CHAPTER 7

A HYBRID GENETIC-GRASP ALGORITHM FOR OPTIMIZING AOMDV ROUTING

7.1 INTRODUCTION

QoS routing searches for a path that satisfies the QoS requirements like bandwidth and less delay etc. It is proved that QoS routing is considered as NP-Complete problem, and so for the approximation algorithm or heuristic based algorithm has not been developed. So, a GA algorithm has been used in the proposed approach for better MANET routing. As MANET topology may be changing frequently, routing method should be adaptive and intelligent accordingly. This chapter is mainly concerned to provide robust algorithm that ensures the optimal path.

Most real world optimization problems involve minimization and/or maximization of more than one function. Generally, multi objective optimization is not restricted to locating one solution for a Multi objective Optimization Problem (MOP), but a set of solutions called non-dominated solutions. Every solution in this set is a Pareto optimum and when plotted in objective space they are collectively called the Pareto front. Obtaining a Pareto front for a given MOP is the goal of multi objective optimization. Usually, MOP search spaces were very large, and evaluating functions need great time. These features make it hard to apply deterministic techniques, so stochastic methods are widely proposed in this domain. Among them, evolutionary algorithms (EAs) are investigated by researchers, and some of the most well-known algorithms for solving MOPs belong to this class like NSGA-II, PAES, and SPEA2.
Evolutionary algorithms are nature-inspired search strategies based on natural selection and they suit tackling MOPs due to their ability to find multiple trade-off solutions in one run. Well-accepted EA subclasses are genetic algorithms (GA), genetic programming (GP), Evolutionary programming (EP), and evolution strategies (ES). These algorithms work over a potential solutions (individuals) set which undergo stochastic operators to search for better solutions. These operators include recombination operator, which ensures cooperation among individuals, and problem variables. Evolutionary algorithms use one population (panmixia) of individuals and applying operators as a whole. Conversely, there are structured EAs, where a population is decentralized. In many cases, decentralized algorithms ensure better search space sampling, leading to improved numerical behavior with respect to an equivalent algorithm in panmixia.

So $F(x) = [f_1(x), f_2(x), ..., f_n(x)]$ are the design objectives to be minimized. For this set of functions, $F(x)$, it is seen that there is no one ideal optimal solution. In a set of Pareto-optimal solutions there is an improvement in one of the design objectives will lead to degradation in one or more of the remaining objectives. These solutions are known as non-inferior or non-dominated solutions.

Hence, it is acceptable and necessary to develop multi-objective heuristic function to deal with the MANET QoS Routing problem. This algorithm based upon Genetic approach is provided for two main reasons:

(i) To optimize route satisfying QoS parameters and
(ii) To provide adaptive route with optimized delay to handle dynamic MANET topology.

This proposed work focus on a hybrid model of GAs with GRASP.
7.2 GENETIC ALGORITHM

Genetic algorithms (GA) are adaptive methods which may be used to solve search and optimization problems (Beasley et al. (1993)) based on the genetic process of biological organisms. Over generations, natural populations evolve according to natural selection. By mimicking this process, GA is able to evolve solutions to real world issues if suitably encoded. Before a GA is run, a suitable encoding (or representation) must be devised. Also a fitness function is required, to assign a figure of merit to every encoded solution. During the run, parents are selected for reproduction and recombined to generate offspring.

It is assumed that potential solutions to problems can be represented as a parameters set (known as genes) joined to form a string of values (chromosome). In genetic terminology, parameters represented by a specific chromosome are called individuals. An individual’s fitness depends on chromosomes which are evaluated by a fitness function.

During a reproductive phase individuals are chosen from a population and recombined to produce offspring, which are the next generation. Parents are randomly selected from a population using a scheme favoring fitter individuals. The chromosomes of selected two parents are recombined, using crossover and mutation. Mutation is applied to individuals to ensure diversity.

GA performance is sensitive to initial population’s quality. The initial population’s "goodness" depends on average fitness of individuals and population diversity. Losing on either count produces a poor GA. By having an initial population with improved fitness values, better final individuals can be obtained. Further, high diversity in the population inhibits early convergence to local optimal solution.
7.3 GREEDY RANDOMIZED ADAPTIVE SEARCH PROCEDURE (GRASP)

Greedy Randomized Adaptive Search Procedure (GRASP) consists of two phases such as a construction phase and an improvement phase. GRASP (Marinakis et al. 2004; Resende and Ribeiro, 2003) became popular in combinatorial optimization. The construction phase uses a randomized greedy algorithm to assign facilities to locations one-by-one by incorporating greedy and random characteristics. In each step, minimizing the total cost with respect to assignments which already made. This provides a feasible solution for iterations. This solution is then exposed for improvement attempts in the local search phase. The improvement phase uses a neighborhood search technique to improve the solution obtained by first phase iteratively. The final result is simply the best solution found over all iterations. Each application of GRASP yields a (possibly) different solution because of the randomization used in the construction phase. The pseudo-code of the algorithm is as follows.

Algorithm GRASP

do while stopping criteria not satisfied
    call GREEDY RANDOM SOLUTION(Solution)
    call LOCAL SEARCH(Solution)
    if Solution is better than Best Solution Found
        then Best Solution Found Solution
    endif
enddo
return Best Solution Found
The construction phase with its pseudo-code is as follows:

**Pseudo-code of the construction phase**

procedure Greedy Randomized

    Construction(Seed) Solution /0;
    Evaluate the incremental costs of the candidate elements; while Solution is not a complete solution do
    Build the restricted candidate list (RCL);
    Select an element s from the RCL at random; Solution Solution {s};
    Reevaluate the incremental costs; end;

    return Solution;

end Greedy Randomized Construction.

At the iteration of this phase, let the set of candidate elements be formed by all elements that can be incorporated to the partial solution under construction without destroying feasibility. The selection of the next element for incorporation is determined by the evaluation of all candidate elements according to a greedy evaluation function. This greedy function usually represents the incremental increase in the cost function due to the incorporation of this element into the solution under construction. The evaluation of the elements by this function leads to the creation of a restricted candidate list (RCL) formed by the best elements, i.e. those whose incorporation to the current partial solution results in the smallest incremental costs (this is the greedy aspect of the algorithm). The element to be incorporated into the partial solution is randomly selected from those in the RCL (this is the probabilistic aspect of the heuristic). Once the selected element is incorporated to the partial solution, the candidate list is updated and the incremental costs are reevaluated (this is the adaptive aspect of the heuristic).
The solutions generated by a greedy randomized construction are not necessarily optimal, even with respect to simple neighborhoods. The local search phase usually improves the constructed solution. A local search algorithm works in an iterative fashion by successively replacing the current solution by a better solution. It terminates when no better solution is found in the neighborhood. The pseudo-code of a basic local search algorithm starting from the solution Solution constructed in the first phase and using a neighborhood N.

**Pseudo-code of the local search phase:**

```plaintext
procedure Local Search(Solution)
    while Solution is not locally optimal do
        Find s N(Solution) with f (s) < f (Solution);
        Solution;
    end;
    return Solution;
end Local Search.
```

The effectiveness of a local search procedure depends on several aspects, such as the neighborhood structure, the neighborhood search technique, the fast evaluation of the cost function of the neighbors, and the starting solution itself. The construction phase plays a very important role with respect to this last aspect, building high-quality starting solutions for the local search. Simple neighborhoods are usually used. The neighborhood search may be implemented using either a best-improving or a first-improving strategy. In the case of the best-improving strategy, all neighbors are investigated and the current solution is replaced by the best neighbor. In the case of a first-improving strategy, the current solution moves to the first neighbor whose cost function value is smaller than that of the current solution.
7.4 METHODOLOGY

In this study, the proposed hybrid GA-GRASP is applied to MOP to optimize the parameters of RABP-AOMDV. As seen in the previous chapter, \( \alpha \), \( \beta \), and \( \gamma \) are constants such that \( \alpha + \beta + \gamma = 1 \) and \( \alpha = 0.33 \) and \( \beta = 0.34 \) in the proposed RABP-AOMDV. \( \alpha \), \( \beta \), and \( \gamma \) are the weightage provided to each parameter, optimal weighing will provide optimal paths. Figure 7.1 shows the flowchart of the hybrid GA-GRASP.

![Figure 7.1 Flowchart for Hybrid GA-GRASP](image)

The procedure for the proposed hybrid GA-GRASP is as follows:

Many heuristics generate initial population. In this implementation, initial population comprises of solutions produced by the construction phase of GRASP.
An initial solution initialized randomly is subjected to local search for a feasible and good solution. GRASP mechanism is applied with local search and constructive phase. Once the above process gets over, the obtained best solution can be considered as an initial population of genetic algorithm process. In that, the GA operators such as selection, crossover and mutation can be performed for determining the fitness function of every individual. Finally the best individual can be selected.

The selection criteria are used to select two parents for crossover operator. In the proposed GA, two parents are randomly selected by giving equal probability of selection for each individual in the population. The selected individuals are applied in two point crossover followed by the mutation. The fitness is evaluated based on the rate adaptation, bandwidth, power and packet delivery ratio. The fitness function is formulated as:

\[
F(t) = \frac{e_{s,d}}{e_s \cdot d} \sqrt{\frac{1}{\sum_{i=1}^{s-2} e_{s,d}^{i}}} \]

Where \(e_{s,d}\) - Residual energy between the path source to destination
\(R_s\) - Current rate adaptation
PDR - Packet delivery ratio
\(BW_{s,d}\) - Average bandwidth between Source and Destination
\(g\) - Packet generated by the node

7.5 RESULTS AND DISCUSSION

The simulation results of all the investigations are summarized in this section. Table 7.1-7.4 summarizes the resultant values for the metrics
packet delivery ratio, packet loss rate, End to End delay and remaining energy achieved by various proposed optimization methods.

### Table 7.1 Packet Delivery Ratio Achieved

<table>
<thead>
<tr>
<th>Speed (Kmph)</th>
<th>RABP-AOMDV</th>
<th>Optimization using GRASP</th>
<th>Optimization using GA</th>
<th>Optimization using GA GRASP</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0.954931</td>
<td>0.961</td>
<td>0.9792</td>
<td>0.982</td>
</tr>
<tr>
<td>30</td>
<td>0.935715</td>
<td>0.9478</td>
<td>0.9656</td>
<td>0.9778</td>
</tr>
<tr>
<td>45</td>
<td>0.856227</td>
<td>0.8623</td>
<td>0.8756</td>
<td>0.8808</td>
</tr>
<tr>
<td>60</td>
<td>0.836545</td>
<td>0.843</td>
<td>0.8585</td>
<td>0.8635</td>
</tr>
<tr>
<td>75</td>
<td>0.690521</td>
<td>0.6969</td>
<td>0.7033</td>
<td>0.7141</td>
</tr>
<tr>
<td>90</td>
<td>0.644042</td>
<td>0.6506</td>
<td>0.6575</td>
<td>0.6632</td>
</tr>
</tbody>
</table>

**Figure 7.2 Packet Delivery Ratio Achieved**

It is observed from Figure 7.2, the performance metric PDR of proposed hybrid GA-GRASP-AOMDV is significantly higher. At 15 kmph,
the proposed hybrid has an improved PDR of 2.53%, 2.19% and 0.29% and at 90 kmph the PDR of 2.97%, 1.94% and 0.87% when compared to RABP-AOMDV, GRASP and GA respectively.

Table 7.2 Packet Loss Rate Achieved

<table>
<thead>
<tr>
<th>Mobility Speed (Kmph)</th>
<th>RABP-AOMDV</th>
<th>Optimization using GRASP</th>
<th>optimization using GA</th>
<th>optimization using GA GRASP</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.8 Kmph</td>
<td>0.04506874</td>
<td>0.039</td>
<td>0.0208</td>
<td>0.018</td>
</tr>
<tr>
<td>18 Kmph</td>
<td>0.06428517</td>
<td>0.0522</td>
<td>0.0344</td>
<td>0.0222</td>
</tr>
<tr>
<td>36 Kmph</td>
<td>0.14377267</td>
<td>0.1377</td>
<td>0.1244</td>
<td>0.1192</td>
</tr>
<tr>
<td>54 Kmph</td>
<td>0.16345503</td>
<td>0.157</td>
<td>0.1415</td>
<td>0.1365</td>
</tr>
<tr>
<td>72 Kmph</td>
<td>0.30947922</td>
<td>0.3031</td>
<td>0.2967</td>
<td>0.2859</td>
</tr>
<tr>
<td>90 Kmph</td>
<td>0.35595806</td>
<td>0.3494</td>
<td>0.3425</td>
<td>0.3368</td>
</tr>
</tbody>
</table>

Figure 7.3 Packet Loss Rate Achieved

The Figure 7.3 shows the Packet Loss Rate of proposed approach at various mobility speeds. It is clear that at lower speeds, the proposed hybrid GA-GRASP achieves significant lower packet loss than in higher speeds. At 10.8
kmph, a decreased Packet Loss Rate of 60.06%, 53.85 and 13.46% is achieved by the proposed hybrid GA-GRASP when compared to RABP-AOMDV, GRASP and GA respectively. But at higher speeds like 90 kmph, decreased Packet Loss Rate of only 5.38%, 3.16% and 1.66% is achieved by the proposed hybrid GA-GRASP when compared to RABP-AOMDV, GRASP and GA respectively.

Table 7.3 End to End Delay Achieved

<table>
<thead>
<tr>
<th>Mobility</th>
<th>RABP-AOMDV</th>
<th>Optimization using GRASP</th>
<th>Optimization using GA</th>
<th>Optimization using GA GRASP</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.8 Kmph</td>
<td>0.00223905</td>
<td>0.002283</td>
<td>0.002369</td>
<td>0.002325</td>
</tr>
<tr>
<td>18 Kmph</td>
<td>0.00662471</td>
<td>0.006674</td>
<td>0.006843</td>
<td>0.006761</td>
</tr>
<tr>
<td>36 Kmph</td>
<td>0.02022082</td>
<td>0.020358</td>
<td>0.020947</td>
<td>0.020631</td>
</tr>
<tr>
<td>54 Kmph</td>
<td>0.03396416</td>
<td>0.034643</td>
<td>0.035475</td>
<td>0.035173</td>
</tr>
<tr>
<td>72 Kmph</td>
<td>0.11263786</td>
<td>0.11453</td>
<td>0.117153</td>
<td>0.115229</td>
</tr>
<tr>
<td>90 Kmph</td>
<td>0.13093209</td>
<td>0.133263</td>
<td>0.136804</td>
<td>0.134915</td>
</tr>
</tbody>
</table>

Figure 7.4 End to End Delay Achieved
It is observed from Figure 7.4 that the proposed method has slightly higher end to end delay when compared to RABP-AOMDV and GRASP method. At 15 kmph, a decreased End to End Delay of 3.84%, 1.84%, is observed for the proposed hybrid GA-GRASP when compared to RABP-AOMDV, GRASP and GA respectively.

**Table 7.4 Remaining Energy in Joules**

<table>
<thead>
<tr>
<th>Mobility</th>
<th>RABP-AOMDV</th>
<th>Optimization using GRASP</th>
<th>optimization using GA</th>
<th>Optimization using GA GRASP</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.8 Kmph</td>
<td>402</td>
<td>404</td>
<td>410</td>
<td>412</td>
</tr>
<tr>
<td>18 Kmph</td>
<td>386</td>
<td>394</td>
<td>397</td>
<td>400</td>
</tr>
<tr>
<td>36 Kmph</td>
<td>364</td>
<td>367</td>
<td>373</td>
<td>375</td>
</tr>
<tr>
<td>54 Kmph</td>
<td>338</td>
<td>340</td>
<td>342</td>
<td>346</td>
</tr>
<tr>
<td>72 Kmph</td>
<td>302</td>
<td>305</td>
<td>308</td>
<td>313</td>
</tr>
<tr>
<td>90 Kmph</td>
<td>287</td>
<td>290</td>
<td>296</td>
<td>301</td>
</tr>
</tbody>
</table>

**Figure 7.5 Remaining Energy in Joules**
It is noted from Figure 7.5, the proposed hybrid GA-GRASP saved energy when compared to RABP-AOMDV and the optimization using GA and GRASP individually.

### 7.6 CONCLUSION

In this study, the proposed hybrid GA-GRASP is applied to MOP to optimize the parameters of RABP-AOMDV. It is observed from the simulation results, that the GRASP and GA individually achieve better performance than the RABP-AOMDV but in the proposed hybrid GA-GRASP the performance is significantly higher in terms of packet delivery ratio, packet loss rate and remaining energy level.