Comparative Study of Cluster Head Selection Techniques in VANET under traffic conditions

Manoj Sindhwani*, Dr. Charanjeet Singh
School of Electronics and Electrical Engineering,
Lovely Professional University, Punjab

Abstract- *Among the various technologies that are constructing its pillars deep in the field of engineering, there come the ad-hoc networks. The ad- hoc network can be mobile and wireless network. The devices in ad-hoc networks have connection without any central co-coordinator. Ad-hoc networks are divided into two types' i.e. Mobile ad-hoc networks and Vehicular ad-hoc networks.VANET is the most popular network now days. To increase the efficiency of VANET the work is majorly stressed upon clustering techniques in VANET, as clustering technique ensures higher mobility and stability. Also, the clustering uncomplicated the issues of vehicular nodes by selecting the fittest Cluster Head on the bases of various parameters such as mobility metrics, relative velocity, relative distance or cluster member lifetime etc. Dynamic clustering scheme is stressed upon providing the stability to the VANET network as it possess dynamic topology hence requiring stabilization and longer cluster head lifespan. VANETs present a largest real time application but lacks security, scalability, efficient routing and clustering protocols. The significant aim of the study to stress upon the clustering and to compare the efficient technique out of existing and proposed technique.*

1. INTRODUCTION:

Vehicular ad-hoc networks (VANET) is the sub-class of Mobile ad-hoc networks (MANET), VANET can be considered as nodes on wheels, In this network the node have the capability to communicate with other node directly or indirectly. The main purpose behind the popularity of VANET is the safety and security of the vehicles and drivers as the vehicles speed is increasing day by day with advance technologies and smooth roads.

Two types of communication are possible which are vehicle to vehicle and vehicle to infrastructure type of communication. Due to the decentralized type of network security, quality of service and routing is the major issues in the network. In vehicle to vehicle type of communication, vehicles exchange information with each other. For the efficient communication between vehicles, various routing protocols have been proposed in recent times. In the research, the highest degree algorithm is designed for the selection of Cluster Head (CH) under MAC protocol and compared the cluster head selection procedure of prediction based algorithm. The comparison parameters are: Delay, Packet Delivery Ratio (PDR), Jitter, Throughput and Packet loss.

1.1. Architecture and Characteristics of VANET

VANET creates a self-organizing wireless network using its mobile nodes, there also exists a full fledge architecture including other units as RSU, OBU, AU. VANET is a prime component of Intelligent Transport Network which aims at improving the traffic efficiency so as to provide a better safety on road. VANET possess a dynamic topology where occurs frequent connections and disconnections of the vehicular nodes. The architecture of the VANET is shown in fig 1.1.

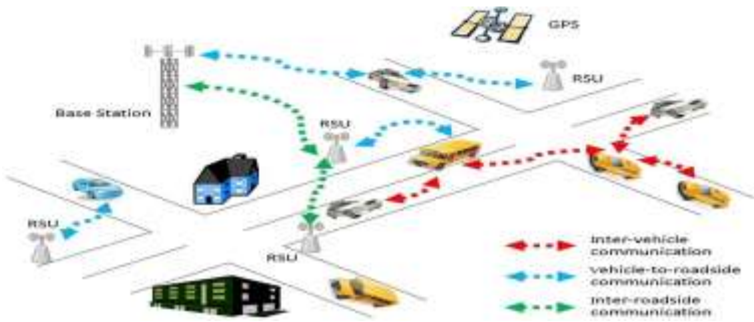


Fig 1 Vanet Architecture

1.1.1. Characteristics of VANET

- **Unlimited transmission power:** Power dissipation is the major issue in the wireless ad-hoc network devices but in VANET the vehicles have sufficient amount of battery power which helps in the communication over the network.
- **High capacity:** The devices which are present in the vehicles for communication purposes have a high capacity to react in the network. The intelligent network operates in high scalable and mobile network with excellent sensing, computing and maintaining capacity [14].
- **Division of the network**: The network under VANET is frequently divided into subgroups for better communication purpose. The cluster formation under the network is an example of the division using location based scenario where the network is divided into small cluster nodes with cluster head as a communication node [16].
- **Topology change and connection setup**: VANET topology changes from one region to another region very frequently. When the vehicle moves and changes their position constantly in the dynamic scenario, the topology of the network is changed from one position to another, as a result, the chances of continuous connectivity reduces. But many researchers designed the protocols which explain the solution of the problem and prove that the dynamic change can be maintained under the topology change. The connectivity is dependent on the wireless links and the vehicular connectivity with each other or with RSU [8].

1.2. Applications of VANET

Applications of VANET are categorized into three sections. Safety, transportation and convenience.
These applications are discussed below with examples:

- **Safety applications:** It avoids the accidents on the roadside by providing the information of the adjacent vehicles within time and the driver rapidly takes action according to the safety information. Safety applications also include different types of warnings. Some of them are as follows:

- **Crash warning:** The warnings generated by the OBU in the vehicle, will be detected by the fixed RSU and the opposite lane vehicle. Thus, the system tries to transmit the information or data through the vehicle which are coming in opposite direction and approaching towards the destination.
- **Cooperative maneuvering:** It informs about the exchange of relative positions and the dynamic change in between vehicles like land merge and cooperative driving.
- **Transportation applications:** Applications raised for the security of the driver and passenger. Transport application secures the resources as well as time because it provides the information about the road condition, collision and route information [21]. Road condition includes information about the traffic, congestion, construction, and blockage. Collision includes the crash warning similarly route information includes the geographical region of the overall road routes [3].

VANET applications also include intelligent vehicles, reducing petrol consumption, Entertainment etc.

1.3. Major Issues in VANET

Issues are termed as the drawbacks of the VANET network but the drawbacks are useful for further research which opens the new schemes. There are some issues which are related with VANET. These issues are as follows:

- **High Mobility:** Due to high mobility all the nodes in the network are not able to communicate properly with each other because of the rapid movement of the vehicles. Due to mobility vehicle changes its topology and the vehicle which is selected for communication purpose will leave the network. The link between the vehicle and RSU will break and the whole network is not able to communicate under high mobility. It also decreases the efficiency of the system.
- **Time constraint:** VANET is used for safety message delivery, road accidents, route, congestion and much more. So the exact delivery time for the transmission of the information from one node to another node is difficult under VANET. For example, suppose safety message takes 200ns to reach the destination but due to real time constraint it takes 300ns, so it is a drawback of the network [10].
- **Security:** Security includes authentication, confidentiality, and integrity. It is important to the vehicle that it must be authenticated by the network administrator so that it can participate in the network configuration. The message send by the vehicles will also be authenticated. Therefore, a system wants to be introduced to such type of schemes which enables message to known and also recognized by central authorities in the cases of accidents [20].
- **Geographical tracking:** For the actual location of the vehicle GPS tracking is required which helps in the communication over the wireless network. If there is no proper system for location identification, the delay factor will involve in the network automatically [11].
- **Delay:** In VANET delay is a major issue which destroys the whole network under maintained condition

also. The delay should maintain under high congestion network. The delay is increased by congestion, link breakage, overhead, packet loss etc. Collision leads the jamming problem in the network, so to overcome this problem delay should be minimum [23].

2. Clustering Mechanism in VANET:

Clustering is one of the control techniques used in VANET to make the frequent topology changes (because of more speed of vehicles) less dynamic. There are a number of clustering techniques proposed by various researchers to easify the formation of clusters by applying different clustering algorithms. Figure 2 is a general description where the dynamic topology serves as an issue and

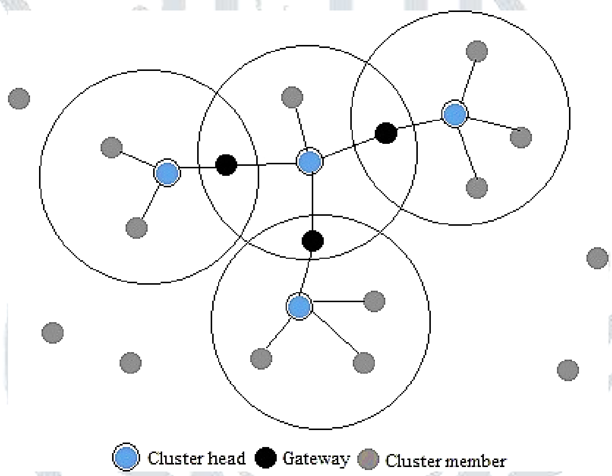


Fig. 2: Clustering mechanism

stable clustering is used to resolve it. The vehicles start forming a cluster using clustering techniques and the nodes in the cluster are called Cluster Members (CM) among which one node is chosen as the Cluster Head (CH) with the help of clustering algorithms.

2.1. Prediction-based Algorithm

This is one of the cluster head selection algorithm technique. According to prediction-based method the cluster-head is selected randomly with respect to their position in the cluster. Generally the node present in the center is selected as CH and other members in the corners are elected as Cluster Members.

The example is shown in the figure 3.

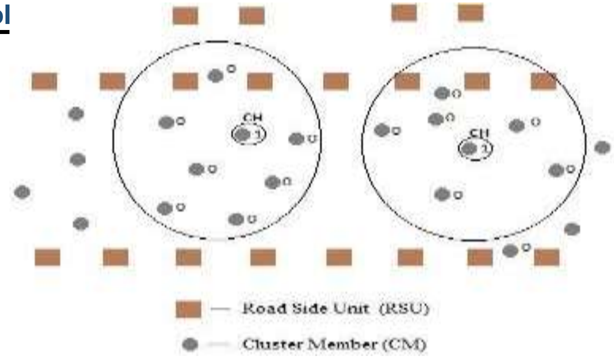


Fig 3: Model of prediction-based algorithm

2.2. Highest- degree Algorithm:

This is the proposed cluster head selection algorithm technique. According to this method the node with maximum number of neighboring nodes and relatively less speed is considered to be cluster head. The node with minimum neighboring nodes and more speed will be given least priority, and all these members are named as Cluster Members.

The example is shown in the figure 4.

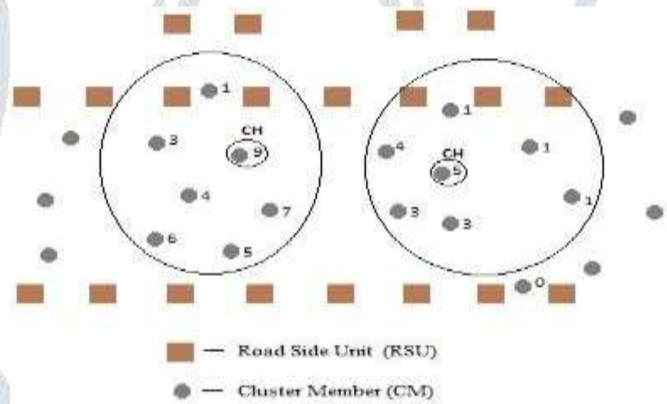


Fig 4: Model of Highest-degree algorithm

Algorithm: 1. Higher degree algorithm for cluster head selection

---

1. **Input:** ‘n’ // number of vehicles
2. cluster [n]; no = 0; ind
3. dist [n] [n-1] = Hold the distance matrix
4. for (i = 0 to n; i = i+1)
5. for (j = 0 to n-1; j = j+1) {
6. dist [i] [j] = sqrt((x-x1)^2+(y-y1)^2) }

```
min = dist [i] [0]
for (j = 1 to n; j = j+1) {
if dist [i] [j] < min {
min = dist [i] [j]
ind = j }
if (ith vehicle && indth are not present in any cluster) {
cluster [no] = i , ind
no = no+1 }
else
cluster [where i or indth vehicle already present] = i or ind
// Time t random simulation
speed [n] [n-1] = to hold the speed matrix; prior := n*n
for (i = 0 to n; i = i+1) {
for (j = 0 to n-1; j = j+1)
speed [i] [j] = dist [i] [j]/time }
for (i = 0 to n ; i=i+1) {
for (j = 0 to n; j = j+1)
for (k = 0 to n-1; k = k+1) {
if (speed[j][k]<min)
speed[j][k] = prior
prior--
}
} //For each cluster find the maximum priority points and define cluster heads
Output: Selection of cluster heads and efficient data transmission
```

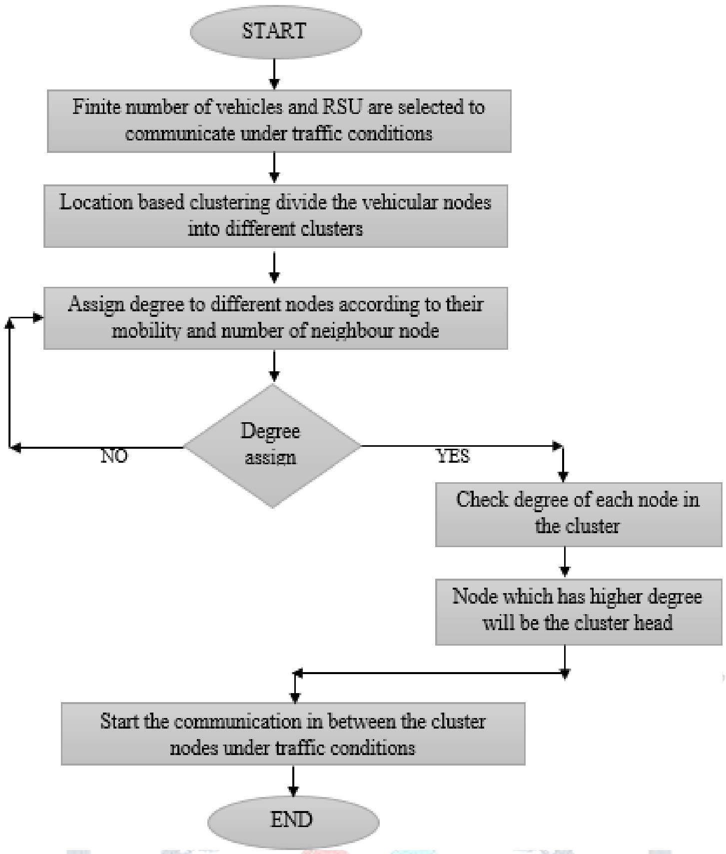


Fig. 5: Flow Chart of highest degree algorithm

3. Simulation and Results

We have designed lane model for both prediction based algorithm and highest degree algorithm using Network Simulator 2.35 . NS2 is a discrete simulator which uses Object Oriented Tool Command Language (OTcl) and C++ commands for simulation. It works on UNIX operating system which is more compatible with the commands. Tool Command Language (Tcl) is used to script the program on the notepad with extension .tcl, when NS2 compiles the program it calls the inbuilt simulation objects of C++. The objects of the simulator combine with the OTcl and provide the simulated trace file. The trace file is a data file which consists of the overall output values of the simulation. When we compile the trace file it will provide the graphs and Network Animator (NAM) files. NAM provides the virtual view of the whole network in which virtual nodes is visible. IP protocols, routing protocols, and multicast routing protocols are inbuilt protocols in NS2. It provides Constant Bit Rate (CBR), Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) as traffic packets. Applications of NS2 are as follows:

- Provides virtual scenario of the whole network. (NAM)
- Future predictions without wasting any resources.

- Easy to handle.
- Trace graph applications.
- Performance evaluation by graphs (X graphs)
- Inbuilt routing protocols, antenna, and MAC protocols (IEEE 802.11)

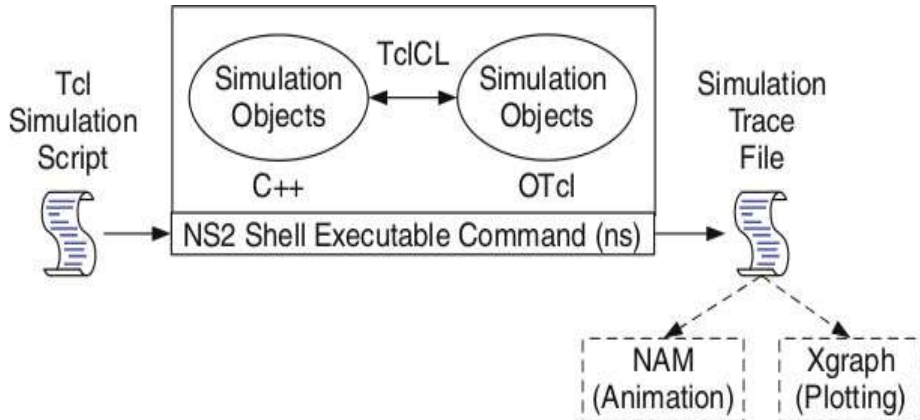


Fig. 6: Network simulator architecture

3.1. Design model snapshots

- **Network deployment:** The network is deployed with the finite number of 35 vehicular nodes. In the network RSU's are deployed for the better communication links. Each node can communicate independently and no cluster heads are selected in the network.

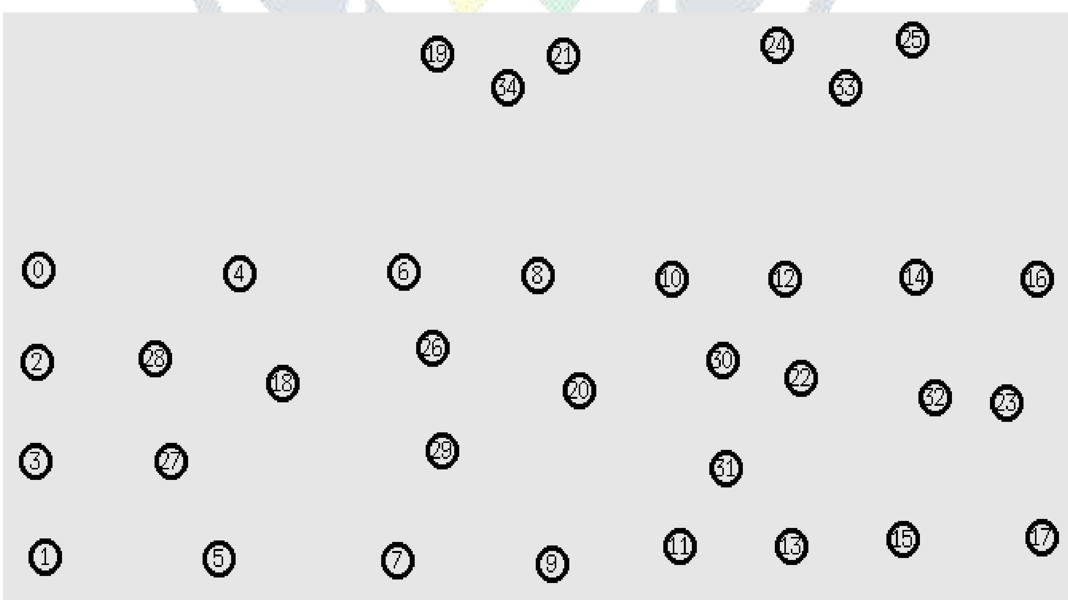


Fig. 7: Network deployment

The RSU's in the network are marked with the red color and with green color, vehicles are marked. In the starting of the simulation, every node has been an equal priority that is 0.

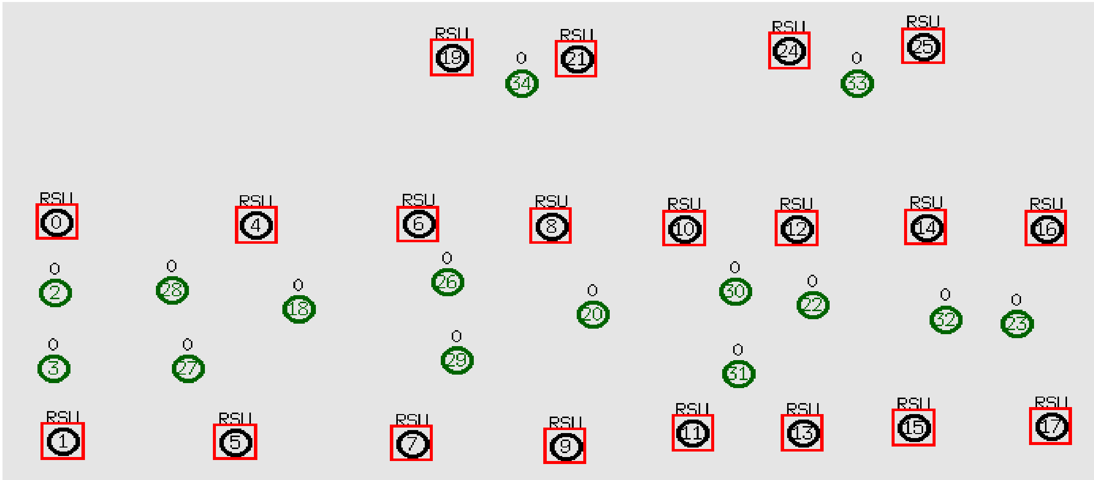


Fig. 8: Network deployment with RSUs and vehicles

- **Cluster head selection using prediction based algorithm (Problem snapshot):** In the starting of the simulation, every node has an equal priority that is '0'. Vehicular nodes start communicating for the cluster head selection in a network. The nodes applied speed formula and calculated the stability. The maximum stable node will be selected as the cluster head node in the network and set priority '1' as shown in the Fig. 9.

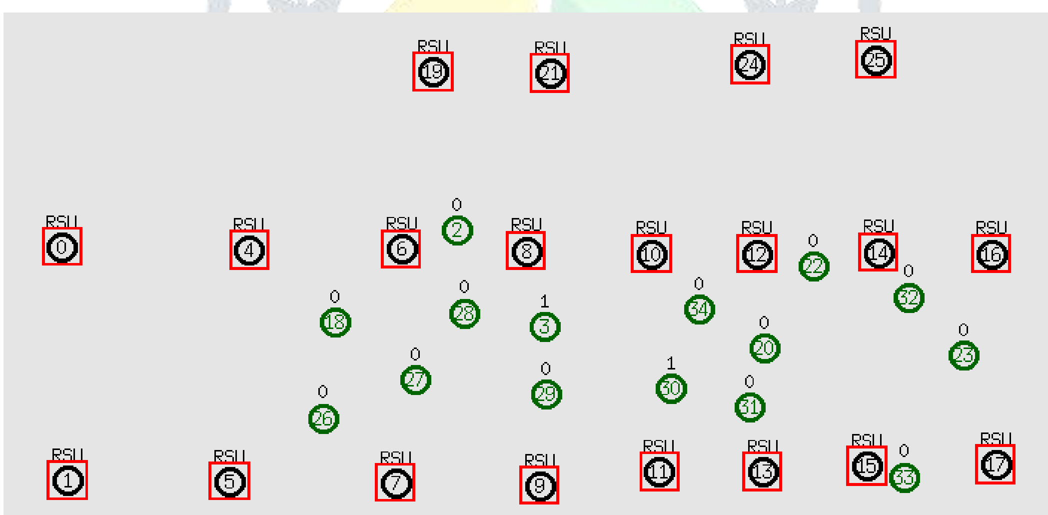
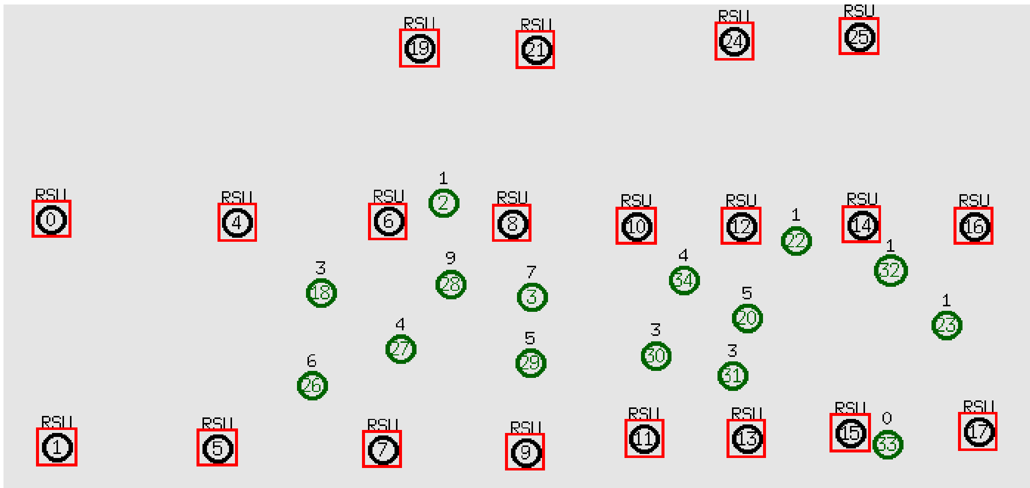


Fig. 9: Cluster head selection using prediction based algorithm

- **Cluster head selection using a highest degree algorithm (Solution snapshot):** The network deployment is same as prediction based algorithm. In the initial stage, every node in the network is marked with the same priority as '0'. The nodes applied same speed formula and calculate the stability. The maximum stable node will be selected as the cluster head node in the network and set the highest priority number as shown in the Fig. 10.

Fig. 10: Cluster head selection using highest degree algorithm



The source and destination nodes are defined in the network. The source node is responsible for communicating with destination node through the cluster head as shown in the Fig. 11.

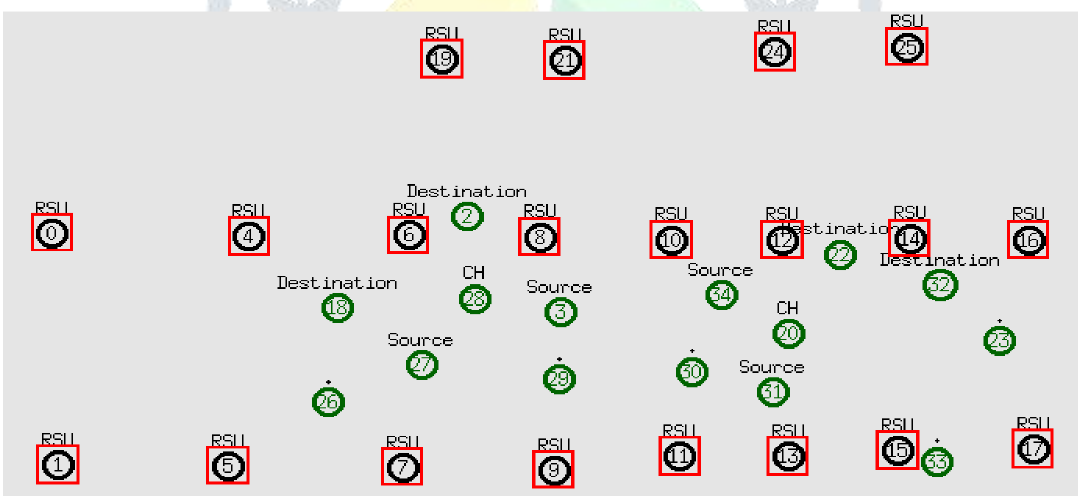


Fig. 11: Selected cluster head

4. Conclusion

We compared the existing technique i.e. Prediction-based algorithm and proposed technique i.e Highest-degree algorithm. Design model for the both techniques are also shown. We found that the Highest-degree algorithm chooses stable cluster-head then the prediction-based algorithm. In the future work the stability of the cluster head can be increased by considering various parameters into existence. Also the delay, packet overhead can be decreased using efficient cluster head selection technique.

References

[1] Chan-Ki Park., Min-Woo Ryu, Kuk-Hyun Cho, "*Survey of MAC Protocols for Vehicular Ad Hoc Networks*", Smart Computing Review, vol. 2(4), August 2012.

[2] Bernsen, J., Manivannan, D,"*Greedy routing protocols for vehicular ad hoc networks*", Wireless Communications and Mobile Computing Conference, IWCMC'08.l, pp. 632-637, 2008.

[3] Kumar, A., Tyagi, M., "*Geographical Topologies of Routing Protocols in Vehicular Ad hoc Networks– A Survey*, IJCSIT, Vol. 5, 2014.

[4] Harish Laxmichand Sharma and Pankaj Agrawal, "*Multipath reliable range node selection distance vector routing for VANET*, International Conference on Electronic Systems, Signal Processing and Computing Technologies, proceedings of IEEE, pp. 280-283, Jan 2014.

[5] Li-Ling Hung, Chih-Yung Chang, Cheng-Chang Chen, Yu-Chieh Chen, "*BUFE-MAC: A Protocol with Bandwidth Utilization and Fairness Enhancements for Mesh-Backbone-Based VANETs*", IEEE transactions on vehicular technology, vol. 61(5), June 2012.

[6] Cristina Rico Garcia, Andreas Lehner, Thomas Strang, "*A Reliable MAC Protocol for Broadcast VANETs*, 2010.

[7] Jagruti Sahoo, Eric Hsiao-Kuang Wu, Pratap Kumar Sahu, Mario Gerla, "*Congestion- Controlled-Coordinator-Based MAC for Safety-Critical Message Transmission in VANETs*", IEEE transactions on intelligent transportation systems, vol. 14(3), September 2013.

[8] Ganan, C., Munoz, J. L., Esparza, O., Mata-Díaz, J., Alins, J., "*PPREM: privacy preserving revocation mechanism for vehicular ad hoc networks*", Computer Standards & Interfaces, vol. 36(3), pp-513-523, 2014.

[9] Patil V, P.Smt., " *Vanet Based Traffic Management System Development And Testing Using Aodv Routing Protocol*" IJSER, pp.1682-1689, 2012.

[10] Bojin Liu, Beh., Dipak, Chen, "*Assessing the VANETs local information storage capability under different traffic mobility*", Proceedings of IEEE , pp. 1-5, March 2010.

[11] Jing Zhao, Yang Zhang, "*Data Pouring and Buffering on the Road: A New Data Dissemination Paradigm for Vehicular Ad-Hoc Networks*", IEEE transactions on vehicular technology, vol. 56(6), November 2007.

[12] Peng Fan, James G. Haran, John Dillenburg, Peter C. Nelson, "*Cluster-Based Framework in Vehicular Ad-Hoc Networks*", Ad-hoc-now 2005, lNCS 3738, pp. 32 – 42, Springer, 2005.

[13] Bijan Paul, Md. Ibrahim, Md. Abu Naser Bikas, "*VANET Routing Protocols: Pros and Cons*", International Journal of Computer Applications, vol 20(3), April 2011.

[14] H. A. Omar, W. Zhuang and L. Li, "*VeMAC: A TDMA-Based MAC Protocol for Reliable Broadcast in*

VANETs," IEEE Transactions on Mobile Computing, vol. 12(9), pp. 1724-1736, Sept. 2013.

[15] Nitish Sukhla Pranjal Katiyar , Nikhil Devgan , Nitesh Kumar, Aarti Gautam Dinker, "*Comparison of the MAC Protocols in Vehicular Ad-Hoc Network*", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 3(5), May 2014.

[16] N. C. Rathore, S. Verma, R. S. Tomar, G. S. Tomar, "*CMAC: A cluster based MAC protocol for VANETs*," International Conference on Computer Information Systems and Industrial Management Applications (CISIM), , Krackow, pp. 563-568, 2010.

[17] Zhuang, W., Ismail, M., "*Cooperation in wireless communication networks*", IEEE Wirel. Commun., vol. 19(2), pp. 10-20, 2012.

[18] Manishaben Jaiswal, "COMPUTER VIRUSES: PRINCIPLES OF EXERTION, OCCURRENCE AND AWARENESS ", International Journal of Creative Research Thoughts (IJCRT), ISSN:2320-2882, Volume.5, Issue 4, pp.648-651, December 2017, http://doi.one/10.1729/Journal.23273 Available at http://www.ijcrt.org/viewfull.php?&p_id=IJCRT1133396

[19] Manishaben Jaiswal "Big Data concept and imposts in business" International Journal of Advanced and Innovative Research (IJAIR) ISSN: 2278-7844, volume-7, Issue- 4, April 2018 available at: http://ijairjournal.in/Ijair_T18.pdf

[20] Manishaben Jaiswal " SOFTWARE QUALITY TESTING " International Journal of Informative & Futuristic Research (IJIFR) , ISSN: 2347-1697 , Volume 6, issue -2 , pp. 114-119, October-2018.

[21] Zhao, B., Valenti, M.C., "*Practical relay networks: a generalization of hybrid-ARQ*", IEEE J. Sel. Areas Commun., vol. 23(1), pp. 7–18, 2005.

[22] Zhang, J., Zhang, Q., Jia, W., "*VC-MAC: a cooperative MAC protocol in vehicular networks*", IEEE Trans. Veh. Technol., vol. 58(3), pp. 1561–1571, 2009.

[23] Fan Yang, Yuliang Tang, "*Cooperative clustering-based medium access control for broadcasting in vehicular ad-hoc networks*", IET Communications, vol. 8(17), pp. 3136– 3144.

[24] Ramon S. Schwartz, Anthony E.Ohazulike, Christoph, "*On the applicability of fair and adaptive data dissemination in traffic information systems*", IEEE Vehicular Networking Conference (VNC), pp. 116–123, 2011.

[25] Kartik Pandit, Dipak Ghosal, "*Adaptive Traffic Signal Control With Vehicular Ad hoc Networks*", IEEE transactions on vehicular technology, vol. 62(4), May 2013.

[26] Christoph Sommer, Reinhard German, Falko Dressler, "*Adaptive Beaconing for Delay- Sensitive and Congestion-Aware Traffic Information Systems*," Technical Reports, CS-2010- 01, January 2010.