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Neuro-Fuzzy Routing with Clusters in Wireless Sensor Network

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Abstract - Wireless Sensor Networks (WSN) are used in a extensively large number of applications. Based on the advanced development of sensors nodes, routing of data becomes an interesting concept in WSN. Many routing protocols were designed by researchers all over the world concerning about battery power, sensing data, networking lifetime and transmitting data etc. This paper concentrates on routing the data in an intelligent manner than the existing routing protocols. Aggregating the data with the help of clusters from the nearby nodes and the cluster heads are responsible to send the collected data to one or more Sink Node(SN) that request for data. This paper ponders on clustering with neurons in the cluster heads and thereby gathers the needed and correctly sensed information very faster based on fuzzy inference system. Neuron in the form of cluster heads gathers and remembers the data. With the help of NS2 simulator this algorithm is very clear that it surpasses the other routing protocols in an abundant number of ways.

Keywords **:** Neurons, Clustering, cluster head, SN, Routing, Energy efficient, Fuzzy.

I. INTRODUCTION

WSN is an interconnection of stumpy energy devices called sensor nodes that are distributed to capture environment modes, like movements, trembling, high temperature, volumes, or density and send the grouped data packets to the SN in the Network (A.I. Saleh et al.,2017). Autonomy, Reliability, Robustness and Flexibility are the requirements needed to monitor an environment.(Chahat Aggarwal et. Al 2018). Individual sensor nodes assemble the data from the atmosphere and handover it to the Cluster heads. SN gathers cluster heads information and does all types of data processing and computational activities. WSN nodes may be assumed to be static or dynamic according to the situations. Each node communicates with each neighbour node through the clusters heads. The cluster heads forms an interconnection with themselves to work properly even though a cluster head fails to send data or it may suffer from other environmental problems. Wireless Sensor nodes (each node) have a built-in device known as concentrator(forwards the data broadcast signals), so the nodes are capable of routing data packets independently all over the network rendering to a predefined sending process (Abreu et al., 2014). Sensor nodes lose their battery power due to the digital processing and transmission of data. So energy should be saved in order to maintain the network properly. The four modes of nodes are Cluster Head, Cluster member, Dead Node and isolated node.[Manju Bhardwaj]

As sensor nodes consume more power, many efficient routing protocols are necessary to be developed for reducing power consumption and prolong the lifespan of the system. An intellectual routing protocol is introduced in this research in order to route the data efficiently and accurately. In this paper we have proved by using the NS2 simulator that this neuro-fuzzy based routing protocol outperforms the other protocols used in Sensor Networks. The throughput is calculated for different network parameters using the NS2.

II. BACKGROUND

The WSN encompasses constituents such as sensor nodes and these nodes are connected to a cluster head. Various cluster heads gathers the data and connects with SN to transmit the congregated data. The topology of the network may change regularly that indicates the self-regulating protected routing data. Hence, the direction-finding information must be refreshed at every time to direct the data to SN. Based on the original application of the sensor nodes, data may be transported from sensors to SN by using four different techniques. They can be classified as; (i) Event Driven Routing (EDR), (ii) Continuous Routing Mechanism (CRM), (iii) Query-Based Routing (QBR), or (iv) Hybrid Routing Mechanism (HRM). In EDR, data is

conveyed to SN when an incident of regular event is triggered. Agreeing to CRM, data composed by the sensors flows endlessly to the Base Station(SN). Alternatively, in QBR, data is regulated to the Base Station as a response of the explicit request of the SN. To conclude, HRM associates a number of above mentioned routing protocol or altogether of the previously mentioned routing protocols (Papadopoulos et al., 2012). Query driven routing mechanism is focussed at a greater view due to movement of nodes in the network.

Routing is based on the concept of directing the data from the cluster heads towards one or more base stations (SN), i.e., the variety of the routing path or the arrangement of cluster head nodes to intentional destination (SN). To realise the above mentioned process, there are assured stages that should be applied to WSN. The different stages in the each phase divide the data aggregation process to the scheduled operation. Information gathering process could be done based on dividing the phases such as route discovery, replying to the routed data, and last phase known as maintenance phase.

Route finding is a preliminary step to construct the system topology and required direction-finding mechanism. The route discovery mechanism wishes to find the maximum path between sensor nodes and at the equivalent time reduce the liveliness of the network with less battery intake. i.e. route detection imparts the nodes in what way to keep in touch with the SN (Ma et al., 2013). The data reply phase might monitor the path detection phase. In data reply phase, the individual nodes starts giving reply data to the Base Station(SN) by means of collected data during the route discovery phase about the number of paths and the network topology.

The intention of data reply phase is to diminish the power consumption wherever it carries data packets from a node to another in the routing path. Additional objective of this particular phase is to increase more reliability and delivery ratio of data transferred decreasing the overhead. Maintenance phase is always there to check whether there occurs a problem in routing the data. If a problem occurs in the routing phase then the maintenance phase begins to resolve the problem. Some of the problems that are faced are mostly the error in the routing path, non-reliable data; battery consumes more power and node separation in the network. (Ma et al., 2013).

III. PREVIOUS WORK

A multi-aware query driven (MAQD) routing protocol recommended by (Ahmed I. Saleh et.,al 2017) is created with the help of neuro-fuzzy inference system. Conferring to routing protocol MAQD, whenever the base station required to assemble data from specific/all nodes, it spread a request message named (REQ) requiring the nodes from which the data is to be collected. A special table is constructed immediately whenever the queried nodes receives SN's request, and announces the query message to the neighbour nodes. On receiving the query the nodes should reply to the SN. The path is carefully chosen affording to SN's responsiveness which is obviously mentioned in the query. Hence, MAQD used the message called REQ not only to broadcast SN's query but also to recognize the network topology.

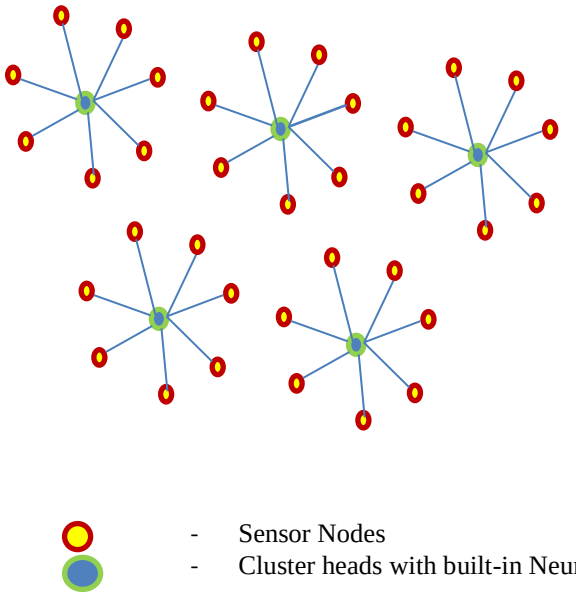
Two important tasks are outperformed by the REQ messages broadcasted by the SN to the adjacent nodes. First task is to reply for the data, and the second important task says about the topology updates of the nodes. The base stations are more conscious regarding the power consumption, time delay, the shortest path and the total cost and its flexibility. The REQ message is received by the nodes and it will check whether it has to reply or not. It also saves the node which sends the REQ as a neighbour from the table. The optimal next node (ONN) is chosen based on the data reply using neuro-fuzzy interpretation procedure and authenticates it before sending the data to it. Whenever the authentication of the ONN is not valid, it is deleted from the table. The node in turn must choose another node from its table so that it becomes the next ONN. A maintenance module is used to handle the situation when the neighbours table of the node becomes empty; the duty of this module is to reconstruct the node table so that new neighbours can be detected automatically. A new node is selected as the destination in the ONN. Subsequently path identification, based on the base stations awareness, data is responded to the SN or base station. A multi-aware query driven (MAQD) routing protocol is comprised of six well-designed sections, which are dispersed over three modules, namely; (i) Route Discovery module, (ii) Data Reply module, and (iii) Route Maintenance module. Route Discovery module and Data Reply module are dual consecutive modules, which are in progress instantaneously when SN queries about the data from all/some nodes, while Route Discovery module will taking place when a disaster in the node has happened throughout the data broadcasting(Ahmed I. Saleh et.,al 2017).

IV. PROPOSED WORK

The diagrammatic representation of the data collection mechanism from sensor nodes to the cluster heads is shown in Fig.1 as a systematic procedure.

The existing routing protocol communicates with the help of individual sensor nodes. Each Sensor Nodes should be aware of receiving and sending data. In this protocol the nodes communicate directly with the cluster heads. Cluster heads in turn communicate within themselves and

direct the data to SN. Cluster heads send a "Hello" request message to the nearby sensor nodes to seek its attention. A query is forwarded from the cluster head to the neighbour sensor nodes which are very near to the cluster head. The cluster head in turn assembles data from the sensor nodes and keep it securely. As soon as the SN passes the query to the Cluster Heads they start to transfer data to the SN. Also, the routing protocol should consider the life time, adaptability, fault tolerance and shortest path.



- Sensor Nodes
- Cluster heads with built-in Neurons

Figure 1. Data collection using Neurons.

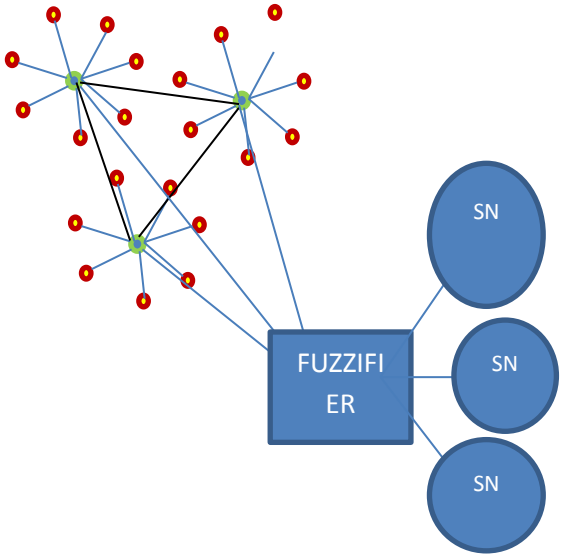
The cluster heads runs a self-healing technique to withstand their power.

The data are collected in the cluster head and summed to be produced to the SN. The inputs are considered as Synaptic inputs from the sensor nodes towards the neuron. Let us consider there are 'n' number of inputs. Assume that the signal data is considered as 'S_1 , S_2, S_3,..... S_n'. The strength of the connection is measured in terms of wk_1, wk_2, wk_3,.... wk_n. Neurons collect the data and aggregates it ie.,

$$\sum = S_1wk_1 + S_2wk_2 + S_3wk_3 + \ldots\ldots + S_nwk_n.$$

If the correct input is not received by the cluster head, then the strength of the connection is checked and the self-healing module will be executed if the signal strength is weak. Self-healing module runs a small battery back-up process. Immediately data within the weak node will be transferred to a nearby cluster head. The cluster head in turn checks for the data redundancy and will transfer it to the base station. From the above equation it is very clear that signal strength is calculated for each and every node. Cluster heads acts as neurons so that they can remember large amount of information for a very long period of time.

Data are collected by the individual sensor nodes from their surroundings and transmits it to the neighbouring cluster head. The above diagram states that the clusters form a topology within the cluster heads and gathers the data from the sensor nodes by passing a "Hello" message.



- Sensor Nodes
- Cluster heads with built-in Neurons

Figure 2. Neuro Fuzzy routing with cluster heads.

On receiving the "Hello" message the sensor nodes pushes the data accumulated by them to the cluster head. Communication is done within the cluster heads to check whether they have redundant data. If they have redundant data only one copy of the data is kept in a cluster head and others are removed in order to save memory as well as power. Since the cluster heads communicate each other, the SN can get the data from the cluster heads very easily. The SN sends a request to the cluster head and those nodes sends the response to SN if they possess the data. If the data is not available then the cluster head sends a wait signal to SN. The adjoining cluster heads communicate with each other and checks whether the data is available with their nearby cluster heads. The process of checking for the redundant data is done by the fuzzy inference system. Thus, the fuzzy inference system produce accurate data. If correct data is received then the cluster head will transfer the data to the SN which requested for the data. Most of the processes are done by cluster heads and hence the SN energy can be saved.

V. ALGORITHM

Step 1. Assume there are n number of sensor nodes. ie., S_1 , S_2, S_3,..... S_n

Step 2. Consider the strength of connections as wk_1, wk_2, wk_3,.... wk_n.
Step 3. 'n' is the number of sensor nodes in the network.
Step 4. Let us assume that there are 'm' number of Cluster Heads with one or more SN
Step 5. All parameters form the sensor nodes are summed towards the cluster head to collected the data.
Step 6. Clustering of Sensor nodes are done by Neurons.
Step 7. Data are transferred between Cluster heads and SNs using fuzzy logic.
Step 8. Find the nearest cluster head by sending "Hello" message.
Step 9. Route data to the SN if it is available.
Step 10. If J is Nearest clusterhead Then
Initialize i=1;
For k= 1 to m
If(i = 1) then
CH[k] obtains data from the sensor nodes
Collect and transmit data to the SN that demanded the data.
i++;
end if
Else
Step 11. Cluster head checks its neighbour to find the requested data.
Step 12. If the data is found send it to the SN. If data is not found it checks whether there is a cluster head node with weak signal.
Step 13. If so then Self – healing module is activated for that particular node.
Step 14. Check for the data and if it is found send it to SN.

The above algorithm works with neurons and fuzzy inference system that outperforms the existing algorithms for WSN. It works with various sensor nodes, cluster heads and delivers an efficient routing with energy saving. Simulation results shows that this routing protocol routes the data in a very accurate and in a fastest way because the cluster heads are interconnected and allowed to study about the details they have.

VI.RESULTS

The proposed algorithm is implemented by using NS2 simulator. Two parameters are considered for analyzing the performance of the proposed algorithm and they are namely Energy Conservation and The Throughput.

1 Energy Conservation

The energy conservation for the sensor is its main concern of the network. Once the sensor gets its energy drained then it must be replaced or recharged. Frequent replacement and recharging will drastically reduce the global performance of the network. The conservation of energy is essential irrespective of various applications. The residual energy of a node is considered as the amount of remaining energy available for a node.

Residual energy of network is the average of the residual energy of all the active sensors in the network. The resultant residual energy of WSN with and without neuro-fuzzy tuning system is represented in the Figure 3. The figure shows resultant residual energy of the network on deploying the nodes 50 in the area of 10000 m^2 by applying both neuro-fuzzy and non-fuzzy systems.

The proposed neuro-fuzzy based system is able to achieve the increased residual energy of network for most of the calculated probabilities. Therefore, this routing protocol is able to route the data accurately without any delay in WSN.

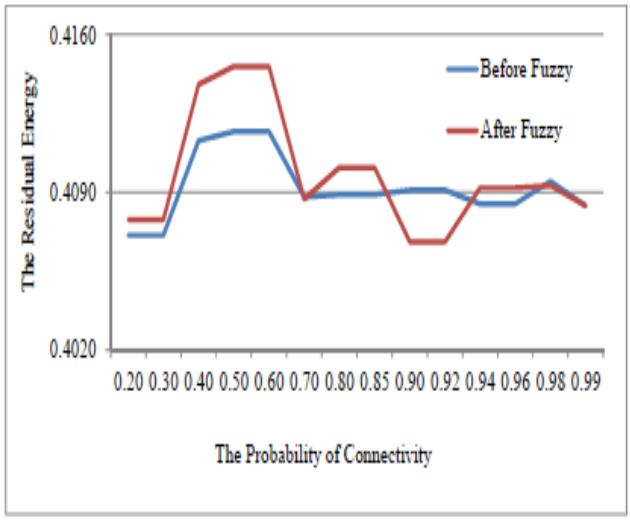


Figure 3. The Residual Energy Vs The Probability of Connectivity (50Nodes deployed in the area of 10000 m^2)

2 The Throughput

Throughput can be stated as the proportion of the entire number of packets acknowledged to an overall number of packets generated. In the proposed routing energy is reduced by removing only the redundant nodes. An extensive care is taken to allocate the sensors evenly throughout the network, by way of proposed neuro-fuzzy based system.

As expected by neuro-fuzzy based system, single sink is included and it is wholly responsible for all the data collections. The following constraints are considered for the even distribution. That is, the sensors with more number of neighbors are not allowed both in the near and the far off sink position. The data processed by the sensors near the sink will be comparatively more by the sensors at the farthest. Always, it is preferable to have a moderate number of sensors near the sink to avoid data loss and for

the even distribution of the functionalities of the network. The sensor at the farthest will communicate the sink through a long distance which will degrade the throughput. The throughput was calculated based on the different network parameters and is shown in the Figure 4.

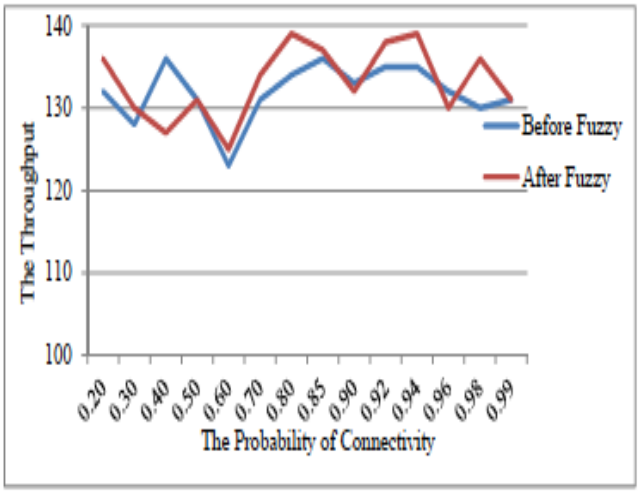


Figure 4. The Throughput Vs The Probability of Connectivity (150 Nodes deployed in the area of 90000 m^2)

VII. CONCLUSION

In this paper, we recommend a neuro-fuzzy based gathering procedure where the cluster head is elected, by considering the energy level of a randomized cluster head within the cluster range calculated based on residual energy and the gathered data is sent to SN. The cluster heads acts as neurons and does all the processing activites. Sensor nodes join the cluster head based on remoteness and cluster head collects the data from nodes in an well-organized manner by which energy can be saved and to route the data in a right and faster way. Using NS2 simulator tool, the projected algorithm is processed and the results are shown very clearly. The performance of this routing protocol is checked with previous routing protocols with simulation results. The simulation results proved that this algorithm outperforms the other algorithms in routing and in relationship to energy consumption and system lifespan.

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