DYNAMIC LOAD BALANCING IN AD HOC NETWORK USING OMNET++ SIMULATER

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ABSTACT

load balancing problem remains a critical issue and has a high priority in ad hoc network especially after the growing demand for this network. Designing effective load balancing strategies for this network is known to be difficult because of the complexity of the structure of the network, due to the nature of the variety of the dynamic connection nodes in ad hoc network. This complexity in ad hoc network may be influenced on many factors like performance, energy efficiency, scalability, power consumption, network topology.

This paper describes five proposed methods for solving load balancing problem by applying them on node, link or on both of the node and link at the same time. The proposed methods are designed for dynamic load balancing based on the fuzzy neural network characterization benefits.

Each proposed method uses some metrics to find load balancing in ad hoc network like bandwidth of link (amount of data that the link accepted it at the time (capacity)), throughput of node (a moment of data that processing at the time), queue state of node (under full ….. over full) ….etc. Since some problems like routing can be depended on these metrics. Load balancing attempts to maximize network throughput by distributing the load between links (or nodes) of the network, for example the traffic may be moved from the overloaded nodes to other lightly loaded.

1- INTRODUCTION

Generally, in computer network, load balancing is an important for distributing the load of traffic across several links from the source in order to reach its destination. where, the most important reason to reduce network efficiency is that the load is greater than the capacity of network [1]. So the objective of the load balancing is created the fairness in sharing the transmission channel. Therefore, improving load balancing became an important hot subject in communication network researches especially in mobile wireless networks, since wireless communication is currently one of the fastest growing technologies as the recent progress in mobile computing and wireless devices [1] Wireless networks can be defined as networks in which the nodes are interconnected by wireless links, Due to increasing development of mobile wireless network there are two main architectures . One of this architectures mobile wireless network is the infrastructure –less mobile network, commonly known as an ad hoc network. Infrastructure – less networks has no fixed base station. Each computer can communication directly with all other wireless enabled computer. Nodes in ad hoc networks can not only be a sender or receiver in a connection, but they can also be responsible for forwarding packets to neighboring nodes to implement the Overall mechanism of routing, it means more than one node that can be used for routing at the same time. Therefore, will make ad hoc networks independent from a central point, but may lead to some particular mobile nodes being unfairly burdened to support many packet-relaying functions and consequently, loading on these hot spots. This load on nodes appears in two major aspects: traffic and power consumption. Load balancing algorithm tries to balance this load [2]. Therefore Ad-hoc can be defined as a wireless network temporarily composed of several different devices or uniform and are linked to the devices without an access point or wireless route because the network will be based on direct contact between the card wireless network, is installed on each device for data transfer from one computer to another, in the network and must be as standards-compliant IEEE . [3].

2- PROPOSED METHODS

The proposed six methods are classified in three categories according to what their metrics deal with:-

Category 1:-Dynamic load balancing of links
Category 2:- Dynamic load balancing of nodes
Category 3:- Dynamic load balancing of links and nodes

The assumptions that made about the networks in this investigation are:-

*All nodes in the network are stationary.

*The topology is any structured network.

*The network is ideal (no node failure or link failure).

*Any node knows its neighbors.

Based on these assumptions the goal is to solve the load balancing problem in the ad hoc network by applying the fuzzy neural network technique.

The next sections describe that methods according to categories explained above.

2.1 Dynamic load balancing of Links

Two methods are suggested to deal with the arrival traffic ,and then the load of links or probability distributed (PD) the load for the links can be determined.

The first method

First method compares the load of the link at any given moment with the size of arrival traffic to decide how probability distributed the load for that link. To solve the load balancing problem locally, a fuzzy neural network (FNN1) is developed. It has two input variables, there are load of the link ,the size of traffic data, and one output variable is probability distributed the load for link(between 0 and 1). This FNN1is located at each node of the ad hoc network to provide load balancing capabilities for links using the above mentioned criteria's (link load(Kbps), traffic size(Mbps)).Consider has the units of product and normalization layers where h=16 is the number of rules, as shown in Figure (١).

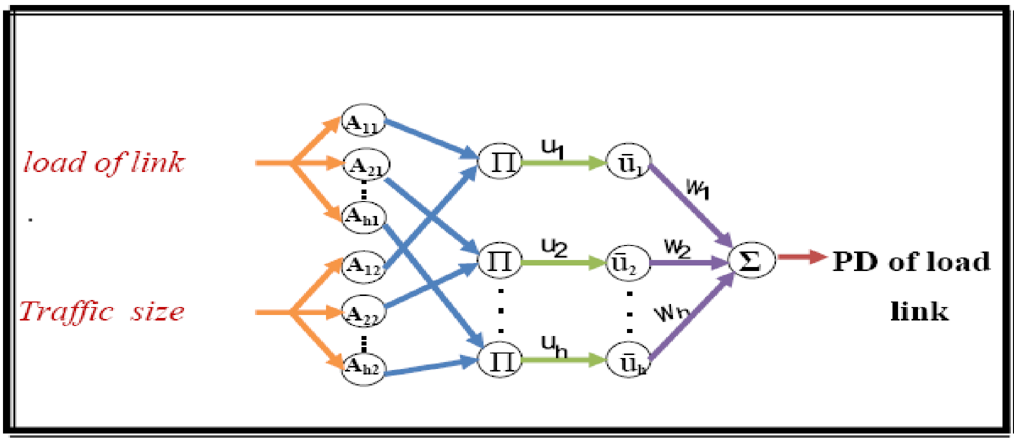

Figure (١) The fuzzy neural networkFNN1

The centers of ranges and imposing linguistic values of membership functions of input variables for**FNN1**are represented below in Table (1).

Table (1) The centers and the linguistic values of (a)input variables and (b)output variable

input variables	Center	*Linguistic value*
Load of link	**3**	*Under loaded*
	8	*Normal*
	13	*Loaded*
	18	*Over loaded*
Traffic size	**2**	*Low*
	4	*Medium*
	6	*High*
	8	*Very high*

(a) input variable

Output variable	*Center*	*Linguistic value*
Probability distributed of load link	**0**	*Zero*
	0.25	*Min - value*
	0.5	*Mid – value*
	0.75	*Max – value*

b) output variable

The ad hoc network contains the **FNN1** at each node. Then **FNN1** received inputs for each links connected with this node. Therefore, the proposed **FNN1** find the load and probability distributed the load for these links.

The second method

This method is based on three measurement factors: the bandwidth of link, the existing current data size on link, and the arrival traffic size to the node at this time. Then the load of link and PD of load of link can be found.

FNN2 is proposed locally, it has three inputs and two outputs variables, as shown in Figure (٢). The input variables are bandwidth of link, link data size, and traffic size, and the output variables are the load of link and probability distributed of load for this link. Consider h as the units of product and normalization layers, where the number of rules is equal to h=27.

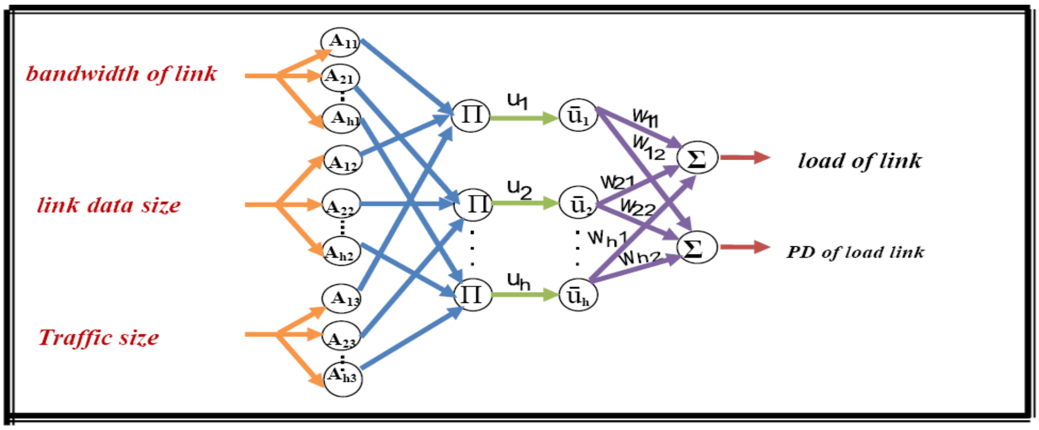

Figure (٢) Fuzzy neural network FNN2

The input variables of**FNN**2 have centers of range sand imposing linguistic values of membership functions that represented below in Table (2). By comparing with related work of [٤], it proposed new protocol for load balancing using fuzzy system to save the bandwidth of the network. But in this work, fuzzy neural network is used to solve the load balancing problem using criteria that are indicted above.

Table (٢)The centers and the linguistic values of (a) input variables and (b)output variables

Input variables	Center	Linguistic value
Bandwidth of link	7	Small
	14	Medium
	21	Large
Link data size	5	Low
	8	Medium
	11	High
Traffic size	2	Low
	4	Medium
	6	High

(a) input variables

Output variable	Center	Linguistic value
Load of link	3	Under loaded
	8	Normal
	13	Loaded
	18	Over loaded
Probability distributed of load link	0	Zero
	0.25	Min - value
	0.5	Mid – value
	0.75	Max – value

(b) output variables

The ad hoc network applies the **FNN2** at each node. Where the**FNN2** received inputs for each link connected with the node, after that it is find the load of link and probability distributed of load for this link.

2.2 Dynamic load balancing of Nodes

Two methods are suggested for solving load balancing problem of the nodes.

The first method

The first method deals with the load on the source node (Kbps)and the load on neighboring node(Kbps), to decide the probability distributed of the load of neighboring node.

FNN3with two inputs and one output variable is depended in this method. Any node in network, receives traffic from the other nodes, therefore, each node at one time may be loaded. The proposed method used the load degree of each node and its neighboring nodes, than the probability distributed of the load of its neighboring nodes can be decided. Figure (٣) shows the structure of **FNN3**, consider h as the units of product and normalization layers where h=25 is the number of rules.

Table (3) explains the centers and linguistic values of the inputs and output variables.

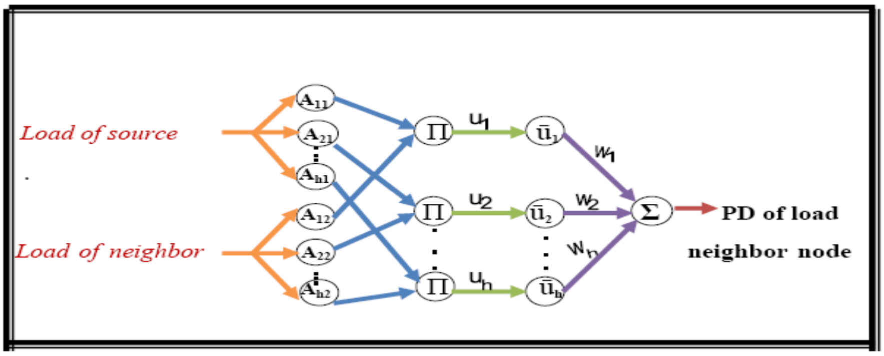

Figure (٣) Fuzzy neural network FNN3

Table (3) The center and the linguistic values of (a) input variable and (b) output variable)

Input variables	Center	Linguistic value
Load of source node	5	Very lightly
	15	Lightly
	25	Medium
	35	Heavy
	45	Very heavy
Load of neighbor node	10	Very lightly
	20	Lightly
	30	Medium
	40	Heavy
	50	Very heavy

(a) input variables

Output variable	Center	Linguistic value
Probability distributed of neighbor load node	0	Zero
	0.3	Min - value
	0.5	Mid – value
	0.8	Max – value

(b) output variable

The second method

The second method in this category, find the load of the node based on three measurements which are the queue size(number of packet) and throughput of the node(Kbps) and arrival rate of traffic to the node (Mbps).

FNN4 with three inputs and one output variables is depended in this method. The inputs are throughput which means the node capacity to process the arrival traffic at time unit, number of packet in the node which is referred by queue size and the last metric is the arrival rate of traffic. From all these metrics, the load of node is calculated using **FNN4**.Figure (4)shows the**FNN4** for this proposed method. Where h is the number of rules which are equal to **36**and considered as the units of product and normalization layers.

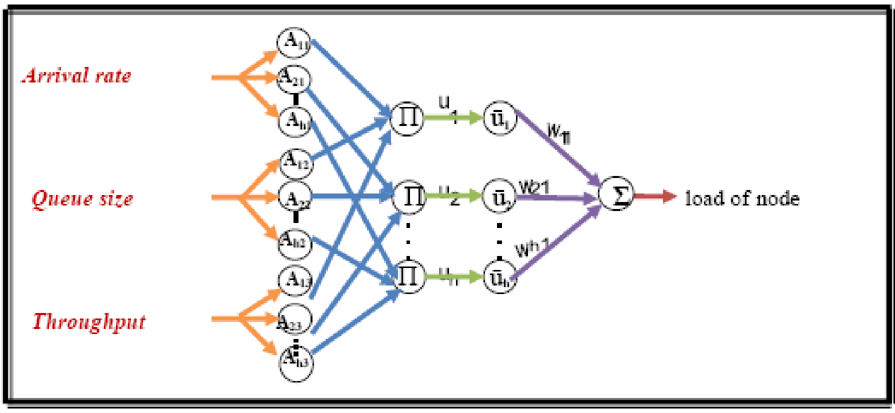

Figure (4) Fuzzy neural network FNN4

The Table(4)describes the input variables of **FNN4** with the centers of ranges and imposing linguistic values of membership functions.

Table (4) The centers and the linguistic values of (a) input variable and (b)output variable

input a variables	Center	Linguistic value
Arrival Rate	2	Less
	8	Medium
	14	More
Queue size	2	Low
	4	Medium
	6	High
	8	Very high
Throughput	10	Small
	15	Medium
	20	Big

(a)input variables

Output variable	Center	Linguistic value
Load of Node	**2**	Lightly
	10	Medium
	18	Heavy
	26	Very heavy

(b) output variable

2.3 Dynamic load balancing of Links and Node

One method is proposed for solving the load balancing problem on the links and nodes

by taking the load of sender node and load of link which connect the sender node

with other neighboring node (receiver) to determine if the load on the sender or on

the receiver node.

In the indictedmethod,**FNN5**is included locally in the ad hoc network, it has two input variables (load of the node and load of the link), and one output variable (load on the sender or receiver node), as shown in Figure (٥). Consider h as the unit of product and normalization layers, where h=20 is the number of rules.

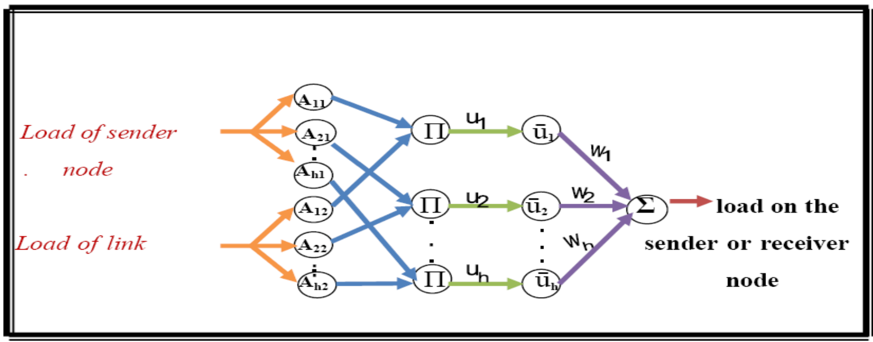

Figure (٥) Fuzzy neural network FNN5

The input variables of **FNN5** have centers of ranges and imposing linguistic values of membership functions that are represented below in Table (5).

Table (5)The centers and the linguistic values of (a)input variable and (b)output variable

input a variables	Center	Linguistic value
Load of the sender node	2	Very Lightly
	10	Lightly
	18	Medium
	26	Heavy
	34	Very Heavy
Load of the link	3	Under loaded
	8	Normal
	13	Loaded
	18	Over loaded

(a)input variable

Output variable	**Center**	Linguistic value
Load on the sender or receiver node	0	Normal
	4	Sender
	8	Receiver
	12	Sender & Receiver

(b) output variable

This **FNN5** receives inputs for the load of sender node and the load of link that connected this sender node with other receiver node, and then the result is defined whether the load on the sender or on the receiver node.

3- SIMULATION OF PROPOSED METHODS USING OMNET++4.1

Simulation is employed to represent the real systems in an accessible way since the study of them is a complex operation. A wide range of scenarios can be investigated for the modeled system because the simulation ability of repetitively running of experiment using different input values. Furthermore, simulation allows a cost effective way for researching of complex real systems.

In this section the six previous methods are simulated in OMNET++ simulator, version (4.1).

the simulation networks which are three different environments(Networks) are designed and these six proposed algorithms would be applied for each one. These environments contain (9 nodes, 18 nodes, and 36 nodes) Tables (6) - (8) illustrate how each node is for any one of these environments connected as, and Figures (٧) - (٩) show that.

Table (6) The nodes connections in AN1

Node	Connections	Node	Connections
0	1, 2, 3	4	2,7
1	0, 5	5	1,7
2	0,4	6	3,7
3	0,6	7	4,5, 6

Table (7) The nodes connections in AN2

Node	Connections	Node	Connections
0	1, 3, 4, 5	9	5,14
1	0,2	10	5,14
2	1,6, 7	11	6,15
3	0,7	12	7,13,16
4	0,8	13	8,12,16
5	0, 9, 10	14	9,10,17
6	2,11	15	11,16
7	2,3,12,8	16	12,15,17
8	4,13, 7	17	14,16

Table (8) The nodes connections in AN3

Node	Connecations	Node	Connecations	Node	Connecations	Node	Connecations
0	1,6	9	10,15	18	12,19,24	27	21,28
1	0,2,7	10	9,11,16	19	13,18,20,25	28	22,27
2	1,8	11	10,17	20	14,19,21,26	29	23,35
3	4,9	12	6,13,18	21	15,22,27	30	24,31
4	3,5,10	13	7,12,14,19	22	16,21,28	31	30,32
5	4,11	14	8,13,20	23	23,29	32	31,34
6	0,7,12	15	9,16,21	24	18,30	33	32,34
7	1,6,7,13	16	10,15,17,22	25	19,26	34	33,34
8	2,7,14	17	11,16,23	26	20,25	35	29,34

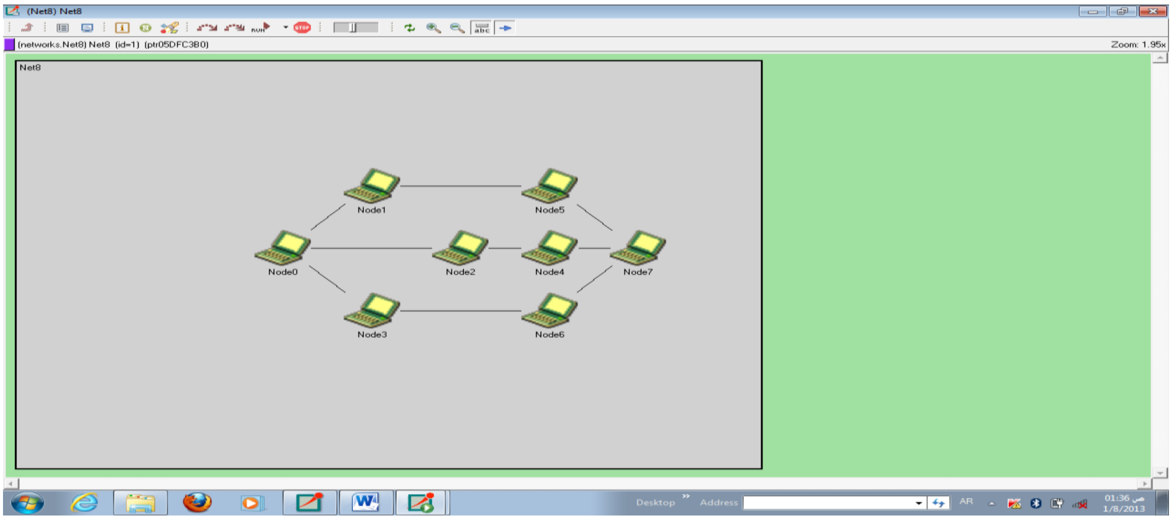

Figure (٧) AN1

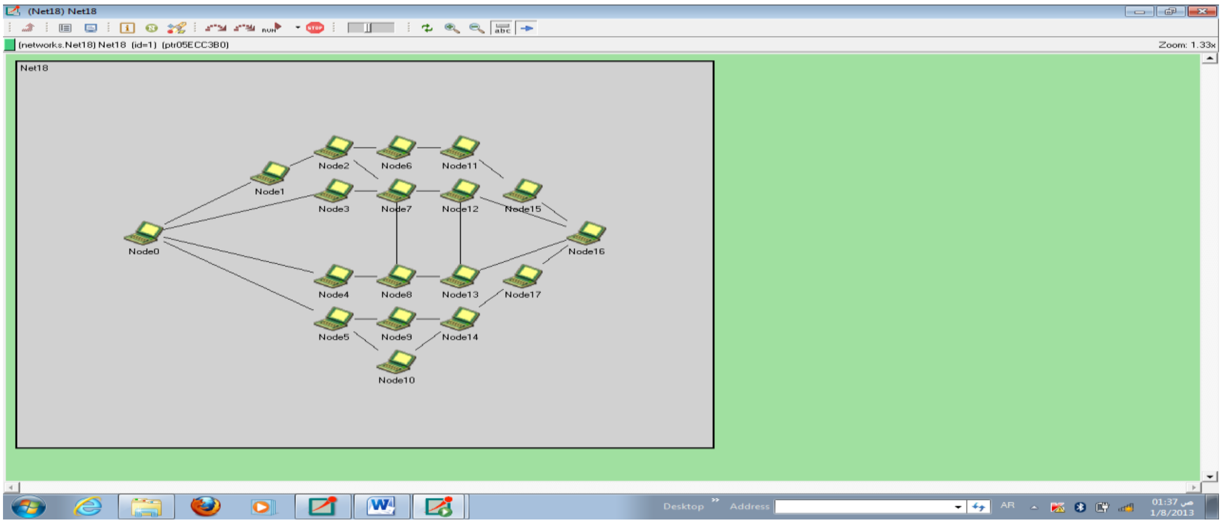

Figure (٨) AN2

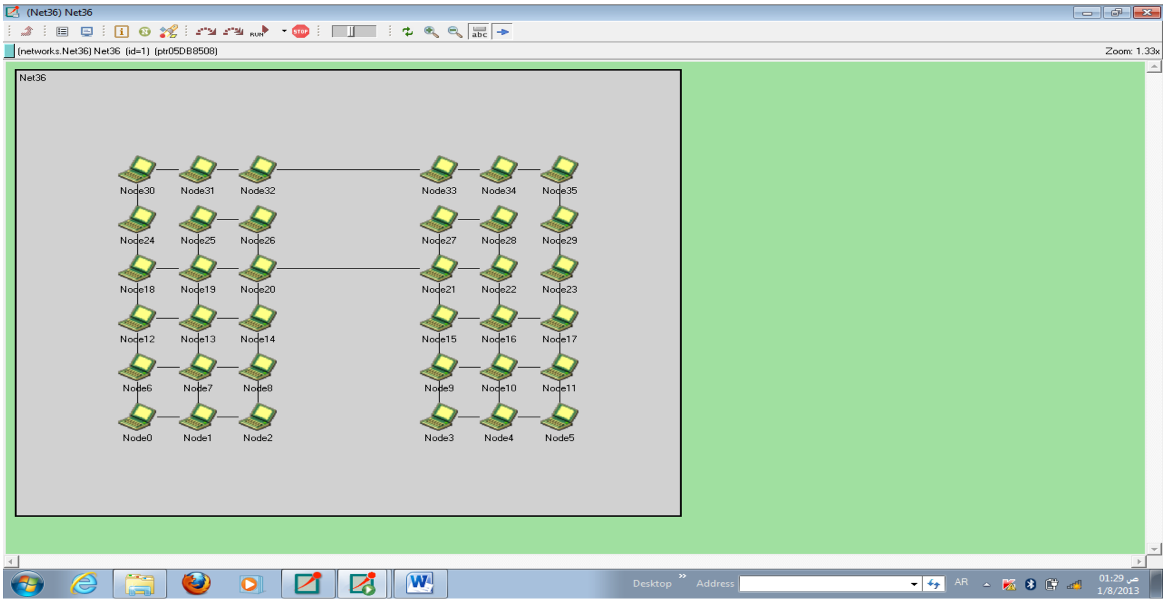

Figure (٩) AN3

After applying**FNN1** on the three networks (**AN1, AN2,** and**AN3**), some results are illustrated as running monitor while the criteria are input. Tables (9) – (11) show that.

Table (9) The simulation results of fuzzy neural network (FNN1) of ad hoc network (AN1) by OMNET ++

Traffic Type	Input variable				Output variable	
	Load of Link (Kbps)		Traffic size		PD of Load link	
	Crisp Value	Fuzzy Value	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
Low Traffic (Kpbs)	8	Normal	111.3	Low - Medium	0.75	Max value
	12	Normal-Loaded	402	High- very High	0.154156	Zero- Min value
	15	Loaded-Over loaded	302.6	Medium-High	0.292507	Min value-Mid value
High Traffic (Mpbs)	10	Normal - Loaded	4.5	Medium – High	0.6021	Mid value-Max value
	3	Under loaded	7	High-Vey high	0.5	Mid value
	18	Over loaded	5	Medium-High	0.375	Min value-Mid value

Table (10) The simulation results of fuzzy neural network (FNN1) of ad hoc network (AN2) by OMNET ++

Traffic Type	Input variable				Output variable	
	Load of Link (Kbps)		Traffic size		PD of Load link	
	Crisp Value	Fuzzy Value	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
Low Traffic (Kpbs)	9.7	Normal-Loaded	303.5	Medium-High	0.512336	Mid value – Max value
	10	Normal-loaded	210.17	Medium-High	0.63147	Mid value-Max value
	4.4	Under loaded –Normal	310.2	High- Very high	0.621489	Mid value-Max value
High Traffic (Mpbs)	13	Loaded	6.9	High- Very high	0.172089	Zero- Min value
	17	Loaded – Over loaded	8	Very high	0.568	Mid value-Max value
	5	Under loaded-Normal	2.3	Low-Medium	0.75	Max value

Table (11) The simulation results of fuzzy neural network (FNN1) of ad hoc network (AN3) by OMNET ++

Traffic Type	Input variable				Output variable	
	Load of Link (Kbps)		Traffic size		PD of Load link	
	Crisp Value	Fuzzy Value	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
Low Traffic (Kpbs)	13	Loaded	300	High- Very high	0.275701	Min value-Mid value
	5	Under loaded-Normal	150.6	Low-Medium	0.75	Max value
	7.2	Under loaded-Normal	299.6	Medium-High	0.588879	Mid value-Max value
High Traffic (Mpbs)	9.2	Normal-Loaded	2	Low	0.75	Max value
	15	Loaded- Over loaded	6	High	0.25	Min value
	17.1	Loaded -Over loaded	6.7	High- Very high	0.1649	Zero- Min value

Some results of simulation details in Tables (12) – (14) show that.

Table (12) The simulation results of fuzzy neural network (FNN2) of ad hoc network (AN1) by OMNET ++

Traffic Type	Input variable						Output variable			
	Bandwidth of link (Kbps)		Link data size (Kbps)		Traffic size		Load of link		PD of Load link	
	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
Low Traffic (Kpbs)	13.2	Small-Medium	11	High	102.5	Low-Medium	13.1897	Loaded-Over loaded	0.245167	Zero-Min value
	9.1	Small-Medium	10.3	Medium-High	208.3	Medium-High	15.1317	Loaded-Over loaded	0.33927	Min value-Mid value
	21	Large	8	Medium	189.02	Low-Medium	7.2306	Under loaded-Normal	0.543393	Mid value-Max value
High Traffic (Mpbs)	8	Small-Medium	10.2	Medium-High	2.3	Low-Medium	13.0405	Loaded-Over loaded	0.311295	Min value-Mid value
	12	Small-Medium	5.5	Low-Medium	4.2	Medium-High	12.0315	Normal-Loaded	0.246751	Zero - Min value
	15.6	Medium-Large	7.1	Low-Medium	4.9	Medium-High	9.5893	Normal-Loaded	0.375	Min value-mid value

Table (13) The simulation results of fuzzy neural network (FNN2) of ad hoc network (AN2) by OMNET ++

Traffic Type	Input variable						Output variable			
	Bandwidth of link (Kbps)		Link data size (Kbps)		Traffic size		Load of link		PD of Load link	
	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
Low Traffic (Kpbs)	13.3	Small-Medium	8.3	Medium-High	200	Medium-High	9.82691	Normal-Loaded	0.375	Min value-mid value
	8.2	Small-Medium	5	Low	105.5	Low-Medium	11.7062	Normal-Loaded	0.31403	Min value-Mid value
	14	Medium	7.2	Low-Medium	180.7	Low-Medium	8.00899	Normal-Loaded	0.5	Mid value
High Traffic (Mpbs)	7.4	Small-Medium	6	Low-Medium	2.1	Low-Medium	12.2231	Normal-Loaded	0.295859	Min value-Mid value
	11	Small-Medium	6.2	Low-Medium	4.2	Medium-High	12.3819	Normal-Loaded	0.215667	Zero-Min value-
	18	Medium-Large	10	Medium-High	3.7	Low-Medium	8.99713	Normal-Loaded	0.5	Mid value

Table (14) The simulation results of fuzzy neural network(FNN2) of ad hoc network (AN3) by OMNET ++

Traffic Type	Input variable						Output variable			
	Bandwidth of link (Kbps)		Link data size (Kbps)		Traffic size		Load of link		PD of Load link	
	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
Low Traffic (Kpbs)	7	Small	9	Medium-High	289.3	Medium-High	18.0001	Over loaded	0.16667	Zero-Min value
	14.5	Medium-Large	10.6	Medium-High	108.2	Low-medium	10.4873	Normal-Loaded	0.380534	Min value-Mid value
	8	Small-Medium	6	Low-Medium	150.9	Low-Medium	12.3408	Normal-loaded	0.309888	Min value-mid value
High Traffic (Mpbs)	12.1	Small-medium	10.2	Medium-High	4.4	Medium-High	14.5814	Loaded-Over loaded	0.3333	Min value –Mid value
	14	Medium	6.6	Low-Medium	5	Medium-High	10.4728	Normal-Loaded	0.373641	Min value-Mid value
	10	Small-Medium	5	Low	2.8	Low-Medium	10.3711	Normal-Loaded	0.36855	Min value-Mid value

Some results of simulation details shown Tables (15) – (17).

Table (15)The simulation results of fuzzy neural network (FNN3) of ad hoc network (AN1) by OMNET ++

Input variable				Output variable	
Load of source node		Load of neighbor		PD of Load the neighbor node	
Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
32.1	Medium-Heavy	12.5	Very lightly-Lightly	0.5	Mid value
6	Very lightly-Lightly	21.1	Lightly-Medium	0.8	Max value
25	Medium	33	Medium-Heavy	0.5	Mid value
40.2	Heavy-Very heavy	49	Heavy-Very heavy	0.3011	Min value-Mid value
44	Heavy-Very heavy	25.2	Lightly-Medium	0.3	Min value
13	Very Lightly - Lightly	13.3	Very lightly-Lightly	0.8	Max value

Table (16)The simulation results of fuzzy neural network (FNN3) of ad hoc network (AN2) by OMNET ++

Input variable				Output variable	
Load of source node		Load of neighbor		PD of Load the neighbor node	
Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
17	Lightly-Medium	12.5	Very Lightly - Lightly	0.8	Max value
36	Heavy-Very heavy	32	Medium-Heavy	0.329	Min value-Mid value
6	Very lightly-Lightly	45	Heavy-Very heavy	0.5	Mid value
10	Very lightly-Lightly	23	Lightly-Medium	0.8	Max value
22	Lightly-Medium	41	Heavy-Very heavy	0.5	Mid value
40	Heavy-Very heavy	27.9	Lightly-Medium	0.3	Min value

Table (17) The simulation results of fuzzy neural network (FNN3) of ad hoc network (AN3) by OMNET ++

Input variable				Output variable	
Load of source node		Load of neighbor		PD of Load the neighbor node	
Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
39.2	Heavy-Very heavy	15	Very lightly-Lightly	0.5	Mid value
20.1	Lightly-Medium	10	Very lightly	0.796072	Mid value-Max value
6.5	Very lightly-Lightly	31	Medium-Heavy	0.62973	Mid value-max value
11	Very lightly-Lightly	47	Heavy-Very heavy	0.5	Mid value-
15	Lightly	10	Very lightly	0.8	Max value
42	Heavy - Very heavy	45	Heavy – Very heavy	0.3	Min value

Some results of simulation details in Tables (18) – (20) show that.

Table (18) The simulation results of fuzzy neural network (FNN4) of ad hoc network (AN1) by OMNET ++

Input variable						Output variable	
Queue size (packet)		Throughput (Kbps)		Arrival rate (Mbps)		Load of node	
Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
3	*Low-Medium*	*14.2*	*Small-medium*	*3.2*	*Less-Medium*	*8.68281*	*Lightly-Medium*
6	*High*	*18*	*Medium-Big*	*13*	*Medium-More*	*23.6621*	*Heavy –Very heavy*
5	*Medium-high*	*12*	*Small-Medium*	*5.6*	*Less-Medium*	*13.4136*	*Medium-Heavy*
2	*Low*	*10*	*small*	*8*	*Medium*	*10*	*Medium*
8	*Very High*	*14.2*	*Small-Medium*	*7.2*	*Less-Medium*	*15.7458*	*Medium-heavy*
7	*High-Very high*	*13.5*	*Small-Medium*	*12.5*	*Medium-More*	*21.7658*	*Heavy - very heavy*

Table (19) The simulation results of fuzzy neural network (FNN4) of ad hoc network (AN2) by OMNET ++

Input variable						Output variable	
Queue size (packet)		Throughput (Kbps)		Arrival rate (Mbps)		Load of node	
Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
6	*High*	*18*	*Medium-Big*	*2.2*	*Less-medium*	*11.0801*	*Medium-heavy*
2	*Low*	*20*	*Big*	*14*	*More*	*18*	*Heavy*
4	*Medium*	*14.5*	*Small-Medium*	*12.2*	*Medium-more*	*17.6182*	*Medium-Heavy*
7	*High-Very high*	*15.7*	*Medium-Big*	*7.9*	*Less-Medium*	*18.7332*	*Heavy-Very heavy*
5	*Medium-high*	*11*	*Small-Medium*	*5.2*	*Less-Medium*	*11.9943*	*Medium-heavy*
8	*Very high*	*18*	*Medium-Big*	*12.6*	*Medium-More*	*24.5689*	*Heavy-very heavy*

Table (20) The simulation results of fuzzy neural network (FNN4) of ad hoc network (AN3) by OMNET ++

Input variable						Output variable	
Queue size (packet)		Throughput (Kbps)		Arrival rate (Mbps)		Load of node	
Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
8	Very High	11.5	Small-medium	7.3	Less-Medium	16.1094	Medium-heavy
3	Low-Medium	15.5	Medium-Big	10.2	Medium-more	16.7044	Medium-heavy
7	High-very high	10	Small	13	Medium-More	21.3102	Heavy-very heavy
2	Low	14.2	Small-medium	8	Medium	10	Medium
6	High	17.2	Medium-big	11.2	Medium-More	22.0929	Heavy-very heavy
8	Very high	18.2	Medium-Big	5	Less-medium	18.4763	Heavy-very heavy

Some results of simulation details shown in Tables (21) – (23).

Table (21) The simulation results of fuzzy neural network (FNN5) of ad hoc network (AN1) by OMNET ++

Input variable				Output variable	
Load of node		Load of link		Load: Sender or Receiver node	
Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
3.5	Very lightly lightly	4	Under loaded-Normal	0.0151635	Normal-sender
15.3	Lightly-Medium	9.1	Normal-loaded	4	Sender
22	Medium-Heavy	5	Under loaded-Normal	4.84086	Sender-Receiver
18	Medium	15.5	Loaded-Over loaded	8.02755	Receiver-Sender &Receive
30.2	Heavy-Very heavy	18	Over loaded	12.0732	Sender &Receiver
28	Heavy- very heavy	10.2	Normal-loaded	8.5154	Receiver-Sender &Receive

Table (22) The simulation results of fuzzy neural network (FNN5) of ad hoc network (AN2) by OMNET ++

Input variable				Output variable	
Load of node		Load of link		Load: Sender or Receiver node	
Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
11.5	Lightly-Medium	18	Over loaded	8.09232	Receiver-Sender &Receive
14.2	Lightly-Medium	3.5	Under loaded – Normal	3.11789	Normal-Sender
16.3	Lightly-Medium	7.2	Under loaded-Normal	3.59222	Normal – sender
31	Heavy – Very heavy	10.2	Normal-loaded	8.1798016	Receiver - Sender &Receive
28.3	Heavy-Very heavy	7.2	Under loaded - Normal	6.40048	Sender - Receiver
2	Very lightly	12.3	Normal Loaded	3.45027	Normal-sender

Table (23) The simulation results of fuzzy neural network (FNN5) of ad hoc network (AN3) by OMNET ++

Input variable				Output variable	
Load of node		Load of link		Load: Sender or Receiver node	
Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy	Crisp Value	Value Fuzzy
9.3	Very lightly - Lightly	13	Loaded	3.98825	Normal-sender
25.9	Medium-Heavy	14.2	Loaded – Over loaded	9.23424	Receiver - Sender &Receive
2	Very lightly	3.1	Under loaded-Normal	0.06688341	Normal-sender
12.3	Lightly-Medium	15	Loaded-Over loaded	6.31	Sender – Receiver
33	Heavy-Very heavy	16.5	Loaded-Over loaded	10.605	Receiver-Sender &Receive
19	Medium-Heavy	18	Over loaded	8.68647	Receiver-Sender &Receive

4- CONCLUSION

In this paper, the load balancing problem in the ad hoc network is discussed. Fuzzy Neural network are used to solve this problem. For this purpose five methods are suggested.

After completing this work, the following conclusions can be derived:

1- The Fuzzy Neural Network technique proves its good performance for load balancing in Ad hoc Network.

2- The load balancing solution in the Ad hoc network must be locally.

3- The number of training epochs of the Fuzzy Neural Network in load balancing isn't increased with the increasing of the size of Ad hoc network (number of nodes & number of links).

4- In applying the load balancing methods on two types of traffic (low and high), it is conclude that, the load balancing in state of low traffic is more flexible than the High Traffic. Because low traffic may be more suitable with link capacity, therefore, this may avoid packet delay or packet loss problems.

5- With compared procedure of the dynamic load balancing with static load balancing, it is found that the first one is good in dealing with the continues changing in network because there is no need to have administer.

6- In this work, load balancing with three types of FNN structures would be taken. Once, N input and one output, here the training and testing take less number of epochs and good result in testing stage, therefore it takes less time to compute the load balancing in any node in network. But with comparing it with the second one (N input and two output) here the operation is complex because that when talking about the training stage the number of epochs will be increased , also in testing stage the result may have less success rate than the first one.

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