

## ANTHOCNET: A SWARM INTELLIGENCE BASED ROUTING PROTOCOL'S PERFORMANCE IN VANETS

Ms. Ritu Sehgal, Dr. Vijay Nehra, Dr. Pawan Dahiya

**Abstract:** Intelligent Transportation Systems (ITS) has brought a new era of communication in last few years. The latest area which is being into focus is Vehicular Ad-hoc Networks (VANETs). The main target is to provide safe journey and reliability to the drivers eliminating the open challenges introduced by the VANETs. Different types of routing protocols to keep networking and communication among different vehicles while moving on the road has been introduced. The older one is the topology based routing protocols but it is not suitable for different and every type of scenarios in VANETs. To overcome few of the open challenges of VANETs, classic optimization techniques can be taken into consideration. These techniques can be formulated as unsolved optimization techniques but again at the cost of new challenges. These problems introduce novel models, limited computational resources and constrained network capabilities. To handle these issues, bio-inspired algorithms can be used. In this paper, different types of Natural computing methods are discussed in brief and how bio-inspired algorithms solve the open issues in VANETs are discussed in brief. This paper also focuses on the different swarm based routing protocols being used till date in VANETs along with a brief state-of-art of such protocols. One of the swarm based routing protocol AntHocNet, which is a hybrid routing protocol is also discussed in brief in the paper and its performance is compared with some classical routing protocols meant for VANETs is also discussed.

**Keywords:** VANET, AntHocNet, Swarm, ITS, Natural computing, NC, Routing protocols, Bio-inspired

### I. INTRODUCTION

Road traffic problems is the most serious issue that has been caused due to vast use of private cars and needs to be solved in modern society. It has been estimated that more than 1.2 million human deaths take place due to road traffic accidents. The longer trip times and increase in the pollution level is the effect of traffic jams that can be seen daily, hence also contributing towards the economic losses due to delays and other transport issues. Due to research in Intelligent Transportation System (ITS), safety in road transport is becoming a reality. Many smart mobility solutions based on ITS is being introduced in the market like Waze (Waze, 2009) or TomTom (TomTom, 2003).

ITS technology is using the concept of sharing the information about traffic conditions with road users by using wireless communication. The major cause of

traffic jams and accidents is misjudgement of drivers. ITS enables the drivers to take better decision under such conditions. Moreover, ITS can automatically takes decision efficiently and conveys the information to the driver. This will also open plethora of other applications for passenger due to the emergence of vehicular communication networks. However, these services possess certain drawbacks: i) system provides traffic information related to the main roads of city, ii) the information updates lasts for 20-30 minutes, and iii) systems are centralized and have fixed and costly infrastructure. Vehicular Ad Hoc Networks (VANETs) emerges as the solution towards such drawbacks as it is being a spontaneous network of self-organized vehicles and roadside infrastructure elements, which allows exchanging the data amongst each other by using short range wireless communications. VANETs monitor the traffic conditions by using vehicles and roadside elements, acting as source of information using their internal sensors. VANETs must be capable in exchanging the real time information; using wireless medium efficiently, thereby needed the communication protocols to adapt in accordance with the continuous change in road traffic environments, etc.

To obtain the mentioned features, VANETs needs to have set of hard constraints. This result in the fact that classic optimization techniques that can be formulated as unsolved optimization techniques opens new challenges. These problems presents limited computational resources, one or more opposing objectives, novel models and constrained network capabilities. These network and computational resources must be handled in two different terms: i) restricted resources (wireless medium, energy, economic cost etc) must be handled by computed solutions; and ii) optimization process should address the problem in constrained time and using a limited computation platform. This results in robust, modern and advanced methods to address the challenges.

One such method that is widely used to tackle complex optimization problems is Bio-inspired algorithms, as it uses Natural Computing (NC) methods. Near-optimal solutions can be obtained in timely fashion using these algorithms. NC in optimization is becoming popular amongst the researchers these days. Some features which makes NC attractive are: i) they are generic tools (do not require full problem knowledge), ii) can be tailored in terms of memory size, numerical accuracy, and iii) they provides reduced computational complexity.

These features of NC motivate the researchers to address optimization problems in the domain of vehicular networks. In this paper, we have tried to show the feasibility to solve optimization problems in VANETs. We formulate the question about applying NC to efficiently address the observed open issues in VANETs,

which can be expressed as hard-to-solve optimization problems. The general hypothesis of this paper is as “NC is suitable to efficiently address VANET optimization problems, overcoming some limitations of traditional methods”. Afterwards, we performed the experimentation phase in which AntHocNet is compared with AODV and AOMDV routing protocols. Section 2 gives a brief review about the introduction of NC algorithm in VANETs. Section 3 discusses the working of AntHocNet which is the main focus area of this paper. Section 4 briefs the simulation process carried out which is further strengthened by the results.

## II. NC APPLIED IN VANET

Bio-inspired algorithms are categorized as Evolutionary Algorithms (EA), swarm intelligence and Simulated Annealing (SA). EAs are based on Darwinian Theory of evolution (Fogel et al., 1966; Holland, 1975). Darwin proposed that a population of individuals capable of reproducing and subjected to (genetic) variation followed by selection result in new populations of individuals increasingly more fit to their environment (De Castro, 2006). These natural processes applies to computation result in genetic algorithms (GA) (Goldberg, 1989), genetic programming (GP) (Koza, 1992), evolutionary programming (EP) (Fogel, 1999), and evolution strategies (ES) (Beyer and Schwefel, 2002). Swarm intelligence refers to cellular robotic multi-agent systems which works by collecting simple agents in an environment based on local rules (Bonabeau et al., 1999). Particle swarm optimization (PSO) (Eberhart and Kennedy, 1995), ant colony optimization (ACO) (Dorigo et al., 1996), and artificial bee colony algorithm (ABC) (Karaboga and Basturk, 2007) are some of the swarm based intelligence algorithms. SA is a bio-inspired algorithms and is based on annealing process of metal and crystal (Kirkpatrick et al., 1983).

These natural inspired algorithms can be categorized as: i) Population based or swarm based algorithms; ii) trajectory based algorithms (Figure 1).

### a. Challenges tackled in VANETs using NC

Chiong et al. (Chiong, 2009) has shown application of different bio-inspired computation in different areas, such as, medicine (Dybowski et al., 1996), smart mobility (Stolfi and Alba, 2013), civil engineering (Zavala et al., 2014) and telecommunications (Yang et al., 2015). In our previous paper, where different challenges arising from VANETs have been analyzed, we suggest NC to be an

efficient tool to address the challenges. In this paper we are analyzing the application of NC in data routing.

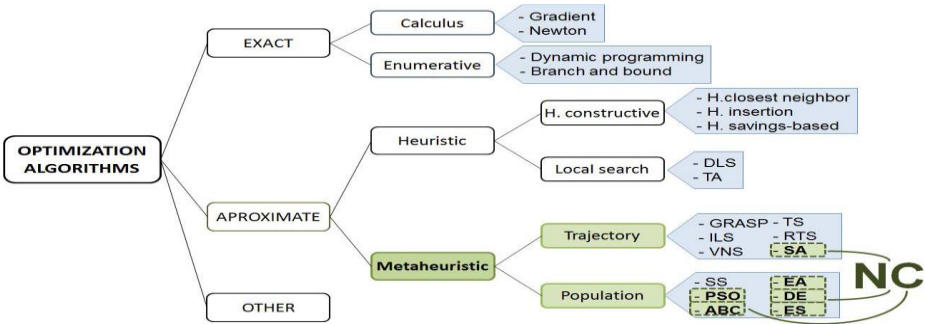


Figure 1: Classification of optimization techniques (Toutouh, 2015)

**b. Natural Computing for VANET Data Routing**

Bitam and Mellouk (S. Bitam, 2014) proposed a bio inspired algorithms apart from traditional used routing protocols used in VANETs. These bio inspired algorithms are inspired from Bee life, ant colony and swarm intelligence. Authors suggested the application of such algorithms in vehicular scenarios and focused this idea to improve the road safety of travelers. These algorithms enhance the QoS of vehicular network.

Authors (Dressler and Akan, 2010) suggested a detailed state of art of different techniques and methods based on bio-inspired networking. Biological principle involved behind different types of swarm intelligence techniques is mentioned along with detailed analysis of Ant Colony Optimization (ACO) technique. Author (Chen et al., 2011) have discussed different data dissemination techniques to handle challenges in VANETs and suggested bio-inspired algorithms as a powerful tool to solve different challenges. Chauhan and Dahiya (2012) proposed a scheme where AODV is combined with ACO to avoid the delay in communication. This delay is caused due to frequent disconnections that often occur in fast changing topology scenarios. They applied the scheme AODV-PGB to repair the broken routes in order to deal with the dynamic changes in the topology of road. To address the issue large number of specific data routing protocols have been proposed and discussed by authors (Dua et al., 2014; Campolo et al., 2015). Correia et al. (2011) designed Mobility-aware Ant colony optimization Routing DYMO (MARDYMO), by applying ACO to Dynamic MANET On-demand (DYMO) protocol, to find efficient routing paths. MARDYMO shows improvement over DYMO but results in increase of routing overhead. MARDYMO initiates a new routing discovery at the source

node to replace the invalid route, when a link is broken thereby increases the routing control overhead.

Author introduced a novel hybrid algorithm based on zonal routing and ACO routing. In this routing ants hop from one zone to another zone. The route discovery is proactive in nature while maintenance of routes comprises reactive routing. The algorithm extracted the features of ZRP and DSR. This hybrid protocol provided scalability to large networks. Rana et al. (2013) suggested a hybrid; multipath routing algorithm called Mobility Aware Zone based Ant Colony Optimization Routing for VANET (MAZACORNET) by effective use of available bandwidth. MAZACORNET uses vehicle's movement, density and velocity as well as fading conditions to provide scalability for dense networks. Li and Boukhatem (2013) introduced new adaptive multi-criteria VANET routing protocol called Vehicular routing protocol based on Ant Colony Optimisation (VACO). VACO finds the best route between a source vehicle and target Road Side Unit (RSU). Routing decision is based on selecting intersections which considers only those road segments having best QoS parameters (calculated using latency, bandwidth and delivery ratio) and is at the closest intersection to the destination vehicle. The Quality of Service Bee Swarm routing protocol for VANET (QoSBeeVANET) (S. Bitam, 2011) is a reactive and distributed routing protocol. This protocol is based on the communication carried by bees. Authors discussed the basic mechanism of communications between bees and deployed that medium in VANET scenario. Authors (Bitam et al., 2013) presented a routing protocol Hybrid Bee swarm Routing (HyBR) to improve timely dissemination of messages. This protocol combines the features of geographic routing as well as topology based routing. It shows an improvement in PDR and overload load for both rural and urban scenarios.

A less number of studies can be found if we shift our focus on the use of NC to optimize VANET routing. QoS improvement is evaluated in most of them in terms of routing overhead, communication delay and reliability.

### III. ANTHOCNET

In section 2, a brief state-of-art is discussed about the availability of swarm based routing protocols for VANET scenarios. The complex problems especially optimization problems can easily be solved using meta-heuristic techniques. It has been found that forwarding the packets from source to destination sometimes results in increase in routing overhead. Some authors concentrate their work to

reduce the routing overhead. This work includes using hello messages, estimating the multi hop connectivity and calculating the power aware link quality.

Researchers concentrating their work on network congestion and maintaining connectivity among vehicles does often approach non-DTN based applications. Their focus is more-or-less on using utilization of bandwidth available, abiding geocasting, using RoI concept and constructing multipath so as to improve connectivity between vehicles.

In this paper, AntHocNet, a swarm based algorithm is analyzed. As seen in section 2 that ACO techniques provides improvements in the existing routing algorithms. Hence, implementation of AntHocNet will definitely be a great asset towards the solution of challenges that are introduced in different vehicular scenarios.

AntHocNet is a hybrid algorithm, where reactive path setup is done followed by proactive path maintenance, probing and improvement. Forward Ants (FANTs) are broadcasted to set multiple routes on demand at the start of data session. Corresponding Backward Ant (BANTs) then retraces the path from destination to source and pheromone value is updated. A node upon receiving several ants of same generation compares the route of new ant with the old route generated previously. The ant will be forwarded only if travel time and number of hops both are within acceptance factor. Hence removing the ants with bad paths often reduces the overhead.

Pheromone tables are used to indicate the respective quality to set up the route and data packets are forwarded stochastically over these paths. Proactive FANTs monitor, maintain and improves these routes. Above introduced functions are described in rest of the section.

#### a. Reactive Path Setup

- Source S broadcast FANT ( $F_d$ ) for destination d.
- An ant is either broadcasted or unicasted from each node, depending on whether the node contains routing information for d or not. Pheromone table  $T_i$  represents routing information of node i.
- The ant is broadcasted if no information is available at node for d. Ants start moving to different paths to reach destination as they are broadcasted all over the network.
- A node upon receiving several ants of same generation compares the path travelled by new ant and the previous ant of same generation. The ant will be forwarded only if travel time and number of hops both are within acceptance factor.

### b. Proactive Path maintenance, probing and improvement

- The source node sends out proactive FANTs during running of data session in accordance with data sending rate.
- Pheromone values are used to choose next hop, formulae being used same as that of reactive FANTs. Here ants are unicasted but they have small probability of being broadcasted at each node.
- This serves the two purposes: an existing path is probed if FANT reaches the destination without a single broadcast. If the ant is broadcasted at any point, it explores the new path thereby leaving the known paths.
- The proactive ants are destroyed if the routing information within the hops is not found. This results in the search of new paths.

Link failures are solved by local route repair process or by unicasting a warning messages to the adjoining nodes in the path.

## IV. SIMULATION & RESULTS

Table 1 shows the parameters that were used during simulation using ns 2.35.

**Table 1: Parameters used during simulation**

Parameters	Value
Terrain Size	652 * 752
Protocol	AODV, AOMDV and AntHocNet
Packet Size	512 bytes
Traffic Type	CBR
No. of Nodes	20, 50, 80, 90, 140
Packet Rate	0.2 Mbps
Simulation Time	1000 ms
Maximum Speed	40 m/s
Minimum Speed	20 m/s
Maximum Connections	30
Performance Metrics	PDR, E2E delay, Throughput

The simulation for the VANET scenario has been carried out by varying the number of nodes. The performance for the swarm based routing protocol AntHocNet is compared with AOMDV and AODV. The performance matrices chosen are as discussed in Table 1.

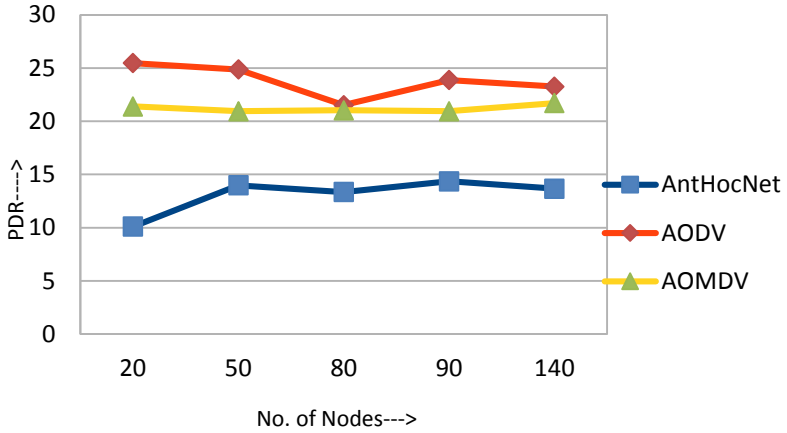


Figure 2: PDR vs Number of nodes

Figure 2 shows the effect on PDR as the number of nodes is increased. AODV is having the better results in comparison with AOMDV and AnthocNet. But it can be seen that the PDR increases with the number of nodes though it is still less than the considered routing protocols.

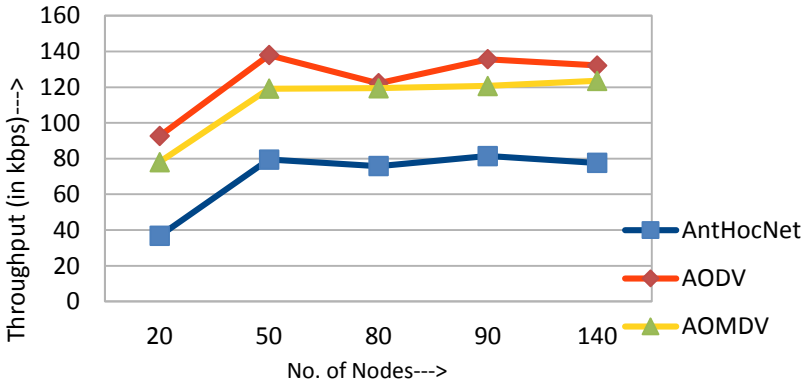
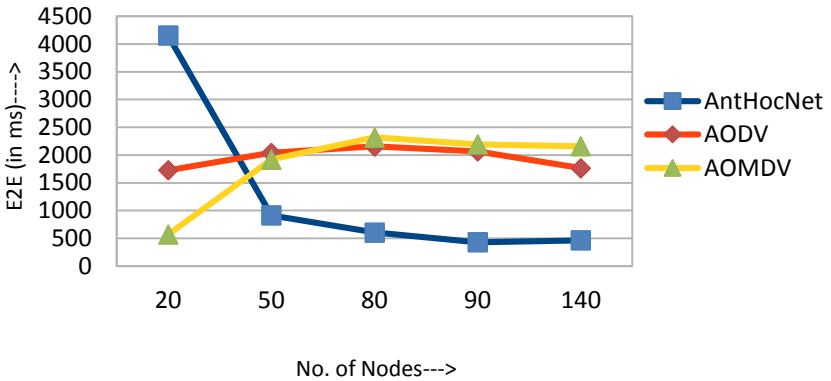


Figure 3: Throughput vs number of nodes

Figure 3 shows the performance of considered routing protocols in terms of throughput. Again AODV outperforms AOMDV and AntHocNet but AntHocnet shows a significant improvement in throughput as the number of nodes is increased.



**Figure 4: End-to-end delay vs number of nodes**

Figure 4 shows E2E delay of AntHocNet is better than the AODV and AOMDV with the increase in number of nodes. The result is very significant for VANETs as it gives good result for higher number of nodes.

**V. Discussion and Future work**

In this paper, implementation of AntHocNet is done for VANETs scenarios varying the number of nodes. The comparison is done between AntHocNet which is a hybrid protocol, AODV is a reactive routing protocol and AOMDV which is a multicast based reactive routing protocol. The end-to-end delay is lower in AntHocNet protocol but for higher number of nodes. This is due to the connectivity established between the large numbers of nodes and hence can be useful in city scenario. The throughput of AntHocNet is outperformed by AODV and AOMDV because of hybrid nature of AntHocNet. Although PDR of AntHocNet is lower amongst the three but with increase in number of nodes, the performance of AntHocNet in terms of PDR improves as compared to AODV and AOMDV. This is due to the fact that as the number of nodes is increasing, it results in better connectivity between nodes resulting in improvement of PDR. Despite the fact that lower value of PDR and E2E is showing contrasting behavior, both the values in case of AntHocNet can be optimized further in order to incorporate AntHocNet in VANETs and this can be advantageous for lower number of nodes. The improvement in AntHocNet for VANETs will provide scalability as well as decrease

in routing overhead. Such swarm based algorithm will be quite useful towards obtaining solution for complex optimization problems in VANETs.

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## AUTHORS' PROFILE



**Ms. Ritu Sehgal** received her B.Tech degree in Electronics and Communication Engineering in 2004 and M.Tech degree in Electronics and Communication Engineering in 2010. She is currently pursuing her Ph.D degree in Electronics and Communication Engineering Department, Bhagat Phool Singh Mahila Vishwavidayala, Khanpur Kalan, Sonipat, Haryana, India.

**Dr. Vijay Nehra** received his B.Tech degree in Electronics and Communication Engineering from JMIT, Radaur, Kurukshetra University, Kurukshetra in 2000 and M.E degree in Electronics from Punjab Engineering College, Chandigarh at Panjab University, Chandigarh in 2002. He earned Ph.D degree in Electronics and Communication Engineering in 2009 from Maharshi Dayanand University, Rohtak. He is currently working as professor in the Electronics and Communication Engineering Department at the Faculty of Engineering and Technology, Bhagat Phool Singh Mahila Vishwavidayala, Khanpur Kalan, Sonipat, Haryana, India. His area of interest include engineering education teaching strategies that promote professionalism and career development, learning style and innovative laboratories that crosscut the curriculum.



**Dr. Pawan Dahiya** received his B.Tech degree in Electronics and Communication Engineering. He earned Ph.D degree in Electronics and Communication Engineering. He is currently working as assistant professor in the Electronics and Communication Engineering Department at the Faculty of Engineering and Technology, Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Sonipat, Haryana, India. His current area of interest includes Digital and Embedded System Design, ANPR, VANETs, Soft Computing Techniques. He is also a member of ISTE.