Fuzzy based Load Distribution Scheme in MultiPath Routing

Dr. Gaytri Devi[1]
[1]GVM Institute of Technology and Management, DCRUST, Sonipat

Dr. Shuchita Upadhyaya[2]
[2]Department of Computer Science and Applications, Kurukshetra University Kurukshetra

ABSTRACT

A scheme of disjoint path selection among overlapping paths has been explored here considering multiple QoS (Quality of Service) constraints, as the disjoint paths provide more reliability. QoS routing has become essential in today's scenario of Internet for the transmission of real time multimedia applications. Taking into account a list of available overlapping QoS constrained paths, we use the Fuzzy logic to find most optimal disjoint paths and also their preference order of optimality . On the basis of optimality proportion of selected disjoint paths, a new load distribution algorithm has been proposed.

KEYWORDS
Load distribution , QoS(Quality of Service),Routing, Multi-path routing ,Fuzzy etc.

1.INTRODUCTION

In the present era of the Internet ,transmission of real time multimedia applications have been increased . Along with the conventional services ,IP networks are also expected to support the requirements of high-speed real-time applications .These applications require bandwidth , delay ,jitter and packet loss probabilities constraints .To fulfil these requirements, QoS have become essential in the network. Quality of Service(QoS) puts some restrictions on the path that may be desired bandwidth, low delay, stable jitter, minimum cost etc. There are many key issues to design QoS enabled network. Among them, the most important element is QoS-routing.The fundamental problem of QoS routing to discover a path between a particular source and destination node that simultaneously satisfies multiple QoS parameters. QoS issues have been explored in[1].

Multi-path routing scheme can be used for the transmission of multimedia applications. Multi-path routing establishes multiple routes between source and destination nodes. The function of having multiple paths is either enhancing the trustworthiness of the data transmission, or load balancing.

Relaibilty of transmission & load balancing are main features of QoS routing. So, multipath can be proved very advantaegous for QoS For multiple paths, there are two characteristics to address:- Path quantity and Path independence. Path independence refers to disjoint paths. Link-disjoint and Node-disjoint are two variations of dispoint paths. Link disjoint paths have no common links and node disjoint paths have no common nodes. Load sharing and fault-tolerance can only be achieved if routes possess disjointness. [2]

If the source has multiple disjoint paths to transfer the flow, it may use multiple paths altogether by distributing the load . By using this concept , congestion can be reduced and delays can be decreased a lot .And , if the source wants trustworthy data transfer, it can send the same packet along multiple disjoint paths. This will increase the reliability of transmission .

Considering the advantages of disjoint paths, this paper is focused on finding disjoint paths. The strategy that has been used for finding disjoint paths is fuzzy logic.

Fuzzy logic is the new emerging technology for evaluating the efficiency of various systems. Fuzzy logic can handle vague data and nonlinear functions .It can be mingled with other techniques for finding the solution of different problems.

By means of fuzzy logic, multiple QoS values can be combined . In order to accommodate the strengths of all QoS metrics in identifying the most QoS support paths, the mutiple parameters can be considered together by combing them into one using Fuzzy logic. Using this strategy, QoS parameters have been combined into one. By using this one metric, disjoint paths have been selected among all overlapping paths .

It is good to specify a load sharing scheme when multipath routing is used, in order to take benefit of the multiple paths to a single destination. So, keeping in mind the advantage of load sharing, a new load distribution scheme has also been proposed in this paper and to achieve this, the same resultant fuzzy value has been used.

The ultimate goal of this paper is to explore a scheme of optimal disjoint path selection scheme that has been proposed in [6] and propose a load distribution method based on fuzzy logic.

The outline of the paper is as follows: Section 2 explains fuzzy logic along with finding the fuzzy values of given paths with an example.Section 3 discusses the load distribution approach on disjoint paths. Section 4 concludes the paper.

2. Calculation of Fuzzy values of Paths

Fuzzy control system consists of four main components: a fuzzification process, an inference system, rule-base and a defuzzification. Firstly, input variables and membership functions are defined and input data is converted to a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. This step is identified as fuzzification. Then , an inference is done based on a set of rules and fuzzification output data where an implication formula is used to evaluate the individual if-then rules and fuzzy ouputs are generated . Lastly, the resulting fuzzy output is mapped to a crisp output in the defuzzification step.[3][4]

Fuzzy logic has been used in this paper for QoS assessment of the paths for disjoint path selection and for ratio of load distribution. QoS assessment is a domain where the association between the input parameters and the output of QoS is complicated. Fuzzy logic makes simpler the complexity of input-output QoS relationship.

The QoS parameters that have been considered are bandwidth and delay .An assumption has been made that a list of overlapping QoS constrained paths exists that are satisfying bandwidth and delay constraints.

Since all the paths are satisfying bandwidth and delay constraints, from the path list, disjoint paths can be chosen by considering either metric - bandwidth or delay. When we choose the disjoint path according to the bandwidth then among the paths having overlapping edges, the path having more bandwidth can be selected in disjoint list. In this way the delay value will be ignored.

This can be done in other way i.e. choosing the disjoint paths based on delay metric (giving preference to paths having lesser delay) consequently ignoring bandwidth value.

In order to accommodate the strengths of both of the metrics in identifying the most QoS support paths, the two parameters can be considered together by combing them into one using Fuzzy logic.By introducing fuzzy logic, multiple QoS parameters can be combined. The proposed approach introduces a fuzzy metric i.e. FM metric produced from bandwidth and delay metrics of found paths .This FM metric represents QoS path significance value. In this way we will be able to choose more appropriate QoS significant paths.

QoS assessment for disjoint path selection using fuzzy logic has been defined in [6].

Here we have applied the same method on the following example and calculated the QoS values for all paths. Based on that QoS value , a load distribution scheme has been proposed in next section.

Example

In the following network , fuzzy logic has been used to find most optimal disjoint paths and also their preference order of optimality as in [6]. On the optimal paths found, a new load distribution method has been proposed in next section.

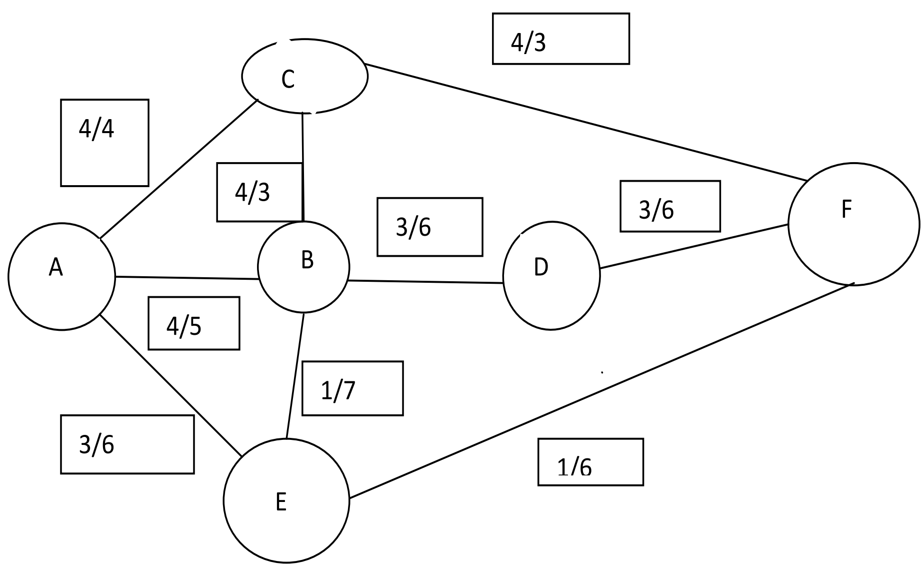

Figure 1- Network with edges depicting residual bandwidth/delay

The overlapping paths source node A for destination F with bandwidth constraint 3 and delay constraint 20 are -

Table1 : Paths with bandwidth & delay values

Path	Bandwidth	Delay
ACF	4	7
ABCF	4	11
ABDF	3	17
ACBDF	3	19

The objective is to find those link disjoint paths whose QoS value is better than their overlapping paths.

Using the defined fuzzy rules and the membership functions as in [6], we are demonstrating the complete process for the first path as below-

The bandwidth and delay values of first path are - 4 and 7

Thus, input values for the fuzzy system

Bandwidth=4 Delay=7

Using the input values we have calculated their degree of compatibility with each membership function.

The membership function for both input are defined as follows:

The bandwidth is defined by the three parameters Low, Medium, High in range (0-20).Applying possibility distribution, the three parameters can have the following bounds-

Low=0,Medium=10,High=20

Similarly, for delay, the bounds are defined as follows-

Low=0,Medium=10,High=20

Using the above bounds, a mathematical function for the membership function of bandwidth and delay can be formulated as follows-

F(bandwidth)= 0 : bandwidth < low

(bandwidth - low)/(medium - low) : low<=bandwidth<=medium

(high- bandwidth)/(high-medium) :medium<=bandwidth<=high

0 : bandwidth>high

F(delay)= 0 : delay < low

(delay - low)/(medium - low) : low<=delay<=medium

(high- delay)/(high - medium) : medium<=delay<=high

0 : delay>high

Degree of membership for inputs

After applying the formula on the inputs,the obtained degree of member ship are-

Input value 1(Bandwidth of first path) - 4

Degree of membership

Low=0.60, Medium=0.40,High=0

Input value 2(Delay of first path) - 7

Degree of Memebership

Low=0.30, Medium=0.70,High=0

Pass these values to the following rule structure -

RULES:
Rule 1: if Bandwidth is Low and Delay is Low then FM is Medium
Rule 2: if Bandwidth is Low and Delay is Medium then FM is High
Rule 3: if Bandwidth is Low and Delay is High then FM is Very High
Rule 4: if Bandwidth is Medium and Delay is Low then FM is Low
Rule 5: if Bandwidth is Medium and Delay is Medium then FM is Medium
Rule 6: if Bandwidth is Medium and Delay is High then FM is High
Rule 7: if Bandwidth is High and Delay is Low then FM is Very Low
Rule 8: if Bandwidth is High and Delay is Medium then FM is Low
Rule 9 if Bandwidth is High and Delay is High then FM is Medium

All nine rules have been triggerd as in Table-2. Since each rule represents AND of two conditions,the output response values have been calculated as the minimum of memebership valuse of two places.

Table2 -Fuzzy Result

Rule	**Bandwidth**	**Delay**	**Fuzzy Resultant**	**Output Value**
1	Low-0.60	Low-0.30	Medium	0.30
2	Low-0.60	Medium-0.70	High	0.60
3	Low-0.60	High-0	Very High	0
4	Medium-0.40	Low-0.30	Low	0.30
5	Medium-0.40	Medium-0.70	Medium	0.40
6	Medium-0.40	High-0	High	0
7	High-0	Low-0.30	Very Low	0
8	High-0	Medium-0.70	Low	0
9	High-0	High-0	Medium	0

Those rules are considered as fired whose output value is Non-zero. Here four(1,2,4,5) out of nine rules have been fired. The output value has been taken as minimum value among bandwidth and delay.

These fuzzy output responses magnitudes are now composited and defuzzified to return actual crisp value.

The five output linguistic parameters have been calculated as:-

Very Low(VL)=max[Rule 7]=0

Low(L)-max[Rule 4,Rule 8]=max[0.30,0]=0.30

Medium(M)-max[Rule1,Rule 5,Rule 9]-max[0.30,0.40,0]=0.40

High(H)-max[Rule 2,Rule 6]=[0.60,0]=0.60

Very High(VH)-max[Rule 3]=[0]-0

For defuzzification ,the output center points have been taken as [5]-

Very low center(Vlc)=0

Low center(Lc)=25

Medium Center(Mc)=50

High Center(Hc)=75

Very High Center(Vhc) =100

Hence the Fuzzy metric value for the first path through defuzzification has been obtained as-

Vlc*VL + Lc*L + Mc*M + Hc*H + Vhc*VH / VL+L+M+H+VH

=0.30*25+0.40*50+0.60*75/(0.30+0.40+0.60)

=7.5+20+45/1.3 =72.5/1.3

=55.7

The fuzzy values for other paths have been calculated in the same manner.

The path table, thus obtained after implementing the fuzzy logic is-

Table3 -Path Table with Fuzzy value

Path	**Bandwidth**	**Delay**	**FM**
A-C-F	4	7	55.7
A-B-C-F	4	11	68.1
A-B-D-F	3	17	82.6
A-C-B-D-F	3	19	88.6

The path having the minimum FM value is the best path.

Finding Disjoint paths

The process of making the disjoint table at destination can be described as follows:

Two lists need to be maintained to implement this process- path list & disjoint list.

Path list contains all the paths with their fuzzy value and disjoint list contains only disjoint paths with their fuzzy value.

1. Sort the paths on the basis of fuzzy value.
2. Take first path i.e. A-C-F & put it on to disjoint list.
3. Take the next path from path list and find whether this path has overlapping edges with the paths available in disjoint list. If so, do not put this path into disjoint list. Here the second path is A-B-C-F. It has overlapping edges with A-C-F. So this path will not be included to disjoint list.
4. Take next path A-B-D-F. It has no overlapping edges with the path A-C-F. So this path will be moved to disjoint list.
5. Now the next path is A-C-B-D-F. It has overlapping edges with the paths available in disjoint list. Hence, it will not be considered for disjoint list.

Therefore, the final disjoint path list with fuzzy values at destination will be

A-C-F -- 55.7

A-B-D-F -- 82.6

Now on these disjoint paths, load distribution scheme has also been suggested in next section.

3. LOAD DISTRIBUTION

Traffic is needed to split over multiple paths in order to share the load among different paths.A load-distribution algorithm divides the traffic among multiple paths for higher network utilization. Data packets are distributed over multiple routes in proportion of the priority level of paths. In our scheme the fuzzy value will be considered as a metric for traffic distribution .The traffic will be distributed inversely proportionally to the fuzzy value of the paths. That is, paths with lower fuzzy value are assigned more traffic, and paths with higher fuzzy value are assigned less traffic. load distribution can be done on this fuzzy value according to the following process-

Algorithm-

Step1 Let the value R_i =100-FM for each path.

Step 2 Calculate the proportion of traffic by the following equation –

$$Pi = Ri / \sum_{i=1}^{n} \mathrm{R}i * 100$$

Where n = Total number of paths

Step 3 Divide the number of packets according to the value P_i as follows-

Number of packets * P_i/ 100 for each path.

In our example, if the traffic load is 150 packets, then the above described algorithm will yield the following load distribution on the two selected paths. The fuzzy metric values for the two disjoint paths 1(A-C-F) and 2 (A-B-D-F) as obtained are-

FM 1 = 55.7, FM 2 = 82.6

Step 1

R_1=100-55.7=44.3,R_2=100-82.6=17.4

Step 2

P1=44.3/(44.3+17.4)*100=71.8

P2=17.4/(44.3+17.4)*100=28.2

Step 3

The load distribution on the two paths may be done proportionally as-

No of packets on path1 = 150*71.8/100= 108
No of packets on path1 = 150*28.2/100= 42
Thus
The load to be sent on path A-B-C = 108 packets
The load to be sent on path A-B-D-F= 42 packets

4. Conclusion

Routing algorithms play an important role in the efficient transportation of data in any network. With the increasing traffic in the Internet and the requirement of Quality of Service for certain applications, there is a need to indentify efficient routing schemes along with efficient load distribution for flows in the Internet. Keeping in view this requirement, in this paper ,fuzzy logic has been used to find the QoS measurement of the given QoS constrained paths. QoS metrics have been combined to get one value using fuzzy logic . The same fuzzy value has been used in load distribution scheme to calculate the ratio of traffic among multiple paths.

References

1. S.Upadhaya, G.Devi , "Exploring Issues for QoS Based Routing Algorithms" published in International Journal on Computer Science and Engineering (E-ISSN : 0975-3397) Vol. 02, No. 05, 1792-1795,2010.

2. X. Masip-Bruina,, M. Yannuzzib, J. Domingo-Pascuala, A. Fonteb, M. Curadob,E. Monteirob, F. Kuipersc, P. Van Mieghemc, S. Avalloned, G. Ventred, P. Aranda-Gutie´rreze, M. Hollickf, R. Steinmetzf, L. Iannoneg, K. Salamatian, "Research challenges in QoS routing", Computer Communications 29 (2006) 563–581

3. Zhang R. & Zhu, X.(2005). Fuzzy Routing in QoS Networks, pp. 880 – 890 Springer-Verlag Berlin Heidelberg 2005.

4. Shehu , A. & Maraj, A. Fuzzy Logic Approach for QoS Routing Analysis

   http://www.intechopen.com/

5. Cohen, A., Korach, E., Last M. & Ohayon, R.(2003). Fuzzy Based Paths Ordering Algorithm in Networks with Imperfect QoS Information.7803-7661,2003, IEEE.

6. G. Devi & S.Upadhaya ,"An approach to Distributed Multi-path QoS Routing" published in Indian Journal of Science and Technology (ISSN: 0974-5645) Vol 8(20),49253,August 2015.