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AN ADVANCED TICKET MANAGER - FUZZY LOGIC BASED AODV ROUTING PROTOCOL (TM-FLAODV) IN MANET

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Abstract: MANET – Mobile Ad Hoc Network, a dynamic and structureless network, has various applications footprints. Routing is an important concept which forwards the packets to destination nodes through the intermediate nodes. But discovering an optimal routing system is challenging because unstable data transmission makes routing more complex. Several works evolved in achieving an optimum routing system. Most of the approaches discussed the single path where it will not work on diverse applications. On the other hand, the existing multipath methods suffer from high energy consumption. In this paper, to overcome these issues, we proposed Ticket Manager - fuzzy logic-based AODV routing protocol (TM-FLAODV). It involves two implementations, such as token manager execution, and the execution of improved fuzzy logic-based AODV routing protocol. The token manager enables a central monitoring system for identifying the node's energy level and other node properties, ensuring there is no link failure in the network. The improved fuzzy logic-based AODV routing protocol achieves optimal multipath routing, which is also effective on diverse applications. To evaluate the performance of the proposed Ticket Manager - fuzzy logic-based AODV routing protocol (TM-FLAODV),the Ticket – ID-based routing management system (T-ID BRM) and the Fuzzy logic based AODV routing protocol are compared (FL-AODV). The comparison metrics taken for consideration are average reliability, average end-end delayaverage link connectivity and Number of Hops. The obtained results prove that the performance achieved by the proposed TM-FLAODV in all aspects is more efficient than the others.

Keywords: MANET, Routing protocol, Multipath, energy consumption

1. Introduction

MANET is a wireless network that contains autonomous nodes which are dynamic in nature. The nodes in the network areindependent and connected as mesh architecture. MANET does not have any infrastructure and central controller [1].In the network, nodes acts as a router that communicates with one another as a multi-hop radio network. Implementation of MANET is very quick during the instance of emergencies like battlegrounds and catastrophes. The infrastructure-less design and nodes communication among themselves makes MANET implementation simple. But during the emergency situation sharing of video services among the first responders, rescue teams, etc is complex [2]. In MANETs, adaptive multimedia transmission is important for achieving Quality of Service (QoS) [3].

Generally, nodes are mobility in nature which has frequent route fails; hence maintaining communication from a source node to destination nodes is problematic. But maintaining communication sessions is more important for determining the best routing methods. MANET's topology is dynamic, in which each node must keep key status information like distance, jitter, delay, packet loss rate to feed the routing algorithm. These nodes' status information is difficult to monitor because of two reasons such topological changes and second is a restriction on network resources like processing, storage, battery, and bandwidth. The unique properties of MANETs make QoS difficult, and results in multimedia communication on MANETs are the most challenging task [3-9].

Current techniques for resource reservation and QoS routing for supporting multimedia transmission over MANETs were summarized in work [4]. In work [5], crucial challenges in power-based routing are described. An energy-efficient routing approach for MANETs with QoS guarantees is discussed in the paper [6]. A brief survey about MANET scheduling strategies and existing MANET power-aware optimization solutions are also discussed [8,10,11].

MANET main characteristics are Dynamic network topology, bit error rate (BER), Multi-Hop Communication, Bandwidth Limitation, Asymmetry in packet loss rate, bandwidth, delay, and Limited energy capacity,

1.1 Importance of energy optimization

In MANET, video transmission faces heavy traffic and this traffic maximizes the energy exhaustion of mobile devices [11].Specifically, high network delay and packet losses arise as video traffic grows rapidly. As a result, energy consumption rises, and QoS performance falls [11]. The network experience congestion and the congestion generate increased buffer consumption along the available network path, resulting in higher packet losses in the event of network resource unavailability [7]. The importance of power-aware optimization routing techniques in MANETs is concluded [10]. The "Ad Hoc On-Demand Multipath Distance Vector with the Fitness Function" (FF-AOMDV) is a novel routing system developed in [12. FFAOMDV employs Fitness Function in multipath routing for minimizing the energy consumptions. It works effectively in defining the ideal path from source to destination to reduce the energy the consumptions. All nodes must contribute to the construction of route pathways among nodes. However, some nodes refuse to cooperate by lending their resources to other nodes for communication purposes.

Organization of this paper: In section 1 introduction is discussed, section 2 describes various existing implantations works and its drawbacks, section 3 describes the proposed workflow and management, in section 4, experimental work is discussed and the conclusion is described in section 5.

2. Related Works

In MANET, nodes are deployed dynamically and mobility in nature, this changing of topological structure from time to time makes designing of routing protocol more complex. Because in MANET special consideration is required for achieving a more reliable and fast routing system. There are two types of routing mechanisms such as table-driven and on-demand routing systems [5]. For the slowly changing topologies, a table-driven routing protocol is efficient because of the other nodes' information in the routing tables. It has an advantage of the minimum delay and packet loss but it results in the maximization of network overheads. The popular traditional table-driven routing methods are Optimized Link State Routing (OLSR) and Destination Sequenced Distance Vector (DSDV) [6]. On-demand routing protocols are proposed for the quickly changing topologies [7]. In which the information about the routing discovery process and routing construction are taken during the time of data transfer is required. The major requirement for an effective network is minimum control overhead and maximum adaptability to quickly changing topologies. In the existing methods, these are achieved by extending the routing time.

The traditional on-demand routing systems are ad hoc on-demand distance vector (AODV) and dynamic source routing (DSR). In recent years, various research works are evolved on improving the on-demand routing systems. Kanellopouloset al [8] proposed the AODV implementation using energy and quality of service (QoS) known as EQ-AODV for maximizing the network life and reducing the network load along with end-to-end delay. Fleury Kanellopoulos et al [9] developed a multipath routing mechanism in WSN for addressing the distance and energy consumption limitations. It uses the distance and energy level of the nodes and assigns the nodes with high energy levels for transmitting the data. In dynamic topology, selecting a relay node based on its delay and stability performance is too complex. To address this Fuzzy logic is introduced which considers the important factors like residual energy, stability, and latency for achieving the high-reliability and low-delay routing paths. Fuzzy logic is the industry-proven mechanism for handling the dynamic decision-making process and continuous changing of systems with the combination of digital information and human experience.In VANET, fuzzy logic is implemented to overcome the multi-objective resource optimization issues. It infers distinct objective weightfunctions according to the services demanded by the customers [10]. Fleury Kanellopoulos et al [11] implemented fuzzy logic for increasing the network lifetime by enhancing the energy efficiency and minimizing the nodes power consumptions simultaneously.

Venkatasubramanian et al [20] proposed a Ticket – ID-based routing management system (T-ID BRM) to achieve optimum route optimization. The author focused on overcoming the network performance issue that occurred during the unstable data transmission. The proposed mechanism contains a ticketing pool system for allocating unique ticket-ID for the nodes under the supervision of T-ID- Routing manager. The T-ID BRM system achieves reliable routing results than the others.

Using fuzzy logic, several new paths have been proposed. During the route discovery phase, a fuzzy logic framework was developed in [12] for selecting nodes using the threshold values through route request packets (RREQ). The geographic routing is one of the efficient next-hop nodes for the packet forwarding mechanism obtained from the research works [13,14]. The authors of [15] advised employing fuzzy logic alone to compromise the mobility level, and received signal intensity indication of nodes and flight autonomy for designing communication routing systems with an efficient performance in FANET. The reinforcement learning and fuzzy logic into FANET are combined in the work [16] for minimizing the hop count created by the optimal fuzzy logic output nodes. These optimal fuzzy logic output nodes utilize the suboptimal nodes and consider them as relay nodes. In the work [17], the author used fuzzy logic for establishing the best route based on the node's parameters and succeeds in selecting the relay nodes. The author used a fuzzy logic controller for enhancing the routing algorithms overall efficiencies [18]. The above studies extensively discussed the implementation of fuzzy logic for identifying the best nodes by considering hop counts, dependability, along with the interruption and delay risks.

2.1 Drawbacks of Existing works:

- Lack of central monitoring system for identifying nodes energy level, because low energy nodes lead to unsuccessful transmissions.
- Most of the approaches deal with the typical applications; hence transmission of multimedia packets was not discussed.
- Lack of routing optimization leads to more energy consumptions
- Inadequate design and absence of packet partition concept fails to handle the large size packet transmissions
- Most of the works discussed the single path routing system, but its application for a single application won't work for diverse scenarios.

2.2 Our Contribution:

- This proposed Ticket Manager - fuzzy logic-based AODV routing protocol (TM-FLAODV) is the extension of Ticket – ID-based routing management system []
- We focused on handling the multimedia packets on transmission, including the file formats on text, images, videos, etc.
- In the existing works, the Ticket manager concept is not proposed; hence the proposed model implements Ticket-manager for enhancing the QoS in monitoring and controlling.
- Implementation of fuzzy logic-based AODV routing protocol for achieving effective multipath routing
- The implementation of a multipath routing system applies to diverse applications
- Implementation of Packet type splitting for effectively handling the load balancing

3. Proposed System

We proposed Ticket Manager - fuzzy logic-based AODV routing protocol (TM-FLAODV) for discovering high-reliability routes in the dynamic network. The existing works are failed to achieve reliability route path because of the rapid dynamic changes in the network topology. In

the proposed work, the Ticket Manager (TM) plays an important role responsible for the entire monitoring and controlling of the network performance. The node which contains a high energy level, bandwidth, memory, and shortest distance is assigned as TM. This selected TM is more efficient and can monitor the entire communication process.
Further implementation of fuzzy logic-based AODV routing protocol involves achieving the shortest routing path. The route constructed by TM-FLAODV is more stable, and the nodes involved in the communication have enhanced performance, ensuring successful transmissions. The reliability of the nodes is measured through the factors like node's residual energy, stability, and delay. Below, figure 1 illustrates the proposed system workflow in detail. Further in this section, the implementation of Ticket manager and fuzzy logic-based AODV routing protocol is described along with the proposed workflow.

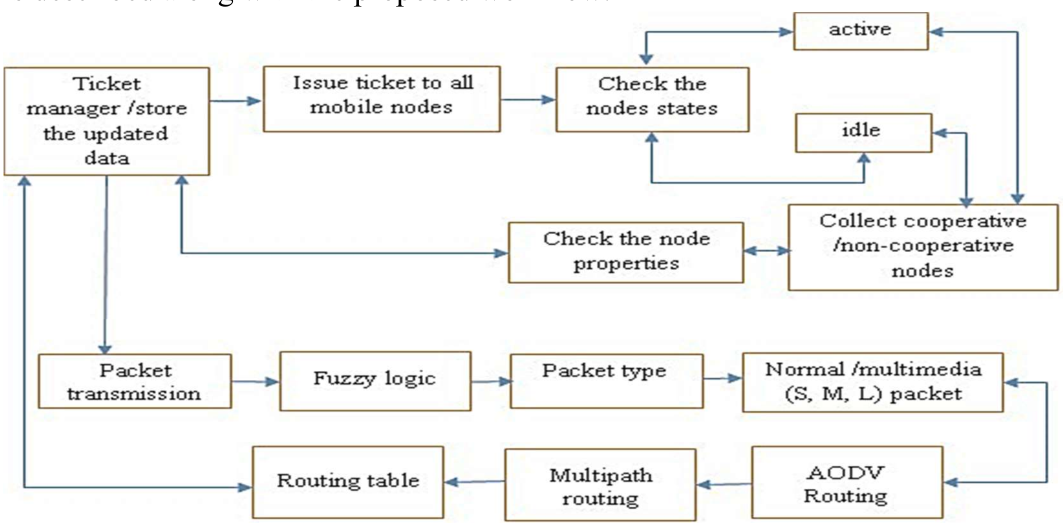

Figure 1: Workflow of proposed TM-FLAODV

3.1 Methodology

Figure 1 illustrates the Ticket structure, in which each node in the network is labeled with a unique ID. MANET is a connection of numerous nodes, and here all the nodes will not take part in data communication. The active nodes are only allowed to participate in data communication in the network. Excluding idle or inactive nodes from the network will lead to a severe lack of network performance. The proposed mechanism assigns each node with a unique Ticket to overcome this issue. The Ticket is systematically registered to the nodes and shared with the Ticket Manager. The Ticket manager can get a particular node's status, whether it is an inactive state or in an idle state. Next, the Ticket manager coordinates all the active nodes and forms a network.
On the other hand, if the status of the idle nodes changed into an active state, the corresponding Ticket of that nodes shared the current status information to the Ticket Manager. The Ticket Manager will include those active nodes also in the network communications. The change of idle state to the active state is determined by the node parameters like node location, node speed, node energy, etc. The proposed protocol collects those node parameters and updates the Ticket Manager regularly.

Figure 2: Node Parameters

The main contribution of the proposed system is;

- Implementation of ticket manager for enhancing the QoS in the aspect of monitoring and controlling.
- Implementation of fuzzy logic-based AODV routing protocol for achieving effective multipath routing

3.2 Ticket Manager

In the proposed system, the ticket manager plays a vital and it is responsible for choosing as well as allocating the nodes with high energy, memory, and bandwidth. Figure 3 describes the architecture of the ticket manager. The ticket manager performs route maintenance and monitoring of the network. It is a static node control that monitors multipath routing and the entire network performance. The implementation of Fuzzy logic-based routing protocol succeeds in discovering efficient, reliable routing.

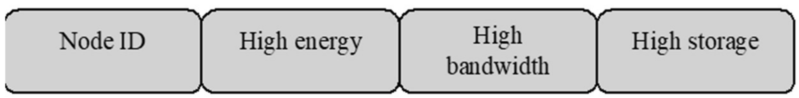

Figure 3: Ticket manager architecture

The T_{iger} is the ticket manager is an essential entity with a high energy level that controls and maintains the entire node's properties and performances. Algorithm 1 defines the properties of the node in detail. Initially, the T_{mgr} deploys a random network model with the range of (1800*1800). Then each mobile node in the network is issued a ticket. A sent request (RREQ) is broadcast to the neighboring nodes. In the network, the message broadcasting process identifies the active nodes effectively. The nodes that are sent the (REPLY) are taken as active nodes. These active nodes are permitted to take part in the data communications. The nodes which do not send the REPLY are accounted as idle nodes. These idle nodes can REPLY anytime, and on that state, their status is changed from idle to active nodes. Then those nodes are also allowed to take part in communications. The T_{iger} has an updated list of information about the cooperative and non-cooperative nodes in the network. Initially, T_{mgr}forms the cooperative node list, and the T_{mgr} can change the list at any time.

$$T_{mgr} \rightarrow M_n, (e) = \sum_{i=0}^{N} \left(\frac{E_{ix} - R_{ix}}{c_t}\right) * 100 \qquad (1)$$

Where E_{ix}initial energy; R_{ix}→Residual Energy;c_t → communication cost with position $M_n = (x, y)$;

$$T_{mgr} \rightarrow M_n, (bw) = \sum_{i=0}^{N} \left(\frac{N_{pkt}(tx) * S_{pkt}}{T_t}\right) (2)$$

The calculation of the number of total packet transmissions with its packet size and total time determines the total bandwidth consumed. Where $N_{ext}(tx)$→ Total transmitted packets;

S_{pkt}→packet size; T_t →total transmission time.

3.2.1. Algorithm for ticket manager

1. Begin
2. Input: Ticket manager
3. {
4. Initialize the ticket manager T_{mgr}
5. $T_{mgr} \rightarrow$ allocate high bandwidth /energy (500gb) // monitoring and route maintains node
6. T_{mgr} allocates the high bandwidth and storage space; // its monitoring node;
7. Issue the Ticket to all mobile neighboring nodes' $T_{mgr} \rightarrow Tm_1, Tm_2, Tm_3 \ldots Tm_n$;
8. To send a "hello" message to all mobile nodes, regardless of whether they have received the Ticket.
9. Check the mobile node status by $T_{mgr} = check$;
10. If
11. Receive the message and send the reply to neighboring nodes Node state = active; Ticket received
12. Else if
13. The message is not received Node state = idle; Ticket is not received ;
14. Update the status of the node to the $T_{mgr} = update$;
15. Collect the cooperative and non-cooperative list from the T_{mgr};
16. }
17. Check the non-cooperative node's properties

i. Calculate the node properties M_n (p)

ii. Mobile node distance M_n, (d)

iii. Mobile node speed M_n, (s)

iv. Mobile node energy M_n, (e)

v. Mobile node bandwidth, $M_{i,j}$, (BW)M_n, (d) $= \sqrt{(x_{i1} - x_{j1})^2 + (y_{i2} - y_{j2})^2}$

18. The above expression calculates the node's distances in which a and b are the coordinate positions.
19. M_n, (s)=$M_{i,j}$(sequance no), set_d$_{st}$(x_{path}, y_{path}, n_{speed})
20. Where the x and y are the position path and n determines the nodes speed
21. $M_n, (e) = \left(\frac{E_{ix} - R_{ix}}{c_t}\right)$
22. Where $E_{ix} \rightarrow$ initial energy;
23. $R_{ix} \rightarrow$ Residual Energy;
24. $c_t \rightarrow$ communication cost
25. $M_{i,j}, (bw) = \left(\frac{N_{pkt}(tx) * S_{pkt}}{T_t}\right)$

26. The total bandwidth is consumed by calculating the total packets transmitted with packet size and total time is taken. Where $N_{pkt}(tx) \rightarrow$ the total packets transmitted; $S_{pkt} \rightarrow$ packet size; $T_t \rightarrow$ total transmission time

3.3 Packet type splitting

In this work, default packets are taken for transmission, which are of multimedia types. The packet which is going to transmit is split and arranged using the multi-threshold mechanism. According to which each incoming packet size and its threshold value are calculated. Below figure 4 describes the packet type architecture. The packet splitting algorithm categorizes the packet size into three different types based on the threshold values. The packets with a threshold value below 25% are taken as small packets, the packet size greater than 25% to less than 65% is taken as medium packets, and the packet size greater than 65% is the largest packets. The small packets contain text files, medium packets contain image/audio files, and the largest packets contain video files.

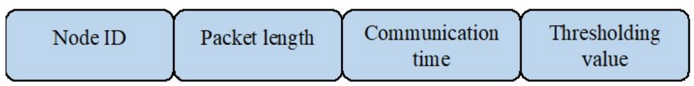

Figure 4: Packet type architecture

Calculate the small size

$T_{mgr} \rightarrow P_{small} = \sum_{i=0}^{N} \left(\frac{P_s}{c_t}\right) > 25\ \%\ \mathit{thereshold}(\ 3\ )$

P_{Small}- small packet ;$P_s \rightarrow$ packet size; $c_t \rightarrow$ communication time (25%) below threshold value update to the T_{mgr}

$T_{mgr} \rightarrow P_{meduim} = \sum_{i=0}^{N} \left(\frac{P_s}{c_t}\right) > 65\ \%\ \mathit{thereshold}(\ 4\ )$

P_{meduim}-mediumpacket ;$P_s \rightarrow$ packet size; $c_t \rightarrow$ communication time (65%) below threshold value update to the T_{mgr}

$T_{mgr} \rightarrow P_{large} = \sum_{i=0}^{N} \left(\frac{P_s}{c_t}\right) < 65\ \%\ \mathit{thereshold}(\ 5\ )$

P_{large}- largestpacket ;$P_s \rightarrow$ packet size; $c_t \rightarrow$ communication time (65%) below threshold value update to the T_{mgr}

3.3.1 Algorithm for packets splitting and type

1. Begin
2. {
3. Update the cooperative nodes list to T_{mgr};
4. Check the incoming packet
5. Packet type splitting (default, multimedia);
6. Calculate the packet queue length;
7. if (packet size $> \mathit{thershold}$ 25%);

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Small packet (text files size kbbs/mbbs);
Else if
(packet size $> thershold$ 55%);
Medium packet (images,audio files);
Else if
(packet size $< thershold$ 85%);
Largest packet (audio,video files);

3.4 Fuzzy-Logic-Assisted AODV Routing Protocol

Applications are of various types in a mobile network, and their efficiency differs accordingly. A single path selection protocol can effectively perform a single operation, but it is not suitable for diverse scenarios. The AODV routing protocol stated in [9] is perfect for typical applications but does not work on multimedia applications. In this work, both typical and multimedia applications are considered. The proposed Ticket based adaptive routing protocol provides a multichannel routing system from source to destination. The proposed protocol provides the optimum paths according to the application types. The adaptive path selection process used in the proposed system is exactly matched with application requirements. Applications have various requirements; an efficient network should select the optimum path by default. The proposed protocol considers each requirement according to the application using the parameters like delay, distance, and bandwidth. The proposed protocol selects the shortest path for a typical application, and for multimedia applications, it chooses high bandwidth, minimum delay, and hop-free paths for routing.

Table 1: Applications and parameters

Application Type	Parameter
Typical	Node Distance
Multimedia	Bandwidth

The application contains simple data with small file size, and the network chooses discrete packets. For transmitting these packets, minimum efforts energy is required. In this paper, no specific protocol is used for transmitting simple data packets. The Ticket manager selects the shortest paths using the neighbor's node's location and other information. The proposed system does not require any additional route discovery for handling typical applications separately and multimedia applications separately. It achieves minimum energy consumptions and overhead, respectively.

The proposed Fuzzy-Logic-Assisted AODV Routing Protocol is mainly focused on enhancing the routing system. The traditional AODV protocol's shortest path standard is taken, and its route reliability is improvised in the proposed system. In the route discovery mechanism, the maximum output value executed by the fuzzy logic system is taken for selecting the most reliable node. The selection parameters consider by the fuzzy logic system are node stability, node delay, and balance energy of the relay nodes. Next is the route selection process; in this process, the highest sum of fuzzy logic output path values is taken for determining the reliable route path for data transmission. Generally, fuzzification is a triangular membership function that contains maximum intuitive and minimum computational overhead [21]. The triangular membership function is taken as input and output metrics for evaluating the fuzzy set in work. Additionally, each node normalized residual energy is calculated in which its less than 10% indicates a higher possibility of link interruption and maximum energy consumption. Suppose the residual energy is higher than 90%, indicating minimum energy consumption on routing data transmission and free from link interruptions. The proposed Fuzzy-Logic-Assisted AODV Routing Protocol with triangular and trapezoidal membership functions are taken for executing nodes normalized residual energy [22]. Each node's network delay (NWD) is calculated by the average link delay with its neighboring nodes [16].

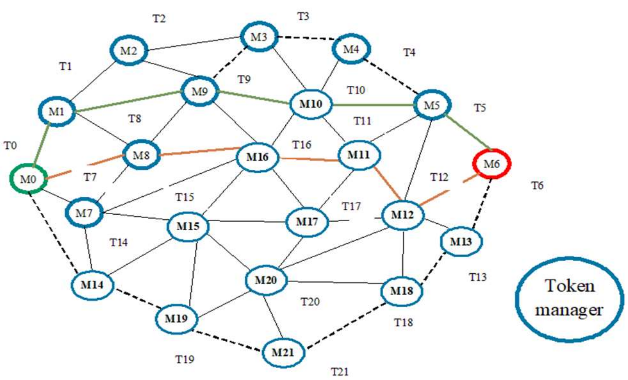

Figure 5: Routing Structure

Above figure 5 shows the proposed routing path established using TM-FLAODV. According to which a network is formed with 21 mobile nodes. Each node is labeled with unique IDs such as M0 – M21 and Ticket T0-T21. Based on the issued Tickets, the Ticket manager has the updated details about the particular node's properties. According to figure 5, the M0-M21 source node is M0, and the sink node is M6. Next, the Ticket manager initialized AODV based fuzzy optimization routing protocol for establishing efficient paths. The available Multipath based on AODV based fuzzy optimization routing protocol is shown in figure 5.

3.5 Routing table maintained by Ticket Manager

Table 2: Routing Table managed by Ticket Manager

Fuzzy rule	Node ID	Ticket ID	Node energy	Node distance	Node BW	Pathfinding
1	M1, M8, M16, M11, M12	T1, T8, T16-T11, T12	good	Good	Good	Current path is good
2	M0, M1, M9, M10, M5, M6	T0, T1, T9, T10, T5, T6	Good	Average	Good	Alternate path
3	M0, M14, M19, M21, M18, M13, M6	T0, T14, T19, T21, T18, T13, T6	Low	low	average	Choose alternate path

4	M0, M1, M9, M3, M4, M5, M6	T0, T1, T9, T3, T4, T5, T6	Good	Good	good	Upcoming path

Based on the properties of the collected node, the Ticket manager applies fuzzy rules and constructs four routing paths. The four paths are arranged based on the node's efficiency level, energy, distance, and bandwidth. The first path i.e, the current path, is high reliability, and the remaining are alternative paths. Path 1 is the network established between nodes M1, M8, M16, M11, M12 with Ticket ID T1, T8, T16-T11, T12. This path contains good node energy, distance, and bandwidth than the others. Path 2 is the network established between the nodes M0, M1, M9, M10, M5, M6 with T0, T1, T9, T10, T5, T6. In this path, node energy is good, distance is average, and bandwidth is good in comparison to path 1; it is taken for an alternate path. Path 3 is the network established between nodes M0, M14, M19, M21, M18, M13, M6 with Ticket id T0, T14, T19, T21, T18, T13, T6. In these path nodes, energy is low, distance is low, and bandwidth is average. This path is not suggested as it has low efficiency. Path 4 is the network established between the nodes M0, M1, M9, M3, M4, M5, M6 with Ticket id T0, T1, T9, T3, T4, T5, T6. It has good node energy, distance, and bandwidth, which is considered the next path to path 1.

3.6 Defuzzification

Defuzzification is converting fuzzy output language to an accurate output language. This work does defuzzification through the center of gravity (COG) method. The COG theory determines the final output as the COG output of the membership function curve and the abscissa area. Let A_i and x_i denotes the area and center of gravity of i-th sub-region.

$$x^* = \frac{\sum_{i=1}^{n} A_i . x_i}{\sum_{i=1}^{n} A_i}$$

$A_i=\int \mu_{\underline{C}}(x)\, dx$ and n is the number of geometrical components

4. Results and discussions:

4.1Experimental results

Network simulator – 2 is the experimental setup for executing the proposed Ticket Manager - fuzzy logic-based AODV routing protocol (TM-FLAODV). NS-2 is a simulation environment where about 120 nodes are deployed randomly using the Random way mobility model. The deployed network range is about 1700 × 1700 m^2 with a mobility range of 10-35/ms, and within this range, the nodes are independent to move anywhere. The link-layer protocol for the proposed execution is both IEEE standards of 802.11 Mac protocol. The WLAN heterogeneous traffic is considered, such as 802.11b and IEEE 802. The data connection is created using the TCP or UDP network topology. The packet size used in this section is about 2000 bytes with 24 MPHS data rates. Table 3 below describes the other simulation parameters used in the proposed execution.

Table 3: Simulation parameters and their values

Simulation Parameter	**Value**
Simulator	Network Simulator-2
Time of simulation	200 s
nodes	120
Simulation area	1700 × 1700 sq.m
Mac Protocol	IEEE 802.11
Data rate	24 Mbps
Radio range	100m
Mobility model	Random waypoint model
Antenna	Omnidirectional antenna
Node speed	10-35 m/s
Packet size	512 bytes
Traffic type	Multicast CBR

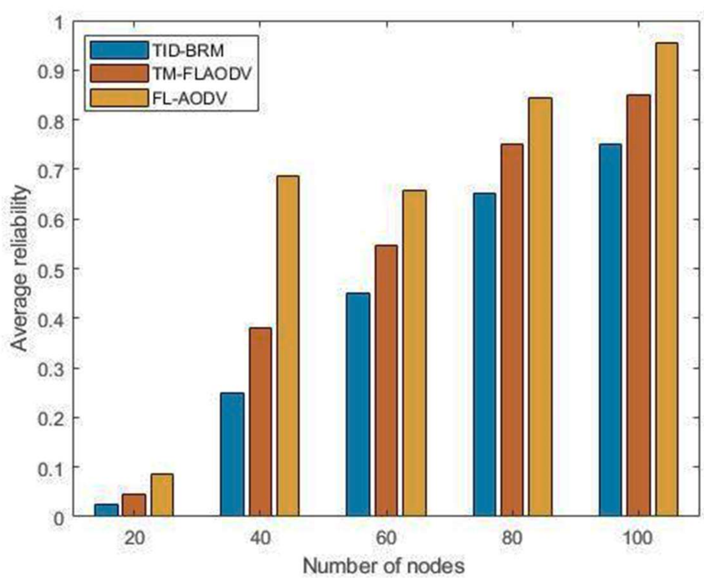

Figure 6: Average reliability vs. number of nodes

A comparison work is carried out with proposed Ticket Manager - fuzzy logic-based AODV routing protocol (TM-FLAODV) with Ticket – ID-based routing management system (MT-ID BRM) and Fuzzy logic-based AODV routing protocol (FL-AODV). The observation is carried out on average reliability achieved by each protocol according to the total nodes. The total nodes involved in the execution gradually increases in the term of 20. The obtained value achieved by each algorithm is graphically represented for discussions. The x-axis shows the total nodes involved in the execution, and the y-axis shows the achieved average reliability by each algorithm. Figure 6 shows the obtained results and comparisons among the three algorithms. According to which the proposed TM-FLAODV average reliability on 20 nodes is 0.0850, 40 nodes is 0.6584, 60 nodes is 0.6854, 80 nodes is 0.8452 and 100 nodes is 0.9541.

Whereas MT-ID BRM average reliability on 20 nodes is 0.0450, 40 nodes is 0.3801, 60 nodes is 0.5474, 80 nodes is 0.7504 and 100 nodes is 0.8511. The FL-AODV average reliability on 20 nodes is 0.0250, 40 nodes is 0.2501, 60 nodes is 0.4501, 80 nodes is 0.6524 and 100 nodes is 0.7501. The comparison values show that the proposed TM-FLAODV achieves more reliability than the others.

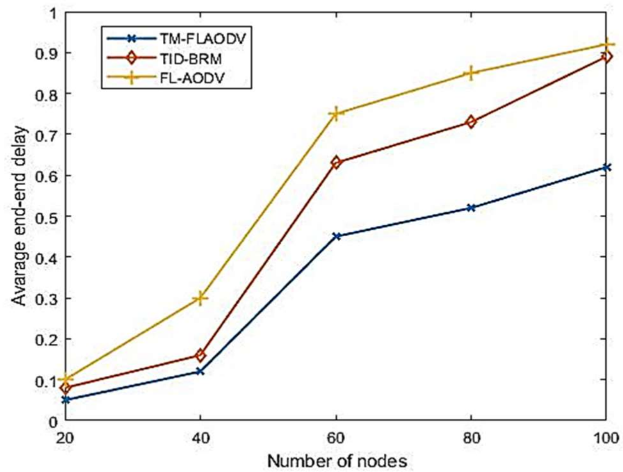

Figure 7: Average end-end delay vs. number of nodes

Figure 7 shows the comparison work carried out between the TM-FLAODV, MT-ID BRM, and FL-AODV. In this execution, obtained average end-end delay is measured with total nodes taken for execution. The total number of nodes involved in the execution is increased in the term of 20 gradually. The obtained value achieved by each algorithm is graphically represented for discussions. The x-axis shows the total nodes involved in the execution, and the y-axis shows each algorithm's achieved average end-end delay. According to which the proposed TM-FLAODV average end-end delay on 20 nodes is 0.0645, 40 nodes is 0. 0.1274, 60 nodes is 0.2854, 80 nodes is 0.4596 and 100 nodes is 0.6877. Whereas MT-ID BRM average end-end delay for 20 nodes is 0.0857, 40 nodes are 1.5467, 60 nodes are 2.847, 80 nodes is 4.5623, and 100 nodes is 5.3245. The FL-AODV average end-end delay on 20 nodes is 1.0024, 40 nodes are 2.6847, 60 nodes is 6.5874, 80 nodes are 8.8864, and 100 nodes is 8.6432. The comparison values show that the proposed TM-FLAODV achieves a minimum end-end delay than the others.

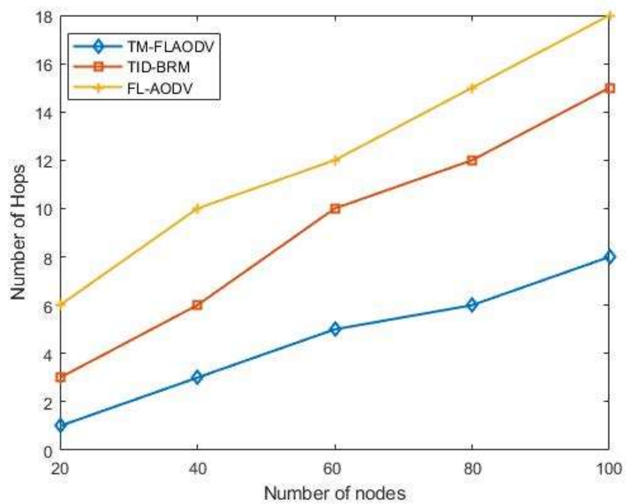

Figure 8: Number of Hops vs. Number of nodes

Figure 8 depicts the comparison between the TM-FLAODV, MT-ID BRM, and FL-AODV in the aspect of total hops obtained by each algorithm concerning the total number of nodes involved. The total nodes involved in the execution gradually increases in the term of 20. The obtained value achieved by each algorithm is graphically represented for discussions. The x-axis shows the total nodes involved in the execution, and the y-axis indicates the total hops obtained by each algorithm. The proposed TM-FLAODV number of hops for 20 nodes is 1, 40 nodes are 3, 60 nodes is 5, 80 nodes is 6, and 100 nodes is 8. Whereas MT-ID BRM number of hops for 20 nodes is 3, 40 nodes are 6, 60 nodes are 10, 80 nodes is 12, and 100 nodes is 15. The FL-AODV number of hops for 20 nodes is 6, 40 nodes are 10, 60 nodes is 12, 80 nodes is 15, and 100 nodes is 18. The comparison values show that the proposed TM-FLAODV achieves a minimum hop count than the others.

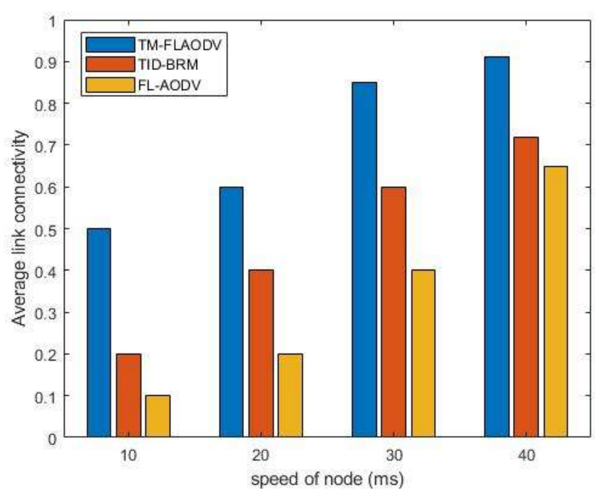

Figure 9: Average Link Connectivity vs. Speed of nodes

Figure 9 shows the comparison work carried out between the TM-FLAODV, MT-ID BRM, and FL-AODV in the aspect of average link connectivity with the speed of nodes. The total nodes involved in the execution gradually increases in the term of 10. The obtained value achieved by each algorithm is graphically represented for discussions. The x-axis shows the total average link connectivity, and the y-axis shows the nodes speed. The proposed TM-FLAODV average link connectivity for 10 nodes is 0.5, 20 nodes is 0.6, 30 nodes is 0.8594, and 40 nodes is 0.9887. Whereas MT-ID BRM average link connectivity for 10 nodes is 0.2, 20 nodes is 0.4, 30 nodes is 0.5864 and 40 nodes is 0.7. The FL-AODV average link connectivity for 10 nodes is 0.08542, 20 nodes are 0.1684, 30 nodes are 0.4335, and 40 nodes are 0.6854. The comparison values show that the proposed TM-FLAODV achieves a maximum average link connectivity count.

5. Conclusions

This paper proposed Ticket Manager - fuzzy logic-based AODV routing protocol (TM-FLAODV). The primary objective of this system is to address the existing issues on achieving a multipath optimal routing system. Additionally, the proposed work is developed for both typical and multimedia applications. Implementation of Ticket manager and fuzzy logic-based AODV routing protocol (TM-FLAODV) are the two important factors in the proposed system. The proposed system is executed NS-2 simulation environment. The transmission packets are text, image, audio, and video formats. A packet splitting algorithm categorizes the size of the packet into small, medium, and largest based on the threshold values. To evaluate the efficiency of the proposed system, a comparison assessment is conducted among the TM-FLAODV, MT-ID BRM, and FL-AODV. The metrics taken for evaluating the performance are average reliability, average end-end delay, Number of Hops, and average link connectivity. The obtained results respective to the algorithms are plotted graphically and discussed. The obtained results clearly show that the proposed TM-FLAODV performance on achieving a reliable route with minimum energy consumption is far better than the existing algorithms.

Conflicts of Interest: "The authors declare that they have no conflicts of interest to report regarding the present study."

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