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MANET ROUTING: OPTIMIZATION BY GENETIC AND FUZZY LOGIC APPROACH

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ABSTRACT

Mobile Ad hoc network is a collection of self configurable mobile nodes with no fixed infrastructure. Since all nodes are in roaming, the topology of MANET is dynamic. Therefore, routing is the highly challenging task when node mobility is high. Different types of routing protocols are proposed in literature, and each has some advantages and limitations. This work proposes fuzzy logic and genetic approach to select optimal routes to satisfy QoS required by applications using MANETs. Fuzzy rule based system is formed by the linguistic variables actual end to end delay (Ae), number of times the node leaves the network (Nl), number of packets dropped (Nd) and number of Rrep generated (Nr). Simulations are conducted with the proposed method. Numeric results show that fuzzy genetic approach for routing improves the performance than existing AODV routing protocol.

Keywords: *Mobile Ad hoc Network (MANET), Fuzzy logic routing, Genetic algorithms.*

1. INTRODUCTION

MANET is a communication network that has a collection of mobile nodes and communicates by wireless medium [1]. Each mobile node functions as a host and a router. All nodes are self configurable nodes, and the network has no fixed infrastructure. Since all nodes roam, the topology is dynamic. Therefore, routing is the highly challenging task when node mobility is high [2]. Various routing protocols had been developed for MANETS. Dynamic optimization in routing is used to find paths that satisfy some optimality criteria and some constraints. Usually, shortest distance, minimal bandwidth usage and minimum delay can be used as optimality criteria. Constraints may be limited power and limited capability of wireless links [3]. Major categories of routing protocols are proactive, reactive and hybrid routing protocols [4]. Proactive routing protocols are table driven approaches i.e. routes to all reachable nodes are evaluated and updated in routing tables periodically. Reactive protocols are on-demand approaches that use route discovery process when a node wants to start the transmission to another node. Reliability and reduced overhead are some of the advantages of these routing protocols.

Ad-hoc On-demand Distance Vector [5, 6] (AODV) is a routing protocol that ensures multi-hop routing between mobile nodes in an ad-hoc network. AODV is a reactive and distance vector algorithm. The algorithm uses various message types to discover and maintain links. When a node attempts to locate a route to a destination node, a route request (RREQ) is broadcast to all neighbors. RREQ travels throughout the network to reach the destination. The route is informed to the source node by sending a RREP to the source. Hello messages (a special RREP) are broadcasted periodically to immediate neighbors which forms a local advertisement for the node's continuing presence. Neighbors use the routes through the broadcasting node and mark the route as a valid route. When hello messages from a particular node stops, its neighbor assumes that the node has left and notifies that link as either broken or snapped. The affected nodes are notified through the sending of a link failure notification (a RREP) to that nodes set.

The major advantage lies in its adaptability to highly dynamic networks and reduced overhead, in addition to lower setup delay for connections and detection of a destination's latest route. But it does need regular updates. Usage of destination sequence number for every route entry is its distinguishing feature. Inconsistent routes are given when source sequence number is very old. Also, periodic updates results in unnecessary bandwidth consumption.

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Genetic algorithm is a computing search technique to find true/approximate solutions to optimization and search problems. As genetic algorithm [7] (GA) is a programming technique that mimics the biological evolution as a problem-solving strategy. When solving a specific problem, the input to GA is a potential solutions domain, encoded with a metric titled fitness function allowing quantitative evaluation of each candidate solution. Each candidate's evaluation is based on the fitness function. Fitness function evaluates a set of chromosomes from a population. To start with, a population of individuals, *P* is created and new population ***P'***. The algorithm routinely chooses individuals for the creation of new ones. The parents produce two offspring using crossover technique. Generation of mutants is also possible. Crossover technique includes random exchange of bits between intermediate population strings. Mutation operators are new string bits. This algorithm provides an optimal acceptable solution.

Genetic algorithms work for the topological design of networks [8]. A chromosome is chosen when it is contained within network parameters. Each chromosome's fitness function is chosen based on the design problem objective which is to reduce the length off source-destination route. The strength of fuzzy controllers lies in the ability to model and to express decisions in a near-natural language, thus efficiently exploiting expert knowledge for building automated systems. Fuzzy control relies on fuzzy set theory which is a generalization of classic set theory in which set membership is not determined by a Boolean expression: it is allowed to be expressed in degrees of membership in the range [0,1], imitating the human, linguistic, non precise approach to describing conditions (cold, warm etc) [9]. By using such an approach, a fuzzy controller can be expressed using rules of the form

IF {condition} THEN {action}.

The membership values control the degree to which each rule "fires", illustrating the interdependent relationship between the rule set and the membership functions [10].

2. RELATED WORK

Hiremath and Joshihave (2012) presented energy efficient routing protocol with adaptive fuzzy threshold energy for MANET [11]. This approach used adaptive threshold energy policy using fuzzy logic approach. Remaining residual energy at each node and energy level of neighborhood nodes are used for selection of routes. Zuo et al (2010) havepresented Fuzzy logic DSR for ad hoc networks [12]. Mobile nodes create inaccurate information for routing. Proposed method use fuzzy logic that take expected life time and number of hops as input parameters and selected highest stability route for transmission from a source node to a destination node. Fuzzy logic DSR was compared with existing DSR for ad hoc networks. Results showed that fuzzy logic approach perform better than DSR approach.

Mohammed Anjum et al (2012) have presented an optimal routing in ad-hoc network using genetic algorithm[13]. AsMANETis mobile, finding shortest path between a source and a destination node that satisfies QoS was a challenging task. The GA algorithm in [13] uses varied length of chromosomes partial cross over chromosomes are used to find partial shortest routes. The proposed approach is compared with DSR routing. End- to End delay, packet loss ratio, time to find route failure is less using the proposed approach. Siwach et al(2012) have presented an approach to optimize QoS routing protocol using genetic algorithm in MANET [14]. To implement QoS routing, optimization is the best approach. In this approach, all possible paths from the source node to the destination node are found and congestion free efficient routing is achieved by using genetic intelligent approach. For the selected path ACKis sent in the reverse order of path selection.

Mohan et al (2012) have presented a reliable routing algorithm in MANETusing Fuzzy [15]. Network topology is represented using peri nets, and fuzzy reasoning is used to find a sprouting tree that was useful to select a reliable route from the source node to the destination node. Degree of reliability was compared with existing routing methods. Result showed that more than 80% reliability was achieved than AODV protocol.

3. MATERIALS AND METHODS

The routing function is a basic control function in wireless networks. In datagram networks, such as the Internet, the routing function decides upon the next-hop interface, when a packet is received on one of the node's interfaces. Furthermore, information about network conditions may be incomplete or outdated. The routing function must find a path that satisfies user requirements. In addition to QoS parameters, in a commercial multi-provider environment, policy constraints must also be seriously considered. Therefore, policy

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parameters must also be included in route computation which further complicates the problem by making the routing asNP-complete problem. Therefore, heuristics such as intelligent techniques should be employed to find a near-optimal solution. In this work, it is proposed to use intelligent techniques such as fuzzy reasoning and genetic algorithms, which are useful in finding an optimal solution.

Genetic Algorithms offer an optimization method in which the stochastic search algorithm is based on biological principles of evolution like selection, cross-over and mutation. GA incorporates these features in computer algorithms to solve difficult problems in the way that nature has done - through evolution. They require the problem of optimization to be stated in the form of a cost (fitness) function. A set of variables for a certain problem is encoded into a coding structure similar to the chromosome. Evolution takes place on the basic criteria of “survival of the fittest”. GA can be used for maximization and minimization problem provided it is properly coded. Thus, they are able to solve a wide range of problems: linear, nonlinear, discontinuous, discrete etc.

Incorporating GAs into fuzzy systems overcomes the difficulties of manually choosing appropriate rules and membership functions for a given problem. The GA takes responsibility for the selection of a rule-set that is high-performing and for the tuning of the membership functions in respect to the rule set. This results in high-performing, robust routing algorithms, which can work over a wide parameter range and which are almost completely computer-designed.

For the nodes in the edges, the following QoS parameters have been defined: throughput, end to end delay and data loss rate. Fuzzy systems are used for faster convergence and GAis used to find the best rule-set, given an initial set of rules expressing expert knowledge. The routing algorithm performs evaluation of suggested paths, given input from the connection request, the current network conditions and the policy, based on linguistic rules. The fuzzy part of the routing Unit calculates the potentiality of each available route. The output of the routing algorithm will result after all possible routes are evaluated, or when a route is evaluated as good enough, in terms of the evaluation function becoming greater than a threshold. The next hops that are subject for evaluation are chosen among the neighboring nodes based on its performance evaluation.

In this work the route selection is based on four QOS parameter namely end to end delay, number of times a node leaves the network, number of packets dropped and number of route error generated. These four parameters become the linguistic variable for the fuzzy system. Genetic algorithm is used to select the significant if-then rule as this is a combinatorial optimization problem. The set of fuzzy rules generated is coded into a chromosome. The fitness is specified by the packet delivery ratio.

3.1Experiments and Results

The linguistic variables used for the fuzzy systems are actual end to end delay (Ae), number of times the node leaves the network (Nl), number of packets dropped (Nd) and number of Rerr generated (Nr). The membership functions for the input and output parameters are shown in the following.

Fig.1 shows the normalized average end to end delay of the network using three membership values low, medium and high. The definition point at which the cross over between membership value occur is shown in table 1.

Similarly figure 2, figure 3 and figure 4 shows the membership function for the different parameters used in this work. The definition point for these parameters are shown in table 2, table 3 and table 4. As number of packets dropped play a very important role in the QoS of the network, this linguistic variable has five Membership functions starting from very small to very large.

The output membership function which defines as which route is to be selected is shown in figure 5. and Table 5.

IF part of the rules defines the situation and 'then' part defines the response of the fuzzy system. The degree of support (DoS) is used to specify the importance of the rule.The processing of the rules starts with calculating the 'if' part. The operator type of the rule block determines which method is used. The operator types MIN-MAX is used in this work. 675 rules are generated and some of the rules are given in Table 6.

Genetic Algorithm is used to improve the initial rule-set as well as the membership functions of our routing unit. Success depends on the ability of the selected route to keep up with the required QoS demand, at low cost and without violating policy.

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Figure (a),(b),(c),(d) shows the performance comparisons of ADODV routing and proposed fuzzy genetic approach.

From Figure (a) it is observed that the number of bits dropped in a second is 4 times lesser in proposed approach.

From Figure (b) the jitter decreases on an average of 41.4% compared to AODV. From this observation it can be concurred that increase in End to End delay increases the jitter. Fuzzy rules based on the end to end delay membership function aids in improving the jitter.

From Figure (c) shows the retransmission attempts made during the simulation time. As nodes leaving the network have low priority to act as an intermediate node, the number of packets retransmitted reduces significantly and hence improving the throughput of the system.

From figure (d) the improvement in the throughput is seen to improve by 10.3% due to the reduction in the packets dropped as nodes with high probability of leaving the network is ignored for the route formation if an alternate route is available.

4. CONCLUSIONS

In this paper a fuzzy logic based genetic approach is proposed to select optimal routes in order to provide better QoS required by applications using MANETs. Fuzzy rule based system is formed by linguistic variables such as actual end to end delay (Ae), number of times the node leaves the network (Nl), number of packets dropped (Nd) and number of Rerr generated (Nr). Simulations are conducted with the proposed method. Throughput, delay, number of retransmission attempts and number of packets dropped are taken as performance evaluation parameters. Numeric results show that fuzzy genetic approach for routing improves the performance than existing AODV routing protocol.

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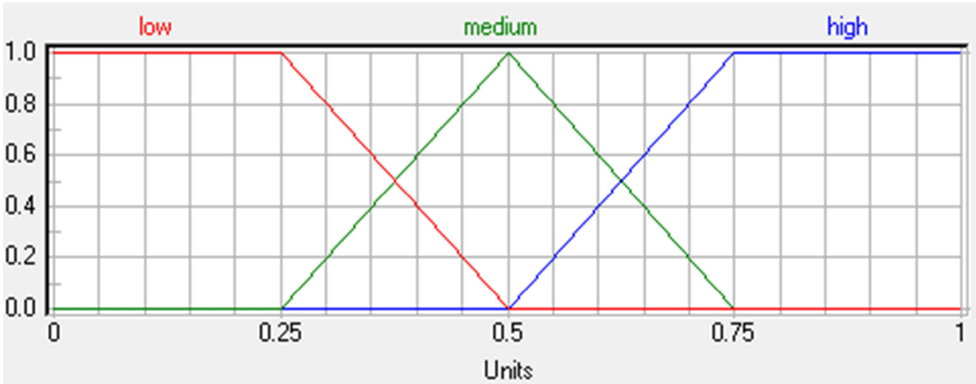

Figure 1: Input Variable MBF of "Ae"

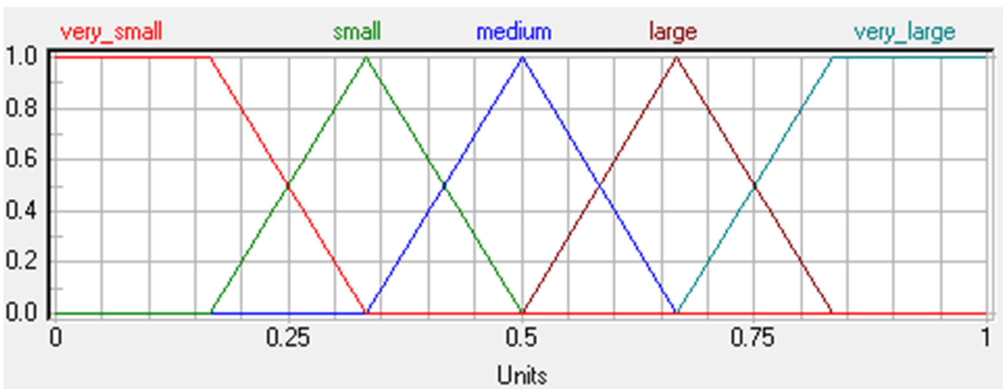

Figure 2: Input Variable MBFof "Nd"

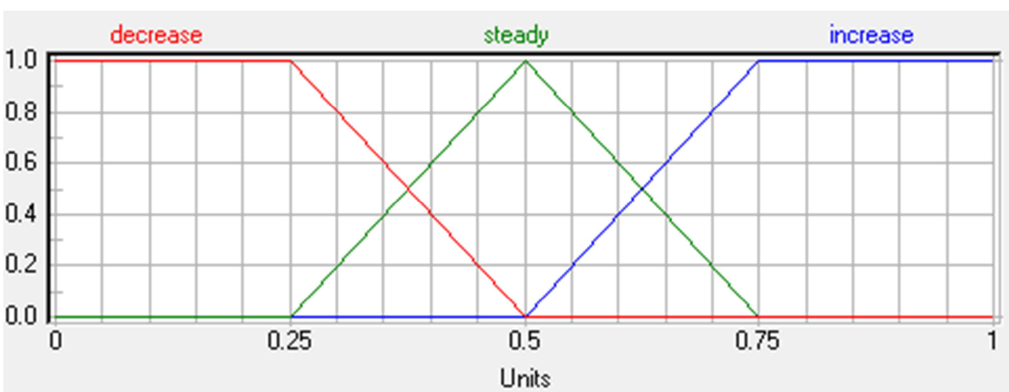

Figure 3: Input Variable MBFof "Nl"

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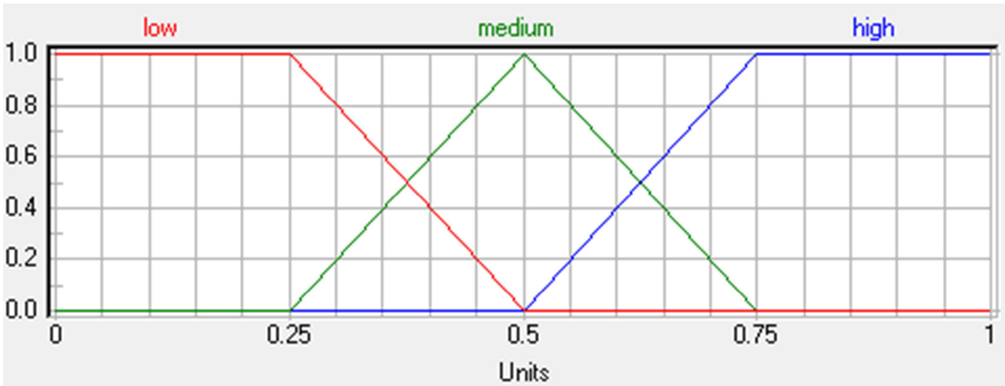


Figure 4: Input VariableMBFof "Nr"

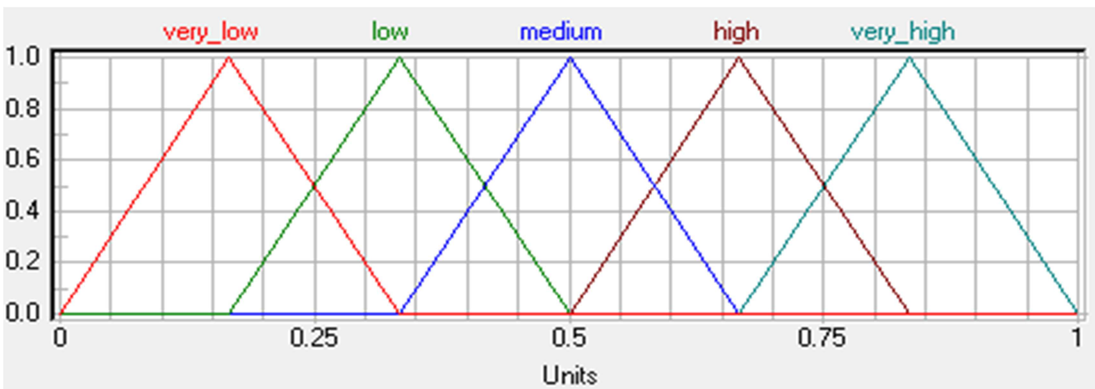
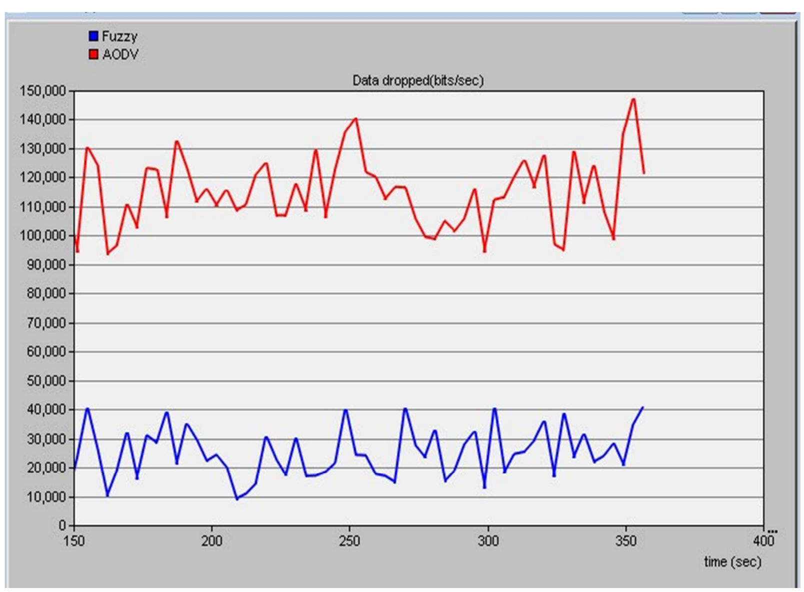


Figure 5: Output Variable MBFof "Route Preference"



Figure(a)

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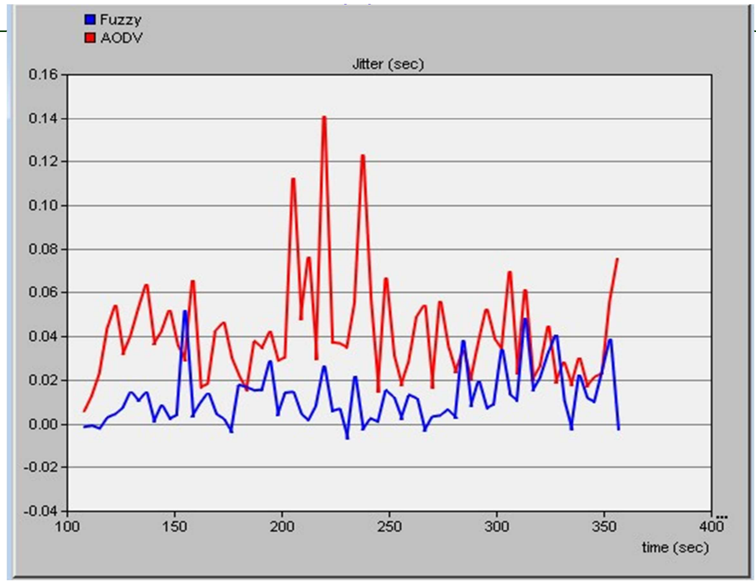
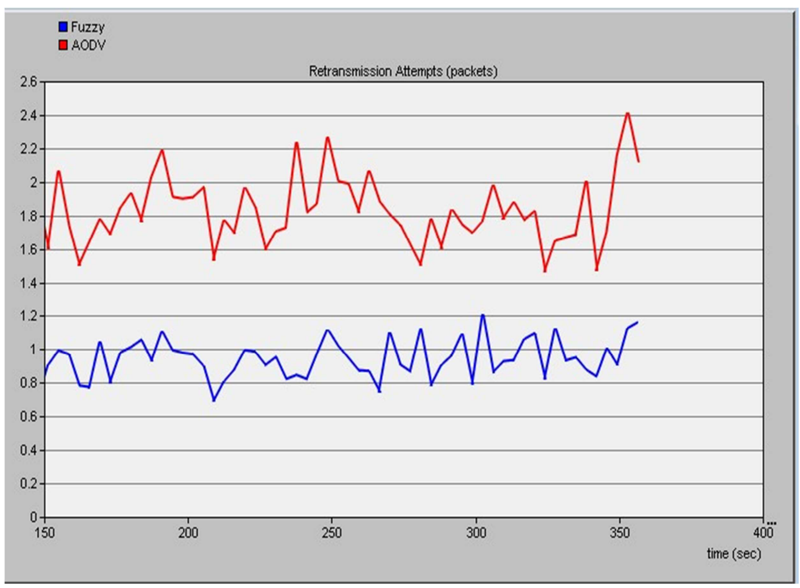


Figure(b)



Figure(c)

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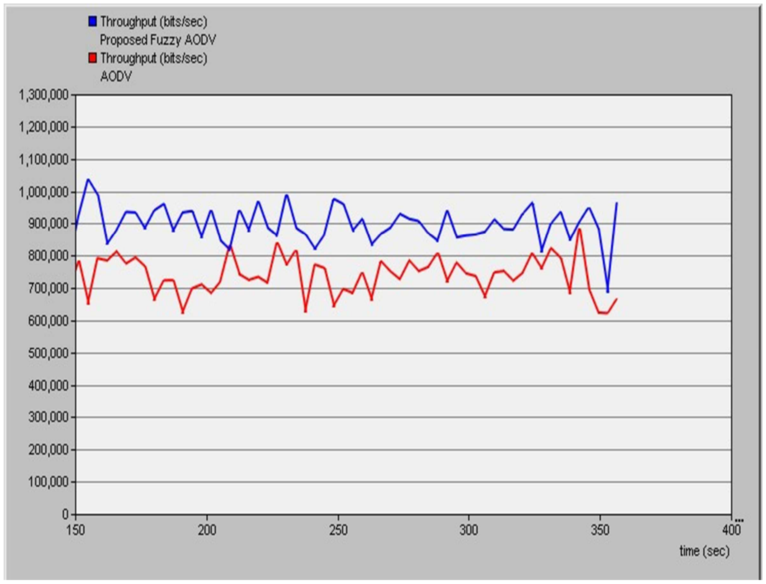

Figure(d)

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Table 1: Definition Points of MBF "Ae"

Term Name	Shape/Par.	Definition Points (x, y)
Low	Linear	(0, 1) (0.25, 1) (0.5, 0) (1, 0)
medium	Linear	(0, 0) (0.25, 0) (0.5, 1) (0.75, 0) (1, 0)
High	Linear	(0, 0) (0.5, 0) (0.75, 1) (1, 1)

Table 2: Definition Points of MBF "Nd"

Term Name	Shape/Par.	Definition Points (x, y)
very_small	linear	(0, 1) (0.16666, 1) (0.33334, 0) (1, 0)
small	linear	(0, 0) (0.16666, 0) (0.33334, 1) (0.5, 0) (1, 0)
medium	linear	(0, 0) (0.33334, 0) (0.5, 1) (0.66666, 0) (1, 0)
Large	linear	(0, 0) (0.5, 0) (0.66666, 1) (0.83334, 0) (1, 0)
very_large	linear	(0, 0) (0.66666, 0) (0.83334, 1) (1, 1)

Table 3: Definition Points of MBF "Nl"

Term Name	Shape/Par.	Definition Points (x, y)
decrease	linear	(0, 1) (0.25, 1) (0.5, 0) (1, 0)
steady	linear	(0, 0) (0.25, 0) (0.5, 1) (0.75, 0) (1, 0)
increase	linear	(0, 0) (0.5, 0) (0.75, 1) (1, 1)

Table 4: Definition Points of MBF "Nr"

Term Name	Shape/Par.	Definition Points (x, y)
Low	linear	(0, 1) (0.25, 1) (0.5, 0) (1, 0)
medium	linear	(0, 0) (0.25, 0) (0.5, 1) (0.75, 0) (1, 0)
High	linear	(0, 0) (0.5, 0) (0.75, 1) (1, 1)

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Table 5: Definition Points of MBF "RoutePreference"

Term Name	Shape/Par.	Definition Points (x, y)
very_low	linear	(0, 0) (0.16666, 1) (0.33334, 0) (1, 0)
Low	linear	(0, 0) (0.16666, 0) (0.33334, 1) (0.5, 0) (1, 0)
medium	linear	(0, 0) (0.33334, 0) (0.5, 1) (0.66666, 0) (1, 0)
High	linear	(0, 0) (0.5, 0) (0.66666, 1) (0.83334, 0) (1, 0)
very_high	linear	(0, 0) (0.66666, 0) (0.83334, 1) (1, 0)

Table 6: MIN-MAX Rules

IF				THEN	
Ae	Nl	Nd	Nr	DoS	RoutePreference
Low	decrease	very_small	Low	0.84	very_low
Low	decrease	very_small	Low	0.77	Low
Low	decrease	very_small	Low	0.09	Medium
Low	decrease	very_small	Low	0.86	High
Low	decrease	very_small	Low	0.99	very_high
Low	decrease	very_small	Medium	0.98	very_low
Low	decrease	very_small	Medium	0.09	Low
Low	decrease	very_small	Medium	0.22	Medium
Low	decrease	very_small	Medium	0.74	High
Low	decrease	very_small	Medium	0.20	very_high