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Research Challenges of Position Based Routing Protocol in Vehicular Ad hoc Networks

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Abstract: - Vehicular Ad hoc Networks (VANET) has emerged a promising technology to improve the security of highway transport integrating cellular technology, wireless LAN and adhoc network. It becomes an important component of the intelligent transportation system (ITS) .VANETs are different from MANET by its fast vehicles movement, dynamic information exchange, and do not have battery and storage constraints. The approach of finding and maintaining an effective routing protocol for VANETs is vital issues as VANETs show various distinctive networking research challenges. Here, we discuss different issues of position based routing in VANETs, research challenges and future perspective.

Keywords: *VANET, MANET, GPSR, GSR, GSCR, A-STAR*

I. INTRODUCTION

VANET is used to describe ad hoc network spontaneously formed over the vehicles moving on the highway transport. Recently, Inter-Vehicle Communication Systems (IVC) has attracted considerable attention from the research community and automotive industry [1]. VANET (Vehicular Ad-hoc Network) is seen to be one of the most valuable concepts for improving

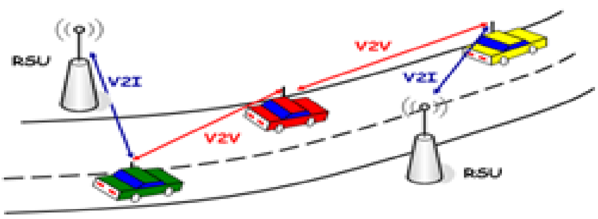


Figure 1: Communication modes of VANET

efficiency and safety of the future transportations, as well as boosting operators' revenue [2]. Vehicular ad hoc network (VANET) is special kind of MANET in which vehicles act as nodes and packets are exchanged between vehicles to facilitate vehicle to vehicle (V2V) and vehicle to roadside communications. VANETs are emerging a promising technology to integrate the effectiveness of new generation wireless networks to vehicles. Analogous to MANET self-organize over an evolving topology, may rely on multi-hop communications, can work without the support of a fixed infrastructure. Nodes (Vehicle) in VANET act as servers or clients for sharing and exchanging information via their shared radio transmission range. There are three communication modes: Vehicle-to-Vehicle (V2V) among vehicles, Vehicle-to-Infrastructure (V2I) between vehicles and Road-Side Units (RSUs), and Vehicle-to-X (V2X) which is mixed V2V-V2I approach as shown in figure 1.According to US highways (2004) statistics, there are almost 42,800 fatalities and more than 2.8 million people injuries. As a result almost $230.6 billion cost to society.In the EU, around 40,000 people die yearly on the roads; more than 1.5 million are injured. Traffic jams generate a tremendous waste of time and of fuel. In 2003, US drivers lost a total of 3.5 billion hours and 5.7 billion gallons of fuel to traffic congestion. If we provide appropriate information to the driver or to the vehicle then it is possible to solve most of these problem.

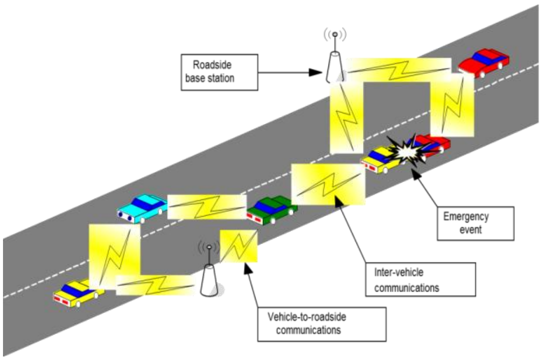


Figure 2: Emergency event occur in highway transport

II. RESEARCH BACKGROUND:

Purpose of VANET is to provide effective, secure and reliable routing algorithm. Many researchers has emphasized in this area. Vanet uses the same principle as Manet. So routing protocols of Manet were applied on Vanet. One popular VANET routing protocol is Ad-hoc On Demand Vector Routing (AODV) presented in [11] which discover a route and establish a path on demand basis. But due to highly dynamic topology and frequently network disconnection, AODV shows that route convergences are very poor and communication throughput is also low in Vanet. Another routing protocol DSR (Dynamic Source Routing) is introduced [13] which reactive in nature. Limitations of DSR are unable to repair link breakage, unnecessary flooding overload the network when there are too many nodes in the network. Namboodiri et al. [3] proposed a routing protocol that is to be only a few hops away from a vehicle to highway. In AODV, created routes can break very frequently due to dynamic nature of topology. To reduce this, two prediction-based AODV protocols are presented. One is PRAODV and PRAODVM. In PRAODV, we can predict the lifetime of a link using speeds and location information of a node. In the estimated lifetime, PRAODV will generate an alternative link and it will choose that link before the link failure. But instead of selecting the shortest path like AODV and PRAOD, among the multiple route options PRAODVM choose a path with maximum predicted lifetime. Vanet is used mainly in two fields. One is Intelligent Transport and another is Comfort Application.

2.1 Intelligent Transport Applications: Intelligent transport application can be considered from the public safety and transport management services point of view.

i. **Public security**: Security applications are the most important VANET application to avoid any hazardous environments. Safety messages can include the following warnings to avoid vehicle accidents in risky locations: traffic signal violation, curve speed, emergency electronic brake lights, pre-crashes, collisions, left turn assistant, lane changes, stop sign movement assistance, and loss of control. Road collision warning systems can reduce the number of vehicle collisions. Obviously security applications have some real-time constraints, as drivers need to inform to the others just up to the information is useful to us.
ii. Traffic management services: Traffic control applications are also time sensitive. This class of application is proposed to increase smooth traffic flow, safety, and comfort of driving, especially in the urban areas. Some of the applications of traffic control are traffic light monitoring and coordination, fastest traffic management, or co-operative cares.

2.2 Comfort Applications:
This class of applications may be intended for passengers to communicate with either other vehicles or ground-based destinations such as Internet hosts or the public service telephone network (PSTN).

i. Vehicle to land-based destination communications is perhaps a very useful capability as it may need to enable the applications such as web browsing, media streaming, email voice over IP etc.
ii. Targeted vehicular communications allow localized communications (potentially multi-hop) between two vehicles for example voice, instant messaging.
iii. Payments of parking can be collected automatically and so conveniently.

iv. Multimedia files such as DVDs, music, news, audio books can be uploaded to the car's entertainment system while the car is in the garage.
v. Infotainment applications offer convenience and comfort to drivers through mobile navigation applications, mobile device integration, and network-based speech processing.

III. Architecture of VANET

VANETs generally do not rely on fixed infrastructure for sharing and exchanging information and apply it to the highly dynamic nature of surface transportation. As shown in Figure 2, classify the VANET architecture into three categories: WLAN/Cellular, Ad hoc, and combination of them called hybrid.

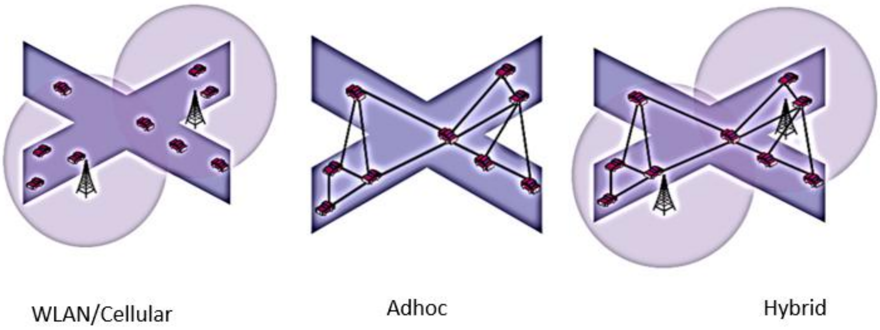


Figure 3: Network architecture of VANET

In WLAN/Cellular, it may use cellular gateways and/or WLAN to connect to the internet, at traffic intersections.VANETs can combine both WLAN and cellular to form the networks so that a WLAN is used where an access point is available and a 3G connection otherwise. Vehicles and road- side wireless devices can form a mobile ad hoc network to perform vehicle-to-vehicle communications. Combining cellular, WLAN and ad hoc networks together implement the Hybrid architecture also been a possible solution for VANETs.

IV. POSITION BASED ROUTING PROTOCOLS OF VANET:

Position based routing protocol uses geographical information in their routing decision can be considered as more appropriate routing protocol for VANET. It uses location information by GPS or street map to select the next forwarding hops. No need to create and maintain global route between the sender and destination. Some of the position based routing algorithms are Greedy Perimeter Stateless Routing (GPSR), Geographic Source Routing (GSR), Greedy Perimeter Coordinator Routing (GPCR), Anchor-based Street and Traffic Aware Routing (A-STAR).

4.1 GPSR (Greedy Perimeter Stateless Routing):

One of the best position based routing algorithm is GPSR. It combines greedy routing with face (perimeter) routing. It uses perimeter mode or face routing when greedy algorithm fails. Assume that a node knows its own location, destination location, and the location of all its neighbours. GPSR perform well for inter-vehicle communication on highways but due to radio obstacle it is not suitable for city environment. In geographic routing it always finds neighbours that are closer to the destination and forward the packets to the neighbours that is closer to the destination. Benefits of geographic routing are node only needs to remember the location info of one-hop neighbours and routing decisions can be dynamically made.

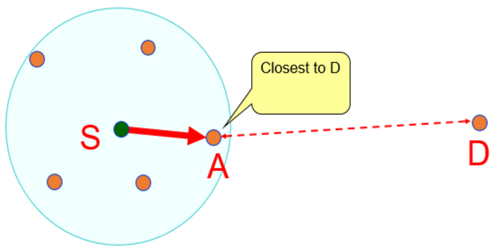


Figure 4: Geographic routing

But the limitation of geographic routing is that it does not always work. There may be a situation when it reaches to a node but node may not find the closest neighbour to the destination. Greedy approach fails in this situation. This situation is called the 'dead end' or local minima or void. Figure 5 shown that greedy algorithm fails that is no neighbour exists which is closer to the destination than itself. To handle this situation Apply the right-hand rule to traverse the edges of a void. When we node becomes local optima then apply right hand rule that is pick the next anticlockwise edge. But limitation of right-hand rule it does not work with cross edges.

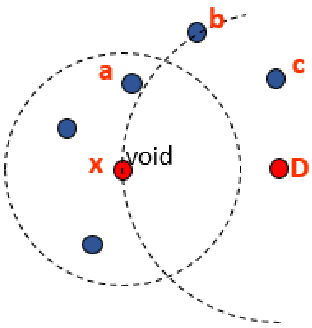


Figure 5.a

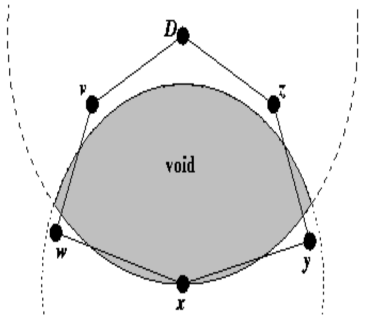


Figure 5.b

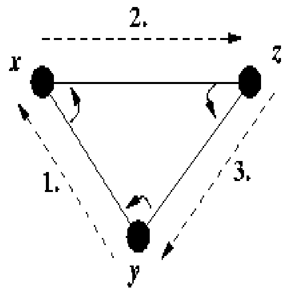


Figure 5.c

Figure 5: 5.a Greedy algorithm fails; 5.b dealing with Void; 5.c right hand rule

So the repair strategy for GPSR is getting around voids using face routing (perimeter-mode forwarding) in planar graphs in figure 6. So we need to make the graph planner.

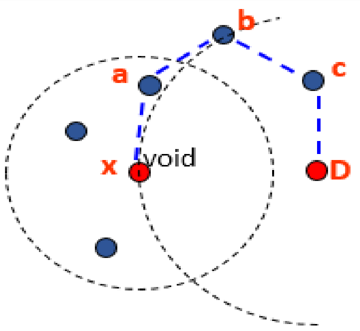


Figure 6.a

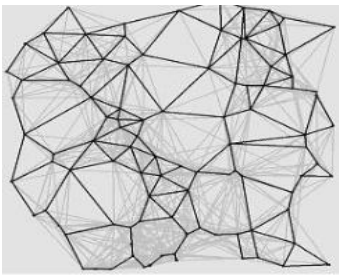


Figure 6.b

Figure 6: 6.a from local minima computes the route in perimeter mode by using right-hand rule around void; 6.b GPSR uses a planer graph traversal technique to forward the perimeter-mode packets To make the graph planner need a planarization algorithm. Convert a connectivity graph to planar non-crossing graph by removing "bad" edges ensuring that original graph will be not disconnected. There are two types of planner graph one is RNG (Relative neighbored graph) and other is GG (Gabriel graph). In RNG, Connection *uv* can exist if $\forall w \neq u, v$, $d(u,v) < \max[d(u,w), d(v,w)]$ as shown in figure 7.a. And in GG an edge (u, v) exists between vertices u and v if no other vertex w is present within the circle whose diameter is uv. $\forall w \neq u, v$, $d^2(u,v) < [d^2(u,w) + d^2(v,w)]$ as shown in figure 7.b.

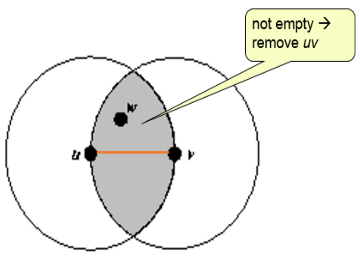


Figure 7.a: RNG

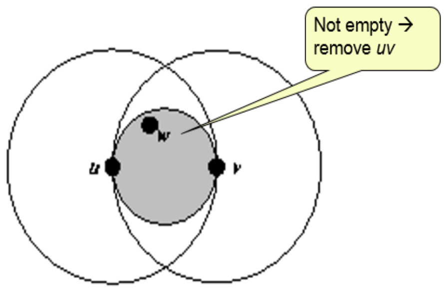
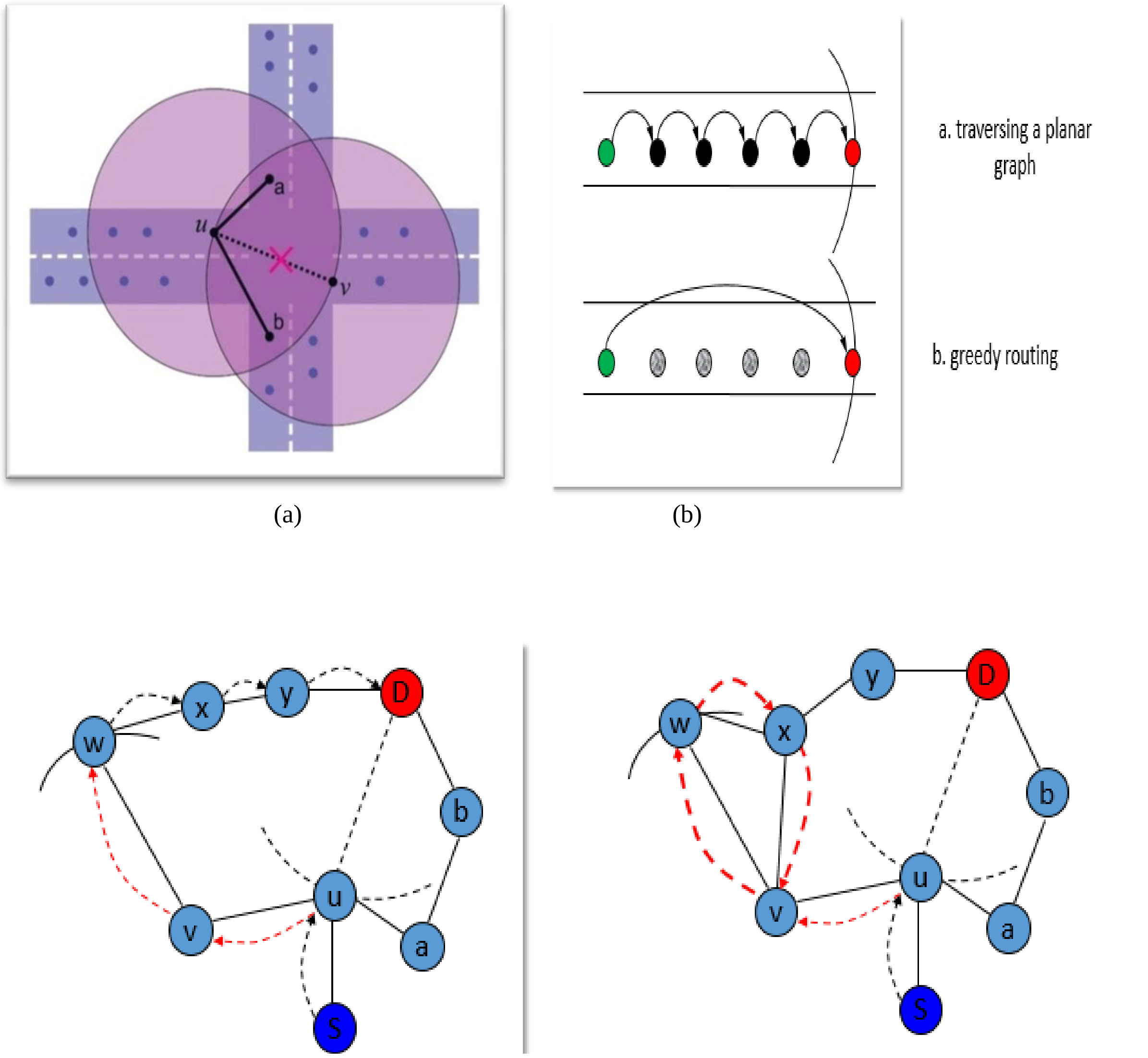


Figure 7.b: GG

However it provides best performance in highway scenario even with distributed nodes. GPSR have to face some research challenges when applied to city environment. It may fail in case where there is no direct communication between nodes due to the obstacles like trees or buildings. Due to the dynamic nature of node mobility in VANET packet can be forwarded in wrong direction because of routing loops can be induced by the right-hand rule used in face routing resulting in higher delays.



(a) (b)

(C) (d)

Figure 8: Challenges in GPSR

a) link uv is removed by RNG since nodes a and b are inside the intersection of two circles centered at u and v. However, because of obstacles (such as trees or high buildings), there is no direct link ua or ub.

b) When it compare to the greedy approach, it may needs to traverse more nodes in routing perimeter mode which increases delays.

c)In node u, greedy forwarding fails. So the forwarding mode is switched to perimeter mode. In a static network, the packet would reach D according to the 'Right Hand Rule

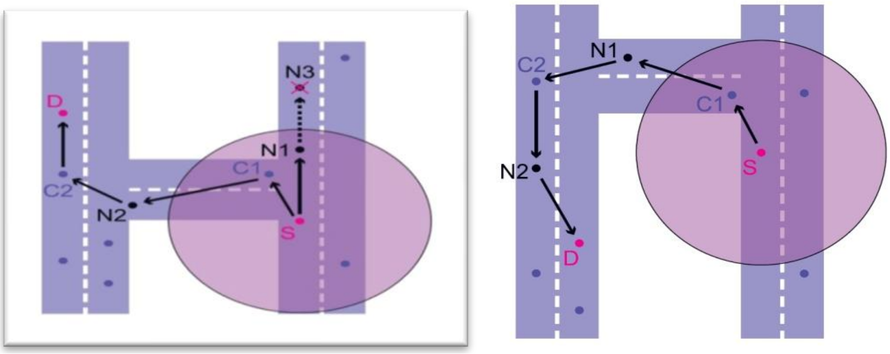
d) When the node x has reached into the v's radio range while node v has already sent this packet then a loop vwx has been created by the 'Right Hand Rule'

4.2 Geographic Source Routing (GSR):

Lochert et al. proposed GSR routing protocol for city environment. Assume that those nodes have the GPS or street map so that it knows global knowledge of the city topology. In order to learn the current position of a desired communication partner Reactive Location Service (RLS) is used. The sender uses the Dijkstra's shortest path algorithm on street maps to determine the junctions for traversing the packet. The sequence of junctions can either be put into the packet header or it can be computed by each forwarding node. Among two successive junctions, a packet is forwarded based on greedy forwarding approach. Use the combination of topological knowledge of street maps and geographic routing GSR becomes a promising routing technique for VANET in urban environments. If the traffic density becomes low then it very difficult to determine the end to end connection which is the main research challenges in GSR.

4.3 Greedy Perimeter Coordinator Routing (GPCR):

Greedy Perimeter Coordinator Routing consists of two parts: a restricted greedy forwarding and a repair strategy. Unlike GSR this algorithm is based on the topology of real world streets and junctions which form a natural planar graph. Therefore it does not require a graph planarization process as GPSR or does not use any global topology information like GSR. The restrictive greedy algorithm is applied when nodes are in street and an actual routing decision is taken only at the junction of streets. So packets are forwarded to a junction node (coordinator) rather sending it across the junction. When stuck into a local minimum GPCR adopt a repair strategy. (1) Coordinator node decides using right-hand rule which street the packets should follow. (2) In between junctions greedy forwarding is applied to reach the next junction. In figure 4 restricted greedy routing and repair strategy in GPCR is shown. GPCR uses two steps for its repair strategy. At first on each junction it has to be decided which street the packet should follow next and the next is in between the junctions restricted greedy routing is applied to reach the next junction. Figure shows the repair strategy of GPCR. Here local minimum node is S. It is switched to the repair strategy for forwarding the packet. At the point the distance to D is less than at the beginning of the repair strategy at node S. So greedy strategy is applied in this situation.



(a) (b)

Figure 9: GPCR routing strategy

(a) Using restricted greedy forwarding packet is forwarded to C1 (coordinator node) from S instead of N1 (regular greedy forwarding).
(b) Repair Strategy: In node S (local minimum) algorithm switched to repair strategy. Packets forwarded to C1 (coordinator node) and it decides which road to follow.

4.4 Anchor based street and traffic aware Routing (A-STAR):

Anchor based street and traffic aware Routing (A-STAR) is specially designed for environment to provide inter vehicle communication system. It is position based routing protocol. To compute the anchor path it takes the information of both street and traffic awareness. To identify the anchor path with large connectivity it uses vehicular traffic city bus information integrate traffic awareness. It uses Dijkstra's least weight path algorithm to compute the anchor path. ASTAR focus a new local recovery strategy for packets that may stuck into a local minimum provides good result for a city scenario which is unlikely of recovery strategy used in GPSR and GSR. It computes a new anchor path from the point of local minimum and the packet is routed using this new computed anchor path. The street at which local minimum is occurred is marked as "out of service" temporarily. Performance of A-STAR is better than GSR and GPSR because it chooses the paths with higher connectivity for delivering a packet. A-STAR guarantees for finding an end-to-end connection in case of low traffic density.

V. VANET Research Challenges and Future Perspective

Following are some of the research challenges in vanet where innovative solutions can be achieved by further research.

a) Routing: A major challenge in protocol design is how to develop reliable routing protocols for comfort applications to ensure that broadcast messages are successfully spread to all the other vehicles. One research challenge in routing is that at first we have to select the node that will forward the data. Our primary goal should have to select the optimal hop for message forwarding. Another important challenge is what to do when a chosen link breaks down. In that situation we have to find a procedure for fast link recovery. Others challenges are efficient route should provide between a source and a destination vehicle to ensure communication, and how to cope with partitioned and merged network.

b) Security Frameworks: It is needed to design reliable and low cost security framework.

c) QoS: Quality of Service (QoS) means level of performance delivered to the users. Two important factors that should be considered for quality of service. One is fast and delay tolerant message transmission and another is to design protocol that is reliable and secure.

d) Broadcasting: Broadcasting is a major research area in VANET because most of the message disseminated in VANET network is broadcast messages. There are several questions arising when designing a reliable and efficient broadcast protocol for VANET. Major research issues are to avoid storm problem in broadcasting, selection of the relay neighbors for message passing and to assure reliability.

e) Data Dissemination and Data Sharing

Following are some security hazards in VANET:

False Information generated by the attacker: An attacker can pass false traffic information like a jam is ahead but no jam in the road to discourage other vehicles using the road.

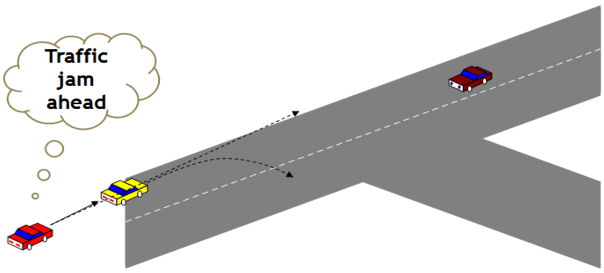


Figure 10: False Information passing by the attacker

Generate Intelligent Collision: An attacker can inject intelligent collision.

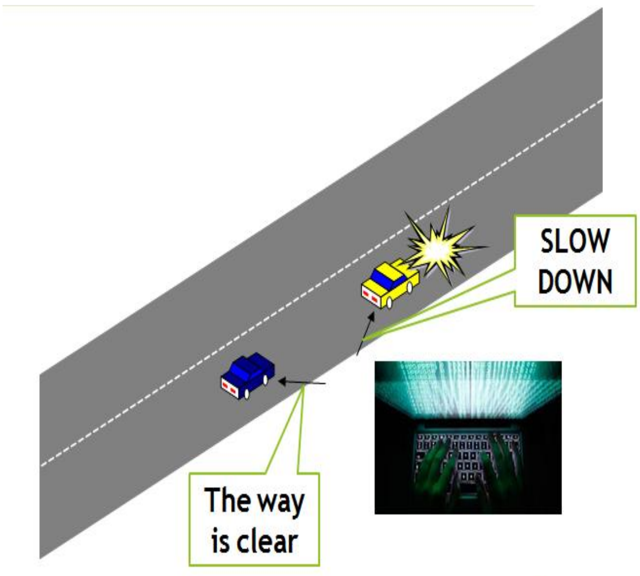


Figure 11: Generating Intelligent Collision

Jamming: A malicious node can generate false packets in the network and create virtual jamming

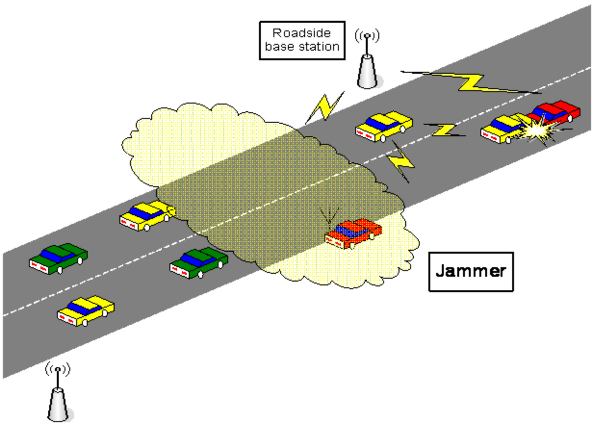


Figure 12: Creating jamming

Tracking: An attacker can use vanet's shared information to track someone. This is obviously a serious security hazard.

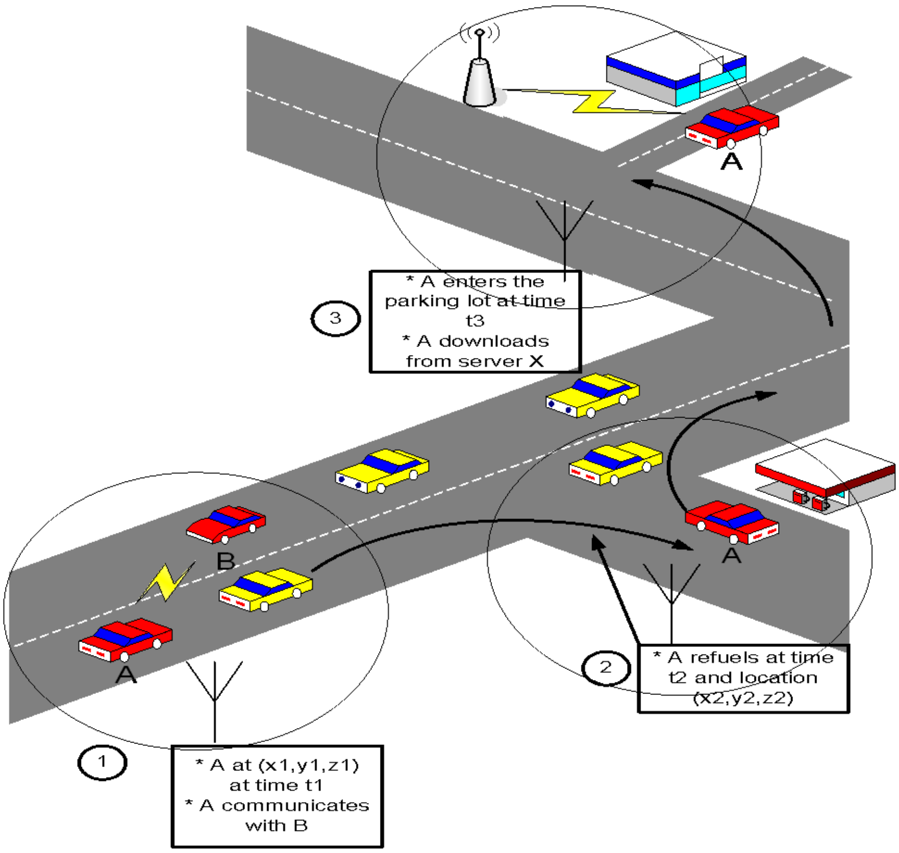


Figure 13: Tracking in VANET

A major challenge in protocol design is how to develop reliable routing protocols for comfort applications to ensure that broadcast messages are successfully disseminated to all the other vehicles in a VANET. Further performance evaluation is required for designing suitable routing protocol for different scenarios. Another issue should also be taken into account- how to combat security hazards in VANET. In future, we want to investigate how to develop methods like digital signature to distinguish between trusted and untrusted sources. Security threat like DoS (Denial of Service) attacks needs to be addressed to mitigate security hazard.

VI. CONCLUSION

A general and secure routing solutions applied to all VANETs situation is extremely difficult. In this paper, position based routing protocol of VANET and its designing challenges have been discussed. In general, location based routing are very much promising protocol due to the geographical constraints. Position based routing protocol is a unicast routing protocol technique that have no hierarchical structure and it uses packet forwarding mechanism to transfer packet from one node to others. We also discussed about the challenges that still need to be addressed. Finally, the deployment of fast, reliable, cost-effective message exchange solution is needed for VANET.

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