Improving network lifetime using optimized coverage in Wireless sensor networks

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Abstract

The main goal of wireless sensor network is coverage. The many methods have been proposed for coverage. For the aim of coverage many challenges posed, such as energy. If coverage not done correctly it causes emptying of network energy and reduction of network lifetime, therefore a mechanism must be created that will use less energy while covering properly done. One of the ways that reduce energy consumption is that while retaining their cover, turn them off. But selecting node for shut down in proposed methods facing with problems, and don't select correctly. In this paper, a selecting node method is proposed for shutting down that work precise without cover elimination. In addition, in this idea press adjusted based on the user need, finally it causes that network lifetime increase while coverage is maintained.

Keywords: coverage, connection, energy consumption, clustering.

1. Introduction

A large population of sensors spread randomly for monitoring area. The goal is, achieving an efficient energy design that keep area coverage in wireless sensor networks is one of the important. Function of these networks and, for this purpose many methods have been proposed. In the protocol ACE [1], partitions of networks into the uniform distributed clusters, focused on ACE clustering algorithm. ACE provides uniform cluster, by reducing overlap among clusters created in initiate phase. Nodes with the highest number of neighbors non-spanning or neighbors in the area of non-overlapping folders consider as optimal head cluster. However, issues related to energy do not discuss in this algorithm and duty of maintaining the cover needed by sensor networks applications is not considered. Clustering was in the context of sensor management, topology control and routing, which has been studied extensively in past. For solving this problem , they offered routing protocol GAF[2] to take control of the network topology and uses node density to increase network life time GAF protocol uses geographical information so that create a virtual grid based on network and select a sensor node to be activated in each cell. CEC [3] clustering protocol, improves GAF by failing to rely on location information. Further reduce of the redundancy of nodes by using grouping them in clusters, where the nodes have more energy select as the head clusters. And also, not GAF nor CEC doesn't warranty the full coverage of area coverage in network.

Algorithm OGDC [4] tries to minimize the number of active nodes by reducing the overlap of areas between active nodes. To ensure that different nodes in each round are active, the node begins to broadcast a turn on message among a random path that nodes working are found.

A node decides to turn off if it covers a point of intersection between two active sensors and if that minimize the overlap area with active sensors. However nodes do not consider their neighbors energy level. So they can send turn on message in the path of nodes with low residual energy. In protocol DAPR [5] distributed activation with preset paths (AAPR) had been provided. The first routing protocol designed by sensor nodes to avoid data routing via low cover areas. The idea behind this approach is that, the node in less accessible area used as well as nodes with less residual energy, as data routing. So that these nodes can collect data for a longer period of time. To accomplish this objective, importance of each node for the task of maintaining the cover measured by the cost conscious. To ensure from balanced energy consumption among head clusters throughout the network life time, many clustering protocol distribute the nodes with a fixed cluster size average non-uniformly. However, obtaining the same number of distributed clusters in time is a major challenge in sensor network clustering. In the applications based on cover the best circumstance for the rule of head cluster it should cover the node in densely populated areas with the highest residual energy. These nodes can support the nodes with more number of members, while excessive energy consumption of head cluster, disable these nodes before other nodes their death shouldn't have impact on network coverage while these node located in populated areas. The methods, consider required a applications for the full coverage of network. Set of nodes of head cluster can be selected based on cost metrics. So choosing head cluster base on each presented cost metric. With the use of available clustering techniques, led to an undesirable situation. Densely populated parts of network will populate with head clusters while areas rarely covered will be without any head cluster.

In such a situation, the nodes with the high cost will be available from the poor coverage areas that transfer value able data to the far distance head cluster nodes, and increase the network life time.

To avoid this situation a clustering scheme has presented that called clustering protocol of coverage maintaining (CPCP). (CPCP) includes 6 phases:

1) To update information.
2) Select head clusters
3) To upgrade route.
4) The formation of cluster.
5) Sensor activation.
6) Data communications.

CPCP expands head cluster nodes uniformly with use of limiting the maximum area of the cluster. Thus cluster that formed in low-covered areas should be same as the clusters in populated areas. Which prevent from the high cost of transition to the far distance head clusters? Also the nodes from low-covered areas select as the head cluster to support the clusters with the less number of nodes compared with the cluster node in high- density areas. Cluster radius (Rcluster) is defined as the appropriate parameter that determines the minimum distance between two head cluster nodes. Using this parameter CPCP prevent from non-uniform distribution clusters within the network. Rcluster can easily head jousted in head cluster nodes by changing

in transition power. In CPCP head cluster nodes communicate, while data routing from head cluster nodes to the sink has done on multiple paths by sensors. In this paper we try to describe the drawbacks of this algorithm and give its solutions. In the fifth step algorithm has no better performance for selecting active and off nodes, because can't determine the node that covered fully by the other nodes. Because we don't need to an accurate data and it makes the network life time reduce. In this algorithm we called our method CPCP-A (accurate). The rest of the paper is organized as follows. In section 2 we review our proposed algorithm (CPCP-A). In section 4 the experiments analyzes with available node is presented. Finally in section 5 we express classification and discussion.

2. Related works

2.1. Techniques of select head cluster for coverage

Working about wireless sensor networks is very broad, the main focus on many presented clustering protocols is yet, and energy efficiency and scalability similarly, a lot of work is done on nodes active protocols. While the focus is on selecting a subset of active sensor nodes that are adequate to meet the needs of network coverage. While they allow remaining sensors for keeping their energy, go to sleep mode. In this selection we discuss about the work done on both of these areas.

2.2. ACE

Divide the network to uniformly distributed clusters focuses on ACE clustering algorithm [6] ACE provides uniform clusters by reducing overlap between created clusters in the initial phase. The nodes the highest number of neighbors non-spanning or the neighbors in non-overlapping folders select as the optimal head cluster. However, energy issues are not discussed in this article. Several articles deal to the clustering methods for the non-uniform classification of sensor nodes. For example in [7] , authors pose the power control issue and clustering in heterogeneous sensor network a clustering network structure created to ensure that transmission power used by all nodes within the cluster is convergent to the same level. The authors in [8] found that used non-uniform networks with high density of node can divide to non-overlapping local clusters. And these clusters have lower density and in sensor scales will have high correlate while the aim of these techniques is to create clusters non-uniformly and sticking together.They don't consider duty of maintaining the required coverage by sensor networks applications. Clustering was in the context of sensor management, topology control and routing which has been studied extensively in the past. For example authors presented routing protocol GAF in [3] to control network topology and use the node density to increase the network life time.

2.3. GAF

GAF uses geographical information so that create a virtual grid based on network and select a sensor node to be active in each cell. Clustering protocol CEC [10] improved GAF by failing to rely on location information. Further reduce of node redundancy, by using groping them, where the node have more energy select as the head cluster nodes and also not GAF nor CEC

guaranteed the full coverage from area coverage in network. The problem of scheduling the nodes [11] for getting in to sleep mode in the networks based on cluster, is studied. Authors present a sleep scheduling scheme based on linear distance. The probability that a sensor goes to sleep mode is proportional to its distance from the cluster. Similar to that is discussed more in [12]. Authors proposed a scheduling scheme of balanced energy which is calculated for the total energy consumption in communication and sensing.

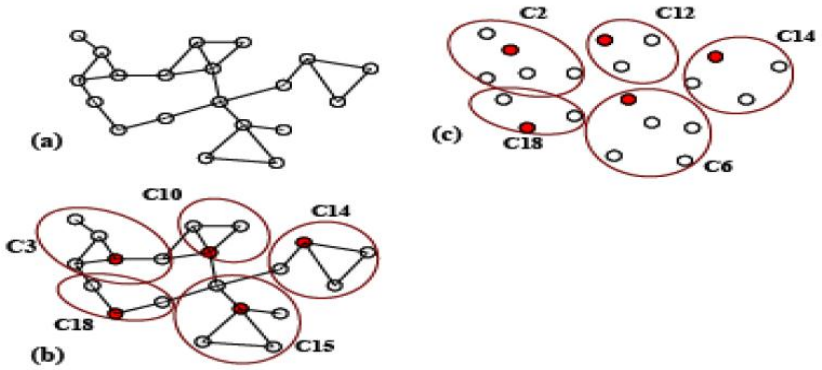

Figure 1: nodes are divided to several clusters in an area.

Thereby ensure that the energy is spent uniformly by nodes. Again, these methods it balance energy consumption of critical nodes, as it per formed in this methods independent clustering algorithm based on estimate its own coverage in each sense is presented [13]. Sensor nodes with the highest expected coverage are the best candidate for the role of head clustering and provides less variation of head cluster roles over time. Therefore, this scheme does not provide the complete coverage of the network.

2.4. OGDC

The proposed algorithm (OGDC)[14] tries to minimize the number of active nodes by reducing overlap areas between active nodes to ensure that different nodes are active in each round, the node begins to broadcast a turn on message along a random path which working nodes have been found. A node decides to turn off if it covers a point of intersection between two active sensors. And if it minimize the overlap area with active sensors. However, the nodes don't consider their neighbors energy levels. So they can send turn on message on the paths of nodes with low residual energy.

2.5. DAPR

Distributed activation with present path (DARP) is presented in [1]. The first routing through protocol is designed to avoid data routings low-covered areas by the sensor nodes. The idea behind this approach is that the nodes in less accessible areas , are used as well as the nodes with

less residual energy as the data routing. So that these nodes can collect the data for a longer period of time.

To accomplish this objective importance of each node measured for the task of maintaining the coverage by a cost metric of conscious coverage. While information about the nodes residual energy covered with the information about how to increase the node sense area. Which combined by their neighbor Node's sense area. To explore the advantage of this method in the sensor networks based on cluster, we introduced several cost metric of conscious coverage. It is assumed that n number of nodes from the set S such that Si ∈ S, and i=1… ns , ns number of nodes are scattered randomly in A area of rectangular shape, we assume that the application require that all sensors, so that the network life time increases. Each node does flexible sense in its sense area C(Si) which estimated by a circular area around the node by its sense radius , as regards this is a simple model of coverage area. Other techniques use a training phase so that sensors train use their sense area C (Si) better based on training data. For each sensor node Si we define a group of neighbor group Ni that contains all nodes I in sense area that overlap partly or fully with the sense node area Si, by using our model that define for the sense area.

$$N(i) = \{ s_j \mid d(s_i, s_j) <= 2 \cdot R_{sense} \} \quad (1)$$

Suppose that d (si,sj) is the Euclidean distance between the nodes si and sj. To reduce active nodes suppose that each point of (x,y) from monitoring area is covered by at least one sensor. Each node need to estimate overlapping sense area with its sense area of neighbor nodes. For this, we assume that sensor nodes have the locate ability. Suppose that for the position of each node and its residual energy for each point of (x,y) from the monitoring area A , we define total energy E total (x,y) , that is available to monitoring that place.

$$E_{total}(x, y) = \sum_{s_j : (x,y) \in C(s_j)} E(s_j) \quad (2)$$

Which E (sj) is the remaining energy of the Sj node.

2.6. clustering protocol to maintain coverage

To ensure about balanced energy consumption between head cluster nodes among network life time, many protocols have distributed the nodes with a average size of fixed node. However, to obtain the same distributed cluster in time is a major challenge in sensor networks clustering. In the applications based on the best, circumstance coverage for the rule of head clusters it should cover the nodes in the populated areas with the highest residual energy. These nodes can support clusters with more number of members. While excessive energy consumption of the head cluster nodes these nodes before the other nodes. Their death should not impact on the network coverage, while these nodes located in the populated areas. Presented methods in [1], consider require applications for the full coverage of network. Set of head cluster nodes can select based on cost metrics that discussed. So, selecting the head cluster based on each presented cost

metrics by the use of available clustering techniques, has led to a undesirable situation. Populated parts of the network populate with the head cluster nodes. While rarely covered areas will be without head cluster. In such a situation, the nodes with high costs will be available from the poor covered areas which transmit data to the far head cluster nodes and reduce the network life time. To avoid this situation a clustering has presented that called clustering protocol of cover maintaining, (CPCP). CPCP contains 6 phases.

- Updating information
- Select head cluster
- Updating the rout
- Cluster formation
- Sensor activation
- Data communication

CPCP expand the head cluster nodes very uniformly by limiting the maximum area of the cluster so the clusters which formed in less covered areas should be same as the nodes that formed in populated areas which prevent from the high cost of nodes transmission to the head cluster. also the nodes select from low covered areas as the head cluster nodes which support less number of node in compared with the head cluster nodes in populated areas cluster radius (R cluster) defined as a appropriate parameter that determines the minimum distance between both of head cluster nodes in the network with the use of this parameter, CPCP prevent from supposedly non-uniform distributed nodes in the network. R cluster can easily set by changing of transmission power in the head cluster nodes. In CPCP their head cluster nodes communicate while routing data from head cluster nodes to the sink is done on multiple paths using with sensors.

3. The proposed ideas

The proposed method is implemented CPCP algorithm. Aim of this method is to turn off some nodes which turning off them doesn't impact on covered area and finally the network life time increases. The presented method like CPCP contains 6 phases:

1) Updating information
2) Select the head cluster
3) Update the rout
4) Forming the cluster
5) Sensor activation
6) Data communications

In fact presented scheme is improve of CPCP protocol.

Phase 1: update information.

For updating information, each sensor node broadcast an updating packet containing its remaining energy to all of its neighbors in its radio range Sense. In this phase, each node that receives this packet sends a asking message to the sender. In this phase the source node can calculate its distance from its neighbors. For example if the node A contains 3 neighbors like B, C, D. the node A can do following calculation: AD: z, AC: y, AB: x. and the other nodes can

also calculate their distance from the other neighbors. in order to reduce packets collision, in this phase use random back off before sending the updated packet , it means that each node calculate its cost of conscious coverage.

Phase 2: head cluster selection.

In the beginning of this phase each sensor determines its activation time. The right time is equal to the current cost of the node. (i.e, cmw, cws, ccc, or cee) each sensor should wait to end of its activation time, before decide whether to declare itself as new head cluster for the next connection or not . if in the activation time a node done receive the aware message from the other nodes then announce itself as the head cluster until its expiration time of activation. And this task had done by sending a aware message to all nodes with in Rcluster range. The aware message contains information about the location of new head cluster. after receiving a aware message from a head cluster node all of the sensor nodes with in the Rcluster range avoid being head cluster. This criterions used to select as the head cluster, the node may select as the head cluster that has less remaining energy. And this could result in loss of cluster data during communication periods. If this sensor nodes does not belong to any selecting head cluster after the head cluster selecting process they find the nearest sensor node, to send their data.

Phase 3: route updating

Head cluster nodes send their data on multi-step directions to the sink. To obtain this route, sink node provides a route discovery message and broadcast across the network. After receiving a broadcast message each sensor node introduces a delay proportional to its cost before sending route discovery message to the nodes in Rbc range. Proportional to its cost before sending route discovery message to the nodes in Rbc range.

In this method each node receives an optimal less costly rout message. Collected costs from sink routing to the node optimized in this method that named conscious covered routing cost.

Phase 4: cluster forming need

in this phase each non-cluster decides to join to the nearest head cluster. Sensor nodes send short join message with its distance from neighbors which has calculated in phase 1, to the selected head cluster nodes. These messages are served as knowledge which node will be as a member of cluster in the next period. Note that there is nno limit on the number of cluster members, only in the cluster area, and thus each node that wants to join to head cluster and within the Rcluster rang, you can do.

Phase 5: sensor activity

In the phase 5 a set of sensor nodes selected to do sensing task in the next period while the other nodes go to sleep mode. Selected active nodes must do the complete coverage of the monitored area during this communication period.

Aim of the presented idea is to turn off some nodes so that don’t impact on the coverage and there by saves energy and finally increases the network lifetime. Head cluster node gains network topology from the incoming data containing distance of nodes.

When the network topology obtained we can turn off some nodes based on coverage and topology.

How to get a topology is as follows which can be explained with an example. Suppose that nodes a,b,c,d located in an area and their distance from each other is as follows:

ab=9m ,ac=8m, ad=7m, bc=15m, bd=12m, cd=14m

We start from node a so that draw a circle with radius 9 and center a and called it b, and do the same work for node c and d it means that we draw a circle with radius 8 (m) and center a and called that circle c. ultimately draw a circle with radius 10 (m) around the node a and name it d. when all the nodes consider of a , which have different distance it, draw a circle to the center of a and draw a circle to the size of its distance and then we come to node b. select a point on the circle b and named it b. this point is the location of b. then draw a circle to the center of b and distance of bc=8. This circle intersects circle c in two points. These two points could be the location of c. we can work on the circle in counter-clock wise direction or the opposite clockwise. In the figure 1 the opposite clockwise is considered. Then we draw a circle to the center of c and distance of cd=14. This circle intersects the circle d in two points. The point is acceptable that is in opposite clockwise direction of first intersection. This point can be location of node d. this work will continue until achieving the whole topology. Figure 1 show the process:

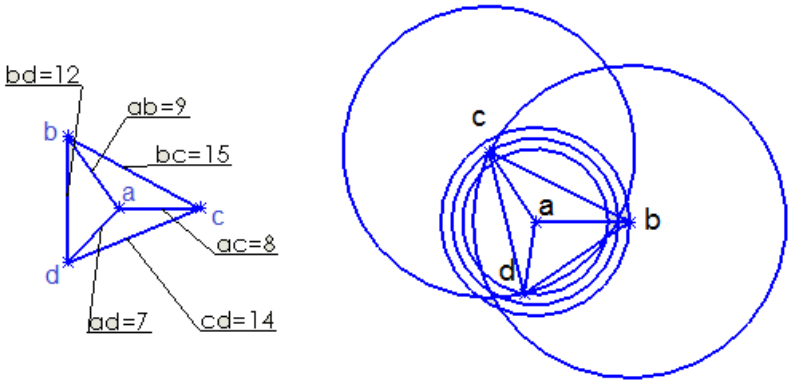

Figure 2: example extraction of topology

Head cluster node after obtaining the network topology , can calculate the amount of overlapping based on accuracy of the network and try to turn them off. To better perception we explain the problem with the above topology example.

Suppose that nodes a,b,c,d located in the cluster like the example 1. The goal is that we want to know which of the above nodes can be turned off so that don't impact on the coverage or which of the nodes can be turned off based on used accuracy in the network . to obtain the cover percentage of each node, we can obtain the assumed topology in the coordinate axes using the provision of coordinate axes points:

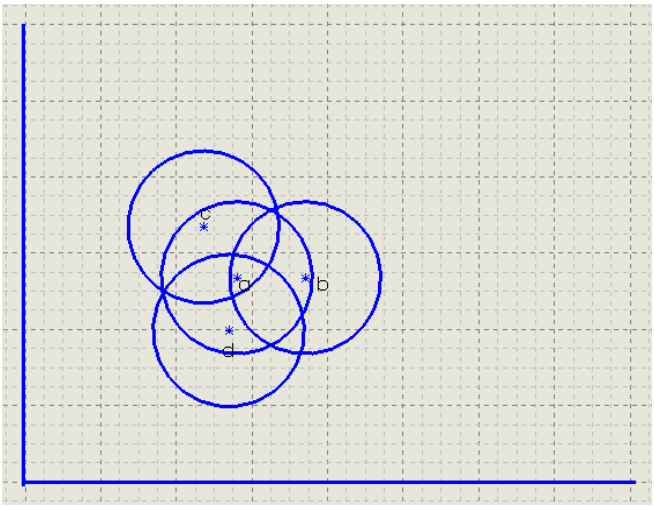

Figure 3: the topology transmission on coordinate axes

In this phase we provide all the points within the a,b,c,d circles, then we obtain collection of a,c,d circles. Finally obtain their unity with a , and express them with percentage.

A cover percentage = $a \cap (b \cup c \cup d)$ (3)

We do the same work to other considered nodes and express their overlap amount based on percentage. Each of the nodes which have the more amount of overlapping select as the node to turn off. After that the head cluster does the calculate operation and select the overlap nodes, by sending a message to considered nodes ask them to go to sleep mode.

This part can set based on questioning and asking and it is not necessary that we always the accurate data of network therefore in such cases we can enter the cover percentage to the network process then we collect data from the network. It is clear that if the cover percentage consider. Low the more number of nodes will go to sleep mode and finally energy will be saved.

Phase 6: data exchange

When the cluster formed and active nodes selected, in data exchange phase of collecting information and send it to the head cluster node. The head cluster nodes collect data from the members of the cluster and routes the collected data packet over the predetermining multi-step directions to the sink.

4. Simulation and evaluation of methods

4.1 Simulation environment

Simulation has done on the Linux operating system Red hat 9.0 using the network simulation on a parameter to the dimension of 200×200 (m) and using 200 nodes which nodes have the same initial energy of 2j.

During the simulation, we implemented several randomly network topology so that gain the average results.

We considered two cases for the base station location. One at the (50, 50) position which is exactly in the of the network and second at the (200,150) position which is near the monitoring

area. Each period tasks 20 second. Receiver and transmitters follows the model [14], that their parameters are:

$$E_{elec} = 5.0 \times 10^{-8} J/bit, E_{tx} = E_{rx} = 5.0 \times 10^{-8} J/bit$$

$$\varepsilon_{free-space-amp} = 1.0 \times 10^{-11} J/bit/m^2, \varepsilon_{two-ray-amp} = 1.3 \times 10^{-15} J/bit/m^4$$

Etx , Er is the power of transmit and receive per bit. Experiment is done by DAPR , CPCP-A and protocols.

Assumption

- All of the node are static and have limited resources.
- The base station has no resource limiting.
- All of the nodes have a data per moment for sending.
- Nodes are not equipped with the simulation results.

In the simulation, the amount of coverage is considered 100% for each node. In figure 4 , 200 nodes are considered. In the first phase of simulation we decided to show the cover percentage with the number of active nodes. Thus, in each period that algorithm runs, number of nodes that cover the area are considered and express it as a percentage that cover the area. In figure 4, all three algorithms in the early stages. Somewhat as 100% try to cover the area. But gradually the performance of algorithms separated from each other and as shown in figure 4 CPCP-A algorithm has better performance than the other algorithms.

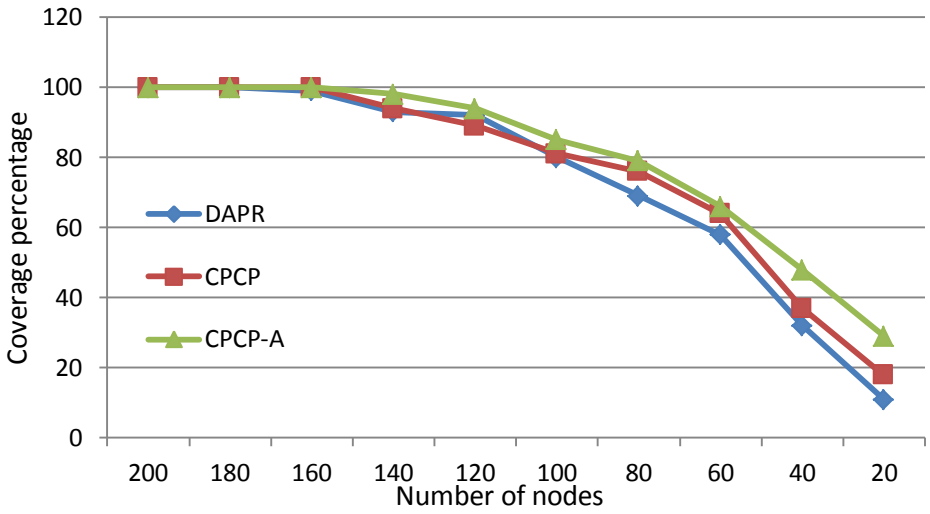

Figure 4: cover percentage with number of active nodes.

In the figure 5, number of live nodes per moment review by using three algorithm of CPCP-DRDA- CPCP_A. CPCP algorithm has better performance than DRPA algorithm. Between these two algorithms, CPCP-A algorithm has better performance that is shown in the figure.

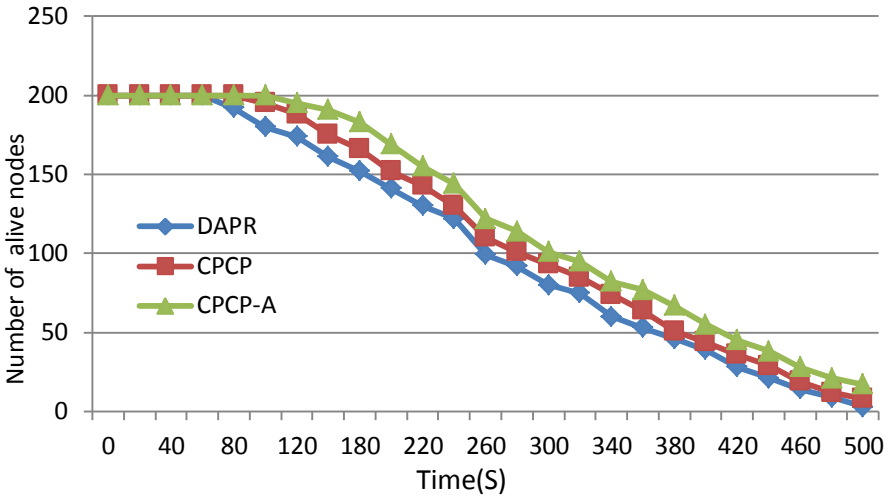

Figure 5: number of alive nodes

The last phase of the simulation is the amount of energy consumption per moment of time. Thus, in the figure 6 the average energy consumption of nodes are consider as shown in figure the amount of energy consumption of CPCP-A algorithm is better than DARP, CPCP algorithm.

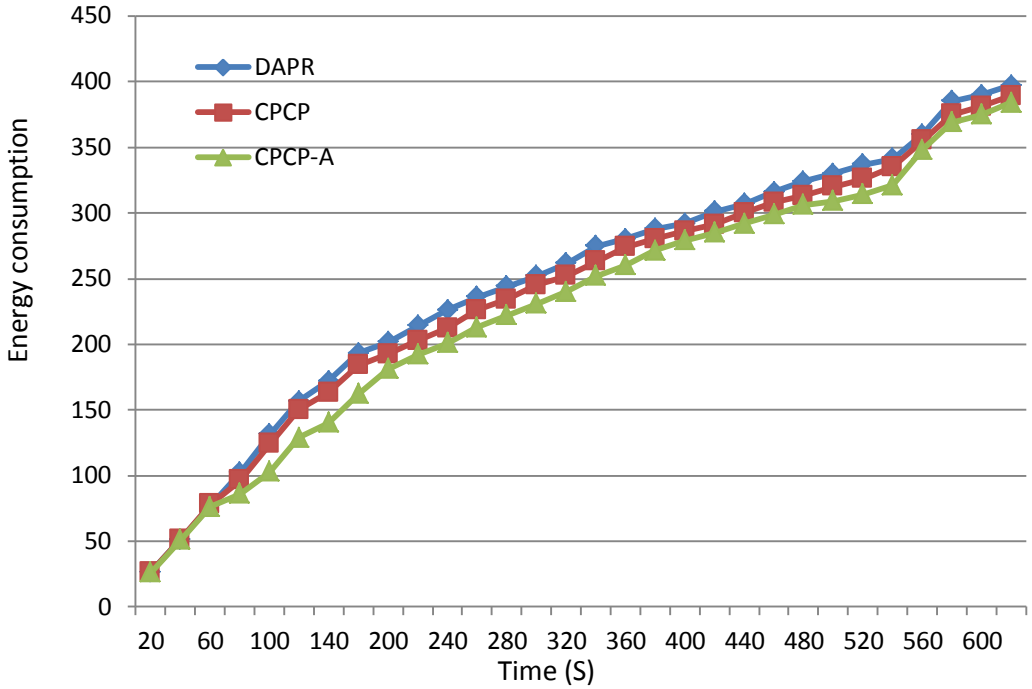

Figure 6: Energy consumption

If the percentage of cover is not important for our network , or in other words we just want earn information about the network , In that case we can give the amount of error percentage and review the amount of coverage , it may the coverage don't be 100% but the number of active nodes decrease and the network lifetime will increases.

4. Conclusion

In this article we solve the problem of coverage in cpcp protocol. In CPCP protocol selecting nodes failed to turn off. Because the amount of nodes coverage is not considered for turning off and therefore lack of coordination in turning off the nodes causes that the energy cannot managed properly and finally the network lifetime decreases. In the presented idea accurate and distributed method to find the network topology has been presented so it makes that the supposed location of all nodes determined in a regular topology and finally with having this topology we can determine the cover percentage of nodes by the other nodes and attempted to turn them off and ultimately increase the network lifetime. In the future works we try to use this method of localization mechanism in the wireless sensor networks with the assumption that the nodes are not equipped with GPS.

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