A Routing Protocol called AATRoP- to Counter the Problem caused by High Mobility in VANET

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ABSTRACT
VANET uses the concept of vehicle to vehicle connection to communicate between each other. Here each vehicle behaves like a wireless router and performs the function of data and information transfer between them. Routing is one of the key research issues in VANETs as it plays an important role in public safety, data transfer and commercial applications. In VANET, routing of data is a challenging task due to high speed of nodes (i.e., vehicles) movement and rapidly changing topology. Recent research showed that existing routing algorithm solutions for Mobile Ad Hoc Networks (MANETs) such as DSR and AODV are not able to meet the unique requirements of vehicular networks. We identify three very different conditions that a vehicular broadcast protocol needs to work in: i) dense traffic regime; ii) sparse traffic regime; and iii) regular traffic regime. In this paper, we study the existing protocols namely GSR, GPSR (GPCR) and A-STAR and propose the design of a new protocol which incorporates and integrates the use of these existing routing protocols.

General Terms
VANET, Routing, Network Topology, Intelligent Transport System, GPS.

Keywords
VANET, Routing Protocol, A-star, high mobility.

1. INTRODUCTION
Vehicular Ad Hoc Networks (VANETs) are special case of Mobile Ad Hoc Networks (MANETs). VANETs are distributed, self-organizing communication networks between moving vehicles. Broadcasting in vehicular ad hoc networks (VANET) is emerging as a critical area of research. At a fundamental level, safety and transport efficiency is a mandate for current vehicle manufacturers and this has to be provided by the vehicles on the road as well as air as opposed to also using the existing wireless communications infrastructure.

In this paper, we compare the existing routing protocols i.e. Geographic Source Routing (GSR), Greedy Perimeter Stateless Routing (GPSR) and Anchor-based Street and Traffic Aware Routing (A-STAR) and propose a new routing technique, Anchor-based Aerial Traffic Routing Protocol (AATROP) which accounts for the wireless communication in aeroplanes through the air-surveillance systems for particular areas to prevent hazards such as plane hijacking.

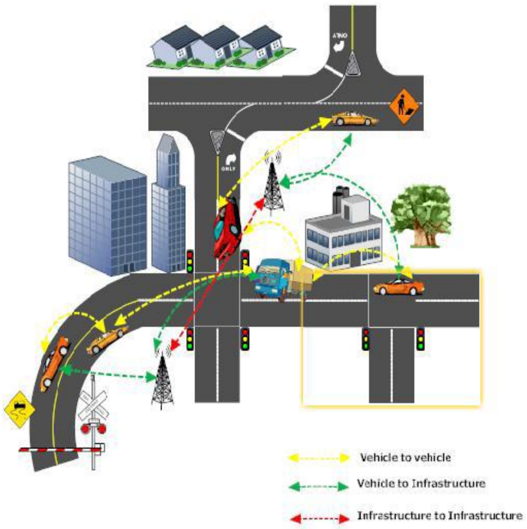
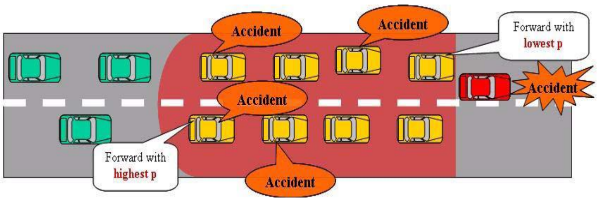


Figure 1: Vehicular Ad Hoc Network overview

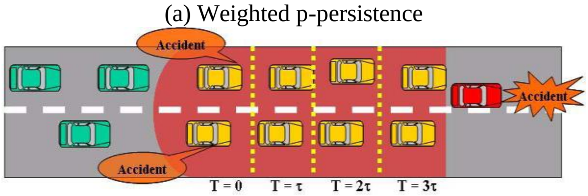
2. DIFFERENET REGIMES FOR BROADCASTING IN VANET
The whole traffic coming for broadcasting can be divided into 3 distinguished categories: dense, sparse and regular, former ones being the extreme conditions.

2.1 Dense Traffic Regime
When the traffic density is above a certain value, one of the most serious problems is the choking of the shared medium by an excessive number of the same safety broadcast message by several consecutive cars. Because of the shared wireless medium, blindly broadcasting the packets may lead to frequent contention and collisions in transmission among neighboring nodes. This problem is sometimes referred to as *broadcast storm problem*[1].
Observe that the slotted p-persistence scheme can substantially reduce the packet loss ratio at the expense of a slight increase in total delay and reduced penetration rate.

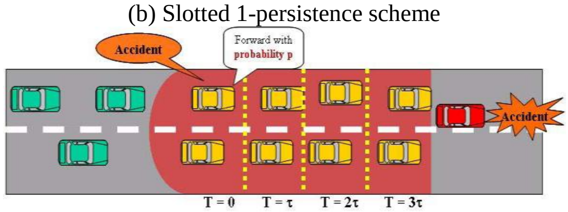
2.2 Sparse Traffic Regime
At certain times of the day (e.g., between midnight and 4 am in the morning) the traffic density might be so low that multi-hop relaying from a source (the car trying to broadcast) to the cars coming from behind might not be plausible because the target node might be out of the transmission range (relay range) of the source. To make the situation worse, there might be no cars within the transmission range of the source in the opposite lane either. Under such circumstances, routing and broadcasting becomes a challenging task.



(a) Weighted p-persistence



(b) Slotted 1-persistence scheme



(c) Slotted p-persistence scheme.

Figure.2. Broadcast Suppression Techniques

2.3 Regular Traffic Regime

For both sparse and dense traffic scenarios previously considered, it is likely that the local connectivity experienced by each vehicle in a network would also reflect the global connectivity, e.g., a vehicle in a dense network is likely to observe a dense local topology while vehicles in a sparse network are likely to have zero or only a few neighbours or observe a sparse local topology. More specifically, all vehicles operating in these two extreme regime will observe the same local topology which also reflect the real global topology. In a regular traffic regime, however, not every vehicle see the same local topology, i.e., some may have very few neighbours while some have many neighbours. In this case, some vehicles will have to apply the broadcast suppression algorithm while some will have to store-carry-forward the message in order to preserve the network connectivity.

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3. EXISTING ROUTING PROTOCOLS

3.1 VANET's Characteristics

Unlimited transmission power: Mobile device power issues are not a significant constraint in vehicular Networks, since the node (vehicle) itself can provide continuous power to computing and communication devices.

High computational capability: Operating vehicles can afford significant computing, communication and sensing capabilities.

Predicable Mobility: Unlike classic mobile ad hoc networks, where it is hard to predict the nodes' mobility, vehicles tend to have very predictable movements that are (usually) limited to roadways. The movement of nodes in VANETs is constrained by the layout of roads. The vehicles are communicating among each other directly when they are within the transmission range. Roadway information is often available from positioning systems and map based technologies such as Global Positioning System (GPS).

Potentially large scale: Unlike most ad hoc networks studied in the literature that usually assume a limited network size, vehicular networks can be extended over the entire road network and include many participants.

High Mobility: Vehicular network scenarios are very different from classic ad hoc networks. In VANETs, vehicles can move fast. It can join and leave the network much more frequently than MANETs. On highways, relative speeds of up to 160 km/h may occur, while density of nodes may be 2-3 vehicles in 1 km on low busy roads. On the other hand, in the city, relative speeds can reach up to 40 km/h and nodes' density can be very high, especially during rush hour.

Partitioned network: Vehicular networks will be frequently partitioned. The dynamic nature of traffic may result in large inter-vehicle gaps in sparsely populated scenarios and hence in several isolated clusters of nodes.

Network connectivity: The degree to which network is connected is highly dependent on two factors: the range of wireless links and the fraction of participant vehicles, where only a fraction of vehicles on the road could be equipped with wireless interfaces.

3.2 MANETs Routing Protocols

The routing protocols in MANETs can be classified into two categories, proactive and reactive and they can be classified by their properties.

3.2.1 Proactive routing protocols

The proactive routing protocols are based on the table-driven approach. In Table-Driven routing algorithm (e.g., DSDV [2], OLSR [3]), every node maintains the network topology information in the form of routing tables by periodically exchanging routing information. Routing information is generally flooded in the whole network. Whenever a node requires a path to a destination, it runs an appropriate path-finding algorithm on the topology. Information is maintained even if these paths are not currently used. The main drawback here is that the maintenance of un-used paths may become a significant part of the available bandwidth if the network topology changes frequently. In the case of vehicular networks, the movement of vehicles are extremely so dynamic so that we did not further investigate proactive approaches.

3.2.2 Reactive routing protocols

Reactive routing protocols are based on on-demand approach (e.g., DSR [4], TORA [5], and AODV [6]. Protocols that fall under this category do not maintain network topology information. They obtain the necessary path when it is required, by using a connection establishment process. These protocols do not exchange routing information periodically. Even though the protocol performs well in static and low-mobility environments, performance degrades rapidly with increasing mobility. In this situation, reactive routing approach is fit into very limited number of routes of vehicular communication application. On the other hand, the routing protocol is classified into two approaches; Topology based routing, Position based (geographic) routing. Topology-based routing (e.g., AODV [6]) only considers topology connection of the nodes. The drawback is its large latency.

3.3 VANETs Routing Protocols

3.3.1 Position Based Routing

Position based routing assumes that each node have knowledge about its physical/ geographic position by GPS or by some other position determining services. In it each node also has the knowledge of source, destination and other neighboring nodes. A position based routing protocol consists of many major components such as "*beaconing*", "*location service and servers*" and *"recovery and forwarding strategies".*

Beaconing: In it a node forwards packet with the current physical position and the unique id (IP ADDRESS) to the neighbouring node if node receives beacon from its neighbour. It updates its information in location table.

Location service and servers: When a node does not contain current physical position of a specific node in its location table or want to know current physical position of any specific node then location service assisted to find current position of a specific node.

Forwarding and Recovery strategy: Forwarding and recovery strategy are used to forward data from source to destination node.

3.3.2 Greedy Perimeter Stateless Routing (GPSR)

Working Technique

Greedy Perimeter Stateless Routing (GPSR) is one of the best examples of position based routing. GPSR uses closest neighbor's information of destination in order to forward packet. This method is also known as greedy forwarding. In GPSR each node has knowledge of its current physical position and also the neighboring nodes. The knowledge about node positions provides better routing and also provides knowledge about the destination.

GPSR protocol normally devised in to two groups:

Greedy forwarding: This is used to send data to the closest nodes to destination.

Perimeter forwarding: This is used to such regions where there is no closer node to destination. In other words we can say it is used where greedy forwarding fails.

Issues/ Drawbacks

1. Greedy forwarding measured as unsuitable for the vehicular networks where the nodes are highly mobile and the node may not be able to maintain its next hop neighbours information as the other node may gone out of range due to high mobility. This can lead to data packets loss.
2. The second problem may occur during beaconing mechanism that beacons may lost due to channel destruction or bad signal. This problem can lead to removal of neighbour information from location table.

Hence there is need of such position based routing protocols, which merge position information with the road topological structure in order to make possible vehicular communication in presence of radio obstacles.

3.3.3 Geographic Source Routing (GSR)

Due to deficiencies of GPSR in presence of radio obstacles, network demanded new routing strategies that can compete with challenges occured due to radio obstacles. Therefore, Geographic Source Routing (GSR) is proposed. In city area there are buildings and tress etc that may create problems in direct communication among nodes. Hence, previously proposed protocol GPSR for highways may not perform well in city environment. The motivation for new routing protocol for city is stated below in details.

Working Technique

There are two main issues in the city environment, one is dealing with high mobility issue in the city and other is topology structure of a city. In GSR position based routing is used that support the city map also. Vehicles have navigation system installed so getting map of city is normal. GSR use reactive location service to find the physical location for node. GSR use "*switch back to greedy*" method for local recovery. After a packet reach to its local maximum, it switch back to greedy forwarding.

Issues/Drawbacks

The disturbances due to radio blocking and due to buildings and trees in the city may lead to ineffective working of this protocol.

3.3.4 Anchor-based Street and Traffic Aware Routing (A-STAR)

Similar features as of GSR, with the effective communication between nodes and the updating of the status table.

Working Technique

Same like GSR, A-STAR was proposed for city environment. Both GSR and A-STAR compute the number of junctions to reach the destination but A-STAR also use traffic information and street awareness in path finding. A-STAR uses statically and dynamically rated maps to find the number of junctions. In statistically rated maps, A-STAR uses schedule of buses to ensure the high connectivity. In dynamically rated maps, A-STAR collects the latest information of traffic to find the anchors/junctions to compute the path. It means that connectivity is high on wider roads with high traffic (more vehicles). More vehicles less weight and fewer vehicles more weight. This dynamic process helps this protocol to calculate anchors more accurately.

Local Recovery

A-STAR uses a new recovery method. When a packet face problem to pass from a junction, that junction is marked as "*out of service*" so other packets are restricted to traverse that junction until that junction changed to "*Operational*" state. When any junction is out of order each node in the network is informed about that junction and updates their routing information and city maps by marking that place out of order. Therefore, no node will use that junction as anchor to be traverse to reach destination. When the out of order junction becomes operational each node aware about the usage of that junction and may adopt that junction for forwarding the packet towards destination. So as compared to other position based routing protocols, A-STAR adopt higher connectivity anchor based paths to find the route towards destination in large city environments.

3.4 Gaps of MANETs and VANETs Routing Protocols

3.4.1 MANETs Routing Protocol

•AODV - Large latency of packet transmission
•DSR - Large latency of packet transmission
•OLSR - High bandwidth consumption due to dynamic topology.
•GPSR - Frequent network disconnection, Routing loops, too many hops and Wrong direction.

3.4.2 VANETs Routing Protocol

•GSR - End to end connection is difficult in low traffic density
•GPCR - End to end connection is difficult in low traffic density
•A-STAR - Routing paths are not optimal and results in large delay of packet transmission.

4. ANCHOR-BASED AERIAL TRAFFIC ROUTING PROTOCOL (AATRoP)

4.1 Design Goal

We know that ASTAR has following features:
*It can be successfully applied to areas of dense traffic like those of city limits.
*It can handle with proper methodologies the highly mobile nodes within the network.
When we extend the view of VANET one step further to encompass the vehicles in air we find that ASTAR is best suited routing protocol for transmission of data packets. This is aerial network that operate at higher altitude are also characterized by highly mobile nodes (e .g: aeroplanes).Though the traffic is limited whenever a communication has to be applied to the nodes on ground it is always best suited to use ASTAR protocol which we will reasonably put forward specifically for Arial networks as “Arial Anchor based Traffic Routing Protocol” (AATRoP).The following section describes the working of AATRoP.

4.2 Design Principle

We propose to use a per-hop routing based approach which uses local connectivity information (1-hop neighbour topology) to make a routing decision. The motivation for using local connectivity in this protocol design is to ensure the maximum reachability of the message. In addition, other safety applications also rely on these beaconing messages; therefore, the local connectivity is already a given piece of information which the routing protocol can utilize. We claim that the local topology information is sufficient for proper handling of the local packet.
Information such as global topology (traffic volume/ density, or a more comprehensive n-hop neighbors topology, where n > 1) will be useful for designing a hierarchical protocol. For example, one possible approach is to use the available global information to identify which of the three traffic regimes one is operating in and then augment that with local information that can be obtained via broadcasting periodic hello messages. The coarse information could, in principle, reduce/eliminate the use of periodic hello messages in the dense traffic regime, thus saving bandwidth. However, this approach may not be practical in the early deployment period due to the following reasons:
1. Global topology information may be collected and disseminated by the existing infrastructure.
2. Vehicles may be able to cooperatively exchange the topology information in order to estimate the traffic density.

4.3 AATROP

In this paper, we propose a new VANET protocol known as the AATROP protocol that is *based on the A-STAR* protocol. This protocol enables the communication between nodes with super high mobility. By super high mobility, we are referring to the nodes as aero vehicles such as aeroplanes, jets and helicopters. The air traffic is already considered well connected with the ground stations and the Air Traffic Control (ATC), but still the problem of hijack occurs! So the proposed protocol offers a solution to it. We explain the protocol step by step.

4.3.1 Layers

The protocol works in three different layers, namely upper layer, middle layer and the bottom layer.

Upper Layer
This layer refers to the layer of atmosphere in which aeroplanes fly in a high mobility. This layer defines the projected and current trajectory of the plane as well as accounts for the connection between various interfaces (present in the Middle Layer).

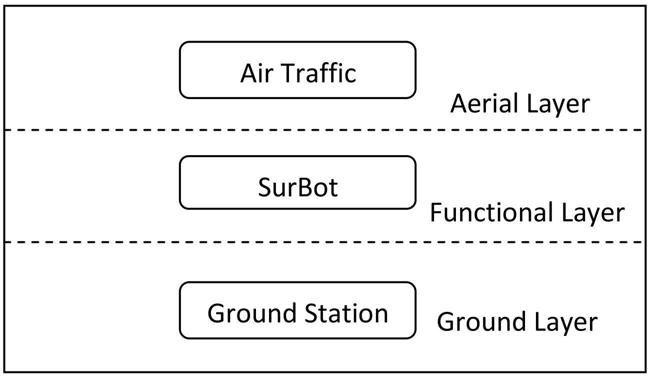

Figure 3: Working Layers of AATROP

Lower Layer
This layer defines the various ground stations pertaining to the area over which the air traffic passes. This ground station receives the info from the middle layer and processes it as required. The ground stations are stationary and monitored by the local area topology, governed by the country in which that area belongs.

Middle Layer
This layer mentions the interface which connects the high mobility air traffic with the stationary ground station. For achieving proper synchronization of the air traffic and ground station, the interface should be mobile too. We propose the interface to be a Surveillance Bot, which is used for surveillance over a pre-defined area and sends the info to the ground station. These special purpose bots act as nodes with low mobility for the highly mobile air traffic.

4.3.2 Surveillance Robot (SurBot)

This is the bot which is designed with a special purpose of monitoring the activities happening in an area. It is interfaced for serial communication with the ground station. This enables the SurBot to send signals to the station. The SurBot is constantly in motion and will be connected to the ground stations, one at a time. When data packet is to be transmitted to destination from an aerial node the next bot will be chosen on the basis of the current topology and updating in the routing table that represents the current network topology. If the transmission is to the aerial node then the header will include the flag indicating this scenario. There will be bots provided for a collection of VANETS on ground and these bots act as super node that encloses a group of or individual vehicles that have agreed to be the part of the network. The bots are fixed in proper orbits and revolve around a specific area. These hovering bots are configured so as to keep track of nearest aerial node. Whenever data is to be transmitted by aerial node, the bot buffers it and sends with a compatible speed to the node on ground only if the intended destination falls under its purview. Otherwise the bot transfers the data to the next bot until the intended receiver‘s bot is found.

4.3.3 Working Technique

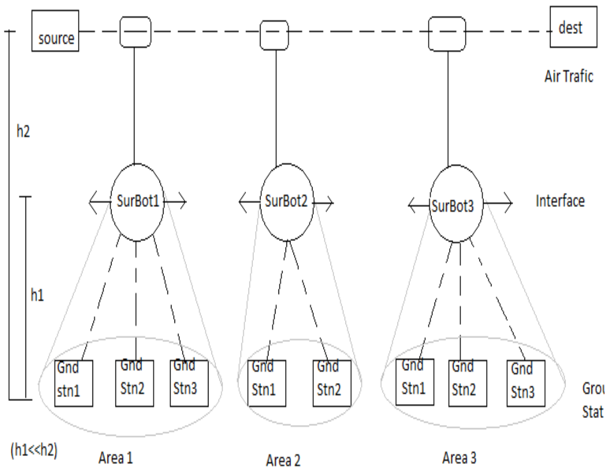

Figure 4: Proposed Working of AATROP

AATROP can be considered as extended version of ASTAR specific ally to accommodate aerial traffic. The protocol transfers data just like how it is done in ASTAR. But there will be an additional need to accommodate the connection between a highly mobile node(s) with those that are comparatively of low speed. A scenario is considered where in a highly mobile node in air wants to establish a communication with a VANET on land. The highly mobile node will always pose a challenge on the tracking of it and sending and receiving data to and from will be difficult as well. We clearly need an interface here that buffers the data apart from keeping the routing information those changes instantaneously making it compatible to the speed of the aerial node. The main job of this interface would be to keep track of the node's greatly changing position and hence this has to be mobile. The whole mechanism transmits data on the underlying principles of ASTAR, and the interface supports a reliable packet transmission from a node with higher mobility to that with the lower mobility.

4.3.4 Validation of the Method

With the sudden change in network topology the data if sent an instant before the change can be successfully routed to the receiver as the data will be sent by the surveillance that keeps polling the aerial node's presence in it's orbit. The surveillance bots then on the basis of the address of the intended receiver will decide on the route to be taken for transmission and if need be send the packet to ground VANET and allow it for further transmission. The flag in the header will now be discarded as it is no more aerial transmission now. The flags will help the bots to identify whether the data is to be routed to aerial nodes or ground nodes. The former requires instantaneous transmission whereas the latter does not.

5. Simulated Result

The data obtained from the air traffic control is used for the simulation. The following graph shows the different trajectories the aircraft had followed and the blue line represent the one obtained from the Surbot which is in close proximity with the actual result.

Figure 5: Simulation of trajectories

6. Conclusion

The protocol clearly tries to successfully handle the transmission and reception of data when the nodes with high speed are present in the network by continuously monitoring for aerial specific node they prove to be aptly suited for aerial traffic. Their position above the ground which is revolutionary around an orbit ensures the fast transfer of data even to the intended receiver on the ground from the aerial node..

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