Clustering In VANETs

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***Abstract*—We present our proposed algorithm in this paper, a reactive Location Routing Algorithm with Directional Cluster-Based Flooding (LORA-DCBF) for inter-vehicle communication in the context of optimizing traffic flow and increasing vehicular safety. We consider the performance and motorway environment with associated high mobility in highway and compare LORA-DCBF with Location Routing Algorithm with Cluster-Based Flooding(LORA-CBF).In our proposed algorithm, it is possible to have more than one cluster heads in the limited area, but with two opposite direction, this strategy have more stability in the clusters form and more effective. We use a microscopic traffic model, developed in OPNET, to simulate our proposed algorithm to validate our research and shows that LORA-DCBF is more effective in Vehicular communications.**

Keywords—Location routing algorithm with directional cluster based flooding, Ad-Hoc networks, VANET networks, inter-vehicular communication, rotating.

I. INTRODUCTION

Generic routing protocols have the design goals of optimality, simplicity and low overhead, robustness and stability, rapid convergence, and flexibility [1]. However, since mobile nodes have less available power, processing speed and memory, low overhead becomes more important than in fixed networks. The high mobility present in vehicle-to-vehicle communication also places great importance on rapid convergence [2]. Therefore, it is imperative that ad-hoc protocols deal with any inherent delays in the underlying technology, be able to deal with varying degrees of mobility, and be sufficiently robust in the face of potential transmission loss due to drop out. In addition, such protocols should also require minimal bandwidth and efficiently route packets [3].

The past few years have witnessed the growth of wireless technologies that have gained increased relevance and acceptance in the form of laptops, PDA's, and personal area networks, all of which require ad-hoc connectivity [4]. The areas of personal computing and communications are converging and evolving to create new patterns of technological deployment and human behavior because of communication-enabled technology [5]. Our hypothesis is that a vehicular point-to-multipoint deployment is likely to become the first properly mature ad-hoc implementation of these emerging technologies [6].

Economic costs due to transportation delays are reflected in the billions of dollars spent on construction projects and the resulting loss of productivity caused by billions of man hours of lost time on the congested streets and freeways, not to mention health costs related to increased air pollution levels and fuel consumption of stationary automobiles [7]. Presently, according to model simulations, the most common cause of transportation delay in the United States is vehicular accidents, representing nearly 40 percent of nonrecurring delays of freeways and principal arteries.

Although passive safety systems such as seat belts and air bags have been used to significantly reduce the total number of major injuries and deaths due to motor vehicle accidents, they do not improve traffic flow or lower the actual number of automobile collisions [8]. In order to actually lower the number of vehicular accidents, computer and network experts propose active safety systems, including Intelligent Transportation Systems (ITS) that are based on Inter-vehicle Communication (IVC) and Vehicle-to- Roadside Communication (VRC). Presently, technologies related to these architectures and their related technologies may, in the future, significantly optimize traffic flow, which, in turn, can have important economic and safety ramifications [9].

Active vehicular systems employ wireless ad-hoc networks and Geographic Positioning System (GPS) to determine and maintain the inter-vehicular separation necessary to insure the one hop and multi hop communications needed to maintain spacing between vehicles [10]. Location based routing algorithms form the basis of any Vehicular Ad-hoc Network (VANET) because of the flexibility and efficiency they provide with regards inter-vehicular communication. Although several location-based algorithms already exist, including Grid Location Service (GLS), Location Aided Routing (LAR), Greedy Perimeter Stateless Routing (GPSR), and Distance Routing Effect Algorithm for Mobility (DREAM) to name a few.

This paper proposes a Location-Based Routing Algorithm with Cluster-Based Flooding (LORA-CBF) as an option for present and future automotive applications due to the following three advantages:

1. It employs local information to improve the traditional routing used in non-positional algorithms
2. It minimizes flooding of its control traffic by using only the selected nodes, called gateways nodes, to disseminate its messages.
3. We can have two cluster head in limited area with two opposite directions so will have more stability in clusters form.

II. LORA-DCBF SUGGESTED PROTOCOL

LORA-CBF is formed with one cluster head, zero or more members in every cluster and one or more gateways to communicate with other cluster heads. Each cluster head maintains a "Cluster Table," which is a table that contains the addresses, directions and geographic locations of the member and gateway nodes [11].

We propose a reactive algorithm for mobile wireless ad-hoc networks, which we have called Location Routing Algorithm with Directional Cluster-Based Flooding (LORA_DCBF). The algorithm inherits the properties of reactive routing algorithms and has the advantage of acquiring routing information only when a route is needed [12]. LORA_DCBF has the following features: Firstly, this protocol improves the traditional routing algorithms, based on non-positional algorithms, by making use of location information provided by GPS. Secondly, it minimizes flooding of its Location Request (LREQ) packets. Flooding, therefore, is directive for control traffic as it uses only the selected nodes, called gateways, to diffuse LREQ messages. The function of gateway nodes is to minimize the flooding of broadcast messages in the network by reducing duplicate retransmissions in the same region. Member nodes are converted into gateways when they receive messages from more than one cluster head. All the members in the cluster read and process the packet, but do not retransmit the broadcast message**.** This technique significantly reduces the number of retransmissions in a flooding or broadcast procedure in dense networks. Therefore, only gateway nodes retransmit packets between clusters (hierarchical organization) [13]. Moreover, gateways only retransmit a packet from one gateway to another in order to minimize unnecessary retransmissions, and only if the gateway belongs to a different cluster head and the direction of packet receiving is same with itself.

Apart from normal Hello messages, the protocol does not generate extra control traffic in response to link failures and additions. Thus, it is suitable for networks with high rates of geographical changes. As the protocol keeps only the location information of the [source, destination] pairs in the network, the protocol is particularly suitable for large and dense networks with very high mobility.

The protocol is also designed to work in a completely distributed manner and does not depend upon any central entity. The protocol does not require reliable transmission for its control messages, because each node sends its control messages periodically and can, therefore, sustain some packet loss. This is, of course, important in radio networks like the one being considered here, where deep fades are possible.

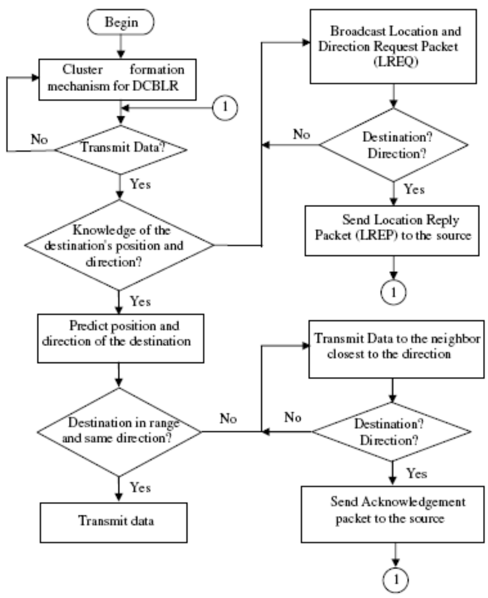
The algorithm we propose in this work does not operate in a source routing manner. Instead, it performs hop-by-hop routing as each node uses its most recent location information of its neighbor nodes to route a packet. Hence, when a node is moving, its position and direction is registered in a routing table so that the movements can be predicted, which is necessary to correctly route the packets to the next hop to the destination.

Upon receiving a location request, each cluster head checks to see if the destination is a member of its cluster. Success triggers a Location Reply (LREP) packet that returns to the sender using geographic routing, because each node knows the position and direction of the source and the closest neighbor based on the information from the LREQ received and the Simple Location Service (SLS). Failure triggers retransmissions by the cluster head to adjacent cluster-heads (Reactive Location Service, RLS). The destination address is recorded in the packet. Cluster-heads and gateways, therefore, discard a request packet that they have already seen. Once the source receives the location of the destination, it retrieves the data packet from its buffer and sends it to the closest neighbor to the destination.

Basically, the algorithm consists of four stages:

1. Cluster formation
2. Location and Direction discovery (LREQ and LREP)
3. Routing of data packets
4. Maintenance of location information.

Figure 1 shows the flow diagram of LORA-DCBF Algorithm.



A. Cluster Formation

The LORA_DCBF algorithm initializes by first forming clusters. When the communications start, every node begins as undecided, starts a timer, and broadcasts a Hello message [14]. If the undecided node receives a Hello message from a cluster head before the timer expires, it becomes a member. Otherwise, it becomes a cluster head.

Cluster heads are responsible for their clusters and have to send a Hello Message periodically. When a member receives a Hello message, it registers the cluster head and responds with a reply Hello message. The cluster head then updates the Cluster Table with the address, position (longitude and latitude) and direction of every member in the cluster. When a member receives a Hello packet from a different cluster head, it first registers the cluster head and changes its status to a gateway and broadcasts the new information to the cluster heads. After receiving the Hello packet, the cluster head updates the Cluster Table with the new information.

In the case where the source wants to send a message to the destination, it first checks its routing table to determine if it has a “fresh” route to the destination. If it does, it first searches its Cluster Table to determine the closest neighbor to the destination. Otherwise, it starts the location discovery process.

B. Location and Direction discovery (LREQ and LREP)

When the source of the data packet wants to transmit to a destination that is not included in its routing table, or if its route has expired, it first puts the data packet in its buffer and broadcasts a Location Request (LREQ) packet.

When a cluster head receives a LREQ packet, it checks the identification field of the packet to determine if it has previously seen the LREQ packet. If it has, it discards the packet. Otherwise, if the destination node is a member of the cluster head, it unicasts the Location Reply (LREP) packet to the source node.

If the destination node is not a member of the cluster head, it first records the address and direction of the LREQ packet in its list and if the source is the same direction with the source, it will be rebroadcasts the LREQ packet to its neighboring cluster heads, otherwise it discards the packet.

Each cluster head node forwards the packet only once. The packets are broadcast only to the neighboring cluster head by means of a directional antenna that routes them via the gateway nodes. Gateways only retransmit a packet from one gateway to another in order to minimize unnecessary retransmissions, and only if the gateway belongs to a different cluster head. When the cluster head destination receives the LREQ packet, it records the source address, direction and location. From this, the destination’s cluster head can determine the location of the source node. The destination then sends a LREP message back to the source via its closest neighbor.

Finally, the packet reaches the source node that originated the request packet. If the source node does not receive any LREP after sending out a LREQ for a set period of time, it goes into an exponential back off before re-transmitting the LREQ. Hence, only one packet is transmitted back to the source node. The reply packet does not have to maintain a routing path from the source to the destination, and the path is determined from the location information given by the source node. It is important to note that the path traversed by the LREQ may be different from that traveled by the LREP.

C. Routing of data packets

The actual routing of data packets is then based on the location of source, destination and neighbors and directions of source and destination. Since the protocol is not based on source routing, packets travel the path from source to a destination based on locations. The packets find paths to the destinations individually each time they transmit between the source and the destination. Packets are transmitted based on the knowledge of their relative position. Because the transmission is in the direction of the destination node, the path found will be shorter and stronger than in other routing mechanisms. In non-positional-based Routing strategies, the shortest path is measured in hops. Therefore, the path found may not be the shortest, but the path found using location information will be significantly shorter. If the source of the data packet does not receive the acknowledgement packet before its timer expires, it will retransmit the data packet again. This situation might occur during packet loss due to drop out or network disconnection.

D. Maintenance of location information

The LORA_DCBF algorithm is suitable for networks with very fast mobile nodes because it maintains and updates the direction and location information of the source and the destination every time the pairs send or receive data and acknowledgment packets. The source updates its direction and location information before sending each data packet. When the destination receives the data packet, its direction and location information is updated and an acknowledgment packet is sent to the source.

LORA_DCBF uses MFR (most forward within radius) as its forwarding strategy. In MFR the packet is sent to the neighbor with the greatest progress to the destination. The advantage of this method is that it decreases the probability of collision and end-to-end delay between the source and the destination.

III. NEIGHBOR SENSING

Each node must detect the neighbor nodes with which it has a direct link. To accomplish this, each node periodically broadcasts a Hello message, containing its location information, address, direction and status. These control messages are transmitted in broadcast mode in one direction and received by all one-hop neighbors that they located in same direction with the source, but they are not relayed to any further nodes. A Hello message contains the following information:

- Node Address.
- Type of node (Undecided, Member, Gateway or Cluster head)
- Location (Latitude and Longitude)
- Node moving direction.

A. Forwarding strategy

LORA_DCBF uses MFR (most forward within radius) as its forwarding strategy. In MFR the packet is sent to the neighbor with the greatest progress to the destination. The advantage of this method is that it decreases the probability of collision and end-to-end delay between the source and the destination.

IV. LORA-DCBF IN COMPARE WITH LORA-CBF

To validate LORA-DCBF, we compared LORA-DCBF against the results of LORA-CBF algorithm. The simulator for evaluating two routing protocols is implemented in OPNET. The simulation models a network of 250 mobiles nodes, moving around a 6283 m length circular road.

The LORA-DCBF and LORA-CBF algorithms employed periodic beaconing to inform neighboring nodes about their presence and both used source-initiated on-demand ad hoc routing protocols to discover routes and they make use of their predictive algorithm to select the best route based on the geographic locations of their neighbor nodes. The main difference here is that LORA-CBF makes the cluster that each cluster has the cluster members with different mobility direction. On the other hand LORA-DCBF makes use of member direction to form the cluster that cluster head and all the cluster members move in same direction. So we could have two cluster head near each other in a geographical limited area, but they must be in different mobility direction.

Figure 2 and 3 show routing overhead result for LORA-CBF and LORA-DCBF. Results show similar behavior for two algorithms, but LORA-CBF has slightly greater routing overhead compared with Routing Overhead.

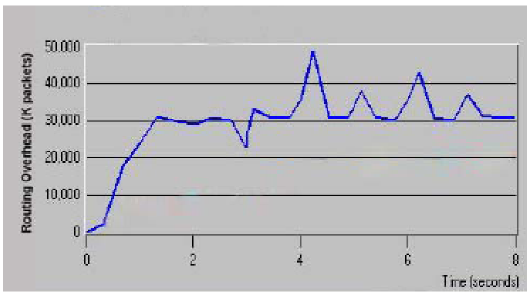


Figure 2. LORA-CBF Routing Overhead

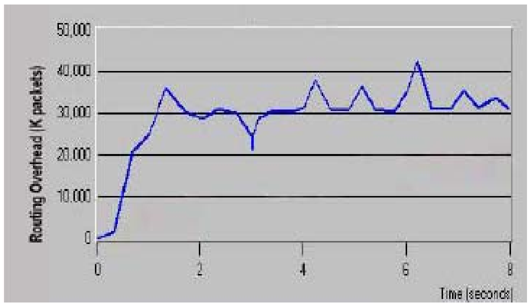


Figure 3. LORA-DCBF Routing Overhead

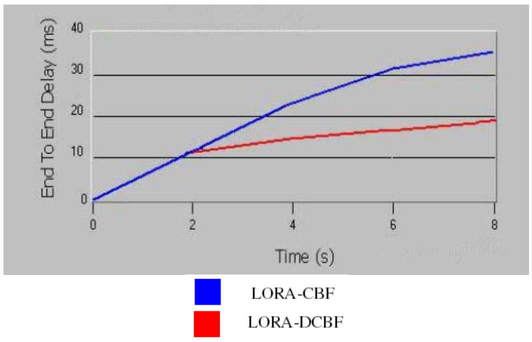


Figure 4. End to End Delay

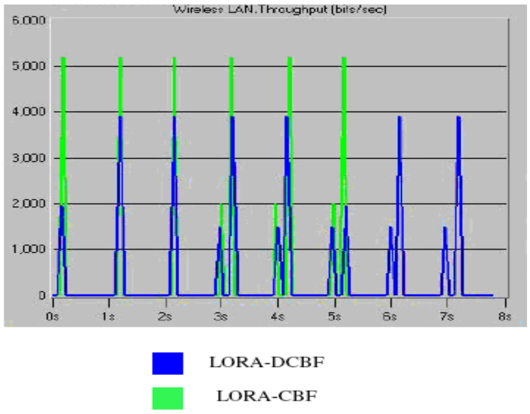


Figure 5.Throughput

End-to-End delay (EED), which is presented in Figure 4, LORA-DCBF performs better because it has the more stable cluster formation.

Figure 5 compares the throughput of the algorithms considered. LORA_DCBF shows good results, because one of the factor for LORA_DCBF is to select the cluster based on node direction so it make a robustness rout between cluster head and cluster member.

V. CONCLUSIONS AND FUTURE WORK

In the near future, automobiles may have factory installed wireless ad-hoc network capabilities to improve traffic flow and safety, in part, because it is more cost effective than continually undertaking massive construction projects, which are proving to have limited success. Consequently, future developments in automobile manufacturing will include new communication technologies to help provide more effective spacing and collision avoidance systems. In order to avoid communication costs and guarantee the low delays required for the exchange of safety-related data between cars, inter-vehicle communication (IVC) systems based on wireless ad-hoc networks represent a promising solution for future road communication scenarios, as it permits vehicles to organize themselves locally in ad-hoc networks without any pre-installed infrastructure.

LORA-DCBF is an algorithm that can possibly be used in future wireless ad-hoc networks because of its reactive geographic routing algorithm, which employs GPS in conjunction with its predictive algorithm, both of which are necessary in mobile networks. Furthermore, LORA-DCBF uses a gateway selection mechanism and direction to determine the cluster to reduce contention in dense networks, which is a predictable scenario in highly congested traffic conditions. Finally, the hierarchical structure of LORA-DCBF facilitates its deployment as part of vehicular ad hoc networks because it requires minimal deployed infrastructure. Future work related to the development of LORA-DCBF will include the integration of GPS, predictive algorithms and geographical maps into a sole architecture and deploy it on a test bed.

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