Lifetime Enhancement to Improve Data Transmitted for Clustering Protocol in Heterogeneous Wireless Sensor Networks

Alaa A. Hussain 1, Basim Abood 2, Kadhim Mahdi Hashim 3
1College of Administration and Economics, University of Sumer, Iraq
1alaa91Hussain@gmail.com
2College of Computer Science and Information Technology, University of Sumer, Iraq.
2bas.eng1984@gmail.com
3College of Education for Pure Sciences, University of Thi-Qar, Iraq.
3kadhimmehdi63@gmail.com

Abstract
The Routing Protocols in Sensor Networks come from many different ways from mandatory registration in fixed networks: there is no architecture in WSN, wireless connections are inaccurate, sensor networks may fail and routing protocols have to meet stringent energy saving criteria. There have been several routing algorithms commonly set up WSN. In the sensor network, a large number of inexpensive sensors with small batteries are deployed in the area to be monitored, which has to survive for a long time, where it is difficult or even impossible to implement the sensor battery replacement. Consequently, power consumption is an important factor to consider when designing WSN.
We proposed a new scheme to investigate the cluster in heterogeneous WSN, the clustering by using Fuzzy-Logic Stable Election Protocol (SEP_ FUZZY ), since the Fuzzy Logic Inference System (FIS) is used in the clustering process. FIS work with two input (nodes' remaining-energy(R-energy), and its distance from the base station(D2BS)). Results from the simulation indicate that the lifespan of the network reached by the suggested approach will be improved by almost (47 %, 35.7 %, and 23.8 %) more than that gained by the protocols "(LEACH, PEGASIS, and SEP)".

Keywords: clustering, WSNs, Fuzzy logic, SEP.

1. Introduction
A Wireless Sensor Network (WSNs) are defined as wireless networks without infrastructure and self-organized contain hundreds of sensing nodes and can be thousands of nodes that equipped with sensors, computing, radio transmitters, and receivers or other wireless devices of communications, and power components. The restricted energy dilemma is one of the most critical problems that need to be addressed
in order to receive WSN with a long life [6]. And since, in some situations, the method of replacing the batteries of these nodes is a difficult topic or not feasible.

This is why many academics are interested in Wireless Sensor Networks (WSN) and develop energy-efficient protocols and algorithms. A homogeneous sensor network has the same sensor nodes, while a heterogeneous sensor network (HWSN) has two or more node types. Hierarchical WSN are structured into clusters in which each node only responds to its particular cluster-head, which conducts special forces such as data collection, cluster synchronization, and data transmission to Base Station (BS) [1, 2].

![Figure 1. A typical Wireless Sensor Network](image)

This paper is organized as follows.

Part 2: demonstrates the wireless sensor networks in detail and the technique used, in addition to Fuzzy Logic (FL) and all equations and basic details.

Part 3: explains the system model that has been used to enhance WSN lifetime and balance energy consumption in more detail.

Part 4: explains the results of our proposed protocol and compares it with three known protocols.

Part 5: explains the conclusions of the proposed work

2. Related Work

Working on wireless network clustering algorithms is of high significance for enhancing network efficiency and is also of major importance for specific use. There are a variety of possible clustering systems in the literature.

In [3], Pro Wendi and other, proposed the (LEACH) hierarchical clustering process for the WSN. It is a clustering-based protocol that contains distributed clusters. In LEACH, a random number of sensors is selected at a prescribed time (P) as cluster heads (CHs), and this function is rotated over the WSN nodes to spread the energy load between the network devices. The rest nodes join the proper clusters depending on the strength of the signal from cluster-heads. The LEACH process is divided into stages, each round starts with the configuration stage where clusters are assembled, then the steady-state stage where data is transmitted to the CH from cluster component nodes and then to the sink or base station (BS). S. Lindsey and C. Raghavendra [4], proposed a
(PEGASIS) protocol, it improves LEACH protocol by organizing nodes in a chain and allowing nodes to rotate on top of the chain. The origin of this protocol is that to connect to the BS, the sensor nodes only need to share information with their nearest neighbours. A new round in PEGASIS begins when all sensor nodes establish contact with B. This communication ensures that power is distributed across all nodes of WSN and decreases the energy needed to transfer data across the path. The PEGASIS implemented to increase the lifetime of the WSN, and to decrease the bandwidth that is spent on communication because it only allows local administration between nearby nodes, and Distributed Energy Efficient Clustering (DEEC) In this protocol, depending on the ratio of the remaining energy of each sensor node and the average energy of the wireless sensor network, CHs are selected. In DEEC, the ideal value of the network lifetime is determined by estimation and used to calculate the reference energy that must be dissipated from each node during the round. DEEC allows uniform power consumption by network nodes by rotating CH between all nodes in the network. DEEC has the advantage of being a global algorithm for the clustering. However, for heterogeneous networks, the efficiency of homogeneous systems is weak since the low-power nodes may have a higher likelihood of selection than the high-power nodes.

The Stable Selection Protocol (SEP) deals with the heterogeneity impression, in terms of the sensor power. SEP uses a probability-weighted strategy for choosing CHs, depending on the available resources in the nodes. This will increase network stability (stability is defined as the period from network service start up before the first node dies). A percentage of nodes in SEP display higher energy than other nodes. The likelihood is calculated appropriately, based on the residual power of the sensors. The authors demonstrate that SEP will improve the time of network reliability when opposed to LEACH.

Bala. et al. proposed the determinist-SEP (D-SEP) witch was suggested as being a multi-level hierarchical protocol. D-SEP improves network service life and stability compared to SEP. The authors in [9] Advocated an Enhanced SEP (E-SEP) is a heterogeneity method with three levels. E-SEP imposes new nodes called intermediate nodes which serve as a bridge between both the advanced and regular nodes. In [10] the Distance-Based – SEP (DB-SEP) protocol has been proposed with two parts, the first one is the energy of the sensors and the second is the CH distance, the next to the station is more likely to become CH.

In this paper, we introduce a new clustering strategy called (SEP-FUZZY) that improves the performance of the SEP protocol by applying Fuzzy Logic. SEP-FUZZY increases the life of the nodes and provides a longer network stability period. We are studying the effect of the SEP-FUZZY protocol on variables of heterogeneity which detect the imbalance of power in the system. The residual power (R-Energy), and the distance from the station to the sensor node (D2BS) input were taken into account in the fuzzy system. Such parameters are not closely linked, so the use of fuzzy logic is simple to deal with. The fuzzy method also doesn't require a lot of numerical complexity; hence it's ideal for WSN. According to what has been assumed, each node itself decides whether to be the head of the cluster or not. This approach will operate in all situations, since node coordinates are not needed. In this method it is more effective than existence method by choosing appropriate inputs for fuzzy system, and better group will be formed.

3. Stable Election Protocol and Fuzzy Approach

3.1 Stable Election Protocol (SEP)
A. Network model

In this part, we'll explain the SEP protocol in this section. Suppose there are nodes of the sensor N. Nodes must still relay data to a base station, which is always far from the sensing area. The system is structured into a clustered hierarchy in which each cluster has a CH, which is responsible for performing fusion function to minimize the combined data produced by the sensors within the same cluster.

In SEP, the odds of selection are determined by a node's initial energy compared to that of other nodes inside the WSN. This prolongs the stabilization cycle (time before the first device's death), which is important for many applications where accurate input from the network system is needed.

where $E_0$ is the initial capacity of specific node, and $m$ is the portion of CHs which possess and $\alpha$ is the factors more energy over usual.

Therefore, there are $mN$ to CHs prepared with an initial power of $(1 - \alpha)E_0$; and $(1 - m)N$, (normal sensors) with an power of $E_0$. The cumulative initial power of the sensor network at both stages is thus

$$E_{total} = N(1 - m)E_0 + mNE_0 (1 + \alpha)$$

$$= NE_0(1 + \alpha m)$$

Thus the system's total power is multiplied by a factor of $(1 + \alpha m)$. Let $P_{adv}$ be the weighted likelihood of advance sensors in the voting. Optimum likelihood One can calculate the $(P_{opt})$ of each node to turn out to be CH can calculated by (2).

$$P_{adv} = \frac{P_{opt}}{1+\alpha m} \times (1 + \alpha)$$

(2)

The threshold is given by (3).

$$T(s) = \begin{cases} \frac{P_{adv}}{1-P_{adv}} \times \frac{1}{r \mod \frac{1}{P_{adv}}} & \text{if } s \in G \ 0 \text{ otherwise} \end{cases}$$

(3)

In this article, we find a communication system involving of N devices (nodes) spread above a large area to track the atmosphere continuously. We make some assumptions for a WSN regarding the nodes and the appropriate network model.

- Deployed dynamically on sensor nodes.
- Upon installation all the sensor networks and base station are static.
- Nodes can adjust the power of the transfer according to the location of the receiver nodes.
- When initially installed, all the sensors may not have the same amount of resources.
- The station does not need to be placed far from the sensor field.

B. Model Electricity Use

The first_order radio setup to be used in LEACH[8] is for the practical. $E_{fs}$ and $E_{mp}$ are the sum of energy per bit dissipated in the RF amplifier by the difference d 0 from (4) and (5) as seen below
\[ E_n T(k) = \begin{cases} k \times (E_{elec} + E_{fs} \times d^2) & , \text{if } d < d_0 \\ k \times (E_{elec} + E_{mp} \times d^4) & , \text{if } d \geq d_0 \end{cases} \] (4)

\[ d_0 = \sqrt{\frac{E_{fs}}{E_{mp}}} \] (5)

The amount of energy consumption in receiving a packet with \( k \) bits can be calculated by (6).

\[ E_n R(k) = k \times E_{elec} \] (6)

The radio energy model parameters present details in Figure 2, and Table 1.

![First order Radio model](image)

**Table 1: radio model Parameters**

| Parameter | value |
|-----------|-------|
| \( E_{elec} \) | 50 nJ |
| \( E_{fs} \) | 10 pJ |
| \( E_{mp} \) | bit \( \frac{m^2}{\text{bit}} \) | 100 pJ |
| \( E_{mp} \) | bit \( \frac{m^4}{\text{bit}} \) |

**3.2 Fuzzy Clustering Approach**

In the mid-1960s, Zadeh established the notion of fuzzy logic[11] as an extending of the idea of an ordinary fuzzy set. Its apps had also expanded rapidly in evolutionary control systems and pattern recognition. It has the benefits of being simple to execute, and reliable[12]. The Fuzzy Logic model is used to select the best cluster head to transmit data packets when the sensor detects an event. Consequently, fuzzy logic aims to calculate the optimum value (Optimal-CH) for the best CH that depends on the (R-Energy), and the distance from the base station (D2BS), as seen in figure. (3)

![Fuzzy Clustering System structure](image)

Figure 3. Fuzzy Clustering System structure with two inputs (R-Energy, and D2BS), and one output of (OPtimalCh).
Figure 3 Shows Fuzzy logic with 2 input factors (R-Energy and D2BS) and universal-discourse output (OptimalCh)[0, .1] and to [0, .150] to [0, .1], and [0, .100], respectively. Three membership functions were used in Fuzzy grouping, nine output vector membership functions were used for each entry, as seen in Figure 4.

Figure 4.Membership graph for two inputs (remaining energy (R-Energy), and normalize Distance Sensor to Base station (D2BS), and one output (OPtimalCh).

The inference engine, which consists of a rule base and various methods to infer the rules, manages the fuzzified values for the fuzzy approach. Tables 2 demonstrate the IFTHEN rules for the suggested system, with a minimum of $3^2 = 9$ for the Fuzzy rule base, Center_of_gravity method[13] given by equation (7) is used to defuzzify the process of:

$$\text{OPtimalCh} = \frac{\sum_{k=1}^{n} U_k \cdot c_k}{\sum_{k=1}^{n} U_k}$$

(7)

Where $U_k$ is the output of rule base k, and $c_k$ is the core of the reference membership function for the base list of rules n.

Table 2. IF-THEN RULES

| N  | Inputs       | Output          |
|----|--------------|-----------------|
| 1  | Low          | Near            | L.Weak          |
| 2  | Low          | Medium          | Weak            |
| 3  | Low          | Far             | V.Weak          |
| 4  | Medium       | Near            | V.Medium        |
| 5  | Medium       | Medium          | Medium          |
| 6  | Medium       | Far             | L.Medium        |
| 7  | High         | Near            | V.Strong        |
| 8  | High         | Medium          | Strong          |
| 9  | High         | Far             | L.Strong        |
4. Performance Evaluation

Use this model of network service helps to calculate the network lifetime parameter in data gathering rounds before the very first node runs out of resources. This measurement is known as Death of the First-Node (FND). It was widely used in works of literature [5, 14-16]. Figure 5 shows the chart of the new method which is an improvement of SEP by fuzzy logic in heterogeneous WSNs.

4.1 Simulation Setup

Under Windows 7 (32 bits) simulations are achieved in MATLAB R2014a. For our suggested random distribution in the region of 100 sensor nodes, this field implies that ($\propto$=1,P=0.2,m=0.2). Where respectively $\propto$, m are economic factors for the percentage of heterogeneity of nodes as developed, and P is an optimal choice probability of a device to become the CH. The topographical region is split between 100 m and 100 m in height. This field has a maximum of 30 m for perceived transmission. Within these areas the efficacy of the suggested system is tested. Only one sink of data is situated at center. The testing was done over 3000 rounds. For the dissipation of broadcast-hardware energy we use a simpler model shown in figure 2. The simulation parameters are presented in detail in Table 3.

| Parameter                              | Value                        |
|----------------------------------------|------------------------------|
| Topographical Area (meters)            | (100m x 100m)                |
| Sink location (meters)                 | (50m x 50m)                  |
| Number of nodes                        | 100                          |
| Limit of transmission distance (meters)| 30m                          |
| Initial energy of node                 | 0.5J                         |
| Packet data size                       | $4 \times 10^6$ bits        |
| No. of MFs (in each input and output variable) | 3                           |
| No. of IF-THEN rules                   | 9                            |
| No. of transmission packets (rounds)   | $3 \times 10^5$              |
Figure 5. Flowchart of SEP-FUZZY strategy
4.2 Simulation Results

Table 4 lists the specific period of time which correlates to the first dead node measured using the four separate strategies. The time in the suggested system for the First Death Node (FDN) is significantly longer than the time in LEACH, PEGASIS, and SEP for a first node die. It is apparent from Table 4, and Figure 6 that the suggested approach outperforms SEP in order to manage power usage and optimizing network existence. The lifetime of the network obtained with the proposed technique increased by almost (47%, 35.7% and 23.8%) higher than that accomplished by the protocols (LEACH, PEGASIS and SEP) respectively.

Figure 6. Amount of alive nodes based on various strategies as a result of rounds (LEACH, PEGASIS, SEP and proposed).

| protocols      | LEACH | PEGASIS | SEP  | Proposed |
|----------------|-------|---------|------|----------|
| The first dead node (Rounds) | 632   | 891     | 945  | 1439     |

Figure 7 shows that the average energy usage of a WSN for the four strategies as a function of the transmitting rounds. As the round time increase in the field, the suggested technique is doing better than three protocol methods (LEACH, PEGASIS, and SEP). This means that the suggested approach reaches improved energy equilibrium in a WSN.
Figure 7. Energy usage of multiple methods (Leach, PEGASIS, SEP, and proposed)

Also, the packets forwarded to the station are a critical point for some implementations. Comparative analysis of four separate transmission data packet approaches as seen in Figure 8. It can be shown that, relative to (LEACH, PEGASIS, and SEP), the findings have been best reported by the new methodology.

The data packets mean information transmission that is both electricity-saving and efficient (especially secure and significant). In other words, data packets are routed with multi-path forwarding through different node-disjunct pathways to avoid congestion problems and lengthen the life of the network.

Figure 8. Data Packet transfer to base station based on various methods (LEACH, PEGASIS, SEP and proposed)

Moreover, Figure 9 demonstrates that the new method result is the small number of cluster heads to instigate data transmission to the base, save power for this system and
Lastly enhance the lifespan of sensors to send all of their data to station through the best CHs.

![Figure 9](image)

Figure 9. No. of cluster heads based on different approaches (LEACH, PEGASIS, SEP, and proposed)

Note that the simulations above are conducted assuming all nodes are stable with enough power before the nodes die. There are some instances in the real world in which certain devices are in the essential path, and their ability to operate smoothly is disrupted. It could cause WSN output fluctuations. Since there are several criteria to remember, it can be very important and difficult for additional research on these topics.

5. Conclusion

We also suggested a new clustering system based on the fuzzy logic in this paper to increase energy efficiency and accomplish network load balancing to SEP in WSNs. Since each node decides its suitability to become a cluster-head candidate based on the residual power and the distance from the node to the base station. The efficiency of the proposed approach is measured against the same parameters and contrasted with the LEACH PIGASIS and SEP levels. The simulation findings demonstrate the efficacy of the latest method in extending the life of WSN distributed by random sensors.

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