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A comprehensive study for Geocast routing and its tool on VANET

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***Abstract*— Geocast Routing is the recent trend towards vehicular communication in enhancing the efficiency of data dissemination. The escalating amount of Intelligent Transport System (ITS) application is favored by Geocasting. In this expose we present a survey on recent protocol of Geocast routing and also other protocols that has been implemented into the Geocast. Functional & qualitative parameters were considered for comparison. Additional comparative character like scenario, periodic beacons, forwarding strategies, recovery strategies and zone used, etc were analyzed. And in addition to it another comparison that leads to simulation tools & its parameters are also compared for those Geocast routing protocols. This comparative reading provides platform for imminent research trials in Geocast Routing.**

Keywords*— *Geocast routing; ITS; FPBR; DHVN; CAGR; EEFG; CAGFP; EEMD; GEOSVR; T-TSG; GEOSPIN; GEOMOB; SAS-GP; CAG; IB-CAGR

I. Introduction

A wireless sensor network (WSN) usually consists of one base station able to manage all the communication between other nodes/station [1, 2]. A MANET even is a WSN if its scope is that of sensing the environment around the network [3, 4]. However, the word ‘Mobile’ and ‘Ad-Hoc’ are often used to refer to all those network connectivity of words continuously moving in any direction.

In recent times Vehicular Ad Hoc Networks (VANETs) have attained approval due to its usage in number of applications like security alert messages (in case of emergency), entertainment etc. Various government and private agencies have invested a lot of money in number of different projects in this area to upgrade the welfare and interests of the passengers in the vehicle. In all these applications, communication is broadcast from the source to the target for various effective operations [5, 6, 7].

The vehicles on the thoroughfare correspond with each other either in Peer-to-Peer (P2P) way or by utilising the prevailing infrastructure. In the previous case, the communication is called as Vehicle-to-Vehicle (V2V) while in the latter, it is called as Vehicles- to-Infrastructure (V2I). The infrastructure backing is provided by the closest Road Side Units (RSUs), which may turn into an intelligent router to direct all the movements of the vehicles on the road. If the automobiles are within the reach of RSUs, then messages are dispatched to them directly, else they are delivered to nearby RSUs of the vehicles. But due to the high kinesis and scant distribution of the vehicles on the road, routing among the vehicles always poses a demanding job which may lead to a prolonged message delivery deferment. The message transmission in VANETs monitors store and forward strategy in which messages are retained at specific intermediate nodes until the optimum forwarding nodes (Vehicles/RSUs) are located [8].

This process may experience colossal delay due to this stratagem. As VANETs are employed in wide areas of applications as discussed above, its consequential delays may affect the performance of quite a few of these applications. Some standards have already been implemented in VANETs such as WAVE [9] and ETSI EN [10]. ETSI EN 302 636 gives direction of how Geo Networking, which is a network layer protocol, works for ad hoc networks especially in VANETs. It provides communication amongst vehicles without the need of any coordinating infrastructure. Vehicles specify the area where the message has to be transferred and intermediate nodes relay the message to vehicles in that particular area.

The rest of paper is prepared as follows: in section II classification of different Geocast routing protocol were analyzed. Comparison with various parameters among Goecast routing protocols and its simulation tools were presented in section III, followed by conclusion in section IV.

II. Goecast Routing Protocol In VANET

A. Reliable Freestanding Position-Based Routing in Highway Scenarios(FPBR)

FBPR [11] segregated the task of routing into numerous well defined modules to attain desired functioning. The routing modules are radio networks, beacon rate, location prediction, next hop selection, location service, and data broadcasting. For Communication purpose path loss model for highway traffic environment is used. The path loss for propagation distance PT^{d}_{loss} is expressed as

$$PT_{loss}^{d} = PT_{loss}^{d_0} + 10nlog_{10}\left(\frac{d}{d0}\right) + Y_{\sigma} + \gamma PT_{loss}^{c} \quad (1)$$

Where PT_{loss}^{d} denotes path loss at reference distance, n represent path loss exponent, Y_{σ} presents normally distributed random variable with zero mean with standard deviation as σ, relative vehicle direction is represented by γ represent the relative vehicle. FBPR implies dynamic beacon rate over vehicle density. Location Prediction (LP) algorithm is applied to make alterations on vehicle's stale location entry at the routing table. This entry will be made just before any transmission of a packet. NHV is selected using most forward within adjusted radius (MFWAR).

MFWAR regulates transmission range of proximate vehicles in accordance with the moving direction. Location service is used to trace the destination location whenever a data packet arrives without destination location information. Redundancy strategy is used for re-dissemination of discovery packets, if the discovery packet does not reach to intended relay vehicles. The re-broadcast happens by back up vehicles, by modifying the distance between current forwarder and next hop vehicle. An implicit acknowledgement is used in FPBR.

B. Dissemination protocol for Heterogeneous Cooperative Vehicular Networks- DHVN

The DHVN [12] considers: (i) roads topology, (ii) network connectivity and possible partitioning in case of low traffic density, and (iii) heterogeneous communication capabilities of the vehicles. This protocol assists an effective and optimized way to proliferate infotainment information in both highway and urban environments. It provides a higher efficiency for vehicles with good dissemination properties (buses, trucks, etc.) To be elected as relays. It unravels the precincts of the protocols by executing a dependable broadcasting protocol that fulfills the ensuing objectives: high delivery ratio, low latency, and minimum bandwidth usage (as only a limited number of vehicles are involved in the broadcast scheme).

On the same road, DHVN disseminates the packet in the two directions. Each receiver on the road initiates a timer based on the distance from the sender. It retrieves the sender position information from the packet header and estimates the back off timer as follows:

Timer T= 1 / (dist + Car_ht*(MD)) (2)

Where dist is the distance between the sender and the receiver, Car_ht is the vehicle's height; MD is the maximum additional distance. The SNF(store and forward) approach, nodes carry the information along with their movement and transmit it periodically. In DHVN, the choice of the SNF period is crucial. The probability of connection of two disconnected vehicles after ζ is

$$P(x) = (1 - Pc(x)) * Pc(x - (SNF * \Delta V)) \quad (3)$$

C. Coverage-aware Geocast Routing in Urban Vehicular Networks- CAGR

In CAGR [13] protocol, works under urban scenario. It uses GPS for tracing the destination vehicles with in the network. This CAGR uses periodic beacon packet to find the neighbor node distance. Coverage based strategies were adopted for forwarding strategies. The coverage graph of i^{th} vehicle $G_c(i)$ is expressed as

$$G_c(i) = \langle V_c(i), E_c(i) \rangle \quad (4)$$

Where $V_c(i)$ is set of vertices and $E_c(i)$ is set of edges in the coverage graph. The vertex set $V_c(i)$ is a collection of road segments RS_x^v defines as

$$RS_x^v \in V_c(i), 1 \le x \le m, \forall TR_v \in TS_i \quad (5)$$

Where TS_i is set of trajectories at i^{th} vehicle and $TR_v = \{RS_1^v, RS_2^v, RS_3^v, ..., RS_m^v\}$ is the course of v^{th} vehicle. The $E_c(i)$ is a collection of edges strained between two road segments of either same route or two different routes. The coverage graph is utilized to calculate coverage capability. The Coverage capability of vehicle v for any destination Geocast region DGR is denoted by $\tau(v, DGR)$ and calculated as

$$\tau(v, DGR) = \max\{MV(l), \rho(v, DGR)\} \quad (6)$$

Where, $MV(l)$-calculated matrix value of path l and $\rho(v, DGR)$ - a set of all routing paths reaching to DGR from vehicle v.

D. EEFG - Economical and Environmentally Friendly Geocast

The mail goal of EEFG [14] protocol is to mitigate CO_2 emissions from vehicles. This work on city scenario. This protocol uses GPS for vehicle tracking to find the out the appropriate distance. The main intention of the protocol is to deliver a TLS's information to approaching vehicles inside the regions of interest (ROIs). It calculates and adjust its speed to optimal to maintain the emission of CO2. ROIs are defined as the ranges that cover the intended receivers of a message. Here, ROIs - road sections where the suggested S_R results in CO_2 emissions reduction.

$$S_R = \min\left(\max\left(\frac{d - d_{dec1} - h_{\min 2}}{T_{l2} - \alpha_1}, S_{Rl}\right), S_{\max}\right) \quad (7)$$

The optimum S_R is the maximum speed that permits the vehicle to pass the TLS without stopping or decelerating.

E. CAGFP - Context Aware Geocast Forwarding Protocol for inter-vehicle communication

This CAGFP [15] Protocol forwards safety alarms for relevant section of the road. Based on IEEE 1609 standard, beacon safety messages are periodically disseminated in the CCH (Control Channel). This protocol solves the broadcast storm problem. Each vehicle follows this algorithm to receive a packet. When vehicles receive the accident information, it updates the neighbor list. For each entry at the list it calculates the distance from the sender. If the distance is calculated then it will be added into the list. As per the distance the list will be sorted in ascending order. If the vehicle is spotted at top of the list, then it reforms the accident message. If the vehicle is not at the top, then extract the vehicle order from the list and set the timer as listX0.5ms. If no packet is received during the waiting period, then it updates the list and re-forwards accident information. If the packet is received during the waiting time, then cancel the timer and stop the re-forwarding.

F. EEMD-Energy Efficient Min Delay based Geocast

This protocol EEMD [16] seeks to reduce the quantity of energy consumed in packet forwarding and also to catch the optimum relay nodes by integrating energy consumption and packet delivery delay. In this routing when a node wants to transmit the data packets it, 1) First chooses the forwarding region 2) Finds the relay node in forwarding region. If the relay node is not in that forwarding region then eliminate the node. Otherwise for all relay nodes in forwarding region, calculate the energy consumed by one hop packet forwarding of node. Estimate the packet transmission failure due to queue buffer overflow of the node. Estimate the packet loss due to failure reception of wireless signal of the node. Evaluate the one hop packet transmission failure probability of the node. Calculate the probability of a successful packet transmission of the node. Calculate the energy efficiency of packet forwarding of the node. Calculate the energy efficiency of the packet forwarding paths. Then select highest first ‘N^{th}’ path that has highest energy efficiency of packet forwarding.

It addresses the issue by considering two typical conditions: dense and sparse traffic densities. 1) Dense traffic - each node has numerous neighbor nodes within its transmission range. Inter-vehicle communication often jams because of enormous amount of packet transmission. The average packet waiting time is related to the average system size based on little’s formula. Let W_q denote the average packet waiting time in the queue buffer of relay nodes. The probability that an arriving packet finds n packets in the queue buffer is identical to the stationary distribution of queue buffer size. Thus, the distribution of waiting time in the queue buffer is

$$W_q = \int_0^{\infty}[1-W_q(t)]dt = \int_0^{\infty}\rho e^{-\mu(1-\rho)t}dt = \frac{\rho}{\mu-\lambda} \tag{8}$$

2) Sparse traffic - some nodes become packet carriers and temporarily carry packets until they find suitable neighbor nodes within their transmission range. The packet forwarding policy in such intermittent inter-vehicle communication links lies in forwarding packets as soon as possible to reduce packet delivery delay.

G. GEOSVR-A Geographic Stateless Vanet Routing

GEOSVR [17] is a unique stateless routing protocol for VANET. This routing coalesced with node location and digital map. Two algorithms were comprised with GeoSVR: 1) optimal forwarding path algorithm and 2) Restricted forwarded algorithm. It aims to eliminate the local maximum problem and sparse connectivity, while it improves the impact of unreliable wireless channel problems. To find the optimal forwarding path reckon a path, which the packet has to traverse along, towards the destination based on node location and digital map by providing a global directive to eliminate local maximum.

With optimal forwarding path, consider the vehicle density on every road to avoid spare connectivity. The Dijkstra’s algorithm is then applied to find a shortest path with a minimum weight as optimal forwarding path. The equation that calculates the derivation of path is as follow:

$$\sigma(t_m) = \sqrt{\frac{1}{n}\sum_{p_i=p_1}^{p_n}\left(t_{pi}-t_m\right)^2}\,(p_i \in R) \tag{9}$$

Where’ σ (t_m)’ - derivation of the path, ‘t_m’ - average of types, and ‘n’ - number of roads in this path. Restricted forwarding algorithm chooses a neighbor in a restricted range for forwarding packets, in an effort to reduce packet loss due to excessively distant wireless communication attempts. The restricted forwarding range equation is shown below; this equation is the free-space propagation model in wireless communication.

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} \tag{10}$$

Other factors in natural environment influencing wireless communication include electromagnetic environment and antenna gain in addition to the communication distance. Therefore, we define k as the impact of above factors. Thus (10) becomes:

$$P_r(d) = k\,\frac{P_t \lambda^2}{(4\pi)^2 d^2} \tag{11}$$

The packet is forwarded to the next relay node along this path. The restricted forwarding algorithm is used to choose the next hop based on this path, for every relay until the packet reaches the destination. According to equation, the free-space path loss equation is:

$$FSPL = k\left(\frac{4\pi d}{\lambda}\right)^2 \tag{12}$$

H. Traffic light based time stable Geocast routing for urban VANET - (T-TSG)

Some of the ITS applications are used as warning system that disseminate information that needs to be live for a specific time interval in a specific geographic region. This time duration varies from types of warning. This T-TSG [18] has four concepts, 1) Geocast Region (GR) Identification: T-TSG recognized Geocast routing by considering location of the incident, road architecture of the incident region and direction of the vehicle involved in this incident. 2) Traffic light based forwarding vehicle selection: always chooses NHV from the Lane having Green light ON. 3) Geocast Message Stable

Region (GMSR) and Stable Vehicle Region (SVR) region: TSG also identifies the lane where Geocast message needs to be stable for specific time duration and the group of vehicles responsible for life time management of Geocast message. 4) TTSG routing algorithm: T-TSG has three phases completeness Geocast routing algorithm. The phases of T-TSG are Forwarding, Disseminating and Re-Live (FDRL).

I. GEOSPIN - Geocast routing based on Spatial Information in VANET

The geographical space that has a sequence of Geospatial coordinates and timestamp, which generates trace over the moving object is said to be spatial trajectory [19]. This routing technique has been divided into 2 phases. 1) It extract the mobility patterns for each vehicle from GPS data. 2) Then it applies a distributed algorithm for routing message based on the information of individual trajectory patterns. At the clustering objects were treated as clusters.

It has ordering points to identify the clustering structure (OPTICS) [20]. The density based clustering algorithm that reuses density based spatial clustering of application with Noise (DBSCAN) [21]. In the second phase, it follows Zone of Interest (ZoI) in sparsely connected VANET to send the message from source. If the neighbor node is not in the ZoI, then it follows Store, carry and Forward technique for further communication.

J. GEOMOB - Mobility-Aware Geocast algorithm

This routing works under urban scenario in VANET from DTN (Delay-Tolerant Network). This DTN deals with high mobility and connectivity issues. This DTN utilize schemes, which uses expensive pair wire contact probability calculation and sharing. And also this schemes deploy node mobility information at Macroscopic and Microscopic mobility level. 1) Macroscopic mobility- traffic trend of all vehicle in urban scenario. 2) Microscopic Mobility- captures mobility pattern of single vehicle or node.

When comparing both the mobility, Macroscopic is quite stable. The key idea of Geomob [22] is to use two mobility for message routing. An optimal routing path is selected based on the macroscopic mobility when a message is selected. To forward message to destination, here it sends the message with its path.

K. SAS-GP- semantic and self-decision Geocast routing protocol

SAS-GP [23] initially executes an algorithm for locally determining the semantic Geocast area. It uses traffic information system and Digital map for its operation. To broadcast message it follows three phases. 1) Spread phase-deliver the message to the border of Semantic Geocast area. 2) Preserve phase – maintain the message and notifying to all the vehicle that enter semantic Geocast area, whenever event occurs. 3) Assurance phase – to guarantee the delivery of message to all the vehicle that are inside sematic Geocast area.

L. CAG-Cache Agent-based Geocast

In CAG, two additional concept have been added, like re-caching and connectivity assurance algorithm (CAA) [24]. This CAA work in full range radio transmission. Here vehicles are off two category. 1) Cache Agent (CA) 2) Cache User (CU). Here total network area were divided into junctions.

To find the CA among other vehicles, here a particular junction point of the location is chosen and vehicle belong to particular is CA and other vehicle were assumed to be CU. Those identification has certain characteristics like junction ID, vehicle average speed, and total number of stops between source and destination, etc. Those characteristics information will be passed to CU by the CA periodically. Once the CU receives information, it update information at Cache agent table during Geocasting.

M. IB-CAGR- Intersection Based Connectivity Aware Geocast Routing

This IB-CAGR [25] protocol, choose the path based on real time traffic information with packet delivery delay. It calculate the traffic density by node density with segment density. This use OFABS (On-the-Fly Adaptive Beaconing System), when proportionate with the traffic density.

The forwarder store data packet into its cache, rather than resend it, when no intersection node is found. The whole path is divided into path segments and during data dissemination, node density (no of neighbors of sender) as well as segment density (no of nodes present in path segment) is combined and finally the data packet reached the target, the information about node density and segment density are summarized to calculate traffic density.

Dis-connectivity occurs due to change of direction, variation of vehicle speed and quality of channel used.

III. COMPARISONS OF GEOCAST ROUTING ON VARIOUS ROUTING MATRICES

The several recently developed Geocast routing protocol were examined based on routing metrics of VANET. The study provides strong characteristics of each Goecast routing protocols of VANET. From the comparison we find out that each and every protocol has unique routing strategies & goals for evaluation. We considered the following characteristic (refer Table1) scenario, GPS, periodic Beacons, forwarding strategies, recovery strategy zone and message.

In addition the simulation parameter like, Tools, Vehicle density, velocity, transmission range, performance metrics, traffic lights, obstacle and network size for each Geocast routing protocol were also compared (refer Table2).

TABLE1. COMPARATIVE ASSESSMENT OF GEOCAST ROUTING PROTOCOLS

PROTOCOL	YEAR	EXPANSION	SCENARIO	GPS	Periodic Beacons	Forwarding Strategy	Recovery Strategy	Zone / Region	Message
FPBR [11]	2012	Free standing position based routing	Highway	Yes	Yes	NHV based	Back Node based Recovery	-	-
DHVN [12]	2012	Dissemination Protocol for Heterogeneous Cooperative Vehicular Networks	Highway/Urban	Yes	-	Broadcast	Transmission Duplication	-	-
CAGR [13]	2012	Coverage-Aware Geocast Routing	Urban	Yes	Yes	Coverage based	No Recovery Policy	-	Packet
EEFG [14]	2012	Economical and Environmentally Friendly Geocast	City	Yes	Yes	TL'S Information	Calculate & Adjust its speed to optimal	ROI	-
CAGFP [15]	2013	Context aware Geocast forwarding protocol	Highway	Yes	Yes	Defer time	-	ZOF:rectangle	Beacon Safety message
EEMD [16]	2013	Energy Efficient Min Delay-based Geocast Routing	Urban	No	Yes	1. Energy Efficiency 2. Selected optimal relay node	-	ZOF:rectangle ROF:Circle	Geocast message
GEOSVR [17]	2013	Geographic stateless VANET routing	Urban	No	Yes	Restricted Forward Algorithm, Stateless Routing	Optimal Forwarding Route	Position & Map	Packet
T-TSG [18]	2013	Traffic light based time stable Geocast	Urban / Highway	Yes	Yes	1.Behavior of Traffic light 2.Set of Vehicles	Link Recalculation	ZOR / ZOF ROI:Regional Intersection	Broadcast / Geocast message
GEOSPIN [19]	2013	Geocast Routing Based on SPatial INformation	Urban / Highway	Yes	Yes	1.Locaton based data	Store & Carry & Forward	ZOI	Routing / Geocast message
GEOMOB [22]	2014	Mobility-Aware Geocast algorithm	Urban	Yes	No	1.Location based 2.Transmission Queue	1.Buffer Mgt 2.ACK are flooded	ZOR:Rectangle	Geocast Message
SAS-GP [23]	2015	Semantic and self-decision Geocast protocol	Urban / Highway	Yes	Yes	Broadcast	1.Waiting Time 2.Start broadcast only for failed vehicle (Re-Transmission)	ZOF:Forward	Warning Message
CAG [24]	2015	Cache agent based Geocasting	Urban / Highway	-	-	1.Cached packet 2.cached agent 3.cached user	1.Recache technique 2.Duplicate Copy of cached information	NHV	Cached Packet
IB-CAGR [25]	2016	Intersection based connectivity aware Geocast routing	Urban	No	Yes	Greedy Forwarding	1.Stored packet from cached is transmitted	-	Data message

TABLE2. COMPARATIVE ASSESSMENT OF GEOCAST PROTOCOL (SIMULATION TOOLS AND PARAMETERS)

NAME	Scenario	Tools	Vehicle Density(v/km2) highway(v/km)	Velocity (km/h)	Transmis sion range(m)	Performance Metrics	Traffic Lights	Network Size
FPBR [11]	Highway	Opnet	33, 66, 100, 133 v/km	1.6-5.0 m/s2	300mts	PDR, Delay Hop, Average end to end delay, Network Overhead, MAC Overhead, Number of Hops	Yes(Lane)	Length-3m x width -4m(lane),3000m highway
DHVN [12]	Highway/ Urban	NS3	50-550	30-50km/h	350s	PDR increase, Transmission Duplication decrease, Reception Duplication	-	3000 x 3000 m2
CAGR [13]	Urban	NS2	-	-	-	Increase delivery ratio, shorter the delay	Yes	-
EEFG [14]	City	Integration, MATLAB	500 vehicle	-	200m	reduce CO2 emission, Reduce fuel Consumption, Reduce Idling Time	-	-
CAGFP [15]	Highway	Veins, Omnet++	53, 66, 90,(density) 200(Vehicle)	33.3 m/s	300mts	-	Yes	unidirectional highway length 100km
EEMD [16]	Urban	NS2,SUMO	50-500 vehicle	5-30 m/s	250m	average power Consumption, end to end delay	Yes(3 lanes)	5000x 5000 m
GEOSVR [17]	Urban	NS2	150Vehicles,1000Vehicles	2Mbps, 2Mbps	250m	packet delivery ratio, Network latency	Yes	-
T-TSG [18]	Urban / Highway	NS2	500-1000 in all lanes	20-60 km/h	250m	Better Message Delivery rate, Negligible Network Load, Lower end to end delay performance	Yes(Lane)	2 x3 double lane road+ six junction points
GEOSPIN [19]	Urban / Highway	Veins, Omnet++, SUMO	200	100, 325, 550, 775, 1000	1800, 5400, 9000 sec	delivery rate, dropped message decreased, Overhead reduced	-	15kmx 15 km
GEOMOB [22]	Urban	ONE simulator	200 taxis, 300 buses	6 Mbps	500m	delivery ratio, overhead ratio, average latency, average hop connect, average buffer time	-	-
SAS-GP [23]	Urban / Highway	NS2, SUMO	25-600, 50-300	45m/s, 25m/s	250m	Reduce Overhead, Delivery Ratio	-	12000 x 30 m2, 2600x 3000 m2
CAG [24]	Urban / Highway	NS2, MOVE	100-500	5-60 km/h	250m	Packet delivery, Network load, One hop Disconnection, Packet loss	Yes	4x 4 double lanes, 1000m square distance
IB-CAGR [25]	Urban	NS2	150 nodes	30-150 km/h	500m	packet delivery ratio, packet delay, routing overhead, Accumulated number of successful delivery packets, Average hop count	Yes	500-5000 mts

IV. CONCLUSION

In this paper, critical and comparative analysis of recent Geocast routing protocols has been made in terms of various Geocast metrics. The deep study of recent Geocast routing protocols leads us towards future research challenges towards Geocast routing in VANET. Our work will give better outcome for future work for Geocast Routing.

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