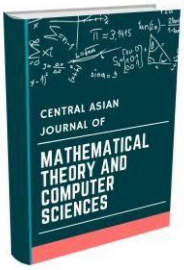

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Article

Priority Based Lightweight Cluster Routing for Efficient Communication in Vehicular Ad Hoc Networks

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Abstract: A vehicular ad hoc network (VANET) is a network that is dynamic and has no infrastructure. In VANET movable autonomous vehicles rely on wireless communication systems to form an autonomous, self-organized, and infrastructure-less network. VANETs are prone to frequent path failure due to their high mobility. High mobility causes the node state to change continuously, so routing and communication between vehicles are challenging tasks in VANET. At this point, to provide efficient routing, this work proposes a priority-based lightweight clustering model (P-LWCM) for cluster-based routing. In the proposed work, stable and efficient cluster heads and members are selected for routing in VANET. The proposed system uses various parameters including mobility, Packet Loss Ratio (PLR), Packet Misrouting Ratio (PMR), and Priority Ratio (PR) to select a vehicle as a cluster head or to include a node as a cluster member. An elected cluster head and members have a long lifetime in the group they belong to and efficient routing is possible. The performance of the proposed model is analyzed in terms of packet delivery ratio (PDR), and end-to-end delay (EED). Simulation results show that the proposed system outperforms the Weighted Clustering Trust model (WCTM) in all aspects.

Keywords: VANETs, efficeint routing, clustering, priority based routing

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1. Introduction

VANET refers to the network with a collection of vehicles. In VANETs communication happens between vehicles (Vehicle to Vehicle- V2V) or Vehicle to infrastructure (V2I) [1], [2]. VANET characteristics may cause various issues in routing the messages such as high mobility causes frequent path failures and wireless communication is more error-prone. Routing in VANET is a challenging task. For efficient routing in VANETs, many routing protocols are proposed. VANET is a unit of MANET. However, MANET protocols are not suitable for VANETs, because of high mobility and other dynamic characteristics of VANET. Various protocols proposed for VANET include position-based, infrastructure-based, and cluster-based protocols [3], [4].

Due to the high mobility and irregular distribution pattern of vehicles in VANETs, creating a reliable network and maintaining communications is a difficult challenge [5], [6]. By grouping related vehicles into several virtual groups or clusters, clustering technology has proven to be an effective way to increase routing scalability and reliability [7]. A capital asset called a cluster head is responsible for monitoring communication within each cluster. While vehicles in different clusters (intercluster) can communicate with each other indirectly through cluster heads, vehicles in the same cluster (intracluster) can communicate with each other directly [8], [9]. Figure 1 shows the cluster based routing in VANETs.

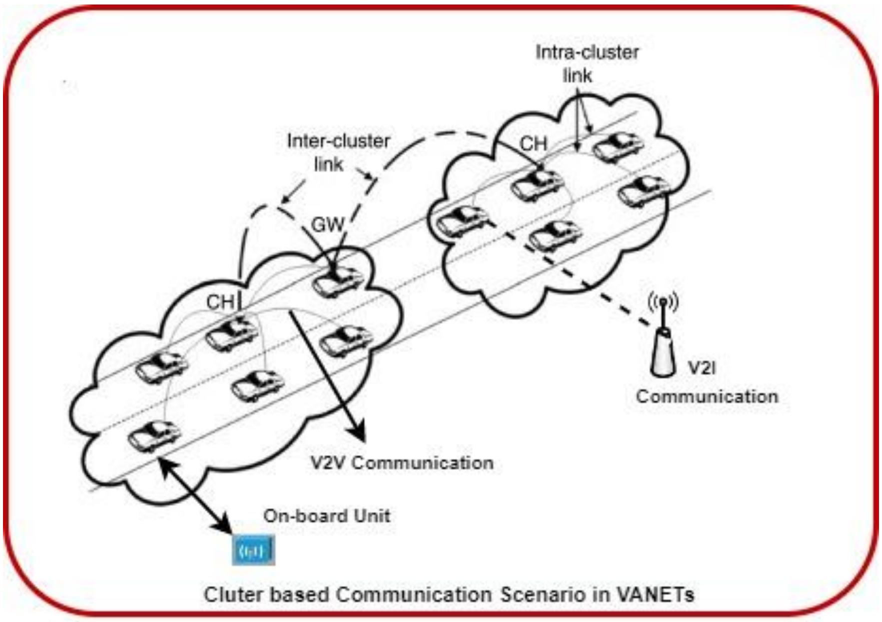

Figure 1. Cluster based routing in VANETs

In communication networks, clustering techniques are used for VANETs to group similar vehicles [10], [11]. Therefore, to provide equal channel access, clustering approaches can effectively reduce channel contention among cluster members. In addition, clustering methods can offer spatial reuse of assets such as bandwidth under the control of the cluster head [12]. Due to the high degree of mobility of VANETs, selecting a cluster head and increasing cluster stability is a difficult task.

In VANET, the cluster procedure works by splitting nodes into groups; each group has its cluster head and cluster members. The cluster head communicates with cluster members when it has information to communicate [13], [14]. Clusters are framed dynamically with the cluster head; any member can join a group (or) leave a cluster [14]. The cluster head will be selected based on satisfying some predefined factors based on the cluster head algorithm. In this paper, the cluster head is selected based on its low Packet Loss Ratio (PLR), Low Packet Misrouting Ratio (PMR), and high Priority Ratio (PR) value, the node that satisfies all these parameters will become the cluster head [15]. After electing clusters by using a P-LWCM, head selection information is broadcast to all its neighbors [16].

2. Related Works

This section covers various cluster-based routing protocols of the proposed work. The efficient routing between V2V and V2I is possible with adaptable cluster routing mechanisms. Additionally, interfacing Internet of Things (IoT) concepts for routing saves energy in terms of power consumption [17], [18], [19]. A cluster head [20] selection depends on the cumulative value of the Packet Dropping Ratio (PDR), PMR, Packet Falsely Injected Ratio (PFR) and Packet Altering Ratio (PAR). Cluster head formation is evaluated based on these parameters. This algorithm increases the packet drop ratio and decreases end to end ratio.

Electing a trustworthy Cluster Head (CHS) [21] focused on CHS model to ensure safe transmission through cooperating nodes. Based on this algorithm clusters have a limited lifetime. High mobility may cause cluster head reselection. The performance of pro-active & reactive protocols was proved by Ramamoorthy et al. [22], According to this work, the reactive protocols with clustering mechanisms provide better results in framing clusters and cluster members. Additionally, the routing overhead can be minimized with on-demand routing mechanisms [23]. Vehicular Multi-hop algorithm for stable clustering (VMASC) [24] is a clustering algorithm; it selects a head by having the least mobility of node. The last movement of the node identified by using the speed difference between neighbor nodes and a cluster head may change frequently based on speed metric.

Hassanabadi [25], combines both mobility and connectivity metrics of nodes. This algorithm increases cluster head lifetime up to about 50% when compared with other algorithms, but overhead occurred while selecting the cluster head. Storing cluster-based data in the cloud improves the efficiency of the routing. The cloud offers better platforms to store and retrieve data on an on-demand basis [26].

Mobility-based Metric for Clustering MOBIC [27] proposed to elect a cluster head, which has the least mobility nature while comparing it with other neighboring nodes. It results in the selection of a more stable cluster with better performance [28]. A novel clustering scheme [29] was introduced for efficient cluster-based routing. In this scheme, the cluster is selected based on relative mobility between nodes at a multi-hop level. It avoids unnecessary re-clustering.

Adaptive Service Provider Infrastructure for VANETs (ASPIRE) [30] proposed for VANETs to create large clusters for providing high network connectivity. It lowers cluster head duration, and increases cluster head changes dynamically. Affinity Propagation (AP) Algorithm [31] applying an affinity propagation algorithm, improves cluster stability but results in the breaking of Cluster Head Selection (CHS) frequently when speed dynamically charges. Liu et al. [32] proposed an algorithm, this algorithm considers mobility position based on Global Positioning (GPS) to form a cluster and cluster head when mobility is high the location causes changes. Dynamic source routing [33] is more adaptable for constructing clusters. The source-based routing delivers the packets quickly by following the header of packets. A cluster head can be elected among a group of nodes without overhead.

Trust schemes [34] have more scope in VANETs for message dissemination. The emergency and nonemergency messages will be delivered without overhead. Multihop communication mode is utilized for grouping nodes for routing the messages. The basic clustering mechanism is based on the mobility of nodes considered for framing clusters. In the Vehicle-Heading based Routing Protocol VHRP [35], cluster heads are selected based on vehicle travel direction, and the head is the first node in the group. A vehicle is moving in the same direction in a group considered as members of a group. This algorithm is introduced to increase cluster stability. Wormhole Attacks [36] cause information disclosed in cluster-based routing. The packets are misrouted among wormholes to the not intended destination. Cluster-based routing should be robust against wormhole attacks.

IoT plays a vital role in VANETs to offer infrastructure-based routing [37]. On board Units and other sensor devices can be added to control routing mechanisms. The IoT devices can sense the toxic gas levels to offer a non-emission environment. The clustering mechanism can be useful for grouping the vehicles based on the emission levels of the gases. In a forced-based algorithm [38], the Cluster Head is elected based on force. If the total forces are positive then vehicles moving in the same direction otherwise vehicles moving in the opposite direction. The basic idea is to add vehicles moving in the same direction in a group to improve cluster stability. In Mobility based clustering in VANETS using affinity propagation (APROVE) [39], every node in topology broadcasts beacons to its directed neighbors to make independent decisions on cluster head selection. In this scheme, the elected cluster life span is too small. During message transmission [40], the cluster heads can face message gossip via blockers. The blockers can block the message dissemination for emergency services. The Cluster should be robust in safeguarding messages. The cluster mechanisms with cryptographic mechanisms will improve the security of messages.

3. Materials and Methods

3.1. Priority Based Weighted Trust Model

In the proposed P-LWCM, node characteristics are combined to elect a node as a cluster head (or) to include a node as a cluster member. Node characteristics such as mobility of node, PLR, and PMR are considered in the proposed work. The cluster head selection procedure starts by putting all nodes in promiscuous mode to obtain various cumulative values for node characteristics by evaluating the below formulas.

a. Packet Loss Ratio (PLR)

PLR calculated as the Number of packets lost (PL) divided by the Number of packets sent (PS). Equation 1 depicts the PLR calculation formula.

$$PLR = \frac{PL}{PS} \tag{1}$$

b. Packet Misrouting Ratio (PMR)

Calculated as the Number of packet Misrouting (PM) divided by Number of packets sent (PS). Equation 2 depicts the PMR calculation formula.

$$PMR = \frac{PM}{PS} \tag{2}$$

c. Priority Ratio (PR)

PR is achieved with below formula's

High Mobility (HM) of the node→Low priority (LPR) (Low Trust) (3.1)

Low Mobility (LM) of the node→ High priority (HPR) (High Trust) (3.2)

PLR, PMR & PR are calculated in every node for an appropriate round trip time in the mill seconds, and then the cluster head selection procedure takes place. First PLR is calculated by evaluating equation 1 its cumulative value is considered, second PMR calculated by assessing equation 2 and its cumulative value is considered, the third priority of the node considered by evaluating equations 3.1 and 3.2, the priority of the node is calculated based on the mobility speed of the vehicle (node), the vehicle has low mobility will be assigned with high priority, the value given for high priority is one, and the vehicle contains high mobility is assigned with low priority, the value given for low priority is zero. All obtained cumulative values compared with threshold values. The cluster head election algorithm sets the threshold values; which may vary from group to group. Threshold values are calculated based equations 4 and 5.

d. The threshold value for Packet Loss Ratio (TPLR)

TPLR is Total no of packets sent (TPS).

$$TPLR = TPS \tag{4}$$

e. The threshold value for Packet Misrouting Ratio (TPMR)

TPMR is Total no of packets sent.

$$TPMR = TPS \tag{5}$$

By evaluating the equation, 4 & 5 threshold values were obtained, and values were stored in threshold variables. The threshold value for PR is always set as high (1). Every node in the network participates in the cluster head selection procedure; finally, the node satisfying all parameters will become the cluster head; the remaining nodes in the network are considered cluster members. The cluster head selection procedure is shown in Figure 2. Table 1 shows the algorithm for electing cluster head and cluster member.

Table 1. Algorithm for electing cluster head and cluster member

Algorithm for electing cluster head and cluster member
Step 1: Put node in promiscuous mode to calculate prehistory
Step 2: if (PLR <TPLR && PMR <TPMR) {
if (mobility < threshold speed)
{
Priority→ High
select node as cluster head
else
Priority → low
include node as a cluster member
}
else
include node in a cluster member
}
Step 3: if(NL==NULL)
{
No Broadcast
else
Broadcast to all neighbors
}

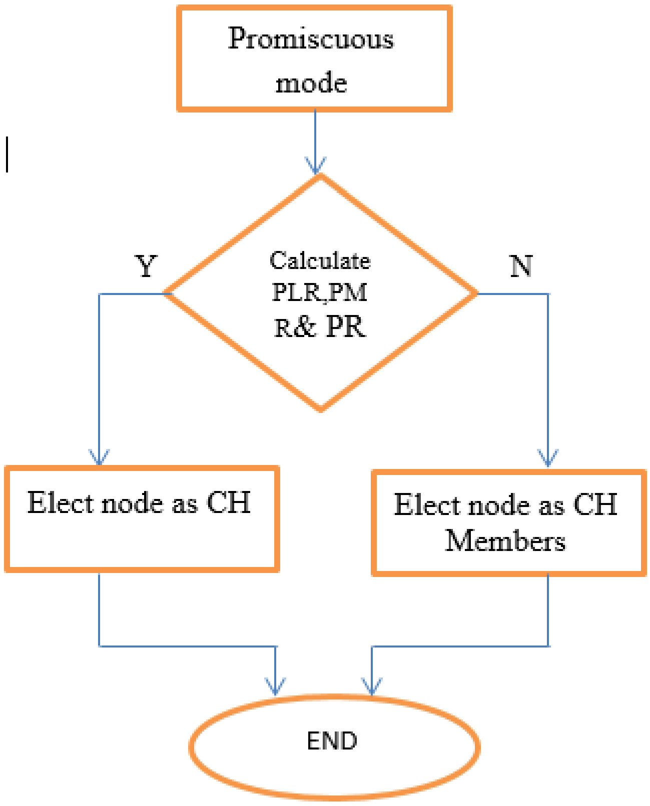

Figure 2. Cluster Head selection process

Once cluster head selection is completed the next step is informing about cluster head to its neighbors. Once the node is elected as head it broadcasts the *"**hello**"* message to its neighbors. The *"**hello**"* message includes the following fields.

Msg-ID: Random number generated by cluster head to avoid duplicates or resending of the same message.

Id-SA: Identity of cluster head.

NL: Destination addresses of its neighbors.

Table 2. Hello Message Structure

Msg-ID	Id-SA	NL

NL (Neighbours List) is generated on the promiscuous mode by every node; in this mode, each node evaluates PLR and other factors to obtain some cumulative values at that time node broadcasts messages to its directly connected neighbors. This NL is stored in the routing table of nodes. By using the NL message about cluster head selection is informed. All neighbors receiving *hello* messages acknowledge with proper ACK to head to tell about their willingness to become a cluster member. Figure 3 shows about how cluster head communicates with neighbours.

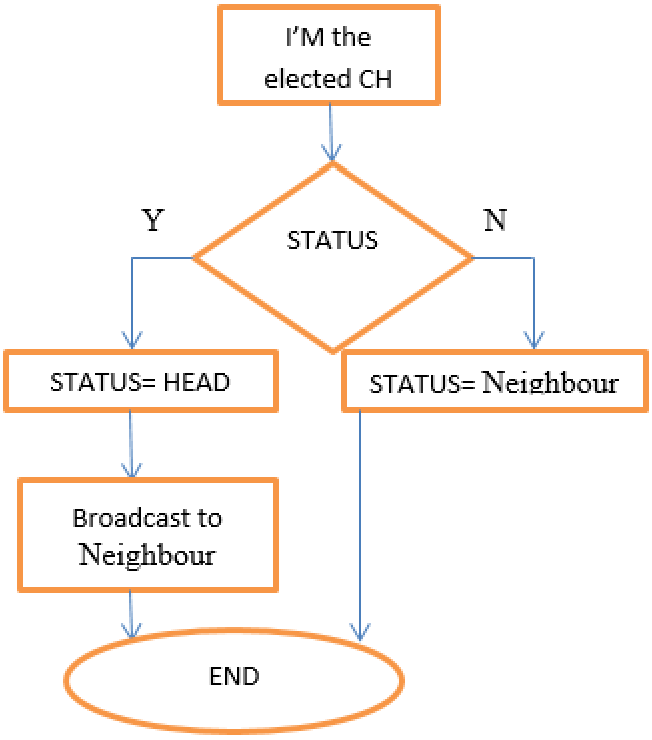

Figure 3. Cluster Head Communication with neighbours

4. Results and Discussion

Simulations are conducted using Network Simulator (NS2) with varying numbers of nodes (40-120). Simulations are carried out with parameters PDR & End to End delay. Proposed P-LWCM is compared with the WCTM [4]. To evaluate the P-LWCM in NS2, PDR & end to end delay are considered. PDR is obtained as a cumulative value from the below formula.

$$PDR = \frac{SDP}{PG} \tag{5}$$

PDR refers to the number of successfully delivered packets (SDP) divided by the total number of Packets Generated (PG). End to End Delay obtained as a cumulative value-form below formula.

$$EED = TTKD \tag{6}$$

End to End Delay refers to total time taken by a packet to reach from source to destination (TTKD).

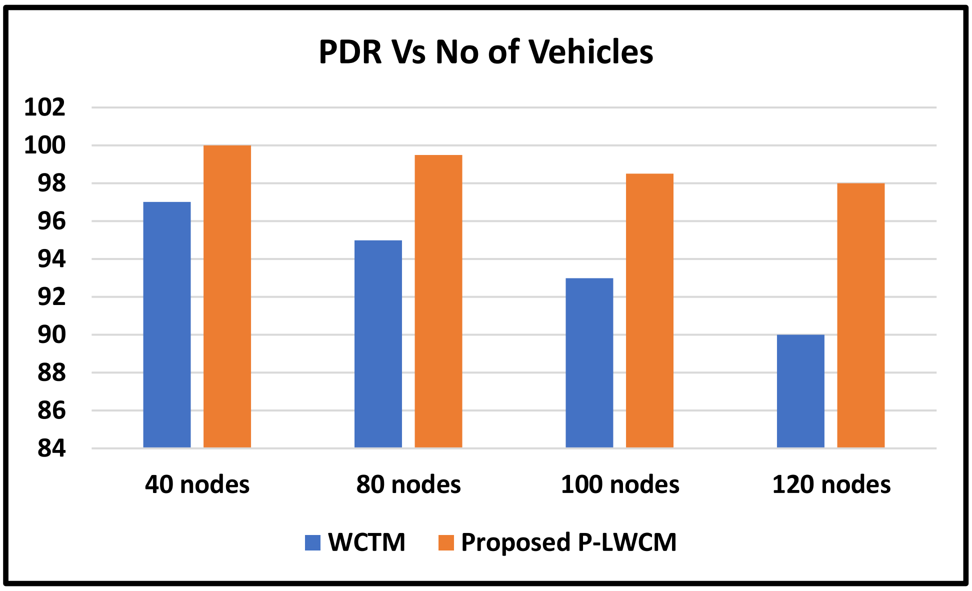

Figure 4. Packet Delivery Ratio

Figure 4 shows that PDR increased with the Proposed P-LWCM while comparing it with the WCTM [4]. The reason is P-LWCM forwards the packets through selected cluster head, and the cluster head is chosen with an effective manner like with less ratio of PLR, PMR and with high PR value. Based on PLR, the leader will drop fewer packets frequently, with PMR head has no history of malicious routing along with this head has low mobility. All this leads the administrator has the capability for an efficient and reliable path. But in the WCTM cluster is elected with low weight, this causes the frequent change of cluster head and re-initiating of cluster head selection procedure. Re-initiating cluster head selection frequently leads to overhead in the network. WCTM depends on the PV (Distance between neighbors) parameter. Based on PV, the node which has a long distance to its neighbors is not suitable to become a cluster head. While selecting cluster head in the WCTM, the nodes which is for away to other nodes in the network are neglected. This problem leads to overhead again. Table 3 summarizes about PDR ratio. The proposed P-LWCM has improved delivery ratio than the WCTM.

Table 3. Percentage of PDR

Schemes	**No of nodes**			
	40	80	100	120
WCTM	97.0%	95.0%	93.0%	90.0%
Proposed P-LWCM	100%	99.5 %	98.5 %	98.0%

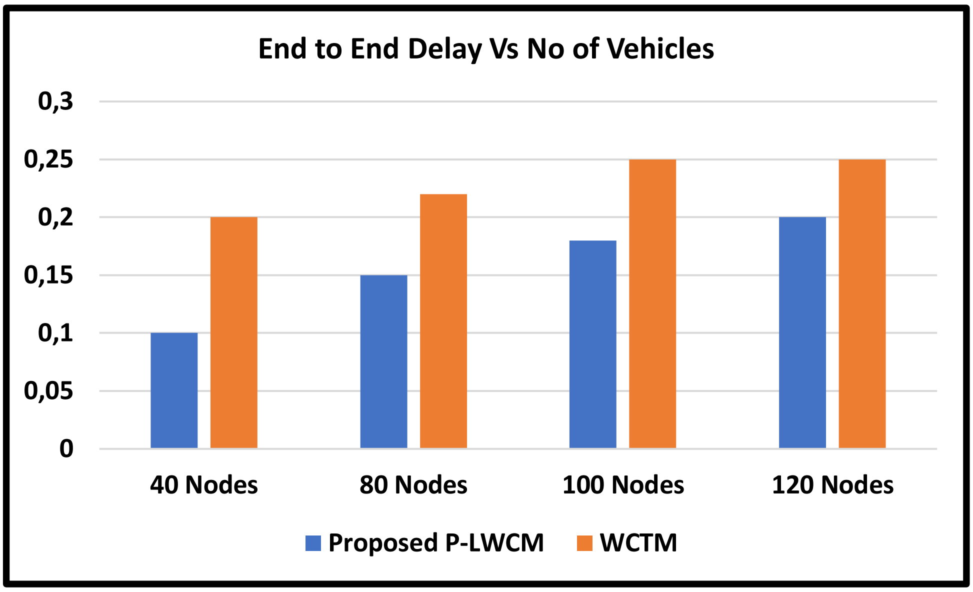

Figure 5. End to end delay

Figure 5 shows that EED increased in WCTM; the reason is it works based on the one-hop method. Cluster head can forward the packets to its members with a one-hop count. If the cluster head needs to send the packet to the other node, which is for away from the head, then the head must depend on intra clustering. Intra-clustering leads to delay. But in the P-LWCM, Intra-clustering is avoided. Cluster head has the capability for multi-hop communication. Multi-hop communication reduces delays.

Table 4. Percentage of EED in seconds

Schemes	No of nodes			
	40	80	100	120
WCTM	0.2s	0.22s	0.25s	0.26s
Proposed P-LWCM	0.1s	0.15s	0.18s	0.2s

5. Conclusion

In this paper, the proposed trust model elects the cluster efficiently by satisfying all node parameters; this selection makes only the eligible node to become the cluster head. Simulation is conducted with various nodes ranging from (40-120) with and without the trust model. Results have shown that without malicious nodes, the trust model significantly improves PDR and reduces end to end delay. Feature work includes an increasing number of nodes ranging from 40-200 to investigate overload, and congestion occurs while electing cluster head.

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