# Performance enhancement of mobile ad hoc network life time using energy efficient techniques

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**ABSTRACT**

Due to the dynamic topology and limited resources in mobile ad hoc networks (MANETs), multicast routing and quality of service (QoS) provisioning are difficult issues. This study introduces an agent-based QoS routing method that uses fuzzy logic to choose the best route while taking into account a variety of independent QoS indicators, including buffer occupancy rate, remaining mobile node battery capacity, and hop count. On the other hand, finding such pathways requires a lot of work in terms of efficiency and security. This study continues to test the security of weak models, and it has been shown that it may be challenging to accept various sorts of assaults. A distributed approach is given that may be used to determine the best resource distribution at each node. Additionally, the least energy-intensive directed acyclic network, network flow is selected from a group using the embedded sleep scheduling algorithm. The process of choosing the flow and allocating the resources for each video frame is adjusted to the characteristics of the network connection channel. Results show that the suggested resource allocation and flow selection algorithms provide considerable performance benefits with minimal optimality gaps at a reasonable computational cost when applied to various network topologies.



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## 1. INTRODUCTION

A mobile ad hoc network (MANETs) is a collection of mobile nodes that interact with one another through multiple-hop wireless links without the need of fixed infrastructure. Nodes in MANETs are completely free to roam around and may join or leave the multicast tree at any time. A quality of service (QoS) assurance must be implemented before multicast services can be created since it may enhance performance and permit the flow of crucial information even in difficult circumstances. Most widely used MANETs routing systems use one or two QoS factors for choosing routes. This is insufficient, however, since the architecture of the MANETs depends on a variety of variables, including connection reliability, node mobility, and the battery life of mobile devices. These elements are interconnected. As a result, selecting the best approach necessitates considering more than one or two aspects [1]–[5]. However, finding a path that fulfils all many conditions is an NP-complete task. There isn't a mathematical representation of it that is adequate. Any continuous function or system may be represented using fuzzy logic.

Fuzzy logic is a theory that relies on many inputs, incomplete information, and fuzzy results. Due to the features of fuzzy logic, Ad hoc networks may utilise it to solve multi-metric issues. Outing is a vital part of multi-hop Ad hoc networks (MANETs). These network nodes are decentralised because they serve as hosts and routers at the same time. Each node has the capacity to forward packets that are beyond the transmission range. MANETs is different from other types of networks because it lacks a fixed infrastructure. In MANETs, the security services component faces a unique set of difficulties. There are two types of challenges: operational and security-related. Security and dependability, service quality, key management, internetworking, traffic monitoring, and power consumption are some of the operational challenges. Packet forwarding, path discovery, denial of service attacks, trust management, and route discovery problems are some of the security challenges. Because of the lack of infrastructure and the consequent lack of authorization mechanisms, it has become common practise to erect a protective barrier and classify nodes as trustworthy and untrustworthy. Such a distinction would have primarily been made in accordance with security policy, i.e., having the required credentials and the ability to have them authenticated by the nodes [6]–[10].

An essential factor is choosing the cluster head (CH), who acts as the co-coordinator in this architecture. Topological adjustments are made by altering the routing tables to reduce the cost of routing. The CH is responsible for managing the nodes in its own cluster, coordinating communications with other clusters, and utilising the least amount of transmission power by avoiding packet flooding. To increase network longevity in this situation, a cluster-based routing system for MANETs is suggested. Using the max heap clustering, which gives each node a priority, the nodes are organised into clusters. Metrics like average power transfer and mobility factor are used to determine this priority. After each iterationa CH is chosen using this priority. To avoid needless election of a node as CH from wasting network resources, the number of regular nodes that fall under such a CH is set to a threshold value. To select the most energy-efficient routes while preventing connection failures for data delivery, a routing system is currently being developed. Each node's residual energy varies depending on the size of the packet and is made up of both its initial and used energy. As a consequence, it may be difficult in most cases to have a clear picture of the membership of the Ad hoc network. As a consequence, in a large network, it is impossible to maintain an established trust link between majorities of nodes. There is no guarantee that a route between two nodes would be built in such circumstances without interruptions, which would go against the selected protocol [11]–[15].

Today's most important navigation and positioning technology is the global positioning system (GPS), which is most accurate outdoors but less accurate indoors. Most long range (LoRa) technology has been used in the internet of things (IoT), but there have been very few localization systems. This project developed the LoRa positioning system, a GPS-free alternative that consists of a LoRa transmitter, LoRa transceiver, and LoRa receiver. The technique was developed by the collection of receiver signal strength indicator based (RSSI), which was then used to calculate distance. A Kalman filter with a particular model has been developed to resist the impacts of multipath fading, especially in indoor situations. The user's location is then estimated using the trilateration method. Both the line-of-sight (LOS) and non-line-of-sight (NLOS) distribution estimation results were subjected to analysis. The performance of the Kalman filter and trilateration are then compared in terms of root mean square error (RMSE). For comparison with LoRa-based location, GPS positions were also acquired. Final point: 90% of the localization technique error for LOS is less than 0.82 metres, compared to 1.17 metres for NLOS, according to the cumulative density function (CDF). Wireless sensor networks (WSN) have seen a rapid increase in applications in recent years as a result of the development of low-cost, compact sensor nodes. In order to reduce network energy consumption and subsequently lengthen the lifespan of the sensor network, the clustering problem is transformed into an optimization problem, and the specific cost function is used to select the CH in a way that the energy utilisation of the network is optimised [16]–[20]. On the MATLAB platform, a lot of simulation work is done to test the approach in different network scenarios with varying network sizes and node counts. Simulated results show that the recommended strategy may extend the network's lifespan in comparison to its opponent by up to 154% in terms of first node death. Furthermore, choosing the optimum set of CH at each round has shown that our recommended method boosts total data delivery at the base station (BS) by up to 59% when compared to the well-known strategy, while also lowering network energy use [21]–[25].

## 2. METHOD

Effective flow selection and resource allocation algorithms for video distribution across cooperative wireless networks may provide end-to-end statistical delay restrictions and lower energy usage. Any sequential multihop multicast tree that generates a directed acyclic graph encompassing the network architecture may be used for the delivery of video content. The effective capacity link layer model is used to mimic the queuing behaviour of the cooperative network. There are other approximation solutions for the flow selection issue, which entails choosing the best flow while using the least amount of energy. The first approach identifies the shortest spanning tree to maximise the sum rate using negative signal-to-noise ratios (SNR) as link weights over the whole network graph, and then conducts optimum resource allocation on the flow corresponding to the tree structure. This method reduces each resource along the path to a single metric fuzzy cost. The clever software agents scour the network gathering data from every mobile node. Data is sent over suitable pathways to establish communication since a cooperative network environment is required. Both unicast and multicast routing are possible with Ad hoc on demand distance vector (AODDV) routing. The on-demand routing technique states that routes between nodes are only built in response to requests from source nodes. If a node receiving this route request (RREQ) is either the destination or has a route to the destination with a sequence number higher than or equal to that indicated in the RREQ, it may send a route reply (RREP). It unicasts an RREP back to the source in this instance. The RREQ is repeated if not. The nodes keep track of the RREQ's source IP address and broadcasting ID. All previously processed RREQs are discarded, and none are sent. Multicast routes are set up similarly. A node broadcasts an RREQ with the multicast group's target IP address and the 'J' (join) flag set when it wants to join one. Any node in the multicast tree with this RREQ received and a multicast group sequence number that is up to date enough to transmit an RREP may do so. The nodes sending the message add references to their multicast route tables as the RREPs propagate back to the source. When a source node gets an RREP, it keeps in memory the route with the fewest hops and the most recent sequence number to the next multicast group member. The source nodes will unicast a multicast activation (MACT) message to its designated next hop after the predefined discovery period. The message's objective is to activate the route.

A multicast route pointer-configured node will be considered configured if it times out and deletes the reference because it failed to receive the message. If the MACT receiver hadn't previously been a member of the multicast tree, it would have continued to keep track of the optimum route from the RREPs it received. It must thus unicast a MACT to its next step up until it reaches a node that was previously a part of the multicast tree. The maintenance overhead is minimised here, despite the fact that route interruptions might sometimes result in large overhead. Routing overhead may be decreased using reverse Ad hoc on-demand distance vector (RAODV) routing strategies. RAODV considers link/route stability while deciding which way to adopt. When an active route fails, the source node, which is aware of route stability, may choose the optimal route from a list of alternatives. To solve the stability issue, a brand-new technique known as the modified reverse Adhoc on-demand routing algorithm (MRAORA) was created. To assess the route stability, this technique alters the RREP packet rather than the RREQ packet. The proposed WSN model is shown in Figure 1.

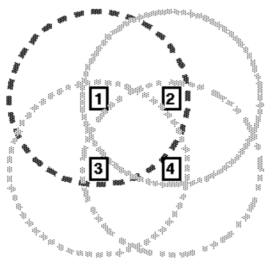


Figure 1. Proposed model of the WSN

In MANETs, broadcasting is crucial because it distributes messages from one source node to all other nodes in the network. The most basic and widely used broadcasting method in MANETs is flooding, in which each node delivers each message it receives precisely once. Despite its seeming simplicity, the broadcast storm issue leads to repeated rebroadcast messages that substantially choke the network and create collisions. Mobile nodes repeat messages with a probability p that may be fixed or computed depending on the local density in a probabilistic manner to decrease the issue of flooding. Additionally, this approach lowers the quantity of rebroadcasts at the price of reach. By keeping track of how many copies of a packet it has previously received during a random access, counter-based techniques, on the other hand, prevent a node from broadcasting a packet.

## 3. RESULTS AND DISCUSSION

A network is frequently represented as a weighted digraph G=(V, E), where V denotes the grouping of nodes and E denotes the grouping of communication links that connect them. The letters |V| and |E| stand for the network's nodes and connections, respectively. The bandwidth and latency constraints for the multicast routing problem are from one source to many destinations.

A BS, denoted by M0, and MK mobile stations (MS), denoted by M1,..., MK, make up the proposed system model. These stations are all capable of sending, receiving, or relaying a scalable video bit stream. The BS must use wireless fading channels to transmit the same multilayer video stream to the MS. A flow is a group of unicast or multicast broadcasts that are visualised as a nearby connections tree. To demonstrate the system paradigm, Figure 2 depicts a prototype network with seven MS and a fixed network flow. This network flow, which has four different paths going to M4, M7, M6, and M3, covers all of MSis shown in Figure 2. The energy algorithm is shown in below:

Algorithm
```
START
Energy for each node
Evaluefromthesetofnodes.
source->MAX(E)&&ACTIVE(S)
Shortest--->(ACTIVE)//using algorithm.
INACTIVE---→unused nodes
SaveEnergy(INACTIVE)
Return START
```

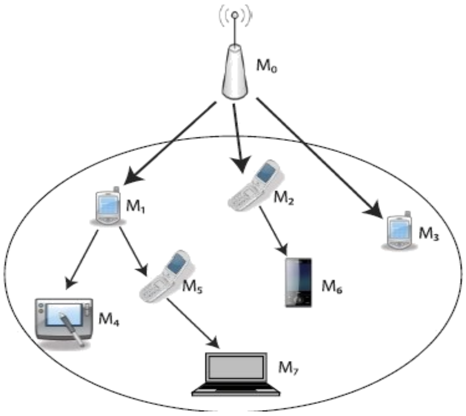


Figure 2. Proposed model of the MANETs

L video layers make up the video stream that the scalable video codec creates. Each layer has a separate queue at each node with a different set of QoS criteria depending on how important it is to the decoding process. The distance between the playback periods of two video frames at the receiver is known as the time frame T, sometimes referred to as the reciprocal of the video frame rate. To prevent playback buffer starvation, the video frame contents for the L layers should be broadcast to all K receivers within this time T in line with the flow Fn architecture. by enabling content to stream concurrently (in parallel) across several network flow channels and by individually considering each branch of the multicast tree for this to be true, channels must be accessible to every MS in the network. The number of channels that may be employed is limited by the number of network routes. M1 and M2 may transmit simultaneously with only two channels needed in the 4-path network flow shown in Figure 2. The number of pathways is often much less than the number of network nodes, and in practise, the number of channels accessible in the wireless technology used for short-range broadcasts is much smaller than the number of network nodes. The amount of battery power that is currently present on each node along the path is the amount of battery power that is left on the path. The sum of a node's available battery power and its necessary transmit power level yields the node's remaining battery power.

$$BP(p(V,D) = min\,\{BP(n), n \in p(V,D)\} \quad (1)$$

The direction of the route is p from the source node to the destination node (V, D). The approach that makes better use of battery life is less expensive. When selecting a route, considering the number of intermediate hops is crucial. It makes it possible for routing algorithms to find the shortest pathways is shown in Figure 3. The shortest network distance influences the minimum end-to-end latency between the source and destination to some extent. The life of the routing path is reduced when data is transported along a route with numerous intermediate hops due to the higher likelihood of route failure brought on by node mobility. Longer end-to-end latency is also caused by more intermediate hops. The simulation parameters are shown in

Table 1. The quantity of intermediary nodes, the size of the battery, and the length of the queue are the three input variables that must be fuzzy. Based on current MANETs information, Figure 3 shows how the words "low," "medium," and "high" are applied to the buffer time, battery power, and number of hops. In Figure 4, the phrases "very low," "low," "medium," "high," and "very high" are used to describe the output variable cost. Table 2 displays the fuzzy rule.

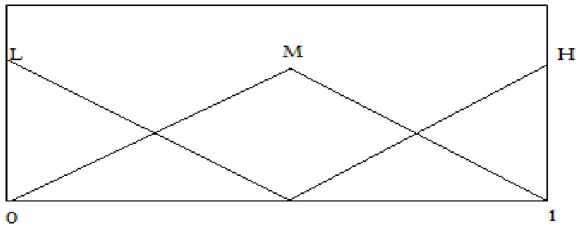


Figure 3. Fuzzy memberships function

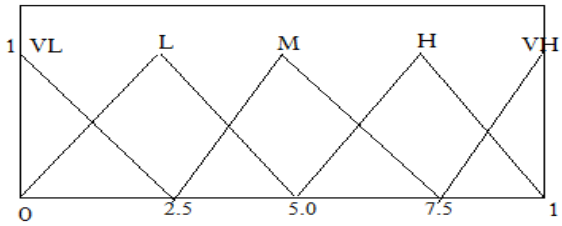


Figure 4. Fuzzy membership function for cost

Table 1. Simulation parameters

| Parameters | Value |
|---|---|
| MAC layer | IEEE 802.11 |
| Simulation area ($m^2$) | 1,500*1,500 m |
| Simulation time | 160 secs |
| Number of nodes | 40 |
| Bandwidth | 2 Mbps |
| Node mobility speed | 0-50 m/s |
| Mobility pattern | Random way point |
| Traffic flow | CBR |
| Packet size | 512 bytes |
| Transmission range | 240 m |

Table 2. Fuzzy rule base

| Q \ BP | Low | Medium | High |
|---|---|---|---|
| Low | Medium | Medium | High |
| Medium | High | High | Medium |
| High | Medium | High | High |

Defuzzification is the process of extracting a crisp value from a fuzzy collection as a representation value is shown in Table 2. Defuzzifiers come in a variety of shapes and sizes. A technique that maximises the wake-up time during a scheduling period at three levels is employed to reduce the delay. Here is a quick description of the solution to this issue. Because all nodes submit their data to the sink node in a standard WSN arrangement, the nodes closest to the sink nodes must handle a higher volume of traffic. Due to sleep/wake scheduling's disregard for the fact that the majority of packets pass via nodes adjacent to the sink node, performance suffers. This article suggests that the latency may be reduced by taking into account the fact that node forwarding requirements vary depending on their proximity to the sink node. The forwarding task and the sleep/wake pattern are directly related, therefore the longer the forwarding task, the longer the waking time. These speeds up the mailing procedure and prevents deadline infringement. A sensor node that is close to the sink node has a lower likelihood of being placed into sleep mode than one that is far from the sink node. Figure 5 depicts the energy consumption of the network. In order to compensate for the greater delay, nodes' wake intervals lengthen as they go nearer to the sink.

Second, because WSNs employ a multi-hop communication mechanism, a node's role in routing is essential. The importance of different nodes varies depending on the network's topology. For instance, if only one node serves as a bridge between two different networks, that node is in charge of transmitting all of the data from one network segment. Thus, latency may be reduced by assigning sleep/wake schedules to nodes based on the traffic load determined by the node's connection relevance. Lightly loaded nodes (nodes for which connectivity is less important) have a shorter waking interval in order to conserve energy, whereas significantly loaded nodes (nodes for which connectivity is important) have a longer waking interval to ensure their availability when needed. The WSN's packet delivery ratio is shown in Figure 6.

Third, regardless of how often an event is picked up in any one part of a WSN, the nodes' normal sleep/wake cycles stay the same. It does not adjust its sleep to waking interval based on the frequency and location of occurrences. Simple concepts of spatial and temporal interconnectedness are used to tackle this issue. Because of temporal dependence, if an event takes place in the sensing zone of the node during one time period, it is likely to occur during subsequent time periods. Therefore, if the nodes can alter and vary their sleep cycle, the latency may be reduced. Figures 7 and 8 show the throughput and end-to-end latency of the WSN, respectively. The parameter analysis of the proposed system is shown in Table 3.

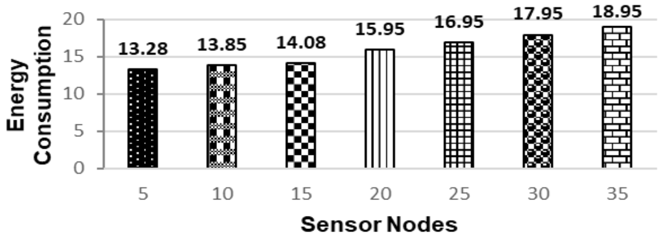


Figure 5. Energy consumption of the network

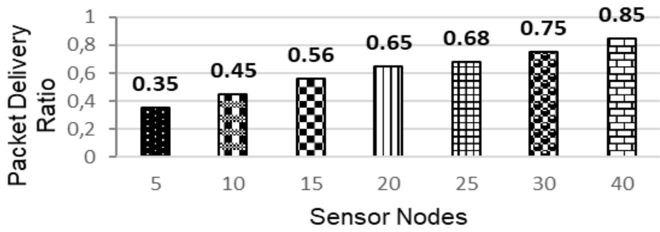


Figure 6. Packet delivery ratio of the network

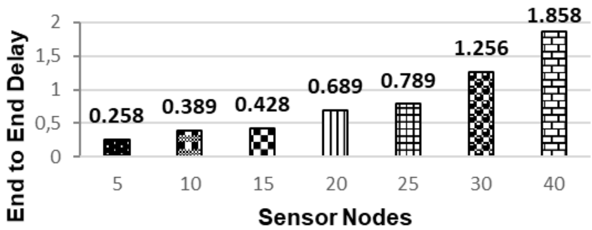


Figure 7. End to end delay of the network

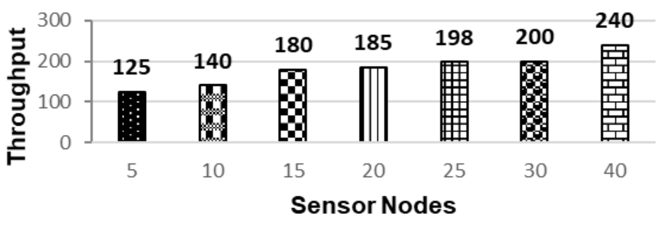


Figure 8. Throughput of the network

Table 3. Parameter analysis of the proposed system

| Sensor nodes | Energy consumption | Packet delivery ratio | End to end delay | Throughput |
|---|---|---|---|---|
| 5 | 13.28 | 0.35 | 0.258 | 125 |
| 10 | 13.85 | 0.45 | 0.389 | 140 |
| 15 | 14.08 | 0.56 | 0.428 | 180 |
| 20 | 15.95 | 0.65 | 0.689 | 185 |
| 25 | 16.95 | 0.68 | 0.782 | 198 |
| 30 | 17.95 | 0.75 | 1.256 | 200 |
| 40 | 18.95 | 0.85 | 1.858 | 240 |

## 4. CONCLUSION

The maximisation of connection stability, route lifespan, and cost efficiency is how this study characterises the QoS aware routing problem. To offer a single cost value for route selection, a fuzzy rule basis is used with additional characteristics such as the number of nodes, buffer time, remaining battery capacity of a mobile node, and others. Intelligent software agents are used to discover multicast routes and serve as the base for dependable multicasting. These agents assist with routing and network maintenance. This research also took into consideration the end-to-end statistical latency restrictions for each network route in order to reduce overall energy consumption and found the best resource allocation technique for scalable video distribution over cooperative multihop networks. In order to consistently provide video content to all demanding mobile terminals, the solution is utilised to discover the most energy-efficient flows composed of hybrid unicast/multicast connections. The efficiency and complexity of two low-complexity approximation methods for flow selection are compared. The findings show significant energy consumption savings, and the performance of the approximation approaches is pretty near to ideal for many network topologies.

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