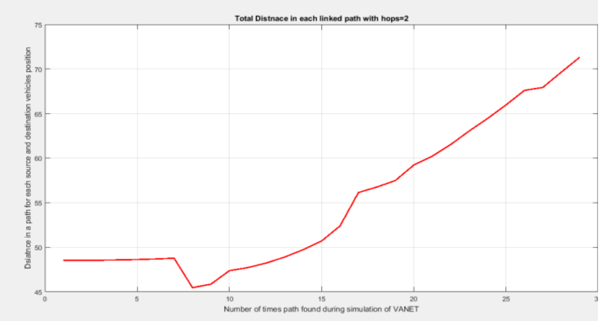


Fig. 8(b): Shorter distance covered

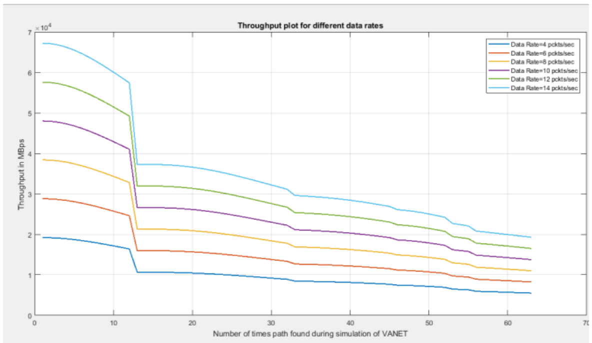


Fig. 9(a): Higher Throughput

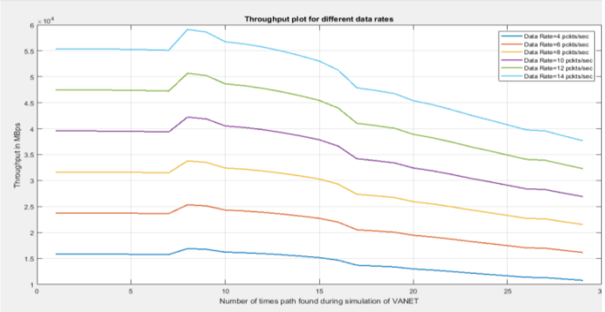


Fig. 9(b): Lower Throughput

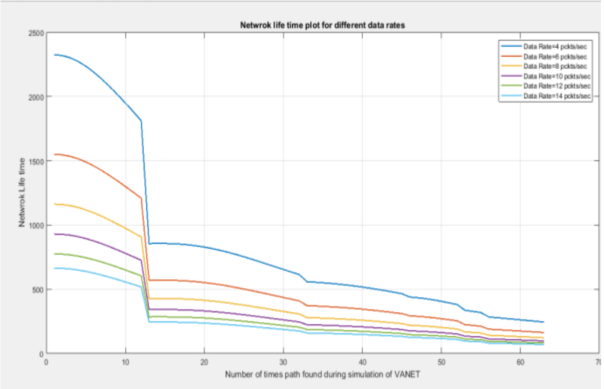


Fig. 10(a): Extended Network Life Time

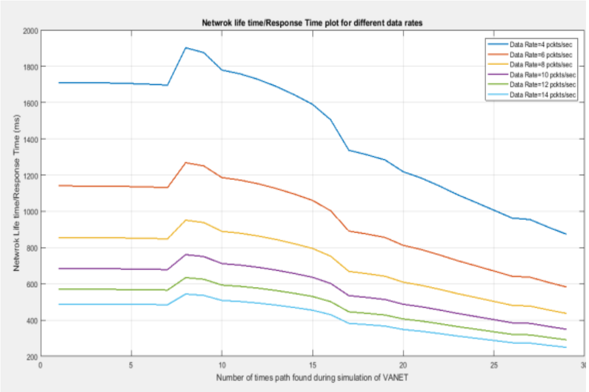


Fig. 10(b) Lower Network life Time

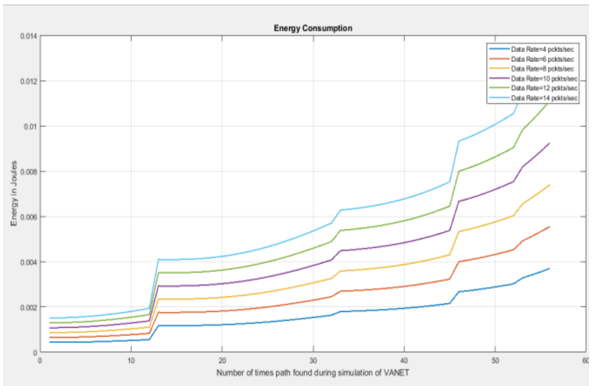


Fig. 11(a) More Energy Consumed

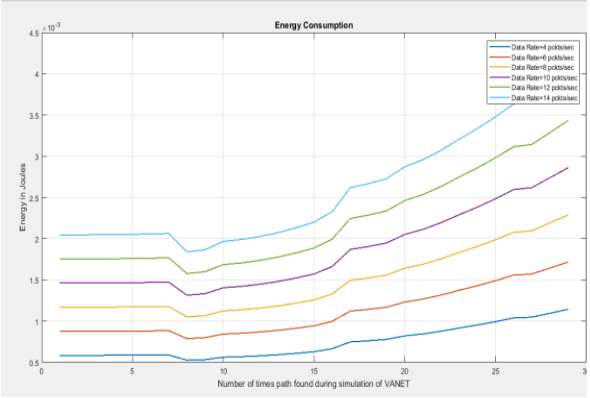


Fig. 11(b) Lower Energy Consumed

IV. CONCLUSION

Primitive presumption by existing research note that vehicles would only interact with each other, but with the advent of internet of things (IoT), vehicular interaction with surrounding devices became a demand. Furthermore, ITSs support multiple communication interfaces: vehicle to vehicle, vehicle to infrastructure and vehicle to cloud (internet), hence, this system is recommended to be of help to these emerging technologies in VANET for proper distribution of loads in order to reduce latency to the minimum.

However, this work has presented a latency-aware model for load distribution in vehicular Adhoc networks. It takes advantage of the road network configuration, the communication medium and mechanism, and the exiting scheduling technique in VANETs to ensure that loads are distributed evenly such that latency is reduced. To improve interaction between vehicles and surrounding devices, the system maps two or more RSUs together via the internet such that each RSU services a VANET cloud site by receiving, storing and transferring messages from source to target. It ensures that when a clustered site is full for request admission, it redirects it to another unit for servicing. The performance result of the system shows that the total distance covered in each linked path increased optimally, the system has higher throughput and was able to maintain a longer network life time. With information being fed into the entry points, more sophisticated polices could be implemented in the future. The information could be explored to predict available route for VANET end-users. Also, with SIM cards being linked with the National Identification Number, the system can be used in addressing vehicular theft by linking the identification number of the vehicles with the owners.

V. ACKNOWLEDGMENT

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