Using the Learning Coverage Model to Increase the Wireless Sensor Networks Lifetime

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Abstract

One of the most important issues of the wireless sensor networks is their energy consumption and life increase. In the sensor networks this is done by different guidelines, including creating planned coverage that causes all nodes would not be active all the time and act alternatively, while whole the network would always be under the sensor nodes coverage. Though there are different methods in this case, yet more effective ones are needed. In this research, a learning – based approach has been designed which decides about nodes being sleeping or awaking per round of nodes operation. Simulation shows that this method can work effectively and network life will increase at least 20 percent of past methods.

Keywords: coverage planning, sensor networks, learning algorithm, energy consumption decrease, lifetime increase.

1. Introduction

Recent improvements in the wireless electronics and transmissions has made posiible designing and manufacturing sensors with low power consumption, small size, suitable price, and variant applications. These small sensors which can do some things like receiving different environmental information (based on sensor type), processing it, and sending it, have caused creating idea for developing networks so called 'sensor wireless networks' (WSN). It is needed to attempt for decreasing energy consumption and as a result increasing network lifetime, because of low power of this network nodes and their inaccessibility to electricity power supply. One of these is to create a rotational scheme among network nodes, so that it would not be required for all nodes to be active simultaneously. Meanwhile it is necessary to cover whole the network every time in order to network performance not to be disturbed and network can do its target without delay and with proper performance. In this research, an intelligent guideline has been proposed to cover sensor networks along with energy consumption decrease and without network efficiency miss. Guideline is a learning approach and will try to improve coverage methods in the sensor networks using an algorithm such as Automata.

2. Previous Works

DCS-Disc algorithm is used in large scales which are unprofitable and useless focused solutions. In this algorithm, one system node determines its own situation based on its own neighborhood data. This algorithm involves two stages: 1. Establishment and 2. Decision making. During establishment stage, every given node is labeled with one determining priority which has been covered by a number of sensor node directions. Often one given node can be covered by a sensor directions and its adjacent neighbor which is identified as a weaker priority. During decision making stage, a sensor node explores high priority uncovered points, after receiving a certain message via its own neighbors. Time complexity of DCS-Greedy Algorithm is $O(n^2wm)$, while time complexity of DCS-Greedy Algorithm is $O(nwm)$. Study results indicate that DCS-Greedy Algorithm has high probability in discovering one extender complex and has a considerable coverage toward DCS-Greedy Algorithm. Ai & Abouzeid have posed max-cover by optimizing MCMS problem [11]. Given points are in the form of T set involving T = {t1, t2, …, tm} and one n set involves oriented sensors whichever have probable situation, P. Then MCMS evaluates maximum number of extender points while optimizing number of active extender sensors. Authors first indicates that proving MCMS problem is one of the difficult efficiencies of network, because

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MCMS is a secondary challenge in total coverage [10] and also is an old and complete problem in the network efficiency. Interpreting decision about max-cover problem can involve one of the following cases: provided set of given points called T, one set of subsets, so that it explores the max-cover problem for every subsets of C with u number of subsets that finally are covered in the form of V component inside T set. In max-cover problem each u subsets involving $\phi 1$, $\phi 2$, …, ϕu are adopted from C set. Then for every subset ϕ_I ($1 \leq i \leq u$), p creates number of versions which are rewritten in the form of $\phi i1$, $\phi i2$, …, ϕip, like one exists in the MCMS problem. And like vasting subset that can be used as input of MCMS problem. In [11] authors also describe given target sensing model of oriented sensor in the test part which depends on whether given objective is placed inside simulated view point or not. They have provided exact formulations based on Integer Line Programming (ILP) and two greedy algorithms including: Centralize Greedy Algorithm (CGA) and Distributed Greedy Algorithm (DGA). ILP formula receive number of n oriented sensors and given target m as well as a number of available objects for every P oriented sensor as inputs. Target function of this formula imposes maximum number of targets that should be covered by multiplying sensors which need to be active by positive fine, e. e is amount that should be small enough so that insures one unique solution. ($e \leq 1$)

Although ILP formula selects optimum work directions for oriented sensor nodes, it is not satisfying about big problems. About networks with large scale, authors have proposed one greedy polynomial innovative time algorithm instead of LP-relaxation algorithm in MCMS problems.

. In [12], authors suggest coverage problem under consideration according to priority. This way, they may select minimum set of directional sensors which monitor overall targets; and, this way they may specify some priorities. A genetic algorithm has been proposed to solve minimum subset. The said algorithm has been executed in MATLAB, because the software provides strong toolboxes. Simulation results show effects of various factors including, sensing radius, view angle, and targets from subset sensors. Number of sensors decreases through increase in sensing radius so that uniform covered scope would be obtained. On the other hand, increase in view angle reduces number of sensors. However, this is relatively less than increase in scope of sensing. Directional sensor deployment is studied through a different method. They present an ILP (integer linear programming) model which includes a set of control points, a set of sensor deployment

locations, as stated before. That is, placement of sensors in sensor field in a way that each control point is covered at least by one sensor, and overall cost of sensors becomes minimized [37, 38].

In [21], authors have created coverage in wireless sensor networks through particle intelligence algorithm. The algorithm is in fact a combination of the two particle swarm optimization and artificial fish swarm optimization algorithms. When particle swarm optimization is imposed for optimizing wireless sensor network coverage, the coverage speed level is high. Anyway, the algorithm is easily trapped by local optimization which leads to early response phenomenon. Using artificial fish swarm algorithm in optimizing wireless sensor network coverage has the same advantages of effective public search efficiency. However, its convergence speed repeats slowly; and, it is hard to use it for finding desirable solution. In the research, effort has been made to integrate the two algorithms and to use advantages resulted from both. General coverage of artificial fish swarm algorithm is used to search for domain of satisfactory solution. Then, particle swarm optimization has been made compatible for quick local search, WSN status and direction adjustment, and removing repetitive and blind areas coverage. This improves obtaining desirable response; however, there are some problems also in terms of complications created in solving the problem.

In [22], an analytical method has been proposed for increasing wireless sensor network lifespan while maintaining those groups separated from sensors. Accordingly, a unique group may provide coverage for area as a whole, at any time. Therefore, only one group may be activated at a time, in WSN. Coverage is in regular rectangular form, after placement of a group of sensors. This way, the research has been capable of increasing coverage lifespan in sensor network and to extend it to a considerable level. Although in general, rectangular coverage has some heterogeneities with covering features of nodes in the network; it seems to be improvable. Various coverage forms will be considered in the next section.

In [24]-[35], we and other coworkers performed some research about different scopes of WSN include reduce energy consumption, routing, data storage and security of wireless sensor networks. These works cover many challenges on WSN and help to better performance for these networks. We used some of the the researches results in this paper.

3. Coverage with Probability Sensing Model

In the probability sensing model, sensing degree is more than one disk. Therefore, to have overlapping in sensing degree is not easily definable. So, in order to optimize coverage increasing

or decreasing numbers of network active nodes is used. To minimize active nodes numbers is often proper guideline for coverage protocol. In this regard, two following definitions are used:

1. First Definition (Probability Coverage)

A region is covered by n sensors with threshold parameter θ, so that:

$$\theta (0 < \theta \le 1) \quad if \quad P(x) = 1 - \prod_{i=1}^{n}(1 - Pi(x)) \ge \theta \qquad (1)$$

Per each x point member of A region, so that Pi(x) is probability that i sensor identifies one event in the x region. Note that in above formula P(x) is the set of probability amounts of all n sensors for covering x point that Pi(x) is identifier of used identification model and threshold parameter θ is defined based on network application type. If in given application, threshold parameter θ is equal to 1 and Pi(x) is a binary function that it events are 0 and 1, used sensing model is Boolean disk model.

2. Second Definition (Covered Points Set)

Point x is inside circumference A, so that points set of under its coverage is defined as follows: minimal covered points in A district, if $P(x) \le P(y)$ is for every $y \ne x$ in A district.

In all distributed protocols that don't have network public information, this kind of coverage for points set is used. To do this, we divide district to small districts and determine set of covered points for every district and finally activate minimal number of nodes. Created coverage have probability more than or equal to θ threshold. To do this, district has been separated to parallelogram triangle. Now this is necessary to calculate total points covered in each triangle. Finally, maximum length of each triangle side should be calculated so that this amount be placed inside (fig.1).
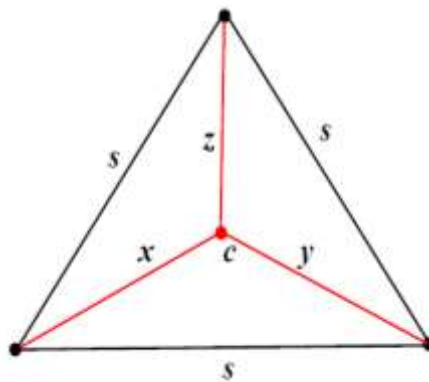

Fig 1. Local position of minimal coverage points with three sensor nodes

Next, we want to activate nodes on every side of triangle. This activation is shown in fig.2. The best current mode for proposed protocol is the same proposed protocol. In this protocol for maximum distance between sensors that is the same parallelogram triangle side and determined by s, an idea is posed. Calculation of s amount is only based upon to know chosen sensing model. Then, s will be considered for both disk and exponential sensing models. S can be calculated for other sensing model as mentioned ones. Proposed protocol emphasis is on probability coverage model. These cases are describing in the following sections. It is necessary to note that coverage model has not been changed in two given parts and also the only parameter that need to be determined and provided to proposed model is the same distance amount between two active nodes, s, which can be calculated through sensing model.
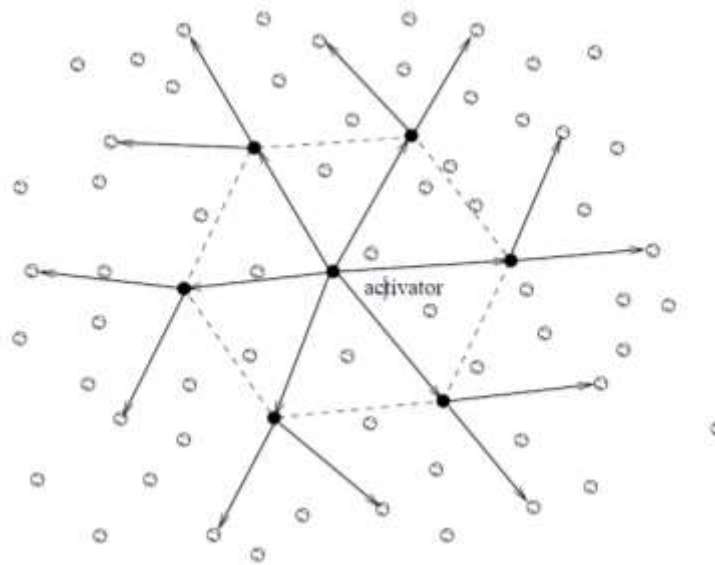

Fig 2. Process of activation network in the proposed model

In the proposed protocol, first one activator node would be activated in the network and also activates all its own one hop neighbor. Then similarly one hop nodes of the first activator node activate their own neighbor one hop nodes that are positioned in s distance. Whole the network has a virtual triangle grid structure during limited time span. Fig.3 illustrates this structure.
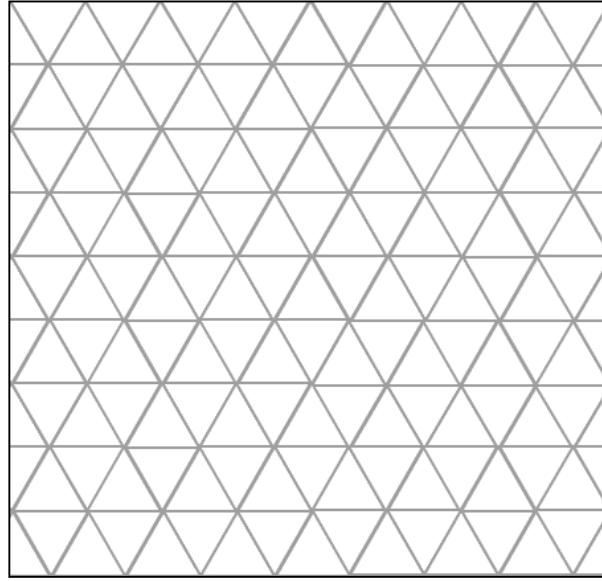
Fig 3. Grid structure of created triangle

Calculation of Maximum Distance in Exponential and Disk Sensing Models

In this section we consider how to calculate maximum distance between two active nodes in given sensing model which is identified by s. First we investigate s amount for exponential sensing model that is calculated as follows:

$$P(d) = \begin{cases} 1 & for \quad d \leq r_s \\ e^{-\alpha(d-r_s)} & for \quad x \geq 0 \end{cases} \qquad (2)$$

In this relation, P(d) is probability of a happened event distinction in d distance of sensor and r is sensing threshold of sensor node that determines each event amount with 1 probability. α is a defined metric for sensing volume decline degree while distance increase. In this research α is called the same sensing decrease degree. Disk and exponential model of sensing is shown in fig.4.
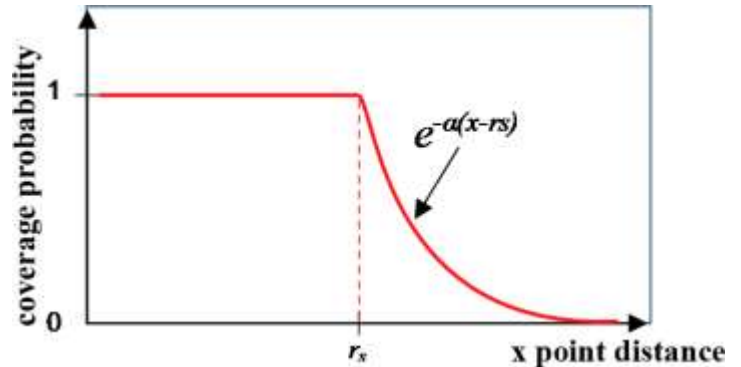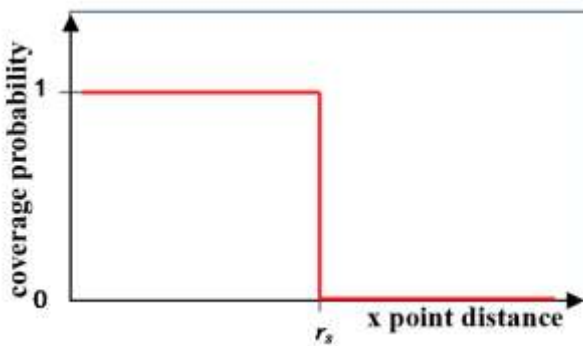
Fig 4. Images of exponential sensing model at right and Boolean sensing model at left are observed.

We have studied exponential sensing for two reasons. First that we can prove similar protocols weak point in distance parameter. Second reason is protection of district coverage regard to exponential process of sensing decrease after radius, r_s. It means that obtained coverage is in fact more than theoretical analyses and estimates. Then we find that given features of exponential sensing model, we can also use it for other models [5,6]. Anyway, wireless sensor networks designers should not need to exact calculation of distance maximum parameter amount, because of mathematical complexity of sensing model and instead can use exponential sensing models.

Following theory describes maximum distance between each two active node, s, for exponential sensing model:

First Theory (Maximum Distance):

Under defined exponential sensing model in section 1, maximum distance between two active sensor nodes in one triangle structure is calculated through following relation, in order to insure coverage probability of points set in θ amount:

$$S = \sqrt{3\left(r_s - \frac{ln(1-\sqrt[3]{1-\theta})}{\alpha}\right)} \qquad (3)$$

First Theory proof

To prove this theory, we need to find coverage points location and also to use some triangle geographical features whichever are located at $\frac{s}{\sqrt{3}}$ distance from each head. It has been shown in fig.5. sensing probability of covered points is equal to:

$$1 - \left(1 - e^{-\alpha\left(\frac{s}{\sqrt{3}}-r_s\right)}\right)^3 \geq \theta \qquad (4)$$

By changing and calculating above mentioned items, following relation can be used for calculating maximum distance:

$$S = \sqrt{3\left(r_s - \frac{ln(1-\sqrt[3]{1-\theta})}{\alpha}\right)} \qquad (5)$$

Given above mentioned relation, we find that in exponential sensing model toward disk mode, however $\alpha \to \infty$, sensing decreases. From the first theory we can find out that $s = \sqrt{3}r_s$ is in disk sensing model.

4- Proposed Method

In this section, proposed method of creating coverage in wireless sensor networks will be discussed. This is a probabilistic covering model based on learning automata which will be studied, in details.

Proposed probabilistic covering protocol

The protocol has been introduced for complete monitoring of environment. The requirement is evident in many wireless sensor networks' applications. Proposed protocol typically assures that all points located in θ range have been covered by a set of sensors. However, probabilistic covering protocol does not suit those applications in need of coverage degree of more than 1, or coverage with variable roles of events; but, they may have any type of distribution. In simulations, uniform random distribution will be used. Considering aforementioned, probabilistic protocol begins activity, after an appropriate value of s is proved. The process does not consider type of sensing model.

Proposed protocol takes place in several rounds, during R seconds. R value is commonly less than that of lifespan of the network. At the beginning of each round, all of the network nodes begin activation with no consideration of neighbors. A number of messages are exchanged for distance between the nodes, to be estimated. It is called work cycle in each round. Protocol time is divided to estimating active and inactive modes at convergence time. This division may be transform to smallest time. After convergence time, convergence message will not be exchanged by protocol procedure or any of nodes, till the next round.

One node in proposed protocol may stay on four active, inactive, waiting, and starting modes. At the beginning of a round, all nodes are in starting mode. A T_s work starting scheduler appropriate for remaining energy of nodes will be considered. A node with smaller T_s time becomes active and informs its neighbors of its status through a message. Sender of activation message is called activator. Activation messages try to make active those nodes located on central vertexes of hexagons; while, the remaining nodes in hexagons go to inactive mode. When a node receives activation message, it may specify if it is located on vertex of hexagon or not, after computing the distance. In case the angle between nodes is equal to $\frac{\pi}{3}$ and their distance is s, node will be activated and turned to an active node. Otherwise, it goes to inactive mode. In real distribution of network, these types of triangulation arrangement and certain vertexes may not be implemented 100%;

because, in proposed scenario, nodes are randomly dispersed in the environment. Proposed model tries to activate the nearest nodes to hexagon vertexes, as observed in figure 5.
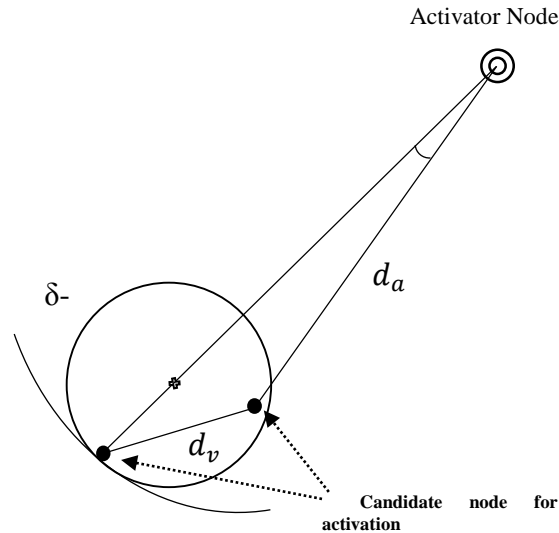

Figure 5- The way nearest sensor node to triangle side is selected

Each node receives an activation message so that it computes a T_a scheduler according to a function of the nearest nodes to vertex of hexagon nodes through following equation:

$$T_a = \tau_a(d_v^2 + d_a^2\gamma^2) \qquad (1)$$

Values of d_v and d_a are equal to Euclidean distance between the node and vertex of hexagon, and the node and activator, respectively. γ is equal to the angle between node and activator line; and, the angle between triangle vertex and activator T_a is also a constant. Please note that, the node nearer to the vertex has smaller T_a. After computing the T_a, a node becomes inactive and remains so, as far as its T_a is not expired or cancelled upon activation request. When smallest T_a is expired, node will be activated. More optimization lies in the way network activators are distributed.

How to Operate Sleeping and Awaking Mechanisms of adjacent Nodes by Learning Automata

Considering the point that sensing radius of the sensor existing in proposed protocol is mostly higher than s, in this triangulation structure all nodes on vertexes or inside each triangle have not to remain on. Therefore, through an adaptation mechanism, in each round only 3 nodes from among those located on vertexes or inside triangles will be on. So, three types of nodes will exist in each round, respectively as listed below:

- *Active node (type 1);*
- *Node Adjacent to active node (type2); and*
- *Nodes far from active node (type 3).*

In order to be active in future round and after the time for current activity is expired, each of nodes has following automata probability.

Table 1- Current and future probabilities table considered for various types of nodes

Type of node	Type 1(%)	Type 2 (%)	Type 3 (%)
Current round probability	100	0	0
Future round probability	25	50	25
Future round penalty	50	10	40
First energy threshold 75% (current round probability)	25	50	25
Second energy threshold 50% (future round probability)	20	60	20

Active current node has low probability of being active in next round; because, continuous activity results in high energy consumption. Nodes close to active node are best alternatives for activity in future round; so, they have higher probability percentage for next round. However, nodes farther are those alternatives with low percentage of probability; because, in adjacent node they are considered as close neighbors. Penalty percentage after being active in current round would be 25, along with supplementary reward percentage. The reason is that, programming has been made just for future round; and, in case member nodes are not available, the process will be compensated via farther nodes and probabilistic approach of coverage. In continuation of work procedure of the protocol and after first round, energy levels of network nodes are not similar. So, energy levels are supposed to be considered in selection of nodes for activity in future round (s).

Conceptual and overall diagram of proposed method is presented in figure 6:
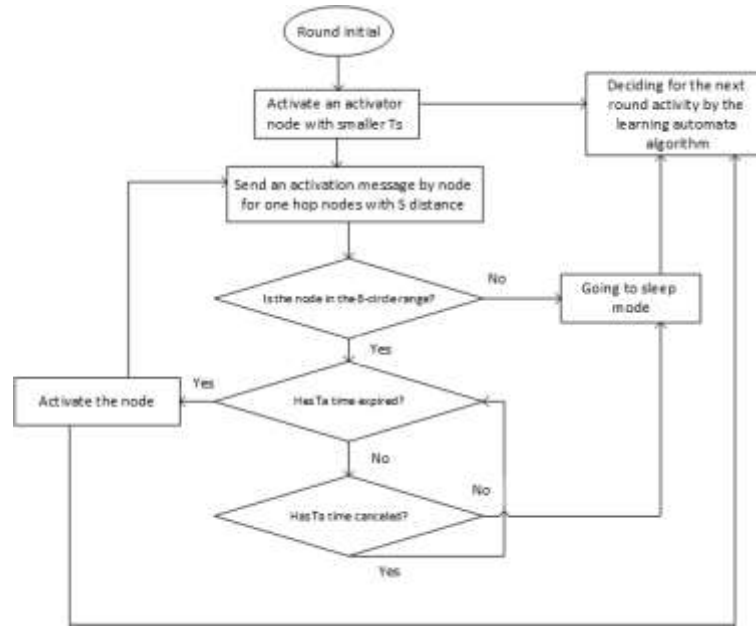
Figure 6- Conceptual diagram of proposed model

Data Collecting Mechanism

In the proposed algorithm, based on described stages in previous sections, minimal number of sensor nodes in every district are in active situation and rest of nodes are sleep. Therefore, after covering and sensing environment while needing routing, shortest route is found by Dijikstra algorithm and data package are transmitted to sink. it is clear that sensor nodes distribution and every nodes direct relation with base station are used for energy costs and collision creation. Therefore, using positioned nodes on optimum route is proposed as a guideline for this problem. These optimum routes are stabilized after once attempt for routing and remained up to time of route unbrokenness.
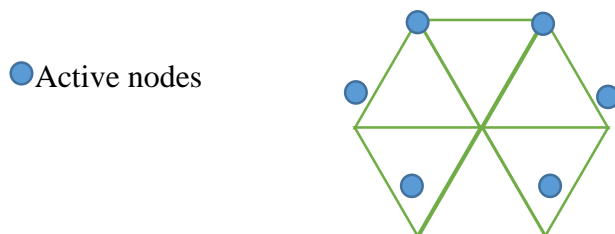

Fig 7. Active nodes position

3-4. Proposed Protocol Analysis

In this section we prove propose protocol accuracy and consider convergence time, messages complexity, and activated nodes number in every round. In the condition that active nodes support network connection, protocol will also be studied with regard to connection.

Analysis Accuracy

Input parameters in our analysis are δ, θ, s, l و τ_a that τ_a is equal to maximum amount of active scheduling. δ is calculated based on network establishment distribution type. Maximum distance between active nodes is also calculated through mentioned relations in previous sections. θ is probability coverage threshold that depends upon network application type. l is covered region length that the district is a square with side 1 in order to simplify analyses. We assume that total radius of nodes sensing is more than district area and disregard border covering. Other hypothesis in the proposed protocol is that one transferred message between two neighbor nodes lasts τ_m. Which also includes delay and release time. Following theorem proves the proposed protocol upper bound convergence. The proposed protocol acts clearly in every point of covered district so that each point of district coverages by θ set of sensors. Convergence time is when the protocol spends time for deciding about expecting nodes. After convergence time, the nodes can't replace their own position up to next round protocol start and don't exchange any messages.

Second Theory (Accuracy and Convergence Time)

The proposed protocol of convergence is done at $\frac{l(\tau_a \delta^2 + \tau_m)}{(s-\delta)}$ time unit with each point of supervised region which is estimated with θ coverage. Unless the nodes density would not be amount that can cover total district.

proof

First we prove the accuracy section. The proposed protocol makes one triangle structure increasingly, so that it a cover whole the area. This means that each point regulates its own T_s by one round start and becomes active if T_s expires (in triangle structure). For example, scheduling T_s of node n_1 is deleted if other node n_2 has become active and n_2 be one side of triangle whose other head be n_1 (see following figure).
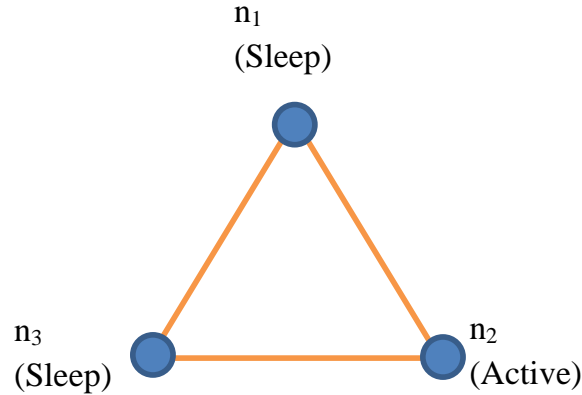
n_1
(Sleep)

n_3
(Sleep)

n_2
(Active)

Fig 8. Adjacent modes and situation of nodes

Next we need to show how much every triangle has covered. Suppose one triangle. Because activated nodes by activator are placed in s distance of one activator, formed triangle by activated nodes have sides with length, s. Given said probability model, district sensing amount in every point of this triangle is the same. So coverage probability in all triangle points is at least θ.

Second, convergence time that is operated in every round of proposed protocol, is limited. Activation message is sent in every stage and at least one node has been activated at each six sides. Now consider one direction, in the worst case new activated node is placed in $s - \delta$ distance of node which was active recently. Then in the worst case, the protocol needs $\frac{l}{s-\delta}$ stage, if first activator node be on the network edge. Maximum time for completing stage happens when chosen nodes for activation have been had the largest scheduling T_S and $T_a \delta^2$ have been completed by 15-4 relation. Adding transport time to τ_m message with largest activation scheduling in the worst case leads to calculating total time as follows:

$$(\tau_a \delta^2 + \tau_m) \qquad (6)$$

The worst convergence time in the proposed protocol is obtained by multiplying this obtained stages amount at the number of $\frac{l}{s-\delta}$ stages. The next theorem is provision of upper bound activated sensors numbers and number of exchanges messages in every proposed protocol.

Third Theory (Active Nodes and Message Complexity)

Active nodes number in the proposed protocol which is obtained through relation $\frac{l^2}{\sqrt{3}\,(s-\delta)^2}$, has direct relation with exchanged messages of protocol in both.

proof: Required nodes number for covering circumference with area l×l is equal to heads number of one triangle network with side, s. This number is equal to $\frac{l^2}{\sqrt{3}\,s^2}$ and can be calculated as follows. First, we tile the circumference by triangle with side of $\frac{S^2\sqrt{3}}{2}$. To do this, we need following number of triangles:

$$\frac{2l^2}{\sqrt{3}\,s^2} \qquad\qquad (7)$$

Since there are three heads in each triangle and each head can relate through six directions with other heads, so total number of nodes are:

$$\frac{3}{6} \times \frac{2l^2}{\sqrt{3}\,s^2} = \frac{l^2}{\sqrt{3}\,s^2} \qquad\qquad (8)$$

Active nodes number in the proposed protocol can also be calculated as the same. But given the triangle with side $s - \delta$, number of active nodes in the proposed protocol network is as follows:

$$\frac{l^2}{2\sqrt{3}\,(s-\delta)^2} \qquad\qquad (9)$$

Because of message complexity in the proposed protocol, we assume that there is only one sent message from each active node. Therefore, number of exchanged messages at each round is equal to number of current active nodes at the same round of the proposed protocol.

Network Connection Analysis

In disk coverage model [3,7,8], it is shown that if one node radio communication domain is twice its sensing domain, then there will be connection at that coverage. This conclusion may not be true about proposed protocol which has one probability coverage. Following theorem proves that in one network with the proposed protocol also nodes are connected by active nodes. In the following theorem we suppose that node relation radius is r_c .

Forth Theory (Network Connection):

In the proposed protocol, connection is created by a set of active nodes, if connection radius, r_c , would be larger or equal to distance between every two active nodes, s.

proof: First we prove that subsets of network active nodes in the proposed protocol are connected if we have one starter node at each round. At first we have one active node that starts network connection. Then during k stage, there should be number of A_k active nodes in the network and k number of message need to be exchanged. Assuming opposition (reductio ad absurdum), we show that set A_{K+1} is also connected.

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So, first we assume that there is connection for A_{k+1}. Therefore, there are nodes which are active at k+1 stage and are not active at k stage. Let each $v \in V$ in which V should has been activated by one activator (called u) in A_k. Since V is active at A_{k+1} stage. First V distance to u is more than s distance to u, then V is more available than u, because $r_c \geq s$. Since v is chosen from V arbitrarily, all current nodes in set V from A_k are available. So A_{k+1} is connected and it is opposite of our assumption that A_{k+1} is possible. Through second stage, we will do this study for network with multiple number of activating nodes (various starters). From previous cases we know that each starter node causes connection with active nodes. Therefore, we should prove that active sets by different starter nodes are also connected. So we use reductio ad absurdum.

Both subsets A and A' that have been activated by two different activators, are connected. If $u \in A$ and $v \in A'$, nearest nodes are in two subsets A and A'. Assume that proposed protocol stages are finished but connection is not established. So distance between u and V is more than itself relational domain. Therefore distance between u and V is more than nodes relational radius. Hence, since protocol is finished, there is no expecting node. Then there are six neighbors of u with distance more than s. Otherwise some nodes surrounding u will be yet expecting. If u' has minimal distance with neighbor v, then we have two cases:

1. $u' \in A'$ where distance between s $\leq$ (u, u') and s $> r_c >$ (u,v), so we have:

$$dist\ (u,v) > dist\ (u,u')$$

Therefore, is $u' \in A'$ closer to $u \in$ A , then $v \in A'$ and this is paradox, since it is assume that v and u are the nearest nodes at A and A'.

2. $u \in A'$, consider v u u' mentioned triangle which has following features and condition:

$$dist(u',v)^2 \leq dist(u,v)^2 + s^2 - dist(u,v)s = dist(u,v)^2 + s(s - dist(u,v))$$
$$dist(u,v) > r_c \geq s \Rightarrow s(s - dist(u,v)) < 0$$
$$dist(u',v)^2 < dist(u,v)^2 \Rightarrow dist(u',v) < dist(u,v)$$

In the other words, u' is closer to v than to u and this is opposition.

5. Experiments

In previous section, CPLA proposed protocol has been explained in details. Here, we are aiming at review of effects of active and inactive mechanisms with learning automata, along with

aggregated algorithm, and proposed routing through some tests. So, according to the table 2, required parameters have been implemented in NS2 simulator. The simulator is used because of its popularity and strength. Effort has been made to evaluate proposed algorithm through three different scenarios with 600, 800, and 1000 nodes so that optimized status of protocol would be specified; and, to see if it is of more efficiency in busy environments or those with less density.

5-1- Simulation objectives

As far as the protocol under comparison also has probabilistic model, effort has been made for evaluation to be made under equal and similar conditions. Compared protocols have been equipped with prevailing mechanisms including active and inactive in which random arrangement structure, disk cover, and approximation structures have been used. In this type of network, to compare efficiency, several basic parameters of the network have to be calculated. These parameters will be explained in details in chapter 5, and the results will be compared. In terms of coverage and as far as wireless sensor networks coverage is visually supported by NS, pursuant to aforementioned mathematical models in previous chapter and observable results it could be proved that network coverage is optimized. Meanwhile, least number of active sensor nodes and minimum full coverage of points have been used.

Introducing simulation parameters

Table 2- Simulation parameters of proposed protocol

Effective parameters	First scenario	Second scenario	Third scenario
Physical layer	Phywireless-Mica2	Phywireless-Mica2	Phywireless-Mica2
Type of antenna	OmniAntenna	OmniAntenna	OmniAntenna
Queue type	DropTail/preQ	DropTail/preQ	DropTail/preQ
Queue length	50	50	50
Energy resource	Battery model	Battery model	Battery model
Network size	250x250m	250x250m	250x250m
Number of AP (access points)	1	1	1
Network distribution	Random	Random	Random

Simulation duration	1000s	1000s	1000s
AP location	Center of network	Center of network	Center of network
AP initial energy	100j	100j	100j
AP range of communications	1200m	1200m	1200m
Number of network nodes	1000	800	600
Communication range of nodes	200m	200m	200m
Sensing time interval	0.5s	0.5s	0.5s
Initial energy of nodes	10j	10j	10j

Given tests for evaluation:

- Network lifetime
- Network packages delivery rate [36]
- Received packages number in the sink.

Network Lifetime Test

Based on methods and strategies already presented, we may find that adaptive active and inactive scheduling mechanism will have direct and close relationship with energy consumption rate in the network. Using minimum active nodes in each time interval may result in appropriate procedure of energy consumption.
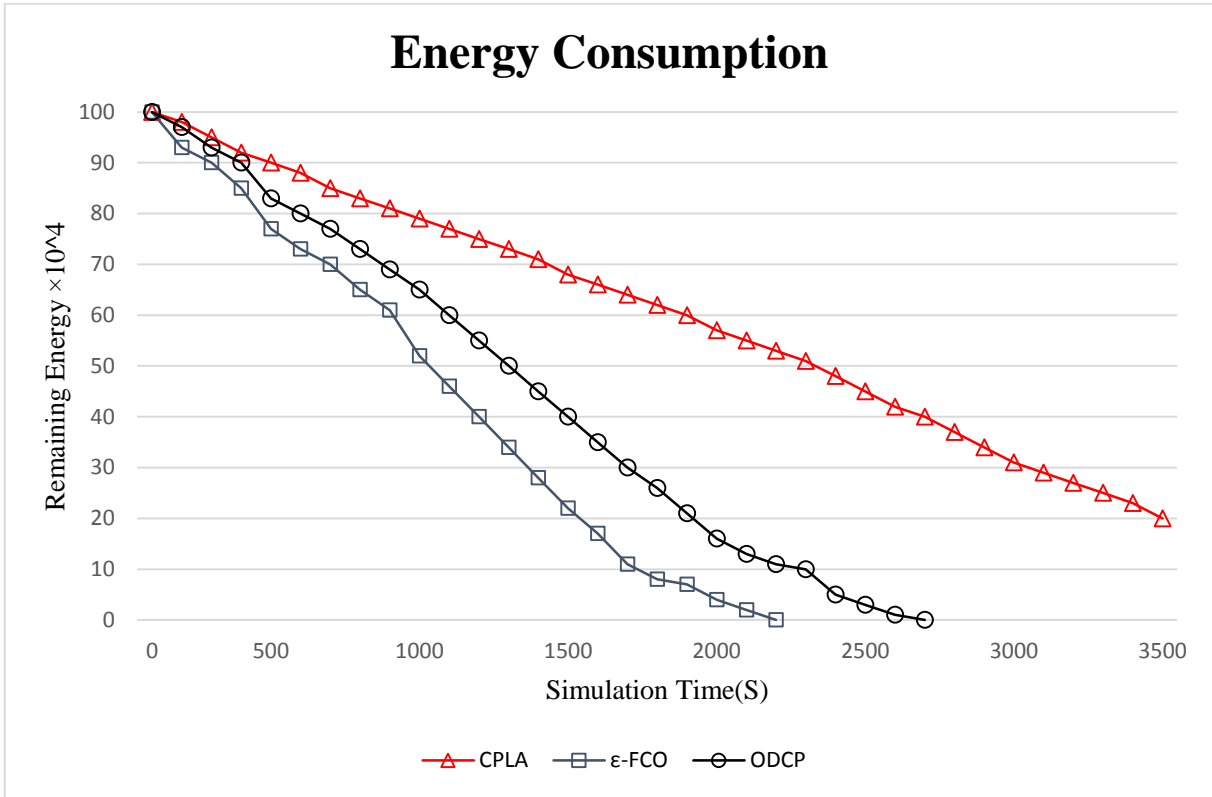
Figure 9- Testing energy consumption rate in CPLA network during activity, comparing to ODCP and ε-FCO protocols

Considering results, this identified that proposed method abbreviated CPLA leads to more energy consumption decrease than previous ones.

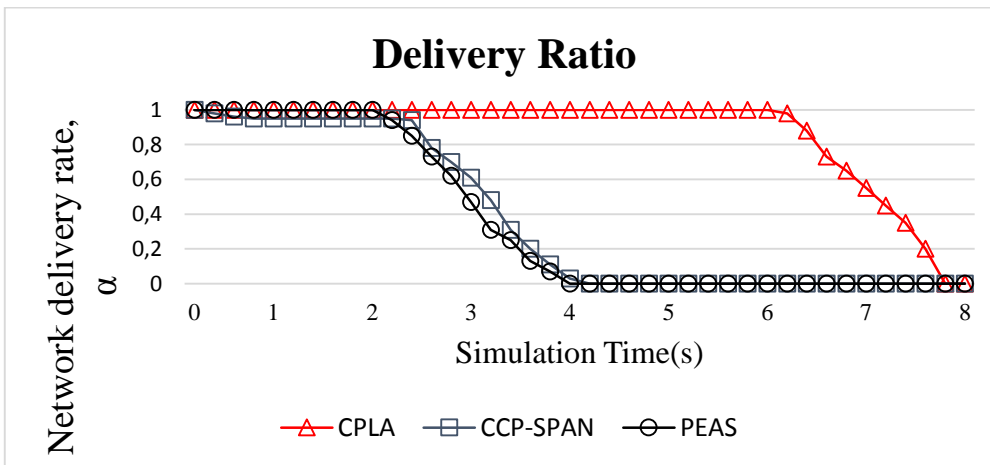**Network packages delivery rate test**

Fig 10. Data packages delivery rate test during simulated time of 4000 seconds

In fig.10 it is observed that CPLA act effectively in delivering packages, because nodes are activated and sends data during proper time.

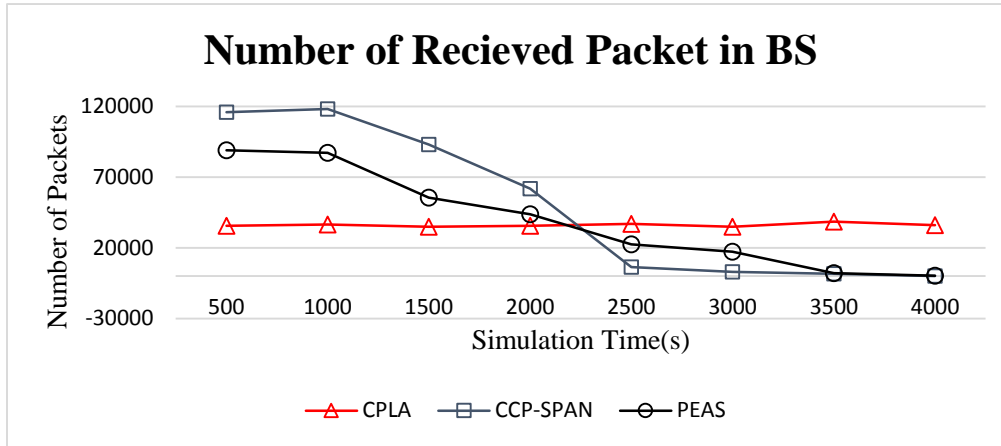**Numbers of Received Packages in Sink**

Fig 11. Test of numbers of received packages in sink; during simulated time of 4000 seconds

As it is shown in Fig.11, the number of delivery packets in the sink in the proposed method is almost uniform throughout the simulation, but in other methods, first, very packets are received and then it goes to zero. This shows that in the proposed method, network performance is almost non-volatile, whereas in other approaches, first a lot of packets is sent and received in the network, and over time, sending and receiving has been very reduced and will be stopped very soon because of the death of the nodes.

6. Conclusion and Future Works

In previous section it was said that proposed protocol can begin mechanism with one starter node. But for networks with vast surface several nodes may need to be active parallel in order to converge coverage faster. Faster convergence means that nodes become active or sleep sooner than expectancy or start modes which will lead to energy consumption decrease of the whole network as well. Because being in expectancy or start modes, certainly consumes more energy than sleep mode. Start with several nodes cause overlapping of points that is because of this process concurrency. In this paper activation details of proposed protocol in several nodes have been studied. This mechanism has considerable effects on active nodes number, convergence time, and whole network used energy. According to the tests, this method can increase sensor network lifetime more than 20 percent of past researches.

Proposed method can be operated on different kinds of sensor networks including oriented wireless sensor networks in the future. Other learning algorithms can be tested. We can use complementary methods for finding the best possible modes. Other experiments can be performed to determine method efficiency more than ever. Functionally, it may be possible to reach better results by implementing some changes.

Acknowledgment

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