Reducing the Wireless Sensor Networks' Delay by Reducing Program's Complexity and by Using Parallel Processing Mechanism

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Abstract. Wireless Sensor Networks have received a big interest of the most researchers in the last years. This is due to the importance of these networks in all fields such as medical field, military field, economic field, etc. In addition, sensors can be used in all locations even in places that we cannot reach due to their ease of distribution in the research area and their low cost compared to other networks. However, the limited energy sources that the sensors carry reduce the life of the network and thus limit its use in some sensitive areas.

Therefore, to reduce sensor nodes energy consumption and extend the life of wireless sensor networks mobile cluster head has been used (Loubna & Nour, 2021), while the cluster head in LEACH protocol was immobile. The energy consumption of wireless sensor nodes was clearly decreased in comparison of LEACH protocol. But when the wireless sensor network is dense (the cluster size is large and the number of sensors in each cluster is large), the moving cluster head maybe runs out of energy before ending the specific period and it's probably to end the specific period before collecting the data from all nodes in the clusters (Purohit & Keswani, 2015).

Thus, to solve this problem, this paper discusses the use of parallel processing by assigning two cluster heads in order to increase the efficiency and to reduce the delay by reducing the complexity of parallel processing technique.

Keywords: WSN, clustering-protocol, parallel processing, programming complexity

Introduction

Wireless Ad-Hoc networks refer to a collection of two or more devices or nodes with wireless communications that communicate with each other without the aid of any centralized administrator, Ad-Hoc networks are the most common networks nowadays because of its use for civil and military purposes.

Ad-Hoc devices can communicate in any time and at any place without using any existing fixed network infrastructure (Devarajan & Padmathilagam, 2015).

There are three types of Ad-Hoc networks (Mamoun, 2007; Heinzelman, Chandrakasan, & Balakrishnan, 2000):

1. Mobile Adhoc Network (MANET)
2. Vehicle Adhoc Network (VANET)
3. Wireless Sensor Network (WSN)
4. Wireless Mesh Network (WMN)

Wireless Sensor Network (WSN) has been used in this paper; the WSN suffers from the death of network because one or more sensor nodes run out of energy. So that, the most of previous searches focus on reducing the consumption of energy in WSN in order to extend the network's lifetime. We can consider several classifications of protocols in previous searches (Mamoun, 2007; Heinzelman, Chandrakasan, & Balakrishnan, 2000; Purohit & Keswani, 2015) like:

1. Table-driven protocols
2. On demand-driven protocols
3. Hybrid protocols

Each of those types has used in networks that have specific dense. The first type has used in networks which have low dense because the building of routing table consumption energy, when the number of nodes increases, building the routing table will consume more energy. The second type has used in networks which have big dense and low mobility because in this type the route between the source and destination initiates on demand so that when the mobility is big, the nodes will consume more energy to initiate routes. The third type has used in networks when area's diameter is more than 1 km and less than infinity. So that, the clustering was the best technique in comparison to the previous studies (Gumaste, Kharat, & Thakare, 2013).

Low Energy Adaptive Clustering Hierarchy (LEACH) known as the most common protocol in reducing the consumption of energy of Wireless Sensor Networks. This protocol depends on clustering, it divides the network into clusters, network's designer defines the number of clusters, and each cluster has fixed cluster head that collects data from sensors in its cluster during the specific period. LEACH improves WSN lifetime but it was less efficient when there is more nodes' density, or, when the nodes are far away from the cluster's head.

Therefore, this paper present a solution to increase the efficacy of WSN depending on clustering but by using two mobile cluster's head and parallel processing technology.

Materials and Methods

Due of the importance of WSN and its use in all fields of life, using it are real time application, the limiting of energy source of these networks and delay of the parallel processing technique. This paper rely on classification, so there is a hierarchy of nodes in the network as follows (Jain et al., 2006):

1) Access-point
2) Mules
3) Sensors

An Access Point is the highest hierarchical level having the highest power level among all the nodes. At the end of each period, it roams the network and collect data from cluster's heads. At the end of the tour, all network's information will be collected. The Mules is the second hierarchical level after the access point. It has less energy than the moving access point and higher energy than the rest of the nodes within the cluster (Jain et al., 2006). The lowest hierarchical level is the wireless sensors nodes that sense data during the tours (Jain et al., 2006). An ID has used for each node that expresses the type of data it collects. Thus, the cluster's head moves towards the nodes having the information that it looks for.

In the purpose of energy saving at high density of nodes, parallel processing technique have been used, and to reduce the delay of data collect reducing program complexity had been applied. The proposed mechanism steps for parallel processing technique are illustrated in the following figure:

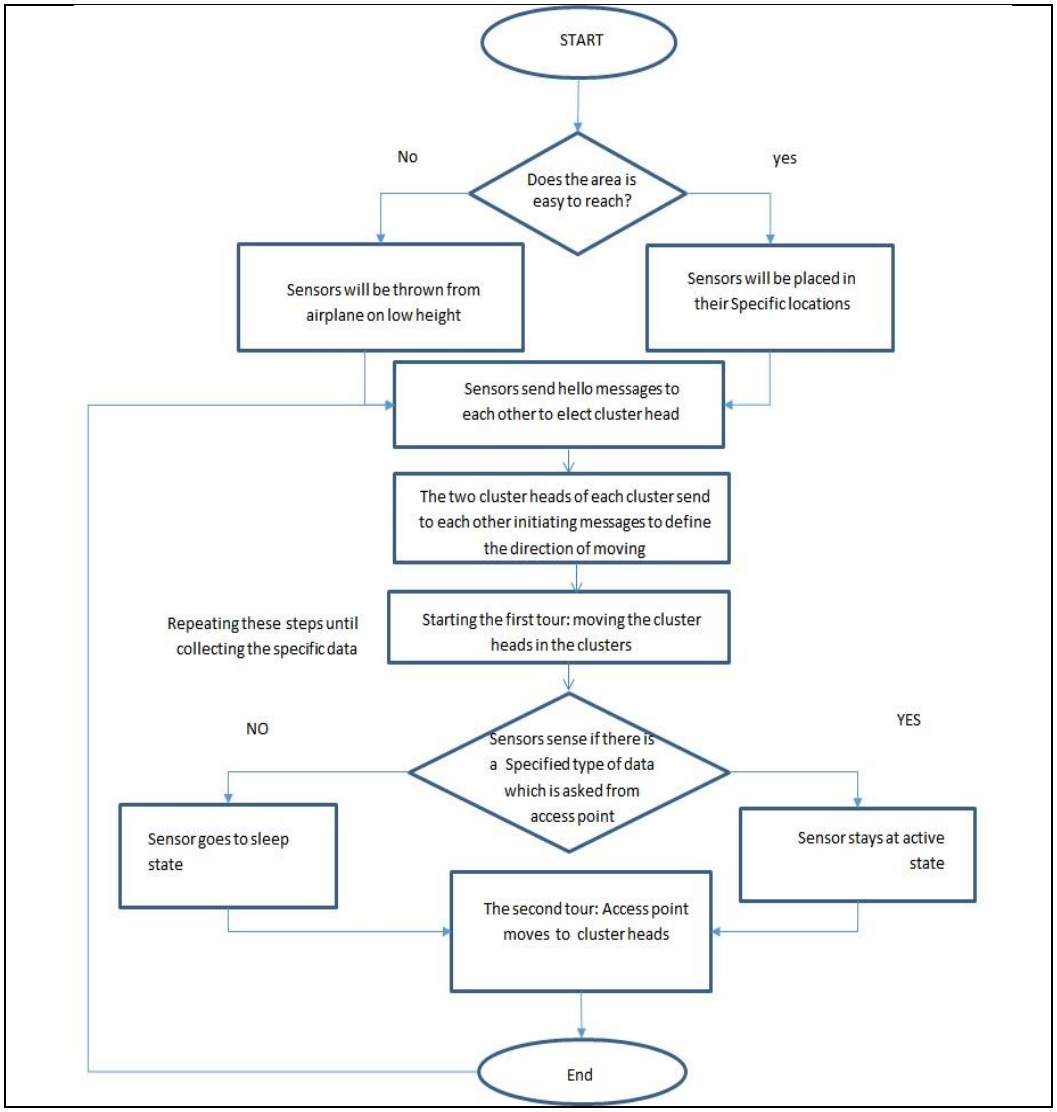

Figure 1. Parallel processing technique algorithm

The previous technique shown in Figure 1 has used to reducing the consumption of sensors in the big dense networks, but it produces delay. The delay increases as the density increases, so to achieve the goal of reducing the delay, the code complexity decreasing method for parallel processing technology had been used. The delay before decreasing the code complexity is:

$$T(n)= T_1(n)+T_2(n)+T_3(n)= n+n^2+n^2 \quad (1)$$

where n: the size of data (number of times that the code runs); T (n): the overall time to execute the code; T_1 (n): Time of execution of simple instructions; T_2 (n): Time of execution of loops; T_3 (n): Time of execution of calculating temperature function.

The complexity time increases when loops have used (for and while loops) then the complexity degree is $O(n^2)$. So that, (For) loops that have used to put sensors in their places had been replaced by (set) instruction. Thence, each instruction is executed for n time and the overall time is the adding n for each instruction so that the overall time becomes: T(n) = O(n). The time in this case becomes lower than before.

In addition, since we apply this mechanism in a specific geographic area, the humidity and temperature will be almost the same in any partial area of it. Therefore, we also canceled the collection function of all nodes' data due to the time that the moving nodes will take to

achieve this process. For each process of capturing the degree of humidity or temperature, the moving cluster leader compares it with the previous value that he has and keeps the higher one. Finally, the function of defining if the sensor node is Active or Sleep is replaced by sending broadcast message to sensors asking them to define their states which running in (n) time instead of (n^2) in while loop.

In result ,the overall time of running code after decreasing complexity by replacing For and While loops and deleting functions became (n) times for each instruction, we know that adding n in every time is less than multiple (n) in each time. So the overall time after decreasing the complexity of code is:

$$T(n) = n+n+n+\ldots\ldots\ldots\ldots = O(f(n)) \quad (2)$$

Results

In order to support the research proposals with practical results, NS2 simulator had been used accompanied by X-Graph application to display the research results.

The following figures show the studied networks after placing the nodes by the network designer in the search area. For the goal of comparing the two cases two scenarios had been applied:

In the first scenario (Figure 2), the network had been divided into two cluster. One cluster's head had been used in each cluster.

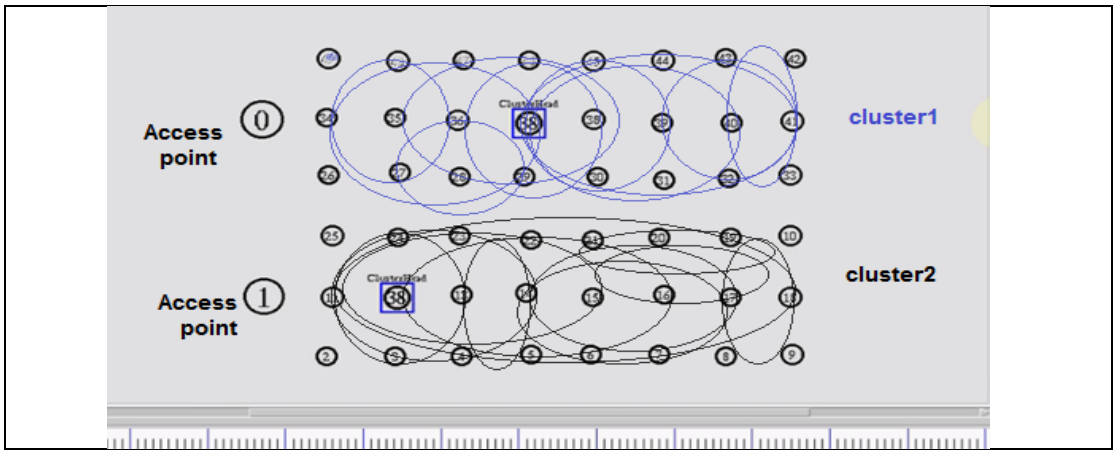

Figure 2. First scenario using one cluster's head

However, in the second scenario, two cluster's heads were elected as shown in Figure 3.

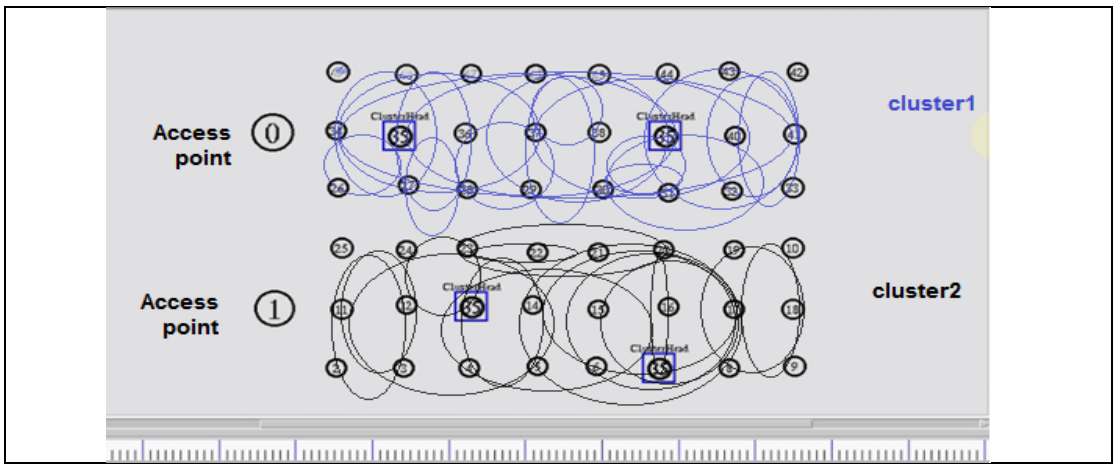

Figure 3. Second scenario using one cluster's head

The output of Xgraph application, Figure 4, shows the difference of the delay between the previous two scenarios before reducing the program complexity.

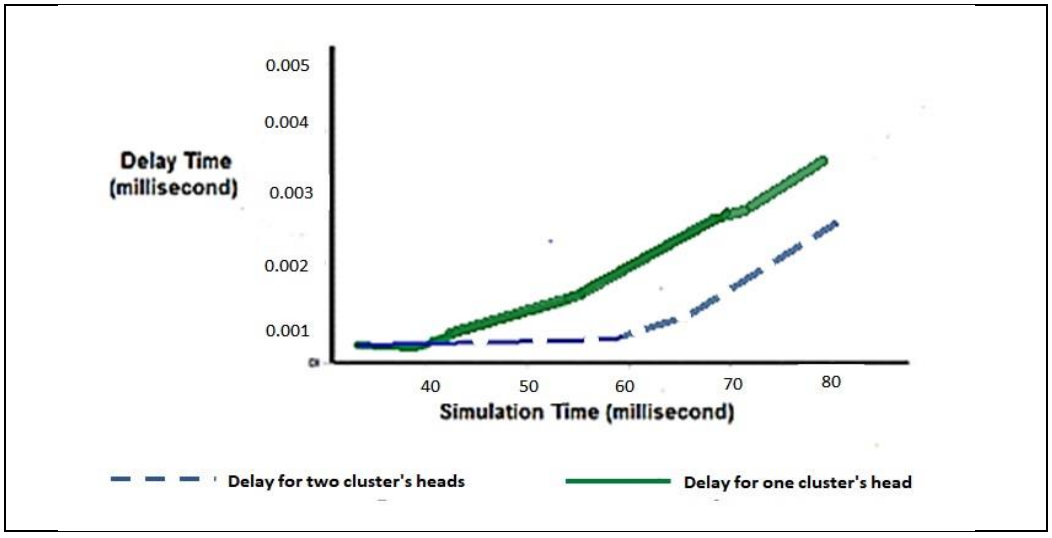

Figure 4. Difference of the delay between the two scenarios

The previous figure shows the time delay at the end of the simulation when applying the proposed mechanism in this research, which is the use of two moving cluster leaders, and here we note that the time delay is equal to *0.003 ms.*

As for the time delay at the end of the simulation when using one mobile cluster's head is greater than the delay when using two mobile cluster's heads, it is equal to *0.0039ms.*

This is a logical result because in the case of only one cluster's head, the head node takes more time to pass over all nodes and longer waiting time to receive the data from all nodes within the cluster.

Now, due to the noticeable reduction in the time delay at the end of the simulation for the second scenario, we have passed to the next step that is calculating the time delay after reducing the program complexity. For getting a good result, we propose to study the optimization problem for the time delay. To achieve that, can use the unimodular matrixes using Python and LateX (Hajrulla, Arban, & Bezati, 2022; Hajrulla et al., 2021). The following figure shows the delay after decreasing the complexity of the software when the simulation is finished, and it was equal to *0.0025ms.*

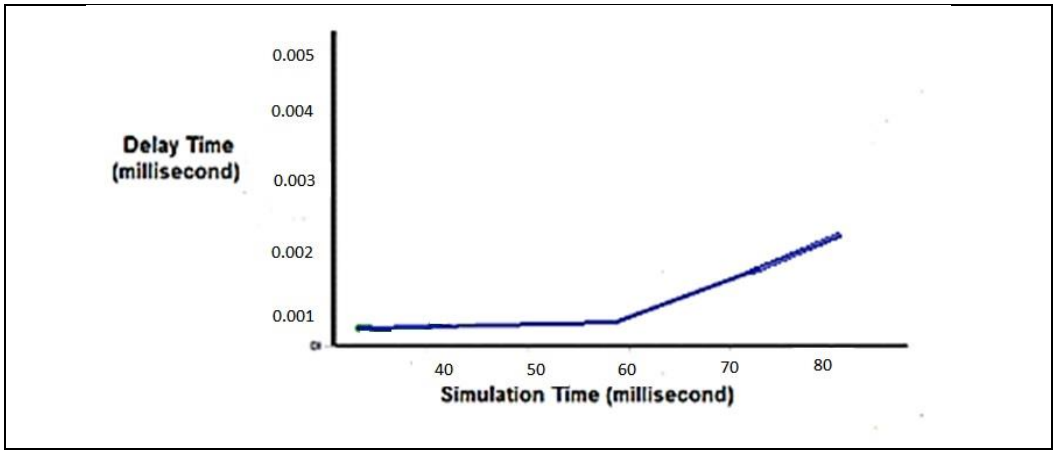

Figure 5. Delay after reducing the program complexity

Conclusions

Decreasing the delay time is one of the most important issues that make the WSN more usable in all fields. This paper discussed the problem of time delay in WSN and suggested an appropriate solution to reach that goal. The proposed solution was based on two ideas: using two cluster's heads and reducing programming complexity.

We can see the improvement in the time delay achieved by this work. In a later study, we will discuss the effect of suggestions that helped reduce the time delay on energy consumption, the topic that is considered as a challenge in the field of WSN.

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