Sensor Communication Management Scheme for Wireless Sensor Network

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Abstract

A wireless sensor network is the combination of a large number of deployed sensors over a terrain. Communication between the sensors is the most important issue for a successful network. It is mandatory that long distance and multi-hop communication will occur between sensors. Sensors relay the sensed data of a particular territory to the command center via a base station. An out of communication range problem may arise for the base station to the sensor due to non uniformed deployment of sensors in hostile areas. To solve this problem a solution of agent sensor based group management technique was proposed earlier. But in that solution the proposed load balancing technique seems to create bottleneck particularly in the agent sensors. This paper proposes a revised sensor communication management scheme using a dynamic load balancing approach based on residual energy of each agent sensors. Moreover the proposal considers that each group will contain a maximum number of member nodes. Performance of the proposed scheme is evaluated by some experimental results.

1. Introduction

Wireless sensor networks are a hastily striking resource to scrutinize the environmental conditions where people wish to implement their thoughts, expertise application etc. Wireless sensor networks are the strategy for many new kinds of applications, and logistics. Wireless sensor network management and their issues are still to be designed for full filling the various application purposes. Management and Structuring of a sensor network after deployment can be an incessant practice. Actually sensor management establishes an association of sensor nodes with other sensor nodes via communication link. Routing strategy, topology control, energy efficiency etc. are to be implemented and evaluated by different management scheme of sensor networks. Communication between sensors can be as diverse as establishing one-to-one relationships by attaching sensor nodes to specific items to be monitored [1], covering an area with locomotive sensor nodes [2] or throwing nodes from an aircraft into an area of interest [3]. As wireless sensor network is collection of sensors and each sensor has limited amount of energy and capacity so management issues like deployment, re-deployment, grouping of sensors and structuring of them are very important. Now a day for the improvement of the wireless sensor network lots of sensor management related research is going on.

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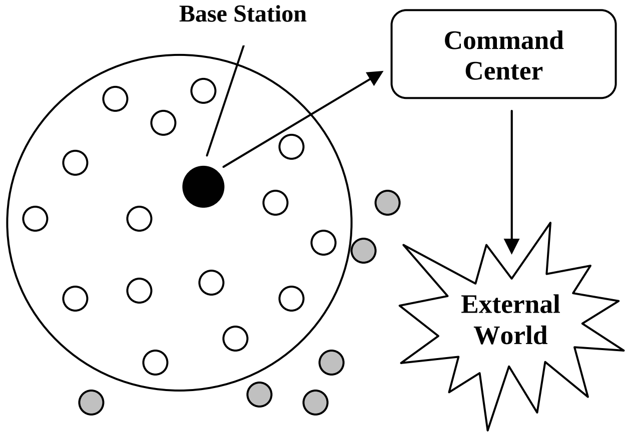
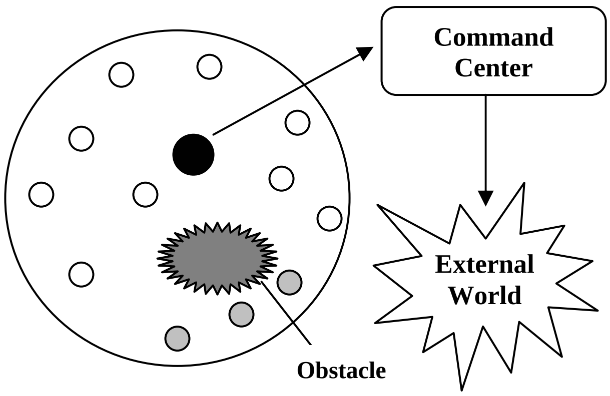
In recent days stint research work is being going on the sensor network management domains. The scope of sensor networks has been increased due to the capability of sensors in building large-scale networks, decreasing the computations task than distributed or local computation and depending on the state of the art of the network. Wireless sensor network may comprise tens of thousands of sensor nodes and multiple applications will be required to be concurrently executed over a single network. It can be a platform for many new kinds of applications, like geophysical monitoring, precision agriculture, habitat or health monitoring, traffic monitoring for transportation, military system, business purposes and in the coming days it will be our part of life by controlling our everyday necessary purposes. In such dynamic complex environments, wireless sensor networks will need to reconfigure and adapt themselves to the changes of environment.

Most common works on sensor network management issues is the cost effectiveness, energy consumption, structuring of nodes etc. To maintain lower communication cost and energy, multi hop routes are to be implemented to collect the sensing information. Multi hop paths minimize the total transmission power by shortening the distance of a radio signal whereas it needs to travel from a transmitter to a receiver. Generally sensors relay the sensed data of a particular territory to the command center via a base station. For the non uniformed deployment of sensors many sensors may deployed in hostile areas. Due to obstacles or out of the scope of communication range from the base station many sensors may fall in an isolate region. The problem can be assumed by considering **figure 1**. In that figure two scenarios presented that shows after deployment there may be some sensors which will be out of the scope of a base station.



(a)



(b)

Figure 1: Sensor Deployment Scenario. a) Sensors out of transmission range of base station b) Sensors lose direct communication from base station due to obstacle

To cope with this problem a solution of agent sensor based group management technique was proposed in [4]. In that solution the use of the load balancing scheme may cause a bottleneck for the agent sensors. So, in this paper we focused mainly on a solution for managing a sensor network to solve this bottleneck condition. Here we propose a revised sensor management scheme using a dynamic load balancing approach. This approach forms group of sensors based on residual energy of agent sensors. Moreover for the group management, each group can contain a maximum number of member nodes. The maximum number can be considered based on the overall topology of the network. Each sensor node will have a node id and by *node_id* a node can get the higher priority to be a member of a group.

The rest of the paper is organized as follows. Section 2 presents some of the related works on this sensor management technique. Subsequently section 3 describes some of the procedural fundamentals of sensor network management; section 4 represents our proposed system model along with the group formation algorithm. Some experimental scenario is chalked out in the section 5. Finally in section 6 we describe our future plan with some conclusive word for wireless sensor network management.

2. Related Work

It is mandatory to mention that lots of research is going on the management architecture of wireless sensor network. Actually present research train gives a huge importance to this particular sensor network issue. Communications take part in sensor network from multiple sources to sink node. As sensor nodes are limited in energy and power so the major focus of present research is on better utilization of the sensor energy. Zhigang Li et. al chalked out the key issues of wireless sensor network management in [5]. So far this is one of the papers that solely narrated management layer architecture for sensor network. The unique requirements of monitoring sensor networks are well analyzed in [6]. This approach assigns neighbor sensors to monitor each other. But the main problem of this approach is that the neighbor sensor may not able to communicate with the base station due to the above mentioned shortage of communication range.

Another approach proposed in [7], instead of monitoring the individual sensors it scans the whole network for available energy information and balances the network accordingly. The main drawback of this approach is that the sensor nodes always have to be power on in active mode. As a result energy degradation will happen very frequently. The sensor network management scheme that we have taken to compare has very little dissimilarities from our proposed scheme. In that proposed sensor management scheme of [4] the load balancing technique for the agent sensors depend upon the distance, which does not seem to be a good solution for load balancing for the agents. It may create bottleneck condition for multiple agents that are to be used as hop for other sensors, which are out of transmission range of base station. Moreover the energy utilization scheme they have shown is quite incompatible than our proposed scheme.

3. Procedural Fundamentals

3.1 Sensor Network Management

Referring the definition of Sensor Management [8], we describe Sensor Network Management as a system or process that seeks to manage and coordinate the sensor nodes in a dynamic and uncertain environment, to accomplish specific mission objectives and improve the performance of perception, by using least amount of energy. The word 'manage' gives a sense of control over the sensor nodes; and 'coordinate' brings out the efficient use of the resources of sensor network.

Energy is a crucial resource in wireless sensor network. All operations performed in the network should be energy efficient. In some applications, the data collected by the network may be of no values unless the observer receives it in time. So, the primary objective of the sensor network management is to save as much energy so that the overall network can work successfully. Generally sensor network management is bound to answer the following questions:

- Which tasks are to be performed?
- Which set of nodes is to be allocated to which task?
- How to coordinate the sensor nodes for a specific application?

3.2 Management Requirements

The management of wireless sensor network introduces various requirements due to scare network resources, dynamic topology, traffic randomness, energy restriction and a large amount of network elements. These requirements are as follows [9].

- Minimal control overhead. Any network management system involves a certain amount of additional control traffic to regulate the various operational characteristics of the networks. In wireless sensor networks, it is extremely important to minimize the signaling overhead, ensuring that the links are not congested and the energy consumption is not increase with management traffic.
- Lightweight. Sensor nodes have limited battery life, limited storage and/or processing capabilities. Hence, a lightweight computation is required in order to alleviate the demand on the battery power.
- Automated, intelligent and self-organizing. Given the dynamic nature of most wireless sensor networks, an adaptive management framework that automatically reacts to changes in network conditions is required.
- Robustness. The divers and hostile environments of wireless sensor networks require a network management system that is able to react to them in order to provide fault tolerance.

3.3 Typical Sensor Network Model

A sensor network in **figure 2** is considered for the description of the deployment structure of sensor nodes. A base station along with other sensor nodes is deployed in the area of interest. The sensor nodes are responsible for sensing and detecting the environment for the specific application. The sensed data are to be transmitted to the base station so that the data can reach to the command center or to the external world. On the other hand the base station is responsible for organizing the activities of sensor nodes to achieve the mission, aggregate collected data, coordinating communication traffic and interacting with command center. After getting the sensed data from the sensor nodes base station send the aggregated data to the external world via command center. Thus the command center uses that aggregated data for various purposes of the real world phenomena with the help of technology.

3.4 Assumptions

In this paper, all subsequent discussions are based on the following assumptions:

- Communications take part from multiple source nodes to the base station.
- Sensors are discovered through repeated beacons.
- Sensor nodes are battery operated with limited power.
- Sensor nodes and base station are stationary.
- The location information of each sensor node is available to the sensor nodes and base station.
- All sensor nodes are equipped with the same type of sensing and communication characteristics, they have the same maximum communication range and maximum sensing range.
- Sensor nodes are capable of reporting its remaining energy and operating in an active mode or sleep mode.

4. Proposed System Model

To utilize the limited energy or power of the sensor nodes here we propose a network architecture for the monitoring and management of the sensor networks. To define the architecture we have to follow a group formation algorithm. In the proposed system model we define two types of sensors: i) agent sensor and ii) isolate sensor. Those sensors which have a direct communication with the base station are called ‘agent’ sensors. And sensors which are out of the scope of communication range from the base station or can not receive the radio signal from the base station due to obstacles are called ‘isolate’ sensors. The agent sensors act as hops for the isolate sensors. Unlike [4] our proposed network architecture forms groups for the isolate sensors where each group contain at most one agent sensor. Moreover based on the residual energy an agent sensor can be a hop for a certain maximum number of isolate sensors. In this case the initialization phase is almost like the approach described in [4]. The dissimilarities we made here by modifying and updating the group formation algorithm. The proposed group formation algorithm is an inexpensive and more energy saving in compare to the existing group formation algorithm.

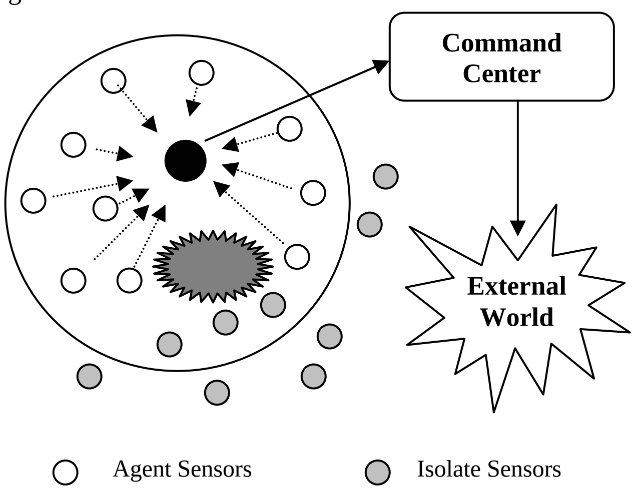


Figure 2: Typical Sensor Network Model

4.1 Initialization Phase

Like [4], in the initialization phase each base station send a beacon message to the deployed sensor nodes. Actually it wants to asses the quality of its communication link to other sensors. As a result the sensor which has direct communication to the base station collects the information of those sensors that can not reach the base station directly.

After the initial radio signal transmission each sensor can have the following information:

- **Agent Sensor (A):** If it has a direct communication link to the base station.
- **Isolate Sensor (I):** If the sensor has a link to an agent sensor but not direct to the base station.
- **Neighbor List (N):** It is the set of sensors which are within the transmission range of a sensor.
- **Hop List (H):** It is the set of sensors which are agent sensors but within the transmission range of a sensor.

4.2 Group Formation Algorithm

In this section we propose our group formation algorithm in **Figure 4**. For each of the isolate sensor we have to calculate the number of neighbor agent sensor those are within the sensing range. The number of the neighbor agent sensor represented by the variable *cardinality (H)*. In the next step isolate sensors are organized in an ascending order according to their number of agent sensors in the neighbor hop list. As all agent sensors have a direct link to the base station so hop communication via agent is not needed for them. Thus we made the consideration that agent_id = 0 for all agent sensors.

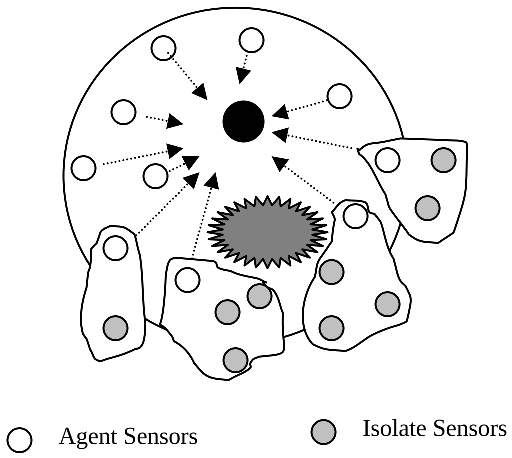


Figure 3: Grouping of Sensors

Now to assign the isolate sensors in a group we first check the number of agent sensors which are neighbor to it. If the number is only one then undoubtedly that agent will use as the next hop for that particular isolate sensor. But if an isolate sensor has more than one agent sensor in its neighbor then our proposed residual energy calculation comes for those neighbor agents. Here *res_energy()* is the function which holds the residual energy value of an agent sensor. It is a major dissimilarity state of our proposed approach with the existing approach of [4]. And the other dissimilarity is allowing a certain maximum number of sensors to be in the group member including an agent. The maximum number is representing by the MAX variable and can be considered based on the overall topology of the network. Each sensor node will have a node id and according to the *node_id* a node can get the higher priority to be a member of an agent group. Thus these characteristics of this algorithm make the load balancing approach more robust and eventually increase the life time of the network.

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Algorithm Group (A, I)

1  for each isolate sensor I_j
    calculate the cardinality(H)
   end for

2  Sort isolate sensors I in a non decreasing
   order of Hop List H

3  for all agent sensor A_j
      set agent_id(A_j)= 0
   end for

4  for each isolate sensor I_j

    if (Cardinality(H)==1)
     Set agent_id(I_j)= Only reachable Agent(A_j)
     add I_j to group_list(A_j)

    else if (Cardinality(H)>1)
      for each Agent A_j in the hop list
        calculate res_energy(A_j)
      end for

      if (Agent(A_j)has highest res_energy &&
           group_list(A_j)< MAX)
        set agent_id(I_j)= Agent(A_j)
        add I_j to group_list(A_j)
      else if(Agent(A_j)has highest res_energy
         && group_list(A_j)= MAX)
         remove Least_Priori Sensor
         set agent_id(I_j)=Agent(A_j)
         add I_j to group_list(A_j)
         repeat step 4 for Least_Priori Sensor

   end for
```

Figure 4: Group formation algorithm

Figure 3 represents our considered sensor network model. In that model we have four groups each having an agent sensor along with maximum three isolate sensors. Here we have considered that each group will contain MAX four sensors including an agent sensor.

5. Experimental Result

An experimental environment has been set up by deploying 200 sensors randomly in an area of 1000 x 1000 m^2 area. For the base station we choose a random position within the area of interest. Initially we consider each node with full of energy having energy level 1 and when a node is out of energy then its energy level considered as 0. For the presence of the obstacle some sensors communication link has been broken out. We compared our proposed sensor management model with the existing group management model proposed in [4] and the system not having any group.

We measure a performance metric percentage of node reachability (%) by calculating the ratio between the number of reachable node and total number of node deployed in the area of interest. **Figure 5** compares the mentioned performance metric with the two compatible schemes. It shows better performance in compare to both of the cases.

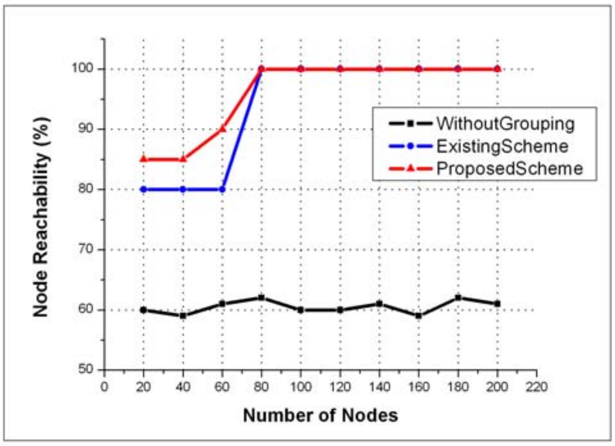

Figure 5: Effect of grouping for node reachability

Figure 6 represented another performance metric for total energy utilization (%) for various numbers of nodes which reflects that our proposed scheme has an improvement for existing scheme. In terms of energy utilization of network it is so important for sensor network management.

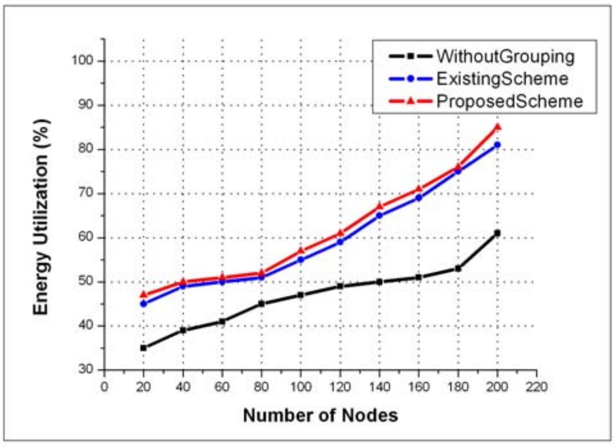

Figure 6: Energy utilization scenario

6. Conclusion & Future Work

Wireless sensor networks are now a day becomes a key technology for the environmental network systems. This paper addresses a different idea regarding the sensor communication management in terms of group formation technique. Here an inexpensive and energy efficient group formation algorithm has been proposed so that the quality and performance of network can be maintained and managed for a successful network. The experimental result indicates that the performance of the proposed scheme is a well load distribution approach than the existing scheme. The simulated result of this paper proved that the proposed scheme could be implemented in a larger extent of wireless sensor network.

In case of advance level of research in wireless sensor network communication management our approach can play an important role. Though the sensor network management is a critical issue for wireless sensor network still we hope our promote progression of this paper will contribute enormously.

7. References

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