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A Fuzzy Based Routing Strategy for Mobile Adhoc Networks (MANET)

Preeti singh[1], Vivek kukreja[2], Preeti Arora[3], Prince Hooda[4]

Student, ECE, NGFCET , Palwal, India [1]

AP, ECE, JB knowledge park, Faridabad, India [2]

AP, ECE, NGFCET , Palwal,India [3]

AP, ECE, JB knowledge park, Faridabad, India [4]

Abstract: Mobile Ad hoc Network (MANET) is an autonomous system of mobile hosts connected by wireless links. MANET can be formed without any preexisting infrastructure. It follows dynamic topology where nodes may join and leave the network at any time and the multi-hop routing may keep changing as nodes join and depart from the network. This paper proposes a fuzzy based routing protocol for MANETS that considers the following parameters as inputs: Hop count and Total Transmission power, data size and highest node speed. On the basis of the outputs of Fuzzy modules an optimal path is proposed. The proposed protocol is implemented in MATLAB-7.0 and our result also shows that our proposed protocol is better than other standard protocols such as shortest path routing and MTPR (Minimum transmission power routings).

Keywords: FLC, Routing, Nodespeed.

I. INTRODUCTION OF MANET

"A mobile ad-hoc network (MANET) is a self-configuring network of mobile routers and associated hosts connected by wireless link" [1,5]. Nodes belonging to a MANET can either be end-points of a data interchange or can act as routers when the two end-points are not directly within their radio range. MANET has certain silent features such as: MANET can be formed without any preexisting infrastructure, it follows dynamic topology where nodes may join and leave the network at any time and the multi-hop routing may keep changing as nodes join and depart from the network. Besides MANETS have very limited physical security, and thus increasing security is a major concern. Every node in the MANET can assist in routing of packets in the network. There are numerous advantages and disadvantages with MANET's as listed below

Advantages
- Independence from central network administration
- Self-configuring, nodes are also routers
- Self-healing through continuous re-configuration
- Scalable: accommodates the addition of more nodes
- Flexible: similar to being able to access the Internet from many different locations

Disadvantages
- Each node must have full performance
- Throughput is affected by system loading
- Reliability requires a sufficient number of available nodes. Sparse networks can have problems
- Large networks can have excessive latency

II. LITERATURE SURVEY

Numerous routing schemes have been proposed earlier for the MANETS. The routing in such an ever changing environment is tedious task. The various vitals for the route determination in such an environment have to be considered so that the communication is successfully and profitably achieved.

Research had been conducted on MTPR based routing schemes for MANETS as described in research paper [2] where in, performance of MTPR protocols for communication was analyzed. MTPR [2] based routing scheme aims in a route selection based on minimum transmission power.

Numerous researches on shortest path routing scheme for MANET has also been proposed. In this routing scheme the shortest path between source and destination was determined. Further research on node mobility and other routing Schemes has been previously done.

A fuzzy based route selection strategy [1] was proposed based on Genetic algorithm-. The input parameters considered were end to end delay, number of packets dropped and number of times a node leaves the network.

The performance of the proposed routing scheme was compared in terms of a) Data dropped b) Retransmission attempt c) Throughput

These works either consider the transmission power requirement or the length of the path selected for communication. For efficient routing of MANETS both the transmission power requirement and length of path together shall play a vital role in route selection. Other important parameters that can affect the efficiency of communication are speed of the randomly moving nodes and size of data on the source node that needs to be transmitted to the destination. Since the nodes are constantly in motion, the duration for which path remains intact shall affect the successful achievability of the complete data transmission. And duration till path remains intact shall depend on the speed of different nodes in the path.

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III. PROPOSED ROUTING SCHEME

An optimal path from source to destination through the intermediate nodes is determined using the concepts of Fuzzy logic theory. The optimal path can any path among all the possible paths i.e., it can be shortest path possible, MTPR path or any other path among all the possible paths between a particular source and destination [1].

Because transmission power directly influences the power requirements by the nodes. In the other way Battery consumption of the nodes to a certain extent depends upon the transmission power used by the nodes. Similarly length of path is also an important factor to be considered for route determination as longer paths offer larger delays in communication. Path with greater number of nodes will require more resources of intermediate nodes for the communication of data. Hence path length is an indispensable factor in the route determination scheme. Path shall constitute of devices moving with different speeds, the devices moving continuously with higher speeds in the path shall be accountable for early breaking of the path. Similarly the size of data is another such factor that's needed to be examined before deciding the finest route. As larger is the size of data larger will be the transmission time of data and Again since the devices are constantly in motion the route intactness is necessary for the complete data transmission. A new routing model based on concepts of Fuzzy logic theory is proposed that considers the above discussed parameters.
Fig.xxx shows the block diagram of proposed model. The new scheme considers the following as input parameters corresponding to each path; Transmission power for data transmission through each path, path length, highest node speed in path and data size .These parameters are input to FLC1 and FLC2, as shown in Fig.1. The output from these FLC's is given as an input to the third FLC. Based upon the values of the parameters from previous FLC's, third FLC gives an output value for each path and from all the values the optimum is chosen that pertains to the optimal path from all the possible paths to the destination.

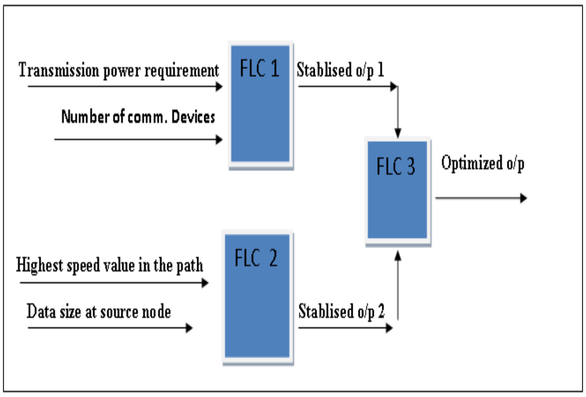

Fig 1 . Inputs to Fuzzy Logic Controller

A Fuzzy logic controller

The basic blocks of FLC have been explained as follows:

Fuzzification Module: This module converts each crisp input into a fuzzy set on the domain of the input variable. For this purpose different types of membership functions are used such as triangular, Gaussians, sigmoid etc. The membership function used in our proposal is triangular.

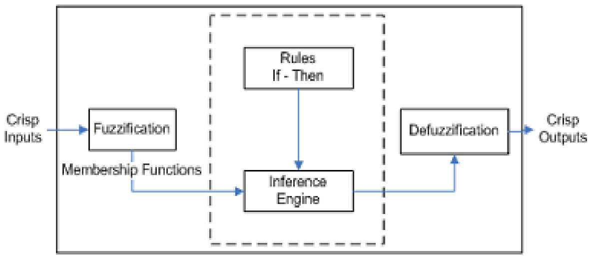

Fig 2 . Fuzzy Logic Controller

Rule Base: This module contains rules of the form 'IF-THEN' where the 'IF 'side of the rule is called antecedent and the 'THEN' side is called the consequent. On the basis of this rule base the inference engine works.

Inference engine: An inference engine is a computer program that tries to derive the answer from rule base. The program used to calculate the result in inference engine is mamdani-type.

Defuzzification module: This module converts a fuzzy set into crisp set. There are several methods available in literature for defuzzifications such as Mean-of-Maxima, Centre of Gravity (COG), Height method etc. In our proposed method we used COG method for defuzzification.

IV. SIMULATION SETUP

MATLAB7 is used for implementation and design of simulator. The reason for using MATLAB is explained as follows:

A. Performance Evaluation Metrics

The parameters under which the performance of the MPTR network is obtained are as follows:-

Hop Count: defined as the number of successive nodes required to establish the path from source to destination.

Average Power Left: It is the average of power remaining at all the devices after the completion of simulation i.e. Power left of the total power on the device after each participations in the communication .Power is calculated and compared when communication is done through shortest path, optimized path and any other path. Power used for transmission of data between two adjacent devices is proportional to the fourth power of distance between adjacent devices.

Packet Delivery Ratio: defined as ratio of number of packets received by the destination to the total number of packets sent by the source.

Infinite Delay cases: It defines the number of cases where in the path breaks before the complete data transmission.

B. Algorithm

The algorithm shown under is used in calculating the above discussed metrics for the paths formed. The nodes considered here are placed at variable. A variable count is used to count the number of paths formed or are feasible. If path exists between S-D pair the value of *count* variable is incremented by 1. If path exists between S-D pair then determine all the feasible paths between source destination pair using function Fsible_paths(). Shortest_path(), MTPR_path() and Optimal_path Send the packets through each of the above mentioned paths using the function

Send_data().This process is repeated for all S-D pairs. A variable called Data_packet is used to find cumulative value of packet received by destination through each of the paths. finally determine the values of PDR and Average Hop Count values through each of the paths as discussed in the algorithm below.

Total Nodes N = variable;
count = Hop_Count =0;
Data_packet_SP=0;
Data_packet_OP=0;
Data_packet_MP=0;

for i =1 to N-1
    for j = i+1 to N
        if (S-D path exists) …….(x)
            Fsible_paths()
            if Fsible_paths() == Nil
Continue//// **Go to line(x)**
            else
              Count ++
            end
        Shortest_path()
        Optimal_path() *%Apply fuzzy*
        MPTR_path()
        Data_packet_SP = Data_packet_SP+send_data()
        Data_packet_OP = Data_packet_OP+send_data()
        Data_packet_MP = Data_packet_MP+send_data()
        Hop_Count1 = Hop_Count1+length(shortest_path)-2;
        Hop_Count2 = Hop_Count2+length(optimized_path)-2;
        Hop_Count3 = Hop_Count3+length(MTPR_path)-2;
        end
    end
end
    PDR1 = 2*Data Packets_SP /count ;
    PDR2 = 2*Data Packets_OP/ count
    PDR3 = 2*Data Packets_MP/count
    PoR = 2*Count / N / (N-1);
    Avg_Hop_ Count1 = 2*Hop_Count1/N/(N-1);
    Avg_Hop_ Count2 = 2*Hop_Count2/N/(N-1);
    Avg_Hop_ Count3 = 2*Hop_Count3/N/(N-1);

V. FLC MODULES

A. Flc1:

Flc1 is 1st Fuzzy logic controller the inputs to which are length of path and power required for transmission over the path. The description of inputs in fuzzy tool is as shown in the figure 3.

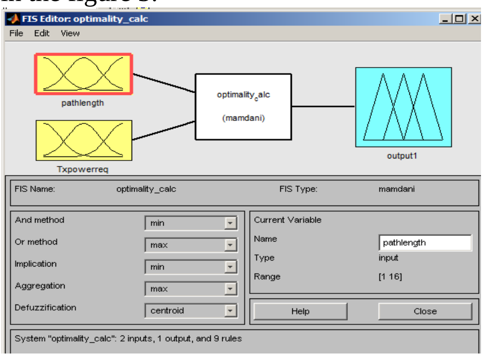

Fig 3. Inputs to FLC 1

*i) **Fuzzification:*** The measurement devices in technical systems provide crisp measurements, i.e. Values input to the FLC are in the form of crisp set. The fuzzification process transforms the crisp values into fuzzy sets by using the membership functions as shown in Fig4 and Fig5.

The linguistic variable for input are characterized by a term of three fuzzy sets, {T(*Input*)} ={[*Low*, *Medium*, *High*]}.

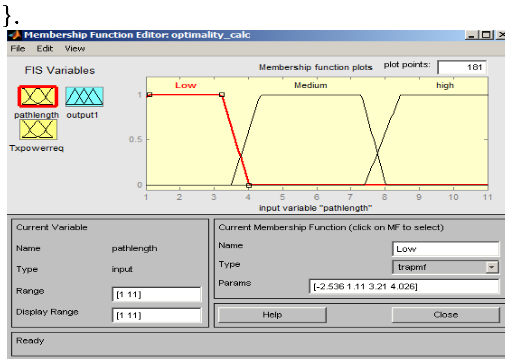

Fig 4 .Membership function of path length

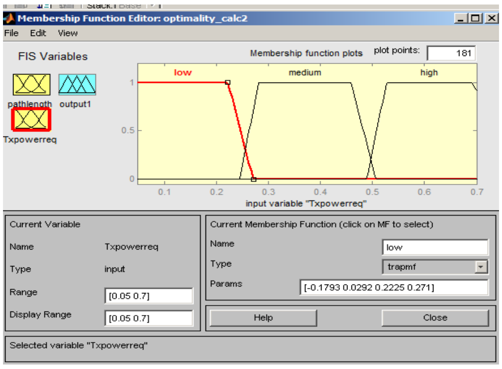

Fig 5 . Membership function of Transmission Power

ii) Rule Base for Flc1

IF-THEN Rules or the fuzzy rule base to combine the input parameters is shown in Table.1. The rule base is built on the basis of the consideration of all the input parameters and finally the necessary changes in the rule base are made through the repeated iterations performed in the simulator

Table1:Rule Base for FLC 1

IF	IF	THEN
Path length	Energy requirement	Optimal value
Low	Low	High
Low	Medium	Medium
Low	High	Low
Medium	Low	Medium
Medium	Medium	Medium
Medium	High	Low
High	Low	High
High	Medium	Low
High	High	Low

iii) Defuzzification of Flc 1

The output of FLC1 is the crisp value evaluated through the membership function as shown in the Fig 5.7. The method for determining the defuzzified value is CoG method as discussed below in equation (1):

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$$\text{Output1\_singlenode} = \frac{m1*A1+m2*A2}{(A1+A2)} \quad (1)$$

Where m1,`m2 are membership values determined through the fuzzification process, the regions i.e. low, medium, high etc are selected on the basis of rule base and A1, A2 are the areas in the selected regions determined through the equations(). The output1_singlenode is the crisp value obtained by applying the Centre of gravity method on the determined areas

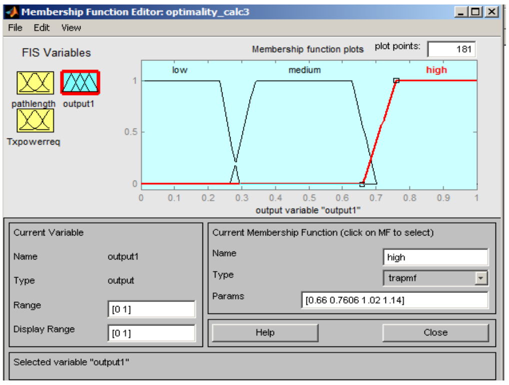

Fig 6 .Membership Function for FLC1 Output

B. Flc2:

FLC2 is 2nd Fuzzy logic controller the inputs to which are Highest node speed value and data size over the source node. The description of inputs in fuzzy tool is as shown in the figure 7

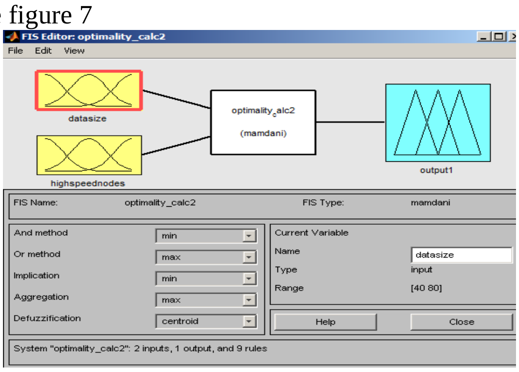

Fig 7 .Input to FLC 2

i) Fuzzification: Values input to the FLC are in the form of crisp set. The fuzzification process transforms the crisp values in to fuzzy sets by using the membership functions as shown in Fig8 and Fig9.

The linguistic variable for inputs are characterized by a term of three fuzzy sets, {T(*Input*)} ={[*Low, Medium, High*]}.

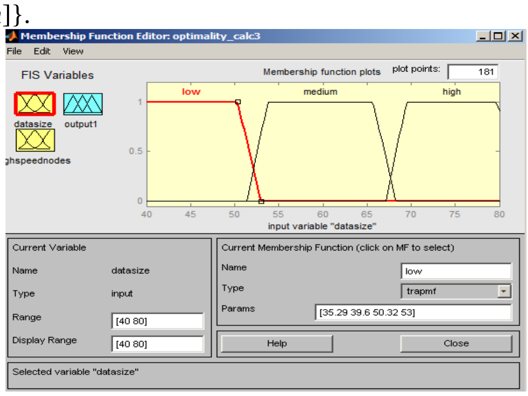

Fig 8 .Membership function of data size

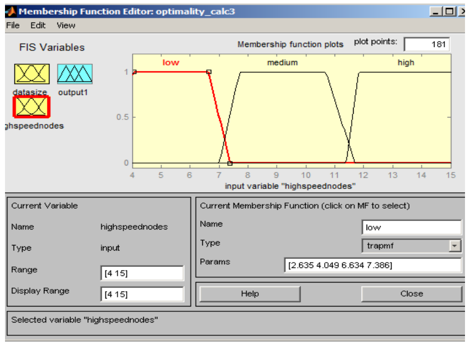

Fig 9 .Membership function of high speed nodes

ii) Rule Base for Flc 2

IF-THEN Rules or the fuzzy rule base to combine the input parameters is shown in Table.2. The rule base is built on the basis of the consideration of all the input parameters and finally the necessary changes in the rule base are made through the repeated iterations performed in the simulator.

Table 2.Rule Base for FLC 2

IF	IF	THEN
Data size	High speed node	Optimal value
Low	Low	High
Low	Medium	High
Low	High	Medium
Medium	Low	High
Medium	Medium	Medium
Medium	High	Low
High	Low	Medium
High	Medium	Medium
High	High	Low

iii) Defuzzification of Flc 2

The output of FLC1 is the crisp value evaluated through the membership function as shown in the Fig. The method for determining the defuzzified value is CoG method as discussed below in equation (1):

$$\text{Output1\_singlenode} = \frac{m1*A1+m2*A2}{(A1+A2)}$$

Where m1,`m2 are membership values determined through the fuzzification process, the regions i.e. low, medium, high etc are selected on the basis of rule base and A1, A2 are the areas in the selected regions determined through the equations(). The output 2_singlenode is the crisp value obtained by applying the Centre of gravity method on the determined areas

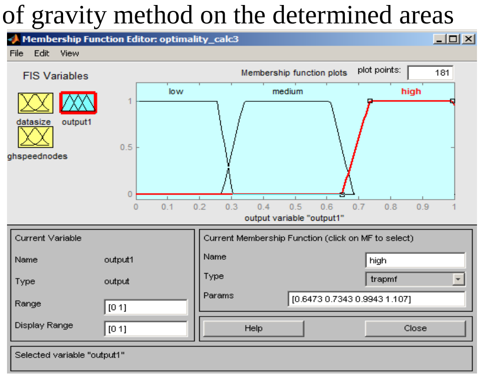

Fig 10 .Membership function of output for FLC 2

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C. Flc 3 – FLC3 is 3rd Fuzzy logic controller the inputs to which are the outputs from FLC1 and FLC2. The Membership function for inputs and outputs of 3rd FLC are drawn similarly as for the FLC1 and FLC2.

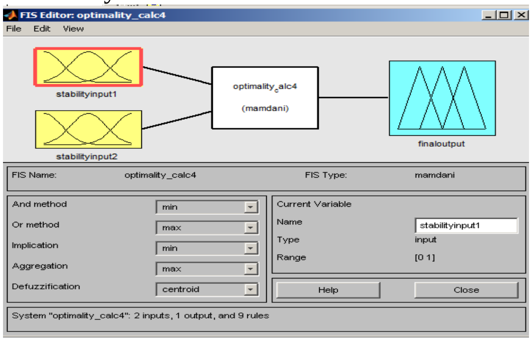

Fig 11 .Inputs to FLC 3

i) Fuzzification

The linguistic variable for inputs are characterized by a term of three fuzzy sets, {T(*Input*)} ={[*Low*, *Medium*, *High*]}.

The membership function used for the fuzzification in FLC3 at input side are shown below

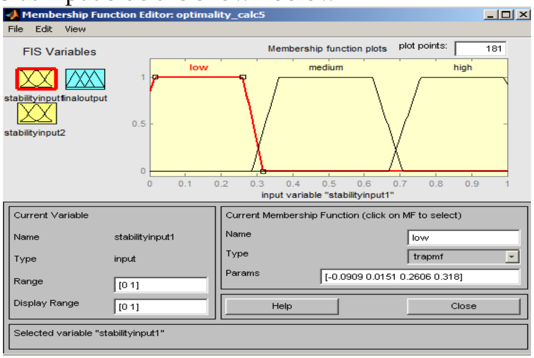

Fig 12 .Membership function of stability output 1

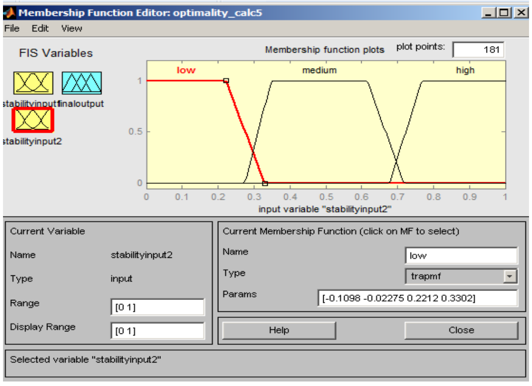

Fig 13 . Membership function of stability output 2

ii) Rule Base for Flc 3-The Rule Base that combines the outputs from FLC2 is discussed in Table2

IF	IF	THEN
Output FLC1	Output FLC 2	Optimal value
Low	Low	Low
Low	Medium	Low
Low	High	Medium
Medium	Low	Low
Medium	Medium	Medium
Medium	High	High
High	Low	Medium

Table 3.Rule Base for FLC 3

iii) Defuzzification of Flc3- The linguistic variables input to FLC3 are the outputs of FLC1 and FLC2. The membership function for the defuzzification is shown below

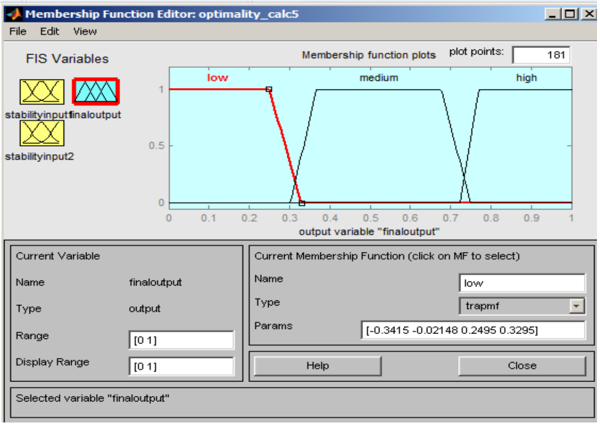

Fig 14 .Membership function of output for FLC 3

VI. SIMULATION RESULTS

A. Snapshot of Simulation Region

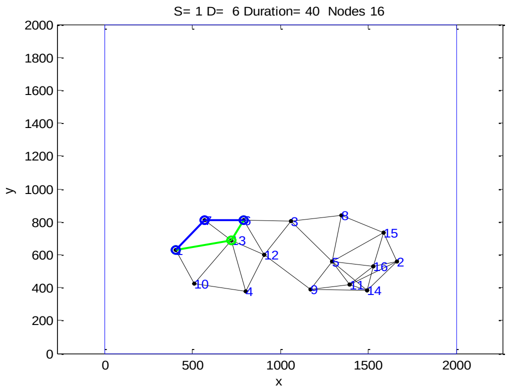

Fig 15 .Snapshot of simulation region of 16 nodes with directed position of comm.devices

The above figure shows the snapshot of the simulation region. The nodes are randomly placed in the simulation region. In the above scenario path is formed between source=1 and destination=6 through the intermediate nodes .

In this case light green colour path is shortest path and dark blue coloured is Fuzzy based optimal path. The light blue colour path is the MTPR path.

B. Simulation Results

i) ***Infinite Delay Cases***

Infinite delay situation corresponds to the situation where in source to destination communication is incomplete i.e, path breaks before the data is entirely received.

The graph below describes the pattern for number of infinite delay cases in case of the three paths considered with the increase in number of nodes in the simulation region.

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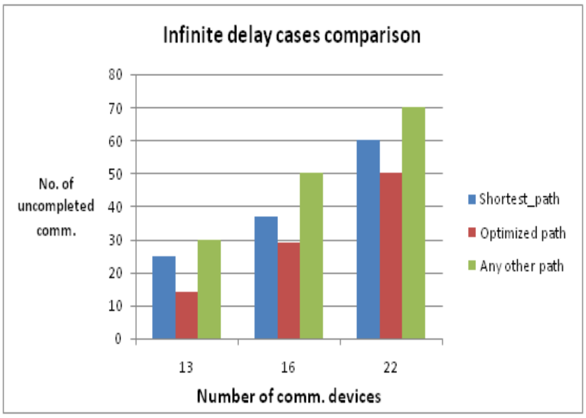

Fig. 16 Delay comparisons

Inferences

- With the increase in number of communication devices, the number of infinite delay cases increases successively
- For each no of communication devices the no of incomplete communication is minimum for the optimized path as can be seen from the graph.
- For each no of communication device the value of incomplete communication for shortest path is greater than the optimized path and lesser than the any other path.
- For each no of communication devices the max incomplete communication are encountered for any other or randomly chosen path.

ii) Average PDR comparison

The graph below describes the pattern for the Avg. value of PDR in case of the three paths considered with the increase in number of nodes in the simulation region.

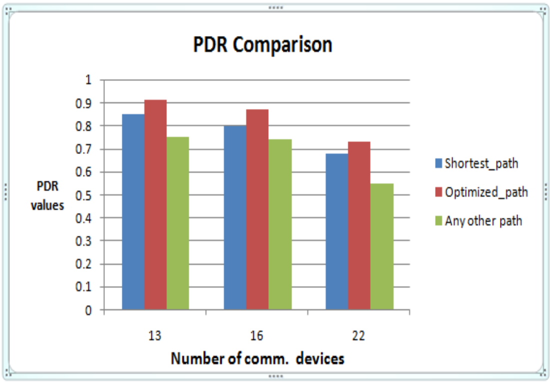

Fig.17 PDR comparison

Inferences

- With the increase in no of communication devices the value of PDR for each path decreases.
- For each number of communication device the value of PDR is max for the optimized path and minimum for any other path.
- Since the optimized path considers the devices speed and the data size as a result the PDR for the optimized path comes out to be maximum.
- Though the number of communication devices is minimum in the shortest path ,the speed of these lesser no of devices can be comparatively larger as a result the PDR comes out to be lesser for the shortest path

iii) Average Hop Count comparison-

The graph below describes the pattern for Avg. hop count in case of the three paths considered with the increase in number of nodes in the simulation region.

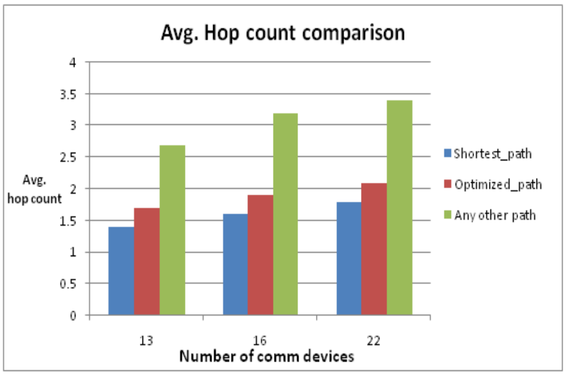

Fig 18.Average hop count Comparison

Inferences

- With the increase in number of communication devices, value of average Hop count is increasing.
- For shortest path the average hop count is minimum, for any other path is maximum and for the optimized path the value lies in between the values of other two discussed paths.
- With the increase in number of communication devices the value of hop count increases because as number of devices in the area increases the longer paths are formed

iv) Average Power Left comparisons

The graph below describes the pattern for Avg. Power left at node when communication is implemented through the three paths considered when number of nodes in the simulation region is increased.

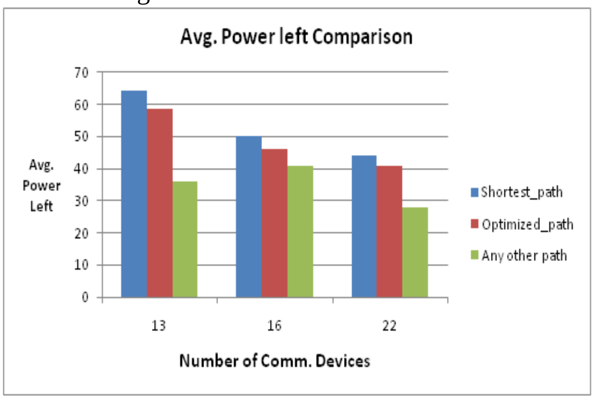

Fig 19 . Average power left

Inferences

- With the increase in number of communication devices the power left is decreasing.
- The value of left power for optimized path is slightly lesser than left power for the shortest path because the shortest path undergo more incomplete communication than the optimized path as a result the power consumption in the case of shortest path communication is lesser.
- In spite of the above situation discussed the value of power left for the optimized path is closer to the power left with shortest path due to the fuzzy path selection strategy.

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VII. CONCLUSION

- Fuzzy tools are relatively easy to apply for combining the input parameters.
- The solution to the transmission power requirements of the data packets in the shortest path algorithm is achieved through the proposed Fuzzy based protocol
- Solution to overcome the unnecessary delay encountered in the case of MTPR protocol has been achieved through the Fuzzy based protocol.
- From the analysis of the proposed Fuzzy based protocol it can be drawn that the above mentioned requirements have been achieved without any considerable changes in terms of Delay, PDR, hop count and power left values for the hybrid scheme.

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