ROUTING OF TRAFFIC SENSORS IN INTELLIGENT TRANSPORTATION SYSTEM

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Abstract

As country develops, the application of technology in each and every field increases to fulfill the demand of people. The application of technology in transportation system is called Intelligent Transportation System (ITS) which has more demand in today's world for traffic management. Vehicular Ad hoc Network (VANET) is one of the technology used in Intelligent Transportation System. In Vehicular Ad hoc Network temporary network is formed within the vehicles or vehicle to traffic infrastructure which has sensors within it for communication. The temporary network establishes and ends after exchanging the required information. This process should happen within fraction of seconds which is more complicated issue in highly mobile vehicles, so routing is a major problem in Vehicular Ad hoc Network. In this work, hybrid two stage heuristic routing protocol which is based on ant colony optimization and particle swarm optimization algorithm is used to make routing more efficient in Vehicular Ad hoc Network. The MATLAB software is used to implement the algorithm. The result shows that two stage heuristic protocol perform better than Ad hoc on Demand Vector (AODV) protocol.

Keywords: *Intelligent Transportation System, Vehicular Ad Hoc Network (VANET), Ad Hoc on Demand Vector (AODV), Ant Colony optimization (ACO), Particle Swarm Optimization (PSO)*

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1. INTRODUCTION

VANET is necessary for transportation system to obtain real time traffic information like origin-destination trips, route flow, link flow, travel time estimation etc. In VANET, sensors collect the information of vehicles to provide transportation services like travel and traffic management, emergency management, electronic payment etc.

Vehicular Ad hoc Network (VANET) is a type of Mobile Ad hoc Network (MANET) used in Intelligent Transportation System to obtain traffic information. VANET is a network formed by moving vehicles with no infrastructure which is formed instantaneously. VANET architecture can be divided into three types WLAN network, Ad Hoc network and Hybrid network.

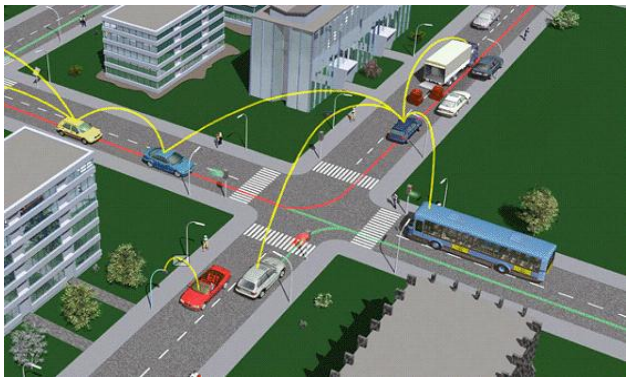

Fig -1: Transportation system using mobile wireless sensor network

Sensors are another important device which consists of basic elements like microcontroller, radio transceiver and energy source. The application of intelligent transportation system is shown in figure 1. The travel time estimation is the application used in logistic departments to deliver goods to customers on time. By using information of travel time estimation one can understand the condition of road, traffic congestion etc. and calculate the travel time for delivering particular goods.

1.1 VANET Protocols

Routing protocols are used to transfer data in a network between entities. In vehicular Ad hoc network (VANET) routing is challenging task because of dynamic change in speed of vehicles. In highways the vehicles average speed is 65 km/h i.e. 17m/s, so the routing should be very quick in fraction of seconds. The routing protocol of VANET are divided into two basic types, they are as follows,

1.1.1 Topology Based Routing Protocol

Topology based routing is protocol uses links of other nodes to transfer data packets in a network to collect information. This routing protocol suffers from huge amount of overhead for route discovery and frequent change in topology limits their scalability and efficiency. Topology based routing protocol is further divided into two types. The proactive routing protocol maintains routing tables for all routing in the topology. In Proactive routing table updates regularly

and sends the information from source to destination. There are two types of updates are available in proactive protocols

- periodic update
- triggered update

Reactive protocols are contrast to proactive protocols because they do not maintains routing tables for routing in changing topology. In this protocol, when source node want to transmit the data and discovered route the query floods is stored until other node is inaccessible. The bandwidth of network is low due to route discovery mechanism. Reactive protocols are Dynamic Source Routing (DSR) and Ad-hoc On-Demand Distance Vector routing (AODV).

1.1.2 Geographic Routing Protocol

Geographic routing protocol uses neighbor location information to perform data packet transmission. The geographic routing protocols collects local information in wireless networks. The node needs the location information of their direct neighbors in order to forward packets. Mobile networks with frequent topology changes, geographic routing has fast response and can find new routes quickly by using only local topology information which is complicated method.

2. PROBLEM FORMULATION

VANET form a temporary network which consists of sensors in moving vehicles. The sensors in vehicles communicate within themselves and exchange of information is possible. The node to infrastructure communication is possible with cellular network. Due to the mobility of vehicles, the topology of network changes frequently, breakages of network links and no central control. So both topology based and position based routing are proposed previously. The AODV (Ad hoc On Demand Vector) protocol is a type of reactive protocol that forms the route whenever required. In route discovery, the route request packet is sent from source to the RSU which in turn sends it to central control unit which is maintained by transportation authority. The destination RSU receives the packet from Central control unit. One of the node is selected as relay node among all nodes, dynamically which establishes route and using shortest path sends the packets.

Effective routing is most difficult task in mobile vehicles because of frequent change in topology. To achieve effective routing two stage heuristic hybrid algorithm is proposed. The two stage heuristic algorithm is based on particle swarm optimization and ant colony optimization. The ant colony optimization is upper level algorithm and particle swarm optimization follows the route produced by ant colony optimization. So that communication is more effective with shortest route.

3. HYBRID TWO STAGE HEURISTIC ALGORITHM

Swarm intelligent technique is a modified form of Ad hoc On Demand Vector protocol and it serves best in routing. The two swarm intelligent algorithms i.e. Ant colony optimization algorithm and particle swarm optimization algorithm are combined and performed routing.

By combining both particle swarm and ant colony algorithm, the hybrid two stage heuristic algorithm is designed. The ant colony algorithm aims to build route for mobile sensors. Particle swarm optimization algorithm tries to determine the links optimal stay time of each node for known route. The route is critical connection between Ant colony optimization and particle swarm optimization. Ant colony is the upper level algorithm and provides route for particle swarm optimization [1].

3.1 Ant Colony Optimization

Ant colony optimization is the algorithm based on characteristics of natural ant's activity of finding the shortest path between its nest and food source. The ants searches their food by depositing the chemical called pheromone which triggers the member of same species. By pheromone rest of the ants follows the previous ants. Between nest and food source if the previous ant finds any shortest path it deposits more pheromone which is followed by other ants. Pheromone is critical component of ant colony optimization and offer possibility to obtain better solution.

3.2 Particle Swarm Optimization

This algorithm is inspired by swarm of insects like honey bee works together to form candidate solution. Here the insect is called particle. The particle moves in search-space using few simple formulae. The movements of particles are guided by their own best known position in search space as well as entire swarm best known position. When improved position are being discovered these will then come to guide the movement of the swarm. This algorithm considers position and velocity of nodes.

The hybrid sensor routing technique is introduced in current approach to improve the performance of transportation network. The hybrid routing protocol is modification of Ad Hoc on demand vector protocol and is related to swarm intelligent. The ant colony optimization and particle swarm optimization are used to form hybrid two stage Heuristic Algorithm. The current approach will have multiple Road Side Unit (RSU) and control server will be present at the center. The routing process will be defined as follows, Road Side Unit to Control Server, Control Server to Destination Road Side Unit, Destination Road Side Unit to destination node by selecting best route. The block diagram of steps involved in traffic sensor routing is shown in figure 2.

Steps involved in traffic sensor routing

- Node Deployment is responsible for placing the node ID in the network. The vehicle ID, X position of node and Y position of node is generated by node deployment algorithm.
- Lane Formation is used to arrange the sensors within the lane.

- Relay Node Selection Process is responsible for selecting the relay vehicle in the network. The Relay Vehicle selection process is triggered by using a probing technique.
- Ad hoc on Demand Vector (AODV) Routing algorithm is frequently used in routing process of VANET. The nodes self organize themselves into clusters at the start of routing process and called as dynamic clustering.
- Heuristic Hybrid Algorithm Routing Process
  In this process multiple routes will be discovered and then for each of the route the characteristics are determined and the best route is determined.

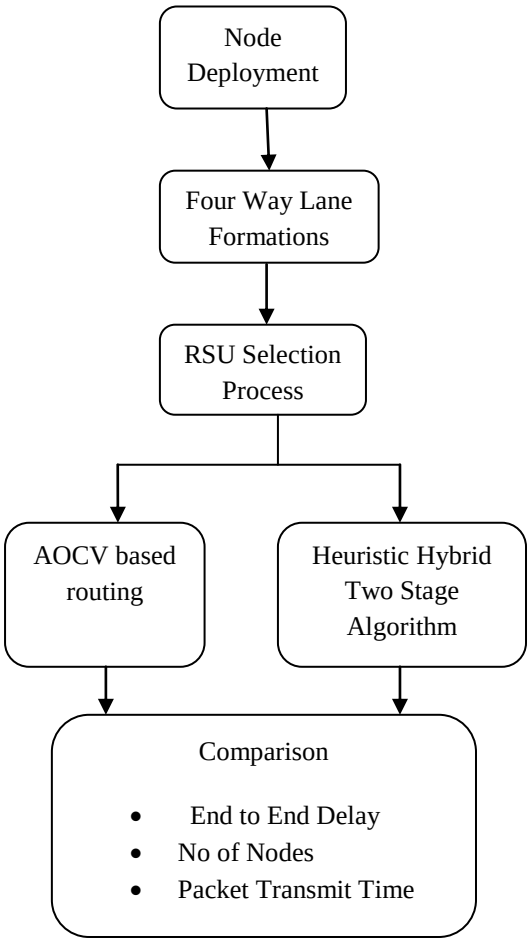

Fig - 2: The block diagram of steps involved in traffic sensor routing

The RSU selection process can be defined as below

1. Node ID of specific Lane and RSU location.
2. Probing Technique is employed within mobile sensors in each lane.
3. The Vehicle which has maximum RSU acknowledgement (ACK) count acts as Relay Vehicle.

Probing technique

1. Number of iteration
2. RSU ACK will be measured for each iteration.

$$\text{RSU ACK} = \frac{\text{Number of reply}}{\text{Number of Packets Generate}}$$

3. Total RSU ACK = Summation of ACK for all iteration.

The following steps are followed for Heuristic Hybrid Algorithm Routing Process

1. The Maximum travel time for each of the sensors are found out

$$h_{i,m} = \left\langle \theta_1 \frac{W - \sum \max(t_k)}{W - \sum h_{i,m} - \sum e_m},\ m \le M-1, m = M \right\rangle$$

$\theta = random\ value\ 0 \le \theta \pm 0.1 \le 1$

$W = total\ time$

$t = time\ between\ nodes$

$em = real\ time\ for\ the\ node m\ to\ m+1$

$M = total\ number\ of\ nodes\ in\ route$

2. The Position of the Particles are updated
3. The Velocity of the vehicle Sensor is updated as follows

$$v_{i,d} = Zv_{i,d-1} + C_1 \times \Theta_2 \times (\text{pbest}_{i,d-1} - h_{i,d-1}) + C_2 \times \Theta \times (\text{I best}_{i,d-1} - h_{i,d-1})$$

Where,

d represents the dth generation for the ACO algorithm

hi, d represents the stay time of the ith particle of the dth generation

hi, d is a vector, and each element of hi, d is $h_{i,m}$

$v_{i,d}$ is the i th particle's velocity at the dth generation

$\text{pbest}_{i,d-1}$ is the personal optimal solution found by the ith particle among its own historical solutions, and $\text{lbest}_{i,d-1}$ is the local optimal solution

Z is a positive inertia parameter

$C1$ and $C2$ are positive constants

$\theta 2$ is a random generated value ranging from 0 to 1

4. RESULTS

Comparing AODV algorithm and Heuristic routing algorithm for some parameters are as follows. The comparison is done for 25 iterations.

4.1 End to End Delay

The comparison of AODV algorithm and Heuristic routing algorithm for end to end delay is shown in figure 4.1 is plotted for 25 numbers of iteration. The time taken should be in millisecond. The figure shows that for heuristic routing in 1st iteration it takes more time to deliver the packets, for 2nd iteration it takes lesser time then the 1st iteration and for rest of the iteration the time taken is less than 2nd iteration and approximately .01ms constantly for all other iterations. But in AODV routing the time is varying for each iteration and maximum time taken by it is 0.14ms and minimum time

taken by it is .03ms which is more than heuristic. The time taken to deliver all the packets using heuristic routing is less compared to AODV routing.

4.2 Number of Hops

The Comparison of AODV algorithm and Heuristic routing algorithm for number of hops are shown in figure 4.2. Number of nodes taken to deliver all packets from source to destination for heuristic more than 200 hops. The average number of hops used by heuristic algorithm is approximately 25 hops which is very lesser than the hops used by the AODV routing.

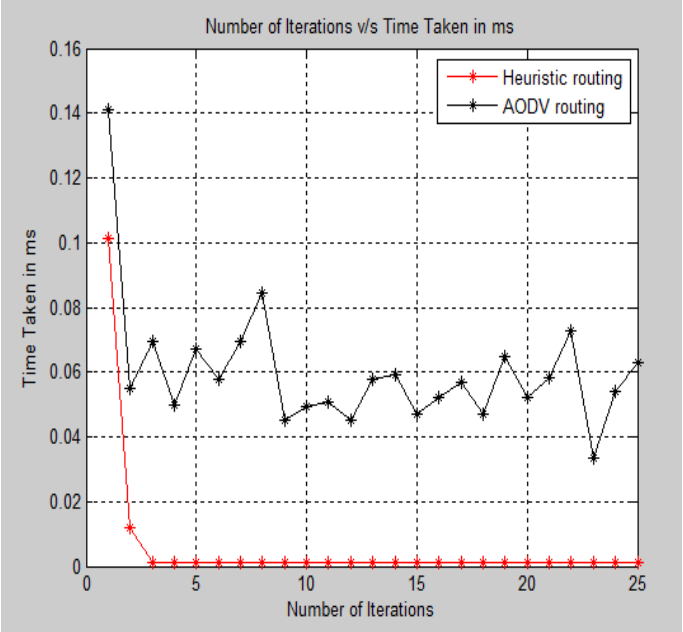

Fig - 4.1: End to End Delay

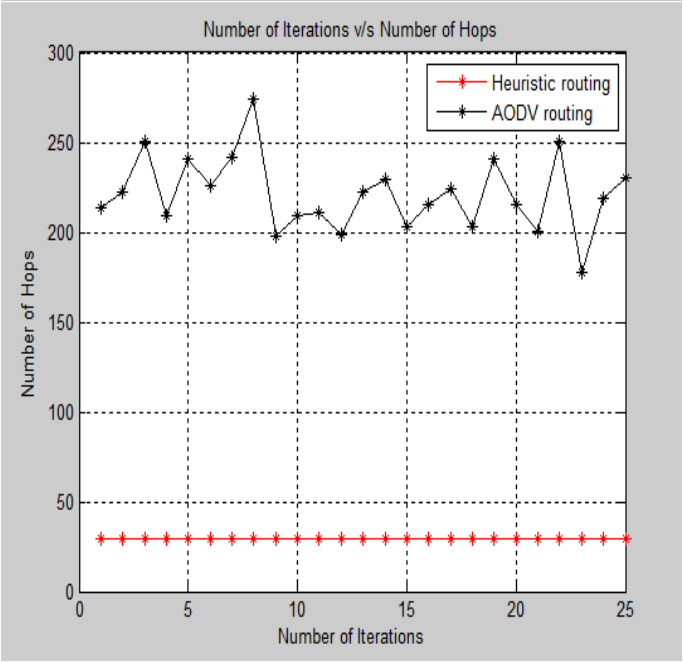

Fig - 4.2: Number of Hops

4.3 Energy Consumed

The comparison of AODV algorithm and Heuristic routing algorithm for energy consumption is shown in figure 4.3. Total number of energy consumed by all the nodes to deliver all packets for AODV routing is more than 10000mJ and that heuristic routing consumes less than 2000mJ energy to deliver all the packets.

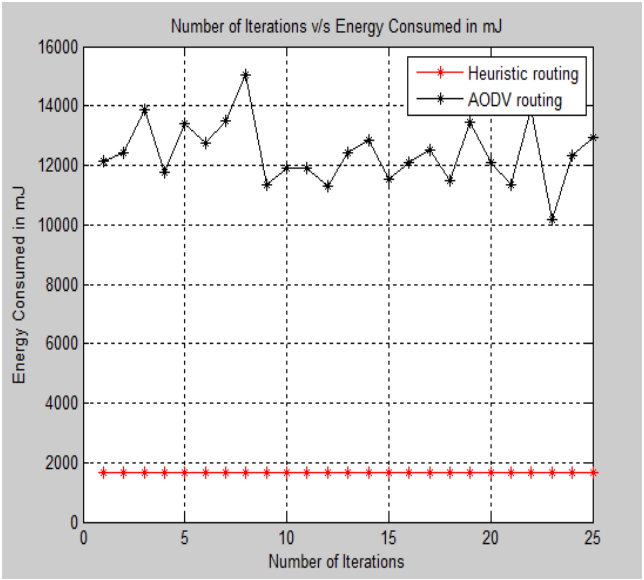

Fig - 3.3: Energy Consumed

5. CONCLUSION

In this project, the more emerging technology intelligent transportation system is discussed. For developing countries with more population intelligent transportation system is very essential to avoid many road accidents, to give better service to travellers, to guide drivers regarding traffic, travel distance, road condition, weather etc. the routing is a major issue in rapidly changing network.

By using hybrid two stage heuristic algorithm based on swarm intelligent for routing gives better results than ad hoc on demand vector algorithm. By comparing the both heuristic and ad hoc on demand vector algorithm parameter like end to end delay, routing overhead, number of hops, energy consumed heuristic algorithm is found to give better results than ad hoc on demand algorithm.

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