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Fuzzy based Link Utilization Aware Path Ranking Scheme for Multipath Routing

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Abstract: In this paper, a multipath-ranking scheme has been proposed based on fuzzy logic if multiple paths are known. The algorithm is based on the assumption that link utilization of each link in the identified paths is known. This paper aims to find the link utilization of complete path using fuzzy controller. The fuzzy metric provides a more precise estimate of how good a path is for future traffic. The output of the fuzzy controller is the path link utilization value on the basis of which paths are ranked.

Keywords: Fuzzy controller, Link utilization, Multipath routing, Path ranking.

I. INTRODUCTION

Most of the routing protocols select only shortest single path on the basis of the various metrics for the traffic transmission between each source-destination pair. Multipath routing protocols select more than one path between source and destination. Internet-wide multipath routing offers, a number of advantages, such as QOS, avoiding congested paths, improving reliability, fast data transmission, etc.[1]. Multipath routing comprises of two major aspects viz., path identification and forwarding. The first aspect considers identification of multiple paths on which data can be transmitted.

The second aspect considers forwarding of traffic on these paths. In between path identification and forwarding there is one more aspect that is selection of limited paths where traffic is to be distributed needs to be considered. Having one or two more paths is generally enough for significant gains in terms of security, performance, and reliability of a network in routing. If large numbers of paths are selected for traffic distribution, overhead of the network will increase by leaps and bounds and hence the cost will become very high. Therefore, it is necessary to find only a limited number of good multiple paths on which traffic can be forwarded. This paper is an effort towards achieving best paths by ranking the various paths using fuzzy logic.

II. FUZZY LOGIC

Fuzzy logic is understood to be a superset of Boolean logic that not only considers the value as true or false but also handles the concept of partial truth and false i.e. the values lying between completely true and completely false. Fuzzy logic was introduced first time by Dr. Lotfi Zadeh of U.C. Berkeley in the year 1960's [2]. It has proved to be tolerant in case of imprecise data, nonlinear functions and can be combined even with other techniques for solving various types of problems. The basic principle of fuzzy logic is to define and use fuzzy groups which are not having crisp boundaries.

In this paper [3], the use of fuzzy logic to describe the state of a path mimics how a person makes a decision, but only much faster. Fuzzy logic incorporates a simple, rule based IF X AND Y THEN Z approach to decide on the congestion level rather than attempting to model the traffic characteristics mathematically.

Fuzzy logic has proved to be very effective in a lot of applications, such as intelligent control, decision making process, QoS routing problem etc. Calculating the best route cannot be done using complex mathematical solutions, but is based on intuitive rules in fuzzy logic. Fuzzy logic applies to all those routes that are candidates for being chosen whereas the chosen paths in this way are the paths that have better quality.

A. Fuzzy Controller [4]

The fuzzy controller or Fuzzy Inference System (FIS) is a fuzzy system model using fuzzy sets to represent the semantic properties of each control and solution variable along with processes, its input and output by using a set of production IF - THEN rules. The rules comprise of an input value, through a collection of fuzzy sets, into a new output representation.

A fuzzy controller consists of four parts: fuzzification module, rule base, inference engine and defuzzification module, as shown in fig. 1.

Fuzzification Module: This module converts each of the input value which is crisp into a fuzzy set. The fuzzy set is a set defined with smooth boundaries. There are a number of membership functions which can be used for defining a fuzzy set such as triangular, trapezoidal, Gaussian etc.

Rule Base: This is a set of rules based on which certain actions are performed. The rules are the condition based on If-Then. The rule base is attached with the inference engine.

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Inference Engine: It is a computer program which derives the answers depending on the input and rule base. It is linked with rule base. Inference engine produces output by finding which control rules are relevant for current input.
Defuzzification Module: Defuzzification is a method of finding a quantifiable result in terms of fuzzy logic. This module then converts the fuzzy control action into a crisp value. There are a number of defuzzification methods available such as bisector, mom, and centroid etc.

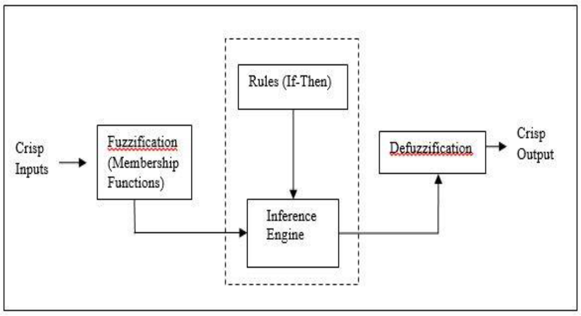

Fig 1. Fuzzy Controller [5]

III. PROBLEM FORMULATION

The basic purpose of multi-path routing is to transmit the data on more than one path so that fast transmission is possible. There might be a large number of possible paths existing between a source and destination. But, if all the paths are used for data transmission, the cost of transmission will become very high. Therefore, only a limited number of better paths should be identified for data transmission. This paper tries to find such better paths using the concept of fuzzy logic.
In this paper the input is assumed to be the various paths along with link utilization of every link in those paths. The input is found using algorithm explained below. The problem is to rank the input paths on the basis of link utilization of each link in each path.

IV. PROPOSED LINK UTILIZATION AWARE PATH RANKING SCHEME USING FUZZY LOGIC

In the proposed work, before ranking the paths, multiple loop-free paths are selected on the basis of link utilization factor, which can be found using the concept of choke packets in controlling congestion [6].

$$u_{new}= a*u_{old}+(1-a)*f……………….(1)$$

Where $\mathbf{u_{new}}$ is new calculated value of link utilization,
The value of **'a'** indicates how fast a node forgets recent history,
$\mathbf{u_{old}}$ is the previous value of link utilization,
f indicates instantaneous line utilization.

Each node monitors the percent utilization of each of its output links. The value of 'u' reflects the utilization of that link. To maintain a good estimate of 'u', a sample of the instantaneous line utilization f is taken to be 0 or 1.

a = capacity / load,
Where capacity indicates the capacity of the link, and load indicates the current load on the link.
Here value of 'a' represents how fast a node forgets its current history. It is calculated on the basis of current values of load and capacity of that link and therefore it helps in forgetting the historic values of the node.
The paths will be identified according to algorithm 1.1. The advantage will be that instead of one optimal (shortest) path more than one optimal path is found so that traffic can be distributed over multiple paths. Different actions are performed at source node, intermediate node and destination node. The algorithm used for finding the multiple paths is as follows:

Algorithm 1.1: MLFP(Multiple Loop Free Paths).

(i) Initialize variables. //Source, Destination, u_{thres}, Load and Capacity, f.
(ii) Initialize u with zero for all links.
path = source //at the source node
(iii) For every node i which is a neighbor of source do
f = 1
a=capacity(source,i) /load(source,i)
//Compute value of u
If u(source, i) < 0 then
u(source, j) = 0.
If(u(source, j) < u_{thres})
send Explorer message to i.
add node i to the path list
endif
end for
//At the intermediate node
(iv) For every node j which is a neighbor of an intermediate node i and does not exist in the path list do
f = 1
a = capacity (i, j) / load (i, j)
compute u
If u(i, j) < 0 then u(i, j) = 0
If (u(i, j) < u_{thres})
send Explorer message to j.
add node j to the path list
endif
end for
//At the destination node
(ix) Destination node stores all the explorer messages information in its routing table
(x) End.

A. Fuzzy Controller structure for link utilization Aware Routing Scheme

Fig. 2 shows the block diagram of proposed routing scheme based on link utilization as input and path ranking is done on the basis of output weights. The path with minimum output weight is given the highest rank.

The first step is that the algorithm 1.1 computes the possible available routes and the value of the link utilization for each link in all the computed paths.

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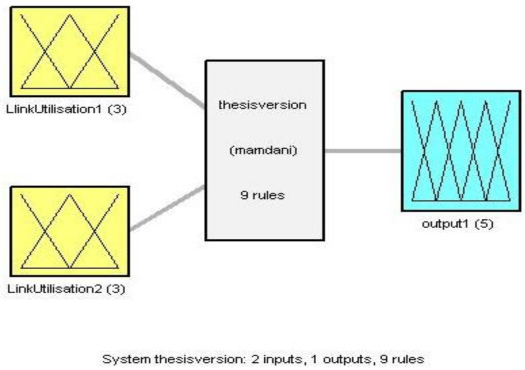

Fig. 2: Block diagram of proposed fuzzy controller

Working of Fuzzy Controller is explained as follows:-

i. Link utilization value of two links of a path is input to the fuzzy controller.
ii. Then apply the effect of link utilization to compute the results using Mamdani Fuzzy Controller.
iii. Output of Fuzzy Controller is used to compute the crisp value for the each route. The route with minimum output weight is given as the best rank.

The blocks shown in figure of Fuzzy Controller are explained below:-

a) Input Link Utilization: To compute the ranking of the routes, the Fuzzy Controller uses link utilization as input parameter, which is calculated using algorithm 1.1

b) Fuzzification: Crisp value of link utilization of first two links of a path is provided as input to the Fuzzy Controller. Then the fuzzification of the input data is done by using the membership functions as shown in the fig. 3.

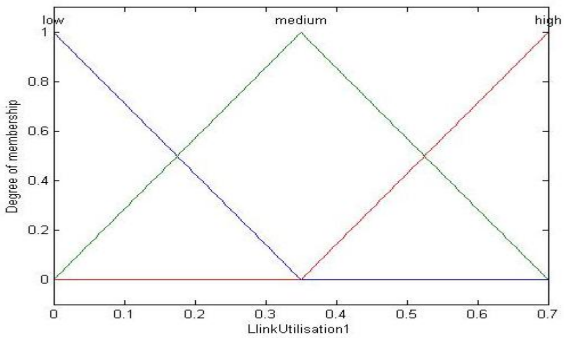

Fig. 3: Membership function

c) Membership Function: A fuzzy set can be defined mathematically by assigning to each possible individual in the universe of discourse a value representing its grade of membership in the fuzzy set. There are a number of shapes that can be used for the membership function of each input such as bell, triangular, trapezoidal and exponential shapes. We have chosen the triangular shape because of its simplicity. The semantic variable for all input parameters is characterized as:

{T(Input)} = {[Low, Medium, high]}

In the present work, the triangular membership function for input is defined for the Link Utilisation for each link, which is further represented by the three parameters low, medium and high in range (0-0.7). Applying possibility distribution; the three parameters can have the following bounds-

Low=0
Medium=0.35
High=0.7

The equations which are used for fuzzification that defines the membership functions are as follows:-

F (Link Utilization) =
0, if link utilization (u) <= low
(u - low) / (medium – low), if low <= u <= medium
(high - u) / (high - medium), if medium <= u <= high
0, if u >= high.

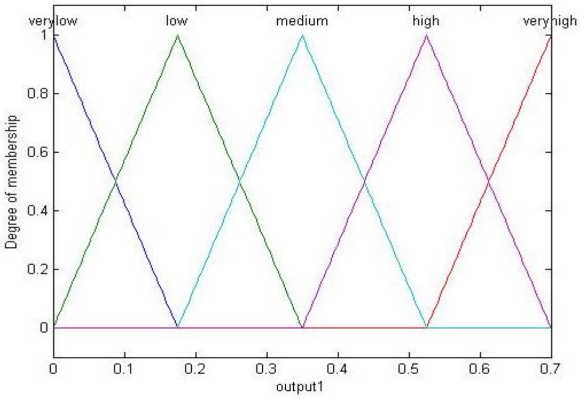

Fig. 4: Output Membership Function

d) Rule Base: Rule base Table I is used by mamdani inference engine to infer the optimality of routes generated from multiple iterations performed by simulator.

TABLE I FUZZY SET OF OUTPUT PARAMETERS (RULE BASE TABLE)

	Low	Medium	High
Low	Very_low	Low	Medium
Medium	Low	Medium	High
High	Medium	High	Very_high

Thus, the output parameter, (FM) is described using five linguistic variables: “Very Low”, “Low”, “Medium”, “High” and “Very High” as shown in the table 1 and fig. 4 above. Output parameter Fuzzy sets: FM {Very Low, Low, Medium, High and Very High}

In the proposed fuzzy scheme, the path is considered as the best path having minimum value for FM. The procedure of rule structure has been formulated according to it.

e) Defuzzification: Two inputs to the fuzzy controller are the link utilization of first two links, and then they are

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fuzzified to get a single crisp value, which is again fuzzified with next link's link utilization value. This process continues until we get a final crisp value of whole path using defuzzification. Centriod method has been used for defuzzification. The path which is having lowest crisp value is considered to be the best path.

V. EXPERIMENTAL SETUP AND RESULTS

The proposed scheme was implemented using MATLAB for the network shown in fig. 5. The network consists of six nodes. The capacity at each link is assumed to be fixed at 10 and the load is shown on the each link of the network.

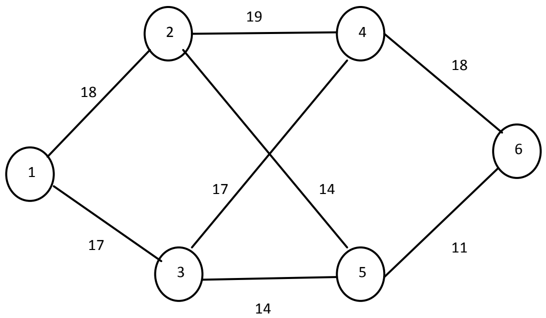

Fig. 5: Example Network.

Using algorithm 1.1 various paths are identified along with link utilization values are shown in the table II.

TABLE III PATHS IDENTIFIED USING ALGORITHM 1.1

Path Identified	Link Utilization Values over the Links
1-2-4-6	0.444, 0.473, 0.444
1-3-4-6	0.411, 0.411, 0.691
1-2-5-6	0.444, 0.489, 0.090
1-3-5-6	0.411, 0.489, 0.173
1-2-4-3-5-6	0.444, 0.473, 0.411, 0.489, 0.248
1-3-4-2-5-6	0.411, 0.411, 0.473, 0.489, 0.316

Then these link utilization values were fuzzified according to the fuzzy controller defined in previous section to obtain the link utilization value of each path.

TABLE IIIII PATH 1-2-4-6

Input 1	Input 2	Output
0.444(1-2)	0.473(2-4)	0.425(1-2-4)
0.425(1-2-4)	0.444(4-6)	**0.410(1-2-4-6)**

TABLE IVV PATH 1-3-4-6

Input 1	Input 2	Output
0.411(1-3)	0.411(3-4)	0.393(1-3-4)
0.393(1-3-4)	0.691(4-6)	**0.520(1-3-4-6)**

TABLE V PATH 1-2-5-6

Input 1	Input 2	Output
0.444(1-2)	0.485(2-5)	0.432(1-2-5)
0.432(1-2-5)	0.090(5-6)	**0.287(1-2-5-6)**

TABLE VI PATH 1-3-5-6

Input 1	Input 2	Output
0.411(1-3)	0.489(3-5)	0.427(1-3-5)
0.427(1-3-5)	0.173(5-6)	**0.311(1-3-5-6)**

TABLE VII PATH 1-2-4-3-5-6

Input 1	Input 2	Output
0.444(1-2)	0.473(2-4)	0.425(1-2-4)
0.425(1-2-4)	0.411(4-3)	0.399(1-2-4-3)
0.399(1-2-4-3)	0.489(3-5)	0.426(1-2-4-3-5)
0.426(1-2-4-3-5)	0.248(5-6)	**0.339(1-2-4-3-5-6)**

TABLE VIII PATH 1-3-4-2-5-6

Input 1	Input 2	Output
0.418(1-3)	0.411(3-4)	0.393(1-3-4)
0.393(1-3-4)	0.473(4-2)	0.419(1-3-4-2)
0.419(1-3-4-2)	0.489(2-5)	0.428(1-3-4-2-5)
0.428(1-3-4-2-5	0.316(5-6)	**0.378(1-3-4-2-5-6)**

VI. INTERPRETATION OF THE RESULTS

The final link utilization value of the paths identified using fuzzy controller is shown in the following table:

TABLE IX FINAL LINK UTILIZATION VALUE OF THE PATHS

Path	Link Utilization Value
1-2-4-6	0.410
1-3-4-6	0.520
1-2-5-6	0.287
1-3-5-6	0.311
1-2-4-3-5-6	0.339
1-3-4-2-5-6	0.378

On the basis of link utilization value of the paths, the paths can be ranked as follows:

TABLE X RANKING OF THE PATHS

Path	Link Utilization Value	Path Rank
1-2-5-6	0.287	1
1-3-5-6	0.311	2
1-2-4-3-5-6	0.339	3
1-3-4-2-5-6	0.378	4
1-2-4-6	0.410	5
1-3-4-6	0.520	6

Looking at the results, it can be easily observed the path ranking is better in the cases where the link utilization of

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most of the links is lower. It can also be seen that when two paths are compared and most of the links are having similar link utilization values, then even a single link utilization value can prove to be a major factor in deciding the ranking of the path i.e. even a single lesser link utilization value can give a better ranking to that path. If the paths having ranking 1 and ranking 6 are compared, it can be seen that link utilization values of link 5-6 and 4-6 have played a major role in deciding the ranking of these path as other link utilization values are almost similar.

VII. CONCLUSION AND FUTURE WORK

In this paper a path ranking scheme for multipath routing has been proposed. The scheme is based on link utilization values of each link in paths under consideration for multipath routing. This scheme uses a fuzzy controller for identifying the ranking of the paths. In this paper the paths were identified using link utilization values and then they were ranked using fuzzy controller. The scheme was verified using an example network. The results were on expected lines, i.e., the path having lesser link utilization values in most of the links were assigned better ranking as compared to the paths which were having higher link utilization values. Overall, it was concluded that this fuzzy controller can prove to be a very good tool for identifying the ranking of the paths in a multipath routing environment.

In future, this work can be used for load balancing on various paths in a multipath environment.

REFERENCES

[1] Shalini Aggarwal and Shuchita Upadhyaya, "Exploring Mutiple Paths using Link Utilization in Computer Networks", IJCNS International Journal of Computer Science and Networks, Vol.5, Issue 5, October, 2016, ISSN(online) – 2277-5420.

[2] Chiang Kang Tan, Lionel Sacks, "The Use of Fuzzy Metric in OSPF Network", http://www.ee.ucl.ac.uk/~/sacks/projects/ pastproj/ck_tan.pdf.August 3, 2001.

[3] James F. Brule (1985), "Fuzzy Systems - A tutorial ", Ortec Engineering Inc., http://www.orteh engr.com/fuzzy/tutor.txt

[4] P. Chemouil, J. Khalfet and M. Lebourges (1995), "A Fuzzy Control Approach for Adaptive Routing", IEEE Communications Magazine, 33(7), pp 70-76, July.

[5] Poonam, C.K. Nagpal, and Shailender Gupta " A Delay and Spectrum Aware Fuzzy Logic Based Routing Protocol for CRN", published in International Journal of Computer Network and Applications, IJCNA-2016, Vol.-3(1),pp.16-24.

[6] Andrew S. Tanenbaum and David J. Wetherall, "Computer Networks, Third Edition, Prentice Hall".