Study of Traffic Light Systems Algorithms for Road Intersections in VANETs

Bassam Ali M. Almamari, Atul M. Gonsai

***Abstact*—Vehicular ad hoc network is a technology that uses mobile vehicles as nodes in a wireless network to create a mobile wireless network, each mobile vehicle within the range of VANET acts as router or node. Vehicular Ad-hoc network is a most applicable subclass technology of ad hoc network, which aims to build network connection between mobile vehicles(Vehicle to vehicle) and between vehicles and fixed points (roadside units created by applying the principles of mobile ad hoc networks (MANETs).The Nodes in VANET are high mobile due to that Network topology can rapidly change. for the purpose of supporting Smart ITS, the designing of routing protocols in VANETS is important and necessary issue.**

In this paper, we review research works related to the applications of traffic lights at road intersections to attempt of solving the traffic light system problems, we have also gone through various algorithms are based on traffic light system and can be implemented on routers to work on Vehicular Ad-Hoc Networks (VANETs).

***Index Terms*— VANETs, MANTs, Routing, Traffic Lights, Intersection.**

I. Introduction

In the last few years VANETs attained attracting growing attention from both academic and Industrial point of view. This is because of its different applications that extend from road safety applications to traffic control and up to entertainment Applications. Vehicular Ad hoc Network is considered as challenging class of MANETs [1], which facilitates communication and cooperation driving between cars on the road. VANETs are one of the active research and influencing areas in the smart intelligent transportation system (ITS) in order to provide safety and comfort to the road users [2]. in addition of the safety application, VANTES offers valuable real time information to the users such as information of current weather, transit systems, internet access, e-commerce, and other entertainment applications, in the highway roads, VANETS enable automated highway applications, to help the vehicles to move and navigate without the help of their drivers, however such applications are still in the stage of research and experiments, have not yet become realistic [15], Although Vehicular Ad-hoc Networks are considered a subclass of Ad-hoc network purpose, however they have their unique characteristics which distinguish them from others such as special mobility pattern and rapid changing topology [5]. VANETS play a vital role as an assistance for vehicle drivers to avoid any critical situation through vehicle to vehicle information exchange e.g., speed violation, traffic jams, road accidents and congestions, and unseen obstacles, etc. in addition to safety applications. Although the concept VANETS is created by applying the principle of mobile ad hoc networks (MANETS) [7], however, applying the existing routing protocols of MANETS might not be effective due to the unique characteristics of VANETS. VANETS are technology which used moving vehicles in cities and high ways as nodes in a network to create mobile wireless network. VANETs use every vehicle participate in a wireless network as router or node, thus establishment of communication network with a wide range. Nodes in VANETs can be a mobile Vehicle or Road Side Unit (RSU), communicating with each other either through single hop or multi-hop [27]. This paper is organized in to following sections: Section II overviews Routing Protocols in VANETS, Section III describes the problems occur at Intersection and shows the existing routing algorithms we have studies, finally Section IV concludes the paper.

II. Routing Protocols in VANETS

Routing [25] is considered as one of the most important and challenge issue in the real world scenario because of high speed, frequent disconnection of network topology and mobility modeling of node in VANET. Earlier routing in VANET was based on ad hoc routing method [26]. Researchers used traditional topology based routing protocols and position based ad hoc routing method to simulate and implement the concept of VANETS.

Designing routing protocols in VANETS should take into account the capability of establishing the routes dynamically as well as maintenance the routes during the communication process. They should be capable of discovering alternate routes quickly on-the-fly at the time of losing the current used path [3]. During the communication process, real-time applications and safety related applications demand strict time delay, for that reason designing of routing algorithms should select optimal paths to reduce delay in routing process. Multiple routes within a network are required to avoid congestion. The key challenge is to design routing protocols to overcome these problems and to provide communication within minimum delay and with minimum overhead [23]. In our entire work, we will be using only routers with four connections (4 ports in each router) to establish crossroad.

Routing Protocols in VANET can be categorized mainly in to two:

- Topology based routing protocols and
- Geographic or Position based routing Protocols.

In the topology based routing protocols each mobile vehicle (node) is expected to know the entire network topology. These protocols use either proactive or reactive approaches for routing [20]. In VANET environment the mobility factor is high, which leads to the frequent network partitioning and route disconnection demanding re-computation of the topology information [21].

In the Geographic or position based routing protocol, the decision on routing is based on the position of the sender (geographic position), position of the destination and the position of the sender's one hop neighbors.

In the geographic routing, messages can be forwarded to the destination without a need of knowing the topology and without prior route discovery [4]. Position based routing protocols are suitable for VANETs since they offer higher delivery ratio than topology based routing protocols in a highly mobile environment [22]. In our study we focus on the Topology based routing Protocols as we propose to use fixed network topology with stationary routers.

A. Applications

VANETs support a vast range of different applications staring from simple one hop information dissemination, e.g., cooperative awareness messages (CAMs) to multi-hop dissemination of messages over vast distances. Most of the concerns of interest to mobile ad hoc networks (MANETs) are of interest in VANETs, but the details differ. [6, 7] Rather than moving at random, vehicles tend to move in an organized fashion. The interactions with roadside equipment can likewise be characterized fairly accurately. And finally, most vehicles are restricted in their range of motion, for example by being constrained to follow rolls of a paved highway [7]. Majority of VENTs routing Protocols are not capable to give effective routing in crossroad due to the nature of it.

B. Technology

VANETs can use any wireless networking technology as their basis. The most prominent are short range radio technologies [8, 7] like WLAN (either standard Wi-Fi or the vehicle-specific IEEE 802.11p), Bluetooth, Visible Light Communication (VLC), Infrared, and ZigBee. In addition, cellular technologies like UMTS, LTE, or WiMAX IEEE 802.16 can support VANETs, forming heterogeneous vehicular networks. In our work, we are going to use VANET and MANET with Wireless network Standard IEEE 802.11b/g/n along with 802.16.

III. Problem At Intersection And Related Works

Scenario 1: In urban areas the intersections are employed with traffic lights. These traffic lights divide the road in to different red and green light segments. The vehicles move smoothly on a green light segment and when light turns to red they slow down and wait at intersections until the light turns green. Thus, the vehicles tend to cluster at both directions in a red light segment. This clustering of vehicles generates a gap between vehicles and thus creates a traffic hole problem [9] as well as wasting time.

Scenario 2: Traditional Automated traffic signal control systems normally schedule the vehicles at intersection in a pre timed slot manner. This pre-timed controller approach fails to minimize the waiting time of vehicles at the traffic intersection as it doesn’t consider the speed and arrival time of vehicles [24].

We will suggest a scenario to overcome the problem in the Scenario-1 and the Scenario-2, in such a way that focusing on packet carrying and forwarding and rely on the concept of traffic signal system at intersections.

Our proposed work aim is to avoid packet waiting at intersections to overcome the waiting time of the packets in every router, where we calculate the arrival time of the package and distance between a router and the next router. Following are the existing routing algorithms we have studied.

A. Greedy Perimeter Stateless Routing (GPSR)

In [9, 10, and 19], a Greedy Perimeter Stateless Routing (GPSR) is proposed. In GPSR, a node forwards a packet to next close neighbor which is geographically closer to destination node. When local optimum is reached a recovery mode is used to forward a packet to a node that is closer to destination than the node where the packet encountered local maximum. Greedy perimeter stateless routing in [10] proposed a typical position-based routing. It uses greedy forwarding to forward packets initially. When a packet reaches a local optimum, it switches to the perimeter mode. However, greedy forwarding is unsuitable especially for high speed scenarios and may not be able to maintain the next hop neighbors' information due to frequent disconnections. Additionally, since no directional forwarding is considered, the perimeter model often results in longer routes thus extending the transmission delay.

B. Greedy Perimeter Coordinator Routing

Greedy Perimeter Coordinator Routing makes use of street and junctions to forward packets. Here packets are forwarded greedily. GPCR consists of 2 parts: a restricted greedy forwarding procedure and a repair strategy. In all intersection based routing protocols the actual routing decision is made on junctions. In GPCR nodes on junctions are called coordinators. Packets are always forwarded to these coordinators rather than to nodes across the junction. If coordinators are not present, the packets are forwarded to node with the largest distance from the forwarding node. If more than one coordinator is present then one is taken randomly and packet is forwarded to this coordinator. In this protocol a decision is made greedily so that a node with great progress to destination is always selected. When packet reaches a local optimum, Right Hand Rule is used to see to which street the packet should follow as the repair strategy [11, 1, and 19].

C. An Improved Greedy Traffic Aware Routing (GyTAR)

GyTAR [12, 19] is an intersection based routing protocol consisting of 2 modules: dynamic junction selection through which a packet must reach destination and an improved greedy strategy used for forwarding.

In GyTAR a forwarding node looks for the neighboring junctions in digital map. Then it assigns a score to each of these junctions considering the traffic density and curve metric distance to destination. The junction with highest score is selected to forward the packet. Once junction is selected the next phase is to forward the packet between these junctions.

D. Vehicle Assisted Data Delivery (VADD)

In [13, 19], Vehicle Assisted Data Delivery (VADD) is proposed. VADD aims at improving routing in disconnected networks by using the idea of carry and forward together with Vehicular mobility prediction [6].

E. Shortest Path Based Traffic Aware Routing (STAR)

In [14, 19], Shortest Path Based Traffic Aware Routing (STAR) is proposed. Shortest path based Traffic Aware Routing is an intersection based routing protocol proposed for urban areas where traffic density is high and intersections are deployed with traffic lights. In STAR protocol the data is forwarded using greedy forwarding together with carry and forward recovery mechanism [9].

F. Static Node Assisted Adaptive Routing Protocol

In [16, 19] deploys a static node at intersections, this static node stores packet and wait until there are vehicles within communication. The static nodes have a digital street map. SADV have 3 modules:

- Static Node Assisted Routing (SNAR),
- Link Delay Update (LDU) and
- Multi Path Data Dissemination (MPDD).

G. a Virtual Vertex Routing (VVR) protocol

In [17, 19] introduces a new concept called virtual vertex that is proximity of a vertex and uses the information about lines. Proximity of a vertex refers to the area within the circle with vertex as centre and radius is half the radio range. An intermediate node in the proximity uses Floyd Algorithm to forward packet to the destination. In VVR edge connectivity is maintained by exchanging HELLO messages. The basic VVR mechanism includes two parts: Initialization and Vertex Change. VVR model consists of vertices (junctions), edges (straight-line between 2 junctions) and nodes (vehicles). During initialization the shortest path between all pairs of vertices is calculated using Floyd's algorithm. Vertex change: Packets in VVR is forwarded from one vertex to another vertex. When a packet arrives at a vertex, intermediate destination vertex is selected. Here comes the proximity of vertex. That is any node in the proximity of geographical location of vertex acts as a vertex. This process continues until the packet reaches the proximity of last vertex. When the last vertex proximity is reached the packet is greedily forwarded to the destination. The advantage of VVR is that, it rarely falls in to routing holes. This is because of prior knowledge to distribution of nodes. The disadvantage is its high overhead.

H. The intersection-based geographical routing protocol (IGRP)

The The intersection-based geographical routing protocol (IGRP) [18] is also an intersection-based geographical routing protocol which has some similar mechanisms with our work. It chooses the path that maximizes connectivity probability while satisfying the QoS constraints regarding hop count, BER, and end-to-end delay. Between any two intersections on the selected path, geographical Forwarding is used to transfer packets, thus reducing the path's sensitivity to individual node movement. However, to reach this goal, a central control unit, i.e., the gateway is needed to collect the detailed information about the vehicles in its vicinity using a location aware service and the genetic algorithm to choose the optimal routes. Therefore, IGRP could not be considered as a fully distributed routing protocol. Besides, the computation complexity and convergence speed of the genetic algorithm should also be taken into account which may fail some delay-sensitive services. Additionally, the connectivity of IGRP is calculated under the assumption that all vehicles on the road follow a Poisson distribution which seems unrealistic in urban VANETs especially when traffic lights, obstacles, and roundabouts are existing [2]. The impact of traffic light on routing protocol design was investigated in [15, 2] based on an intersection-based routing protocol designed for vehicular communications in urban areas. Although this shortest-path-based traffic light-aware routing (STAR) protocol shows better performance on delay, delivery ratio, and throughput than related routing protocols considering traffic light, its assumptions of high density always connected green light segment, and an onboard video camera to identify the colors of traffic light may limit its applications in practical cases.

IV. Conclusion

The design of VANETs routing protocols is important and necessary issue for support the new requirements of smart intelligent transportation system (ITS), as the fields of wireless devices and telecommunications grow rapidly with new technologies come into exist, there is a need to improve the current schemes of mobile networks keeping on mind the frequently changing of topology, high speed of vehicles , the large number of vehicles in city at the intersections, and other requirement related to it**,** for that purpose there should be a smart traffic single system that adapt**s** with these scenarios at the road intersections. The key challenge is to design routing protocols to overcome these problems and to provide communication with minimum delay and with reduced routing overhead. As a future work, we will give more attention to traffic signal control system as an application of VANETS at the road intersection by editing, modifying, altering or designing a new Dynamic routing protocol that should be adaptive with the metrics of routing. For implementation of the simulation process we will use Topology based routing protocol as based of our proposal research, and use of predefined network topology with a set of Routers to form crossroad with a traffic signal systems.

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