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Persuasive GW and ENB Selection Algorithm for 4G-VMesh Network

[1]P. Dharanyadevi and [2]K. Venkatalakshmi

[1]*Research Scholar, Information and Communication Engineering, Anna University, Chennai, India.*
[2]*Assistant Professor, Electronics and Communication Engineering, Anna University Tindivanam Campus, Tindivanam , India.*

Address For Correspondence:
P. Dharanyadevi, Information and Communication Engineering, Anna University, Chennai, India.
E-mail: dharanyadevi@gmail.com

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ABSTRACT

Background: This paper proposes an assorted architecture which integrates the 4G LTE-A technologies and VMesh network. The integration of 4G LTE-A and VMesh network assures the services with higher speed and higher data rates than the 3G-VMesh network.

INTRODUCTION

Vehicular Mesh (VMesh) amalgamates the features of vehicular and mesh network (Dharanyadevi 2014, 2015, 2016). LTE-A base station is dubbed as Evolved Node B (eNB). The capacity of the eNB is limited, if several vehicles directly commune with the eNB, it consequences in a bottleneck at the eNB. To overcome the bottleneck, this paper proposes a Gateway and Evolved Node B Selection Algorithm (GESA). GESA finds the finest gateway and eNB to route the request from source to destination. This paper solves the trade-off between collision, delay and delivery ratio, while using the 4G technology in VMesh network.

4G-VMesh Network Architecture:

As illustrated in Figure 1, 4G-VMesh network is an assorted network, which consists of IEEE 802.11p based vehicle and Evolved Packet Core (EPC) network components. Each vehicle in the 4G-VMesh network can function as an Ingress Vehicle (IV), Neighbor Vehicle (NV) and Gateway (GW). IV is the vehicle which sends the request. NV is the vehicles which are within the coverage area of IV. GW functions as an entry to another network. The EPC network components are Mobility Management Entity (MME), Packet Data Network GW (PDNG), Policy Charging and Rules Function (PCRF) and Serving GW (SG) (Dharanyadevi 2016). MME offers the control plane function for mobility between existing access network (2G/3G) and LTE-A. PCRF supports the policy control traffic and dynamic mobility management. PDNG supports the bearer or network traffic. SG is designed for transmitting and receiving packet between EPC and a vehicle (Amitava 2010, Ghassan 2012).

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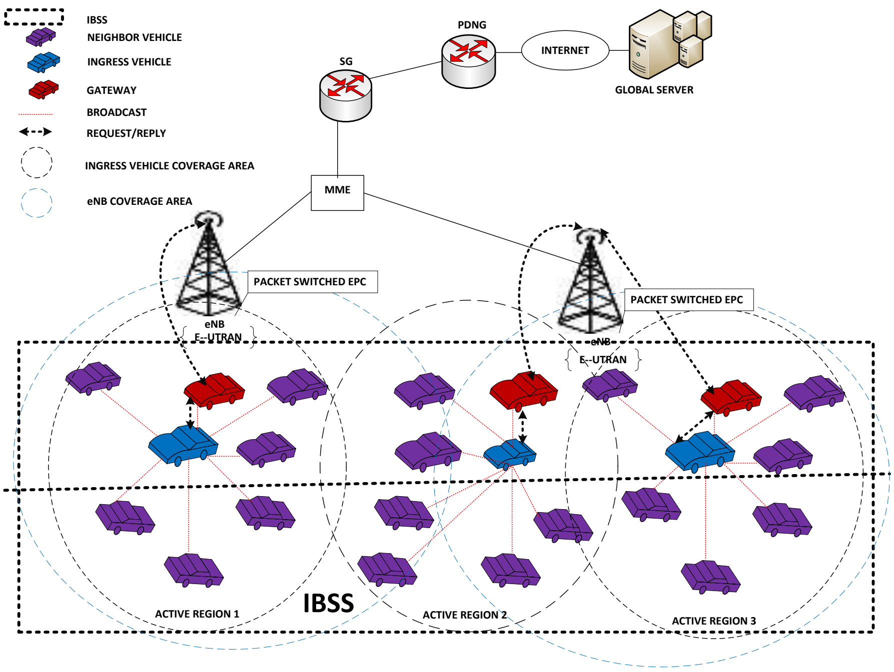

Fig. 1: 4G-VMesh network architecture

GW selection:

IV gets its co-ordinates and acquires beacon from its neighbor vehicles (NV). Each neighbor vehicle transmits its Vehicle ID (VID), LTE-A Received Signal Strength (LRSS) and co-ordinates. Then IV calculates the $fv(GS_n)$ for each NV, as given in Equation (4.1).

$$fv(GS_n) = \frac{LSQ_n}{D_{i,v_n}} \qquad \forall n, n = 1,2,3,\ldots, g \tag{4.1}$$

where,

$$LSQ_n = 2 * (LRSS_n + 100) \tag{4.2}$$

$$D_{i,v_n} = \sqrt{(w_2 - w_1)^2 + (x_2 - x_1)^2} \tag{4.3}$$

'Fv(GSn)' is the GW Selection (GS) mechanisms Fitness Value (FV) of the n^{th} NV, '*LSQ*' denotes the LTE Signal Quality, 'D_{i,v_n}' is the distance from IV to n^{th} NV, '(w_1,x_1)' are the co-ordinates of the IV, '(w_2,x_2)' are the co-ordinates of n^{th} NV and 'g' is the maximum number of NV's. The request packet from IV is forwarded to the optimal GW. The optimal GW is the NV that has the highest FV among all NV.

ENB selection:

GW gets its co-ordinates and acquires beacon from its neighbor eNB which encompass of ENB ID, buffer intensity (free space in the buffer) and co-ordinates of eNB and calculates '$fv(eNBS_h)$', as given in Equation (4.4).

$$fv(eNBS_h) = \frac{Bin_h}{D_{g,e_h}} \qquad \forall h, h = 1,2,3,\ldots, a \tag{4.4}$$

where,

$$D_{g,e_h} = \sqrt{(p_2 - p_1)^2 + (q_2 - q_1)^2} \tag{4.5}$$

'$fv(eNBS_h)$' is the FV for eNB selection of the h^{th} eNB, 'Bin' denotes the buffer intensity, 'D_{g,e_h}' is the distance from GW to h^{th} eNB, 'a' denotes the maximum number of eNB's, '(p_1,q_1)' are the co-ordinates of the GW and '(p_2,q_2)' are the co-ordinates of the h^{th} eNB. The request packet from GW is forwarded to the optimal eNB. The optimal eNB (OeNB) is the eNB that has the highest FV among all eNB.

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Algorithm 2: 4G-GESA

// GW SELECTION//

1: IV gets its co-ordinates and sends the beacon message to each NV.
2: Each NV transmits its vehicle ID, co-ordinates and LTE-A RSS.
3: For each NV, the IV calculates LTE signal quality, distance between IV and NV and FV of the GW selection as given in Equation 4.2, 4.3 and 4.1.
4: From the FV of GW selection mechanism, the NV which has highest FV is chosen as the optimal GW.
5: IV transmits the service request to the optimal GW.
6: The GW turns on its 4G interfaces (E-UTRAN) to facilitate the communication with the LTE-A eNB.

//ENB SELECTION//

1: GW gets its co-ordinates and scans for the eNB.
2: If there is only one eNB then
3: GW sends the request to the eNB.
4: Else if, there are two or more eNB 's
5: GW will broadcast the beacons to each neighbor eNB.
6: Each eNB transmits its ENB ID, buffer intensity and co-ordinates.
7: For each eNB, the GW calculates the distance and FV of the eNB selection as given in Equation 4.5 and 4.4.
8: From the FV of eNB selection mechanism, the eNB, which has highest FV is picked as the OeNB.
9: GW forwards the request to the OeNB.
10: From OeNB, the request is forwarded to the EPC components.
11: The global server processes the request and sends the response.

Simulation Setup:

To support the LTE files, 4G-GESA and existing mechanisms are implemented using network simulator ns-allinone-2.33 in Ubuntu. The performance of the proposed (4G-GESA) and existing (4G-CVMT, 4G-FQGwS) are assessed in terms of Average Response Time (ART), Packet Delivery Ratio (PDR), Packet Collision Ratio (PCR) and Routing Overhead Ratio (ROR).

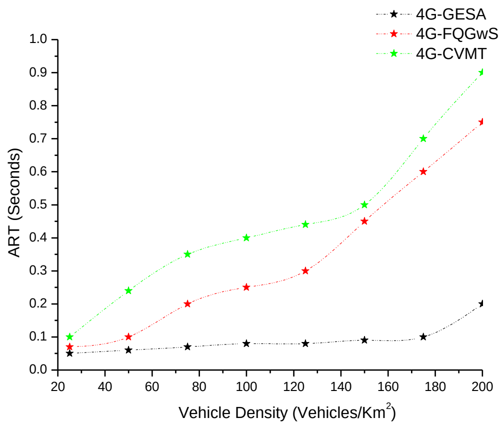

Fig. 2: VD on ART

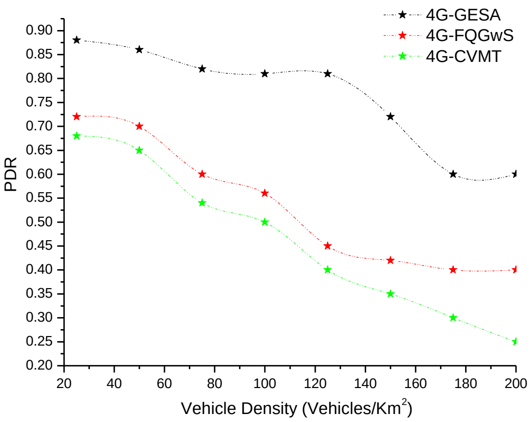

Fig. 3: VD on PDR

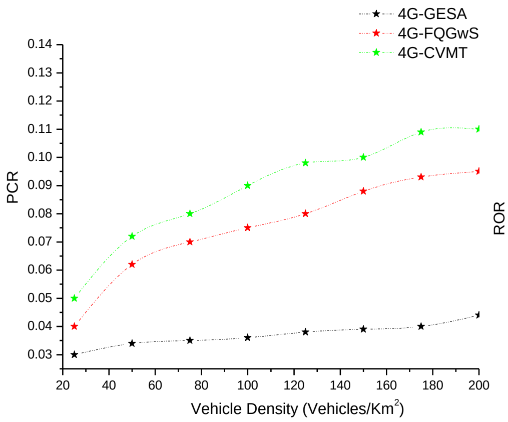

Fig. 4: VD on PCR

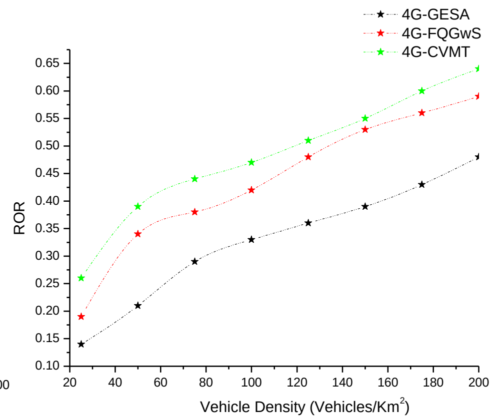

Fig. 5: VD on ROR

Figure 2 illustrates that once the vehicle density (VD) raises, the ART of the existing and proposed mechanisms also increases. In 4G-FQWS and 4G-CVMT, the selection of cluster head and GW are complicated, thus leads to service delay in the routing process. In proposed mechanism, the selection of GW and eNB are self-governing and it consumes lesser time for communications. Thus the proposed mechanism of ART outperforms the existing mechanisms ART. Figure 3 illustrates VD on PDR. In proposed mechanism, owing to the minimization the bottleneck and network traffic at the eNB, the PDR of 4G-GESA outperforms the existing mechanisms.

Figure 4 illustrated that when the VD increases, the PCR of the proposed and existing mechanisms also increases. Increase in VD consequences in more retransmission, packet loss and collisions. 4G-GESA minimizes the collision and network traffic by the eNB selection mechanism. Hence the proposed mechanism collision is less when compared to the existing mechanisms. Figure 5 illustrates that when the VD increases, the ROR of the 4G-GESA, 4G-CVMT and 4G-FQGwS also increases. The GW discovery mechanism used in 4G-CVMT and 4G-FQGwS creates confusions in the routing process, which consequences in routing overhead. In order to minimize the confusions in the routing discovery process, the optimal GW and eNB are picked independently and reserved ahead before transmitting the packet. Thus the proposed mechanism ROR is less when compared to the existing mechanisms.

Conclusion:

This paper proposes Gateway and Evolved Node B Selection Algorithm (GESA) for 4G-VMesh network. From the performance metrics it is justified that this work outperforms the existing mechanisms in term of ART, PDR, PCR and ROR. In future, the GESA can be applied in the 5G-VANET system which may offer a continuous Internet connection for the international travelers.

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