International Journal of Computer & Information Technologies (IJOCIT)
www.ijocit.org & www.ijocit.ir
ISSN = 2345-3877

Improve Lifetime in Wireless Sensor Network

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Abstract:- A Wireless Sensor Network (WSN) consists of some wireless nodes which are known with these characteristics: small size and constrained energy source. Considering the energy constraints of nodes in Wireless Sensor Networks (WSNs), routing by efficient energy is significant, so considerable effort has been taken to design efficient routing protocol in order to prolong the lifetime of WSNs. Clustering is an effective procedure for prolonging the lifetime of the network and timing of nudes activities. One of the parameters determining the speed of operation, emergency response and disaster management, in utilize of Mobile sensor network, extending the lifetime of sensor network and consequently available resource is one of the primary concerns and has an important role in crisis management. In order to conserve energy and prolong network's lifetime this study uses the energy aware algorithm to introduce and implement the proposed algorithm. To achieve this aim, with managing the time of nodes activity and managing the neighbor nodes in the communication path between source and sink, a new clustering method is introduced. The simulation results shows the improvement of network lifetime. Finally, the presented Flow Augmentation Modified (FAM) algorithm and clustering algorithm are simulated by Glomosim software and then the results are evaluated.

Keywords: routing, clustering, energy aware routing, lifetime, wireless sensor network .

1. Introduction

WSNs have drawn a lot of attention to themselves in recent years. A WSN consists of many distributed sensor that are placed in random locations to monitor physical and environmental conditions such as: sound, pressure, temperature, vibration and motion [1]. The critical issues of these networks are as follows: detecting the relevant quantities, monitoring and collecting data, assessing and evaluating the information, decision making and alarming functions [2]. Because of the limitation of the nodes energies in WSNs, energy efficient routing is very important. Therefore, one of the most important fields of research in WSNs is to prolong nodes lifetime and consequently network lifetime. Network lifetime can have different definitions but in this study , it is defined as the death time of the first network node. In a WSN, nodes are distributed in the environment in an ad hoc fashion. Each node in its radio range is neighbor with some other nodes. Transmission range has a direct relationship with the energy of each sensor node. In other words, if the sensor has larger range to send its data, more nodes will have the possibility to receive the information of source node but the source node needs to consume more energy. As a result, it may face problems to send the next data and loses its connection with other nodes. The reminder of this paper is organized as following: fundamental concepts such as concept of clustering and its algorithms have been investigated in section 2. Section 2 presents related works. In section 4, Assumptions and Algorithms for achieving these assumptions have been expressed, Respectively. Simulation results have been achieved by Glomosim simulator and have been studied in section 5 and it's subsections, and final conclusion of this study is expressed in section 6.

2. Fundamental Concepts

2.1. Clustering

Clustering is one of the main approaches in designing energy-efficient protocol and the scalability of wireless sensor network. Making use of clustering decreases the overhead of communication and consequently reduces the energy consumption and wave interference between nodes. In most of the applications, cluster organizing is a

natural method for grouping the neighbor nodes in order to utilize the relevant data and remove Redundancy [3].

2.2. Clustering Algorithm

Clustering algorithm in WSNs is divided into two groups: centralized and distributed. Centralized algorithm in large networks has a limited usage because collecting the required information in one place isn't energy effective. Distributed approaches (local) are better for larger scales. In these approaches, a node decides to be a cluster head or cluster member only according to its neighboring information. Clustering protocols are divided into two groups: static and active. In static clustering, clusters are formed permanently, while in active clustering, this process is often done in "time periods". "Each period" includes initialization phase and Steady-state phase. Initialization phase P_4 Is done at the beginning of "each period". Performing the initialization phase imposes a lot of overhead on the system in each phase [4]. In the following, FAM algorithm will be examined and then the proposed clustering algorithm will be explained.

3. Related work

In this section, we will briefly describe related work of extended lifetime routing in Wireless Sensor Network. One of the most interesting areas of research in wireless sensor networks is coverage in order to convert energy. In these approaches, when the neighbor nodes can provide coverage, the node will be kept in sleep mode [5]. Smart routing algorithms can also be used For energy conservation, generally they are called power-aware routing and processing algorithms. There are several strategies to reduce energy consumption [6]. LEACH is the first and most famous clustering-based protocol in wireless sensor networks. Creation of clusters is performed in the distribution and uses random clusters in order to have a fair distribution of energy load among all nodes in the network. Data are collected by the head clusters of nodes in each cluster and then will be processed and aggregated, they will be sent to the base station [7],[8].

The greatest number of routing algorithms in wireless sensor network focuses specifically on conserving battery power of nodes to enhance the

lifetime of network wireless sensor network . Aslam M. et.al [9] concentrate on how these extended protocols work to increase the lifetime and how quality routing protocol are improved for WSNs, also they highlight some of the issues confronted by LEACH and extended versions of LEACH.

MEAODV (Multi-path Energy Aware AODV) routing [10] is one another cluster based energy efficient routing algorithm. MEAODV utilizes the topology of network and divides the network into one or more logical clusters, restricting the flooding of route request outside the cluster. J.H Chang and L. Tassiulas, (1999), [11] introduces first model of maximum lifetime routing algorithm as a linear programming problem for single destination. They proposed: Flow Redirection algorithm (FR) and Maximum Residual Energy Path (MREP) heuristic routing protocols. The FR is a redirection based algorithm where small amount of flow is redirected in such a way that the resulting flow to the destination will finally have the same lifetime in all paths, hence the minimum lifetime over all the nodes will become more. In MREP algorithm, the idea was to support the flow on the path whose minimum residual energy after the flow augmentation will be longest. Simulation result of [11] is compared with Minimum Total Energy (MTE) [12]. MTE chooses the path with the least transmission energy consumption. Simulation result shows that FR and MREP routing algorithms are near the optimum. They also offered Flow Augmentation algorithm (FA) for the multi commodity case [13]. FR and FA algorithms provide optimal flow rates based on knowledge of complete topology and packet generation rate at each node.

This paper presents a solution to the issue of energy conservation, by focusing on smart routing algorithm usage. Our work is based on the FA algorithm and FAM algorithm, changing FA has been obtained. FAM algorithm prevents a node for placing in more than one path simultaneously before update energy [14]. Then we use FAM algorithm on a cluster infrastructure, In addition, Significant point of our work is the special design of clustering algorithm with the dual sleep

scheduling, and also turning off transmission path's neighboring nodes.

4. Methodology

4.1. Assumptions

Sensor networks are homogenous, so all it's nodes have same system resource. Also the a mount and type of node power consumption in the time of sending, receiving and sensing obey a model with same parameters.

- The simulation area of field is considered two dimensional and radio range is disk model (all directional with equal range) .
- Nodes have fixed information generation rate.
- Sensors are fixed in their location. in other words, sensor are placed in their location in the time of distribution and don't have the ability to move in the environment. Therefore, network's topology is static.
- Sensing environment and preparing the data of each sensor node to be sent is done independently. In order to sense, they don't need coordination or permission from base station or neighbor nodes.

Consider a wireless sensor network with N nodes. let K_i Represent the set of immediate neighbors of node i $(i \in N)$, e_{ij}^{t} indicates the average power consumed for data transmission from node i to node j and E_i be the initial battery level of node i . a set consisting of origin and destination nodes called commodity which is show by c $(c \in C)$. $O^{(c)}$ is a set of origin nodes where information is generated with rate $Q_i^{(c)}$. $D^{(c)}$ is a set of destination nodes in which any node can be reach in order for the information transfer of commodity c. e_{ij}^{r} be cost of received information sent from node i to node j. $S_{ij}^{(c)}$ be the traffic generated at node i to node j and Y_{ij} be the amount of data that need to be transmitted from node i to j.

4.2. Main Algorithm

Flow Augmentation Modified (FAM) Algorithm is used as Main algorithm in this study. The purpose of this algorithm is to find the best link cost function, the amount of energy consumption to transfer data unit to the receiver and also to maximize the system lifetime. Function of FAM algorithm: calculates cost of the shortest path for

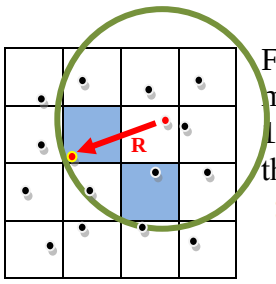
a commodity c that $c \in C$, cost of link (i,j) is computed through eq(1) if and only if $E_i - e_{ij}^t > 0$, the path cost is given by the sum of the link costs.

$$cost_{ij} = e_{ij}^t \frac{E_i}{R_i} + e_{ij}^r \frac{E_j}{R_j} \quad (1)$$

$\frac{E_i}{R_i}$ shows energy consumption rate, so the nodes that have higher rate of energy consumption have more cost. If $c \in C$ commodity can not find a path to its destination ,the algorithm stops otherwise it continues. Computing rate of augment $\lambda\, Q_i^{(c)}$ an each shortest cost path of its commodity and update the residual energy accordingly. Go to step 1 [13]. The following consider the infrastructure of proposed clustering algorithm.

4.3. Clustering Network

All the network is grid for clustering and every grid is considered as a cluster which has a cluster head and some members. The size of each side of grid is **r** and the radio range of node is **R**, R is computed via eq (2) & eq (3) [14]. In order to connect and join two neighboring grids, the distance between two nodes in the farthest point of two grids shouldn't be larger than R, as shown in Figure 1.



For example: if the dimensions of network are 1000×1000 and R=100 then $r \approx 44$

$$r^2 + (2r)^2 \leq R^2 \quad (2)$$

$$r \leq \frac{R}{\sqrt{5}} \quad (3)$$

Figure 1: Computation of grid.

A number is allocated to each grid and node (routers). Each node has a fixed coordinate (x , y) and according to the coordinate of each node, its location in each grid & its offset from location (0,0) can be defined. According to the following formulas and comparing the coordinates of each node with the length and width of the whole network and that of each grid, the local grid of node is achieved via eq (10).

Node Number: when the network starts to work, a number is allocated to each grid. Grid Number: as our main network is divided into virtual grid, a number is allocated to each grid when the network starts to work. eq (4) & eq (5) respectively shows the number of columns in virtual Grid.

$$(\text{Network x})/r \quad (4), (\text{Network y})/r \quad (5)$$

eq (6) & eq (7) respectively shows node's value of variable x of Local grid and node's value of variable x in Local grid.

$$\text{Local Grid } x = (\text{node } x)/r + 1 \quad (6)$$

$$\text{Local } x = \text{Mode } (\text{node } x)/r \quad (7)$$

eq (8) & eq (9) Respectively shows node's value of variable y of Local grid and node's value of variable y in Local grid .

$$\text{Local Grid } y = (\text{node } y)/r + 1 \quad (8)$$

$$\text{Local } y = \text{Mode } (\text{node } y)/r \quad (9)$$

and grid number achieved by eq (10).

$$\text{Grid No} = ((\text{Local Grid } y - 1) * (\text{Network } x)/r) + \text{Local Grid } x \quad (10)$$

the center of each grid is calculated via the following :

$$x \text{ Center of Grid} = (\text{Local Grid } x * r) - r/2 \quad (11)$$
$$y \text{ Center of Grid} = (\text{Local Grid } y * r) - r/2 \quad (12)$$

4.4. State Transition

Each grid can be placed in each of these three states. the proposed algorithm has dual sleep mode. In other words, "one time sleep period" and "two time sleep periods" which will be explained more later . In the proposed algorithm, the network activity for all nodes is in the form of equal and simultaneous "time period". When the network starts to work, time is divided into "odd time periods" (one time periods) and "even time periods" (two time periods). The nodes which are in the active or discovery mode (one time sleep) have "odd time periods" and the nodes which are in the sleep mode(two time sleep) have "even time periods".

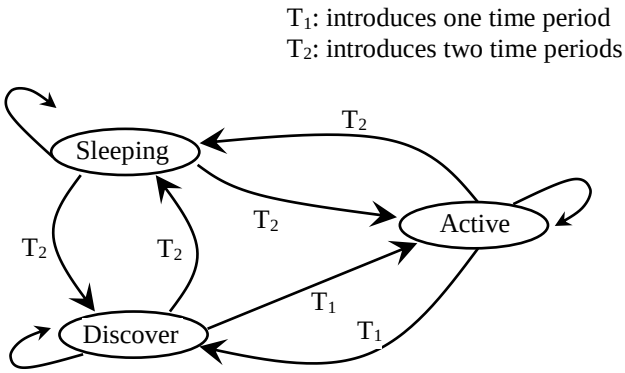


Figure 2: The graph of state transition in the proposed algorithm.

Decision making of about each of these nodes mode and how to choose them in one of the aforementioned states of the proposed algorithm and the activity of each node will be explained later.

4.5. Network Initial Phase

In initial stage, nodes achieve the different amounts of various variable such as: grid number,

node number, residual energy, the sum of node links cost , the coordinate of grid center, the cost to different sinks (which are initialized through performing routing algorithm) by identifying the neighbors in local grid ,because of their fixed position and definite initial energy. in this phase, nodes are placed in discovery mode and then they turn on their radio Simultaneously and send the discovery message(MSG-hello) to their neighbors to identify then & to choose one of the three modes of activity based on the mentioned amounts.

- Nodes Ranking: in order to achieve one of the three working modes, each of grid nodes have to be ranked according to residual energy, sum of each link cost, distance from the grid center, grid density or a combination of these parameters.
- Selection of node mode according to the achieved rank. Active mode: The node with the first rank goes to active mode. When a node goes to active mode arranges its timer for T_1 second and acts as the cluster head in its local grid for a "time period" (T_1). Discovery mode: The node with the second rank goes to discovery mode. a node in discovery mode arranges its timer for T_1 second and goes to one time sleep. Sleep mode: All the grid nodes, except those in the first (active mode) and second (discovery mode) rank go to two time sleep mode(T_2). Now every node is in one of the three modes. Then via performing bell man-ford routing algorithm, head nodes complete their routing table by exchanging messages and become a convergent network. After the initial phase, the network will have "odd time periods" (T_1) and "even time periods"(T_2).
- Odd time periods (T_1) : at the end of "each period" (one time periods) active and discovery nodes (which had one time sleep) enter a discussion to choose a head (active node). Among these two, the node with higher scores is chosen as the head and the other node is chosen as the discovery node (one time sleep).
- Even time periods(T_2): at the end of each "even time period" (two consecutive one time periods), the nodes in sleep mode (two time sleep) wake up and enter a discussion with active and discovery nodes (which had one time sleep) to choose a cluster head (active node) and among

then the node with higher scores is chosen as the cluster head. The node with the second rank goes to discovery mode (one time sleep) and other nodes go to sleep mode (two time sleep).

4.6. Activity of the Active Node

A fixed time is allocated for routing from the beginning of "active time period" (the initial phase of each "odd time period"). the routing results are used at the rest of the time of that "active period" (Steady state). The node that goes to active mode, turns on its "one period" timer (T_1)(at the same time discovery and two time sleep nodes turn on their timers (once in each "two periods")) to understand how long it stays in active mode. After T_1 seconds and at the beginning of the "next time period" in each "odd time period" the active node enters a discussion with a node which has been in discovery mode. And in each "even time period", it enters a discussion with a node that has been in discovery mode and also the nodes which have been in two time sleep mode. In each step of routing , either with bellman-ford's algorithm in which distributed routing is done or in Dijkstra's algorithm in centralized routing is done, each node which is chosen as a member of path has to update its residual energy according to membership in the new path.

4.7. Last Step

When routing is done at the last step and the sink is found by the node, algorithm returns the answer to the source in the same path toward the sink. In the return way, when the algorithm reaches any of the route active nodes tells them to say to their single-hop neighbor (from that moment) to sleep for "one time period", i.e, to be placed in discovery mode. (in the condition that the neighbor hasn't been chosen by other sources as a member of the other path). The neighbor nodes sleep finishes at the end of the "Active time period" and this node, discovery node (one time period), sleep nodes (two time period which has been ended) enter a discussion. The sleep order of path neighbor nodes before transfer is to prevent irrelevant listening in the time of transferring and as a result to prevent their energy waste. The above explanation was about clustering phase and how to choose the node mode in each cluster. Now that the general base of the network has been identi-

fied, it is time to perform the FAM algorithm. So in the proposed network, first a clustered base is provided for the network and then the FAM algorithm is performed and during routing in the FAM algorithm body, the discovered path neighbor are required to go to one time sleep mode to transfer data, prevent listening a Receiving unnecessary packets and also to prevent energy waste. Therefore in this proposed structure, as the neighbor nodes in the chosen path of data transfer and the nodes that have gone to two time sleep mode in the cluster go to sleep, less energy is consumed and the lifetime of system is prolonged. In the following, the proposed algorithm and FAM algorithm will be simulated, will be Performed by Glomosim simulation software and then the results will be analyzed.

5. Simulation Results

The simulation results have been achieved by Glomosim simulator and based on the following structure.

Regarding the conditions of the initial structure of network, after 50 times of simulation and distribution via bellman-ford algorithm, the following results have been achieved.

Table 1: The Condition of Initial Structure of Network

Total number of nodes in the network	100 - 1000
Routing protocol	Belman-ford
Mac layer protocol	802.11
Initial energy of each node	217 mWhr
Number of sources	10 – 20
Number of cluster(grid)	proportionate to the number of nodes from radio wave Equation
Number of sink	1-10
Dimension of network	1000 * 1000 m^2
Layout nodes	Uniform
Simulation time	15 min
Mobility	No

5.1. First Experiment

The average of energy consumption in the network in comparison to the increase in the number of nodes through data transfer. In this experiment, (the results are shown in Figure 3) the number of source nodes is 10 and the number of destination nodes is 5 and 1000 data packets are transferred.

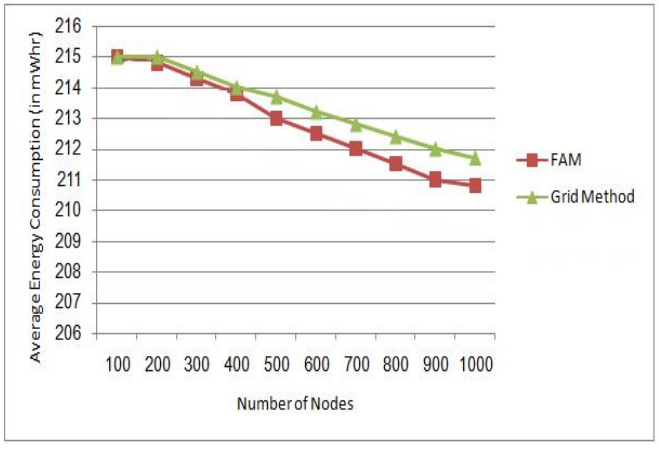


Figure 3: The average of energy consumption.

5.2. Second Experiment

The residual energy in the network in comparison to the increase in the number of data packets. In the second experiment (the results are shown in Figure 4), The number of packets has been considered as the main parameter to compute the residual energy of nodes.

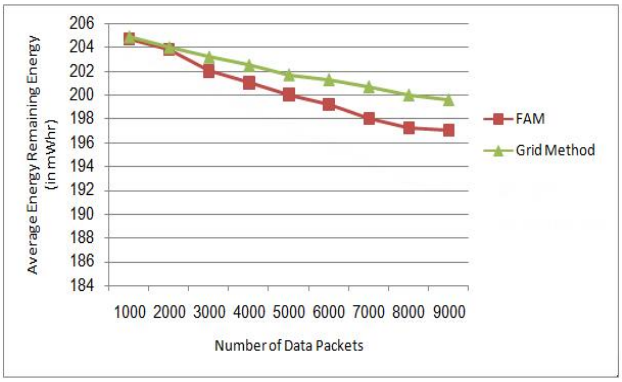


Figure 4: The Residual Energy In The Network

First in each path, 1000 packets (data packets) are transferred from source to the sink and then the number of transferred packets increases and the results are compared together in two modes. The number of nodes is 1000 which is fixed.

5.3. Third Experiment

The network lifetime in comparison to the increase in the number of packets. The results of this experiment are shown in Figure 5, For this experiment,1000 nodes are considered in the network. The number of source nodes is 20 and the number of destination nodes is 10. The number of data packets in this experiment is from 1000 to 9000. The lifetime in this experiment is compared by dividing the achieved time after a node goes to sleep into the total time of simulation.

6. Conclusion

The limited source of energy is one of the main problems in wireless sensor network, and if node energy is depleted, the entire system is lost. Hence one of the main areas of research is designing an energy - efficient algorithms to make us able to consume energy as efficient as its possible. The implementation FAM algorithm is based on clustering and specific management on nodes activity that we succeeded to increase the maximum lifetime of the system. The based on manage of node's activity, and parameters such as node's residual energy and node's position, rated will be based on Score gained, for one of three working modes: Active, Discover and sleep.

The main idea is very simple, a new sleep schedule has been made use of resources more efficient

and all the nodes in each time period for negotiations and select the cluster head, not energy consumed. But by dividing time periods into, even and odd periods, in even periods, all nodes in a cluster can enter the negotiation but, in odd periods, only active node and discover can negotiate. And the energy expenditure of the other nodes will be prevented also during sending data, neighbor nodes of the data transmission pat , go to sleep mode for one or more time periods, and unwanted Sense And consequently waste of energy is prevented. Simulation results show that the efficiency of the proposed method is better compared to FAM.

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