

A NEW ENHANCED VERSION OF VLEACH PROTOCOL USING A SMART PATH SELECTION

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ABSTRACT: Wireless technology becomes a fast developed research field in order to respond to our needs. It has various applications such as health care, emergency situations, industrial applications and home automation. It has several challenges like security and quality of service. Sensor node has a limited energy related to its tiny battery. Hence, energy efficiency is considered as an important challenge in Wireless Sensor Networks (WSNs). This paper aims at describing the various routing categories and the different efficient routing protocols. Along with this, a new enhanced version of the VLEACH protocol based on selecting the routing path efficiently is also proposed in this paper. The efficient selection process is based on electing the Cluster Heads (CHs) and the Vice-CH according to the highest residual energy. In addition, it uses a cooperative routing between the CHs and Vice-CHs in order to reduce the network energy consumption. Implementation of Basic VLEACH and Proposed VLEACH is done using NS-2 Simulator. Simulation results show that the new scheme is more efficient than the original VLEACH protocol. This protocol will increase the lifetime of sensor networks. So the proposed work can be applied in various WSNs which are deployed in remote areas and recharging of sensor nodes is an issue.

Keywords: WSN, VLEACH, energy efficiency, CH.

1. INTRODUCTION

For several years, the need of observing and controlling phenomenon such as temperature, pressure or the brightness is very important for many areas applications .

The wireless sensor network technology have been changed the world and our life's way. It resolves the control and observed system using a very intelligent way which involves its application in several research fields. A wireless sensor network is mainly composed of a huge number of sensors dispersed on areas for monitoring and intercommunicating through a wireless way as shown in Fig.1.

This advanced technology is still limited due to different problems such as routing protocols, energy consumption, security and data aggregation.

Collecting and communicating data or information are the most important feature of the network; that drain most energy. Therefore; several characteristics must be taken into account in order to ensure the best system performance.

This paper is organized in five sections: the first section explain the different characteristics and categories of routing. The second section presents the new proposed scheme. The third section present the implementation of the new solution and its comparison with the original protocol. The forth section includes the conclusion and the future works.

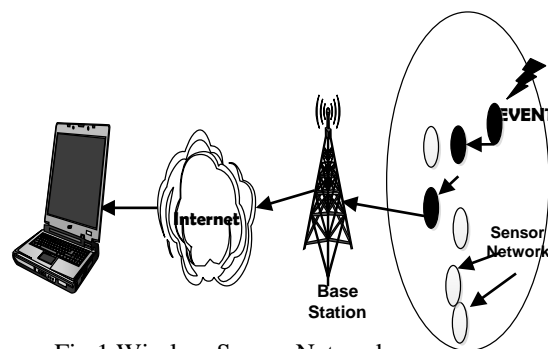


Fig.1 Wireless Sensor Network

2. RELATED WORKS

In WSN, node energy represents a very serious problem which is resolved using different efficient methods. The node capacity is very limited . Hence, routing data efficiently is an important challenge in WSNs. This section presents the different characteristics of routing and the main routing categories and the different routing protocols. Our work focuses on the hierarchical routing category.

2.1 Routing Protocols in WSNs

Routing [1] is a function which aims to distribute messages from a network source node to a destination node. To complete this goal, various routing protocols were appeared.

The characteristics that distinguish between routing protocols are as follow:

- **Energy consumption:** Since the routing power of a wireless radio strongly depends on to distance and the presence of obstacles, multi-hop communication will reduce the network energy consumption comparatively to direct communication. However, using multi-hop routing certainly lead to significant overhead for managing the network topology and medium access control. Direct routing will be more efficient if the entire sensor nodes were very close to the sink node [2].
- **Scalability:** this characteristic is very important and it represents the number of sensor nodes deployed for sensing data in network area. Several applications need enough scalable routing protocols to sense events .
- **Mobility:** It is considered more required for responding to new applications needs because it allows routing data regardless of location.
- **Route Selection:** WSN routing protocols can be categorized based on the path computation. This category defined how the source node finds a route to a destination node. This routing family is subdivided into three sub-categories [3]. Each routing family has its advantages and drawbacks as shown in Table 1 :
- **Proactive Routing Protocols:** Named as table driven protocols which ensure the availability of routes before their needs. This routing family maintains routing tables of all network nodes using periodic dissemination of routing information .
- **Reactive Routing protocols:** This routing category establishes route when it is required from a node. As a result, this routing technology is more suitable for large networks.
- **Hybrid Routing protocols:** This routing family is based on the combination of both proactive and reactive techniques.

TABLE 1. Routing Protocols comparison

Protocol type	Advantages	Disadvantages
Reactive	Reducing routing overhead Free from loops Because Path is available when needed	Search delay before transmitting Important message traffic control Possible invalid route in cache No information about routes quality Slow convergence
Proactive	Up-to-date routing information Small delay Establish routes quickly Lower latency because Information is available all the time	Routing information is not fully used High resources consumption Possibility of creating loops
Hybrid	Scalability Up-to-date routing information within zones	Inter zone routing latency High Complexity More resources for large size zone

- **Classification:** Network structure allows us to distinguish different classes of Protocols, Additionally, routing protocols can be subcategorized into three subcategories according to their functionalities: Data centric (DC) routing protocols, the hierarchical routing protocols, and the Location-Based routing protocols.
- **Data aggregation:** The data aggregation in sensor networks permits a global and a collaborative scheme instead of individual in a given area. MIN, MAX, or AVERAGE represent a well known simple aggregate functions that result a message summarizing the information contained in n messages. Consequently, the messages number is reduced and the network energy consumption is decreased.

Routing protocols can be divided into three different families [4] [5]:

2.1.1 Data centric(DC)

In data-centric routing is based on queries system, the sink transmits queries to sensors located in selected regions and waits for data. Since data is being requested through queries, attribute-based naming is necessary to specify the properties of data. The main idea of the DC routing is to combine the data transmitted by node sources in route (in-network aggregation) taking into account the information redundancy and the number of transmissions minimization. Consequently, the network energy consumption is reduced and its lifetime is extended. Unlike the basic end-to-end routing, DC routing family [4] [5] permits establishing paths from multiple sources toward a single destination . Some Data centric protocols are as follows:

- **DD [6] : Directed Diffusion**
- **RR [7] : Routing Rumor**
- **SPIN [8]: Sensor Protocols for Information via Negotiation.**
- **COUGAR [9]**
- **AQUIRE [10]: ActiveQuery Forwarding In Sensor Networks**

$$T(n) = \begin{cases} P/1 - P(r \bmod 1/P) & \text{If } n \in G \\ 0 & \text{Otherwise} \end{cases} \quad (1)$$

2.1.2 The Location-Based routing protocols:

In this routing category, sensor nodes are dispersed randomly on regions and mostly known by their geographic localization. Their positions are defined by GPS (Global Positioning System) tool. The distance separating sensor nodes is

estimated by the signal strength received from sender nodes and positions are calculated by communicating information to their neighbours. Thus, this location based method can't be practically used because it requires specific hardware components and imposes significant computational overhead to the sensor nodes. Some Location based routing protocols are as follow:

- **GEAR [11]: Geographical and Energy Aware Routing**
- **GAF[12]: Geographic Adaptive Fidelity.**
- **MECN [13]: Minimum energy communication network**

2.1.3 The QOS based routing protocols

QOS is very required for several applications. In order to satisfy the QOS requirements (e.g., delay, reliability, and bandwidth) different protocols are invented. These methods have the goal of establishing a trade-off between energy consumption and data quality.

- **SPEED[14]: A real time routing protocol.**

2.1.4 The hierarchical routing protocols

Hierarchical routing is designed for reducing the sensor nodes energy consumption efficiently by integrating the clustering and multi-hop communication concepts.

Clustering represents an efficient method which is based on data aggregation. That allows decreasing the number of messages routed in the entire sensor network. Cluster construction is mainly based on the sensors energy and members proximity to the cluster head. Combining the multi-hop communication and clustering approaches ensure higher network scalability. Some Hierarchical routing protocols are as follows:

- **LEACH [15] [16] [17]: Low Energy Adaptive Clustering Hierarchy**

It is the first hierarchical protocol designed for saving the network energy. It is based on the clustering mechanism which organizes the network in a number of clusters as shown in Fig.2.

In each cluster, an important element is chosen for aggregating its data members and transfers them to the BS. This node is known as cluster head (CH) and it is selected based on the following probability T (n):

The operating process of this protocol consists of two main phases: the setup phase where the CHs are selected and the steady phase where the clusters data are routed to the BS by the CHs.

The main shortcomings of this protocol are the random selection of the CH and the direct communication between the CHs and the sink node.

Several versions of this protocol are designed in order to outcome these shortcomings [18].

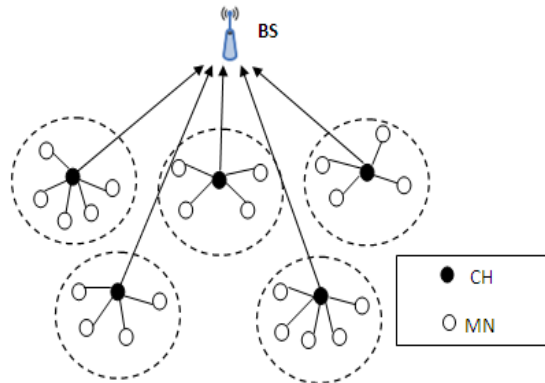


Fig.2 LEACH scheme

• **VLEACH [19]:**

It represents an improved version of the protocol LEACH which designs a novel scheme. Each cluster is mainly based on three elements as depicted in Fig.3:

The original CH set: defines the different CHs selected for aggregating data from their members and transmitting them to the BS.

the vice-CH: The new element which is designed for replacing the CH if it dies

the cluster nodes set: Their responsibility is restricted to collect significant data from the environment and transmit them to the adequate CH. In the basic LEACH, the CH is required to execute various operations (receiving and sending and aggregating data) . In addition, This basic scheme does not control the distance between the CHs and the BS. As a result, the CHs dead early.

However, V-LEACH extended the network lifetime using a vice-CH node which replaces the CH after its death.

V-LEACH scheme permits prolonging the network lifetime. However, the vice-CHs are selected in random way which represents the main drawback of V-LEACH protocol.

For resolving this serious problem, a various number of approaches are appeared.

In [20], authors design an enhanced version of V-LEACH protocol. The main improvement in this work is enhancing the vice-Cluster Head selection by combining the Minimum distance and the maximal residual energy and minimum energy factors. This new combination allows replacing the CH by a stronger node (the new selected Vice-Cluster Head). Consequently, the Improved V-LEACH extended significantly the network lifetime.

In [21], authors design a novel version of V-LEACH protocol named as LEACH-VH. The aim of this enhanced version is modifying the Vice-Cluster Head (VH) selection by considering the maximum residual energy. In this protocol, Both the CH and VH are chosen taking into account the highest residual energy. In each cluster, the CH and VH are selected based on the highest residual energy and the second highest residual energy respectively.

The VH is in sleep mode before the death of the CH is dead. When the CH dead, the VH wakes up for replacing the CH and taking its major role.

The sleep mode considered in this approach allows reducing the energy consumed in the network and prolongs the network lifetime.

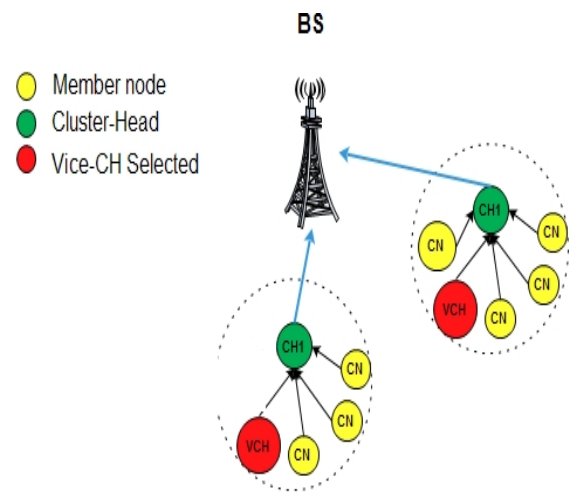


Fig.3 VLEACH protocol

3. NEW SCHEME

The new scheme defined a novel version of V-LEACH protocol. This new version aims at improving the intra-cluster and inter-cluster communication. It improved the CH and the vice-CH selection considering the highest residual energy instead of the random selection.

In addition, it allows controlling the distance between the vice-CH and the BS. This version uses the direct transmission for the nearest vice-CHs. However, it uses another vice-CH for routing data and controlling the farthest distance between the vice-CHs and the BS as shown in Fig.4.

The second vice-CH is elected efficiently among the remaining vice-CHs. It is selected using the distance separating it from the BS. Consequently, the routing path is elected efficiently. As a result, this cooperative routing permits reducing the energy consumed and extending the network lifetime.

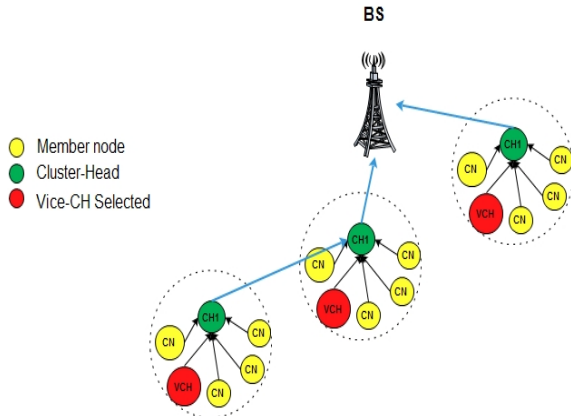


Fig.4 The new scheme

4. SIMULATION AND RESULTS

The objective of this section is studying the performance of our new protocol using NS2 simulator. The parameters considered are listed in Table 2 and the BS position is varied for evaluating the efficiency of the novel protocol. Different metrics are considered (energy consumption and the number of alive nodes) for two different BS locations: (50,100) and (100,200), in order to prove the impact of the BS location on the performances of the new scheme and the original protocol. Table 3 summarizes the improvement of the new scheme comparatively to the basic V-LEACH.

TABLE 2 Simulation parameters

Parameter	Value
Simulation area	100*100
Number of nodes	100
Simulation time	400 sec
Node's initial energy	2 J
Number of CHs	5
BS locations	(50,100),(100,200)

4.1. Energy consumption

From simulation results (Fig.5 and Fig.6), it is clearly shown that the new protocol improves significantly the network energy consumption. The protocol uses a smart path selection based on the energy and distance. It elected the CHs and the vice-CHs according to the highest energy. In addition, It uses another closest CH for routing data to the BS. Consequently, the energy consumption is minimized comparatively to the

basic V-LEACH. Also, the new protocol allows reducing the network energy even if the BS location is far.

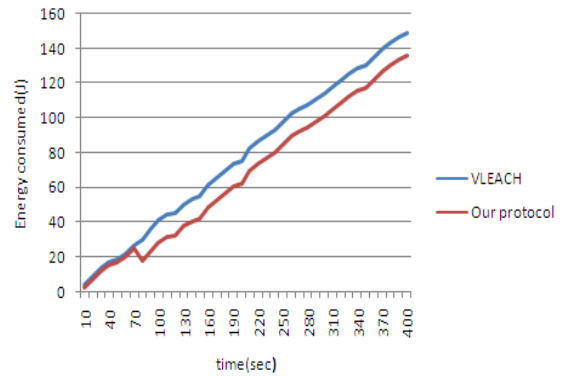


Fig.5 energy consumed at BS location(50,100)

4.1. Alive nodes

Simulation results (Fig.7 and Fig.8) show that the new scheme increases the number of the alive nodes in comparison with the original V-LEACH. This is due to the efficient selection of the CHs and the vice-CHs. Moreover, the use of another closest CH which decreases the energy consumed. Hence, the network lifetime is significantly increased.

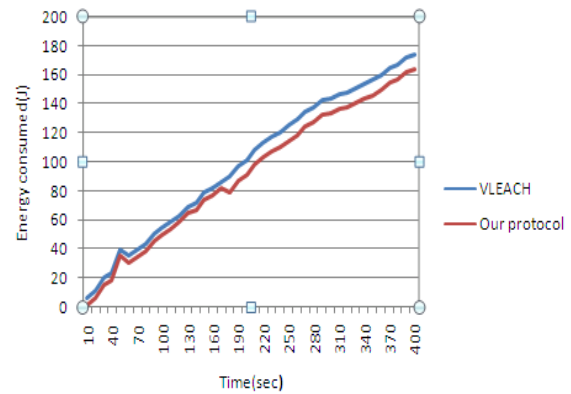


Fig.6 energy consumed at BS location(100,200)

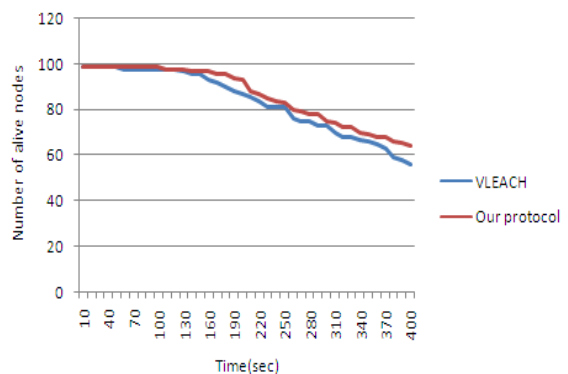


Fig.7 Number of alive nodes at BS location(50,100)

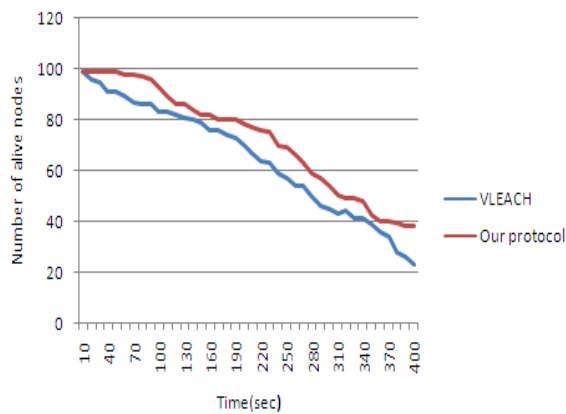


Fig.8 Number of alive nodes at BS location(100,200)

TABLE 3 The Improvement of the new scheme comparatively to V-LEACH

Improvement of The new scheme comparatively to VLEACH		
	BS-Loation1	BS-Location2
Energy consumption	47%	46%
Number of alive Nodes	49%	47%

5. CONCLUSION

This paper describes the different routing categories and some protocols, LEACH protocol which represents the first efficient hierarchical approach designed for saving energy in WSN and its improved version VLEACH.

This paper proposes a novel improved algorithm of VLEACH protocol which improves the path selection. The new scheme consists of selecting the routing path efficiently. Its process is based on electing the CHs and the vice-CH according to the highest residual energy. In addition, it uses a cooperative routing between the CHs and vice-CH in order to reduce the network energy consumption and control the farthest distance separating the vice-CHs from the BS.

Simulation results show that the new approach improves significantly the network lifetime even if the BS is located in a farthest position.

The future work will be the study of the performance of the new scheme using other QOS parameters.

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