Analyzing the performance of AFRA with its traditional routing algorithms

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Abstract – *In modern world, routing algorithm metrics plays a vital role to measure the performance and throughput among the networking entities. There are two types of metrics – indirect and direct. Direct metrics are depends on one variable and other depend on more than one. Say number of hops between the source and destiny is a measure of direct and packet delivery ratio is a measure of indirect. The main objective of this work is to evaluate the projected routing algorithm for wireless ad-hoc networks based on performance. The evaluation has been done through simulation practices using network simulation tools. This network simulation tool gives a platform to compare the projected fuzzy routing algorithm results with the results of the traditional routing algorithm like* ***distance vector, link state and dijkstra's routing****. Moreover, the projected work also includes the simulation environment that could be used as a packet flow for traffic creations to analyze the behavior of various routing protocols within the area of ad-hoc networks.*

Key Words: Dynamic Load Balancing, Trapezoidal Fuzzy Repertory Table, Trapezoid Number

1. INTRODUCTION

Load balancing [1] plays a vital role to minimize latency for a packet between client and server over the heavily loaded network systems. Dynamic load balancing policies [2], [3], [4], [5], [6] present the possibility of improving load distribution at the cost of improving performance, flexibility, reliability, scalability and availability. The operating cost of dynamic load balancing may be large [7], to a huge heterogeneous distributed system. Among the Static load balancing policies and Dynamic load balancing Zhang et al. [8] shown that the static load balancing policies are more desirable when the system loads are light and fair or when the overhead is not insignificantly high. This paper went into the dynamic load balancing which may also facilitate us to distribute among various network systems and make a parametric tuning to develop the system performance, flexibility, reliability, scalability and availability.

Here we have projected a new technique called FRT technique to minimize the traffic and latency by means of quantifying various routing metrics [4] like packet delivery ratio (pdr), routing overhead, end to end delay. Latency is a measure of time delay over the communication systems. In addition to that this technique can also be applied on both hop by hop and end to end traffic managements. Based on the traffic nature, static and dynamic routing is applied. In general the static routing algorithm does not consider the current load condition of the network, due to this mostly router applies the dynamic routing algorithm. Usual dynamic routing algorithm includes: distance vector routing, link state routing algorithm and dijkstra's routing.

1.1 DISTANCE VECTOR ROUTING

In this algorithm, every router maintains a table which takes every router in the subnet as the index, and every router corresponds to one table item which has the lists of optimum distance known to each goal, and the transmission line it used. The distance measurement unit that we use may be the hop count or time delay or packet number of along the way lining up and so on. By exchanging the information between the neighbors router updating its internal table constantly. There are some pros and cons exist in the distance vector routing algorithm: although this algorithm can always get the right answer, the speed of converging the answer obtained is very slow. For the simple reason that the two adjacent router in the same network do not know whether it is adjacent or not in this algorithm, so the result is that the numbers of the change times among all routers tend to the infinity value when the network is disconnected. The key problem of it is that when the X router tells the Y router that there is a path, the Y router can't know whether it is on this path.

1.2 LINK STATE ROUTING

There are problems in the distance vector routing algorithm: one is that it needs long time to converge to a stable condition that is count-to-infinity. The other is that

it does not consider the line bandwidth when the algorithm selects the path. For these reasons, the distance vector routing algorithm is to be replaced by a new algorithm, which is called link state routing. Each router must complete the following work in this algorithm:

Find its neighbor nodes and its network address: find the neighbor nodes needs send a special HELLO packet on each point-to-point line, the other end of the line sends a response to explain who it is. Measure the delay or the cost to the each neighbor nodes: to get a reasonable delay value, people uses the average time which is from a sent ECHO packet to with one received ECHO packet. Structure a packet which includes all the information which it just knew: each router creates a packet which contains sender mark and a sequence number and the age and one neighbor list.

Transmit this packet to the other routers: use the diffusion method to release link state packet. Calculate the shortest path to each router: after the router obtains the entire link state packet, people can construct a complete subnet structure, run the Dijkstra's algorithm on every router in order to calculate the shortest path of every possible target.

1.3 DIJKSTRA'S ROUTING

In the following graph, we use the ABCDE to represent the router in the computer network, each router can connect to the one or many other router. Using the shortest path from a source router to the destination router, we can explain the thought of the algorithm.

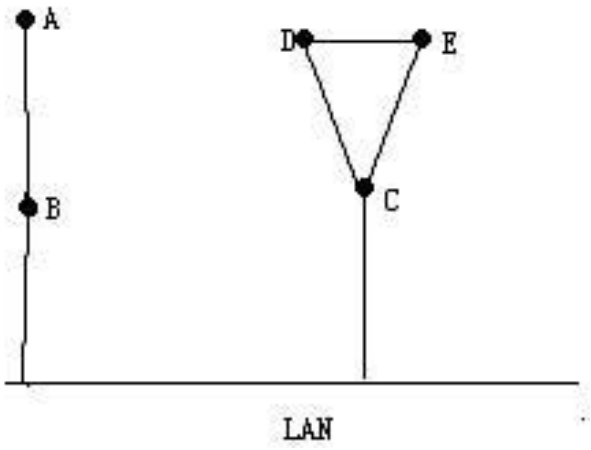


Fig. 1.3: The model of router

It is supposed that the distance between router A and other routers are the adjacent matrix as shown below. The Distance can be a time delay or hop. ∞ means the distance between two routers does not exist.

Table 1.3.1: The distance between routers in Dijkstra

Distance	A	B	C	D	E
A	∞	2	3	6	4
B	2	∞	1	3	5
C	3	1	∞	8	7
D	6	3	8	∞	9
E	4	5	7	9	∞

Table 1.3.2: The calculation process of shortest path in Dijkstra

End	Distance from A to other router			
	i=1	i=2	i=3	i=4
B	2			
C	3	1		
D	6	3	8	9
E	4	5	7	
Increased path	B	C	E	D
S	AB	ABC	ABCE	ABCED

Running Dijkstra algorithm on each router vertex, we can obtain the entire shortest path from each router to another router. In the practical computer network, the operation of Dijkstra algorithm is to judge whether the router C in model route the packet to the D router firstly or to the E router. Computer network is connected each other, but in some special circumstances they are not connected or can only send or receive data packets of the router, as to the time delay that the same line in the both directions is not equal, we also can run the Dijkstra algorithm to obtain the shortest path from each router to other router. Actually, each link is denoted twice for each direction it is done once, then the two values can be taken on average. Using the Dijkstra algorithm, we can find the shortest path is an sequence by increasing the length of path from router A to other routers. The processes of using Dijkstra algorithm from A to each router vertex are as follows: S is a collection of the shortest path that has been obtained.

2. TRAPEZOIDAL FRT

Dr.Lotfi A. Zadeh, is the father of fuzzy sets and fuzzy logic, in 1965. Fuzzy sets are generalized sets such that the

membership is a real number in the [0, 1] range instead of 0 and 1 only.

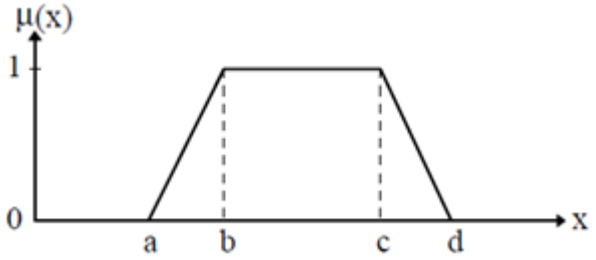


Fig. 2: Fuzzy Trapezoidal Graph

Fuzzy logic proved to be a very powerful concept in the various disciplines, and industries applications. Dynamic load balancing policies is probably aimed to improving load distribution at the cost of high performance, flexibility, reliability, scalability and availability.

2.1. Rating attributes using trapezoid numbers

A fuzzy repertory table (FRT) also looks like a rectangular matrix with elements (as columns) and constructs (as rows). Each row–column intersection contains a rating. Such a rating is a trapezoid number showing how a user applied a given construct to a particular element. A trapezoid number (a,b,c,d) is a fuzzy set that has a membership function of the following form:

$$\mu(x)=\begin{cases} 0 & if \quad x \le a, \\ \frac{x-a}{b-a} & if \quad a < x < b, \\ 1 & if \quad b \le x \le c, \\ \frac{d-x}{d-c} & if \quad c < x < d, \\ 0 & if \quad x \ge d. \end{cases}$$

By using trapezoid numbers, the FRT technique [9], [10], [11], [12], lighten up the restriction, of the classical repertory grid technique, that the ratings must be crisp numbers in a predefined range. Moreover, trapezoid numbers enable the FRTs to provide categorical and numerical data types that may be given by means of linguistic terms. For instance, in the FRT developed in our Load Balancing scenario, taking traffic attribute F1 as an example, packet delivery ratio of a routing port is rated on a 1–4 rating scale (this rating provides an indication of packet forwarding preferences: 1— Less traffic, 2 — Moderate traffic 3— High traffic and 4—Very High traffic).

There are totally five different scales are used in software to quantify a metric such as Nominal, Ordinal, Interval, Ratio and Absolute. In the FRT table, each value is expressed by a membership function that is determined from the construct type and direct interaction with the user.

Unordered-discrete or nominal scale:

There are no unique numbers or strings. Just to define the elements labeling or naming is used.

E.g: router make name, ethernet cable name, etc.,

Ordered-discrete or ordinal scale:

A number states precisely an element's position in the series established by the scale

E.g: packet number, acknowledgement number, etc.,

Crisp interval value:

The user assigns two numbers, x and y, to an element in such a way that the interval between these two values is meaningful for him. The trapezoidal function associated with this value is a=b= x & c=d= y.

Boolean:

Checks the attributes whether it exists or not.

E.g: connection checks, success or failure;

Absolute scale:

The user assigns a number, x, to an element. The function associated with this value is one with the parameters a = b = c = d = x.

E.g:, age, date, weight, etc.,

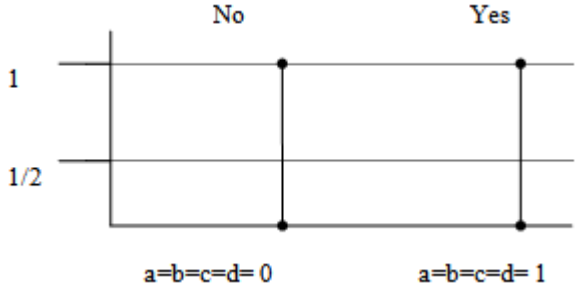


Fig. 2.1: Boolean Representation

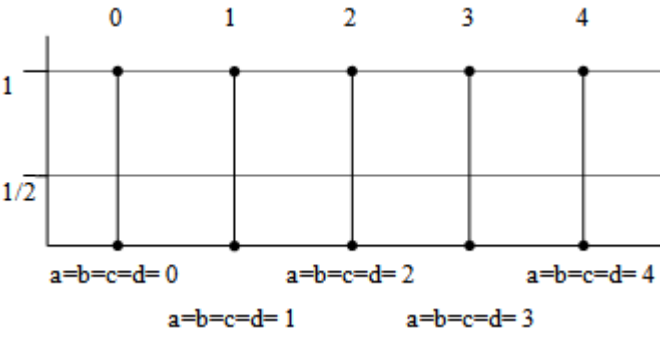


Fig. 2.2: Fixed Value Rating from 0 to 4

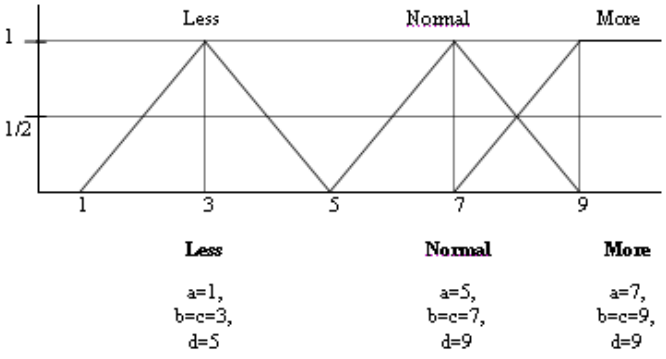


Fig. 2.3: Rating for the attribute

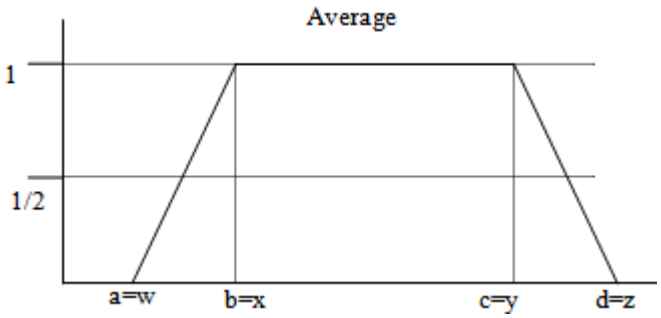


Fig. 2.4: Continuous fuzzy value for Trapezoidal Representation

Table 2.1: Rating attributes using trapezoid numbers

Set	Complexity Attribute	Rating Scheme	Assignments for the Trapezoid Numbers
F_1	Hop count	Ranking using crisp values range from 0 to 255	a=b=c=d=0, a=b=c=d=8 a=b=c=d=9, a=b=c=d=15 a=b=c=d=16, a=b=c=d=255
F_2	Size of the load balancing system (in LOC)	Ordered discrete type – Any numerical value of count	Low: a=500, b=1000, c=1500 and d=2000 Average: a=1500, b=2000, c=2500, and d=3000 High: a=2500, b=3000, c=3500, and d=4000 Very High: a=4000, b=4500, c=5000, and d=5000
F_3	Bandwidth Utilization	Ranking using crisp values range from 0 to 5	a=b=c=d=0, a=b=c=d=1, a=b=c=d=2, a=b=c=d=3, a=b=c=d=4, a=b=c=d=5
F_4	End to end delay	Ranking using crisp values range from 0 to 5	a=b=c=d=0, a=b=c=d=1, a=b=c=d=2, a=b=c=d=3 a=b=c=d=4, a=b=c=d=5
F_5	Routing Overhead	Ranking using crisp values range from 0 to 255	a=b=c=d=0, a=b=c=d=8, a=b=c=d=9, a=b=c=d=15, a=b=c=d=16, a=b=c=d=255
F_6	Processing Delay	Ordered discrete type – Any numerical value of count	Less : a=1,b=c=3, and d=5 Normal : a=5,b=c=7, and d=9 More : a=7,b=c=9, and d=9
F_7	Queuing Delay	Ordered discrete type – Any numerical value of count	Less : a=1,b=c=3, and d=5 Normal : a=5,b=c=7, and d=9 More : a=7,b=c=9, and d=9
F_8	Throughput of the system with respect to the load balancing alg.	Ranking using crisp values range from 0 to 5	a=b=c=d=0, a=b=c=d=1, a=b=c=d=2, a=b=c=d=3, a=b=c=d=4, a=b=c=d=5

3. TRAPEZOIDAL FRT IN LOAD BALANCING

In this work, our approach is constructed with the inspiration of a communication model observed in FRT (fuzzy repertory table) combined with the capabilities of the fuzzy logic technique. The projected algorithm first determines the crisp path rankings for all eligible paths between the source and destination nodes from the viewpoint of fuzzy inference. The path with the highest ranking is then chosen to route the traffic flow. The path congestion rate in this paper represents the degree of the path usability in the sense of the multiple criteria required. Whenever traffic flow is routed to a chosen path, a packet is dropped when it arrives at a full buffer. The fuzzy Inputs are chosen as the traffic rate, bandwidth, throughput, end to end delay...etc based on the metric we used in the table. The fuzzy output is load balancing, shaping traffic.

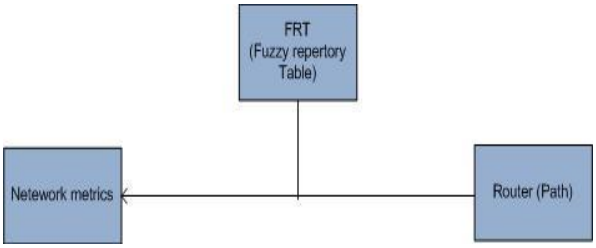


Fig. 3.1: FRT interface b/w Network metrics and Router

Identification of path with enough quality is a tedious process in any network because of vast number of factors that affects it. Also identifying path delay, path utilization, shaping traffic, congestion control, flow control, bandwidth, processing delay, hop count, MTU (maximum transmission unit), reliability etc. There are numerous amounts of metrics (attributes) available to rank the Path to send the packet on that path, but the difference is usage of technique and Factors/attributes. Elements and constructs (dimensions of similarity and differences between elements) are central to knowledge representation in repertory grids. The most basic form of a repertory grid is a rectangular matrix with elements as columns and constructs as rows.

Table 3.1: FRT process on Construct and Element

	Construct1	Construct2	.	Construct n
Element1				
Element2				
. .				
Element n				

Each row-column intersection in the grid contains a rating to show how a person applied a given construct to a particular element. Thus, if the element is closest to the left pole of the construct, he places a tick; otherwise, a cross. Within classification problems, the elements of a repertory grid will be those classes which we want to learn to classify and the constructs will be the input variables, whose different values can distinguish a class from another one. Since we are interested in to obtain the input variables plus their definition domains (the rating used by the expert to value each input variable) that the expert uses in a classification task and in the same way in which he uses them, for facilitating their integration into the knowledge acquisition process, we will need to make several changes to the classic repertory grid.

To realize the result we have taken the free source of network simulator 2 (ns-2) as a standard simulation package and extended it to implement our advanced fuzzy routing algorithm with OSPF, distance vector, link state routing algorithm. The aim of the simulator is to closely mirror the essential features of the concurrent and distributed behavior of a generic communication network without sacrificing efficiency and flexibility in code development.

NS2 configuration of AFRA:

```
set val(chan)  Channel/WirelessChannel
set val(prop)  Propagation/TwoRayGround
set val(netif) Phy/WirelessPhy
set val(mac)   Mac/802_11
set val(ifq)   Queue/DropTail/PriQueue
set val(ll)    LL
set val(ant)   Antenna/OmniAntenna
set val(ifqlen) 50
set val(nn)    5
set val(rp)    AFRA
```

```
//AFRA trapezoid variables assignment:
for (i=0;i<100;i++)
 if (bandwidth[i]!=0)
  { if(bandwidth[i]>=0 && bandwidth[i]<=1500)
    {    degree[i]=0;
         printf("\nDegree of Node %d is:  %f -- x=%d [1]", i,degree[i],bandwidth[i]);  }
   else if(bandwidth[i]>=1500 && bandwidth[i]<=2000)
   {     degree[i]= ((float)(bandwidth[i] - 2000)/(float)(1500-2000));
         printf("\nDegree of Node %d is:  %f-- x=%d [2]",i,degree[i],bandwidth[i]);   }
   else if(bandwidth[i]>=2000 && bandwidth[i]<=3500)
   {     degree[i]= 1;
         printf("\nDegree of Node %d is:  %f-- x=%d [3]", i,degree[i],bandwidth[i]);   }
   else if(bandwidth[i]>=3500 && bandwidth[i]<=6000)
   {     degree[i]=((float)6000-bandwidth[i])/((float)6000-3500);
         printf("\nDegree of Node %d is:  %f-- x=%d [4]",i,degree[i],bandwidth[i]);   }
  else  {  degree[i]= 0;
           printf("\nDegree of Node %d is:  %f-- x=%d [5]",i,degree[i],bandwidth[i]);  }
       }
```

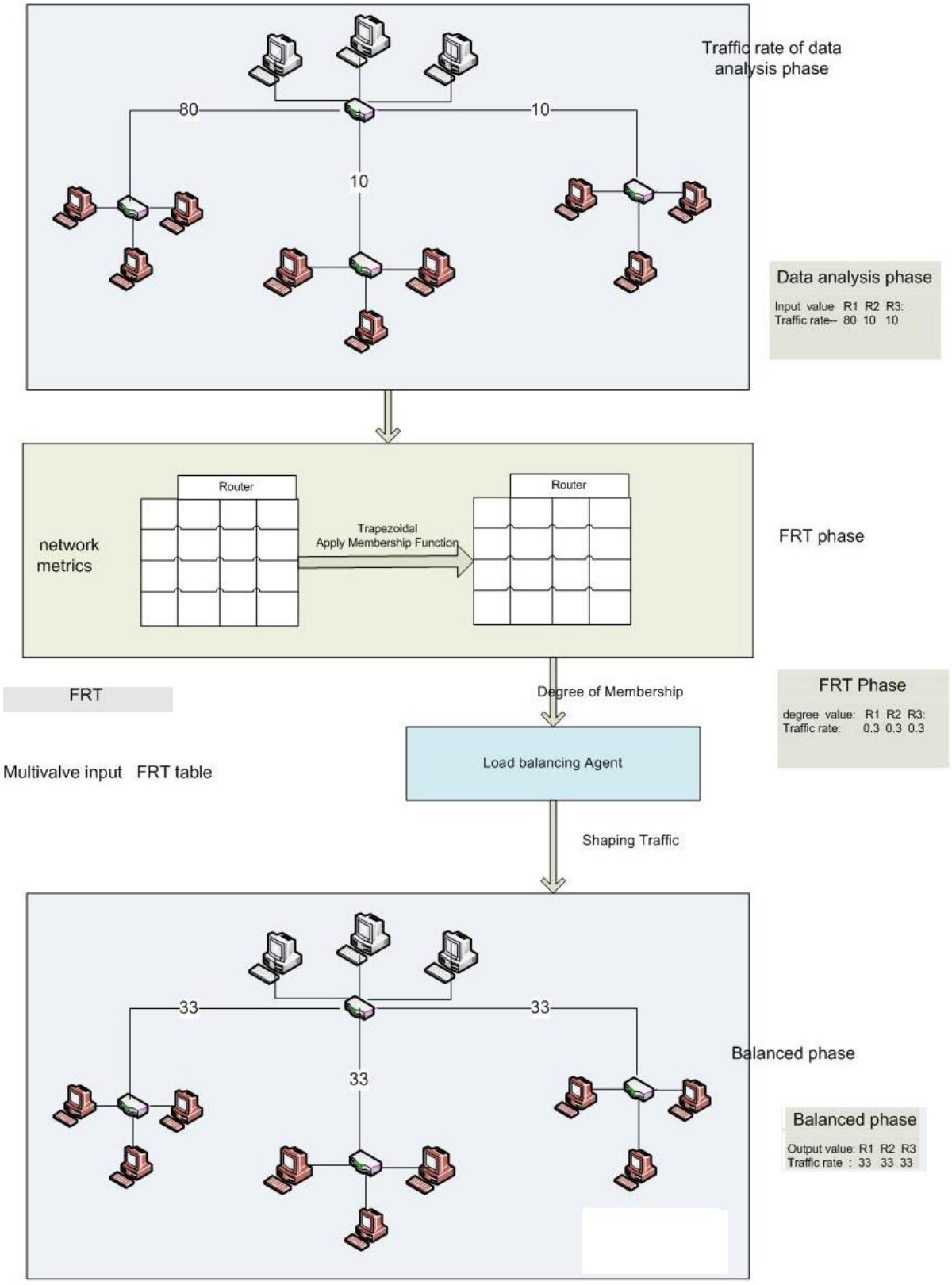
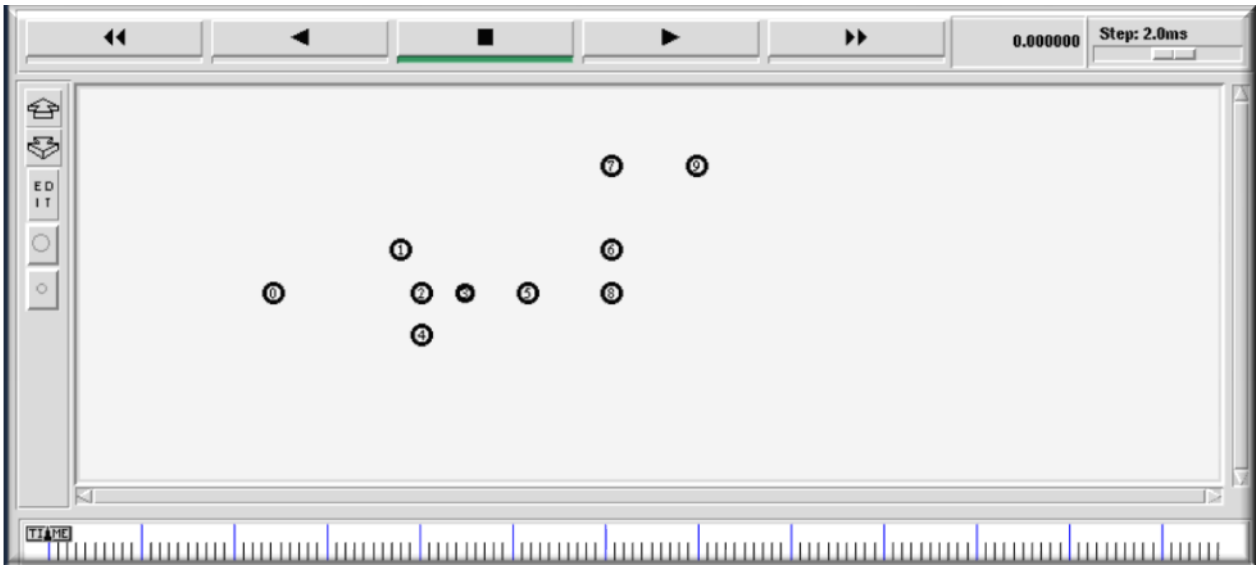



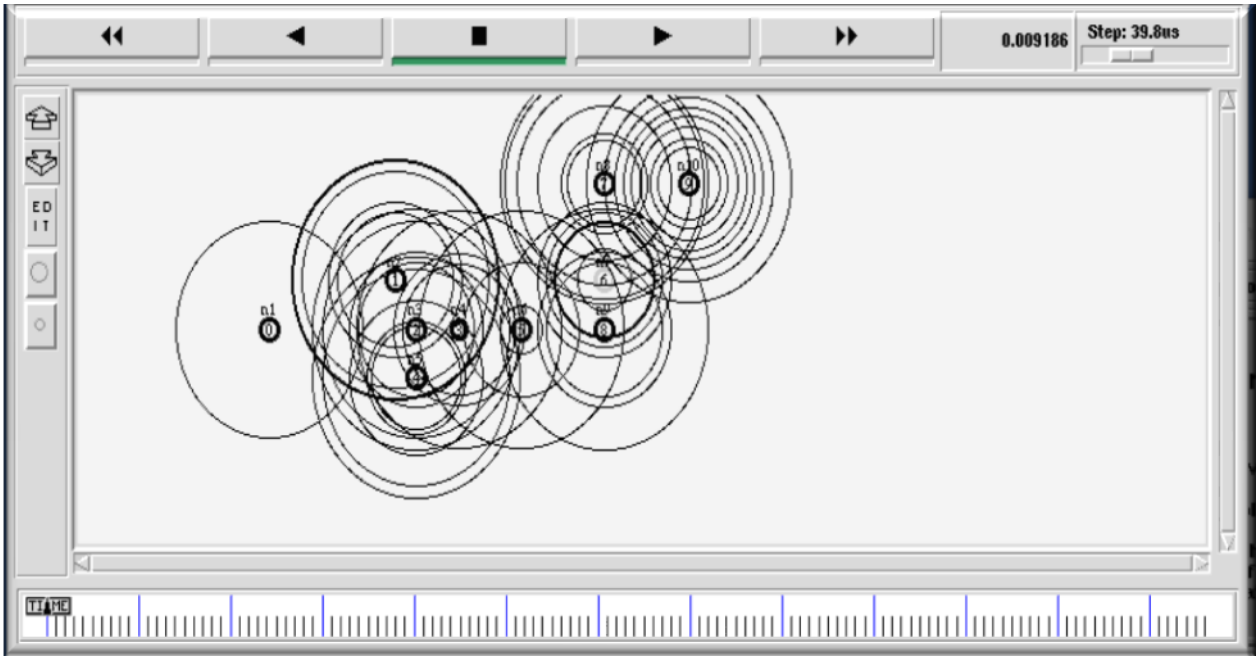
Fig. 3.2: Basic View of Projected Fuzzy Load Balancing Architecture

4. RESULTS

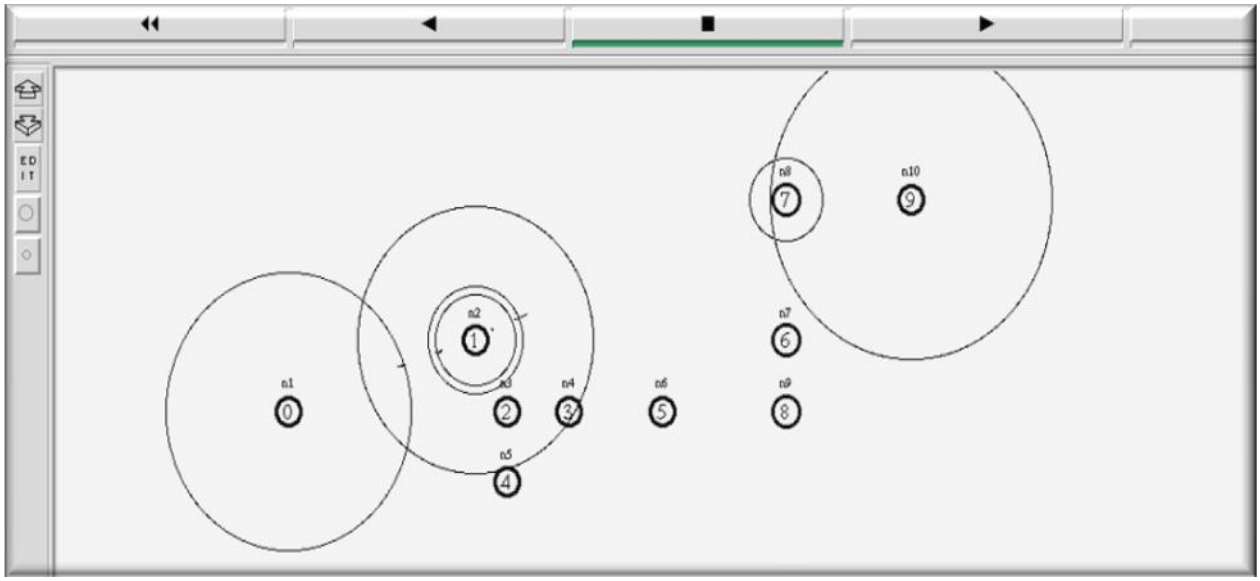
i. Network Definiton: Initially on the network, the number of nodes is defined which is about to communicate one over the other through wireless channel.



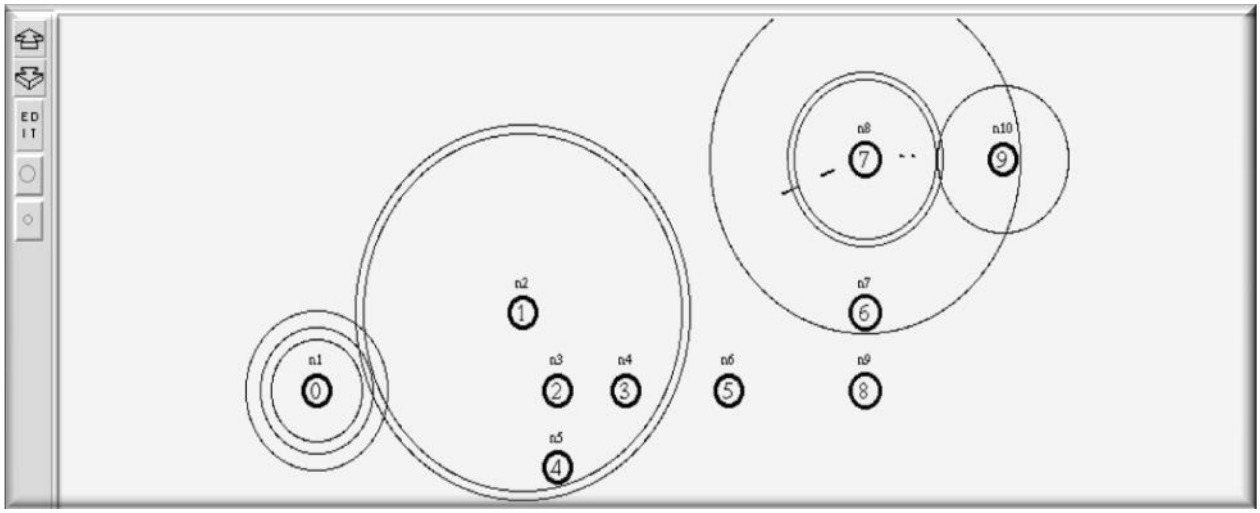
ii. Discovering Other Nodes: Now the nodes on the network tries to discover its neighbour for communication through wirelss channel.



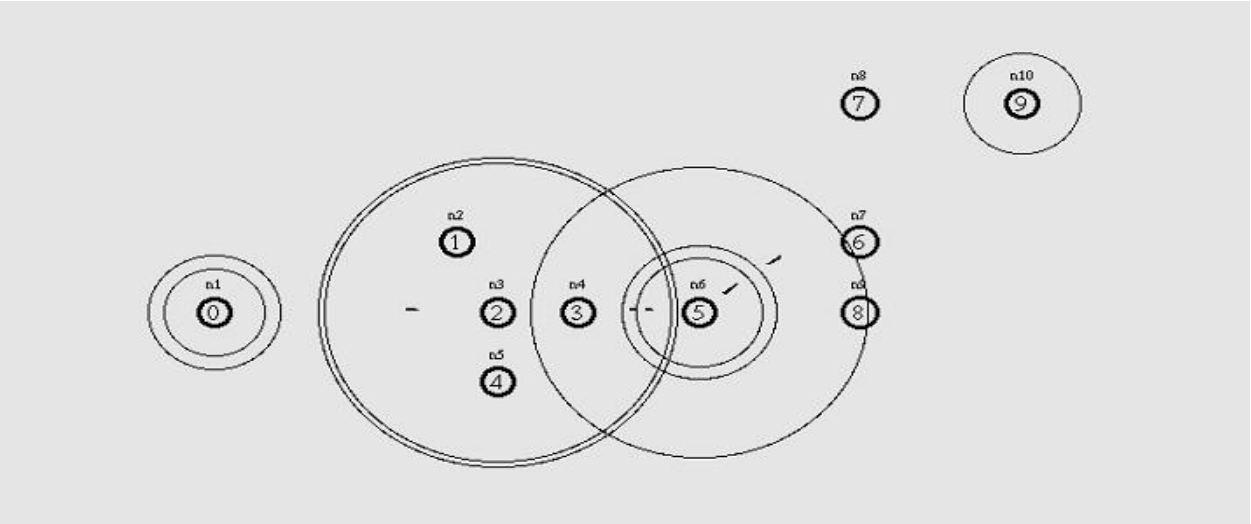
iii. Goal: To communicate between n1 to n10. In between n1 and n10 nodes, there are various other nodes are also presented. Some of these nodes can act as intermediate nodes when the signal strength is attenuated. Hence the communnication takes place through n1,n2,n8,n10



iv. Here n2 and n8 act as the primary intermedaite node for to communicate n1 with n10.



v. When the Bandwidth utilization increases on n1,n2,n8,n10 route then FRT algorithm come into picture to shred the load via n1,n3,n4,n6,n10.



5. CONCLUSIONS

Our fuzzy repertory table based routing algorithm metrics result will be compared with other routing algorithms such as Distance Vector, Link State & OSPF to run on the network topology. The expected results will indicate that the proposed algorithm does a better job at dispersing traffic in a more uniform manner throughout the network. In addition to that it will also handles an increased traffic load as well as decreased transmission delay by utilizing network resources more efficiently. The advantages of such an intelligent algorithm include increased flexibility in the constraints that can be considered together in making the routing decision efficiently and likewise the simplicity in taking into account multiple constraints. In the near future the next generation networks will have capabilities including soft-switches, which allow such an intelligent technique -based routing algorithm to shapes the traffic & load balancing autonomously, and then they can be substituted with the conventional routing algorithms.

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