Cluster Head Selection based on Neural Networks in Wireless Sensor Networks

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***Abstract—in* this paper we describe our experience to implement a proposed algorithm of routing protocol based on Neural Networks (NNs), our approach focus on improving the clustering performances. The energy consumption is an important factor for the Wireless Sensors Networks (WSNs). In our solution based on the Neural Networks tool and the routing protocol LEACH (Low-Energy Adaptive Clustering Hierarchy) we introduce the criterion of the consumed energy for the process of the election of the Cluster-Head (CH). The sensor node with the highest level of the energy is selected to be the Cluster-Head. The results of the simulation show that our proposed solution performs better than classical LEACH.**

Keywords—neural networks; wireless sensors networks; backpropagation; cluster head; LEACH; energy consumption

I. INTRODUCTION

Wireless Sensor Networks is spatially distributed nodes that could communicate the data obtained from a monitored or controlled field by a wireless channel. WSNs are a leading area of research for the variety applications that could be developed such as the pressure, the light, etc. Depending on the architecture of the WSNs, the sensing data can be sent either direct to the Base Station (generally Sink) or through nodes. The communication is related to the battery of the sensor node. The lifetime of the network in WSNs belongs to the strategy used for managing the energy consumption [1].

The Machine Learning is the science that permits to a computer to learn from it-self and give predictions for new situations, it consist of receiving some inputs data and use some statistical analysis to predict an output value. There's a lot of methods such as Support Vector Machines (SVM), logistic regression, and Neural Networks which we used as a method to improve the clustering for routing protocol LEACH, it's a black box because we couldn't explain how it works, inspired by biological neural networks it's a system that use examples for the process learning without being programming which permit to resolve a complicate tasks that we couldn't by using the classical methods [2].

Many works were developed for WSNs, E. Eldosy et al. [3] propos a new technique to reduce the battery consumption based on the Artificial Neural Network, and in [4] F. Zesong et al. give variety issues of WSNs using the technique of Multi-Objective Optimization (MOO), and new tool for environment monitoring J. Aarti et al. [5] by using the Internet of Things (IoT) in Wireless Sensor Networks, other method used by D. Rita et al. [6] introduce a node prioritization based load balancing approach to improve Cluster-Head selection in Wireless Sensor Networks, X. WANG et al. [7] propos an improving LEACH using wavelet Neural Networks, H. Rashid et al. made a survey on Machine Learning in wireless Sensor Networks to show tools used to improve the working efficiency [8].

The remainder of this work as follow as: section 2 Artificial Neural Networks, Wireless Sensor Networks in section 3, forwarding by an overview of Routing Protocol LEACH in section 4, for section 5 Proposed Algorithm, Simulations and Results in section 6.

II. ARTIFICIAL NEURAL NETWORKS

The Machine Learning (ML) is defined as the science that studies the ability of a computer to learn from it-self without being programmed, it's a branch of Artificial Intelligence (AI) [9]; the process learning is done by observing examples, and understands the relationship between the inputs values and the outputs values to make decisions better for new examples. The object of this approach is making a computer to learn automatically without a human introducing. There are three main methods of learning; Supervised, Unsupervised, and Reinforcement learning [10].

The Neural Networks is a supervised learning, it consist of analyzing a labeled examples, each example with an input and desired output, after the training of the

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datasets, the algorithm will be able to make decision for a new dataset and give a predicted output.

The Neural Networks (NNs) is a mimic model of a human brain, it tray to inspire from the human think and resolve complicate applications [11] like video games, pattern recognition, and computer vision… etc. The human brain is a complicate neural system, it has 10^{11}neurons fully interconnected. As shown in Fig. 3, the cell body (Soma) is responsible to send a pulse or not, the result is transmitted by the axon, the inputs signals use the dendrites, and synapses are the point of the contact.

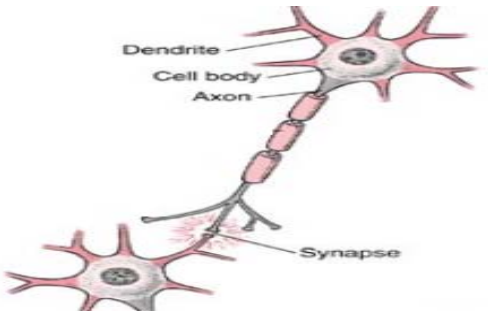

Fig. 3. Biological neuron

The Neural Networks (NNs) consist on neurons connected via weighted connections that permit to associate the input layer to the output layer, trough a transfer function of the sum of the products of inputs values and their weights, see Fig. 4, and it store the information, thus NNs doesn't need data storage. The four elements constituted the model that is adopted for artificial NNs.

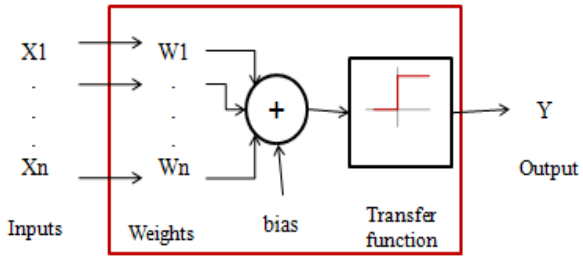

Fig. 4. Artificial neuron

The training process considered as supervised learning because it learn from labeled examples. The main applications of NNs are classification and prediction. The model is organized in layers, offer the capability to perform nonlinear statistical training and detect complicated relation between variables without requiring formal statistical training, but as any model it has some issues such as the greater computational burden, and the over fitting.

Back propagation is the most powerful algorithm of Neural Networks (NNs), it compute the error between the actual output computed by using forward pass, and the desired output given in the datasets, then a backward pass for adjusting the weights in order to minimize the error. The algorithm is repeated until some specific conditions is satisfied [12]. There are many versions of the algorithm, but the most standard steps are:

- ✓ Forward propagation
- ✓ Compute error between actual output and desired output
- ✓ Backward propagation to minimize error calculated
- ✓ Repeat iterations

III. Wireless Sensor Networks

A. Sensor node

WSNs are constituted of distributed units called sensors; they are a small component composed of sensing unit, processing unit, transceiver, and power unit, see Fig. 1

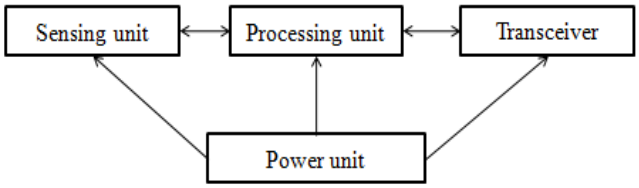

Fig. 5. Units of a sensor node

The sensing unit is composed of sensor and ADCs (Analog to Digital Converters), the data well be send to the processing unit which is composed usually of a microprocessor and a small amount of memory, then information well be transmitted to the transceiver which is responsible of managing the communications, all those operations are made by the electrical power provide from the power unit [13].

B. Architecture of WSNs

The communication process need a considerable amount of energy, that means the WSNs performances belong widely to the power offered by the sensor. Many efforts were done to develop strategies for managing the routing in WSNs [14] and conserving the energy consumption, the famous structures of WSNs are the hierarchical structure and the flat structure, see Fig. 6.

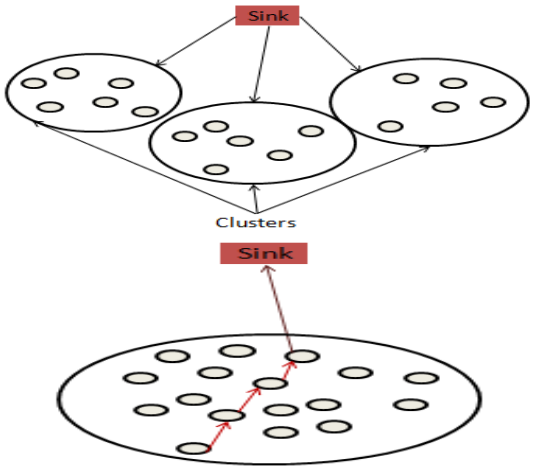

Fig. 6. (a) Hierarchical structure; (b) Flat structure

Hierarchical structure: widely used in WSNs, where the network is classified into groups, and each group has a specific node called Cluster-Head (CH), this node manage the communication with either other nodes called members nodes or the Base Station (BS), popular routing protocol are LEACH, PEGASIS (Power Efficient Gathering in Sensor Information Systems).

Flat structure: all nodes are responsible of the establishment of the communication, they collaborate to send the sensing data into the BS, its ideal for the data centric routing, and the famous routing protocol used are SPIN (Sensor Protocols for Information via Negotiation) and DD (Directed Diffusion).

The structure of the network and the type of the application are very important in the conception of the WSNs, it can save a very important amount of the energy during the communications as result it influence in the lifetime of the network.

C. *Issues of WSNs*

Researches deal with a diversity of problems in order to have a low-power routing and conserving the accuracy and the scalability of the network [15], the global issues are:

- Data reporting model
- Data aggregation
- Energy consumption without losing accuracy
- Node heterogeneity
- Scalability
- Fault tolerance

IV. ROUTING PROTOCOL LEACH

LEACH is widely used for the hierarchical architecture of WSNs, thus permit to conserve the power by dividing the network into groups called clusters, and each group elect a specific node named Cluster-Head (CH) responsible of the communication with the Base Station (BS) [16]. Algorithm of LEACH run in rounds, see Fig. 7, each round is composed on two phases; construction and communication.

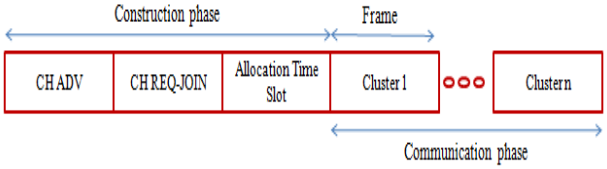

Fig. 7. Phases of LEACH

In the first phase, there's a construction of clusters by selecting the Cluster-Head (CH) and established a media access policy for each group, and the choice of CH made by:

- Each sensor n generate a random number
- Each sensor compare the random number with the threshold defined as:

$$T(n)=p/1-p*(r \bmod (1/p)) \text{ if } n \in G, \text{ and } 0 \text{ elsewhere} \quad (1)$$

Where: n= given sensor; p= probability; r= current round; G= set of nodes weren't CH in previous round.

- If this random number is less than the function of Threshold $T(n)$, then this sensor n is elected as a Cluster-Head (CH).
- Each CHs send a notification request to inform other sensors
- Sensors non-CH chose which CH follow basing on the strength of the signal received from CHs, and returned a response message to the CH chosen.
- Each CH creates a schedule TDMA in order to allow a slot for each member sensors, and send the TDMA.

In the second phase [17], the members sensors by using the TDMA schedule send their data in their proper slot, if they have to send, if not they turn off their interfaces, which permit to conserve their power. CHs aggregate the data and send it to the Base Station (BS) directly.

V. PROPOSED ALGORITHM

The main goal of our proposed algorithm is improving the clustering in routing protocol LEACH,

especially for the phase of selecting the Cluster-Head (CH) [18]. We introduce in our algorithm based on Neural Networks a specific criterion, such as the selection of CH is depending on the amount of remaining energy. Our technique elects the CH for the node with the highest level of the energy. In that way the energy could be more conserved, as consequence the lifetime of the network could be extend.

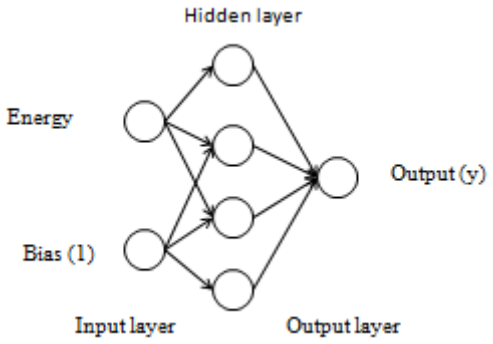

Fig. 8. Structure of proposed NNs

Our model is composed of three layers, see Fig. **8**. The first layer is the input layer with two nodes, one for the energy and other for the Bias. The second layer is the hidden layer with four nodes and the Transfer function used is the sigmoid function. The last layer is the output layer with one node that can take as a value "1" for the node selected as CH or "0".

VI. SIMULATIONS AND RESULTS

In our simulation we used the network simulation OMNETT and we used a single hope and the node send data to the Cluster-Head or to the Base Station. The parameters of the simulation are: 100 identical nodes are randomly deployed in the area with range 250m*250m. The data packet length is 6400 bits. We compared the results between the LEACH and our proposed LEACH with the Neural Networks (LEACHNN) in terms of survival nodes and energy consumption. The results were favorable for our new approach of LEACH based on Neural Networks besides LEACH.

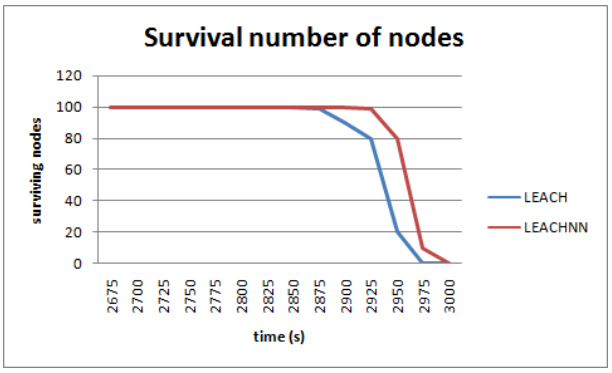

Fig. 9. Survival nodes in LEACH & LEACHNN

The figure presents the variation in the time of survival nodes in the network, for LEACH and our proposed LEACHNN. The results show that our LEACHNN performs better than LEACH which save the energy consumption and extend the life time of the network.

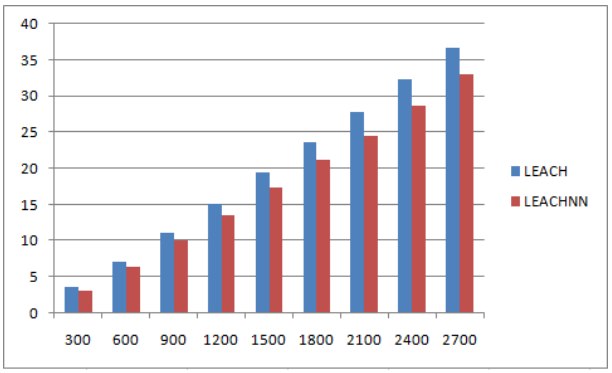

Fig. 10. Consumed energy of LEACH & LEACHNN

The figure shows that the consumed energy is lower in LEACH based on NNs compared to LEACH and the TABLE I bellow show that our proposed LEACH ameliorate the network's performances around 11% in terms of the power consumption.

TABLE I. Energy consumption of LEACH and LEACHNN

Time (s)	**Energy (LEACH)**	**Energy (LEACHNN)**	**Difference**
300	3.6	3.1	12%
600	7.2	6.4	11%
900	11.1	10.1	10%
1200	15.2	13.5	11%
1500	19.4	17.4	10%
1800	23.6	21.3	10%
2100	27.9	24.6	12%
2400	32.3	28.7	11%
2700	36.7	33	10%

VII. CONCLUSION

In Wireless Sensor Networks, the parameter of the energy is very important, and researches try to optimize the consumption of the power, which is usually impossible to replace it. Sensors node have limited resource of the energy (batteries). By conserving the power during the communications, the performances of the network can be more optimized. This paper describes a new approach of clustering in routing protocol LEACH using the algorithm of Neural Networks. The results show that by conserving the power of the energy, the lifetime of the network sensors was extended.

REFERENCE

[1] Kaur Jaspreet and Rai Dr. M.K, "Dynamic Clustering in Wireless Sensor Network," vol. I, Mar. 2013.

[2] Abu Alsheikh Mohammad, Lin2 Shaowei, Niyato Dusit, and Tan Hwee-Pink, "Machine Learning in Wireless Sensor Networks:Algorithms, Strategies, and Applications," , 19 Mar 2015.

[3] Eldhose Elby K and G Jisha, "Active Cluster Node Aggregation Scheme in Wireless Sensor Network Using Neural Network," no. 1603-1608, 2016.

[4] Fei Zesong et al., "A Survey of Multi-Objective Optimization in Wireless Sensor Networks: Metrics, Algorithms and Open Problems," 13 September 2016.

[5] Jaladi Aarti Rao, Khithani Karishma, Pawar Pankaja, Malvi Kiran, and Sahoo Gauri, "Environmental Monitoring Using Wireless Sensor Networks(WSN) based on IOT.," vol. I, Jan-2017.

[6] Devi Rita, Kumar Amit, and Dhawan Vinay, "A Node Prioritization Based Load Balancing Approach To Improve Cluster Head Selection In Wireless Sensor Network," vol. III, no. 8 – 12, February 2017.

[7] Xiaopeng WANG, "Improved Routing Protocol of Wireless Sensor Network Based on Wavelet Neural Network," , 2016.

[8] Husain Rashid and Vohra Dr. Rajan, "A Survey on Machine Learning in Wireless Sensor Networks," vol. III, Jan 2017.

[9] Karunanayake Piumika, Könsgen Andreas, and Förster Anna, "Poster Abstract: Adaptive Protocol Parameters for Wireless Sensor Networks using Machine Learning," , July 2017.

[10] Ahmad, Khan Zaki and Samad Abdus, "A Study of Machine Learning in Wireless Sensor Network," vol. IV, July-August 2017.

[11] Sharma Vartika, Raj Sharma Kritika, and Sharma Susheva, "Simulated Annealing Based Neural Network for Dynamic Clustering In Wireless Sensor Network," vol. III, 2014.

[12] LeCun Yann, Bengio Yoshua, and Hinton Geoffrey, "Deep learning," vol. 521, 2015.

[13] Jangra Ajay, Swati, Richa, and Priyanka, "Wireless Sensor Network (WSN): Architectural Design issues and Challenges," vol. III, no. 9, 2010.

[14] Al-Karaki Jamal N. and Kamal Ahmed E., "Routing Techniques in Wireless Sensor Networks: A Survey," , 2004.

[15] Rajkumar, B A Vani, Jadhav Kiran, and Vidya S, "Wireless Sensor Networks Issues and Applications," vol. III, no. 1667-1673, Sept-Oct 2012.

[16] Cordina Mario and James, Debono Carl, "Applying an SOM Neural Network to Increase the Lifetime of Battery-Operated Wireless Sensor Networks," no. 25, 2010.

[17] Singh Inderjeet, Pooja, and Varsha, "Neural Network based LEACH Clustering Algorithm in WSN," vol. VI, February 2017.

[18] Farah Sanhaji et al., "Clustering Based on Neural Networks in Wireless Sensors Networks," in International Conference on Computing and Wireless Communication Systems (ICCWCS), Larachi, 2017.