Using a Short-Term Predictive Algorithm to Improve the Communication's Speed in Fast Mobile Ad-Hoc Networks

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Abstract: In this paper, we present a distributed and reactive routing algorithm for fast mobile ad-hoc networks. Based on previous simulations' results on CBLR algorithm, we outperform the communication's speed using a short-term predictive algorithm. To evaluate the algorithm on fast mobile ad-hoc networks, we developed a microscopic traffic model to represent the mobility of the vehicles on motorways. Finally, we evaluate the algorithm over three different scenarios based on four parameters: Route Discovery (RD) time, End-to-End Delay (EED), Number of retransmissions and Average Data Throughput.

1. Introduction

Ad-hoc wireless networks are defined like the integration of two or more devices equipped with wireless and networking capabilities. Such devices can communicate with another node that is immediately within their radio range or one that is outside their radio range. For the latter scenario, an intermediate node is used to relay or forward the packet from the source toward the destination.

Many algorithms for ad-hoc networks have been established, and they can be classified as proactive and reactive [1-4]. Proactive algorithms maintain route on a continuous basis. Thus, when the source node needs to send information to the destination, the route to the next hop can be used immediately. On the other hand, in reactive algorithms, before sending the information, the sender needs to initialise a Route Discovery (RD) phase. A deficiency of Mobile Ad-hoc NETwork (MANET) routing algorithms is that they do not account for the geographic location of mobile nodes. Because of this, some routing algorithms based on location information have been proposed [5-6]. This kind of routing algorithms is more suitable for networks with high mobility.

Until now, results for the characterisation of inter-vehicular data traffic on a motorway using ad-hoc networks over IEEE 802.11b radios are limited. We have shown some preliminary results in [7], and in this paper we have introduced a microscopic traffic simulation model to represent the mobility of the vehicles on motorways.

The rest of the paper is organised as follows. In section 2, one of the versions of the Cluster-Based Location Routing algorithm is introduced. In section 3, we show the scenarios evaluated and results obtained; finally, in section 4, we present our conclusions and discussion of the future work.

2. Cluster-Based Location Routing (CBLR) Algorithm

The Cluster-Based Location Routing (CBLR) algorithm can be classified as distribute, reactive and based on location information of the mobile nodes. The first version of CBLR algorithm [7] has the disadvantage of predicting the position of the next hop. That issue limited the possibility of transferring information in speed higher than 30 m/s. Another improvement in this work is the radio utilized for communication. In [7] the radio utilized was IEE 802.11 and in this work we have evaluated the communication with IEEE 802.11b.

This version of CBLR algorithm is formed with one cluster-head and one or more members in every cluster. Each cluster-head maintains a "Cluster Table". A "Cluster Table" is defined as a table that contains the addresses and geographic locations of the "member nodes". We have assumed that all nodes can gather their positions via GPS or some local coordinate system. The cluster-head also maintains a Cluster Neighbour Table that contains information about the neighbouring clusters (addresses and geographic locations). For each neighbouring cluster, the table has an entry that contains the member or members through which the cluster-head can be reached.

Basically, the algorithm consists in four stages:

1. **Formation of clusters.**
2. **Location discovery (LREQ and LREP).**
3. **Routing of data packets.**
4. **Maintenance of location information.**

2.1 Formation of clusters.

Every node when the communications start, begins like Undecided; starts a timer and broadcasts a "Hello" message. If the Undecided node receives a "Hello" message from a cluster-head before the timer expired. it becomes a Member otherwise; it becomes a cluster-head.

The cluster-head is responsible for the cluster and has to send every period of time a Hello Message, when one member receives the Hello Message it registers the cluster-head and responds with a Reply Hello Message, then the cluster-head updates the Cluster Table with the address and position (longitude and latitude) of every member in the cluster.

When one member receives a Hello packet from a different cluster-head, it broadcasts the new information to the cluster-heads allowing them to update its Cluster Neighbour Table and communicate via the member.

2.2 Location discovery.

When the source of the data packet wants to transmit to a destination that is not included in its Routing Table, 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 seen the LREQ packet before. 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.

Each cluster-head node forwards the packet only once. The packets are broadcasted only to the neighbouring cluster-head, by means of using omni-directional antennas to route them via the member nodes. When the cluster-head destination receives the LREQ packet, it records the source address and location. From this, the destination's cluster-head knows the location of source node. The destination's cluster-head then sends a LREP message back to the source via its neighbouring cluster-heads.

Finally, the packet reaches the source node that had 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. The path is determined from the location information given by the source node. The path traversed by the LREQ may be different from that traversed by the LREP.

2.3 Routing of Data Packets.

Mobility of nodes may cause loss of information being transferred and this is a very important aspect to consider in the development of routing algorithms. In our CBLR algorithm we address this problem using a predictive algorithm (Figure 1).

Selecting the right predictive algorithm depends on at least two factors: the time of the prediction and the type of data. The first factor can be divided into short-term prediction and long term prediction. A difficulty is to decide the precise meaning to both terms. In the context of computer systems, it is reasonable to assume short-term prediction in the range of seconds, minutes or hours and long term-prediction in the range of days, weeks or months. The second factor can be either numeric or Boolean. We have considered an algorithm that copes with short-term prediction of system events and numerical data.

The predictive algorithm tries to extrapolate the position of the next hop k positions ahead in time. For example, a simple technique is to assume the data follow a linear trend.

$P_{j+k} = P_j + ?P * e$ ………….. (1)

Where:

P_{j+k} future position of the next hop, P_j current position of the next hop.

? P interval between current position and previous position of the next hop.

e factor indicating the period of time of packet lost.

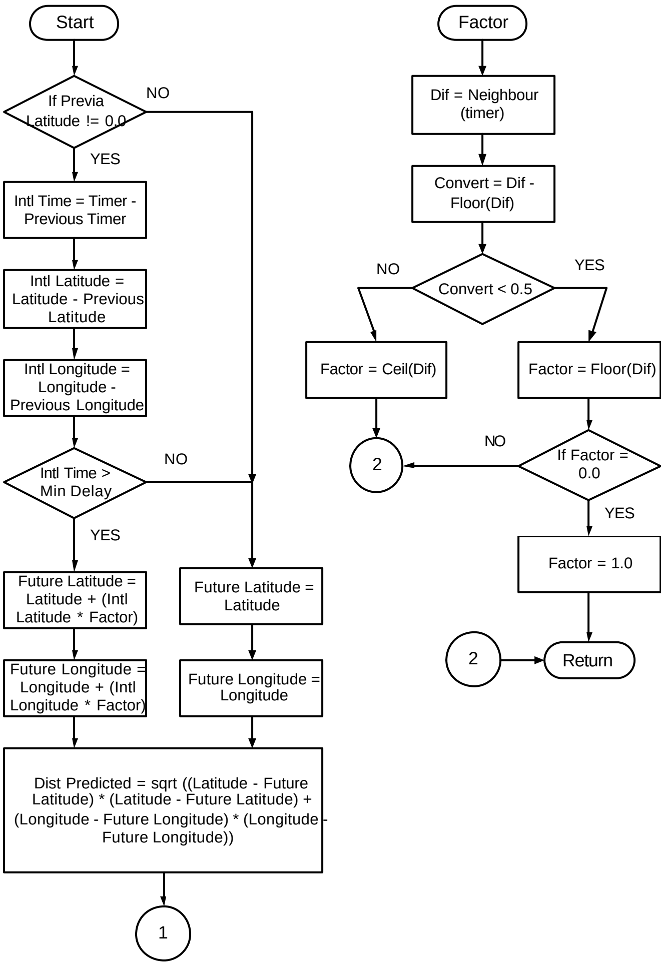


Fig. 1: Short-term predictive algorithm.

In CBLR, a hello message is broadcasted every period of time. Every node keeps the location's information of every neighbour from which it has received hello messages. When the node receives a packet for a different node, before retransmitting it, the node predicts the locations of that node based on the previous locations. If it predicts that the node is in its range, it sends the packet directly, otherwise it finds a closest node to the next node. In wireless networks based on contentions, it is common that packet are lost, the predictive algorithm also addresses this difficulty calculating the period of time that the node has received the last hello packet from the neighbour node.

2.4 Maintenance of location information.

CBLR algorithm is suitable for networks with very fast mobile nodes, because it maintains the location information of the source and destination, during the interval of transmission of data. The source updates its location information before sending every data packet, when the destination receives the data packet; it updates its location information and replies with an acknowledgment packet to the source.

3. SCENARIOS EVALUATED

We have considered three different scenarios with vehicles moving in opposite directions (Fig. 2).

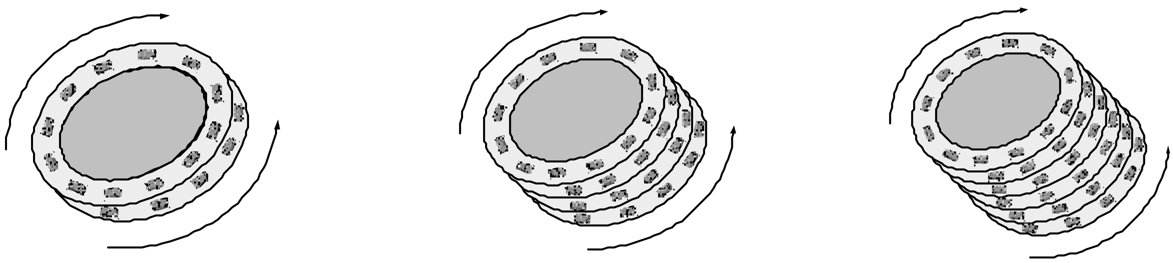
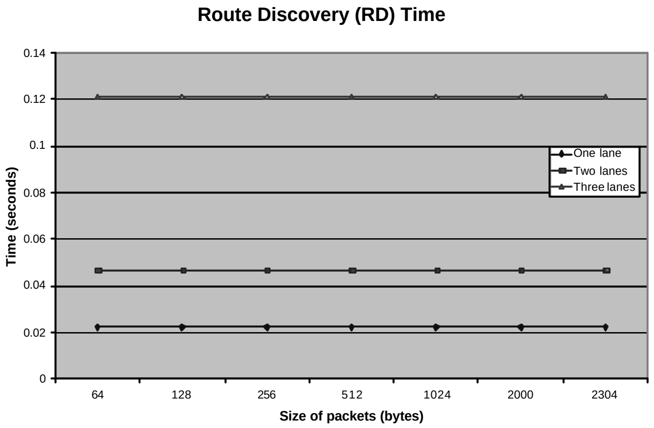
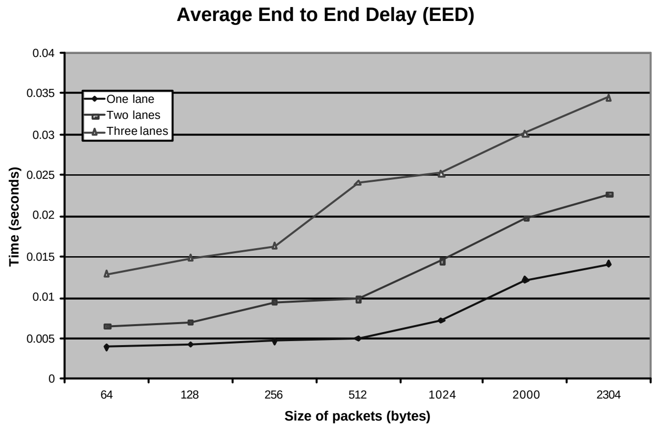


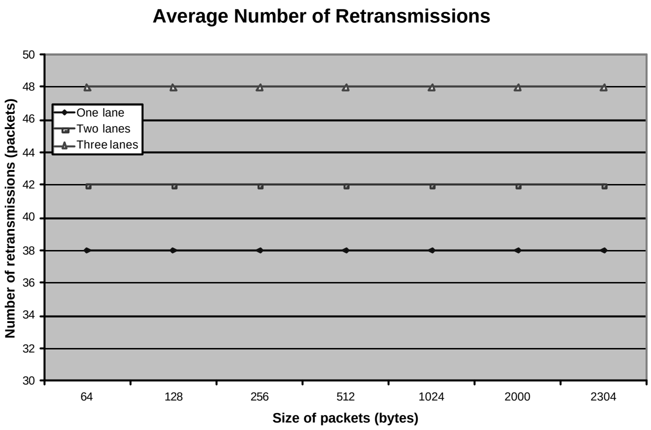
Figure 2. Scenarios evaluated. Vehicles are considered to be arranged in an endless loop. Only speed is considered.

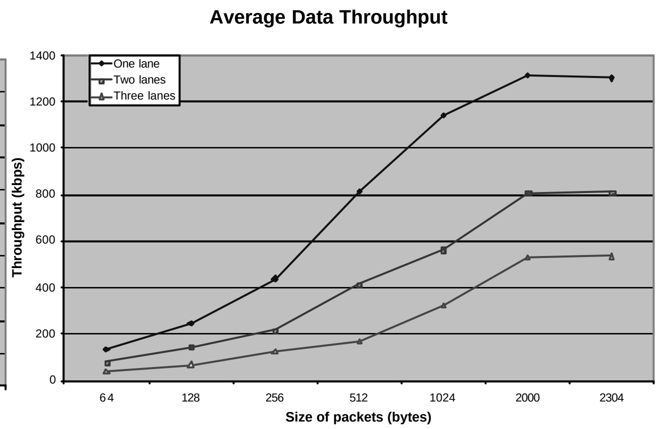
Figure 2 shows the scenarios evaluated with 64, 128 and 192 vehicles respectively and a length of 4.8 km. The circular topology allows a non-causal system to be considered but can reasonably be used to represent one, two and three lanes of a motorway. The transmission range for every wireless card in each vehicle is 300 m and they are spaced 150 m from each other when the simulation starts.

Results Obtained by Simulations Using OPNET 9.0.C









4. CONCLUSIONS AND FUTURE WORK

Using a short-term predictive algorithm, we increase the transmission speed from 30 m/s to an average speed of 42 m/s in this work. The throughput in all scenarios is 100%. The source transmits 100 packets and the receiver receives the same number of packets. In terms of route discovery (RD) time and retransmissions, the sizes of the packets do not impact with he result obtained by simulations. The average end-to-end delay increases with the size and number of vehicles. Finally, the average data throughput decreases with the number of vehicles. Our future work will be focused in reduce the route discovery time (RD) and the number of retransmissions.

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