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Presenting a Method for Efficient Energy Consumption in Wireless Sensor Networks Using the Topology control and Fuzzy Systems

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Abstract: According to importance the energy consumption in wireless sensor networks, aim of this research is presenting a method to efficient energy consumption in wireless sensor networks. The proposed protocol is based on the basic protocol of topology control with dynamic weight regarding the status of neighbor nodes. Each sensor node has been found its single-stage neighbor, in the first round; it creates graphs and routing using the topology control and only by the distance parameter. In the next periods, regarding the differences in the residual energy of nodes and their load traffic in the previous round, using the fuzzy inference system and applied fuzzy rules and by applying the parameters of residual energy, traffic load and distance, will be performed for selection the connectivity node. The proposed idea is that the degree of any node is not more than 4. One advantage of an efficient protocol in topology management is having the number of optimal neighbor. As the number of connected neighboring nodes is less and more optimized, work efficiency is higher. Due to balancing the energy consumption in all network nodes, the network lifetime, which is the most important concern of wireless sensor networks, is increased. Simulation results show that the proposed algorithm compared with baseline algorithms has better efficiency and performance.

Keyword: Wireless Sensor Network, Topology Control, Energy, Fuzzy logic.

I. INTRODUCTION

Recent advances in electronics industry and communications has been allowed to the production of multi-purpose sensor nodes along with low-cost and low energy consumption in small dimensions with the possibility to communicate over short distances.

These sensor nodes that include components for sensing the environment, data processing and communication have provided the necessary conditions for the emergence of sensor networks. Sensors convert the changes of physical and chemical parameters to electronic parameters.

A wireless sensor network consists of many sensor nodes which is deployed into the mentioned phenomenon or very close to it with high. Location of sensor nodes no necessary to pervious set and adjust. This feature enables the possibility the deployment of this type of nodes randomly and completely in inaccessible or dangerous places. On the other hand, this feature raises the necessity to consider the ability of the self–configurability protocols and algorithms for these networks. Another feature of sensor networks is the collective effort of sensor nodes. Sensor nodes are equipped with a simple processor in order to perform the brief process on data rather than the sending of received raw from the environment and on one hand, local computation will be operate only by helping of their close nodes. This performance means sending the necessary small data and processed instead of sending the raw data and multiple causes the reduce network traffic and also, it caused that data operations perform better and easier. Wireless sensor networks used for measuring the temperature, pressure, light, humidity, etc. [6].

Also, nodes can be deploying on the human body, underwater or on vehicles transportation etc. In fact, each node can be a processor, a receiver/transmitter with a power supply [4].

The most important applications of wireless sensor networks are as follows [18]: In police organization to control the traffic conditions of roads and intelligent highways, identification and tracking arms smugglers in the border areas, In the battle to identify and survey equipment and force the enemy, classification and follow-up the arrangement and direction of enemy forces and friendly forces can be used the wireless sensor networks. Also, to identify the contaminated environments, monitoring the

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environment and frequent and intensive studies to collect information and using the monitoring devices, etc.
Wireless sensor networks used in studying and analyzing the statue of building structures, various applications in the field of wireless sensor networks, medical, etc.
Some applications of wireless sensor networks needs to send the security packet from origin to destination. Therefore, path should be chosen so that it can be provide the required reliability of sent package. On the other hand, energy considered as one of the important parameters of wireless sensor networks. In the most of applications and protocols, according to energy restriction of sensor nodes, reducing power consumption and thus increase the length of the network life is very important [17].

A major issue in wireless sensor networks, Management and energy efficiency in the network. This requirement dependent to various factors which network can be loses its energy through them with a gentle gradient, dynamically. The importance of subject of the paper which is discussed, are saving energy and long-term use of the network.

One of the best ways in which to store and manage energy in the network is discussion of topology control and the connected nodes methods in wireless sensor networks. This solution concludes itself: models, construction and various features to current methods. This performance distributes the overhead of network power and will help to better manage the network. Therefore, the main objective of this research was to develop an efficient method for energy consumption in wireless sensor network using the fuzzy inference system. In addition, management and topology control in wireless sensor networks and distributed topology control algorithm is proposed. Then, an algorithm is proposed for the management and type of connected network with an efficient network based on approach of suggested fuzzy systems. Also, in this paper, to explain the reasons for the use of fuzzy models and compare simulation results, and finally, conclusions is presented.

Literature Research

Topology control is the method of connection and finally, it is relationship between wireless sensor nodes that follows some goals such as improvement the network coverage, dynamic routing, improvement the communication and connectivity, reduce energy consumption and restore of link because of the fact that control distributed topology, is desired connectivity. Methods that have been designed known to control methods. These methods depending on the kind of information that need to build connective node will be divided into three categories: Location-based approach, Direction-based, and finally, neighbor-based approach [9].

In location-based approach assumed that the nodes are aware of their geographic location, for example, nodes can be equipped to GPS systems in order to finding their location LMST & WDTC algorithms belongs to this category and only differences between two algorithms is that WDTC increases network longevity[13]. FLSSK & R&M algorithms follow up the location based approach.

In direction- based approach assumes that the nodes no aware of their position, but they can be used to estimate their neighboring nodes, relatively. This information is usually obtained using a directional antenna. Algorithm CBTC [16], Belong to this category in which each node arises some cones in around of its environment and set the radius of its release. Of unique features of this algorithm is that it can be run as distributed and locally and also, it ensures the network connectivity. In neighbor-based approach assumes that every node hold information about its neighbor nodes such as ID and it can be sort neighbors based on some criteria such as distance or quality of links. Algorithms of KNEIGH [1], and XTC belongs to this category which algorithm XTC has the most conformity with real environments [19, 20].

II. Management of Topology

If the lifetime of wireless sensor network is considered to be relatively short, those algorithms which store lower energy but has less delay could be more appropriate. Since wireless sensor network topology is constantly changing [12] and also reduce radio interference are a large number of packets, ensuring the reliability of these networks is very difficult.

For a long deployment in wireless sensor network, the life of node batteries should be prolonged and it can be done by minimizing the power consumption and by nodes. One way to minimizing the energy consumption is implementation the topology management algorithms in wireless sensor networks. This algorithm can be classified in three categories topology management: 1. topology discovery, 2.Sleep cycle management 3. Clustering [5]. Topology discovery includes a network management station or base station which determines the organization or topology of nodes in sensor networks. Physical connections or logical relationships of nodes in the network reported to the station manager, which holds a topology map of wireless sensor.

One way for algorithm of topology management in order to store of energy in each node is that each node should be ON whenever necessary and rest of times will be OFF. Wireless sensor network is a deployed accumulated. It means that a large number of nodes is available in per area of network. For example, in an area which has deployed 10 nodes, full coverage area may be achieved by only three nodes. This means that 7 nodes will be sent redundant or duplicate information. These additional nodes are considered as superfluous nodes and may not always be necessary. Redundant can be put into sleep mode whenever these waste nodes will be no necessity. Setting of waste nodes, putting

them into sleep and wake up them again is one of the responsibilities of sleep cycle management algorithms.
The main use of energy in wireless sensor network is data transmission. Another way to reduce energy consumption is that lower nodes which are tools of data collection connect to the base station. Clustering algorithm are used to reduce the number of nodes that transmit data to the base station. These algorithms will be sort deployed nodes in wireless sensor network as node or cluster. Each node are known in the cluster as a cluster leader or cluster head (CH). Nodes which are in a cluster, but are not head cluster, become a member of the nodes. Member nodes, transmit their data to a cluster, which usually, this load has lower energy consumption during short trips. Then, cluster head will be integrate all the received information from the member nodes for sending to base station with a smaller volume. "Fig. 1", shows an overview of the sensor network topologies. Part (a) shows a hierarchical network that cluster nodes are located in black color at a high level network and has responsibility of data collection of member node at low-level network in gray color. Cluster head combine received information in order to processing them and send them with lower volume to the base node. In result, energy consumption of network nodes will be lower and lead to a long life of network. Part (b) is a peer to peer network, each node exchange its information with its peer node, and this causes that energy kept life of the network shorten.

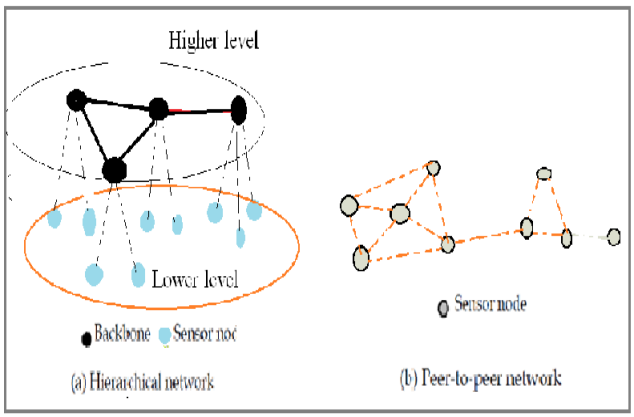


***Figure-1**. Overview of the Sensor Network Topologies.*

To strengthen the performance of the algorithm, other than duties of a typical sensor nodes and cluster nodes can be defined a new role as relay [7, 10]; and backup clusters for definition the other cluster nodes. "Fig. 2", shows the using algorithm in wireless sensor networks for three categories of discovery topology, sleep circle management and clustering.

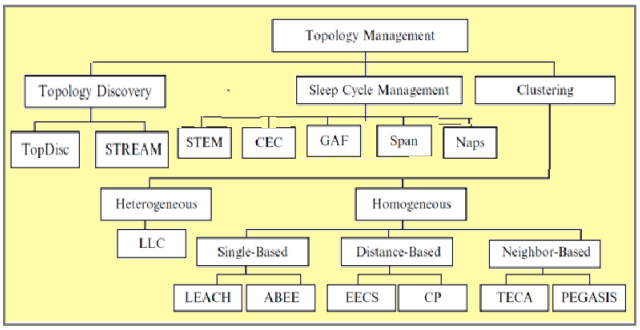


***Figure-2**. Components and Segmentation of Topology Management Algorithms in Wireless Sensor Networks.*

On one hand, protocol stack of sensor network has five layers, including physical layer, link and media access control, network, transmit and application, and also has a three-phase of energy management, move management and task management[14] Task of physical layer is modulation operation, sending and receiving at the low level. Media Access Control layer should be able to communicate with any neighboring nodes and with minimize conflict as broadcast distribution The network layer has the task of routing. Transmit layer has the task of management of packets transmission flow as necessity. Depending on application was designed for network, different types of software applications can be used on the application layer in order to provide different services.

Energy management phase with involvement in all the layers determines the energy consumption of nodes. In fact, we need to energy aware algorithms and protocols in order to reduce energy consumption. Phase of move management which refer to the use of location-aware methods in different layers identify and record the movement of nodes, so nodes are moving and, if necessary, is managed. Management phase schedule and balance the tasks of nodes. Despite these mentioned items, nodes in sensor network which can be work with energy-aware methods, they can route data in a mobile sensor network and share resource between the nodes.

In research [14], another protocol stack has been proposed for sensor a network which is called cross-layer. In this protocol stack, a boundary is very weak between different layers and layers have been developed in a hierarchical framework and integration is developed. This loosened of the layer boundaries is for the sake of restrictions and special applications of sensor networks and makes it possible to optimize and adaptable strategies and protocols for sensor networks.

III. Related Works

Due to this that wireless sensor network nodes are very small and their energy supplied by the battery and also,

battery energy is limited, therefore, researchers have been provided different algorithms to minimize the energy consumption in wireless sensor networks. but favorable result has no obtained yet for solving the energy shortage problem entirely, or close to it. Scientists To achieve this goal create a proper topology to continue their efforts. Therefore, the consumption energy of nodes must be minimized in order to increasing the node life. So, reducing the error and increasing the tolerance of error in wireless sensor networks causes that energy and time duration of nodes will be kept and increased[3]. Some protocols has been created and developed which we can be refer to WDTC and LMST with a better efficiency and performance rather than the other proposed protocols. So, by the solving the problem of energy nodes that are important challenges of wireless sensor network [8,10], many unresolved issues will be responds in this area.

In follow, The two neighborhood-based algorithm will be described. To understand the algorithm of this kind, we offer the following definitions. Definition (k neighborhood graph): by assuming that N is a set of nodes which is distribute in a given area of R and [N]=n. By having k which is 0<k<=n-1, we show the graph k neighborhood will be built on the N by the symbol GK=(n,Ek). GK is a directed graph which comes from connecting of each node with nearest neighbor k. Also, directed arrow is (u,v) ∈ Ek if and only if $\delta(u,v) \leq dk(u)$ which dk(u) is its distance between node u and its neighboring node k. Note that created neighboring relation is asymmetric by GK. It means that nodes u and v exists so that v is neighbor of u in GK but u is no a neighbor of v [1].

- LMST1 Protocol

This protocol made of a simple graph indirectly. So that, v is a collection of nodes and E is a set of edges, so that, $E = \{(u,v): d(u,v) <= dmax\ , u,v \epsilon V\}$ here d_{max} is the maximum transmission range of node [11].

Available neighbors is defined for each nod as $NVu = \{v \in V(G): d(u,v) \leq dmax\} and\ Gu = (NVu\ , Eu\ )$ which this graph is called decreasing graph G. Of this algorithm can be used to solve of binary and reduce the cost of telecommunications. LMST goes according to the following four steps:

1. Step of the collection of information: Each node will be send one message of Hello in order to identify their neighbors by maximum of its ability, periodically that is called Nvu. Node u makes available one graph according to its neighbors.
2. Creation the Topology: each node creates a local MST and this MST belongs to the local geometry of the graph.
3. Definition the maximum power: each node has a definition of sending power which is same as access to the most distant neighbors.
4. Creation the topology with both side edges: most relationships of G0 may be one-sided. There are two ways to achieve the bidirectional communication topology: (1) Converting all one-way to two-way communication in graph G0, (2) deleting all unidirectional communication.

- WDTC Protocol

WDTC[2] protocol is also derived from MST base protocol. The only major difference is the use of weight in selection of decision-making of this protocol [13].

This algorithm is used for communication that the energy consumption of networks along with limitation Steps of performance of this algorithm of topology control are as follows:

1. In the first phase: Each node will be distribute one message of Hello by maximum of its ability, periodically. This message concludes node ID, location position and energy.
2. Node u devoted each edge of the graph with the weight function defined as:

$W_{(u,v)} = W_{(d_{uv}, E_u,} d_{uv} \leq d_{max}$ where d_{uv} is Euclidean distance between nodes of u and v. E_u a nd E_v are remaining energy of u and v nodes. Function of W must be increased due to the increasing u and it is logical that weight of link will be increase by increasing the distance and it will be decreased by E_u and E_v . Weight of edge is as the function of relational cost of network nodes. w defined as follows: $W_{(u,v)} = d^a_{uv}(\frac{1}{E_u} + \frac{1}{E_v})$ where d^a_{uv} considered as consumption energy for sending the information package between two nodes of u and v with distance of d_{uv} . The cost of a function is symmetrical as that $W_{(u,v)} = W_{(v,u)}$ that it ensures that all links are two-way. The purpose of this algorithm is having the edges with minimum energy consumption and higher weight. Thus, the function $W_{(u,v)}$of is defined as required.

3. Then, each node continues the calculation of MST-WT_u of graph G_u according to Kruskal's algorithm which is dependent on the weight of $W_{(u,v)}$. $MST - WT_u$ Indicates he edge height and energy consumption information over the edge. As a result, collection of node neighbors u can be formed according to the distance and energy consumption and energy consumption tend to balance out. It means the aim of the work will be reducing the energy consumption, too.

IV. Suggested Method

A. Research Methodology

[1] - Local minimum spanning tree

[2] - weighted dynamic topology control

In this study, after collecting relevant information from a variety of sources, articles and books in the field of wireless sensor network, to review the efficient protocol in topology control to reduce energy consumption is discussed. Then, suggested idea and proposed algorithms has been simulated that simulated protocols compare and evaluate based on the same scenarios and after how performance of existing algorithms, diagram of preparation and the results have been checked, conclusions have been made, finally. In this study, an application coding was done which produce one hundred nodes in random places to feel the temperature of the surrounding environment and by sending data packets and information packets, the necessary information collect to the network control processes and routing. Simulation environment used in this study was simulator of NS2 and energy parameters remaining nodes, normal routing load, time of the death belongs to the first network node and similar items have been studied.

B. Suggested Method

In this study, we are looking for a way to improve the wireless sensor network topology control in connectivity rate of neighboring nodes. Also, It is assumed that the radio range of sensors, with increasing distance, is low [15]. (This assumes correspond to the reality). This method will be suggest by utilizing the fuzzy logic.

Meaning the fuzzy logic to be noted that in the real world, many arguments and human reasons have aspect of uncertainty and approximation [2]. Phase inferences also consist of the following main parts: 1. fuzzification, which converts input parameters to fuzzy values do gives. 2. Knowledge base, which keep all functions and fuzzy rules in itself 3. Inference engine, which determines the mechanism of argument system 4) defuzzification, which convert the output of the system to a certain number of true values. The overall process is shown in "Fig. 3".

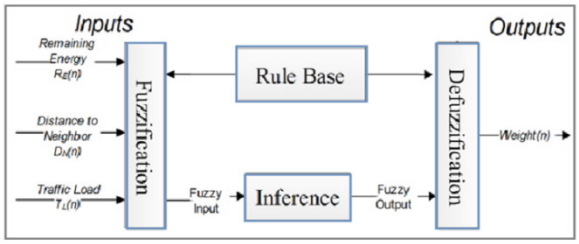


Figure-3. *Overall Block Diagram of a Fuzzy Inference system.*

Topology control or connectivity of wireless sensor networks, related directly to the amount of energy consumption, death time of network nodes, collision rate and especially, the efficiency of network routing. Therefore, based on the characteristics of the mentioned methods, we are looking for finding the solutions and avoidance of their impairment. Therefore, a method based on fuzzy logic to make dynamic topology of a network will be used to deal with any possible error Therefore, only criteria of distance which is used in the most of known protocol known in this area cannot be consider as a criteria. Therefore, the parameters such as the amount of residual energy node, the level of traffic on the node in the last round and distance have been used as input-phase system. Thus, each node has a higher value on the output of system can be connected to the start node. "Fig. 4", shows a diagram of the proposed method.

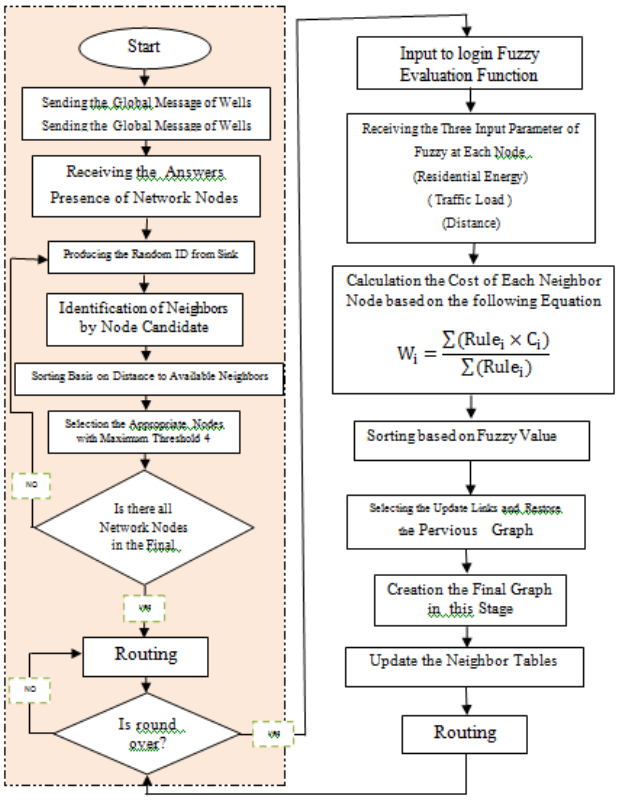


Figure-4. *Proposed Method Diagram,*

Reasons for using fuzzy logic are as follows:

Despite of other optimization algorithms and decision, making we need to take the right decision at any Moment, since selection one topology between nodes in the immediate period will be criteria for decision-making. In other words, half of routing and energy efficiency of the next round, for the sake of the current topology of the network graph of nodes. So, only the first step in terms of distance, we attempted to create a topology of network, but from the first round onwards for variation in the residual energy and traffic nodes on each node, our decisions will be accurate. We proposed a fuzzy logic based on information available on the network between neighbor nodes in network in order to choose the best option or options. But because of the fact that the weight of each of the parameters of our decision-making is different, so, the best method with minimal

overhead on the network without repeat is the use of a fuzzy logic with three input parameters of the residual energy, value of distance to neighboring nodes, load and one output node which is called weight of node. Output parameter of fuzzy system is the value of the node in the process of topology.

Another important reason for using fuzzy logic is this that in fuzzy system can be convert written rules by human to phase system and phase-system will be act according to the applied rules. Table 1 display 27 applied rule to phase system of proposed method. Due to the change of results in each case, the result of running the simulation will be change, too. So, we should be having the necessary accuracy in selection of result for various cases of phase rules.

Also, in the proposed method, one aware topology control of the energy traffic load is presented in wireless sensor network which operate about node connectivity of network dynamically and immediately.

In this method, to be able to obtain a report on the status of a node should be divide time of protocol activity into units of time. The equal division for this that fair establish in different time periods. Method the selection of this sampling period should be clever, because if you select a short interval, the accuracy report is not obtain and new topology will be calculate with a high error. Also, if we consider time efficiency, accuracy decision will be no achieved any time since during this long period of time, the node may have a different behavior.

As fuzzy logic and triangular model which suggests each input parameter fuzzy system includes a graph of triangulation in each diagram. Because of the triangle marked and the same can be used to treat a parameter variables x axis other values on y-axis.

The primary volume of energy in the beginning of network is considered 10 for high threshold and 0 for low threshold which will be indicate finishing the energy node in network. This volume of energy for each node to be placed at three levels of High, Medium and Low. Amount of network switching nodes is placed in one of these surfaces or at two levels. According to the lower amount of the remaining energy, node represents the low value.

Second inlet of suggested phase system is the distance from neighboring nodes. For example, in the proposed network, the maximum distance is considered equal to the radius of the network. This variable can be between zero and 1 for one node. As this amount is high for a node, lower priority to the selected node to participate in the process of topology graph. In other words, increasing of this parameter can be increase power consumption, too.

But third inlet of suggested phase system is considered by traffic load of node in recent sampling time. This parameter concludes the participation rate of this node in a network routing process. Higher volume shows congestion and possibility. So, priority node selection for participation in the network topology will be reducing in the former routs.

In this study, the phase-field system for decision-making and for fuzzification and defuzzification of triangular membership functions are used. For the distance to the source node's neighboring nodes, each node will have a numeric value. This amount is limited in the range of between 0 to 70/71 meters. For each numerical value of three input phase system, we have to imagine a case. Each parameter is multiplied based on the number of levels in other parameter to obtain all possible scenarios. The rate of remaining energy of nodes classified in three levels, distance of source node to the neighboring node of traffic levels and sampling interval To consider all the possible scenarios, 3 mode is intended that a total of 27 cases will be occur. So, in every moment of the work, network with each input level is admittedly one of the modes available in 27 cases which each of these cases represents a rule. Value NC can be calculated according to table 1 for different modes.

Table-1. *Fuzzy Rules Proposed for Three Input Parameters.*

Rule	**Antecedent**			**Consequent**
	Remaining Energy $R_{E_{(n)}}$	**Distance to Neighbor** $D_{N_{(n)}}$	**Traffic Load** $T_{L_{(n)}}$	**Node Cost** $NC_{(n)}$
1	Low	Low	Low	Low
2	Low	Low	Medium	Medium
3	Low	Low	High	Low
4	Low	Medium	Low	Medium
5	Low	Medium	Medium	Medium
6	Low	Medium	High	Low
7	Low	High	Low	Low
8	Low	High	Medium	Low
9	Low	High	High	Low
10	Medium	Low	Low	High
11	Medium	Low	Medium	High
12	Medium	Low	High	Medium
13	Medium	Medium	Low	Medium
14	Medium	Medium	Medium	Medium
15	Medium	Medium	High	Low
16	Medium	High	Low	Low
17	Medium	High	Medium	Low
18	Medium	High	High	Low
19	High	Low	Low	High
20	High	Low	Medium	High
21	High	Low	High	Medium
22	High	Medium	Low	High
23	High	Medium	Medium	High

24	High	Medium	High	Medium
25	High	High	Low	Medium
26	High	High	Medium	Medium
27	High	High	High	Low

For example, one instance of computation will be described for finding the node weight. Suppose that node A has a residual energy of 8 Joule, the distance amount will be equal to 30 meters and traffic load equals to 6/6, too. According to "Fig. 5", residential energy of nodes located on two triangles of high and medium. In point of 8 on a vertical axis, we draw one perpendicular. Two triangles with have medium and high center will be cut together. We parallel cut points on y-axis. So, the below numeric values will be output.

$$\mathrm{R_E}(8)\mathrm{Medium} = 0.4$$

$$\mathrm{R_E}(8)\mathrm{High} = 0.6$$

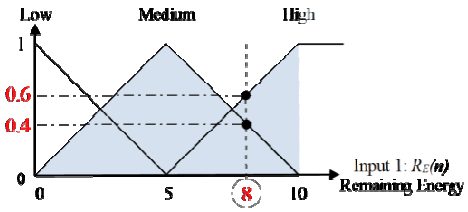


Figure-5. *Shows an Example of Fuzzy Numbers of the Remaining Energy of a Node and the Resultant Phase.*

For the distance rate of neighbor to source will be act as above same computation which lower values are obtained according to "Fig. 6":

$$\mathrm{D_N}(30)\mathrm{Low} = 0.2$$

$$\mathrm{D_N}(30)\mathrm{Medium} = 0.8$$

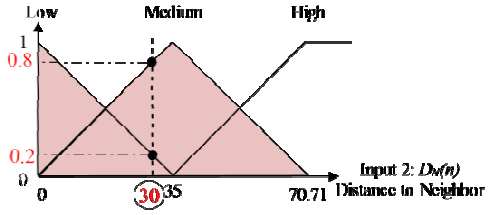


Figure-6. *Shows an Numerical Example of fuzzification for Rate of the Fuzzy Distance of the Source Node with the Neighbors and the Resultant Phase*

Finally, for the third input parameter, one phase has been sampled which is indicating the traffic load in the neighboring node in period of time. "Fig. 7", is a model.

Parallel value on y-axis will be as follow for nodes with transactional traffic at a rate of 6.6:

$$\mathrm{T_L}(6.6)\mathrm{Medium} = 0.7$$

$$\mathrm{T_L}(6.6)\mathrm{High} = 0.3$$

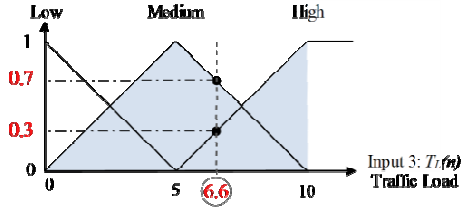


Figure-7. *Traffic Load of Neighbors and its Resultant Phase.*

$$\mathrm{R_E} = 8, \quad \text{Medium} \,\&\, High \Longrightarrow M = 0.4\ , \quad H = 0.6$$

$$\mathrm{D_N} = 30, \quad \text{Low} \,\&\, Medium \Longrightarrow L = 0.2\ , \quad M = 0.8$$

$$T_L = 6.6, \quad Medium \,\&\, High \Longrightarrow M = 0.7\ , \quad H = 0.3$$

Now, for every phase of every Parameter, we have other parameters. So, we will be achieved to 2^3.
Table 2 shows the rules of above example and numeric values of each rule.

Table-2. Presentation of the Rules Numerical Values.

Rules	***Value***	***Result***
$R_{E_{Medium}} \times D_{N_{Low}} \times T_{L_{Medium}}$	$0.4 \times 0.2 \times 0.7$	0.056
$R_{E_{Medium}} \times D_{N_{Low}} \times T_{L_{High}}$	$0.4 \times 0.2 \times 0.3$	0.024
$R_{E_{Medium}} \times D_{N_{Medium}} \times T_{L_{Medium}}$	$0.4 \times 0.8 \times 0.7$	0.224
$R_{E_{Medium}} \times D_{N_{Medium}} \times T_{L_{High}}$	$0.4 \times 0.8 \times 0.3$	0.096
$R_{E_{High}} \times D_{N_{Low}} \times T_{L_{Medium}}$	$0.6 \times 0.2 \times 0.7$	0.084
$R_{E_{High}} \times D_{N_{Low}} \times T_{L_{High}}$	$0.6 \times 0.2 \times 0.3$	0.036
$R_{E_{High}} \times D_{N_{Medium}} \times T_{L_{Medium}}$	$0.6 \times 0.8 \times 0.7$	0.336
$R_{E_{High}} \times D_{N_{Medium}} \times T_{L_{High}}$	$0.6 \times 0.8 \times 0.3$	0.144
	Sum of All Rule = 1	

We imagine one mode for each value of three phase system parameters. Each of the parameters on the basis of their r levels in other parameter is multiplied to all possible scenarios However, according to Table 3 for the moment; there are 8 modes that are dependent on the input parameters. After corresponding to each mode may be on the table, a specific value of the law will be applied. In other words, the value of each of the 8 case may be different. So, at a fraction of the number 1 is multiplied to determine the exact amount of value.

Each of the above scenarios presents a rule that NC value accordance with Table 1. Thus, using the results of the above-mentioned rules and replacement of fixed numbers rather than the result of any rule, can be achieved the results of mentioned example as described in Table 3.

Table-3. *Computation the Value of the Membership Function for each Rule and Every Rule.*

Rules	***Result***	***Rule***	***Cost(i)***
$R_{E_{Medium}} \times D_{N_{Low}} \times T_{L_{Medium}}$	0.056	11	1
$R_{E_{Medium}} \times D_{N_{Low}} \times T_{L_{High}}$	0.024	12	0.5
$R_{E_{Medium}} \times D_{N_{Medium}} \times T_{L_{Medium}}$	0.224	14	0.5
$R_{E_{Medium}} \times D_{N_{Medium}} \times T_{L_{High}}$	0.096	15	0
$R_{E_{High}} \times D_{N_{Low}} \times T_{L_{Medium}}$	0.084	20	1
$R_{E_{High}} \times D_{N_{Low}} \times T_{L_{High}}$	0.036	21	0.5
$R_{E_{High}} \times D_{N_{Medium}} \times T_{L_{Medium}}$	0.336	23	1
$R_{E_{High}} \times D_{N_{Medium}} \times T_{L_{High}}$	0.144	24	0.5

Now, in the proposed equation, we will be achieved follow numeric value after substitution:

(Relationship 1)

$$Result = \frac{\sum_{i=1}^{n}(R_i \times c_i)}{\sum_{i=1}^{n} R_i} \qquad (1)$$

In above relation, C_i equals to 0 for low value. for medium equals to 0/5 and for high equals to 1.

Value rate of neighboring nodes is considered according to the intended input W_i. In this algorithm, the threshold index is considered as the number 4 of neighbors. Thus, the nodes with higher value have priority participation in topology.

$$W_i = \frac{(Rule_{11} \times C_i) + (Rule_{12} \times C_i) + (Rule_{14} \times C_i) + (\text{illegible})}{(Rule_{20} \times C_i) + (Rule_{21} \times C_i) + (Rule_{23} \times C_i) + (\text{illegible})} = \frac{}{Rule_{11} + Rule_{12} + Rule_{14} + Rule_{15} + \text{illegible}} \; Rule_{20} + Rule_{21} + Rule_{23} + Rule_{24}$$

After the substitution, we have:

$$W_i = \frac{(0.056 \cdot 1) + (0.024 \cdot 0.5) + (0.224 \cdot 0.5) + (0.096 \cdot 0) + (0.084 \cdot 1) + (0.036 \cdot 0.5) + (0.336 \cdot 0.25) + (0.144 \cdot 0.5)}{(0.056) + (0.024) + (0.224) + (0.096) + (0.084) + (0.036) + (0.336) + (0.144)}$$

As a result, we have: $W_1 = \frac{0.438}{1} = 0.438$

The value of neighboring nodes according to the considered input equals to 0.438. In this algorithm, we will consider the threshold number of neighbors. So that nodes with high value have the priority participation in topology. In most algorithms, the maximum number of neighbors has been considered 4. So, according to Table 4, the nodes will be selected at a higher value.

Table-4. *Example of the existing Calculation Tables in the Head Cluster with Sample Numbers.*

Node ID	17	6	22	73	99	18	4
W_i	0.325	0.286	0.393	0.481	0.311	0.438	0.374
Selected Nodes			✔	✔		✔	✔

V. Simulation

One proposed idea has been implemented in the network simulation environment is a simulation NS version 2/34 and results has been evaluated with basic algorithms. Given that the relevant parameters to the network topology control mechanism is intended, so, energy consumption and improve routing in the network are the main objectives of this study. In these tests, many number of sensor node has been distributed in simulation environment and we want to study that proposed method and similar methods how efficient in selection of optimal graph in network.

In all procedures has been used from protocols and routing choice of AODV [3] with dimensions of x 1 m. Time Simulation is considered hundred seconds which one sink with primary energy 100 ml of and transmission range of thousands of meters is located in the network center. The network has 100 nodes which are randomly distributed. The initial energy of each usual is considered 10 ml node and transmission range of 100 meters. Type of produced data is environment temperature.

[3] - Ad-hoc On-Demand Distance Vector Routing

After the implementation of the proposed approach, an overview of the connections can be observed between the nodes on the network at various time interval in the form of lists.

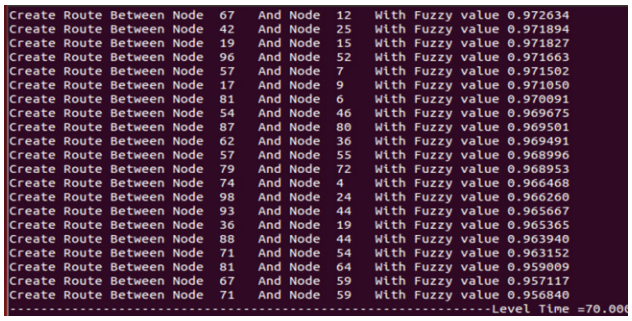


Figure-8. *Display of Logical Connectivity of Network Nodes in the Seventh Round.*

After the implementation of the proposed method, output is displayed as shown in "Fig. 9".

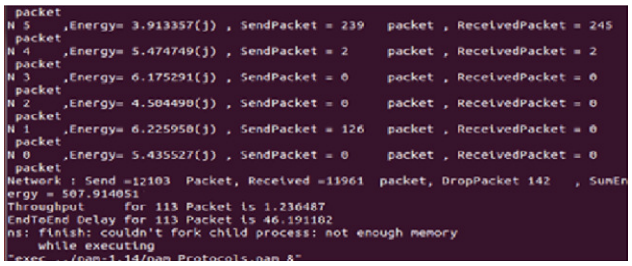


Figure-9. *Display of The Proposed Method Output.*

Also, "Fig. 10", display the graphical mode of signal exchange between nodes in a sensor network which its.

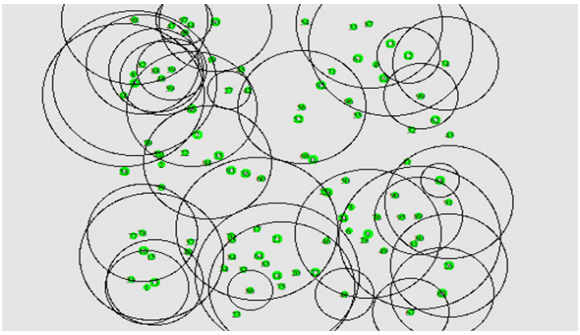


Figure-10. *graphical display of network nodes deployment and exchange of signal between the nodes of the sensor network in propose method.*

Outcome simulation is shown below:

- Test of the Remaining Energy of Nodes

In "Fig. 11", observe that the energy consumption of the proposed protocol has positive and acceptable results to protocols of LMST and WDTC in the same condition with 100 node. Distribution network load on the network nodes and aware routing of energy, traffic load and distance using fuzzy logic causes to improve the transmission of information packets, latency and as result, it causes to increase the overall network efficiency and, ultimately, it helps to better performance.

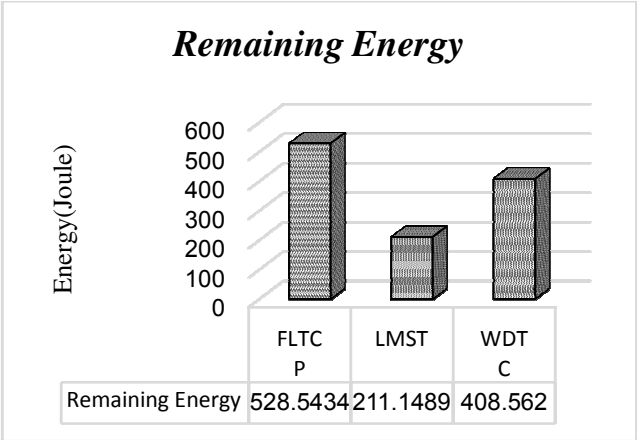


Figure-11. *Diagram of the Remaining Energy of Network in 100 Seconds.*

- Test of the Death Time of the First Node

"Fig. 12", indicates the results of study test about death time of the first sensor node for three protocols in the same condition and represents longevity sensor nodes in the proposed protocol. The results shows that the proposed protocol, has increased energy consumption twice . But the important point in this context is that the death of the first node in the network simulation is 100 seconds for the proposed protocol did not randomly . So, to find of this time, simulation time has been increased to 200 seconds for this test .

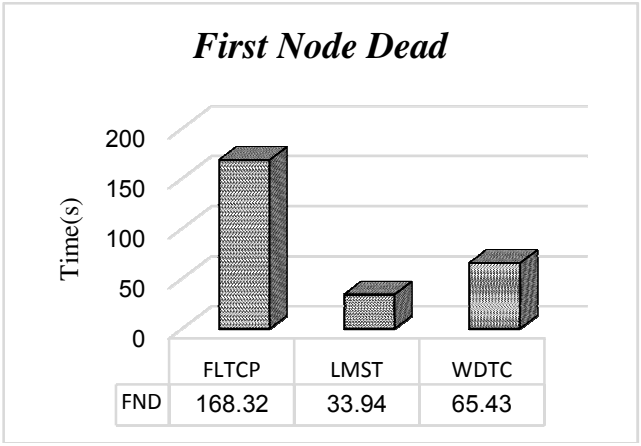


Figure-12. *Test of the Death Time of the First Node.*

- Test of Number of the Routing Packets

The mentioned test shows the number of sent and received packets in order to concluded of this assessment what extent have produced depending on the network to deliver healthy. Always, whatever the number of sent and received

packets is closer together, the protocol process would be more appropriate.

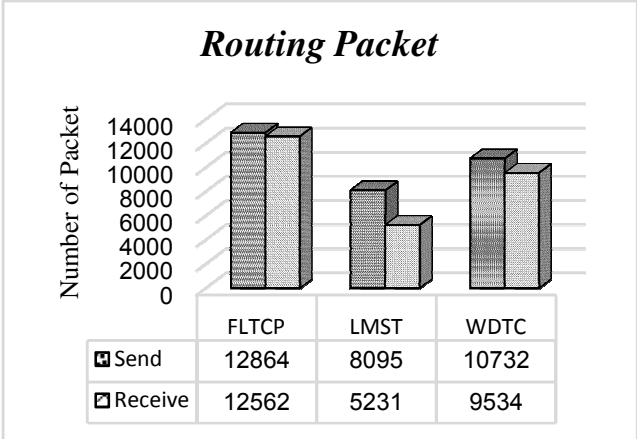


Figure-13. *Number of the Navigated Package.*

- Test of the Number of Lost Packets in Network

In routing network, if routing process will be succeed in transmission of information packets, therefore, number of lost packets will be reduced in the simulation. There are several reasons for loss packet of network information, which some of the most important reasons include: failure link, finishing the energy of interface node, over delay to the threshold, the congestion and such cases. "Fig. 14", shows the test results.

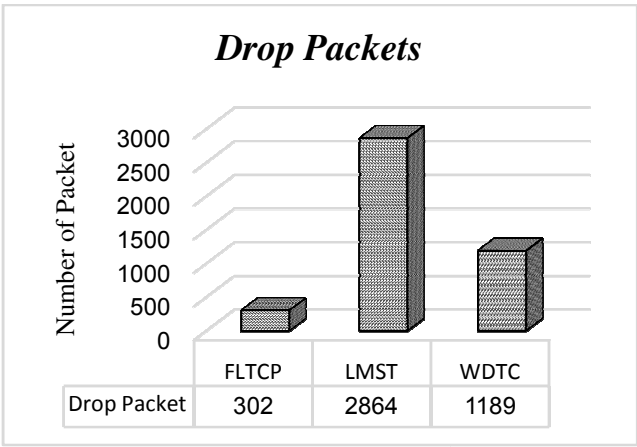


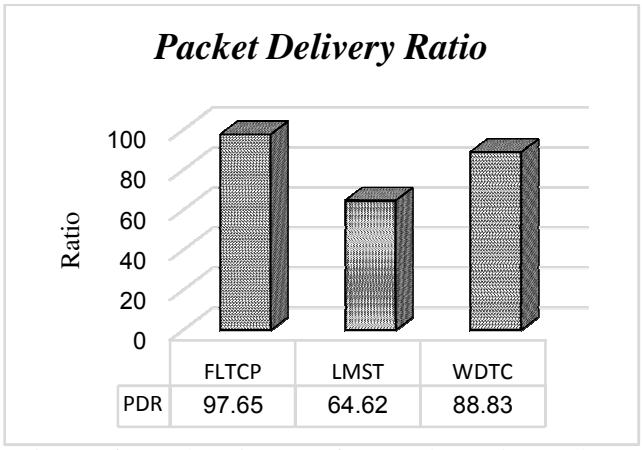
Figure-14. *Diagram of the Number of Lost Packets in Network.*

- Network Packet Delivery Ratio Test

This amount is calculated as a percentage based on the following formula:

$$FDR = \frac{\sum Received\ Packets}{\sum Send\ Packets} \times 100 \qquad (3)$$

In other words, ratio of received information packets is based on percentage over the number of sent packets in network. Certainly, whatever the result of this percentage is higher, network efficiency will be better. The test results are shown in "Fig. 15".



igure ***Figure-15.*** Diagram of Network Routing Packet Delivery Ratio

VI. Conclusions and Future Work

A. Conclusion

In this study, a protocol of aware topology control of energy and traffic load provided in wireless sensor networks that performed concern to network nodes connectivity in real time, dynamically. To insert the variable of traffic load in proposed control system could lead to congestion control, reduce the energy consumption and reduce the number of lost packets lost in network that is one criteria of the quality of service in wireless sensor networks.

In this research, the proposed approach has been considered based on fuzzy logical which is called FLTCP[4] in form of distributed protocol. This approach could efficient the consumption of energy using the combination of topology control and fuzzy system. It means that in first round, using the control and just using the distance parameter operation to create graphs and routing action, then in the next period using fuzzy inference and applied fuzzy rules and by applied the residential energy parameters, traffic and distance operate to select a connected node, to create the graph that this enabled routing network speeds on different nodes of the network. So, in this regard, almost all the energy nodes on the network routing and exchange of information was used for supervising the work and it caused that the death of the first network node will be happen later. The proposed protocol caused to prolong of network life for the sake integration, dynamism and balance in the use of nodes energy and also, it causes to maintain and enhance of fault tolerance. Simulation results shows that the proposed protocol is more efficient in comparison with other similar methods. Table 5 compares the results of the proposed

[4] - Fuzzy Logic Topology Control Protocol

method with other topology control protocols in wireless networks for error tolerance and yv0nmaintain of network connectivity with different approaches.

Table-5. comparison the topology control protocols in wireless sensor networks and proposed method.

Protocol	Approach	Connectivity	Fault-Tolerance
R&M	Loc-based	Yes	No
LMST	Loc-based	Yes	Yes
CBTC	Dir-based	Yes	Yes
RNG	Dir-based	Yes	No
LINT/LILT	Neigh-based	Unknown	No
WDTC	Loc-based	Yes	Yes
XTC	Neigh-based	Yes	No
FLTCP	Loc-based	Yes	Yes

B. Suggestion for Future Work

In this study, which was conducted on the same network, positive results was achieved. Another effective ways which can be useful is third type of nodes which is known as Voter. These nodes are richer than of ordinary nodes in network in range of radio radius and energy. Therefore, much algorithms complexity put into these nodes.

However, due to their nature, nodes Voter can play the role of relay. These relays prevent the network failures and also, it will be increase tolerance of network.

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