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# Multi Constraint Multicasting Analysis with Fault Tolerance Routing Mechanism

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**Abstract:**
Random mobile nodes with minimal mobility make up the popular and demanding mobile ad hoc network (MANET). The network's major challenges are ensuring fault tolerance and increasing reliability. During the route maintenance procedure, existing works failed to balance link tolerance and the reliability of nodes. More tolerance and longer network lifetime is achieved by the use of a fuzzy-based Fault Tolerant Routing Protocol (FFTRP). Network model for mobility and scalability is designed in the first module, whereas in second module, a path reliability-based multicast routing is developed. The Fault-tolerant computation and multicast routing integration are completed in the third phase. Because of these uncertainties, determining the best route from the source to a set of receiving terminals is difficult. To conserve network resources, we used a fuzzy logic technique to try and control these uncertainties. This technique combines all of the route's network characteristics into a single statistic, the "fuzzy cost" or "communication cost". Using the paths with the lowest fuzzy costs, the data is distributed to a group of receivers. In this NS-2 and MATLAB investigation, the proposed EFMMRP outperformed other protocols in terms of packet delivery latency, control overhead and packet delivery ratio.

**Keywords**: MANET; Fuzzy logic; Routing protocol; Multicast routing; Fault tolerance.


## 1. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is a self-configuring network of autonomous mobile nodes that communicate via wireless networks. Routes to the sink node are found through mobile nodes. The network's dynamic structure allows mobile nodes to join or exit. The head of the network verifies each node's identity before it participate in the network. Numerous applications, including military operations, video conferencing, and disaster relief, are supported by MANET deployments [1, 2].
There are many advantages to using multicast routes for group connection, such as enhancing route efficiency and allowing multiple copies of messages to be sent. Because it allows for group communication between several sink nodes and a single source node, MANET's multicasting protocol is one of the most difficult to implement. Tree and mesh based routing systems are the two types of routing protocols [3]. Multicasting is used to send data to multiple recipients at once. It provides short delay, minimal overhead, low bandwidth use and at the end of transmission a high packet delivery rate is also provided.
However, the network metrics uncertainty issues are virtually completely ignored by the many MANET multicast routing methods that exist [4]. Because of its mobility and high mobility, the performance of network measures are constantly changing. At the same time, no viable mathematical technique is able to control all of these problems. Only the Fuzzy Logic System is able to cope with these kinds of ambiguity situations mathematically (FLS). To

address different Quality of Service (QOS) parameter uncertainty issues, it provides a viable approach. It is possible to use fuzzy logic with multiple inputs and a large amount of imprecise information at the same time [5, 6]. MANET makes it harder to implement fault-tolerant routing. Packet loss, energy loss, and packet retransmission are all used in this study to assess the reliability of the link. This figure is used as a threshold to ensure that the network last longer and that there is less packet loss [7]. An evaluation of the FFTRP is carried out with the use of network simulation tools and currently used approaches.
Fuzzy logic is used in this paper's proposed Efficient Fuzzy based Multi-Constraint Multi Routing Protocol (EFMMRP) to manage uncertainty and select the best multicast routing path. Using the paths with the lowest fuzzy costs, the data is distributed to a group of receivers.

**Literature Review**

Kulwinder Kaur and Kamaljit Kaur [8] investigated and shows various ad hoc wireless network protocols and algorithms for fault-tolerant routing. A wide range of issues, including node and connection failures, energy dissipation and transmission power and other issues with handling, were explored and answers provided. As a result of using fault tolerant routing strategies, network throughput, dependability and network longevity were measured.
In order to achieve high route tolerance in a mobile setting, Chandrasekar Reddy and Ravichandra [9] created the Fault Tolerant QoS Routing Protocol (FTQRP). In the event of a route breakdown, it is possible to find an alternative route. As a result, a higher percentage of packets are delivered. The network's mobile nodes move about the network at own interest. The genetic algorithm was previously used to handle routing through the use of redundant networks in previous work on this protocol. As compared to a genetic algorithm, this QOS protocol has a higher fault tolerance rate.

MANET has received numerous proposals for multicast routing systems. Various classification schemes have been devised for the various multicast routing systems now in use. Multicast routing technologies often fall into one of two categories: tree-based or mesh-based. According to research, this is the most generic classification of multicast protocols. There is only one channel between two nodes in a tree-based multicast routing scheme, which makes link transfers more efficient. There are other ways to transmit data packets from one to another node, but the most common method is via a multicast routing protocol that relies on trees. Tree-based multicast routing has to be avoided in wireless networks with a large number of users.
Many routes between two nodes are provided using mesh-based multicast routing algorithms. In large networks with changeable topologies, redundant routing paths make these multicast routing algorithms a better choice. Suneel Kumar Duvvuri and Ramakrishna [10] proposed a multicast routing protocols based on mesh networks include On Demand Multicast Routing Protocol (ODMRP) and its derivatives Pool ODMRP and Patch ODMRP. The terminals in an ad-hoc wireless network is limited to a certain amount of energy. As a result, multicast routing methods that consume less energy are needed in these networks. To make the best use of network resources, several multicast routing methods are presented. The Improved Ant colony-based Multiconstrained QOS Energy (IAMQER) and energy-saving multicast routing methods Network Coding are two examples.

**Fuzzy Logic System**

In a real-world context, fuzzy logic systems (FLS) are used to deal with data that is imprecise, such as low or medium or high or very high. In total, it contains four parts: a fuzzy rule foundation, an inference engine, and a defuzzifier. This protocol uses a fuzzy logic system with three variables: latency, bandwidth, and residual energy as the input data. A new statistic known as fuzzy-cost is offered as a replacement for these several metrics (FC). A minimum fuzzy cost approach was used to determine the best multicast routing path, as seen in Fig. 1

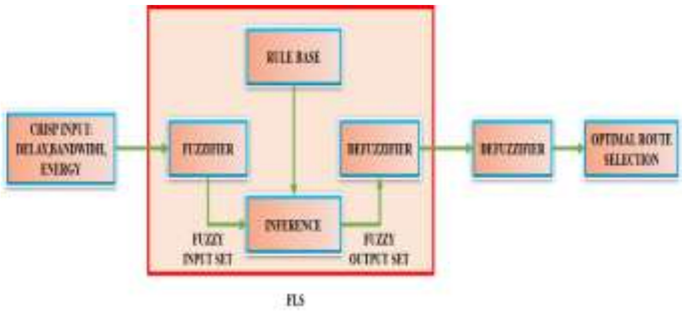


**Fig. 1. Cost-based section of the best possible route.**

**Input fuzzification**

During the fuzzification process, delay, bandwidth, and residual energy are all muddled together. Linguistic terms are the vocabulary used to describe a linguistic variable (value). Latency, bandwidth, and residual energy all have 3 linguistic variables namely Low (the lowest), Medium (medium) and High (the highest). The output variable (fuzzy cost) has four linguistic variables: very low (VL), low (L), medium (M), and high (H) (H).

**The function of membership**

Membership functions are utilized to transform the input into a fuzzy collection of linguistic values (fuzziness) in the fuzzification process. In the suggested protocol, a triangle membership function has been employed to quantify a linguistic phrase. Figures 2 shows the delay membership functions, Fig. 3 shows bandwidth membership functions and Fig. 4 shows residual energy membership functions.

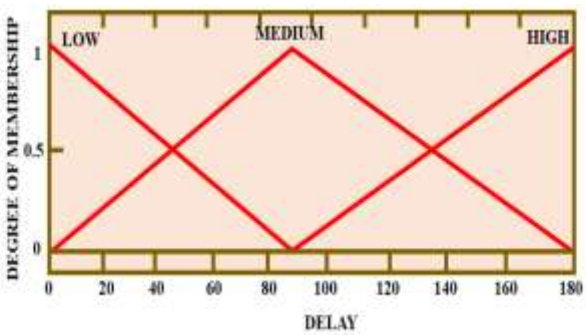


**Fig. 2. Fuzzy member function for delay**

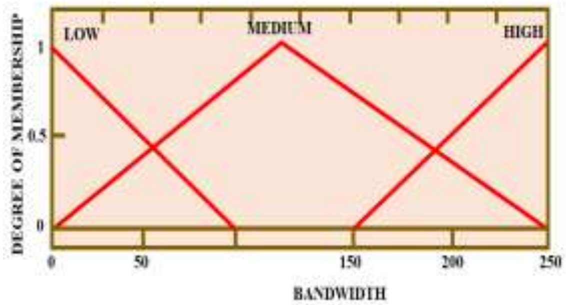


**Fig. 3. Fuzzy member function for bandwidth.**

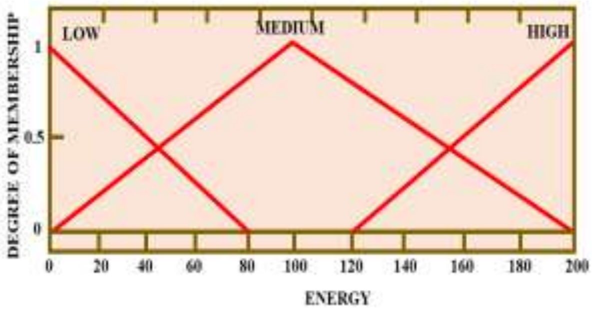


**Fig. 4. Fuzzy member function for energy.**

## 2. METHODS

With mobility, this study proposes the use of a fuzzy-based Fault Tolerant Routing Protocol to strike a compromise between reliability and route tolerance.

**Network model**

T is the current topology of MANET (N, R). A network has n nodes and R routes. Connecting the devices is accomplished by the use of the edges of each. $L_r$ is a measure of the link's dependability, while $E_r$represents the node's residual energy.

**Establishment of multicast routes based on path reliability**

During this stage, reliable data is included in each packet to build a multicast route. In order to adapt to a constantly changing environment, numerous new routes have been discovered, however it is difficult to detect the attackers in the network itself. Reliable path information is embedded in every packet travelling to the target node throughout the proposed multipath route building phase. In this case, all pathways are regarded to be independent of each other. There are no unique nodes on disjoint pathways that are found. The strength of the received signal and the remaining energy are used to select the cluster head. Through multicast routing, CH sends a collection of messages to a variety of various destinations. The CH must first receive joint reply packets from both the destination and intermediary nodes in order to establish a multicast connection. The source and sink IDs, sequence number identifiers, connection reliability information, and residual energy are all included in the Multicast Route request packet. Reliability, residual energy, latency, and bandwidth are used to calculate this score. Reliability estimates for the link are as follows:

$$l_r = \frac{P_d - P_l}{P_T} - E_w \qquad (1)$$

Where, the number of packets that have delivered at their destination successfully is denoted as$P_d$, the number of packets lost is denoted as$P_l$, the total number of packets is denoted as $P_T$ and $E_w$ is the amount of energy lost due to retransmission and packet loss.
The initial energy is given as $E_i$ and transmission energy is given as $E_t$ in energy model. With regard to a constant parameter $(\mu, \nu)$,the transmission energy is computed based on packet reception $N_r$ and transmission $N_t$ and it is deduced as follows:

$$E_t = N_t * \mu + N_r * \nu \qquad (2)$$

The processing, propagation and queuing delays are used to calculate the delay. It is expressed as follows,

$$d = d_p + d_{pg} + d_q \qquad (3)$$

The path reliability metric ($P_k$) is calculated as,

$$P_k = P_1 * \left[\frac{BW_s}{BW_T}\right] + P_2 * \left[\frac{E_t}{E_i}\right] + P_3 * \left[\frac{d}{T_{max}}\right] + P_4 * \left[\frac{l_r}{l_n}\right] \quad (4)$$

Where, $P_1 + P_2 + P_3 + P_4 = 1$, the maximum time for synchronization is denoted as $T_{max}$ and the number of accessible network links is denoted as $l_n$.

**Fault tolerance in MANET**

The majority of extant ad hoc network designs are based on the assumption of non-adversarial environments, i.e. the network's nodes are all collaborative and well-behaved. However, misbehaving nodes are always present in an adversarial environment which leads to drastic decrease in the performance of routing.
The fault tolerant technique is used to potentially avoid a failing node from affecting the network's overall activity. The reliability of system is improved by using fault tolerance. The fault tolerance is of various types namely fault tolerance in network and link failure, fault tolerance in node failures, fault tolerance in energy and transmission power and fault tolerance using message logging, check-pointing, overload reduction etc.
The topology of the network change often due to node flexibility; the transmission range of nodes extend rather far. As a result, there is a chance of node or connection failure and the node have to consume more energy in order to exchange packets from source to desired destination. Due to failures, the routing's overall performance is reduced. When there is a power outage, node failure occurs, resulting in network path failure.
Any routing protocol's functionality is harmed by the fault-prone nodes in a MANET. When a route fails in a fault-prone setting, using greedy routing techniques that proceed down the same path every time potentially result in significant data loss. On the other hand, using all possible paths adds an unnecessary overhead amount to the network. Because the problem is NP-complete due to the lack of exact path information in adversarial contexts, developing an effective and efficient fault-tolerant routing system is intrinsically difficult.

**Determination of fault tolerable routes**

Once alternate routes to the destination node have been established, the neighbor node uses link quality estimation to choose the best routes. The Expected Transmission Period is used to estimate the network quality (ETP). This metric is utilized to gauge the link capacity

 

($l_C$) and the size of individual packets (PS). All mobile nodes, including the source and destination store this ETP value. It is known as,

$$ETP_k = ETC_k * \left(\frac{l_C}{Ps}\right) \qquad (5)$$

Where, ETC denotes the anticipated number of packets to be sent during a given period of time.

**Fault-tolerant fuzzy decision model**

The Mamdani Fuzzy model is used to develop a fuzzy decision process. The Path reliability and predicted transmission count are the fuzzification inputs. It is transformed into crisp values and fed into the fuzzy inference engine. The mechanism of fuzzy decision is represented in Fig. 5.

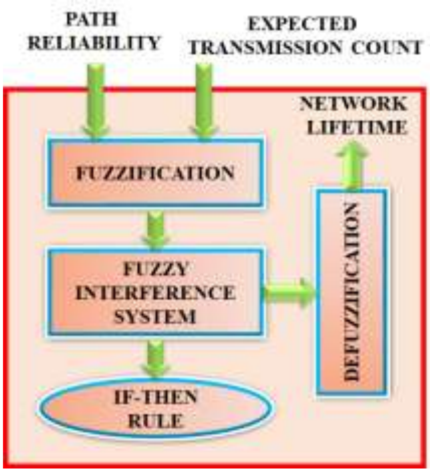


**Fig. 5. Mechanism of fuzzy decision**

Defuzzification is applied to the values after they have been processed. The data is combined into a single output, which is the network lifespan. The network lifespan is long if both crisp values are high

## 3. SIMULATION RESULTS AND ANALYSIS

The suggested method performs efficient data transfer. Initially, nodes are constructed, neighbors are discovered, and a routing path with the shortest possible length is determined. The throughput, packet drop and packet delivery ratio are all investigated. Fig. 6 indicates the creation of nodes.

 

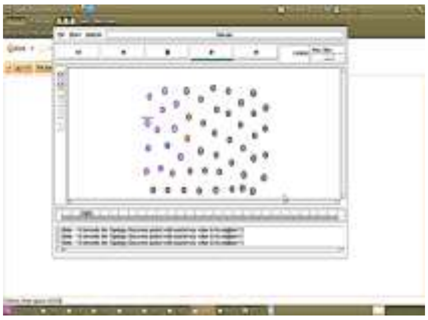

**Fig. 6. Node creation**

The neighbor node discovery is represented in Fig. 7.

**Fig. 7. Neighbor node discovery**

The creation of routing path is represented in Fig. 8.

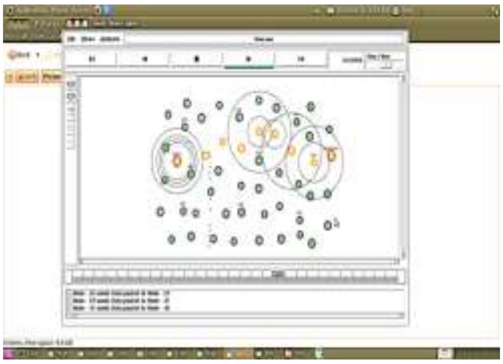

**Fig. 8. Routing path creation**

The final data transmission routing path is shown in Fig. 9.

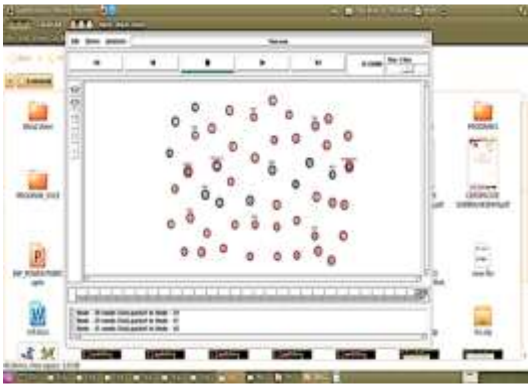

**Fig. 9. Final data transmission routing path**

The graphical representation of throughput, packet drop and packet delivery ratio are shown in Figs. 10, 11 and 12 respectively.

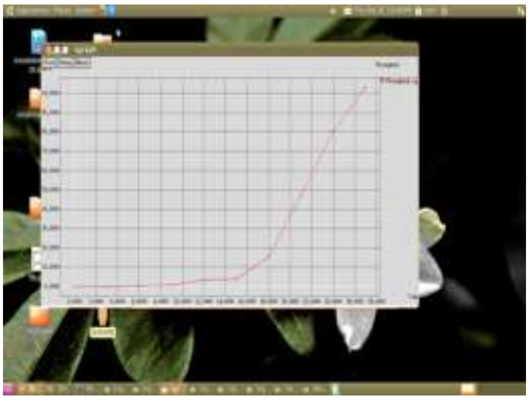

**Fig. 10. Throughput**

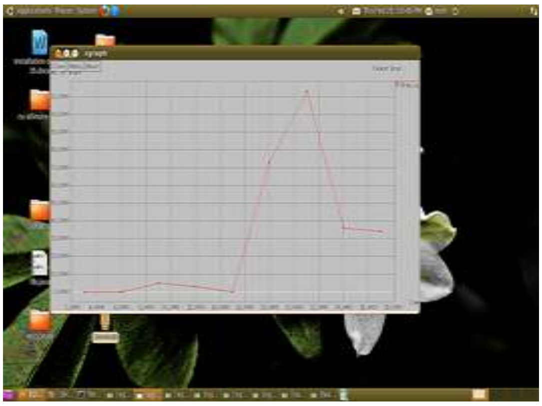

**Fig. 11. Packet drop**

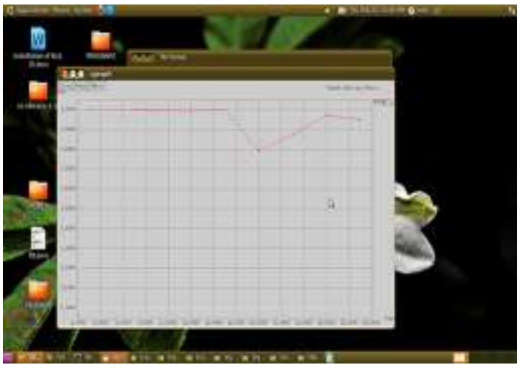

**Fig. 12. Packet delivery ratio**

The propagation delay of the proposed FFTRP is compared with ODMRP and MLSMRP. Fig. 12 represents the propagation delay Vs mobility of proposed protocol with ODMRP and MLSMRP.

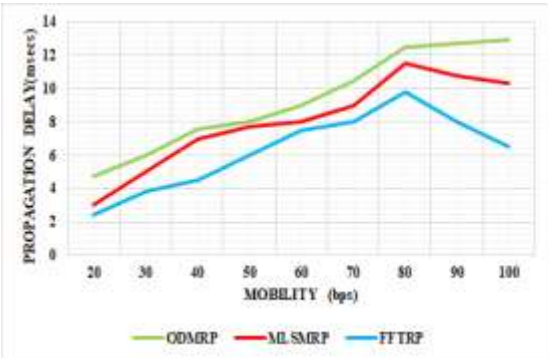


**Fig. 13. Propagation delay Vs Mobility**

The result shows that the proposed protocol has a lower propagation time than existing techniques since the complete delay is taken into account. Finding the fault-tolerant routes reduces the amount of time it takes to go.
The node mobility of the proposed FFTRP is compared with ODMRP and MLSMRP. Fig. 13 represents the node mobility Vs no. of nodes of proposed protocol with ODMRP and MLSMRP.

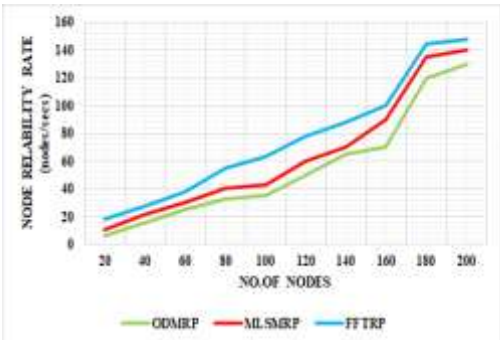


**Fig. 14. Node Reliability Rate Vs No. of Nodes**

From the result, it is seen that the number of nodes and the reliability rate of each node is changeable. There is a higher rate of success with the FFTRP compared to other methods.

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The packet delivery ratio of EFMMRP is compared with ODMRP and MAODV. Fig. 14 represents the packet delivery ratio Vs mobility of EFMMRP with ODMRP and MAODV.

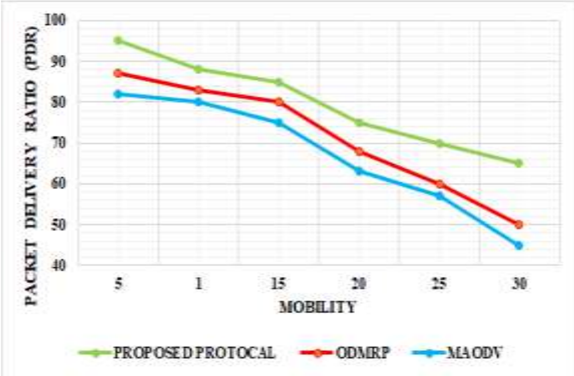


**Fig. 15. Packet delivery ratio Vs mobility**

In Fig. 15, the packet delivery ratio (PDR) drops in relation to the rise in the mobility of nodes. Since the network metrics change frequently because of high node mobility, the source node is unable to establish the best multicast routing path for data packet delivery. Fuzzy logic is used in this paper's proposed protocol (EFMMRP) to manage uncertainty and select the best multicast routing path. The suggested protocol outperforms ODMRP and MAODV multicast routing algorithms in terms of packet delivery ratio. A fuzzy logic system is not taken into account by ODMRP and MAODV while designing the data transmission multicast routing path.

## 4. CONCLUSIONS

FFTRP is proposed in this paper for a wireless mobile Ad-hoc network and it is shown to be highly efficient. Because of the increased device mobility in wireless networks, the network measurements vary often, creating an element of uncertainty. Uncertainty leads to inefficient use of network resources, which prohibits the most efficient multicast routing path for data packet transmission. This study presents an EFMMRP to address these challenges of uncertainty in a MANET by selecting multicast routes based on the minimal fuzzy cost value, hence improving network performance.

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