An Agent-assisted Fuzzy cost based Multicast QoS routing in MANETs

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Abstract:- Multicast routing and provision of QoS (Quality of Service) are challenging problems due to the dynamic topology and limited resources in Mobile Ad hoc Networks (MANETs). This paper proposes an agent based QoS routing algorithm that employs fuzzy logic to select an optimal path by considering multiple independent QoS metrics such as buffer occupancy rate, remaining battery capacity of a mobile node number of hops. In this method all the available resources of the path is converted into a single metric fuzzy cost. This is based on multi-criterion objective fuzzy measure. The path with the minimum fuzzy cost is used for the transmission. Here, the intelligent software agents move around the network and collect information of all mobile nodes. These agents can reduce the network delay and participate in network routing and route maintenance. The performance of the proposed Agent assisted Fuzzy cost based Multiobjective QoS Routing protocol (Agent_FCMQR) is compared with E-AOFR (Evolutionary Ad hoc On demand Fuzzy Routing) and MQRFT (Multi metric QoS routing based on Fuzzy Theory) and the simulation results show that the proposed protocol is superior over existing intelligence based routing protocols.

Key words: MANETs, multicast routing, Quality of Service, mobile agents, multi-objective, fuzzy cost

1 Introduction

Mobile Ad-hoc Network comprises group of mobile nodes that communicate with each other over multi-hop wireless links with no fixed infrastructure support. In MANETs the nodes are free to move randomly and a node may join or leave the multicast tree at any time [1]. The provision of QoS guarantee is of utmost importance for the development of the multicast services since it can improve performance and allow critical information to flow even under difficult conditions [2]. Most of the conventional routing protocols for MANETs consider one or two QoS metrics for route selection [3]. But this is not sufficient since the topology of the MANET is determined by many factors such as link stability, node mobility and battery power of the mobile devices. All of these factors are correlated. Thus, consideration of only one or two factors is not sufficient for choosing an optimal path [4].

However, selecting a route which satisfies all multiple constraints is an NP complete problem [5]. There is no accurate mathematical model to describe it. Fuzzy logic can be used to model any continuous function or system. Fuzzy logic is a theory that not only supports several inputs, but also exploits the pervasive imprecision information [6]. This inherent property of fuzzy logic leads to solve multi metric problems in ad hoc networks.

Shivanajay Manvaha et.al. proposed Evolutionary Ad-hoc On-demand Fuzzy Routing

b) *Knowledge Base Rule Structure:* The fuzzy rules have IF-THEN structure. The inputs are then combined using the AND operator. The following is an example of rule which describes the input-output mapping.

If (Buffer length is "low") AND (Battery power is "high") AND (Number of hops is" Low") Then Cost is "Very Low"

The interpretation is that the route with lower buffer length, high battery power and minimum number of intermediate hops are favorable inputs and hence it yields very low cost. Since each input variable has 3 linguistic states, the total number of possible fuzzy inference rules is 3*3*3 = 27. To find the cost, the above fuzzy rules R1 to R9 are combined and the results are presented in Table 1, 2 and 3.

Table 1: Fuzzy rule base for lower number of hops (N)

BP / Q	Low	Medium	High
Low	Low	Medium	High
Medium	Very low	Low	Medium
High	Very low	Very low	Low

Table 2: Fuzzy rule base for medium number of hops (N)

BP / Q	Low	Medium	H**igh**
Low	Medium	High	High
Medium	Low	Medium	High
High	Low	Low	Medium

Table 3: Fuzzy rule base for high number of hops (N)

BP / Q	Low	Medium	High
Low	High	High	Very high
Medium	Medium	High	High
High	Medium	Medium	High

The fuzzy set parameters and rules are initially set by expert knowledge and then further calibrated through simulations.

c) Defuzzification: Defuzzification refers to the way a crisp value is extracted from a fuzzy set as a representation value. There are many kinds of defuzzifiers. Here we take the centroid of area strategy for defuzzification [20].

$$C = \frac{\sum_{AllRules} x_i . \mu(x_i)}{\sum_{AllRules} \mu(x_i)} \quad (8)$$

where C is the fuzzy cost, x_i is the element and $\mu(x_i)$ is its membership function. This is the most widely adopted defuzzification strategy, which is reminiscent of the calculation of the expected value of probability distributions.

4 Mobile agent model for QoS routing

Agents are the autonomous programs situated within an environment, which sense the environment and acts upon it to achieve the goals [12]. The agents can be static or mobile [13]. Every node in a network maintains an agency for QoS routing.

agent_id
source_id
destination_id
agent.type
agent.history
agent.hopcount
agent.request_info
agent.resource_info
agent_TTL

Figure 4. Data structure of the agent

An agency consists of a mobile forward agent, mobile reverse agent, static fuzzy agents for setting up a feasible path, and a QoS status profile. The data configuration of the agent's structure comprises the following fields: (fig.4)

- agent.ID: the agent's ID.
- source_id : source node address
- destination_id : destination node address
- agent.type: the type of agent in the route discovery and maintenance process. It

distinguishes between forward agent, backward agent and fuzzy agent.

- agent.history: the nodes-visited-stack, contains the IDs of nodes by which the agent passes.
- agent.hopcount: calculates the number of hops by which the agent traversed from the source.
- agent.request_info: includes QoS constrained information.
- agent. resource _info: Each type of agent uses this field to cache nodes resource information such as available bandwidth and link delay etc. This filed is updated by invoking the QoS status profile of a node.
- agent_TTL – how long the particular agent is valid.

The QoS status profile (figure. 5) consists of information such as buffer length and remaining battery power of a mobile node. The monitoring agent collects these information and updates the QoS status profile at regular intervals. All the parameters are computed within a given continuous time window. In the QoS based routing algorithm, the forward agent and the reverse agents are mobile agents. They are adopted to establish the routing strategy of mobile nodes

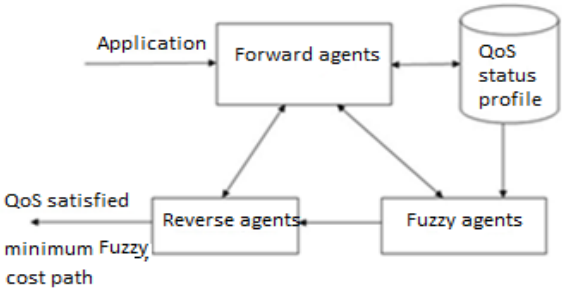

Figure 5. Agency for QoS routing

4.1 Forward agent

The source node creates a forward agent and writes into its own address and then continuously sends the forward agent to each adjacent node in flooding mode. When a neighbor node receives a forward agent, it checks whether there exist some visited nodes in its travel records. If exists, it shows that circulation appears in agent travel and delete it

Current node	Local time	Travel record
S	t_s	S
A	t_A	S,A
B	t_B	S,A,B
D	t_D	S,A,B,D

Figure 6. The change of data structure in the routing process of the forward agent

from the stacks. If the visited node is not the destination node, the value of the hop counter is incremented by 1 and updates the travel record in the forward agent.

The QoS resources information such as available remaining battery capacity, queue length of the nodes are updated in the forwards agent's data structure. By the flooding communication, the intermediate nodes can copy and broadcast the forward agent. The forward agent finds the QoS route that satisfies specified QoS by using following steps.

- *Link pruning*. The forward agent prunes all the links in the collected connectivity information that do not satisfy the minimum guaranteed bandwidth.
- *Check path for delay satisfaction*. Once the paths are found with the threshold bandwidth, the forward mobile agent checks the paths for eligibility of delay requirement satisfaction. If more than one path is available with delay requirements, the path with minimum fuzzy cost is selected among the eligible paths. In the case of path unavailability, the mobile agent informs the source to reject the application and disposes itself.

4.2 Reverse agent

The task of the reverse agent is to return to the source node 'S' along the path of the forward agent, and to implement the corresponding routing algorithm. When a forward agent