RESEARCH ARTICLE OPEN ACCESS

Hybridization of Meta-heuristics for Optimizing Routing protocol in VANETs

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ABSTRACT
The goal of VANET is to establish a vehicular communication system which is reliable and fast which caters to road safety and road safety. In VANET where network fragmentation is frequent with no central control, routing becomes a challenging task. Planning an optimal routing plan for tuning parameter configuration of routing protocol for setting up VANET is very crucial. This is done by defining an optimization problem where hybridization of meta-heuristics is defined. The paper contributes the idea of combining meta-heuristic algorithm to enhance the performance of individual search method for optimization problem.
Keywords **–** Hybridization, Meta-heuristic, Routing Protocol, VANET

I. Introduction

Vehicular Ad-Hoc Network (VANET) is the emerging and important technologies which provide various services like Road traffic and Road Safety directly improving the Intelligent Transportation System (ITS) services. VANET provide communication among vehicles i.e. vehicle –to-vehicle communication as well as between roadside infrastructure i.e. vehicle-to-infrastructure communication.

VANET are self organizing network which is formed by collection of nodes that are moving vehicles which are geographically located which do the work of transmission, reception and routing to other nodes without any help of any centralized control.

Several VANET routing protocols have been defined which caters to different application. These Protocols are broadly classified into topology based, Position based, Cluster based and broadcasting Protocols [1]. Topology based routing approach can be further categorized in to three groups: Proactive routing, Reactive routing and Hybrid routing.

The scalabity of the network with a high number of nodes, frequent changing network topology, data delivery reliability, obstacles which leads to packet loss and network fragmentation are the challenges which impact the performance of the VANET as well as its routing protocol.

Mainly all the VANET application depends on the routing protocol used. Therefore an optimal routing strategy that makes better use of resources is crucial to deploy efficient VANETs that work in frequently changing network topology. So finding well-suited parameter for configuring the existing protocols is the way of improving their performance drastically [1].

OLSR protocol is widely used to deploy VANET. It's a unicast proactive protocol which has simple operation but the continuous exchange [6] of control packets leads to network congestion thereby decreasing the performance of VANET, indirectly depending on the selection of the parameters. OLSR uses hop-by-hop routing, i.e., each node uses its local information to route packets [2]. From C.Gomez et.al work one can understand that OLSR has good scope of improvement and can be optimally tuned by changing the configuration Parameters.

To resolve this issue, offline optimization problem has to be defined. The optimization problem is to find minimum cost protocol with respect to QoS. This falls under the Combinatorial Optimization Problem where we have to find a optimal solution with minimum objective function i.e. communication cost. Number of possible combinations can be taken this makes it very complex job [1].

Therefore we make use of automatic intelligent tool, Meta-heuristic algorithms. In most of the optimization problem individual meta-heuristic algorithm is applied to fine tune the configuration parameter [1].

Jamal Toutouh et.al [1] used meta-heuristics algorithms and applied to OLSR protocol for finding the optimized parameter for configuration. Four different techniques: Particle Swarm Optimization (PSO) , Differential Evolution (DE) ,Genetic Algorithm (GA) , and Simulated Annealing (SA) was

used separately .R.K Chauhan and Arzoo Dahiya [3] came up with a scheme that avoids the delay of communication that occurs due to frequent disconnection in routing. For this, the Meta heuristic search i.e. ant colony optimization (ACO) is combined with AODV and route repair strategy is applied to ACO. Pijush Kanti Bhattacharjee et.al [4], among the various Meta heuristics algorithm the Swarm Intelligence Technique has been implemented in AODV.

From this one can understand that meta-heuristics are used as standalone method for solving the optimization problem.

But now the interest of researches is to use the concept of high level algorithm namely hybrid algorithms. In which two or more algorithm is combined to improve the quality of the solution and minimize the execution time. This paper introduces the idea of using hybridization of meta-heuristics by combining Genetic algorithm (GA) and Simulated Annealing (SA) i.e. Hybrid GA-SA for optimizing routing protocol thereby improving the Quality of Service (QoS) to apply to VANETs. The reason for choosing this hybrid method is explained in following section

The organization of the paper is as follows: first literature survey of where individual meta-heuristic algorithm is used. Then the concept of hybridization of meta-heuristics is explained. Finally the paper concludes with the summary and future research scope.

II. Problem Overview

2.1 Proposed Hybrid approach of metaheuristics in VANETs

Optimization problem is choosing the best configuration as a set of parameters that best fits the specific behavior of VANETs. With countable configurable parameters of the routing protocol but the number of combinations of value that take is more. So automatic intelligent tool like meta-heuristic is chosen in particularly the high level algorithm that is hybrid algorithms.

In hybrid algorithm not any single meta-heuristic is used rather it combines the meta-heuristics algorithms thus leading to hybridization of meta-heuristics.

Hybridization means trying to combine two or more algorithms to enhance the performance of the single search method for optimization problems. This is to combine the best features of the combined algorithms into a new high level algorithm. Hybrid models can be combined on two basis 1) type of methods to hybridize- here we consider combining two meta-heuristics or meta-heuristics with specific search method like any dynamic programming or AI techniques 2) level of hybridization-it refers to degree of coupling, the sequence with which it is executed and control strategy. Degree of coupling could be loosely coupled where the meta-heuristics preserve their flow ie high level of hybridization and strongly coupled where the hybrid meta-heuristics inter-change their inner procedures ie low level of hybridization. The sequence of execution could be sequential or parallel. The control strategy could be coercive where the one meta-heuristics has the main flow where as other is the subordinate to the main flow and cooperative where two meta-heuristics cooperatively explore different search space differently [5].

2.2 Metaheuristic Algorithm and its types

Metaheuristic is to bring together basic heuristics in higher-level frameworks It directs the search strategy which will explore the search space to find the optimal values. Meta-heuristics Algorithm can be differentiated on various characteristics used to select the algorithms. The characteristics could be based on a) Origin of algorithm b) Objective function c) Number of solutions d) Neighborhood structures e) Memory Used.

Based on these characteristics, it can be classified into five categories [8]

Nature-inspired Algorithm Population-based vs. single point search Dynamic vs. static objective function One vs. various neighborhoods structures Memory usage vs. memory-less methods Nature-inspired Algorithm-these are based on source of the algorithm like Genetic and Ant Algorithm. Population-based vs. single point search-these are based on the number of solutions considered at a given time. Single Point search are Iterated Local Search , Tabu Search.

Dynamic vs. static objective function-algorithm are classified based on how the objective function is used. Whether the function remains the same till the end of search or modified as the search progresses.

One vs. various neighborhoods structures-Mostly Metaheuristic algorithm work on one topology, some uses various neighborhood structures like Variable Neighborhood Search where the search is spread across different structures.

Memory usage vs. memory-less methods-this is the important characteristics to differentiate the metaheuristics algorithm where the memory is used for search process or not .Memory involves the moves performed, the space searched.

Combining the characteristics from different algorithm to improve the performance of optimization leads to Hybridization Method. It involves combining population based algorithm with single point search algorithm. Therefore we broadly classify into two types, Local area based algorithm and Population based algorithm.

2.3 Local area based algorithm

A Local area based algorithm starts from an initial point and describes a trajectory in the state space and tries to find a better solution in the space. These kind focuses on exploitation rather than exploration where they find a solution in single direction without doing a scanning of the entire search space. Local area based algorithms also called as Trajectory methods include Simulated annealing (SA), Tabu Search (TA), Iterated Local Search and Variable Neighborhood Search.

Simulated Annealing is method for finding a nearly global optimal value of a given function. The name comes from annealing technique, where it involves heating and controlled cooling of crystal to reduce the defect and reach a state where it's strong and sturdy.

The algorithm begins by generating an initial solution chosen randomly and by initializing the temperature parameter T. Then, at each iteration a solution s' is randomly sampled and it is accepted as new current solution depending on f(s), f(s') and T. s' and s is replaced only if f(s')< f(s) or f(s')>=f(s) , with a probability which is a function of T and f(s') - f(s).[8]

Algorithm 2.3.1
Simulated Annealing Algorithm (SA):

```
s is GenerateInitialSolution()
T intialsied to T0
while termination conditions not met do
  s' is suchas PickAtRandom(N (s))
  if ( f (s') < f (s)) then
              s' replaces s
  else
   Accept s' as new solution with probability
p(T,s',s)
 endif
Update(T)
Endwhile
```

The temperature T is reduced during the process, thus at the start of the search the chances of taking uphill moves is high and it slowly decreases, converging to a simple iterative algorithm. The acceptance probability is always > 1 when the new solution is better than the old one and gets smaller as the new solution is more bad than previous one. And also gets smaller if temperature decreases.

Simulated Annealing is one of the best and easiest methods to solve combinatorial optimization problem.

2.4 Population area based algorithm

Population based algorithm uses a set of solution i.e. population of solution rather than a single solution in every iteration of the algorithm, uses a natural way to explore the search space.

Yet, the final performance depends strongly on the way the population is manipulated. The most studied population-based methods in combinatorial optimization are Evolutionary Computation (EC) and Ant Colony Optimization (ACO). In EC algorithms, a population of individuals is modified by recombination and mutation operators and in ACO a colony of artificial ants is used to construct solutions guided by the pheromone trails and heuristic information [8].

EC algorithms are inspired from nature's evolution process where at every iteration number of operators is applied to every individuals of the current population to generate next generation population. Crossover/ Recombination is applied to two or more individuals to produce new individuals. The performance of the algorithm depends on the selection of the individual which will form the current population based on the fitness i.e. the objective function. Higher the fitness, more chances to chosen as parent for the new generation.Genetic Algorithm is inspired from EC algorithms which are used for combinatorial optimization problems. Combinatorial optimization problem is a problem in which the number of possible solution is finite and not continuous. Techniques used are inspired by nature evolution process, such as inheritance, mutation, selection, and crossover.

The evolution begins from a population of randomly generated individuals. It's an iterative process, in each iteration the population participating is called a generation. Candidate solutions are the individuals in the population being evolved by the algorithm.

The fit individuals are selected from the current population and each individual under goes recombination or crossover to recombine two or more individuals to form a new generation.

In each generation, the fitness is evaluated for every individual in the population. The fitness is usually the value or the quality measure of the objective function in the optimization problem being solved This selection process is the most important part ,as individuals with a higher fitness value have a higher probability to be chosen for population of next iteration.

The algorithm stops when either a maximum number of generations have been produced, or a satisfactory fitness level has been reached for the population.

Algorithm 2.4.1
Genetic Algorithm (GA):

```
INITIALISE population with random candidate
solutions
EVALUATE each candidate solution
While termination condition is not true do
        SELECT individuals for next generation
```

RECOMBINE pairs of parents
MUTATE the resulting offspring
EVALUATE each candidate solution
End

Both the metaheu ristic algorithm is designed to explore search space with best solution and as well as improvise the search method to explore unvisited areas to generate quality solutions.
"A metaheuristic will be successful on a given optimization problem if it can provide a balance between the exploitation of the accumulated search experience and the exploration of the search space to identify regions with high quality solutions in a problem specific, near optimal way'' [8].

Optimization problem is choosing the best configuration as a set of parameters that best fits the specific behavior of VANETs. Therefore to enhance the performance of metaheuristic search method, the concept of Hybridization is used. Hybridization method is to merge two or more algorithms to increase the performance of the single search method for optimization problems. The popular way of hybridization is to use the trajectory methods in population-based methods. Also finding a right balance for combining the Intensification and Diversification effect of the metaheuristic algorithm for deciding which two or more component can be exchanged among metaheuristic for Hybridization effect. Intensification is to search carefully around good quality solutions found in the past search. Diversification, on the other hand, is to direct the search to unvisited area.

2.5 Hybrid GA-SA

Hybrid GA-SA algorithm is combining Genetic algorithm and Simulated Annealing.

In this we combine the trajectory components in population-based methods. As we saw the strength of SA Algorithm is the cooling schedule and acceptance criterion. The objective function guides the acceptance criterion and it also includes a changing amount of randomness. The decrease of the temperature factor drives the system from diversification to intensification. In GA selection, mutation and recombination process determines the diversification and intensification strategy.

The power of local area based methods is established in the way they explore a capable region in the search space. In this local search is the driving component, a capable area in the search space is searched in a more controlled way than in population-based methods. In this way there is less chance of missing a good solution as compared to population-based methods.

Hybrid approach is applied in various problems like a hybrid GA-TS (Genetic Algorithm – Tabu Search) algorithm is used for optimizing networked manufacturing resources configuration [6]. Hybrid GA-TS is used for channel equalization and fiber tracking in wireless communication [7]. Hybrid Genetic and Simulated Annealing is used to solve travelling salesman problem [8]. In this hybrid approach has shown successful performance. But unfortunately this hybrid approach in optimization problem in VANET is limited.

In summary, population-based methods is superior in identifying potential areas in the search space, whereas trajectory methods are better in exploring potential areas in the search space. Thus, hybridization of metaheuristics in several ways deals to unite the advantage of population-based methods with the strength of trajectory methods.

III. Conclusion

In this paper a new approach for optimization problem where hybrid approach of meta-heuristics for tuning configuration parameters for routing protocol is suggested. By using this hybrid approach where goodness of two or more meat-heuristics is combined to chose the best suitable configuration for the protocol that makes better use of the resources and improves the performance of the VANET. Future work includes using hybrid approach for tuning OLSR Protocol coupled with network simulator (ns-2)

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