# A new multi level clustering model to increase lifetime in wireless sensor networks

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## Abstract

*Most of clustered models in wireless sensor networks use a double-layered structure. In these structures a node is considered as cluster-head and has the responsibility of gathering information of environment. Static attribute is the main disadvantage of these clustering method. because as traffic rises in environment as time passes, cluster-head nodes energy and its close nodes, is consumed rapidly and so these nodes that has important role in data gathering, are break down. This issue is considered as age decrease in network life time and finally, network death. In this paper, a new three-layered dynamic model is introduced that its main goal is to increase network life time. The dynamic of this model is because the cluster-head node and the nodes nearby, that build layer 1 and layer 2 respectively, according to location analysis and traffic rate are replaceable and can change network connectivity. This paper discusses when and how network connectivity should change. The proof of the proposed issues is done using simulation methods.*

## 1. Introduction

A wireless sensor network consists of hundreds or thousands of sensor nodes that have the responsibility of collecting information from the environment they are located. Each sensor node consists of a sensor module, a computational module, memory and wireless connection module with limited range. This connection has great affect in many applications f sensor nodes such as military, medicine or natural environment [1, 2].

The main job of sensor networks is to gather information from the environment they are located at. The direct transmission of data from data sources to main node is almost impossible because usually the main node is farther than the data source and sensor nodes has limited energy source, So we use multi-step paths for routing. Although still there is some nodes in the path that always transmit data and so increase the possibility of damage and energy loss. For solving this problem, clustering model is used. In this structure, sensor nodes are grouped in some clusters and a main node is selected as the head node of the cluster. Model-based cluster architecture is known as scalable architecture. The head node of the cluster has more energy consumption than common nodes. This node is capable of extracting useful information from received information, omits data redundancy and finally producing output data with much smaller volumes.

In these structures, death time of the first node is one of the most important parameters of system life-time. Because in most sensor networks, data is directed to the head node of the cluster, these neighbor nodes of the head node are facing a large volume of data sending and so their energy is consumed more rapidly than the other nodes. Also, because the static structure of the network, when these nodes are down, the nodes farther to the head node are made to select a replacement for these nodes and this job is also energy consuming and causes data coverage decrease and network inefficiency. In the other words, being static is the main problem of these systems.

In this paper, a new approach of a dynamic three level model is introduced. In this clustered model, head node is located in the highest level. The close nodes to the head node that are one step close to the head node are located in the second level and the other nodes are in the lowest node. The main idea of this model is that as the sending traffic from the second level grows, the situation of the first level node and in some cases, the connectivity of the second level nodes is changed. In other words, we use traffic size of a working unit according to transmission power for monitoring the network and changing network interconnections. In this method, the changes of level one nodes and their

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traffic are monitored. If the distance between level one node and some level two nodes that has heavy traffic is higher than an upper bound, level one node calculates their availability in network life-time and the delay caused by them according to sending traffic size through these nodes. Id transmission power unit is high enough; level one node decides to change location or interconnection in the network. But, before deciding for changing interconnection, the overhead of interconnection change and node replacement is also considered.

In the second section, the previous works are mentioned. In section 3, our proposed model for implementing dynamic three level cluster models is described. In the fourth section, using a simulating environment, we simulate our proposed model and finally in section 5, a summarized achievement of this method and future works are mentioned.

## 2. Related works

In recent years, many protocols and algorithms for clustered models are proposed. [3-12]. Most of these algorithms have a static hierarchy, in these structures, some nodes are selected as the cluster header according to one or more properties such as number of neighbors, energy consumption and etc. . For instance, a average weighting algorithm mentioned in [6] uses this mechanism. In [5] the author illustrates a clustered model that its goal is to maximize network life-time by measuring the size of optimal cluster and optimal node devotion to the head nodes. In [8] the idea of data gathering that optimizes "energy latency" parameter is proposed. In [9], a multi-level clustered model is proposed. In this model, the required structures for density of the head node are described to minimize the total energy assumption for the network. In [10] a clustering protocol named LEACH is introduced. This protocol used cluster header orbit as a toll for configuring network traffic. In [11] a multi jump network is introduced. This model has an upper bound for network life-time by minimizing consuming energy for sending a packet from a source node to a destination node using an optimal number of supporting nodes.

In [13] a two level clustering model for sensor networks is proposed. In this model sensor clusters around strategic locations and header nodes are distributed so that their location has flexibility. Papers mentioned above use a static structure. A model that considers being dynamic is [14]. In this model, it is assumed that a sensor node is not connected automatically and pacing header nodes for creating a connected network topology is researched. But the problem of placing header node as a model with limited moving capabilities in the sensor infrastructures and wireless local networks is considered in [15,16] in these papers systems are static and in order to have interconnection, an environments with small number of gates are considered.

In this paper a three level clustering model is proposed that its main goal is to lengthen network life-time. The dynamically of this model is because of the header node and their neighbors as the first and second level of this mode respectively could be moved according to location analysis and network traffic and change network interconnection. In order to have this functionality, in this paper, an algorithm is proposed that shows when and under what conditions, and how the network interconnection should change. Generally, the goal of this model is to find the best interconnection for the network when there is heavy traffic and therefore this interconnection, optimizes network life-time and output.

## 3. THREE LEVEL DYNAMIC CLUSTERING MODEL

Although in today's clustering models, the energy consumption of sensors and traffic templates are greatly considered, sensors that are used as the close nodes to the cluster headers, because of permanent usage, are omitted quickly from the network life cycle. This problem causes much longer jumps and longer routes for connecting to cluster headers and this causes the higher costs in connections. This idea is one of the most important shortcomings of today's static clusters that questioned the network efficiency. In order to overcome this problem, we propose a dynamic three level clustering model that its main character is its dynamics. In this three level model, the first and second levels are cluster headers and their neighbor nodes respectively and could change according to network traffic.

In this dynamic model, when the consumption power increases, the level one and level two nodes change interconnection according to heavy traffic sources. The advantage of this idea is that because of changes in network interconnectivity, the level one node is always located in a environment that most of the level two nodes are transmitting most of the traffic in that environment and so this decreases network connectivity power consumption because of their being close to the cluster header. This closure of level one and level two nodes solves packet lost problem too. Generally, considering the problems discussed, this model improves network life-time, power consumption and network output.

Next, we introduce implementation of this model as well.

### 3.1. Proper time for interconnection changes

Before we consider time and nodes changes problems, we have to define some parameters:

L1: Level one Node

L2: Set of Nodes that are located in the distance less X to the cluster header node and make level 2.

N: set of nodes that in the active routes are selected as the last available jump node

R: the Radius of node availability in N

S: the set of nodes that are in both L1 and N

$P_i$: the measured traffic according to the number of frames sent from node i

T: a Set consists of packet traffic of each sensor in S that sorted Ascending.

$E_i$: Energy consumed by nodes for transmitting as packet to the next step.

Deciding to change interconnection should be done by having an unaccepted functionality in data transmission route. When a level one node recognizes these conditions, it considers changes in network interconnection. For doing this, the level one node, considers changes in data routes in two cycles. According to the comparison of these two cycles, if data sources are the same but previous S nodes and current S nodes are different, level one node decides to have more analysis. In this case, level one node, studies nodes that are in previous S node and are not in current S node, if traffic f of these nodes are less than f percent of T, there is no need to change. Otherwise, is these nodes are sending heavy traffic (more that 1-f), level one node starts searching for better situation in order to change interconnection, the amount of f is dependent to data production rate. In the next section we consider finding of the best connectivity.

### 3.2. Determining the best interconnection

Considering the great extent and the number of nodes in this extent that a cluster covers, finding an optimal interconnection is a complex problem. In order to reduce the complexity of this problem, we propose our method based on the idea of changing interconnection according to their closure to the sensors with heaviest traffic. In general, for changing interconnection, we base our idea on this fact that we move level one node such that it is located close to the level two nodes with the heaviest traffic or the level two nodes move so that the traffic is distributed. For knowing and determining nodes with such amount of traffic in level 2, we search list T and select the highest from this list.

If the highest node in T are according to density parameters and traffic volume, so the result of analysis is to direction of interconnection changes is from cluster header to that node or the level two nodes are relocating considering the node. Of course because of this change in interconnection, we might activate some of the inactive nodes in level two or deactivate some of the active nodes or consider some of the level three nodes, as level two nodes. If the cluster header is changed, in this case, for simplifying, we use a linear change template. In the other words, the cluster header changes in a direct linear line. In the cases that has many level two sensors that has heavy traffic, in order to decide how to change, we use a weighted average according to node distance between level one sensors and level two sensors and the traffic between them. In this method, the situation that has equal distance from other level two nodes with the easiest traffic is selected as the new situation for changing interconnection. Parameter determining distance is calculated using the equation below:

Space * traffic volume = distance

this interconnection change and finding such situation is in fact, finding a center for series of heavy traffic routes and is a ideal point for nodes with heavy traffic but could be worst situation for total consumption power in routes with light traffic. So level one or level two nodes study the effects of the change to the total power and energy consumption of the network before any change. If the compared power was optimal, the change is done.

### 3.3. Sending a packet while changing interconnection

After the interconnection and new situation of the nodes is determined, we have to find a method so that while changing interconnection, the produced data is not lost. The method we have selected tried to while preserving the continuously of the data, the change is done without problem. For changing the interconnection according to the current network traffic we have used two different mechanisms for two different situations. In the first situation, we conFigure. the transmission power of some sensors in order to ensure receiving of the data to the cluster header node. And in the second method, we have used some of the intermediate nodes as temporary level 2 nodes for expanding the available routes.

The level one node uses a step by step method for changing from one situation to the other one. This step by step movement is done by a direct linear movement between intermediate points. In each point, level one node studies how to be available while moving to the next intermediate point or for the changing level two nodes. If in the next new intermediate point level one node, is located in the domain of level two nodes, simply, declares level two nodes to use their radio power for covering the movement of level one node or level two node. Otherwise, if node level one recognizes that while moving, it loses its connection, it declares the issue of using new level two nodes. When these routes are established through new nodes, the interconnection of level two is changes, the level two routes expands and the information are transmitted through new sensors to the level one node. This action is repeated until the moving nodes gets their new situations and the interconnection is established.

### 3.4. The Proposed Algorithms

When an unacceptable functionality is discovered in the network, the interconnection change is studied. In this situation, we mark the level two nodes with heaviest traffic. Then, for finding the best interconnection, the situation which has the equal distance (Space*Traffic) from level one nodes and level two nodes is selected. After that, we calculate total power of the sensors in the new interconnection. If the new transmission power difference is less than the old transmission power difference beyond a lower bound, the interconnection change is done. The interconnection change is done step by step and by moving the level one and level two nodes. In Figure. 1 we can see the pseudo code of the algorithm.

## 4. Simulation

The optimality of the proposed dynamic algorithm is proved by using simulations and its results. In this section of network functionality, we describe simulation environment and the practical results of model implementation in this environment. Network functionality in these experiments are implemented according to a goal seeking application. This functionality gives us this capability that always all the nodes in the network should not be active and only some of the sensor are involved in action. Level one node controls the configuration of data processing in each sensor. In order to avoid conflict, protocol TDMA is used.

We have used NS environment for simulation. In this environment, we assume that the network consists of various numbers of nodes (100-250) that are distributed randomly in a 500*500 environment. The first situations of level one node are randomly chosen in the determined environments. The initial energy of nodes is 5J. When a power of a node is completely out, the sensor goes down. The most range for each sensor is 50 meters.

Dynamic_clustering()

1. if an unacceptable packet traffic detected changing the network topology;
2. detect the m nodes k1,k2,k3,…,km in L2 with highest packet traffic
3. search new location for nodes in L1 or L2=center of ( k1,k2,…,km)
4. calculate new routes and new N
5. $TP_{old} = \sum_{\forall i \in N} E_i \times P_i$
6. $TP_{old} = \sum_{\forall j \in N_{new}} E_j \times P_j$
7. IF $TP_{old} - TP_{new} < Thereshold$ then chang_topology(L1,L2,N)
   Else remain at the same topology

Change_topology(L1,L2,N)

8. While (new position not reached) process one stride
9. For ($i \in N$)
10. If (dist(i,NL)>R[i]) then insert_new_node(i)
11. Else R[j]= dist(I,NL);

Insert_new_node(i,NL)

12. If { dist(i,i1)<R[i] and dist(i1,NL)<R[i1] } then search_and_insert i1
13. Update new routes and topology information
14. If(i1 not in N) then
    15. Begin
    16. Insert i1 in N and L2
    17. Update routetable[i]
    18. End
19. Remove i from N

**Figure. 1. The peseudo code of proposed algorithm**

In these experiments we assume that the network must make goal seeking action and level one and level two nodes could move with the speed of at most 6 m/s. the goals are entered from out world. The set of initial sensor nodes are chosen in the way that a convex skin of sensors is distributed in the environment. The sensor circuit of the other nodes is off and could get active according to goal situation. The constant speed of the goal is between 3 to 6 meters per second. The constant move direction is dependent to goal initial situation so that it can move from the convex skin. For each node, the packet production rate is the constant amount of 1 packet per second.

### A. Parameter Evaluation

In this section some results about life-time parameters, energy consumption and network output are studied with or without using our dynamic model. We propose our methods for showing functionality and use these methods:

-Average energy of each packet: shows the average energy in sending or receiving a packet
-Average life-time of a node: a good parameter for measuring our network life-time according to average time of the node being active.
-Delay of each packet: the average time that a packet gets the gate from the node.
In order to do the simulations, we have to produce random interconnections using various modules. Then for each of the interconnections, we do the simulation. After doing these simulations, it is clear that 90% of simulation results are between 7% to 15% of the average sample. In the simulations done next, we have used an unlimited traffic. In this experiment, the mode is in the interconnection change situations for 15 times. in this case, we have 30.4 meters movement in average.
The consuming energy. Figure. 2 illustrates the effect of this dynamic model and the movement between levels on the energy consumption. This chart is calculated according to average energy of each node. The results show that movement between levels has 10% of energy consumption compared to static methods. Also, it is shown that when a level one or level two nodes goes closer to the nodes with bigger workload, it reduces the transmission power and in most cases the number of jumps to be made. This type of energy consumption also means grow in node life-time that is shown in Figure. 2.

Network dynamics output has positive effect on the network output, as we can see in Figure. 4, our idea has at least 15% increase in packet output. Because our idea of dynamic network increases life-time of nodes according to Figure. 3, nodes can produce and support more packets. Totally, a level one or level two node mostly gets closer to the jumps with heavier traffics in order to decrease the number of jumps by the packets. The less number of jumps, the less the probability of data loss would be and so more packets gets to the cluster header. Finally, the simulation results show that using the proposed dynamic structure causes improvements in network life-time, energy consumption and network output.
In summary, we can say that the average life-time of each node increases by decrease in energy consumption of each packet and also the output increases.

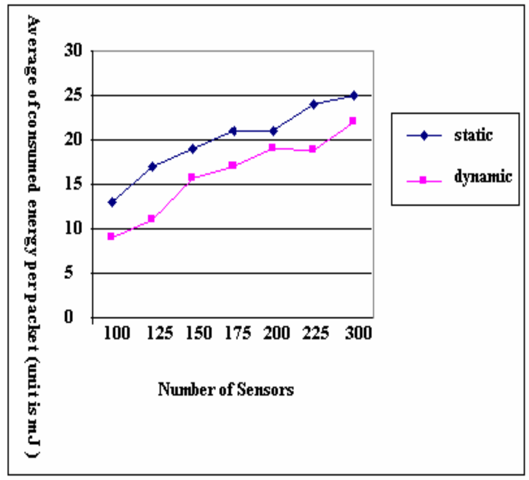


Figure. 2. Average of consumed energy in each node for variouse number of sensors

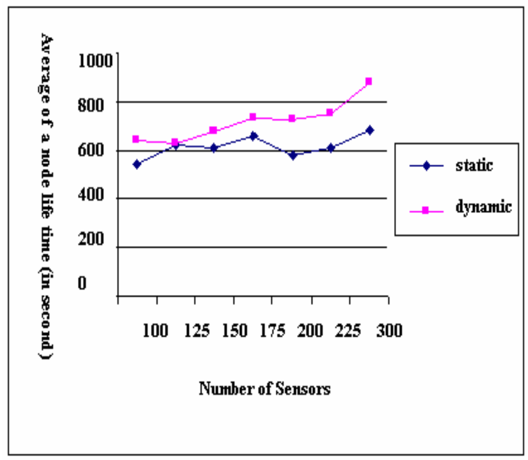


**Figure. 3. Average Life-Time of each node for variouse number of sensors**

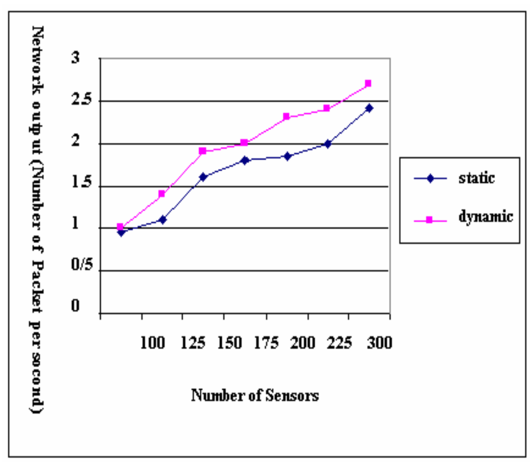


**Figure. 4. Network output for variouse number of sensors**

## 5. Conclusion

What is discussed in this paper is a new dynamic clustering model for wireless sensor networks; the dynamics of this model is because according to traffic templates and current network situation, network interconnection and node locations change. The important parameters considered in this model are time required for interconnection changes and the arrangement of nodes in different levels, the way that interconnection change is done and finally the management of network efficiency while interconnection changes. The simulation results show that this interconnection change increases the average life-time of the network by decreasing the average energy consumption for transmitting each packet in the network. Also has a positive effect on the output of the network. The next work in this issue is studying and changing this model in order to adapt it when facing limited real-time traffics. The other issue that we are discovering is to find an intelligent dynamic model to increase network life-time.

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