Adaptive Hybrid Routing Protocol for VANETs

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Abstract—Within VANETs, vehicle mobility will cause the communication associations between vehicles to deteriorate. Hybrid routing is necessary as one size fits all approach is not suitable for VANET's due to diversity in the infrastructure consisting of mobile nodes, stationary nodes, road-side units (RSU), control centres etc. Therefore, in the proposed system, we implement a hybrid design methodology, where we syndicate features of reactive routing (AODV) with geographic routing and proactive routing protocol. Adaptive Hybrid Routing Protocol(AHR), vehicles use proactive routing protocol for V2I communication and reactive routing protocol with geographic routing protocol for V2V communication. The system integrates features of both reactive and geographic routing protocols along with proactive routing schemes. It combines these routing protocols in a manner that efficiently uses all the location information available and exit to reactive routing as the location information degrades. As compared to the existing standard routing protocols, the analysis and simulations show that the routing overhead has been significantly reduced. It demonstrates how such a performance enhancement would yield a scalable and efficient routing solution in the context of VANET environments. Even in the occurrence of location errors, proposed system works efficiently and obtains scalable performance, thus making it an optimal protocol for VANETs.

Keywords*-VANETs, Efficient V2V Communication, V2I Communication, On-Board Units, NS2, SUMO, AODV, GSR*

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I. INTRODUCTION

The basic idea behind VANET is to increase safety, security and reduce the unnecessary expenses caused due to collisions. A statistic states that accidents are the predominant cause for approximately 1.2 million deaths and about 50 million accident related injuries. This has made vehicular accidents likely to become the third-leading cause of death in 2020 from ninth place in 1990[21]. VANETs can be implemented and can monitor traffic, escape collision, navigate vehicle, control traffic lights and traffic congestion by providing signals to drivers. Vehicle safety is one the most researched and talked about topic in today's world of increased mobility and Intelligent Transportation System (ITS) [23] is the future of all transportation systems. Range of concepts and protocols deal with this. Vehicular Ad-Hoc Networks (VANET) is one of those concept which helps us achieve greater control and co- ordination between vehicles with increased safety. A communications technology which fits within this is Dedicated Short-Range Communications (DSRC) technology[16]. Based on inputs from various sensors that detect vehicle flow will be able to observe traffic to synchronise traffic lights and to direct vehicle owners of alternative routes and thus reduce vehicle congestion. A dedicated control channel can be used to broadcast public safety information and emergency services can be prioritised to change traffic signal to reduce response time. On road, vehicles can communicate with other vehicle to ensure safety, such as minimum vehicle space, collision detection[1]. This when extrapolated to entire traffic infrastructure provides better safety to drivers and passengers and improves overall efficiency of the transport infra. Thus the numerous known and yet to be found applications of DSRC has the potential to change the urban transport landscape as we know it today[14].

An important application of VANET communication is seen in rigorous system that increase passenger protection manifold by sending alert messages from vehicle to another. VANETs by virtue of being a mobile network topology requires a robust communication protocol that can withstand frequent topology modification and provide good performance. Since all the nodes are transportable in nature and the movement rate is high, the links between the nodes gets broken easily[15].

There are two major classifications in VANET routing protocols: 1) Topology-based routing and 2) Geographic (position-based) routing. Fig 1 shows the types of VANET Routing Protocol. Packet forwarding is accomplished in Topology-based routing protocols using the link's state information [6] to forward the packet from source node to the destination node [12]. Topology based routing protocol can be further classified into Proactive and Reactive Routing protocol[2]. Position-based routing protocols depend on the information about the physical position of the participating nodes. Researchers have examined the working of various existing topology-based routing protocols and their consequences have revealed that the ad hoc on-demand distance vector (AODV)[8] protocol possesses the superlative performance and lowermost routing overhead among all topology based routing protocols[20]. The major drawback among all topology based routing protocols is that the efficiency lowers as the network proportions increases, demonstrating the scalability issues [12].

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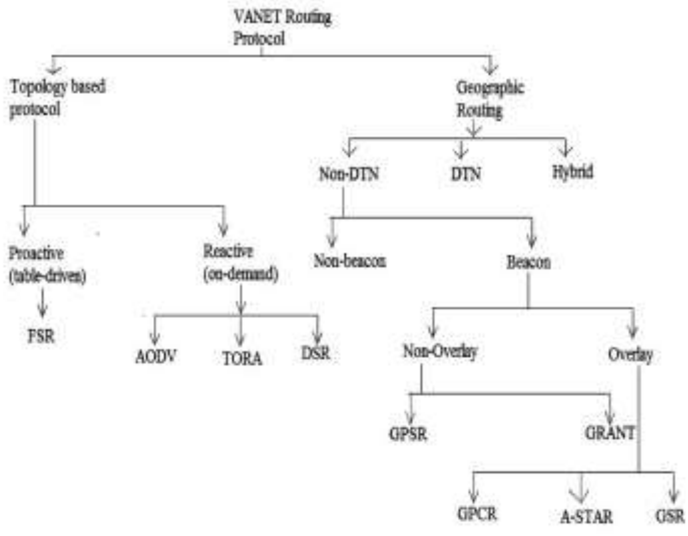

Fig 1: Types of Routing Protocols in VANET

The RSU acts as a buffer point or a router or even an access point which can provide data and store them when needed [5]. Vehicles upload or download data from these RSU's. Routing based application, car to home application, car to infrastructure application and car to car traffic application are the classifications of the applications [20]. Applications of VANETs can be as follows:

Post-Crash Notification: Warning messages are broadcasted from the vehicles involved in an accident about its position to trailing vehicles to help take decisions on time and highway patrol for tow away support.

Remote vehicle personalisation/diagnostics: It helps in uploading of vehicle diagnostics from/to infrastructure and downloading of personalised vehicle settings.

Internet Access: If RSU is working as a router, internet can be accessed by vehicles through RSU's.

Route Diversions: Helps make trip and route planning in case of road congestion.

Electronic Toll Collection: Electronic toll payment can be done through a toll collecting point. On-Board Units (OBU) of the vehicle shall be read by the toll collecting point. OBUs work via on-board odometer or techograph and GPS [17] as a backup to determine how far the vehicle has travelled by reference to GSM and digital map to authorise the payment of the toll via a wireless link.

Parking Availability: In metropolitan cities, notification regarding the availability of parking helps to find parking lots and availability of parking slots in it in a certain geographical location.

Time Utilisation: While waiting for a relative or a friend in a car, one can browse internet and also can transform jam traffic into a productive task if he downloads his email and read on-board system.

Fuel saving : When toll is collected at the toll system application without stopping the vehicle, around 3% fuel is saved, which is consumed by a vehicle when it normally waits for 2-5 minutes[17].

II. Related Work

In A Hybrid Reliable Routing Protocol for Efficient Routing in VANETs[3] algorithms for Processing and Forwarding Route Request packets and GPSR Greedy Forwarding Algorithm are presented. Benefits and drawbacks of various protocols using various approaches are analysed. Implementation of hybrid Routing protocol in VANET[4] presents analysis and simulation of Hybrid Protocol routing in VANET. It shows that even in existence of high location errors the protocol has less overhead and no scalability issues. A Hybrid Routing Protocol for VANETs[5] explains the architecture and working of Hybrid Protocol routing in VANET. This paper shows that our protocol is more efficient in terms of performance even in case of his number of nodes. In Fast and Reliable Hybrid Routing for VehicularAd hoc Networks[6] protocol for efficient vehicle to infrastructure communications is proposed. Communication to infrastructure is provided by establishing On Board Units which broadcasts beacons packets in a multi-hop fashion in a constrained range. In A New Scalable Hybrid Routing Protocol for VANETs[7], the routing protocol is proposed to overcome issues caused due to link failures. This protocol incorporate features of reactive routing with location- based geographic routing.

The FRHR routing protocol[6] exploits the fact that most unicast data traffic will pass through the RSUs. A real time vehicle is expected to maintain monitoring the frequent timely multi-hop broadcast of beacons from On Board Units in its neighbourhood which would give them a steady, dependable and comparatively minimum delay route to a corresponding RSU. Advantage of fixed infrastructure is utilised from infrastructure-assisted routing, especially in safety applications where RSU's are installed to make vehicular communication more dependable and minimise the undesirable delay. These RSU's are immovable and are interconnected through dependable backbone network and higher bandwidth[11]. Data packets are transmitted between these units using high bandwidth network, independent of their geographic locations[10].

FRHR enable vehicles pro-actively to build and maintain routing table entries for RSUs while searching for other vehicles only on-demand. The FRHR protocol includes the following functional procedures: Forwarder self-election, Registration and Localization process as well as route discovery and maintenance. The FRHR routing protocol adventures the fact that most unicast data traffic will pass through the RSUs. Maintaining routes to RSU's is important as connections to RSU's are at a higher reappearance rates than straight to other vehicles[13]. Therefore, FRHR builds and maintains routing table entrances for RSUs while searching for other vehicles only on demand. The FRHR protocol discovers and maintains Registration and Localisation process. RSUs are established in the road topology network, from the outskirts of the city towards its centre.

III. OVERVIEW

Vehicles need to locally broadcast small beacon packets intermittently. These periodic beacon packets include the information such as the vehicle's ID and the current location

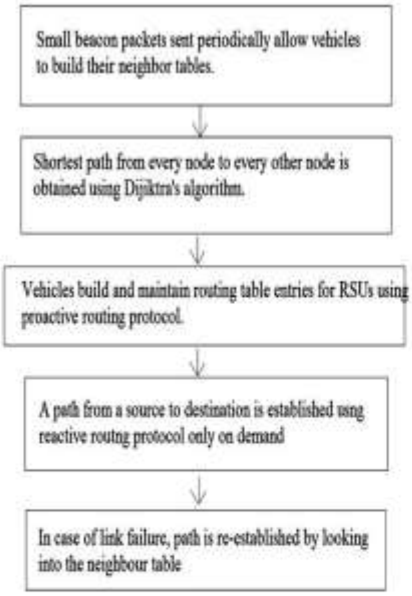

Fig 2: Flow of Adaptive Hybrid Routing Protocol

coordinates. These beacon packets also allow vehicles to build their neighbor information table. The proposed system procedures geographic (position-based) routing protocol to create the neighbor vehicle information. Fig 2 shows the overview flow of the proposed approach. Each RSU has an exclusive ID and are linked to each other by a wired/wireless network. The routing information is gathered on every hop by a beacon message called a service advertisement message which is a multi-hop transmission, transferred by each RSU in FRHR on a periodic basis. Vehicles regulate fresh routes to RSU's upon acceptance of these advertisements and help them uninterruptedly find the best candidate, called the corresponding RSU, to register with them. In addition, vehicles also keep their location informed to corresponding RSU's, therefore allowing them to push the new robust routes to their registered vehicles. These static units hold up the list of all the registered vehicles and their entire route list towards them, while vehicles build a table of the routes between adjoining RSU's. If the source vehicle has no route to the destination vehicle, then source vehicle initiates the route discovery in an on-demand fashion. The reactive routing protocol AODV along with geographic routing protocol (GSR) is used to discover routes to the neighboring vehicles.

IV. THE PROPOSED APPROACH AHR

Vehicular nodes locally broadcast small beacon packets periodically. These periodic beacon packets include the information about vehicle's ID and the current location coordinates. Using these beacon packets, vehicles build their neighbour table. Fig 3 shows the architecture of the proposed approach. Each RSU has an exclusive ID and are linked to each other by a wired/wireless network. The routing information is gathered on every hop by a beacon message called a service advertisement message which is a multi-hop transmission, transferred by each RSU in AHR on a periodic basis. Vehicles regulate fresh routes to RSU's upon acceptance of these advertisements and help them uninterruptedly find the best candidate, called the corresponding RSU, to register with them. In addition, vehicles also keep their location informed to corresponding RSU's, therefore allowing them to push the new robust routes to their registered vehicles. These static units hold up the list of all the registered vehicles and their entire route list towards them, while vehicles build a table of the routes between adjoining RSU's. The source checks up its neighbour routing table. The source checks whether it can find any closer neighbour vehicle in the direction of the destination vehicle. If closer neighbour vehicle exists, the source forwards the RREQ (Route Request) packet to that vehicle. If a closer neighbour vehicle does not exist, the RREQ packet is forwarded to all vehicles in neighbouring range. The technique is recurrent till the RREQ packet reaches the destination vehicle. When the a route reply packet (RREP) reaches the destination, it is then guided through the entire path attained from backward learning to the source. The node would establish the forward path from the source by recording its previous hop. A full duplex path is established by sending request and reply packets. The source uses this path to send packets to the destination. This established path is used for packet transmission unless a link failure occurs. After establishing a path from the source to the destination the packet transmission takes place via the established path unless there is link failure. When link failure occurs, intermediate vehicles uses route repair (RRP) packet to locally repair broken routes, instead of just reporting a broken route to its source vehicle. After recognising a broken link, the intermediate vehicle buffers the received packets to the destination vehicle. The intermediate vehicle then checks in its neighbour table whether it has any node closer to the destination node. When intermediate finds a node closer to the destination node, it updates its neighbour table and the data packets are forwarded to that vehicle. When an intermediate fails to find a node closer to the destination node, RRP packet is flooded to all the nodes with a TTL field set. RRP packet thus when received by the neighbouring vehicles, they check their respective neighbour table to find a node closer to the destination node. When this node finds a neighbour vehicle, reply is indicated using a route repair reply (RRRP) packet and the data is forwarded to the next vehicle. When this node fails to find a neighbour vehicle, RRP packet is flooded to all its neighbouring vehicles after decrementing the RRP packet TTL field. The procedure is repeated until the destination is reached. If an intermediate vehicle is not successful in locally

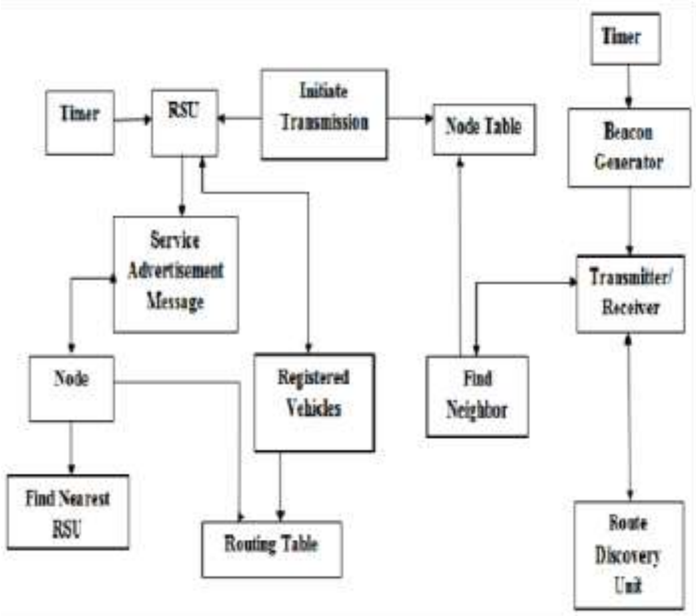

Fig 3: Architecture of Proposed System

repairing a broken link, a route error (RERR) packet is sent to the source vehicle.

V. VANET SIMULATION

a. Visual Simulation

"Simulation of Urban MObility" is an open source, microscopic, multi-model traffic simulation. SUMO gives the user a better idea about the placement of traffic lights, junctions of roads, road networks etc. in a map. A clear idea about path of the vehicle run, the speed and manner of the vehicle run can be understood an thus collision can be avoided[19]. Fig 4 shows the SUMO Environment Layout. In the project, a SUMO network file describes the traffic-related part of a map. SUMO gives the user a better idea about the placement of traffic lights, junctions of roads, road networks etc. in a map. A clear idea about path of the vehicle run, the speed and manner of the vehicle run can be understood an thus collision can be avoided.

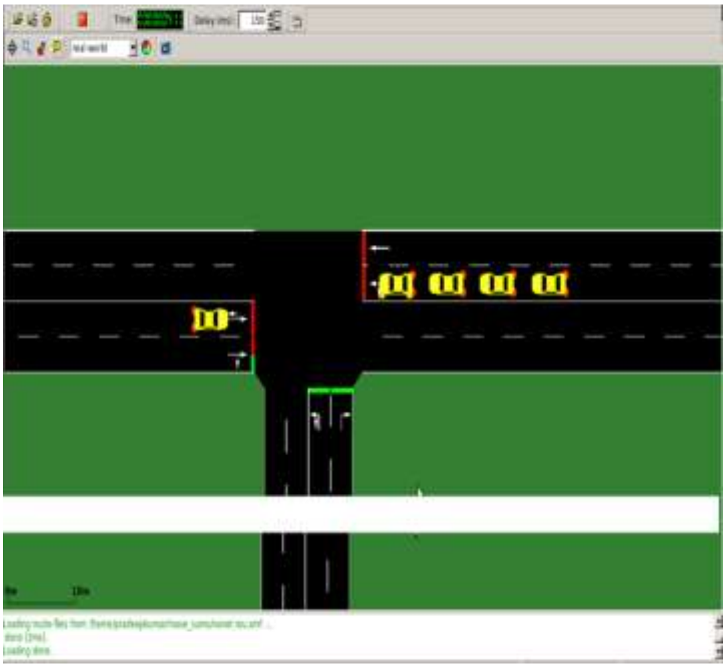

Fig 4: Screenshot of a SUMO window

b. Performance Evaluation

Routing protocol's performance is evaluated using NS2 simulator. Nodes present in the network are placed as to create a highway scenario with On-Board Units established on the sides of the road lane. We used Throughput, Packet Delivery Ratio, Delay and Overhead to evaluate the performance of the proposed system. In this project, as a simulation tool, Network simulator 2 is used. NS2 was selected as the simulator partly for the reason that it contains open source code that is modifiable and extensible and partly because it provides a range of features.

Simulator	NS2
Network Area	500 * 500
Channel Type	Channel/WirelessChannel
Propagation Model	TwoRayGround
MAC Layer	802_11
Max packet in ifq	50
Number of Nodes	30
Routing Protocol	AODV
Antenna Model	OmniAntenna
Communication Range	250

Table 1: Simulation Setup

c. Evaluation Measures

A performance metric is a standard used in a routing algorithm to determine the effective value of measurement observed by a packet while travelling from the source node to the destination. Performance parameters used to measure and evaluate the effectiveness of the proposed algorithm are Throughput, Packet delivery ratio, End to End Delay, Routing Overhead[18].

Throughput: In communication networks, Throughput is the amount of digital data per time unit delivered over a physical or logical link. It is measured in bits per second (bits/s or bps), occasionally in data packets per second or data packets per time slot.
Throughput = (packet/sec) = Number of packets send successfully-Total time
Fig 5 shows the graph for Throughput of AHR protocol and FRHR protocol. We observe that the throughput of AHR protocol is consistently more than that of FRHR protocol. We observe that in both the protocols, FRHR and AHR, with the increase in the number of nodes there has been a steady increase in the throughput value.

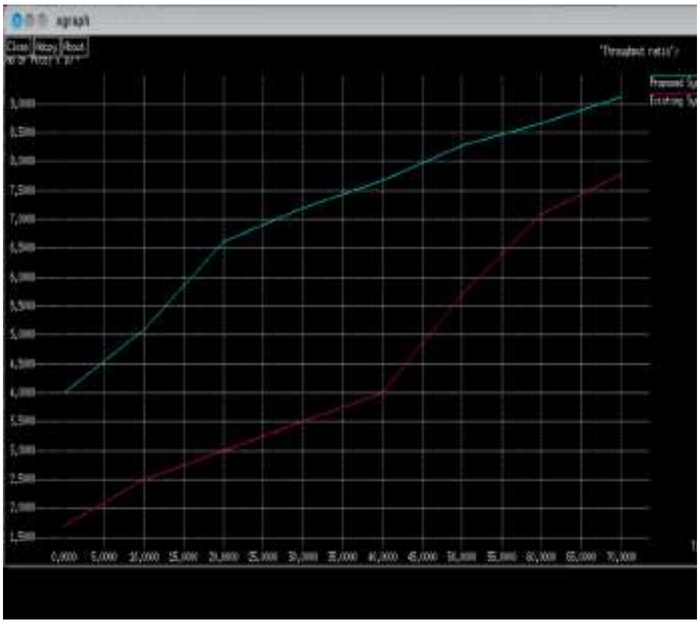

Fig 5: Throughput of FRHR versus AHR Protocol

Fig 6: Packet Delivery Ratio of FRHR versus AHR Protocol

Packet delivery ratio (PDR) : Packet delivery ratio is the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination. The greater value of packet delivery ratio means the better performance of the protocol.

PDR= Number of packet receive / Number of packet send

Fig 6 shows the graph for Packet Delivery Ratio of AHR protocol and FRHR protocol. We observe that the delivery ratio of transmission packets of AHR protocol is consistently more than that of FRHR protocol. We observe that in both the protocols, FRHR and AHR, with the increase in the number of nodes there has been a steady increase in the delivery ratio of packet value.

Delay: The average time taken by a data packet to arrive in the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted.The lower value of end to end delay means the better performance of the protocol.

End to End Delay= Arrive time – send time / Number of connections

Fig 7 shows the graph for End to end delay of AHR protocol and FRHR protocol. We observe that the delay of transmission packets of AHR protocol is consistently more than that of FRHR protocol unless the number of nodes significantly increases. We observe that for FRHR protocol, delay is high but as the number of nodes increases the overhead of FRHR protocol is less as compared to that of AHR protocol.

Overhead: The scalability is one of the major factor for the MANET. Infrastructure is going to increase as network grows. Various protocol is try to perform differently[22]. Routing

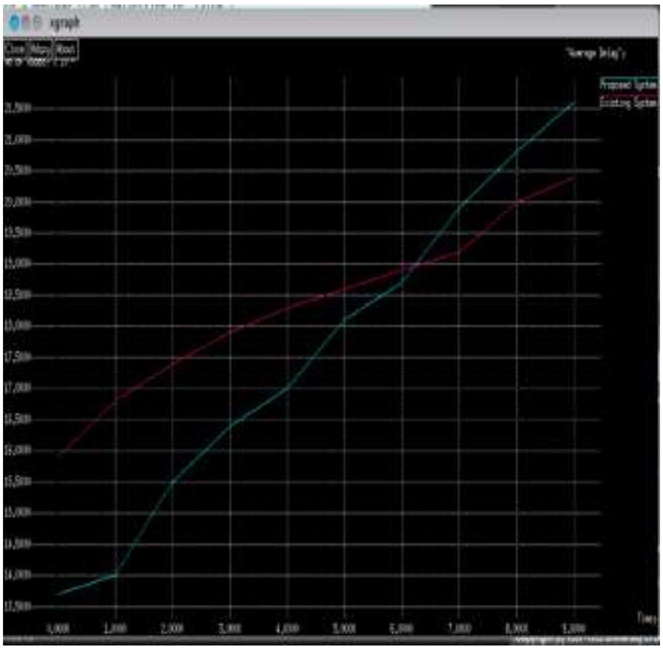

Fig 7: Delay of FRHR versus AHR Protocol

overhead can be defined as total no of routing packets send by node.

Routing overhead = total number of routing packet sent / number of data packet received

Fig 8 shows the graph for Overhead of AHR protocol and FRHR protocol. We observe that as number of nodes increases the overhead also increases. For FRHR protocol, overhead is high but as the number of nodes increases the overhead of FRHR protocol is less as compared to that of AHR protocol.

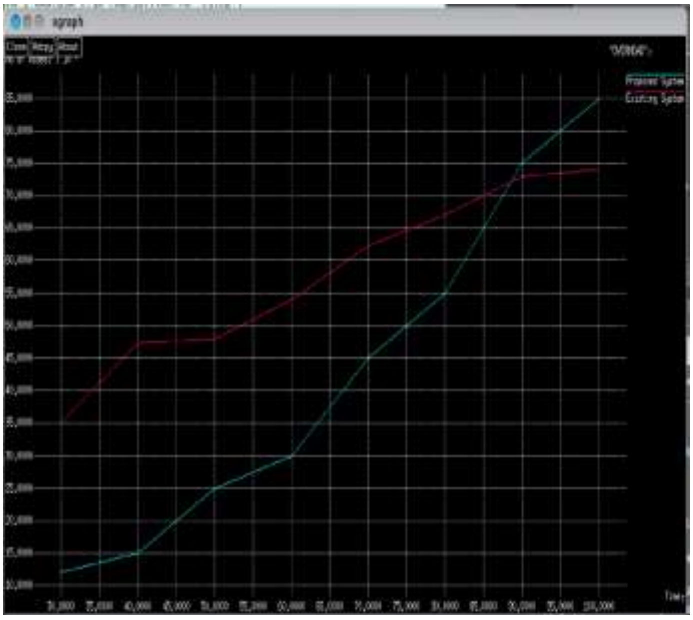

Fig 8: Overhead of FRHR versus AHR Protocol

VI. CONCLUSION AND FUTURE SCOPE

Vehicular Ad Hoc Networks is a developing and encouraging technology. This gives a wide analysis for the current challenges and solutions. Apart from ensuring availability of information that provides a safer driving behavior and a better travelling experience, the network is an economic, communication, and knowledge management enabler. Adaptive Hybrid Routing Protocol associates features of reactive routing AODV with location-based geographic routing GSR along with proactive routing to on-board units. The proposed system has presented a novel inter-vehicle infrastructure-assisted routing approach for reducing the network traffic congestion. The system adapts according to the current routing environment and then communication between the on-board units takes place.

As future work, Adaptive Hybrid Routing Protocol can be deployed in more scenarios within harsh urban vehicular environments. There are many possibilities present in VANET for improvement. The characteristics of VANETs make the secure routing problem more challenging and novel than it is in other communication networks. Another challenge associated to routing in VANETs is data sharing and resourceful information dissemination. Supplementary areas for enhancements and improvement include the combination of privacy and security procedures.

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