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C-QoS-AOMDV: A cluster based QoS aware multipath routing protocol for MANET using hybrid soft computing techniques

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Abstract

Mobile ad hoc networks (MANETs) favour flexible routing protocols because a single route exceeds certain limits. It has many advantages over one-way routing approaches, including high productivity, low end latency, high energy efficiency, and long network life expectancy. As MANET terminals are powered by batteries, energy efficiency is a crucial requirement for many applications. C-QoS-AOMDV is a cluster-based QoS-aware multipath routing protocol for MANET that uses hybrid soft computing techniques to further improve QoS. The main contributions of proposed C-QoS-AOMDV routing protocol are given as follows. In C-QoS-AOMDV routing protocol, we present a modified bird mating optimization (MBMO) clustering technique which reduces the total energy consumption of the network. We compute cluster head (CH) based on the multiple constrains for data transmission between cluster members to corresponding CH node. Then, the mine blast optimization (MBO) algorithm is used to optimize multiple constrains to compute trust degree and maximum trust degree to select CH. Third, we illustrate hierarchical decision tree based deep neural network (HDT-DNN) which is used to compute the next intermediate node for further data transfer between one CH to another CH. Finally, the proposed C-QoS-AOMDV routing protocol is implemented in Network Simulator (NS-3) and the results are compared to the cutting-edge technology protocols AOMDV, AOMDV-QoS, and GE-QoS-AOMDV.

Subject Classification: *Primary 68M12.*

Keywords: *MANET, Routing protocol, Cluster head, Quality of service, Trust degree computation.*

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1. Introduction

MANET is comprised of terminals communicating wirelessly over a network. The ad hoc network offers a peer-to-peer multi-level routing service that functions as a source/synchronization and current antecedent for all nodes. Temporary networks offer numerous advantages, including self-regulation, power generation, transmission conditions, network mitigation, and vastly different properties based on traffic congestion (see [1]). When attempting to modernise these networks to support applications with quality of service (QoS) requirements, we recognise the need for further investigation. In radio frequency ISM bands, the physical layer has interference issues, data adaptation delays, and inattentive signal effects, and QoS guarantee is especially challenging. Lei Chen and W.B. Heinzelman [2]. We distribute channel access to the MAC layer, which causes known hidden and vulnerable node problems. Such issues have become quite complex, making it difficult to regulate the speed of NPs. Trail mechanisms during the network layer must cope with rapid changes in terrain, and if support for QoS is necessary, they must allocate existing paths to meet QoS requirements.

To develop effective protocols for MANET, we must consider the network's defining characteristics. Ch. Niranjan Kumar and N. Satyanarayana [3] proposed a multipath QoS routing protocol for traffic segmentation that minimizes packet loss and latency. Traffic is generally unpredictable when the network conditions are poor. The channel is wireless, so it is turned off for shutdown, multiplayer effects, and time delays. The MANET option makes it difficult to identify information about the local environment of low-level hosts worldwide. Establishing a distribution schedule guaranteed for the package makes it difficult to establish cooperation between neighboring hosts without central control. In MANET, all hosts share the same physical fire channel, and each host function includes activities with neighboring hosts. This unpredictability complicates the guarantee of successful operations. The main advantage of these brackets is that they support a wide variety of services as the infrastructure instantly creates a low-level network. It is also widely used in multimedia communication, in emergencies such as natural disasters, military conflicts and medical facilities. MANET's problem is that it is difficult to maintain direct media outlets, such as audio and video, due to the high demand and sharp constraints in the presence of dynamic network topologies, see Bouk et al. [4]. In these cases, MANET suffers permanent damage that affects the performance of the TCP. The most important problem of TCP in MANET is its inability to detect path defects and losses due to network congestion, which are very common in MANET, see Verma et al. [5]. To this end, Goyal et al. [6] proposed a multicasting routing protocol which considers topography changes and path errors and rebuilds broken links from the uplink node to the node next to the downlink node. Recent MANET studies (Miao et al. [7], Sridhar et al. [8]) focusing on the integration of MANET into infrastructure networks, e.g., cellular or data networks, provide network users with an established standard (QoS) for network users, time and place. The steering wheel's connection to the infrastructure network consists of numerous gateway modules connected to a variety of interfaces. These gateway terminals connect multiple networks, some of which may be mobile or adaptable.

The remaining sections are organised as follows. Existing works and their limitations in relation to MANET's efficacy are discussed in Section 2. Section 3 identifies current research gap in MANET protocols and proposes novel C-AOMDV-QoS routing protocol to address this gap. The main clustering algorithm using MBMO is discussed in Section 4. Next, in section 5, a comparative analysis of proposed and existing routing protocols is done. Finally, in section 6, main contributions, important findings, and limitations of this research work are summarized.

2. Related Literature

Johansson et al. [9] have presented a paper and developed a cache update program in a variety of contexts, based on apparent cache expiration, shutdown, and trail error. The Monarch panel simulates a network simulator with QoS measurements. The simulation results obtained using the specific approach give a lower rate than the variability of the dynamic source path updated by QoS. K.B. Gurumoorthy and A. Nirmal Kumar [10] have proposed network QoS stability sheet, QoS-based updates and routing algorithms which can save numbers and make better decisions. A service path standard (QR) based on a genetic algorithm (GA) is proposed to reduce the distance between reduced QoS stability and sub-optimal solutions. This routing involves a cluster algorithm designed to integrate with GA-based QR. This creates a more integrated long-term communication, eliminating the optimal solution by unstable clusters, and sometimes hindering the movement of neighbors. GA-QR network evaluates specific measures: performance, final delay, and overhead. Meena Rao and Neeta Singh [11] have utilized the KF-MAC protocol which reduces the density of QoS systems while transferring data from one source to another. If engraving technology is used as a cassette of Q network nodes, the Firefly optimization algorithm sorts and updates cluster nodes to find cluster nodes. The network nodes initiate data transfer and interact with the TDMA-based MAC path. The KF-MAC protocol monitor performs effectively with QoS systems including bandwidth, latency, bit error rate, and vibration. On the basis of the simulation study, the evaluation of a particular protocol concludes that the proposed protocol yields superior results to the existing power path protocol and the modified dynamic source path protocol. In addition, the KF-MAC protocol facilitates the transmission of random data with a low average power consumption. Using encryption technology, Mariappan Rajashanthi and Krishnasamy Valarmathi [12] have recommended an advanced standard service-based secure multi-routing system for secure data communication. Additionally, The paper presents the AODV-BR protocol for optimal multitasking routing with optimal fuzzy logic. The optimal path is created by the grey wolf optimisation strategy's adaptive evolution. Consequently, the optimal delivery route for data key management apparatus will be selected from the authorised routes. On the basis of parameters such as delay and pocket allocation, the end-to-end efficacy of the intended technology is assessed. The simulation results indicate that the proposed work is far more advanced and energy-efficient than the existing work.

3. Proposed Work

3.1 *Research Gap*

In recent years, rapid growth of technologies and their dynamic environment have created abnormalities in MANETs. The major problem in the MANET is that there are different performance metrics associated with node mobility, received signal strength and resource constraints. Therefore, the routing protocol plays an important role in temporary network connection nodes that are unable to communicate directly with each other. QoS measurements should be available on MANETs to ensure rapid and reliable transmission of information. GE-AOMDV-QoS software meets QoS requirements with low latency and high reliability. Most of the routing protocols proposed for QoS enhancement (see [13], [14]) do not solve MANET's problems completely. In addition, QoS ignores most of the MANET routing protocols currently in use. Lastly, maintaining QoS and making decisions for user navigation is a difficult task. GE-

AOMDV-QoS fails to perform over QoS measurements such as latency, vibration and Packet Data Ratio (PDR) well. For further enhancements in QoS, we propose a cluster based QoS aware multipath routing protocol for MANET using hybrid soft computing techniques (C-QoS-AOMDV). The main contributions of proposed C-AOMDV-QoS routing protocol are given as follows:

- We offer the modified bird mating optimization (MBMO) method for clustering in the C-QoS-AOMDV routing protocol, which improves overall network energy consumption.
- We compute cluster head (CH) based on multiple constrains for data transmission between cluster members to the corresponding CH node. Then, mine blast optimization (MBO) algorithm is used to optimize multiple constrains to compute trust degree and maximum trust degree to select CH.
- Third, we illustrate hierarchical decision tree based deep neural network (HDT-DNN) which is used to compute the next intermediate node for further data transfer between one CH to another CH.
- Finally, the proposed C-QoS-AOMDV routing protocol is implemented with NS-3 tool and the results are compared with the existing state-of-art protocols like AOMDV, AOMDV-QoS and GE-QoS-AOMDV.

1.2 *Model of the Network Implementing the Proposed Routing Protocol*

Figure 1 shows the network model of proposed C-QoS-AOMDV routing protocol in which network consists of several mobile nodes and the mobile base station. We compute clustering using the mobile nodes local information, i.e., position, location and velocity of the nodes for energy efficient routing. Then, we select the best optimal CH using multiple metrics including mobility, received signal strength, data delivery rate and latency. The highest trusted node acts as CH of the cluster. Finally, the inter cluster routing is performed using efficient neighboring node selection which acts as an intermediate node to transfer data from source to destination.

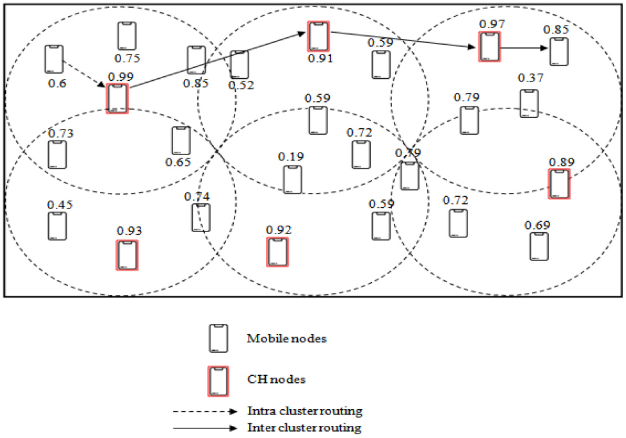

Figure 1

Network model of proposed C-QoS-AOMDV routing protocol

4. Cluster based QoS aware Multipath Routing Protocol for MANET

4.1 *Clustering using MBMO Algorithm*

The structure of the Modified Bird Mating Optimization (MBMO) algorithm includes bird species and their union. As a result, each bird's gene is seen as a variable, and each bird represents a potential resolution to the optimization problem. In this way, the crossbreeding characteristics provided for females are parthenogenesis and polyandrous, while the gene obtained is considered as a solution of the corresponding objective value. Later, male characteristics incorporated in this study include monogamy, polygenesis, and the future process. Following is a detailed process showing the mating and transformation for each bird.

4.1.1. Crossover Process

Monogamy is the relationship between a male and female bird. Individual bird mating behaviour can be categorised as follows.

$$BMO_{os} = BMO_{m} + \gamma(BMO_{f} - BMO_{m}) \tag{1}$$

where BMO_m and BMO_f are bachelor birds, BMO_os represents the progeny of the bird mating optimizer, which is the resulting brood, and varies with time. As increases, the magnitude decreases in a straight line and approaches zero.

Polygyny is a variant of polygamy wherein a man has intimate relationships with two or more females. The breeding procedure of polygenic animals is outlined below.

$$BMO_{os} = BMO_m + \gamma \sum_{n=1}^{k} (BMO_f^n - BMO_m) \tag{2}$$

where BMO_f^n k-th represents an intriguing female bird and n represents the total number of intriguing female birds. Regarding revenue, this is a reference to the volatile relationship between the male bird community and its intriguing female birds. In particular, prokaryotes are produced using the same method as birds, and their breeding system is comparable to that of agitated birds.

Parthenogenesis is the asexual reproduction that occurs when a female bird incubates without the presence of a male. As suggested, each parthenogenetic bird is the optimal solution because it attempts to pass on its best genes to its offspring. The volume of mutations in the study was 0.01. The production vector for mutations can be obtained as follows:

$$BMO_{os} = BMO_p \pm \mu \times BMO_p \tag{3}$$

where BMO_p is the optimization of parthenogenetic bird mating and μ is the cut-off factor taken as 0.001. Considering other mutations in monocots, polygons, arbitrary and polyandry birds, their function is also described below.

$$BMO_{os}(y) = y^l + \eta(y^u - y^l) \tag{4}$$

where y refers to a gene that counteracts mutation, y^l and y^u indicates the lower and upper border of the gene respectively, and η is a random number between 0 and 1. Thus, a group of birds can be formed into a team as shown below:

$$BMO = [BMO_1, BMO_2, BMO_3, ..., BMO_j, ...BMO_K]^T$$

$$BMO = \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \cdots & \beta_{1i} \cdots & \beta_{1q} \\ \beta_{21} & \beta_{22} & \beta_{23} \cdots & \beta_{2i} \cdots & \beta_{2q} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \beta_{j1} & \beta_{j2} & \beta_{j3} \cdots & \beta_{ji} \cdots & \beta_{jq} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \beta_{k1} & \beta_{k1} & \beta_{k3} \cdots & \beta_{ki} \cdots & \beta_{kq} \end{bmatrix} \tag{5}$$

5. Comparative Analysis of Proposed and Existing Routing Protocols

5.1 *Performance Comparison over Node Density*

In this exercise, we divide the number of mobile nodes from 250 to 1250. The standard network area is 1000 m * 1000 m and the node speed are 10 metres per second. Next few graphs compare proposed and existent routing protocols in terms of end-to-end (E2E) delay, energy consumption, throughput, routing overhead, packet delivery ratio, and packet loss ratio at varying node densities of 250, 500, 750, 1000, and 1250. Figure 2 shows an E2E delay of proposed and existing routing protocols. It shows that the E2E delay of proposed C-QoS-AOMDV routing protocol is 87.02%, 78.16% and 78.07% lower than the existing state-of-art AOMDV, AOMDV-QoS and GE-QoS-AOMDV routing protocols respectively. The energy consumption of suggested and current routing techniques is shown in Figure 3. It is evident that the suggested C-QoS-AOMDV routing protocol uses 64.68%, 25.77% and 13.16% lower energy than the existing state-of-art AOMDV,

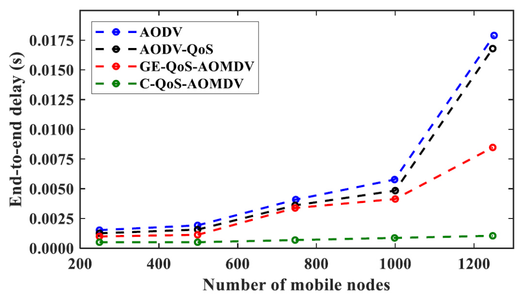

Figure 2

End-to-end delay with node density

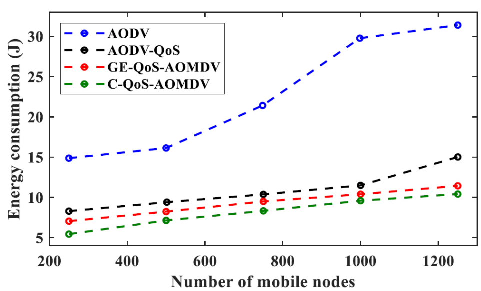

Figure 3

Energy consumption with node density

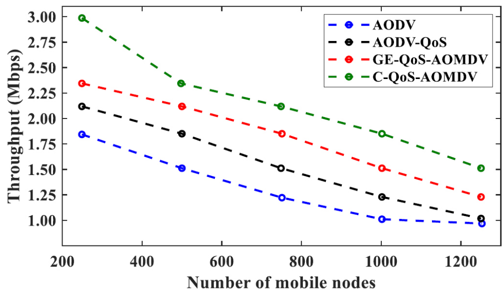

Figure 4

Throughput with node density

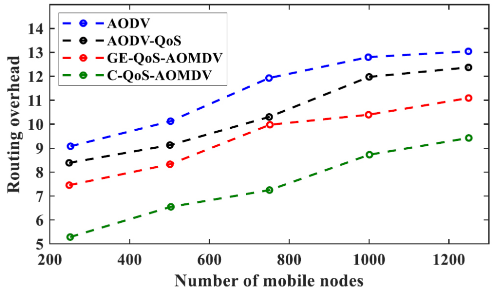

Figure 5

Routing overhead with node density

AOMDV-QoS and GE-QoS-AOMDV routing protocol respectively. Figure 4 shows the throughput of proposed and existing routing protocols. It demonstrates that the throughput of the proposed C-QoS-AOMDV routing protocol is 39.06%, 28.51% and 16.25% higher than the existing state-of-art AOMDV, AOMDV-QoS and GE-QoS-AOMDV routing protocols respectively.

Figure 5 shows the routing overhead of proposed and existing routing protocols. It shows that the routing overhead of proposed C-QoS-AOMDV routing protocol is 34.7%, 28.72% and 21.28% lower than the existing state-of-art AOMDV, AOMDV-QoS and GE-QoS-AOMDV routing protocols respectively. The packet delivery ratio for suggested and current routing techniques is shown in Figure 6. It is evident that the proposed C-QoS-AOMDV routing protocol has greater packet delivery ratio than the current state-of-the-art AOMDV, AOMDV-QoS, and GE-QoS-AOMDV routing protocols, respectively, by 16%, 13.13%, and 6.07%. The packet loss ratio of proposed and current routing methods is shown in Figure 7.

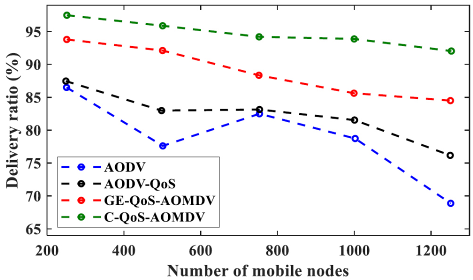

Figure 6

Packet delivery ratio with node density

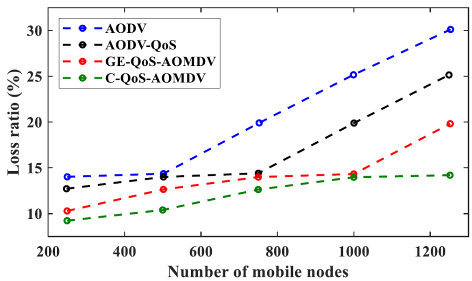

Figure 7

Packet loss ratio with node density

It demonstrates that the proposed C-QoS-AOMDV routing protocol has packet loss ratios that are, respectively, 41.89%, 29.98%, and 15.17% lower than the state-of-the-art AOMDV, AOMDV-QoS, and GE-QoS-AOMDV routing protocols already in use.

5.2 *Performance Comparison over Node Speed*

In this test, the mobile speed is varied from 5 m/s to 25 m/s, the fixed network area is 1000 m × 1000 m and the number of nodes is 1250. Next few plots present comparison of the performance between specific and existing routing algorithms with respect to node velocities varying as 5, 10, 15, 20 and 25 m/s. Figure 8 represents E2E delay of proposed and existing routing protocols. It shows E2E delay of proposed C-QoS-AOMDV routing protocol is 59.2%, 50.64% and 34.89% lower than the existing state-of-art AOMDV, AOMDV-QoS and GE-QoS-AOMDV routing protocols respectively. The energy consumption of suggested and existing routing techniques is shown in Figure 9. It demonstrates that the proposed C-QoS-AOMDV routing protocol uses less energy than the current state-of-

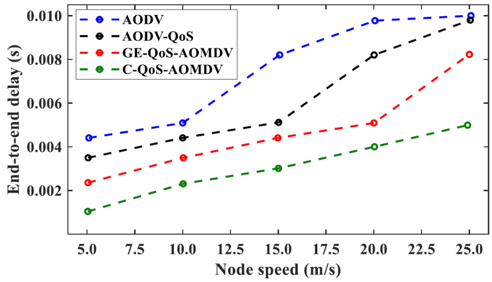

Figure 8

E2E delay with node speed

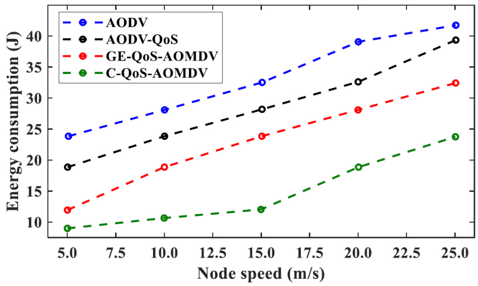

Figure 9

Energy consumption with node speed

the-art AOMDV, AOMDV-QoS, and GE-QoS-AOMDV routing protocols, respectively, by 13.86%, 48.03%, and 35.69%.

6. Contributions and Findings

In this paper, a modified bird mating optimization (MBMO) algorithm is used for clustering which improves overall energy consumption of MANET. A mine blast optimization (MBO) algorithm is, further, used to optimize multiple constrains to compute trust degree and maximum trust degree to select cluster head (CH). Finally, a hierarchical decision tree based deep neural network (HDT-DNN) is used to compute the next intermediate node for further data transfer between one CH to another CH.

The mean end-to-end latency of the suggested C-QoS-AOMDV routing protocol is 81.08 percent and 48.26 percent lower than existing routing protocols, depending on node density and node speed. In node density and node speed scenarios, the proposed C-QoS-AOMDV routing protocol consumes 34.54 and 32.53 percent less energy than existing routing protocols, respectively. The average throughput of proposed C-QoS-AOMDV routing protocol is 27.94% and 3.50% higher than the existing routing protocols over node density and node speed scenario respectively. The average routing overhead of proposed C-QoS-AOMDV routing protocol is 28.23% and 23.45% lower than the existing routing protocols over node density and node speed scenario respectively. According to the proposed C-QoS-AOMDV routing system, the typical packet delivery ratio is 11.73% and 4.021% higher than the existing routing protocols over node density and node speed scenario respectively. The average packet loss ratio of proposed routing protocol is 29.01% and 15.68% lower than the existing routing protocols over node density and node speed scenario respectively.

Assessment of proposed C-QoS-AOMDV routing protocol, as done in this research work, is limited by the capabilities of research network simulator (NS-3). As a future effort, it would be interesting to evaluate various scenarios for the integration of proposed routing protocol within existing infrastructure networks.

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