QOS-AWARE TRANSMISSION FOR MULTIMEDIA APPLICATIONS IN MANET USING ACO WITH FUZZY LOGIC

1Gatete Marcel, 2Dr.N. Vetrivelan.
1Research Scholar, School of Comp. Sciences & Applications, Periyar Maniammai University, Thanjavur, TN, India
2Director, Centre for University Industry Interaction, Periyar Maniammai University, Thanjavur, TN, India

Abstract: Achieving the required Quality of Service for efficient routing is one of the crucial challenges often faced in MANET (Mobile Ad-hoc Network); an infrastructureless wireless network. Being also one of the best features which determine the working performance of this type of ad hoc wireless network, QoS has been often taken into consideration by various researchers conducting their investigations in diverse MANET’s applications for emergency situations such as military fields’ operations, natural disaster containment strategies, etc. For such applications, QoS-related researches are for example required for studying routing related matters including the appropriate solutions aiming at providing high QOS. In order to achieve this type of routing features’ requirements; how to determine which definite method is necessary to identify the exact location of any participating node is one of the important problems faced by various researchers. Nodes’ locations play a very important role in determining the optimal paths for packets to pass through on their way to the destination. When those paths are found, high QoS is achieved resulting in high end-to-end packet delivery ratio and minimized end-to-end delay with a highly rated throughput. Various routing methodologies aiming at improving QoS in MANET have been proposed which, of course, have some limitations. In order to contain all those negative issues, we propose a new routing algorithm; QAMACF (QoS-Aware transmission for Multimedia applications using Ant Colony with Fuzzy optimization), a protocol implemented based on Ant Colony Optimization and Fuzzy Logic techniques. We choose this method because it has been proved to be the most excellent mechanism in providing high QoS in MANET; it is efficient in finding multiple optimal paths to route packets through. Our proposed algorithm, combines different popular MANET’s routing features; multicast techniques for fast and efficient route discovery processes and multimedia data transmission mechanisms capable of transmitting any type of packets either ordinary or multimedia data such as images, photos, videos, etc. For selecting an optimal path, we use three prominent QoS parameters namely Residual energy (Re), Distance (Dr), and reachability (Rc). The experiments are conducted using three popular routing metrics; end-to-end packet delivery ratio, end-to-end delay, and throughput. The evaluation is performed by comparing our proposed algorithm with the already existing and popular ones; ABC (Ant colony Based Cluster) routing, fuzzy integrated ant colony optimization, ACO (Ant Colony Optimization), and Dynamic Core Based Multicast Routing Protocols (DCMP). Results obtained using the ns-2 simulator for all the studied cases prove that our proposed algorithm produces the best results.

Index terms: MANET, QoS, Ant Colony Optimization, Fuzzy Logic, Multicast, and Multimedia applications.

1. INTRODUCTION
The prominent advantages of ad hoc networks have prompted the fast development of multiple wireless applications which have been used in various domains such as the education, entertainment, commerce, emergency services, military fields, etc. Different Wi-Fi enabled mobile devices especially laptops, handheld devices such as smartphones and tablet pcs are frequently used in our daily life nowadays. For example, the usage of wireless connections to access the Internet in the US will be increased with up to 207 million users in 2017 [1]. Owing to the regularly increasing popularity of mobile devices, daily MANET’s demands and requirements proportionally augment. MANET is generally an infrastructure less network with no need of configuring a central manager such as a router, access point, etc. Nodes are mobile in nature, thus making a dynamic topology [2]. Due to MANETs’s self-organizing nature, bandwidth is sometimes constrained; to address this, a virtual backbone network is sometimes configured. This type of network is defined as spin playing a major role in routing, connectivity management, and broadcasting operations. Moreover, routing protocols are one of the other issues to be taken into consideration as they play an important role in achieving high QoS (Quality of Service); a major factor in evaluating MANET’s routing performance. As seen in [3], scheduling mechanisms are also necessary during the packet transmission and retransmission processes for relaying information from one end to another. Different routing protocols have been proposed for MANET; they use probe packets to detect path cost. The cost contains information about the calculated delay, the number of already available hops, and the total number of packets lost along the way through that
path. That information are traversed throughout the network and are used in creating and maintaining the routing table, with which in turn helps in selecting the best suitable route to successfully relay packets from the source node to the destination node [4]. Routing failures sometimes occur due to the mobility of nodes, unpredictable and dynamically changing network topology, and the prompt network’s disconnectivity events. Each node in a MANET usually acts as a router, which frequently forwards data packets to the end devices. In addition to the previous routing related issues, MANET faces other various problems such as variable network’s capacity, security related issues, intermittent connectivity, battery power and processes’ constraints, unreliable links, and hidden terminal problems [5]. To efficiently route in MANET, protocols’ designers developed various routing algorithms which take into account those frequent MANET related challenges. Clustering is one approach toward minimizing those problems as it helps in providing solutions to resource management related difficulties while achieving the process of partitioning the network into small groups, each one playing a major role as a disjointed cluster. This approach provides various benefits when amplify and assisting in executing coherent routing processes by stabilizing the dynamics of the network’s topology. Hence, most of the protocols’ designers implement this type of algorithm aiming at quickly and efficiently finding the best routes in the network to transmit packets through. Despite those previously mentioned problems, MANETs provide numerous advantages compared to other types of networks: being a self-organizing and infrastructureless wireless network make it easy to access the network and data at anytime and anywhere. Thanks to those advantages, its applications are enormous especially in environments where there are high demands of QoS provisions. QoS are evaluated based on some network parameters; throughput, PDR (Packet Delivery Ratio), jitters, and delay routing metrics. Depending upon the type of the application being used and the end users’ requirements, QoS parameters are sometimes varied. QoS is an essential issue to be taken into account while implementing a new routing protocol for MANET, for example an efficient routing protocol which focuses on providing solutions to QoS-related problems is also able to maintain the throughput and packet delivery’s rates high during the overall packet’s transmission processes as paths and network’s partitioning reduction is achieved. All those achievements are possible with the help of clustering techniques; ACO (Ant Colony Optimization) algorithm [6] was the most proposed by the researchers for QoS-related matters in MANET. In addition, a number of proactive, reactive, hybrid protocols, and fuzzy logic techniques were discussed in [7] where the fuzzy logic theories were applied for providing high QoS in MANET. Despite all these efforts, none of them has provided full-featured QoS for efficient routing in MANETs.

This paper proposes a new and best routing protocol aiming at providing a high routing QoS in MANET; QAMACF (QoS-Aware transmission for Multimedia applications using Ant Colony with Fuzzy optimization) technique. Its main goal is to select an optimal path by combining different techniques; multicast services, transmission of multimedia data, and Ant colony with fuzzy logic techniques. To achieve this, we use three prominent QoS parameters namely Residual energy (Re), Distance (Dt), and reachability (Re). By increasing the throughput and PDR’s ratios at the same time reducing the delay fraction, we achieve a high Quality of Services. Ant colony optimization technique usually uses two different ants; forward ant (F_ANT) and backward ant (B_ANT). F_ANT collects the neighbor node’s information, in this process, it visits the entire node traversing a variety of available routes. Input parameters are gathered by F_ANT node; those inputs are then supplied to the fuzzy logic system. In this proposed algorithm, Residual energy, Distance, and reachability are used as input parameters. The Fuzzy generates 27 rules, with which, we identify the best most optimal paths to route packets through. Upon finding those optimal paths, we perform multicast transmission between source and destination nodes through those paths. The performance evaluation is conducted by comparing our proposed algorithm (QAMACF) with the existing and popular ones namely ABC (Ant colony Based Cluster) routing, fuzzy integrated ant colony optimization, ACO (Ant Colony Optimization), and Dynamic Core Based Multicast Routing Protocols (DCMP) considering end-to-end packet delivery ratio, throughput, and end-to-end delay; the most prominent routing metrics available in MANETs.

The remaining parts of this paper are organized as follows: Section 2 discusses the related works, the problem definition is presented in section 3, we fully explained the proposed work in section 4, section 5 provides the performance analysis and their relevant outcomes, we conclude our work in section 6, and finally, references are presented in section 7.

2. RELATED WORKS

Ze Li et al. [11] proposed a new protocol; QoS-Oriented Distributed routing protocol (QOD) to achieve a high quality of service (QoS) for highly dynamic hybrid networks. QOD incorporates five different algorithms in order to improve the transmission’s QoS. These are, QoS-guaranteed neighbor selection algorithm used to meet the transmission requirements, for reducing the delay’s ratio, a distributed packet scheduling algorithm was used, while a mobility-based packet
scheduling algorithm was required for reducing the transmission time which flexibly accommodates the segment’s size in accordance with the mobility of nodes. For enlarging the transmission throughput, a traffic redundant elimination algorithm was implemented, and finally, to discard the redundant data, a redundancy elimination based transmission algorithm was utilized which in turn enormously improved QoS in the network. Their Experimental outcomes showed that QOD can achieve high transmission QoS in term of mobility-resilience, scalability, delay, and overhead. They also stated that, in the future, they plan to evaluate the same performance using a real testbed.

Swati Atri et al. [2] designed the ABC (Ant colony Based Cluster head selection) algorithm. In their paper, they combined the clustering algorithm with the ant colony optimization technique resulting in double benefits with some limitation of course namely the overhead incurred during the transmission process due to a large number of simultaneously transmitted packets. The fuzzy rules were used for setting the cluster head selection criterion; they divided the entire network into non-overlapping clusters for this end. Cluster formation was achieved with the help of forward ants and CH elected by the fuzzy logic technique using backward ant packets by referring to the mobility and degree of participating nodes. They concluded their work stating that the cluster formation algorithm for disjoint clusters based on the Ant colony optimization technique promises to be one of the efficient ways of clustering algorithms. They finally suggested that, in future, their proposed algorithm; ABC (Ant colony Based Cluster head) selection algorithm would be further used for overlapping cluster formation in highly dynamic networks.

Tamer DAG [3] proposed a new packet scheduling algorithm; Dynamic Priority packet scheduler with Deadline Considerations (DPD) to provide QoS to applications with different traffic features. It aimed at introducing the delay parameter into a new algorithm; the classical static priority packet scheduling. It considered two constituents of losses; the buffer overflows and deadline violations; those components were used to analyze packet losses. This algorithm was very advantageous in reducing the complication of the static priority algorithm by using the degree of sorting. Another more achievement was its provision of various solutions to very difficult problems which were previously associated with the provision of fairness to applications with different priorities.

Sahaya Rose Vigita et al. [4] designed a new Link and Position based Opportunistic Routing protocol (L-POR), a stateless geographic routing protocol which ensures reliable data delivery. This protocol selects a forwarder node based on its reception power which overcomes the problem related to link instability, a major factor causing unreliable data delivery. They also proposed a backup scheme aiming at handling communication holes. Simulation results revealed that this protocol improves routing performance for highly dynamic networks with high node mobility. As the distance of the node towards the destination had not been considered for forwarder selection criterion in their paper, the path length may not be always minimal causing a varying end-to-end delay. Hence, they proposed that a future research on the same protocol should be done to reduce the hop count for ensuring a lower end-to-end delay.

Dhafer R.Zaghar et al. [5] in their paper, based on the type of application used and users’ needs, proposed a new system in MANET aiming at evaluating protocols’ performance. The behavior of both the traditional approaches and the proposed system were compared through a case study using OLSR, AODV, DSR, and TORA protocols. The proposed system (QoSHFS)’ s results revealed that the OLSR (proactive)’ s performance was the best because its system’ s output was (0.8645). They concluded their work by proposing that the future researchers focusing on the enhancement of their proposed system should consider different network”s features including all applications that may be deployed in MANET such as HTTP, video conference, FTP, etc. using the same method.

B. Nancharaiah et al. [6] proposed a routing algorithm most suitable for Mobile Ad hoc Networks. They stated that as MANETs are unstable by nature and when the network mobility increases, the best path selection process; a critical task in any new routing algorithm’s design becomes very difficult to achieve. They found a solution to this problem by combining the Ant Colony Optimization and Fuzzy Logic techniques. An optimal path was selected by first computing its score value using FIS (Fuzzy Interference System) which was firstly supplied with the path information. This resulted in highly rated end-to-end packet delivery ratio compared to the conventional algorithms to which their new algorithm was compared using distance, power consumption parameters.

Pimal Khanpara [7] conducted a review on the fuzzy logic technique used for efficient routing in ad hoc networks. He explained why the Fuzzy Logic technique is a better approach in achieving an efficient and effective routing in MANET thanks to the uncertainties and randomness mechanisms utilized while computing the optimal paths. He focused his research on reviewing the existing fuzzy theories based on routing protocols which take into consideration QoS parameters as routing metrics. He finally suggested that the future work based on his research would focus on the development of a new routing protocol using Fuzzy
Logic techniques while considering all the important QoS parameters instead of a limited number.

P. Deepalakshmi et al. [8] in their paper proposed a new algorithm; Ant Routing for Mobile Ad Hoc Networks (ARMAN). This QoS routing algorithm was based on Ant Colony metaheuristic method. It was highly scalable, adaptive, and efficient by reducing end-to-end delay in networks with highly mobile nodes. The simulation results also indicated that the proposed scheme can perform better than AODV protocol in dynamic networks because of alternate route maintenance mechanism additionally incorporated in their experiments. They again stated that in their future work, they were planning to enhance the performance of their newly designed algorithm for real-time multimedia data transmission using various mobility models. Bibhash Roy et al. [9] designed a new algorithm for mobile ad hoc networks. The proposed algorithm aimed at achieving high routing QoS; it combines features of both Ant Colony Optimization (ACO) technique and the Optimized Link State Routing (OLSR) protocol. These two algorithms are efficient in identifying multiple optimal and stable paths between a pair of source and destination nodes. They stated that this algorithm can be optimized in order to support multimedia communications in mobile ad hoc networks based on Ant Colony framework. The algorithm consists of both reactive and proactive components. They again proposed that their work, in the future would be extended using the multicast approach with the help of swarm intelligence and other QoS-related features such as load balancing, energy conservation, etc.

Arash Dana et al. [10], proposed a novel reliable routing mechanism using the fuzzy technique. Their newly designed algorithm aimed at reducing the number of broken routes, thus increasing the reliability during the routing selection process. In their proposed algorithm, a source node chooses a stable path with the help of nodes’ position and velocity information. They also proposed a novel method for route maintenance. The simulation results showed that their algorithm can efficiently reduce the number of broken routes and effectively improve both route stability and network performance. They believe that their proposed protocol can be further investigated based on other practical radio propagation models in order to design a better adaptive mechanism for mobile ad hoc networks.

A. Gowri et al. [11], in their paper, stated that the selection of an optimal path to route packets trough is a fundamental issue arising in MANETs. They proposed a solution to this problem by making caching decisions of the fuzzy logic system more appropriate. This technique alleviates the routing performance’ s degradation caused by the frequent selected low-quality routes; for the purpose of the rebroadcasting operations, only routes having a good routing metrics are selected during route discovery processes. These approaches apply to both uni-path and multi-path routing mechanisms.

G.Santhi et al. [12] proposed a new algorithm; the Fuzzy-Cost based Multi-constrained QoS Routing with the mobility prediction in MANETs (FCMQR) algorithm. Its main purpose was to use bandwidth (throughput), end-to-end delay, and the number of intermediate nodes as QoS metrics to select the most optimal path. With the help of the fuzzy technique, all paths’ resources were firstly converted into a single fuzzy cost, the lifetime of a path was found with the help of mobility prediction mechanisms. The optimal path was selected based on the lifetime and fuzzy cost values: a path with the maximum lifetime and low fuzzy cost was the one selected for transmitting data packets from one end to another. FCMQR protocol proved itself to be an efficient algorithm in providing an accurate method for evaluating and estimating both QoS routing stability and costs routing parameters in MANET. They finally suggested that their proposed protocol should be further investigated based on the most popular metrics such as delay jitter, buffer length, and power consumption rate in order to design a better adaptive mechanism for mobile ad hoc networks.

M. Marimuthu et al. [13] implemented a new protocol; Fuzzy Cost Based Power Aware QoS Routing (FCPAQQR) which, using multiple independent metrics, aims at selecting an optimal path. In order to effectively and efficiently forward packets, they used the Fuzzy inference rule to calculate the QoS-based fuzzy cost of each participating link based on various QoS constraints classified as Time Constraint (Delay and Jitter), Space Constraint (System Buffer), Frequency Constraint (System Bandwidth), and Reliability Constraint (Error Rate). They additionally took into account the Link Expiry Time (LET) and Energy Level constraints. They explained their reason of considering multiple QoS constraints was that they provide better results than taking a single one into account. They suggested that future researchers would incorporate some security mechanism into their proposed protocol.

Taniya Jain et al. [14], focused their study on MANET’s routing protocols and some of the major factors necessary for efficiently designing them; transmission reliability, reachability, energy-efficient routing, effective routing, and location-aided routing. They proposed that further studies would be done to determine more MANET’s factors in order to achieve more efficient routing algorithm’s designs.

Arash Dana et al. [15], for discovering a reliable path, they introduced a Reliable Routing Algorithm using the Fuzzy logic technique; RRAF protocol. Trust and energy values were used to calculate the lifetime of
routes at each node. Every participating node, during the route discovery process, records those two values’ capacities in RREQ packet. At the destination node, with the help of the fuzzy logic system, a new parameter called “Reliability Value” was generated from the inputs i.e. the same values of each route. A path with high-reliability value was selected as a stable route between source and destination nodes. Simulation results showed that RRAF has significant reliability improvements compared to AODV protocol.

Gasim Alandjani et al. [16], in this paper, presented a novel routing scheme in MANET aiming at applying the fuzzy logic approach to differentiated resource allocation. They took into account the traffic’s importance and network’s state features. Routed messages were either transmitted over zero or more maximally disjoint paths toward their destination. With this transmission scheme, some less important packets may be suppressed at the source nodes while the important ones being redundantly routed over multiple disjoint paths for achieving an increased reliability. A performance evaluation was conducted through simulation analysis where the fuzzy routing scheme was compared to the DSR and SMR wireless routing protocols. The outcomes of this comparison proved that the fuzzy routing protocols got better results as their reliability was high with lower delay values for important traffics than did the previous protocols, and in most cases, they offered better performance for all traffics. Their future work will focus on comparing those conventional algorithms with the “crisp”; versions of the fuzzy protocols. The fuzzy logic and fuzzy control to power consumption and directional antennas in MANET will be isolated in this work.

Hongjun Dai et al. [17] presented the dynamic routing protocols and trust evaluation based on the classic theory. The main goal of their paper was to provide the MANET’s modeling technique with the fuzzy interference rules, and, in turn improve the routing protocols’ performance with fuzzy dynamic programming techniques. The experiments conducted using the OPNET simulator revealed that the novel fuzzy trusted DSR protocols were able to achieve the overall packet drop’ s reduction, high throughput’ s rate with the lowered end-to-end delay in MANET. They suggested that in the future work, more optimization techniques should be done to improve the efficiency of the FDP in order to enhance its use in real MANET’ s environments.

determining device such as GPS, only locally available information were used for this end. Simple flooding and fixed probabilistic approaches were evaluated against this proposed mechanism, the outcome showed that the new algorithm exhibits better performance in terms of both the saved rebroadcasts and reachability parameters.

J. Gold Beulah Patturose et al. [21] have reviewed various MANET’ s routing protocols; Multicast Ad-hoc On-Demand Distance Vector (MAODV) protocol, Improved Multicast Ad-hoc On Demand Distance Vector (IMAODV) protocol, On-demand Multicast Routing Protocol (ODMRP), Adaptive Demand-Driven Multicast Routing (ADMR) routing protocols. Their Paper revealed that IMAODV performs better in terms of Packet Delivery Ratio (PDR), and End-to-End delay MAODV, ODMRP, and ADMR.

Shaveta Jain [22] presented a general survey on multicast routing protocols available in MANETs. He classified those protocols into three main categories: mesh-based, three-based, and hybrid-based protocols. The outcomes from her research revealed that mesh-based protocols are efficient in dealing with the dynamicity of topology and are more stable while tree-based protocols are robust for highly successful data transmission operations. She finally stated that these protocols have their own strengths and weaknesses; hybrid multicast provides the best features of both tree-based and mesh-based Protocols.

3. THE PROBLEM DEFINITION

Vineet Bansal et al. [18] discussed various routing problems related to bandwidth, signal power, mobility, and bandwidth parameters. They proposed a new routing algorithm that is totally network-dependent and which efficiently removes all routing related problems. The protocol is based on mobility, signal power, and bandwidth, where the segmentation of nodes substantially reduces the overhead of the entire network and speeds up the routing processes. They finally suggested various optimizations to be added to the protocol in order to accurately access the practical effectiveness of their protocol in medium and large networks.

N. Umamathi et al. [19] presented a protocol for routing in ad hoc networks using Dynamic Source Routing (DSR) and Swarm Intelligence based on Ant Colony Optimization (ACO) to optimize the node’s pause time and mobility. The simulation results showed that their proposed algorithm builds routes based on node’s pause time while achieving better packet’s end-to-end delivery and end-to-end delay ratios. M. Bani Yassein et al. [20] considering node’s distribution and movement issues, proposed a new probabilistic mechanism which dynamically adjusts the rebroadcasting probability. This technique was successful without requiring any help of distance measurements or any location

MANET [2] being an infrastructureless, self-organized, and dynamic wireless ad hoc network; participating
nodes freely and continuously join and leave the network. This dynamicity and the absence of a central manager make it difficult to efficiently manage such networks. The overall operations of an ad-hoc network are constrained by various challenges including difficulties to providing the Quality of Service which is one the prominent requirements for efficient routing in MANETs. QoS" achievement is characterized by high transmission rates, error rates, and MANET" s routing related characteristics can be guaranteed in advance. High QoS is necessary for transmitting high-bandwidth video, image, and other multimedia data. This kind of information is sometimes difficult to transfer in MANET using conventional routing protocols.

Being very advantageous in MANET, QoS" s improvement techniques have been one of the most research topics for the last two decades. Various researchers have proposed a number of routing protocols and mechanisms in combination with various routing metrics for this end. Most of them use various swarm intelligence techniques such as ACO and ACO with fuzzy logic theory by also considering different popular parameters like bandwidth, energy, delay, transmission rate, mobility, pause time, hop counts, etc. Till date, none of those methodologies fully solves the QoS improvement related problems.

4. THE PROPOSED WORK

This paper aims at proposing a new routing mechanism QAMACF (QoS-Aware transmission for Multimedia applications using Ant Colony with Fuzzy optimization) technique. We use this algorithm in combination with three different parameters namely Residual energy (Re), Distance (D1), and reachability (Rc). Those parameters are the most important and popular QoS measurement metrics available in MANETs, those values are collected at each node. We additionally use another prominent technique; the fuzzy logic system which is a mechanism of logic computing based on the “degree of truth” instead of using Boolean logic values; 1 for true and 0 for false. This technique helps us to process these input values in order to determine the degree to which a node is located throughout the network, thus making a good decision in selecting the best route which packets should pass through. To achieve this, it generates 27 rules using those three input values. Those rules are then used to fix a probabilistic value for each path which determines whether this route can be selected as an optimal path or not. The path selection is performed by a F_ANT during the route discovery process.

The next stage is the route maintenance phase, during which, the packet transmission process begins using paths selected between the sending and the receiving nodes. If any problem arises, another optimal path is selected with the help of the fuzzy inference rule. Our proposed approach gains more effective and efficient results when compared with the existing traditional routing protocols and methodologies. Results outcomes are presented by generating PDR, delay, and throughput parameters related graphs.

Our proposed mechanism (QAMACF) mainly aims at achieving high QoS (Quality of Service) for efficiently performing multicast transmission of multimedia files in MANET. To this end, we first select a reliable and stable path with high-link connectivity. The proposed mechanism is explained in details in the remaining parts of this work.

4.1 ACO (Ant Colony Optimization)

Swarm intelligence (SI) is a collective behavior of decentralized, self-organized systems, either natural or artificial. This concept is regularly used in artificial intelligence technology as it is one of the best mechanisms used for solving very complicated issues. ACO is a prominent swarm intelligence approach; a class of optimization algorithms modeled based on the organization of an ant colony. It is built based upon the real world ant behaviors, being a probabilistic technique; it is very useful in solving problems that deal with finding better paths using graphs. Artificial 'ants' -simulation agents- locate the optimal paths by moving through parameter space representing all possible solutions. Natural ants lay down pheromones directing each of them to resources while exploring their environments. The simulated 'ants' similarly record their positions as well as the quality of their solutions to the optimal paths finding" s problems. Those recordings play an important role in later simulation" s iterations, as they are used by the future ants to achieve better outcomes. For example ants initially use random walk approach when multiple paths are available between their nest and the food. During this process, each ant lay pheromone in forward from the nest to the food as well as backward from food to the nest, which is used to find out the most visited path by an ant. ACO [6], a prominent swarm intelligence mechanism is based on this ants’ natural behavior in finding a path toward the desired food. This algorithm is designed to find the best path using the pheromone deposited by the ants. Upon getting the food, they go back to their nests, during this returning back process; they simultaneously deposit new pheromone along the route back to their nest. The already existing pheromone is updated along the way but starts weakening by evaporation as the time passes. Different ants continuously move to the destination node to find out any low cost and the feasible path from that node to the source. Each of them considers two parameters in order to select the next hop to pass through. The first one is the total amount of pheromone deposited along the path toward the next node, and the
second one is the queue length associated with the followed link. Figure 1 presents the process of an ant colony optimization routing protocol.

**Figure 1: Ant Colony Optimization technique**

### 4.2 Fuzzy logic system

Fuzzy logic is a form of many-valued logic in which the truth values of participating variables may range between 0 and 1 as opposed to Boolean logic where those values are either 0 or 1. This system was enhanced to handle the concept of partial truth values ranging between completely true or completely false while imprecise functions are used to manage linguistic variables. Based upon the quality of rules, the fuzzy imprecision is varied. The Fuzzy logic system results will change depending upon the time. It’s a linguistic system for definite rules which are defined in the form of IF-THEN conditions and some Boolean operations; OR, NOT, and AND operators. The fuzzy logic systems are usually used in artificial intelligence applications such as medical diagnosis, subway control system, stock trading, weather forecasting system, knowledge-based system, controlling unmanned military vehicles, and pattern recognition. Those types of systems are mainly composed of four constituents namely the Fuzzifier, Defuzzifier, Fuzzy Rule Base, and Fuzzy Inference Engine. These components are arranged as shown in figure 2 in any Fuzzy Logic System.

**Figure 2: Fuzzy Logic System**

The first process which takes place in the FLS is the fuzzification operation. Here, the Fuzzifier receives the input value called crisp or numeric value. This value is then converted to the corresponding fuzzy value according to the rules used to provide the results defined for these fuzzy inputs. All those operations are performed by the Fuzzifier, the Fuzzy Inference Engine’s role then begins by computing the set of outputs based on IF-THEN rules defined in the Fuzzy Rule Base. The AND operator is required to combine a set of different rules. Deffuzzification process is the last operation performed by Fuzzy Logic System which finally converts the fuzzy output values into their corresponding crisp values.

### 4.3 QAMACF

(QoS-Aware transmission for Multimedia applications using Ant Colony with Fuzzy optimization) For implementing our proposed algorithm, we combine ACO technique with the Fuzzy logic system. The performance evaluation is conducted using a variety of parameters namely Residual energy (Re), Distance (Dt), and reachability (Rc), the multicast transmission approach for multimedia data is used to speed up route’s discovery process. We use mesh based multicast structure[21] as it is advantageous compared to tree-based protocols; it provides redundant routes for maintaining connectivity to the group’s members, in turn, alleviating the low packet delivery ratio problem caused by link failure events. They are robust because they efficiently deal with the dynamicity of nodes’
mobility. Multicast transmission is usually composed by the following three major phases:

a) Group Construction phase
b) Route Construction phase
c) Group Maintenance phase.

a) Group Construction Phase

As presented in figure 1, group construction phase is the first stage of multicast transmission process in MANETs. QAMACF first of all constructs a multicast group of nodes for packet transferring purpose. The group is created in the following manner: Generally, a sender initially floods a join message to all nodes in the network. Interested nodes reply to the sender via the reverse paths. When the reply message reaches the sender node, the membership of this replying node is immediately accepted. The first sender then floods a join message with data payload piggybacked which is periodically flooded throughout the entire network to refresh the membership information and then updates any relevant multicast paths. An interested node will respond to the join message. Note that the multicast paths built by this sender are shared with other senders. The source node is a first member of the group; intermediate nodes regularly forward the multicast packets from not only this sender but also from other senders available in the same group. Among forwarding nodes, some nodes available in the routing structure that are not interested in multicasting packets but play router's role by intelligently forwarding packets to receivers; these are called „forwarders or forwarding nodes”. Group members (senders, receivers, and forwarding nodes) are called mesh nodes; a node ( for example node „y”) is an upstream (parent) or a downstream (child) node of any other given node (node „x”), if it is closer or farther away from the root of the tree than the node x.

b) Route Construction Phase

The second phase deals with the route construction process. Upon completing the group constructing operations in the first phase, with the help of this multicast group, a route between any source and destination node pairs is found; we use ACO with fuzzy logic for this end in order to achieve high QoS for efficient multicast routing of multimedia data. In this phase, two different processes are performed in order to select an optimal path: Route Discovery and

- Route Maintenance.

Figure 3: Multicast Transmission in MANET

During the route selection process, each node sends a beacon message to its neighbor node. It consumes some amount of energy; nodes playing router’s roles will consume some more energy compared to ordinary nodes because they are in an active state during the overall period of packets’ transmission process. To this end, we need to find out the residual energy of each node during this route’s selection process. The residual energy and distance are very the important metrics for this operation. For example when a distance between any two participating nodes located along the route toward the destination node is high; the network link passing through that particular node’s route is weak and will be easily broken due to frequent mobility of the nodes. The distance between any two nodes is calculated by using Euclidean distance function

\[ D = \sqrt{1} \]  

(1)

From eqn (1), the variables and are the x coordinates of nodes A and B, and their y coordinates. Using this equation, we calculate the distance between the two nodes. The Reachability parameter [20] is then calculated using eqn (2),

\[ R = (N-1) \times 0.8 / A \]  

(2)

Considering the eqn (2), R refers to the Reachability of a node, N, a number of available mobile hosts, while A refers to the area (surface) occupied by the node, and r is this node’s coverage range.

Route Discovery process

At this stage, a route is discovered between a pair of nodes. A source node is connected to a destination node through intermediate nodes during this route
discovery process. The following steps are used to discover the route:

1. The source node multicasts a hello message to each of its neighbor nodes.
2. The forwarding node; ANT (F_ANT) then forwards this message to other nodes.
3. During this process, F_ANT collects information related to residual energy, distance, and reachability of each node.
4. Upon reaching the destination, Backward ANT (B_ANT) follows the same path with the reverse direction.
5. The collected information by the F_ANT is used as input to the fuzzy logic system.
6. The fuzzy logic system then generates 27 rules based on these three input parameter metrics.
7. By manipulating those rules, an optimal path is selected based on the probabilistic values obtained by evaluating each of the available routes using QoS parameters.
8. This process is repeated till the end of the session (when the most optimal path is found to route packets through).

Figure 4: Route discovery process using QAMACF

Figure 4 presents the fully working process of QAMACF architecture where multimedia files; video, audio, and image packets are transmitted. Note that F_ANT’s packet header contains information related to the QoS routing parameters; Residual energy (Re), Distance (Dt), and reachability (Rc).

Pseudocode 1: Route Discovery process

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>INP</td>
</tr>
<tr>
<td></td>
<td>UT</td>
</tr>
<tr>
<td></td>
<td>Rs,</td>
</tr>
<tr>
<td></td>
<td>Dt,</td>
</tr>
<tr>
<td></td>
<td>Rc.</td>
</tr>
</tbody>
</table>

2. Initialization:
   \[ I = \{ Rs \rightarrow \Phi; Dt \rightarrow \Phi; Rc \rightarrow \Phi \}; \]
3. Begin
4. Execute_RD();
5. Forward_F_Ant();
6. visit neighbor_node
7. if (curr_id = dest_id)
   break;
   else calculate I from equation (1) and (2) then assign I \rightarrow FLS
   end if;
8. Check_FRL();
   Begin
   if (P = H || P = VH) then curr_node \rightarrow selected;
   else if (P = VL || P = L || P = M) then curr_node \rightarrow rejected;
   end if;
   End
9. Recall_RD();
10. End
11. OUTPUT: The Select_Optimal_Rout.

Table 1: Symbols and their meanings

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rs</td>
<td>Residual Energy</td>
</tr>
<tr>
<td>Dt</td>
<td>Distance</td>
</tr>
<tr>
<td>Rc</td>
<td>Reachability</td>
</tr>
<tr>
<td>(\Phi)</td>
<td>Null</td>
</tr>
<tr>
<td>RD</td>
<td>Route Discovery</td>
</tr>
<tr>
<td>F_Ant()</td>
<td>Forward_ANT</td>
</tr>
<tr>
<td>FLS</td>
<td>Fuzzy Logic System</td>
</tr>
<tr>
<td>I &amp; P</td>
<td>Input &amp; linguistic value</td>
</tr>
<tr>
<td>FRL</td>
<td>Fuzzy Rule</td>
</tr>
<tr>
<td>H &amp; VH</td>
<td>High &amp; Very High</td>
</tr>
<tr>
<td>L, VL &amp; M</td>
<td>Low, Very Low &amp; Medium</td>
</tr>
</tbody>
</table>

The Pseudocode contains a detailed explanation of the fully working procedure of the proposed QAMACF algorithm. For route discovery purposes, the QOS input parameters i.e. residual energy (Re), distance (Dt), and reachability (Rc) are initially set with null (\(\Phi\)) values.
Table 2: Fuzzy Rules

<table>
<thead>
<tr>
<th>Residual Energy (R_E)</th>
<th>Distance (D)</th>
<th>Reachability (R)</th>
<th>Probability (P)</th>
<th>Node Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Very Low</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Very High</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Very High</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

Referring on table 2, by applying the ACO technique, the F_ANT collects information about all those nodes present in the whole network by multicasting hello messages throughout the network. The value (I) is supplied to the fuzzy logic system (FLS) which in turn generates fuzzy rules (FRL) accordingly by using Fuzzy inference engine from the fuzzy rule base. It then assigns the linguistic value (P) to the input parameters. Those values are finally compared with the generated output; this comparison helps in choosing the most optimal path from available ones located in the route along the way toward the destination. The linguistic values are Very Low (VL), Low (L), Medium (M), High (H) and Very High (VH). As, we can see in table 2, the totality of 27 rules with the relevant probabilities of a node to be selected based on linguistic values (p) are generated by the Fuzzy Inference Engine. For example, a node with low Residual Energy but with both high distance to the neighbor node and reachability; the probability value this node may be selected as an optimal path is low, whereas a node whose residual energy is low with a high distance but with the medium value of reachability; the probability this node may be selected is very low. When a node whose residual energy and distance are medium but the reachability value is low; this time, its selection’s probability value generated is high. The same procedure is followed while generating all the 27 rules. Table 1 exhibits the meaning of symbols and notations used in pseudocode 1.

a) Route Maintenance
During the packets’ transmission process, the selected paths must keep a high capability to hold the uninterruptible data transfer processes in order to achieve high QoS which minimizes routing delays and packet drops’ incidents in the same time providing high data delivery ratio. Throughout this routing session, one problem arises when due to the mobility nature of participating nodes in the network, distance between a pair of nodes have a high probability of changing resulting in both an unexpected change of their reachability value and an increased broken links’ rate. To this end, a periodic update of new available optimal routes is compulsory which immediately and automatically are selected to replace the one which were previously broken, consequently enabling uninterruptible data transfer.

b) Group Maintenance Phase
The group maintenance phase is the last stage, here; the multicast group is maintained in an efficient manner. Due to mobility nature of MANET’s nodes; a participating node can easily fall out of its group’s communication range. To detect this abnormal event, the source node periodically sends hello messages to the multicast group members, waits for some time period for the reply message from multicast group’s members. If any group member replies to the hello message, this node is immediately considered both as alive and active to be continuously used for communication purposes otherwise the one that does not reply to the hello message is automatically considered as dead. This principle is repeated until the end of the session. The main purpose of the maintenance process is to keep the...
routing and data transfer processes effective and efficient. These procedures previously described are applied in our proposed QAMACF’s implementation in order to achieve high QoS for multicast transmission of multimedia data in MANET.

5. PERFORMANCE EVALUATIONS

In this section, we compare our proposed QAMACF protocol with the existing algorithms; ABC (Ant colony Based Cluster) routing, fuzzy integrated ant colony optimization, ACO (Ant Colony Optimization), and Dynamic Core Based Multicast Routing Protocols (DCMP). Through simulation analysis, we prove that our proposed approach offers best results when compared to the existing ones. The performance evaluation aims at identifying the optimal paths to route multimedia packets through in order to achieve high QoS in MANET. Those algorithms are briefly discussed below:

- **ABC (Ant colony Based Cluster):**
  With ABC technique, cluster formation is achieved using the ACO (Ant Colony Optimization) technique to select the most stable path. A fuzzy logic system is then utilized to select the appropriate route by generating fuzzy rule with the help of parameters; B_ANT PKTs, mobility, and degree of nodes.

- **ACO (Ant Colony Optimization):**
  Here, route discovery and maintenance processes are two approaches used in order to choose an optimal path. F_ANT would forward route request message to the neighbor node and then travel along the network to reach the destination. The B_ANT also traverses along the same path but with a reverse direction. Based upon the collected information such as delay (D), bandwidth (B), and Hop Count (HC), the probability value is accordingly calculated. A path with a high probability value is selected as an optimal path. For route maintenance phase, routes are maintained in an efficient manner.

- **Fuzzy integrated ant colony optimization:**
  With this mechanism, fuzzy rules are generated with the help of the following parameters; distance value (D), delay (I), Capacity (W), and power consumption (P). F_ANT collects that information at each and every node along the way. Based on the probabilistic value, the route is then selected as an optimal path to route packets through.

- **Dynamic Core Based Multicast Routing Protocols (DCMP):**
  DCMP is an on-demand and mesh-based multicast routing protocols with which more than one source nodes are available. Those nodes are classified as active, core active and passive source nodes. An Active source sends the join request message with control packet at a regular interval of time-based on ODMRP routing protocol’s rules. A core active source node is also an active source node, which plays an important role for one or more passive sources nodes available in the network. Passive sources are only used for packets forwarding purposes; they work on behalf the nearby active sources. All those nodes are responsible for creating a shared mesh network. The key concept in this protocol is to make some sources passive, which then forward data packets through their core nodes. The major advantage of this protocol is its increased scalability, packet delivery ratio, and reduced control overhead.

5.1 Simulation Environment

The performance evaluation is conducted by comparing our proposed algorithm QAMACF with the already existing approaches as previously mentioned using NS-2 (Network Simulator) while applying the parameters presented in table 3.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of nodes</td>
<td>50</td>
</tr>
<tr>
<td>Interface type</td>
<td>Phy/WirelessPhy</td>
</tr>
<tr>
<td>Channel</td>
<td>Wireless Channel</td>
</tr>
<tr>
<td>Mac type</td>
<td>Mac/802_11</td>
</tr>
<tr>
<td>Queue type</td>
<td>Queue/DropTail/PriQueue</td>
</tr>
<tr>
<td>Queue length</td>
<td>201 Packets</td>
</tr>
<tr>
<td>Antenna type</td>
<td>Omni Antenna</td>
</tr>
<tr>
<td>Propagation type</td>
<td>TwoWayGround</td>
</tr>
<tr>
<td>Size of packet</td>
<td>256-1280</td>
</tr>
<tr>
<td>Protocol</td>
<td>QAMACF</td>
</tr>
<tr>
<td>Traffic</td>
<td>CBR</td>
</tr>
</tbody>
</table>

Table 3: Parameter values for simulation
As presented in table 3, a network size of 50 nodes is created for our performance evaluation. Each node randomly moves with a speed ranging from 1 to 20 m/sec in a simulation area of 500*500M with the transmission range of 250m, the overall simulation time is set to 200 secs. The traffic management operations are performed using Constant Bit Rate (CBR) with the generation rate of 100 kb/s. Each data packet’s size ranges from 256 to 1280 bytes. IEEE 802.11 for wireless LANs is used at the MAC layer with radio propagation model of Two-Ray Ground. The pause time is regularly taken after 10secs.

5.2 Performance Metrics
We use the following three metrics to compare the performance of our proposed algorithm with the already existing ones:

(i) **Packet delivery ratio (PDR):** It is defined as the ratio of data packets received by the destinations to those generated by the sources.

(ii) **Throughput:** It is the total number of packets delivered over the total simulation time.

(iii) **End-to-end delay:** The average end-to-end delay of a data packet is the total amount of transmission delay of packets. It consists of propagation delays, queuing delay, retransmission delays, etc.

5.3 Comparative Analysis
We conduct a performance comparison of our proposed algorithm with the existing ones by varying routing metrics as shown in both table 4 and table 5.

Table 4: Performance comparison considering Number of nodes

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>PDR</th>
<th>Delay</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>QAMACF</td>
<td>92.2%</td>
<td>6.3</td>
<td>95.4%</td>
</tr>
<tr>
<td>ABC</td>
<td>83.8%</td>
<td>8.5</td>
<td>93.6%</td>
</tr>
<tr>
<td>Fuzzy integrated</td>
<td>85.4%</td>
<td>8.7</td>
<td>92.1%</td>
</tr>
<tr>
<td>ACO</td>
<td>72.2%</td>
<td>7.9</td>
<td>91.5%</td>
</tr>
</tbody>
</table>

Table 5: Performance comparison considering Number of Receivers

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>PDR</th>
<th>Delay</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>QAMACF</td>
<td>95.5%</td>
<td>11.8</td>
<td>96.5%</td>
</tr>
<tr>
<td>DCMP</td>
<td>94%</td>
<td>13</td>
<td>92%</td>
</tr>
</tbody>
</table>

5.3.1 Performance evaluation with PDR

Figure 5 presents the outcome of our performance evaluation of PDR’s rate with varying the number of nodes. Packet delivery ratio of QAMACF remains high for the overall simulation time compared to other three algorithms; it is slightly decreased when the number of nodes is increased, the same apply to other algorithms; this is due to not having enough capability to handle highly dense networks.
As we can see on figure 6, PDR of our proposed algorithm is evaluated against DCMP’s; an existing and popular multicast protocol. This performance evaluation is conducted considering the number of receivers. During our simulation process, the number of receivers ranges between 10 and 30 nodes. Our QAMACF achieves the best results due to its two prominent features; available high link quality and selection of stable paths capabilities. One interesting observation is that the PDR of both protocols continually increases proportionally to the number of receivers, this situation proves that our proposed algorithm; QAMACF is outperforming as it keeps a high PDR which DCMP never attains.

5.3.2 Performance evaluation with Delay
Looking at figure 7, as long as the end-to-end delay network’s parameter is concerned by varying the number of nodes, the proposed algorithm’s delay is maintained to the lower level when compared to the existing ones during the overall simulation time even when the number of nodes is increased making our protocol a better one. This best performance behavior of our proposed algorithm is achieved thanks to the following features; F_ANT preliminarily collects information regarding the available distance between the source and its neighbor node in combination with its reachability value before starting the path selection process. With the help of fuzzy logic system with which paths that have lower distance and reachability values are firstly selected as optimal paths; for this, the probability that a data packet will delay reaching the destination is minimized. Another observation is that all four algorithms’ delays are almost the same when the number of nodes is low starting increasing progressively and proportionally to the number of nodes.

As we can see on figure 6, PDR of our proposed algorithm is evaluated against DCMP’s; an existing and popular multicast protocol. This performance evaluation is conducted considering the number of receivers. During our simulation process, the number of receivers ranges between 10 and 30 nodes. Our QAMACF achieves the best results due to its two prominent features; available high link quality and selection of stable paths capabilities. One interesting observation is that the PDR of both protocols continually increases proportionally to the number of receivers, this situation proves that our proposed algorithm; QAMACF is outperforming as it keeps a high PDR which DCMP never attains.

5.3.2 Performance evaluation with Delay
Looking at figure 7, as long as the end-to-end delay network’s parameter is concerned by varying the number of nodes, the proposed algorithm’s delay is maintained to the lower level when compared to the existing ones during the overall simulation time even when the number of nodes is increased making our protocol a better one. This best performance behavior of our proposed algorithm is achieved thanks to the following features; F_ANT preliminarily collects information regarding the available distance between the source and its neighbor node in combination with its reachability value before starting the path selection process. With the help of fuzzy logic system with which paths that have lower distance and reachability values are firstly selected as optimal paths; for this, the probability that a data packet will delay reaching the destination is minimized. Another observation is that all four algorithms’ delays are almost the same when the number of nodes is low starting increasing progressively and proportionally to the number of nodes.
5.3.3 Performance evaluation with the Throughput parameter

Throughput is one of the most important metrics for evaluating newly designed protocol’s performance. In figure 9, we again present the performance of our proposed algorithm - QAMACF- in comparison of ACO, ABC, and fuzzy integrated ACO techniques. The results obtained, varying the network’s size i.e. the number of nodes while considering throughput as an evaluating parameter metric, we prove that our proposed algorithm attains the maximum ratio of throughput compared to the existing ones. Recall that QAMACF is a multicast protocol capable of transmitting ordinal data packets and multimedia files such as video, audio, etc.

![Throughput vs No. of Nodes](image)

**Figure 9: Throughput vs No. of Nodes**

Figure 10 illustrates the effects of the total number of packets received by the source from multiple receivers. As in [figure 6], the number of receivers is varied starting from 10 to 30 in totality but here, a different behavior is discovered, the experimentation results show that the throughput value of both protocols varied starting from high to low when we increase the number of receivers this is due to various receivers simultaneously sharing the same channel. Despite this throughput’s decreasing values; QAMACF again outperforms DCMP, as it keeps its throughput value higher.

6. CONCLUSIONS

MANET is an infrastructureless network, so achieving high QoS is one of its major challenges. Various routing protocols have been designed aiming at providing high QoS in MANET, but till date, none of them highly solves problems inhibiting high QoS’ s achievements. To overcome all those negative issues we proposed a new routing algorithm; QAMACF which is the combination of both ACO and fuzzy logic mechanisms. It also takes into consideration two prominent features in MANET; multicast and multimedia transmissions techniques. For performance evaluation, we used three different parameter metrics namely Distance (D), Residual energy (Re), and Reachability (Rc). Those parameters are accumulated by F_ANT used in ACO at each node by forwarding hello messages. Those collected information are supplied as input into the fuzzy logic System which then generates a combination of 27 different fuzzy rules based on the input parameter provided from the fuzzy rule base available from the fuzzy inference system (FIS), which finally calculates the probabilistic value determining whether a given node present in network can or not be selected as an optimal path. Upon finding an optimal route to transmit packets through, packet transmission process then starts followed by the selected routes maintenance. The experiments were evaluated using ns-2 simulation comparing our proposed algorithm (QAMACF) with the already existing ones; ABC, ACO, Fuzzy integration with ACO, and Dynamic Core Based Multicast Routing Protocols (DCMP). Different scenarios were studied applying various prominent routing metrics; PDR, End-to-End Delay, and Throughput by alternatively varying the number of nodes and receivers. Our proposed algorithm outperforms the existing ones for all the studied cases; this achievement was possible thanks to the combination of multiple prominent techniques used in this protocol’s implementation. Our algorithm is efficient in routing ordinal and multimedia data packets even in highly dynamic MANETs as opposed to the ones.

REFERENCES


