A New Information Propagation Scheme for Vehicular Networks[1]

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A goal in Vehicular Ad hoc Networks (VANETs) is to enable the dissemination of traffic and road conditions such as local congestion and surface ice as detected by independently moving vehicles sometimes called Information Warning Functions (IWF) [1]. Enabling data propagation in a VANET is challenging due to the existence of partitions between nodes described as network fragmentation. Existing routing protocols are based on the formation of an end-to-end path between source and destination or rely on a naming scheme and few exploit the mobility of nodes in a VANET. Resource discovery and naming are problematic under the presence of frequent and rapid arrivals and departures. Related work on this problem is designed to provide Internet services to vehicles through the use of roadside access points which bridges local VANETs to achieve connection-oriented traffic. In this work, we focus on providing IWFs without the use of fixed infrastructure such as access points or satellite communication. We propose a new scheme called Directional Propagation Protocol which is based on the concepts of custody transfer mechanism adopted from Delay Tolerant Networking (DTN) research, cluster formation and the use of attribute based data from MANET methodologies.Each is described next.

Clustering: Vehicles on directed pathways that are within symmetric communication range of one another form interconnected blocks of vehicles as shown in Fig. 1(a). Clusters are defined as groups of nodes that form within blocks (blocks can be comprised of multiple clusters traveling in the same direction). There are many techniques for cluster formation; we adopt the technique of Lin and Gerla [5]. Each block has a header and trailer node located at the head and tail of a cluster respectively, that perform the message transmission

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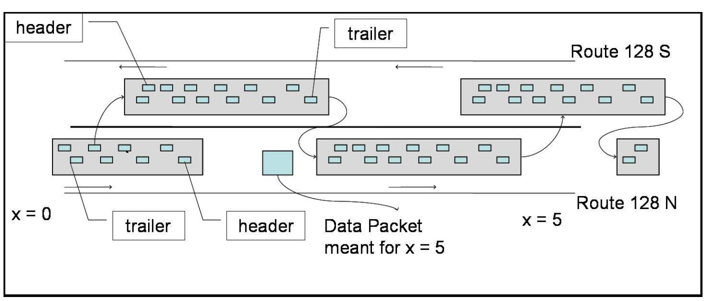
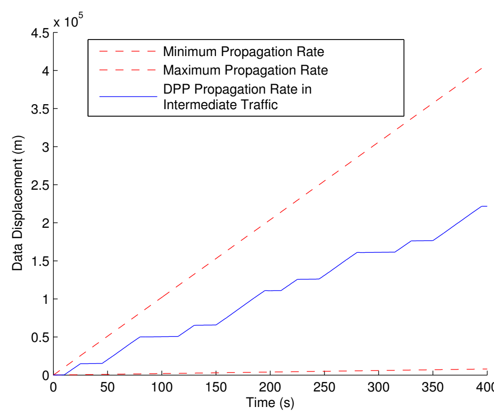
and routing functions.

Custody Transfer Mechanism: We use a custody transfer mechanism adopted from DTN techniques [3]. With such a scheme, a message is buffered for retransmission from the originating cluster until it receives an acknowledgment from the next-hop cluster. In the scenario under consideration, the goal is to propagate data in a single direction. Thus, a cluster does not relinquish custody to another cluster traveling in the opposing direction.

Attribute Based Routing: Attribute based routing concept involves embedding local information in messages to enable each node in the system to make routing decisions based on these attributes and its own state at that instant. Instead of adopting a global naming scheme and maintaining extensive routing tables, we propose to use attribute based data to perform routing. As an example, the TTL (time to live parameter) for each message is a function of time and distance defining the time and distance range for which the data is valid. Thus, the attribute based routing enables the convergence of various techniques and execution of the proposed propagation scheme.



(a)



(b)

Figure 1: (a)Blocks of Vehicles depicted on a highway each having a header and a trailer propagating attribute based data in forward direction (b)Forward Propagation:Data Displacement vs. Time

Data dissemination is directional, forwards or backwards. In forward propagation, a vehicle is assumed to be traveling in a direction (for example, North – N) and data are intended to be propagated in the N direction. The directional information and intended class of recipients for the message are embedded as attributes in the data. The data are propagated to the header of the cluster, which based on own local attributes, attempts to propagate the data further along the N direction by communicating with other clusters located ahead of this cluster. If the clusters are partitioned, the header attempts to use the clusters along the

S direction that may overlap with other clusters along the N direction to bridge this partition. Thus data is forward propagated and custody is transferred once an acknowledgment from the next hop cluster is received, the process being repeated until destination. Within a cluster, the communication is handled by the intra-cluster routing protocol, whereas between clusters we use an inter-cluster routing protocol. The clusters along the S direction provide a temporary path to nodes which were otherwise partitioned.Reverse Propagation, not described here is a special case of forward propagation.

As a measure of performance, we calculate the average message propagation rate of the data in for varying traffic conditions. The vehicles are assumed to be traveling with a constant velocity c m/s. The data propagation rate within a cluster is assumed to be v m/s. A maximum propagation rate of $c + v$ m/s will be achieved in dense traffic conditions when there is an end-to-end path in the form of multi-hop clusters from source to destination. The propagation rate of c m/s, the speed of the original carrier, will be achieved in sparse traffic conditions as there is no data path. In intermediate traffic conditions where there will be instances where there are clusters to bridge the partitions and others where there is no data path to the next cluster. The data propagation rate will vary from c, $c + v$,$-c + v$,$-c$ m/s. This is illustrated in the graph Fig.1(b) for forward propagation.

This average rate will vary for different traffic scenarios and different network conditions but is bounded as shown. For comparative purposes, we have used c, vehicular speed, as 20 m/s and v, RF signal propagation, as 1000 m/s, which are consistent with the values used by Wu et al. [4]. The information propagation speed in this case is an ideal case scenario. More practically, velocity will be constrained by MAC back-offs, collisions, cluster management and other physical layer latencies. A better lower bound can be achieved by using a traffic model that has stochastic arrivals and heterogeneous traffic speeds. The performance of this protocol is also dependent on the size of interconnected blocks on either side of the highway and the occurrence of opportunistic contacts.

In summary, we propose a new algorithm and protocol to enable directional propagation of messages in VANETs without the use of fixed access points. We characterize the upper and lower bounds, and typical performance behavior of the scheme. The cost of message exchange is deterministic and the cost in different scenarios is a function of c, v and the different traffic conditions.

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