Applying Intelligent Agents In Wireless Sensor Networks As Base Stations

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ABSTRACT

This research work presents a new model in Wireless Sensor Network in which data aggregation is done by Multi Agent Systems and causes to prolong the network lifetime. A Time Division Multiple Access (TDMA) protocol is applied for the interconnect communication between nodes to prevent the collision and to save the band width. We also used the Flooding method with some modification to handle the Node Synchronization. The Network Performance measured by means of increasing the network lifetime, balancing the energy consumption between nodes, and increasing the network reliability and security. The empirical result obtained from our model indicates the balance of energy consumption among nodes that leads to an excellent performance when a number of messages are sent from each node.

Keywords: sensor networks; intelligent agents; data aggregation; TDMA protocol.

1. Introduction

Sensor networks are composed of a great number of nodes that are distributed randomly for special operation in a geographical region. Energy of sensors is limited and by finishing energy of the node, each node will be normally a retired node and will be taken out of the network. Inactivity of the nodes that are located in border locations, finish the life of network. Thus, to increase the performance of the network, we should prolong the lifetime of network, by balancing the work between the nodes; the consuming energy of nodes will be equal. Multi agent systems are software or hardware agents working separately, intelligently and concurrent to do a special work. In this paper, intelligent agents are applied in information aggregation sinks of sensor networks. As the maximum energy is dedicated to sending the message, by multi agent system a solution is proposed for balance in sending message in far and near nodes that result into prolonging lifetime of the network, reliability and security in synchronization.

The energy of sensors is limited in sensor networks and by finishing energy of each node, that node will be taken out of the network and as sending message consumes the highest energy in the network and that border nodes are responsible to send more messages, in this paper, we are looking for a solution to balance sending message between different nodes.

To increase the performance of the network, we should prolong the lifetime of the network and create the best cover, in some applications prevent bad node and guarantee security, use suitable synchronization algorithm and above all, increase the reliability of the network. Multi agent systems are software or hardware agents working separately, intelligently and concurrent to do a special work.

In this paper, two topics of multi agent systems and sensor networks are applied together. A model is proposed in which by applying 2 intelligent agents that are located as sink around the sensors zone, we attempt to achieve the mentioned goals. The presence of two sinks nodes increase the reliability of the network because in case of the failure of one of them, the other does its responsibility separately. But by changing the direction of the route of data, load balance will be created on the nodes and less pressure will be imposed in terms of energy consumption to border nodes and thus, life time of the network will be extended.

By considering the agents that used unlimited energy source, as root node in synchronization process, we can prevent bad nodes not to send wrong and false messages, thus the security of the network will be increased.

The proposed model in this paper has the following goals:

1. Using independent multi agents to increase reliability of sensor network

2. Good overlapping of the network to include all the nodes

3. Using a good synchronization method to provide the security of the network

4. Using intelligent multi agents that change the direction of sending data and extend network lifetime.

By considering two or more intelligent agents as data collection nodes and synchronizing nodes of the network, whose duty is changed periodically and are independent from each other, it can be said that sensor network can remove the problem due to the fact that by destruction of a sink node, the rest of them do its duty independently and this increases the reliability of the network.

Sensors are battery operated to provide energy. Thus, we should save energy as possible to prolong the network lifetime. But this is not adequate alone because if the nodes that are near the root as because of their more responsibility to send the information of other nodes to sinks, lose their energy and the network won't work. Thus, we need some methods to divide the duties.

Synchronization is a critical and vital part of infrastructure of a wireless network that is important to link the base and can identity displacement, location, adjacency, saving in energy consumption and mobility in sensor networks.

Due to not using address IP and using radio signals as public broadcast, attacking these networks is done easily. Security didn't consider in these proposed protocols in this kind of network, but by validity, redundancy and avoidance of transferring incorrect synchronization information we can fight with the attack. Overcoming the attack creates overload, increasing traffic and more consumption of energy. This can impose little money in contrast with the security of the network from the attack or preventing the attack. Here by the methods proposed in sensor networks and putting intelligent agents as root node we prevent a kind of attack in flooding synchronization.

2. Related work

In protocol QBCDCP [3], clustering method and a base station as sink that is located in a definite distance of a square space, are used. In this method, besides its bene-

fits, we need an external synchronizer such as GPS to locate each of the nodes and some of them were as head cluster and the rest were sensors that these duties are changed at a time interval and this has extra overload.

Different factors can be involved in saving the energy consumption of a sensor network: Using suitable routing algorithm, using synchronization method or combining them [9] to make the energy consumption minimize, normally, sensor networks don't have special topology and mostly mesh structure is used in them but in [1] saving energy consumption is used, also the linear topology proposed in [4] was used to control a bridge in which some sensor nodes were located in equal distance with each other. In this model, two base stations are located in two ends of the bridge that by using two different algorithms of receiving information such as pressure, temperature and so on are done at definite time intervals. In addition, sleeping and awake techniques that are used for rest and also the lack of wastage of energy at times that there is no need to send information by sensors [2]. Also to save energy consumption, we should reduce energy loss resources such as collision and delay.

Multi agents systems are software or hardware agents with different applications. Naji [5] used FPGAs as calculation agents for paralleling on the processing of a great number of information. Other applications of intelligent agents were using them in E-Commerce, customers are interested to compare the commodities and services of different sellers and buy the best quality with the minimum cost that intelligent agents are the solution [6].

Different synchronization methods are used to reduce energy consumption in sensor networks and most important of them are RBS, FLOODING and TPSN. In [7] the combination of these methods is used.

In sensor networks, multi agent systems are used in some papers. Using the architecture of multi agent systems for overlapping in sensor networks to save energy consumption according to figure (1).
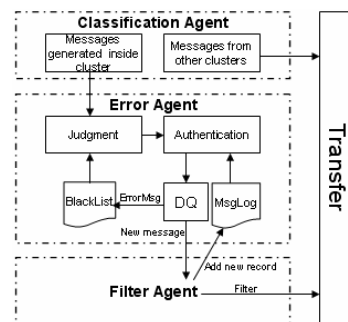

Figure 1: An Energy-Efficient Multi-agent Based Architecture in

Wireless Sensor Network [8].

3. Intelligent multi-agents

A multi-agent system (MAS) is a system composed of multiple interacting. Multi-agent systems are used in different applications such as robots, e-commerce, parallel processing, etc.

Multi-agent systems have several important characteristics:

1. Autonomy
2. Local views
3. Decentralization
4. Flexibility
5. Synchronization
6. Proactive
7. Intelligence
8. The communication between the agents
9. The interaction between the agents

In other words, multi-agent system is a combination of some autonomous and synchronized agents interacting with each other to achieve a common purpose.

For example, one of the big problems of participants in on-line stores is collecting the specifications of sellers, products, services and even other buyers despite the high amount of information.

Intelligent agents (IA) by making possible efficient, exact and comprehensive searches among big warehouses of information and web sites help both sellers and buyers.

An intelligent agent is applied software with pre-defined knowledge base and normally, by a learning system identifies its user's goals and interests.

These agents communicate with each other by message communication. These messages are in the form of Agent Communication Language (ACL). The messages sending agents to each other have different meanings and applications.

4. The Proposed Sensor network model

In the proposed model, 2 base stations that are located in two sides of sensor network zone, are used that are linked to an energy source, one of them coordinates the nodes and the other receives information. In this method, due to load balance, we will have extension of network lifetime. In this model, 2 or more intelligent agents as base station are linked to an unlimited energy source and are located around the sensor network with the distance of L as the following figure.
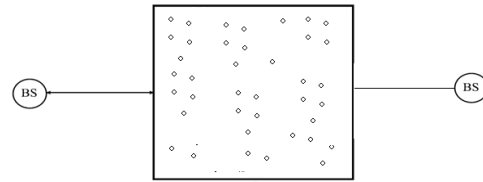

Figure 2: Our proposed model

In each time interval T, only one of BSs collect information but synchronization and sending routing information related to sensors are done by both BS in parallel form. Due to the mobility of routing, the nodes can be different from energy aspect. Generally, the proposed network is consisting of the following conditions:

1. M sensor nodes that are distributed randomly in a sensor field but their success do not change.
2. N (2 or 3) BSs that are around this zone and are linked to an energy source.
3. The link of BSs with each other is by GPS and the architecture of multi-agent systems in them (by BDI architecture).
4. All the nodes do the same but they can be different from energy aspect.
5. Routing is done by MACDRP algorithm.
6. By finishing time interval T, BS node is changed and algorithm is repeated.

Base stations were informed of the location of border sensors and the nodes with the maximum energy and send a good routing algorithm to each of the nodes. Border nodes are classified in a list based on the residual energy. BSs should be in touch with the manager of the network to receive inquiry and sending information, on the other hand, it should be connected to the sensor network to collect sensed information, the amount of residual energy of the sensors and sending schedule for synchronization and transferring the rout of sending data to each of the nodes.

BS's should coordinate with each other and interact common schedule and other required information with each other.

5. Multi Agent Controlled Dynamic Routing Protocol

This protocol is dynamic routing by multi-agent systems and it has a complex calculation capability that is on BSs and routing process and finding the nodes with the maximum average energy are used to define the required BS to collect data. The following figure shows the structure of the model.
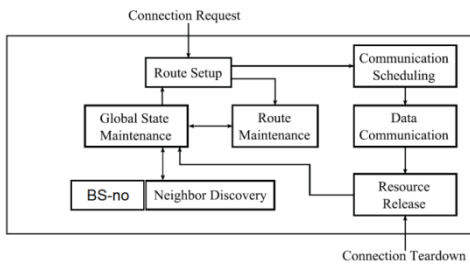
Figure 3: The structure of the model in the nodes surface

In this model, each node should have an address and as it is not possible to have a unique address, we use an address plan [10] that is based on the geographical properties and location. Here, addressing based on class as < ID location, ID the type of node> is used. ID defines the location of a node in one part of the network. BSs keep the location of all the nodes in them and the second ID indicates the type of action of sensor network.

In this algorithm, in each time period T, at first the required BSs should be defined for data collection and the information and schedule of the route of sending data is determined by nodes. BS receives the information of energy status of all the nodes of the network and then selects a set of nodes with above average energy and less distance with BS.

In this stage, collector nodes and Bs are responsible to receive information. Then routing routes are defined and then, BS selects the algorithm with minimum energy such as spanning tree and then sends BS to the nodes with details and number that normally the approach of minimum spanning tree is used. In addition, to avoid the collision between sensor nodes information that intend to send to BS, a special mechanism should be used that we used TDMA method. Here BS dedicates one ID for each node that in each time period, some of the nodes send their data.

The proposed model has the following benefits:

5.1. Synchronization and security

In FTSP algorithm, as all the nodes are allowed to be selected as a root after a time period, the conditions are such that an incorrect node can claim to be a node and other nodes respond to its schedule information, instead of responding to the main root node, thus, the calculations will be full of errors. There are some solutions to solve these attacks and one of them is redundancy method. In this method, the nodes calculate schedule not only via one neighbor but also via many neighbors.

Thus, incorrect node can be identified (if any). If a node is suspected due to receiving incorrect synchronization information, it can give up re-sending the data and distribute synchronization information in the network. In this paper, we used all kinds of BSs to send local time for synchronization, thus bad node in the network cannot replace the root.

5.2. Reliability

Due to using some BSs around the sensor network zone and the fact that BS s are intelligent agent, in case of failure and problem, each remaining BS do its duties, thus reliability of the network is increased.

5.3. Prolong network lifetime

The sensor in different cases including for receiving data from the environment, receiving information from other nodes, sending information to the next node or BS, information processing and even at idle time, consumes energy. The following figure depicted these energies.
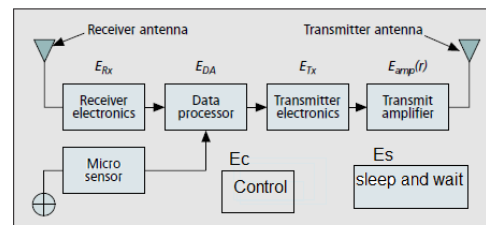

Figure 4: Energy consumption cases in a sensor

The consumption energy of the sensor can be considered as dependent upon the above mentioned issues. It is natural that border nodes near BS consume more energy in comparison to the rest of nodes due to receiving the data of other nodes and sending them to BS, on the other hand, border nodes of opposite side, and consume the minimum energy as they always are sleeping. According to this, the consumption energy is:

$$E = Ecap + Ec + Er + Et + Ep + Esleep \qquad (1)$$

If we want to compare from energy consumption aspect intermediate nodes (Em), border nodes and near selected BS (Es) and consumption energy of destination nodes (Ee). we obtain the average of consumption energy in these nodes and then gain consumption energy for each of 3 kinds of nodes after 2 time periods.
K is bit size of message and m is the number of average message that each node sends in a time period. Considering the formulas and values [3], [10], [11], we can design table (1) in which, each of variables are explained and their values are defined for each of the 3 kinds of nodes.

Table 1: The application of energy in sensors

Variable	Description	Destination nodes(Ee)	Source nodes (Es)	E_m
E_{sleep}	Consumption energy at idle mode		0	
Ec	Consumption energy to control	-	-	-
Et	Consumption energy for sending message to other nodes	Etx+ Eamp(s-s)		Etx+Eamp(s-bs)
Er	Consumption energy to receive message from other nods	50nJ/bit	50nJ/bit	50nJ/bit
Ep	Consumption energy to process message	5 J/bit/message	5 J/bit/message	5 J/bit/message
E_{cap}	To gain data by sensors from the environment	-	-	-
Eamp(s-s)	Consumption energy by amplifier to send message from one sensor to another sensor	1.6 A/N (A:network area N(the number of nodes)	-	1.6 A/N
Eamp(s-bs)	Consumption energy by amplifier to send message from one sensor to a BS	-	4.2A + dbs.L +dbs2 (A :area of the network, L. length and dbs the distance of network to BS)	-
Etx	Consumption energy of radio to send message	50nJ/bit	50nJ/bit	50nJ/bit

As here, the purpose is comparing the energy consumption among different nodes from location aspect and Ecapis equal in all the nodes and we consider it zero. We delete Ec due to the less value of it against other consumption energies; thus, consumption energy in the nodes of proposed model network is as the followings.

$$E= Er+Et+Ep+Esleep \qquad (2)$$

Consumption energy in destination nodes is as the following formula

$$Ee=m (k.Et + Ep) + Esleep \qquad (3)$$

Consumption energy of the nodes near to the selected BS is calculated as the following formula.

$$ES=mn (kEr + k.Et + Ep) \qquad (4)$$

n is the number of nodes using the mentioned node to send messages. Esleep is considered zero as these nodes are normally zero.

Energy consumption of intermediate nodes is as the following formula:

$$EM=mn(k.Er+ kEt + Ep) + Esleep \qquad (5)$$

We consider a part of sensor network in which two BSs are present. By changing the duties of BSs, the direction of data flux is changed as the following figure:
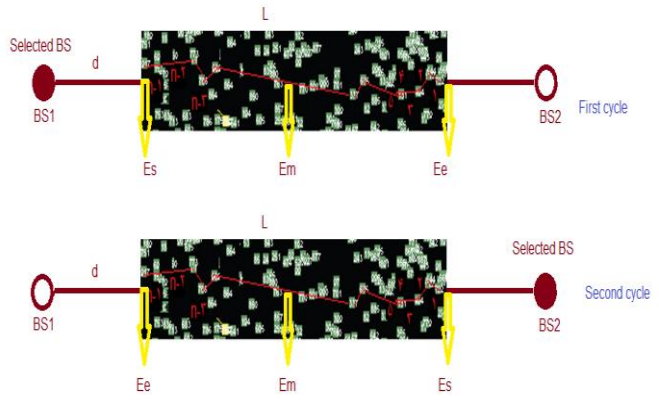

Figure 5: The change in direction of data movement in 2 phases.

If we consider a cross section of sensor network region with n sensor nodes, if BS of the left side collects data, the number of overloads the each node tolerate based on its location in the network is as the followings.
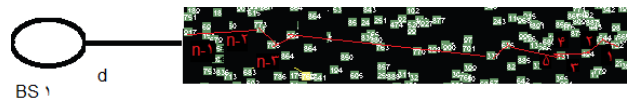

Figure 6: The number of overloads to each node if BS of the left side collects the data

Now if the duties of BS s are changed and right side BS collects data, the number of overloads will be as the followings:
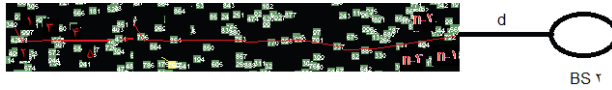
Figure 7: The number of overloads to each node if BS of the right side collects the data

If this cross section is in the form of rectangle with the angle of d=10, L=100, k=8 and the number of sensors is N=100 and each sensor needs to send m=1 message in each cycle. Then, consumption approximate energy of each of source, destination and intermediate nodes according to the above table and formulas is as the followings:

$Ee=5+8(50+1.6.A/N) +Esleep=1690$

$ES= 100(8*50+8*(50+ 4.2A+dbsL+dbs2)+5)=34560500$

$Em=50(8*50+ 8(50+1.6A/N) + 5)+ Esleep=86250$

As the results of the calculations show, energy consumption in the nodes close to BS is much more than intermediate and destination nodes that by changing BS of the nodes located at then, in the second cycle, it will act similar to the nodes that were near selected BS in the previous phase. If we obtain the average of consumption energy for different nodes in the first and second cycle, we find that consumption energy of left side and right side nodes of sensor network are equal, it means that consumption energy for source and destination nodes will be about 34562190. Consumption energy of intermediate nodes after two cycles is 172500 that is less than destination nodes and in the next cycles, one of the intermediate nodes can send data to BS. Here the aim is to show that by changing data collector BS, the energy consumption will be balanced between different nodes.

Now suppose that the destination node is located at the bottom right corner and the sending node is located at the top left corner. In this condition, there is no serious problem because as BS s are moved and the nodes sending data after some time stamp, its symmetrical state is created that by balancing energy consumption between the nodes, the network lifetime will be extended.

6. Conclusion

In this paper, a model of sensor networks with two bases stations is proposed. The proposed model is a solution that results into less energy consumption and prolong lifetime of sensor network but it cannot be applied in everything, as two base stations with unlimited energy cannot be used everywhere. This model has high reliability and it can be used for real time applications where high reliability is required.

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