A Study of Conceptual Connected Communication Vehicular Network Using Distributed Cluster Algorithm

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Abstract. This research paper proposes a Connected Vehicular Communication Network using Distributed Cluster Algorithm (DCA). We are introduced to novel cluster metric, network model. Especially, we propose vehicular communication network on cluster algorithm against changes in environmental changed parameters, and P2P (Point to Point) of a graph such as ring search, neural network and so on. In addition, we use the localized notion of node in conjunction with a universal link metric to derive a DCA for the vehicular network. Moreover, we design a distributed vehicular network that the proposed DCA forms a more robust cluster structure.

Keywords: Distributed Cluster Algorithm · Vehicular Communication Network

1 Introduction

VANET (Vehicular Ad hoc Networks) are employed by intelligent transport systems to operate wireless communications in the vehicular environments [1–3]. VANET are designed to provide a reliable and safe environment for drivers. Their derivers could be informed of situations by vehicular communications and exchanging the own information about surrounding environments. The vehicles in VANET are similar to the mobile nodes in the MANET [4–6]. However, VANET inherit most of the characteristics of MANET, but VANET have some unique characteristics such as high rate of topology changes, and high density of the network, and so on [7, 8]. For our research have the new strategies and considering, we have to propose the congestion in Vehicular Communication network with DCA.

2 Vehicular Communication and System

The main of V2V (Vehicle to Vehicle) communication is to standardize the protocols and interfaces of wireless communication between the vehicles and their environment [9]. It makes different vehicle as well as communicate with access points or the road

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side units. V2V communications form a decentralized network that is well suited for active safety applications. Apart from safety applications, gathered information helps in traffic management to support traffic flow [10–12]. Especially, V2V communication systems are including In-Vehicle Domain, Ad-Hoc Domain, and Infrastructure Domain. In order to enable vehicles and the corresponding infrastructure to exchange data in adequate manner by Radio System [12–14]. There are two types of communication channels used by V2V radio system. (1) ***Dedicated V2V Channels*** have network control and critical safety applications, and road safety and traffic efficiently applications. (2) This system provide ***public channels as specified in IEEE 802.11 a/b/g***. In Fig. 1 shows a cross-layer control architecture in VANET, this is considered for detecting and controlling between some information from the application layer and detection by sensing the channel in the physical layer. In addition, the network layer can control by routing that efficiently rebroadcast the message. The prioritizing and scheduling message at MAC layer can significantly help control in VANET [15].

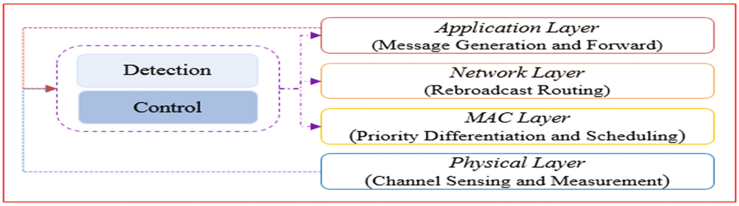


Fig. 1. Cross-layer control architecture in VANET

3 Proposed System

3.1 C-VCN (Connected Vehicular Communication Network) Model

We design that WLAN (Wireless LAN) is based on IEEE 802.11 standard and WWAN (Wireless WAN) is implemented by 3G/4G by hybrid network model. Wireless network is constituted by different layers, and each layer has its own responsibilities. WWAN has already had some acknowledge standards. The most popular one is 3G/4G network. In our research model, 3G/4G wireless network as WWAN part. Each vehicle communicates with its BaseStation (BS). As shown in Fig. 2, BaseStation access to internet through wired network. Generally, 3G/4G network provides relative low throughput with large cell coverage. Our C-VCN model represents vehicular communication network architecture. The involved entities of the network architecture are following Fig. 2 as bellows:

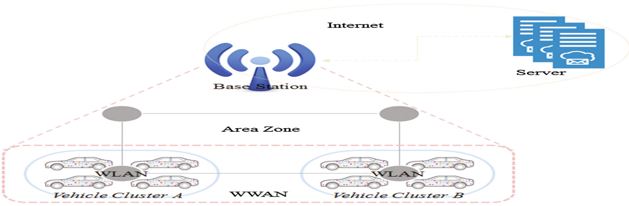


Fig. 2. Vehicular network architecture for connected vehicular communication network. Area zone nodes are vehicle running and in operating network. Communication in vehicle provides an IEEE 802.21 interface and a 3G/4G interface. Base Station is central infrastructure in 3G/4G Cellular Network, and Servers are functional entities that provide service to these clients.

3.2 Connected Communication Vehicular Network (CCVN)

In vehicular communication network, cluster structure is implemented by the cluster algorithm. This support an appropriate topology for distribute node and decide the effect of running algorithm. Our concept is a highly dynamic wireless network, and is motivated by the definition of network capacity. We need to be solved clustering metrics by clustering. This metrics would provide the quantitative definition, and should reflect the characteristic of their network. In general, network topology in VANET is frequently changing. In our simple scenario, considering vehicular network contain V_n nodes. If it takes an arbitrary time, the network topology could be describes as a graph $G = \{V, E\}$, where $V_n = (V_1, V_2, V_3, V_{4,\ldots.} V_n)$ is the set of nodes and E is the set of links between nodes. In a graph $G = \{V, E\}$, the weight matrix is $W = \{w_{ij}\}^n$. Let the matrix M have $m_{ij} = \sum_{k=1}^{n} w_{ik}$ $(i = j)$, *otherwise 0*. M is the degree matrix for weight W. According to this graph, a cluster is named community, and so vehicular clustering can be classified into a community detection problem, which focuses on aggregating similar nodes together with the given features of nodes.

When we assume the following properties for this graph, Fig. 3 is shown the abstraction vehicular network model. We centrality measure for both nodes and links are quantifies the robustness of a network graph with the environmental changes, traffic events, topology modifications, and destination for traffic. After all, VANET is a connected graph, a random node occurs when travels between nodes.

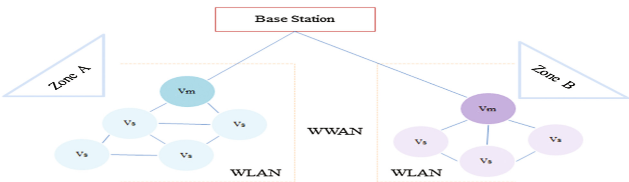


Fig. 3. Abstraction vehicular network model. *G* is an undirected graph. For each link by zone, this has a weight *w* which is defined to represent between node V_m (*Vehicle Master*) and node V_s (*Vehicle slave*). Each node is communicated with V2V, so position and velocity of each node. In addition, each node has the same transmission in WLAN area, is composed equally in the proposed cluster algorithm.

3.3 Distributed Cluster Algorithm for CCVN

In our research paper, the proposed distributed cluster algorithm is designed for the purpose of each vehicles trajectory in CCVN. This algorithm assumes each vehicle is aware of their location and velocity using Base Station. Each vehicle inside vehicle cluster provides their context from the target by Fig. 2. In other words, their location is reached on vehicle distance that can be used in this algorithm to acquisition information such as enable trajectory. ***Algorithm Description***. This is divided into three cases 'initialization', 'cluster maintenance', and 'trajectory'. First, in case of initialization cluster is created and the initial cluster (V_m) is selected by '*head*'. Second, in case of processing, in each vehicle (V_s) node performs their different tasks for cluster maintenance, and recommend in changed trajectory in each cluster. Base Station (BS) broadcast a control message to the entire network the vehicle information such as context, condition, and situation and waits to receive response message from each vehicle or cluster. For BS waits a response message, it has a plan to decide trajectory policy by considerable environment from each vehicle or cluster. When BS receives a response message from them, send to specific zone in the network if it has a rough about the context information. BS performs procedure from Algorithm 1 and show Fig. 4

Algorithm 1 BaseStation Procedure

Describe the Function.
SendBS (Node ID, PacketId, TrajectoryInfo, CurTime);

Task Action.
IF do not received V_m (Head) from the V_s ( ) then,
    sendBS(NodeID, PacketId, TrajectoryInfo, CurTime)
end if
IF received V_m (Head) from the V_s ( ) then,
    sendBS(new NodeID, new PacketId, new TrajectoryInfo, new CurTime)
end if

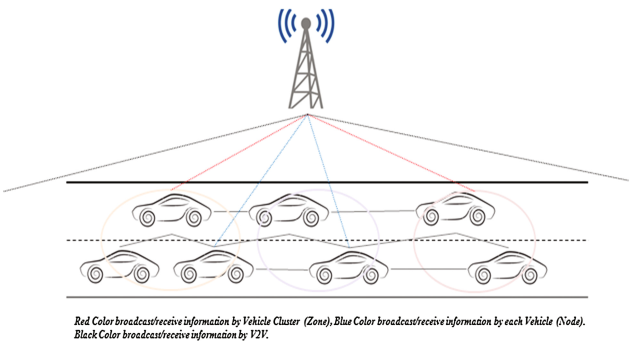


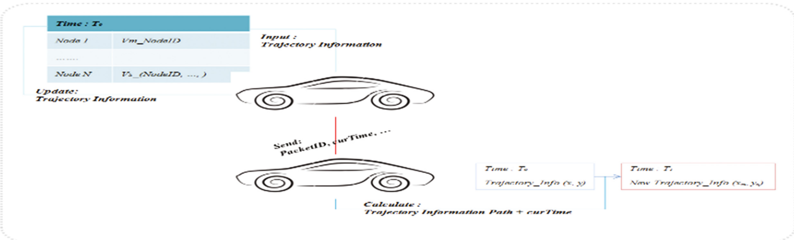
Fig. 4. BaseStation Communication Function. It is a central/individual broadcasting and receiving with trajectory for cluster and particular vehicle.

In DCA, V_m is the central management V_s in which all V_s had a role in managing in the cluster. Then, our algorithm is considered a central algorithm. The V_m is responsible for cluster maintenance in order to make a reliable trajectory. Accordingly, we have solved by reliable trajectory with one/more candidate V_m of another clusters. The cluster maintenance function of V_m is shown in Algorithm 2. The V_m begin to send an information message for their tasks by communication inside cluster, and V_m supposed to be sent at each ΔT_R time interval. Also, we show a Fig. 5.

Algorithm 2 V_m in cluster Procedure

Task Action

While (Trajectory == true) do
  send V_m (Node ID, PacketId, TrajectoryInfo, CurTime);
  $V_m \leftarrow V_s$
  Calculate ΔT_R ( )
  sendV_m ( );
  ………..
  If receive V_m ( ) then,
  Update.information (NodeID, PacketId, TrajectoryInfo, CurTime)
  endIf
  If do not received $V_m \leftarrow V_s$ ( ) then,
  Search.Trajectory.info (new NodeID, new PacketId, new TrajectoryInfo,new CurTime)
  endIf …..



BSM (Base Station Message)

NodeID	PacketID	TrajectoryInfo	curTime

Vm (Master Vehicle in Cluster Message)

NodeID	PacketID	curTime	Other Information

Vs (Slave Vehicle in Cluster Message)

NodeID	PacketID	curTime	Node_TrajectoryInfo	Other Information

Fig. 5. V_m and V_s broadcast/communicate transaction on WLAN and message information

4 Experiment and Evaluation

We have experiment and test the proposed algorithm and from Figs. 2, 3, 4 and 5 with our scenario to show the effect of trajectory on cluster. As well, we have performance of each algorithm which is communicated for trajectory purpose between V_m and V_s. Although we had a weak point of simulation area, this research used networking technology for vehicle trajectory and communication purpose which may be a future advancement by many researchers. This experiment result of our algorithm is shown in Table 1.

Table 1. Experiment Considerable Elements

Parameter	Value
Experiment environment	Gyeongbu express highway, Korea
Number of vehicle (node)	50, 100, 150, 200
Data packet size	1000 byte
Data packet frequency	0.5 Hz
Control packet frequency	1 Hz
Transmission rate	1 Mbps
Communication range	50, 100, 250, 500 m
Traffic type	UDP
Mac protocol	IEEE 802.11

We have experimented our algorithm with vehicle numbers to the effect of network density on clustering performance, and we had a velocity range (25–35 m/s) and transmission range (100 m). We shows the effect number of vehicles on the V_m metric. In our algorithm, we have considered a threshold for changing the V_m. This threshold is defined in a way to decrease changes in some cases. The evaluation result in Fig. 6 shows that increasing the number of vehicle have a positive effect on the V_m. The good

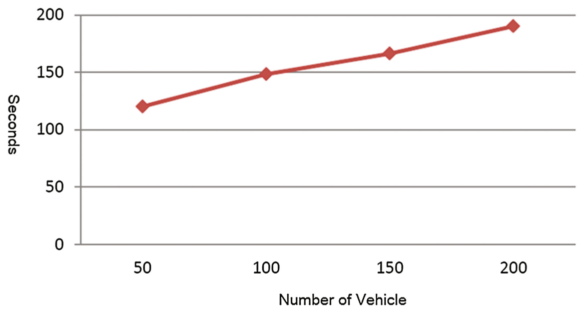


Fig. 6. Increasing the number of vehicle on the V_m.

reason is appropriate V_m metric which is not affected so much by cluster structure changes, and is a vehicle with the most similar movement pattern to the trajectory.

Figure 7 shows the effect of network density changes on packet delivery ratio. In dense networks more vehicles are capable of detecting the trajectory. Accordingly, the number of cluster increase which results in more data message transmission in the cluster. After all, as the number of message increase, the probability of packet collision increases, and packet delivery ratio falls down as a result.

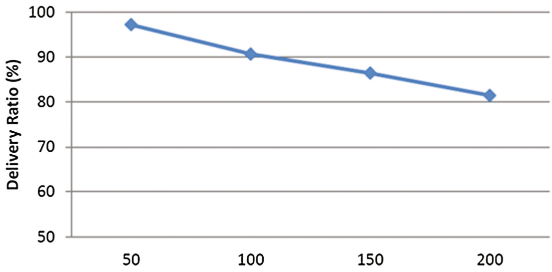


Fig. 7. Packet Delivery Ratio with the effect of network density

5 Conclusions

The vision of V2V Communication in general interested most of the researchers in the automotive industry. Their standardization activities are based on the IEEE 802.11 topology, and will have an opportunity to exchange information among themselves, road sensors and traffic signs by vehicular communication network. In this research paper a small prototype communication network model in highway environment is presented, and also proposed a distributed cluster algorithm for area of vehicular network. Considering the highly dynamic nature of the vehicular network, we emphasize the robustness of the resulting clustering. Network criticality is a global metric that quantifies the robustness of network topology against the variable environment in the network topology. In addition, in the proposed clustering by Fig. 2 that we derived new concept with DCA. For the distributed case, we localize the connection of V2V network and use as a metric for DCA. DCA significantly improves the time of clusters and state change times for vehicle trajectory. It is more suitable for mobile wireless networks such as multi-hop, Ad-hoc network and so on, but our research prototype is limited vehicular communication environment in real world. Nevertheless, we are anticipated in developing in future applications and expansion for vehicle infrastructure.

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