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Improving SEP for Heterogeneous Wireless Sensor Networks

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Abstract

The lifespan of WSNs is crucial, and it primarily relies on the energy efficiency of the sensors, as their power source is often non-rechargeable and non-replaceable batteries. Addressing this issue involves carefully designing of a routing protocol that considers energy saving. This article presents a heterogeneity-aware routing protocol based on the Stable Election Protocol SEP for heterogeneous WSNs to extend the lifespan of the WSN by reducing energy consumption. The proposal employs the Time Difference of Arrival (TDoA) in the cluster-forming process to determine the shortest distance between the cluster head (CH) and sensor nodes in that cluster, thereby minimizing power consumption in all later communication operations. The proposal has been evaluated and compared to three protocols which are SEP, Zonal-SEP (Z-SEP), and Improved Z-SEP (IZ-SEP). The results depicts that the proposed protocol outperforms the three protocols in terms of the largest number of alive nodes in all evaluation rounds and exhibited a greater average of residual energy in nodes by about 90%, 10%, and 5% more than SEP, Z-SEP, and IZ-SEP respectively.

Keywords: Stable Election Protocol (SEP), Clustering Scheme, Wireless Sensor Network, Network lifetime, Routing protocols.

تحسين بروتوكول الانتخابات المستقر لشبكات الاستشعار اللاسلكية غير المتجانسة

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الخلاصة

يعد العمر الافتراضي لشبكات WSN أمراً بالغ الأهمية ، ويعتمد بشكل أساسي على كفاءة الطاقة لأجهزة الاستشعار ، حيث أن مصدر طاقتها غالباً ما يكون بطاريات غير قابلة لإعادة الشحن وغير قابلة للاستبدال. تتضمن معالجة هذه المشكلة تصميماً دقيقاً لبروتوكول توجيه يأخذ بالاعتبار توفير الطاقة. تقدم هذه المقالة بروتوكول توجيه يراعي عدم التجانس بين اجهزة المستشعرات والذي يعتمد على بروتوكول الانتخابات المستقرة SEP لشبكات WSN غير المتجانسة لإطالة عمر شبكة WSN عن طريق تقليل استهلاك الطاقة. يستخدم الاقتراح فرق وقت الوصول (TDoA) في عملية تشكيل الكتلة لتحديد أقصر مسافة بين رأس الكتلة (CH) وعقد المستشعر في تلك المجموعة ، وبالتالي تقليل استهلاك الطاقة في جميع عمليات الاتصال اللاحقة. تم تقييم المقترح ومقارنته بثلاثة بروتوكولات وهي SEP و Zonal-SEP Z-SEP و IZ-SEP

المحسن. أظهرت النتائج تفوق البروتوكول المقترح على هذه البروتوكولات الثلاثة من حيث العدد الأكبر من العقد الحية في جميع جولات التقييم وأظهرت متوسطاً أكبر للطاقة السكونية في العقد بحوالي 90% و 10% و 5% أكثر من SEP و Z-SEP و IZ-SEP على التوالي.

1. Introduction

Wireless Sensor Networks (WSNs) are ad hoc networks that have seen significant development and utilization in various fields, including military, healthcare, and remotely monitoring systems that used for different purposes. WSNs consist of small connected devices named sensors, which have limited capabilities in terms of energy, processing power, and storage space [1] [2] [3] [4]. The main task of the sensors is sensing data from the environment and then transmitting it to a central node. Usually, this central node is named the sink or base station (BS). The sensed data may be transmitted directly from the sensors to the base station if both of them in communication range, or indirectly through intermediary nodes [5] [6].

Generally, the base station is equipped with good resources such as processing and storage capabilities. Additionally, it is often provided by a rechargeable or replaceable energy source (battery). While the other involved sensors in the network usually have limited such as energy. These restrictions particularly in energy source are regarded as a significant challenge in maintaining the sensors' energy levels to prolong the life cycle of the WSN. Maintaining energy becomes a critical requirement in WSN design and operation because the energy resources are limited in such network. Researchers have been actively working on various strategies and techniques to minimize the consuming energy in WSNs. One of these approaches is developing energy-aware routing protocols that based on choose less energy paths for data transmission and avoid routes that consumed high energy. In addition to, balancing the energy consumption among nodes. Thus, considering the energy requirements of Wireless Sensor Networks (WSNs) is crucial in the design protocols and applications [7] [8] [9] [10].

The difference between homogeneous and heterogeneous WSNs drives the developers to create different routing protocols to tackle energy consumption properly.

In homogeneous WSNs, the sensors have the same resources, such as residential energy levels. The main aim of routing protocols that developed for homogeneous WSNs is to balance the energy consuming among nodes and distribute the load among them too. This principle will guarantee that all nodes will consume their energy approximately equally and this extend the network lifespan. Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol is common example of routing protocol for homogeneous WSNs [11].

On the other hand, the nodes in Heterogeneous WSNs have different resources. For example, some nodes have high energy levels named as "advanced nodes", while others have low energy levels named as "normal nodes". Usually, the developed routing protocols for heterogeneous WSNs, aim to take advantage of this heterogeneity and differences in nodes capabilities to optimize energy usage. Advanced nodes are used to implement tasks that require high levels of energies, while normal nodes used to implement fewer demanding tasks. This allocation helps ensure the efficiency in distributing the energy-intensive operations among the nodes. This results in extending the network lifespan [7] [8] [12].

Stable Election Protocol (SEP) [11] is a routing protocol introduced for heterogeneous networks, that objectives to prolong the stable period of the network and prolong its lifetime.

SEP depends on dividing WSN into clusters, where each cluster includes a cluster head (CH) that is nominated by other member nodes. Usually, CHs are advanced nodes. In SEP, the cluster setup process is based on broadcasting messages from CHs, then normal sensor nodes join to cluster with the strong received signal. Depending on the received signal strength (RSS) is not enough to specify the nearest CH because the signal is vulnerable to occlusion, multipath, Fading and Shadowing [13]. Distance between transmitter and receiver influences energy consumption and using RSS to determine this distance is not accurate. As the separation distance between the sender and the receptor is increased the required energy to send a message is increased [14].

Choosing the CH solely based on RSS has its limitations due to the impact of various factors such as multipath effects, signal fading, and shadowing. These factors can introduce inaccuracies in the RSS measurements, making it challenging to accurately estimate the distance between nodes and potential CHs.

This research introduces a new mechanism for establishing clusters in the SEP by adding few managing operations in creating the cluster. This mechanism based on creating clusters that featured with shortest distances between CH and member sensor nodes. This is aiming to minimize the energy consumption in any transmission operation that will be performed between CH and member sensor nodes later.

The proposed approach assumes that each CH broadcasts two consecutive messages. Then, each sensor node computes the Time Difference of Arrival (TDoA) of received messages by analysing the difference time between the arrival time of the received two messages. The suggested approach aims to improve accuracy in determining the nearest CH based on using TDoA instead of RSS. This resulting in saving energy in each transmission operation.

One advantage of using TDoA is less affected by obstacles or obstructions because it is more resistant to occlusion. This attribute makes TDoA more accurate than RSS in estimating distances [13] [14]. By establishing clusters based on TDoA calculations, the proposal achieves energy savings for the nodes involved, as the resulting clusters have shorter communication paths between CHs and member nodes.

The remnant of this research is arranged as follows: Related work is introduced in section 2. Energy model analysis in a network is explained in section 3. The SEP protocol is depicted in section 4. Section 5 introduces the proposed scheme. Implementation and discussion are revealed in section 6. Section 7 depicts the future work. The conclusion is highlighted in section 8.

2. Related Work

Several of the studies that investigated the SEP protocol and proposed modifications to improve its performance, were reviewed in this section.

The research of [11] investigated enhancement to SEP in a three-tier node scenario named enhanced-SEP clustering algorithm. The simulated results were compared to the LEACH protocol only and not compared to other available improved versions of SEP.

The authors of [15] presented the Zonal-Stable Election Protocol (Z-SEP), that is developed to be used in heterogeneous WSNs. Z-SEP used two methods, where a certain number of nodes deliver data directly to BS while others based on clustering technique in transmitting their data.

The authors of [16] introduced the Improved Zonal Stable Election Protocol (IZ-SEP) that was designed to be implemented in heterogeneous WSNs. They suggested using a hybrid approach to communicate between sensors and the base station (BS). Where, some sensors are connected directly to the BS, whereas other sensors depend on the technique of clustering. Simulation results show that IZ-SEP outperforms Z-SEP.

The study in [17] proposed Extended Z-SEP Routing EZ-SEP. It introduced a hybrid connection method nodes base station, where some in implemented directly, while others are via CH. Additionally, it used node energy to partition the field into zones.

The authors of [18] suggested an improved selection mechanism of additional CH for SEP-E. The proposal aimed to balance the load of the network and extend the network lifespan. Initially, the suggested scheme selects a CH and an additional CH for each cluster at every round. The authors compared the obtained results to the SEP-E protocol only.

The authors in [19] proposed a modification of SEP where it changed the electing probability of CHs by taking into account the distance with advanced nodes' residual energy. Additionally, it developed a gateway node at the centre of WSN. It used MATLAB R2017a to implement the proposal. The results showed that the proposal outperformed (ZSEP).

In [20], the authors suggested a cluster-based protocol called Distance and Energy Aware Stable Election Routing Protocol (DE-SEP) aimed saving energy and it regarded as proactive routing. It considered the energy and distance in the task of selecting CH. Additionally, it imposed a restrict on the CHs' number. The results revealed that the proposal outperformed the existing basic protocols for instance SEP.

The authors in [21] introduced Energy-Aware Threshold Sensitive Stable Election Protocol (EATSEP) for heterogeneous WSNs and it's regarded as a cluster-based routing protocol. This protocol takes into account the initial and remaining energy of each sensor node in the process of CH selection. In addition, it attempts to reduce transmission operations over long-distance among CHs to the BS. MATLAB is employed in simulation of the proposal. The obtained results indicated the superiority of the EATSEP in both of energy consuming and network's throughput.

The authors [22] proposed a protocol that tries to specify the best transmission path between sensor nodes and CH. The proposal takes into consideration the network is dynamic. Multi-hop routing is deployed between CHs and base stations to minimize consumed energy.

The study by [23] modified the SEP protocol to improve it. The proposal is designed as two levels of energy for heterogeneous WSN. This study considers the network energy average and the node energy of the current round in the process of selecting CHs. The obtained results have been compared to SEP, LEACH, and DCHS-LEACH.

The authors of [24] proposed Threshold Sensitive Stable Election Protocol (TSEP), that is considered a reactive protocol. Their proposal used heterogeneity that divided into three levels. As it is reactive, it can respond immediately to changes. This study evaluated and compared the proposal with the LEACH, DEEC, SEP, ESEP, and TEEN. The obtained results show that the TSEP protocol outperformed them.

The authors of [25] suggested Enhance Threshold Sensitive Stable Election Protocol (ETSSEP). This proposal depended on dynamically changing the election probability of CH.

It considers the remaining energy level of nodes in the selecting cluster heads process and it aims to form the least number of clusters per round. To implement ETSSEP, MATLAB is used. Where the proposal outperforms SEP and TSEP in stability and network lifetime terms.

The authors of [26] developed the LEACH protocol by decreasing the need for updating the (CH) in homogenous WSNs. The proposed approach assumes that CHs are equipped with a reliable energy source, such as solar energy.

The research in [27] suggested an Improved Threshold-Sensitive Stable Election Protocol (ITSEP) for heterogeneous WSNs. The proposal attempted to control the CHs' number in area with high-density node and introduced an enhanced threshold formula for selecting cluster heads. In addition, it focuses on finding the most energy-efficient routes for data send between CHs and base stations. It aimed to reduce consuming energy and prolong stability of WSNs where results showed improvement in network lifetime.

The above studies investigated the energy consumption of SEP and introduced modifications to minimized consumed energy and extend network lifespan. These modifications can be described in four categories. The first category is focused on dividing WSN into zones, then all communication operations based on these zones such as [11] [15] [16] [17]. The second category investigated the CH selection mechanism as in [8] [18] [19] [20] and [21]. The third category is suggested modification on the threshold formula to improve the SEP performance as in [24], [25], and [27]. The fourth category is investigated by identifying fewer energy routes between CH-sensor nodes and CH-base station respectively by assuming that there is more than one route and selecting the more efficient one [22] and [27]. Most of the aforementioned studies implemented their proposals by using MATLAB which may not reflect the real environment conditions.

This research aims to improve the principle of the clustering mechanism in SEP for heterogeneous WSN which impacts the whole performance with minimum managing operations. It targets formulating clusters that have the shortest paths between CH and member sensor nodes. Sensor nodes use the ToDA to calculate the distance between them and the elected CHs to select the nearest CH. ToDA is more accurate than RSS in calculating the distance. This is a significant step as it will save energy in each sending-receiving process which leads to decreasing the dead nodes number and prolong the network lifetime.

3. Energy Model Analysis in Network

In WSN, the routing protocols depend on two models of energy consumption. The first model is named the free space model and it requires amplification energy in a free space represented by the ϵ_{fs} parameter. The second model is named the multipath fading model and it requires amplification energy represented by the value of ϵ_{mp} . Two models are affected by the distance between the sender and receptor [14]. Figure 1 depicts the radio energy model [14].

Equation (1) shows the relation between distance and required energy to send a packet of data [11] [14].

$$E_{TX}(k, d) = \begin{cases} K * E_{elec} + k * \epsilon_{fs} * d^2, & d < d_0 \\ K * E_{elec} + k * \epsilon_{mp} * d^4, & d \geq d_0 \end{cases} \quad (1)$$

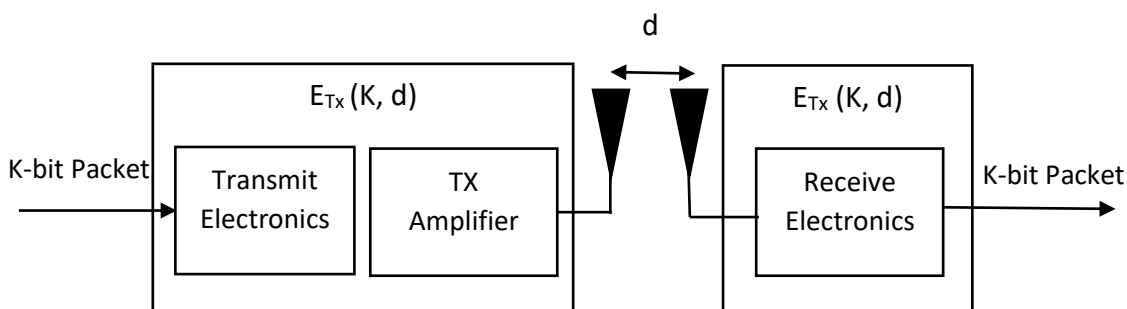


Figure -1 The Radio Energy Model [14]

Where:

E_{TX} : represents the needed power to send a K-packet.

K : number of bits to be sent in a packet.

d : represents the distance separated the transmitter and receptor.

E_{elec} : is electronic energy based on three aspects, which are filtering, modulation digital coding and signal propagation.

ϵ_{fs} : represents the amplification energy in a free space.

ϵ_{mp} : is the amplification energy.

d_0 : is equal to the square root of the dividing EDA free space model by multipath fading model.

E_{DA} : the consumed energy in aggregation [14].

The consumed energy in the CH is influenced by the member nodes number in that cluster and the distance separated the CH and BS. Suppose the deployed sensors number in WSN is equal to N , and network sensors are divided into C clusters. Hence, as an average, the number of sensors in each cluster is equal to N / C . Equation 2 describes the used energy in the CH in a single frame [11] [14].

$$E_{CH} = kE_{elec}N / C + KE_{DA}N / C + K \epsilon_{mp}d_{toBS}^4 \quad (2)$$

Where:

d_{toBS} : represents the distance separated the BS node and CH node as an average.

4. Stable Election Protocol (SEP) Technique

Routing protocols in WSNs can vary based on both the application requirements and the network architecture. A network architecture in WSNs typically falls into three protocol classes: Flat Routing, Hierarchical (Cluster-based) Routing, and Location-based Routing. The SEP is a clustering-based routing protocol commonly used in the network layer (Layer 3) of WSNs. The primary function of the network layer is routing, which involves managing the routing of data packets between different nodes in the network. SEP has been developed for heterogeneous wireless networks, where the nodes are heterogeneous in their energy [11] [28] [29]. SEP employed the heterogeneity attribute to enhance the steady zone of the clustering hierarchy process. In particular, to extend the steady zone (or stable region), SEP uses advanced nodes (indicated as m) and the extra energy factor between advanced and normal nodes (indicated as α). The main concept of SEP is giving each node in WSN the opportunity to become a CH node depending on its available energy.

This protocol aims to balance the consumed energy to extend the stable region. The advanced nodes are characterized by having a higher chance of being CHs than the normal nodes. According to SEP, the total (initial) energy of the heterogeneous setting can be calculated by equation (3):

$$N*(1-m) * E_0 + N * m * E_0 * (1 + \alpha) \quad (3)$$

Where:

E_0 : represents the initial energy of each normal sensor.

$E_0 * (1 + \alpha)$: represents the energy of each advanced node

Equation (3) can be written as:

$$N * E_0 * (1 + \alpha * m) \quad (4)$$

SEP improves the stable region of a system by raising the epoch of the sensor network in proportion to the energy increment. In SEP the epoch can be calculated as equation (5):

$$\frac{1}{P_{opt}} \cdot (1 + \alpha \cdot m) \quad (5)$$

SEP supposes that there are (m) advanced nodes so there is ($\alpha + m$) times more energy. Where P_{opt} represents the optimal probability. SEP adds weight to P_{opt} which can be calculated by dividing the initial energy of each node by the initial energy of a node. equations (6) and (7) show weighted probabilities for normal nodes and advanced nodes respectively.

$$P_{nrm} = \frac{P_{opt}}{1 + \alpha \cdot m} \quad (6)$$

$$P_{adv} = \frac{P_{opt}}{1 + \alpha \cdot m} * (1 + \alpha) \quad (7)$$

At the start of each round, each node $s \in G$ decides to become CH independently depending on opting for a random number within a range of [0, 1]. Based on the opted number the node would be CH in the current round or not. If the selected number is lower than a threshold $T(s)$, the node becomes CH. The threshold is set as expressed in equation (8):

$$T(s) \begin{cases} \frac{P_{opt}}{1 - P_{opt} * \left(r \bmod \frac{1}{P_{opt}} \right)} & \text{if } s \in G \\ 0 & \text{otherwise} \end{cases} \quad (8)$$

Where:

G represents the nodes that did not get the chance to be CHs within the last $1/P_{opt}$ rounds of the epoch. Take into consideration that G could include advanced nodes or normal nodes. SEP includes four phases which are:

1. **Advertisement:** During this phase, each sensor node (usually advanced node) nominates itself as CH for the current round depending on value $T(s)$ expressed in equation (8). The elected CHs broadcast an announcement message to notify other nodes of its role.
2. **Cluster Setup:** Once the non-cluster head nodes receive the announcement messages from CHs, they join the cluster from which they received the strongest RSS.
3. **Schedule Creation:** The CH makes a schedule or assigns time slots for communication within the cluster member nodes. The schedule determines when each member node can transmit or receive data, ensuring efficient utilization of resources and minimizing collisions.
4. **Data Transmission:** The member nodes within a cluster can begin transmitting data to the cluster head. During this phase, the member nodes collect and process sensor data, then send it to the cluster head for further aggregation, fusion, or forwarding.

5. Proposed Scheme

The suggested mechanism relies on modifying the process of the cluster setup in the SEP protocol and it is implemented in the network layer of WSNs. In the conventional SEP, the CHs broadcast a single message to the surrounding nodes, and nodes select their CH to join depend on the highest RSS they receive from potential CHs. Nevertheless, using RSS only in choosing the CH may not always result in selecting the nearest CH, because RSS can be affected by various factors such as multipath effects, and path loss, that lead to estimating inaccurate distance.

The proposed protocol suggests a modification to the process of creating clusters, where each CH broadcasts two consecutive messages instead of just one as in the traditional SEP. When sensor nodes receive these messages, they calculate the Time Difference of Arrival (TDoA) related to each CH. Each sensor node compares the computed TDoA values to determine the nearest CH and then selects it as its cluster head.

The main objective of the proposal is improving the accuracy of selecting the nearest CH based on the using TDoA and not the RSS. The proposal takes advantage of the fact that TDoA is more resistant to occlusion and can provide a more accurate estimation of distances. TDoA offers a direct measure of distance based on the required time for a signal to arrive to its destination. This is attributed to the ability of TDoA in overcoming potential interference or signal attenuation that caused by many factors such as obstacles. This study assumes that the sensor nodes could be either normal or advanced nodes that are not CHs at the current round. Where the sensor node calculates the time difference (time-differ) of messages arrival that are sent from CH. Considering TDoA in specifying the nearest cluster head guarantees choosing the most appropriate cluster [13] [30]. Figure 2 shows the process of distance calculation based on two broadcasting consecutive messages.

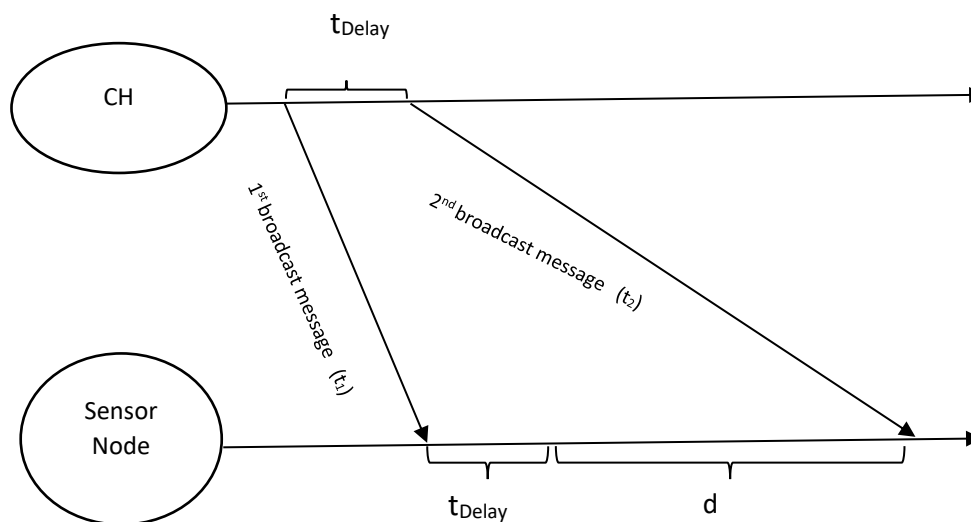


Figure 2: Distance Calculation

Distance is calculated as represented in equation (9):

$$d = c * (t_2 - t_1 - t_{\text{delay}}) \quad (9)$$

Where:

c is the light speed and t_{delay} represents the delay time between two consecutive broadcasted messages (which might be zero). In the proposal, the t_{delay} is assigned to a specified value to avoid collision.

Figure 3 reveals the proposal block diagram. As it modifies only two phases in the original SEP which are Advertisement Phase, and Cluster Setup Phase.

The proposal was developed to be implemented into two components: the first component in the CH node and the second component in the sensor node.

Figure 4 shows the proposed mechanism flowcharts of cluster formatting in (a) the CH node and (b) the sensor node.

The proposed scheme's principle relies on the arrival time of two consecutive broadcasting messages in calculating the distance between the elected CH and other sensor nodes.

This method is more appropriate in formatting clusters with shortest paths between CH and sensor nodes since it uses time rather than received signal strength RSS.

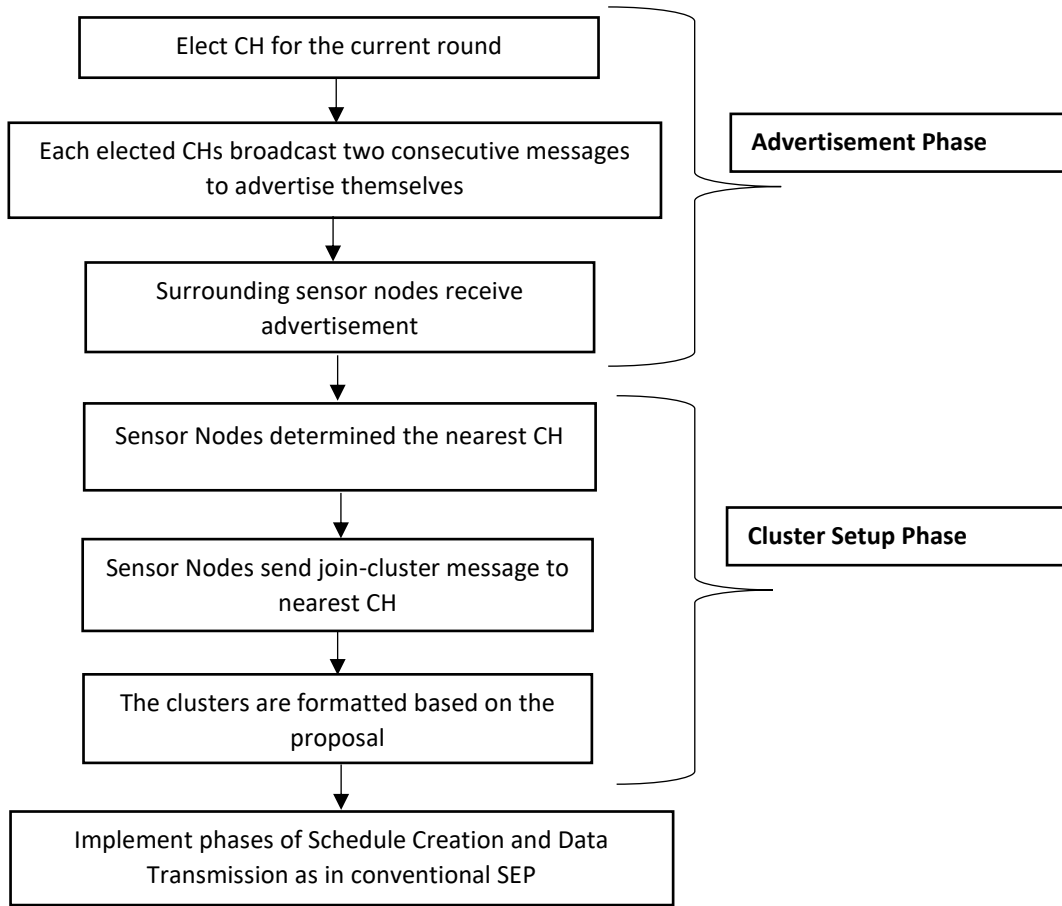


Figure 3: The Block diagram of the Proposal

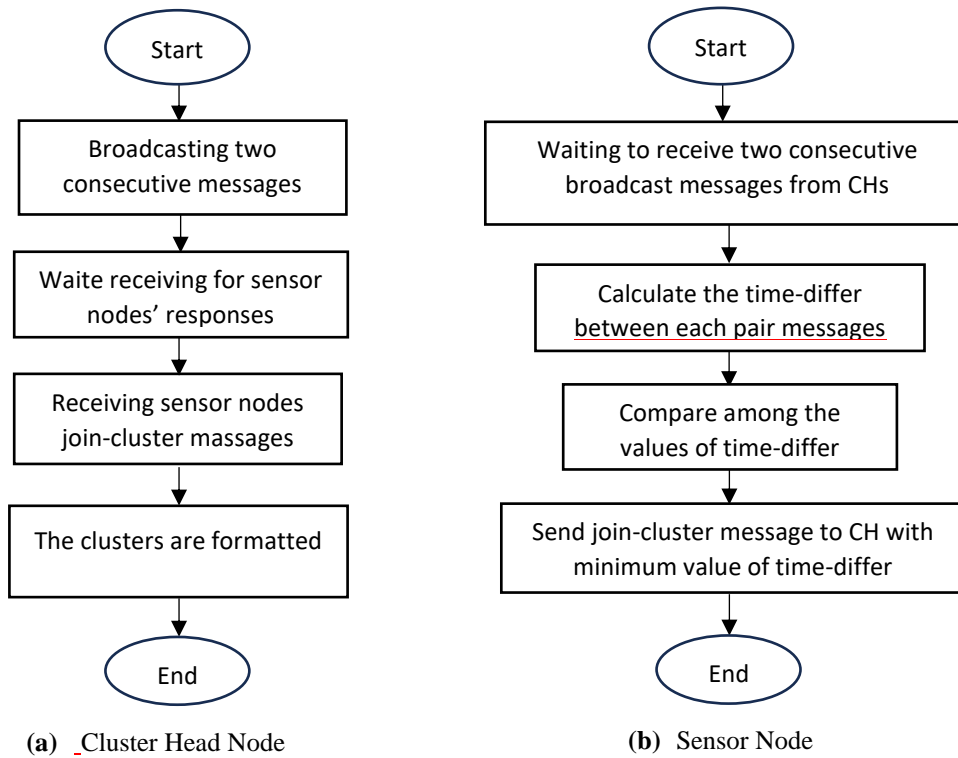


Figure 4: The Proposed Flowchart of Clustering Mechanism

6. Implementation and Discussion

NS2 Simulator is used to perform the experiments and evaluation processes. The implementation simulation parameters are explained in Table 1.

The simulation includes 100 sensors in a 100m×100m region. For comparison and validation purposes four models have been simulated SEP, Z-SEP, IZ-SEP, and proposal.

Table 1: The Used Parameters in Simulation

No.	Parameters	Value
1.	No. of sensor nodes, n	100
2.	Fraction of advanced node, m	0.4
3.	Initial energy	0.5 J
4.	Network Grid	$(0, 0) \times (100, 100)$
5.	energy, E_{elte}	50nJ/bit
6.	No. of rounds	1000
7.	Node Distribution	Random
8.	Data packet size	500bytes

Figure 5 indicates the total alive nodes per round for four simulated models.

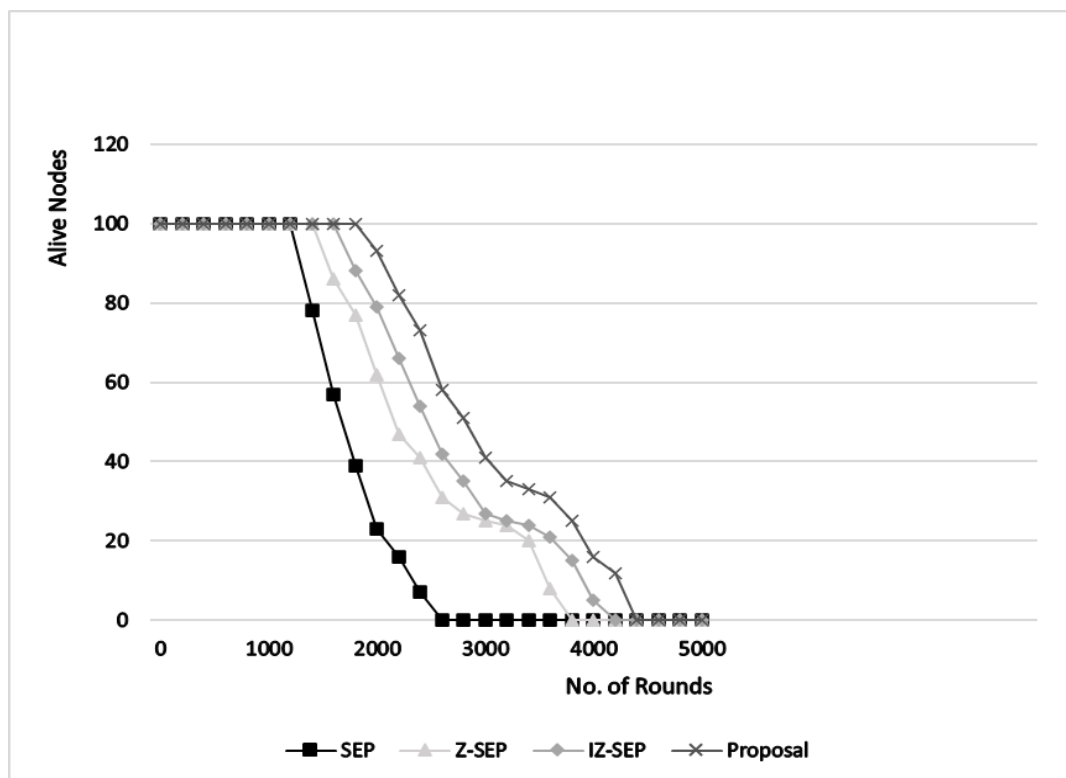


Figure 5: Number of Alive Nodes

The results show that proposal outperforms other protocols (SEP, Z-SEP, and IZ-SEP). The factors contributing to the proposal's superiority and highlighting its advantages are: Shortest Paths and Energy Savings: The proposal utilizes the shortest paths between sensor nodes and CHs, resulting in energy-efficient sending and receiving operations. This leads to significant energy savings for the nodes, enabling them to stay alive for longer durations.

Extended Stable Period: The proposal increases the stable period by approximately 58%, 35%, and 10% when compared to SEP, Z-SEP, and IZ-SEP, respectively as depicted in Figure 5. This extended stable period indicates that the network can sustain stable performance for more rounds before the first node death occurs. The first node death occurs at rounds 1238, 1452, and 1783 in SEP, Z-SEP, and IZ-SEP respectively, while the first node death appears at round 1961 in the proposal.

Enhanced Residential Energy: Figure 6 shows that the proposed method boosts the average residential energy in nodes by about 90%, 10%, and 5% more than SEP, Z-SEP, and IZ-SEP, respectively. This indicates that the nodes in the proposal have more energy available, leading to a prolonged node lifetime and better network longevity.

Superiority Throughout All Rounds: The proposal proves to be superior to other protocols consistently across all rounds. This indicates that the energy savings and efficiency benefits of the proposal persist over time and are not limited to specific scenarios or early stages.

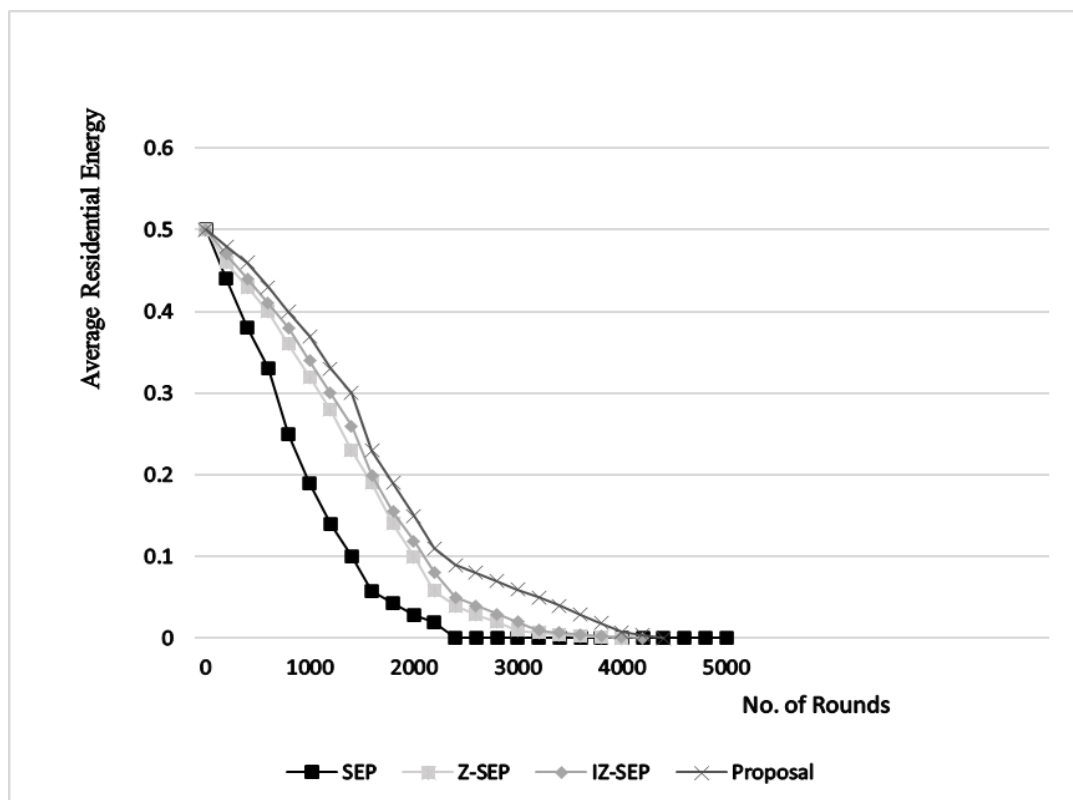


Figure 6: Average Residential Energy

Although the proposal achieved improvement on SEP, it has a limitation which is the requirement of broadcasting two consecutive messages rather than broadcasting one message as in the previous studies in the process of forming clusters.

7. Future Work

While this study contributes valuable insights to enhance the performance of SEP for heterogeneous WSNs, several areas warrant further exploration. Exploring the use of Dijkstra's algorithm [31] to determine the shortest paths among sensors in the context of the SEP for heterogeneous WSNs is a promising avenue for future research. It has the potential to contribute to more energy-efficient routing and improved overall network performance. This would allow for a greater savings in energy consumption that can be achieved in each send and receive operation.

8. Conclusion

Developing Energy efficient routing protocol for WSNs is a significant issue that immense studies tried to tackle it. The dynamic feature of WSNs including devices with different capabilities makes determining an appropriate routing protocol a complicated task. This research studied the routing protocols in heterogeneous WSNs, in particular the SEP protocol. It introduces a new clustering scheme for SEP instead the used one. In the proposal, after identifying the CH nodes, each CH broadcast two consecutive messages. Then the other sensors use the time of each received message to calculate the nearest CH to join. The suggested technique considers using TDoA rather than the available technique, which depends on RSS. TDoA is more accurate than RSS in determining the distance since TDoA is vulnerable to occlusion only while RSS is vulnerable to occlusion and multipath. The proposal has been simulated using the NS2 simulator. SEP, Z-SEP, and IZ-SEP have been simulated using the same simulation model of the proposal for validation and comparison purposes. The results reveal that the proposal outperforms SEP, Z-SEP, and IZ-SEP in terms of live nodes number and average residential energy. The proposal expanded the period of network stability by about 58%, 35%, and 10% to SEP, Z-SEP, and IZ-SEP respectively. The proposal increased the average of residential energy in nodes by about 90%, 10%, and 5% more than SEP, Z-SEP, and IZ-SEP respectively. Therefore, the network life spin has been prolonged.

8. Conflict of interest

The author declares that they have no conflicts of interest.

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