Modified Self-Selection Routing Algorithm for Wireless Sensor Networks

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Abstract

Wireless sensor networks have been the source of increasing interest for researchers because they gather information from multiple sources at the same time. This technology allows small sensors to be distributed across a geographical region to collect data, which is sent to a main server via a routing algorithm to be compiled and analyzed. In wireless sensor networks (WSNs), the issues of energy and lifetime are the most important parameters. In asymmetrical networks, different sensors with various abilities are used. Super nodes, with higher power and wider range of communication in comparison with common sensors, are used to cause connectivity and transmit data to base stations in these networks. It is crucial to select the parameters of fit function and monitoring sensors optimally in a point covering network. The optimal selection and considering the energy of intermediate nodes to select and transmit data and also increasing network lifetime is one of the most important parts of wireless network design. It examines current trends in wireless sensor networks, introduces a new simulation environment to test out several current routing algorithms, and introduces an extension on a variant of self-selection routing. The selection is done by using a novel algorithm that used by simulated annealing. This selection takes remained energy into consideration. This method increases lifetime, decreases and balances energy consumption as confirmed by simulation results. The algorithm extension explicitly takes power into account when routing information to increase network lifetime as compared to the original algorithm.

Index Terms:
Asymmetrical Sensor Networks, Energy, Lifetime.

1. INTRODUCTION

1.1 Wireless Networking Overview

Wireless Network refers to any type of computer network that utilizes some form of wireless network connection. It is a method by which homes, telecommunications networks and enterprise (business) installations avoid the costly process of introducing cables into a building, or as a connection between various equipment locations.
Wireless telecommunications networks are generally implemented and administered using radio communication. This implementation takes place at the physical level (layer) of the OSI model network structure.

Benefits of wireless Network
Small businesses can experience many benefits from a wireless network, including:

- **Convenience:** Access your network resources from any location within your wireless network's coverage area or from any Wi-Fi hotspot.
- **Mobility**: There are no longer tied to your desk, as you were with a wired connection. The employees can go online in conference room meetings, for example.
- **Easy setup:** They don't have to string cables, so installation can be quick and cost-effective.
- **Expandable:** They can easily expand wireless networks with existing equipment, while a wired network might require additional wiring.
- **Security:** Advances in wireless networks provide robust security protections.
- **Cost:** Because wireless networks eliminate or reduce wiring costs, they can cost less to operate than wired networks.

1.1.1 Types of wireless networks

- Wireless PAN
- Wireless LAN
- Wireless mesh network
- Wireless MAN
- Wireless WAN
- Cellular network

Wireless PAN

Wireless Personal Area Networks (WPANs) interconnect devices within a relatively small area that is generally within a person's reach. For example,

Manuscript received January 5, 2015
Manuscript revised January 20, 2015

both Bluetooth radio and invisible infrared light provides a WPAN for interconnecting a headset to a laptop. ZigBee also supports WPAN applications. Wi-Fi PANs are becoming commonplace (2010) as equipment designers start to integrate Wi-Fi into a variety of consumer electronic devices. Intel "My Wi-Fi" and Windows 7 "virtual Wi-Fi" capabilities have made Wi-Fi PANs simpler and easier to set up and configure.

Wireless LAN

A **Wireless Local Area Network (WLAN)** links two or more devices over a short distance using a wireless distribution method, usually providing a connection through an access point for Internet access. The use of spread-spectrum or OFDM technologies may allow users to move around within a local coverage area, and still remain connected to the network.

Products using the IEEE 802.11 WLAN standards are marketing under the Wi-Fi brand name. Fixed wireless technology implements point-to-point links between computers or networks at two distant locations, often using dedicated microwave or modulated laser light beams over line of sight paths. It is often used in cities to connect networks in two or more buildings without installing a wired link.

2. RELATED WORK

2.1 Analysis of Related Work

To better understand of self selection routing, it is useful to review and examine the existing research works in literature. Therefore, recent approaches and methodologies used for self selection routing have been discussed.

A. Babu Karuppiah1, Keerthinath, M. Kundru Malai Rajan, K.Ashif Ismail Sheriff & S. Rajaram (2012) discuss about the Enhancing the lifetime of wireless sensor networks. A Wireless Sensor Network (WSN) consists of many sensor nodes with low cost and power capability Based on the deployment, in the sensing coverage of a sensor node, typically more nodes are covered. A major challenge in constructing a WSN is to enhance the network life time. Nodes in a WSN are usually highly energy-constrained and expected to operate for long periods from limited on-board energy reserves. To permit this, nodes and the embedded software that they execute must have energy-aware operation. Because of this, continued developments in energy-efficient operation are paramount, requiring major advances to be made in energy hardware, power management circuitry and energy aware algorithms znd protocols.

During Intrusion Detection in sensor networks, some genuine nodes need to communicate with the Cluster Head to inform about the details of malicious nodes. For such applications in sensor networks, a large number of sensor nodes that are deployed densely in specific sensing environment share the same sensing tasks. Due to this, the individual nodes might waste their energy in sensing data that are not destined to it and as a result the drain in the energy of the node is more resulting in much reduced network life time. The Power Factor bit is implemented while a node communicates with the Cluster Head. The simulation results show that the network life time is greatly enhanced by this method.

3. METHODOLOGY

3.1 Objective

The algorithm is based on timing protocol of activity duration networks. Timing protocol is one of the grouping protocols which are placed in sensor networks. It uses two step mechanism (initiative and executive) and works on the basis of data communication in shape of single-hop or multi-hop including some super nodes and relay and monitoring sensor. In this protocol, group selection is done by using size function designed in the protocol.
In initiative phase, some nodes which is called "sensor" send their propagation messages to their neighbors. In second phase (executive) which is known as stable phase, data reception or transmission is done from sensor nodes to relay nodes and from relay nodes to destination. Some nodes of super nodes transmit data carefully, like LEACH algorithm, According to the plan The energy is saved by grouping in remaining time of inactive nodes. In grouping protocols, energy consumption is constant in whole network due to periodic circulation of active sensors. Hence, we used this feature in our work. As shown in Figure 1 each round includes two phases: initiative phase and executive phase. The initiative phase includes two parts. The former is devoted to monitoring sensors selection. The latter is for relay sensors selection. It is obvious that using super nodes increases network lifetime.

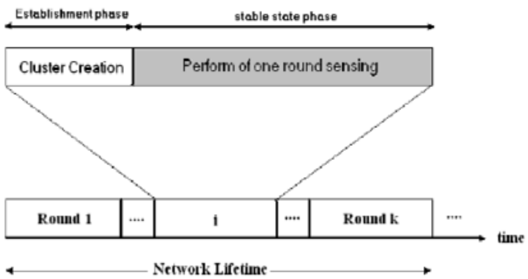


Fig. 4. Timeline of proposed protocol Performance

3.2 Energy Model

The energy model is considered for transmitting and receiving one of data in accordance with LEACH energy model. Assume that the distance between a transmitter and a receiver is d in energy model. If d is more than d0, the multi-path model (with less path coefficient 4) is used; otherwise open space model (with less path coefficient 2) is used.

$$E_{Tx}(l,d) = E_{Tx\text{-}elec}(l) + E_{Tx\text{-}amp}(l,d) = \begin{cases} lE_{elec} + lE_{fs}\, d^2 & d<d_0 \\ lE_{elec} + lE_{fs}\, d^4 & d \geq d_0 \end{cases} \quad (1)$$

E_{elect} is required energy to activate the electrical circuit E_{mp} and E_{fs} are activation energies for power amplifiers in multi-path and open space modes, respectively. Its general form is represented:

(1) With constant coefficients p and q

(2) In receiver case

$$E_{Tx}(l, d) = p + qd^{\alpha} \quad \textbf{(2)}$$

The consumed energy is received with one of data sizes (3).

$$E_{Rx}(l) = E_{Rx\text{-}elec}(l) = lE_{elec} = p$$

In present asymmetrical networks, it is assumed that initial energy of super nodes is several times greater than initial energy of normal sensors. The consumption energy of a relay and monitoring node are denoted by $Es1$ and $Ec1$ in each round respectively.

3.3 Proposed Method

The problem is emphasized on how to design a protocol to increase network lifetime and decrease energy consumption in available nodes. The benchmarks are trying to use more from usual energy of sensors. In covering networks, the physical positions of nodes and times of using them should be considered in designed protocol. The times of using sensor and also the distance between selected node (in fact in relay path) and super nodes have crucial role for energy consumption of that group. Therefore, we should seek for a relation between these two parameters and their energy consumption. At first, we state the problem and considered situations. Then, similar parameters that include timing algorithm based on the super nodes (for point coverage) will be explained below.

Our network contains N sensors named S_1 to S_N . We have M super nodes named S_{u1} to S_{uM} (M<N). The timing algorithm is divided into time intervals with certain rounds and identical intervals T_r Selected group is only active during time of T_r and other nodes are off during a round. during round a , T_r can be computed by considered grouping time, the groups of energy estimate physical parameters of lifetime and types of normal sensors is used in network.

3.4 Provisions dominating the network

The provisions of network are listed below: There are K targets with defined positions in network composed of sensor nodes and super nodes. In considered scenario, sensor nodes and super nodes are randomly distributed. The plan of sensor nodes activities must be guaranteed according to following conditions after running algorithm for network lifetime:

- Targets T_{a1} to T_{ak} must be covered.
- There are nodes S_1 to S_N which perform monitoring task and are deployed randomly.
- The super nodes S_{u1} to S_{uM} are deployed.
- A set of nodes C_1 to C_j should be selected. Each C_j is set of active nodes and is generated by protocol in each round.
- Each set of C_j is necessary and sufficient to cover k targets.

In fact, the objective is to divide sensor nodes into active and inactive groups. Active sensors must be able to communicate and cover. The objective is to use this algorithm for maximizing the groups, reducing energy consumption and increasing network lifetime. In each executive round, it should be checked whether a node is active as a sensor node or a relay node.

- Each normal sensor has initial E_i and high processing power. Common sensors Dissimilar to super nodes have higher energy, greater lifetime and higher processing power.
- All super nodes are connected to each other by a path between two super nodes.
- Each active sensor exists in one of C_j groups and connected to a super node by relay nodes. Each sensor is connected to one of super nodes through Data transmission path.
- Sensor nodes possess initial energy E_i , communication range R_c , and sensing range R_s $(R_c \geq R_s)$.
- This selection must be located and distributed. Decision making is done for using data in neighbouring node with fixed multi-hop distance.

Definition 1:
In define point coverage, it should be said that when the Euclidean distance between nodes and target is Less than or equal R_s, the target is covered.
Definition 2:
Sensors can connect to each other or super nodes if the Euclidean distance is less than R_s.
Definition 3:
Network lifetime is defined as time interval in which all k targets will be covered by a set of active sensor nodes that are connected to super nodes.

3.5 Sensor Nodes Selection Algorithm

As indicated before, designed grouping algorithm which are executed at the beginning of each performance round, includes two sections. The first section is selected active nodes. The second section is attributed to data collection from nodes and data transmission through relay nodes. In the first section, one of C_j groups is formed in a way that must be satisfied in above provisions. When this group is active, all other nodes are inactive (Sleep Mode) and consume little energy. They should be evaluated in next phase. This evaluation is done by considering a series of physical factors of sensors during a round.

3.6 Simulated Annealing Algorithm

SA algorithm is a random hill-climbing movement which shows sort of efficiency.
Procedure Simulated Annealing:

```
    S1 = Choose an initial solution
    T = Choose an initial temperature
REPEAT
    REPEAT
        S2 = Generate a neighbor
            of the S1
    UNTIL s2 establish criteria
    ΔE = objective ( S2 ) – objective (
        S1)
    IF ( ΔE > 0 ) THEN // s2 better
    than s1
        S1 = s2
    ELSE with probability EXP( ΔE/ T
    )
        S1 = s2
    END IF
    Decrease T
UNTIL meet the stop criteria
End
```

Instead of choosing the best movement, a random movement is chosen in this algorithm. If the movement improves the case, it will be accepted all the time. Otherwise, the algorithm accepts the movement with the probability value of 1 ( ). Also, probability reduces due to temperature (T) reduction. Bad movements may be allowed when the temperature is high and decrease as the temperature reduces.
To reduce the temperature, T is multiplied by a coefficient between 0 and 1. Fast decrease of the temperature makes us encounter the problem of local optimality. So we choose a value near 1 for this parameter (for example 0.998).

Start and Preparation:
Entering problem information and adjusting parameters.
1. Producing an answer near the current answer that accepted criteria.
2. Evaluating this answer
2-1) the neighbor is better than the current answer so go to a new answer.
2-2) the probability is greater than the random number so go to a new answer.
Otherwise get back to the first step.
3. Updating the parameters of the problem and the algorithm. Move to the step 1.

Initially, the number of sensors is requested from the user. A binary chromosome generated randomly. In SA step, Optimized chromosome created from Primary chromosome. In this step, for create a neighbor chromosome, Two indexes will be chosen randomly. Then, these indexes, that represent two sensors, will be changed. Then Dikestra algorithm is used to determination relay nodes. If the sensors of a chromosome cover the whole network through this method reduce energy of active sensors and add the value 1 to the lifetime number, and this loop continues until $E_{s1} < E_n + E_{c1}$.

3.7 System Specifications

The network is offered a squared environment. There are T_{ak} targets in the environment that are covered with connection of covering network. $Tars_n$ Includes all targets in sensing domain S_n. They are covered by nodes. The number of targets is located in sensing range of node S_1 which is shown by m_1. The initial energy of common sensors is E_i and initial energy of super nodes is three times greater than E_i. The energy consumed in each round is called Es_1 and the consumed energy of a relay in each round is called Ec_1.

The first section include sensor node selection, checking size function for evaluation and selecting active monitoring nodes that are w time units (the Second is the time unit here). The waiting time of node S_n is computed by a function measuring physical parameters of sensor S_n . Waiting time is stated as a multiple coefficient for total time of a round by using the parameters of a node: remaining energy, initial energy and number of targets seen in the range of a sensor. A sensor decides to sleep or awaken after passing remaining time. If $E_n < E_{s1}\square + E_{c1}$ (E_n is remaining energy of sensor node S_n) then the node cannot be converted to a sensor node. So waiting time is not computed and t_n is waiting time of node n which is equivalent to w. It means that the node is not a sensor.

Otherwise, when $E_n > E_{s1} + \square E_{c1}$, t_n is computed and inspected. When t_n is finished $Tars_n \neq \Phi$, S_n introduces itself as a sensor node and joins active nodes in the group. Then, new selected node shows the position of two-hop neighboring nodes. If there is a node such as S_j at the end of the round that $Tars_n$ and $E_n < E_{s1} + \square E_{c1}$, the node sends the "no coverage" message to super node.

It means that network lifetime is terminated. At this time, a message containing "no completed coverage" is sent to super nodes and the network sends this message to final monitoring destination.

4. EXPERIMENTS AND RESULTS

As seen in the simulations, it shows that the SA algorithm is applied for selection of monitoring sensors in a point coverage network with increase in life time and reduction of average useful energy consumption.

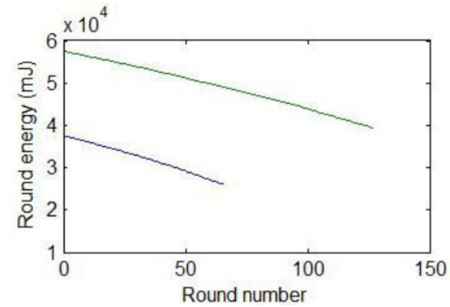


Figure. 4.1. Comparison of network lifetime for new algorithms

As shown in Figure 4.1, a simulation based on 300 sensors was done on the basis of the parameters in Table 1, which is reached to 67 rounds in lifetime of the network.

Also in Figure 4.1 compare the change in network lifetime number for changes in nodes from 300 to 450 sensors; the green line is the result of 450 sensors and the blue line shows the state of 300 sensors.

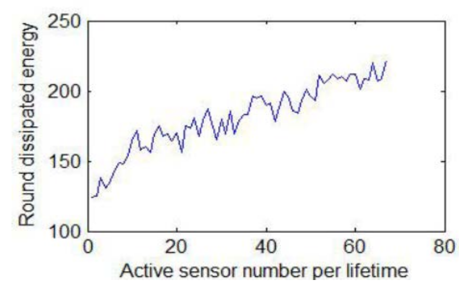
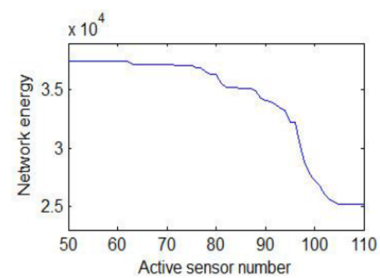


Figure. 4.2. Active sensor number per lifetime

According to Figure 4.2, the chart of average energy consumption, the consumed energy per round increases reasonably and amount of consumption has gentle ascending trend.



Before activation of 76 sensors, the amount of network remaining energy is fixed and by the first lifetime, network remaining energy is decreased. As it is evident in the figure, Energy reduction development has been slow in the early implementation of the program, but gradually according to energy completion of some sensors have to use more sensors to cover the entire environment that leads to drastic reduction of network remaining energy in the last lifetimes.

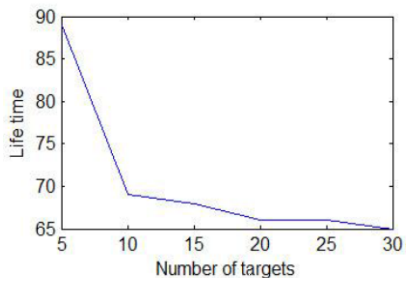


Figure. 4.3. Change of lifetime with increase of number of targets

The lifetime of network has drawn in figure 4.3 by changing the number of objectives and implementation of algorithms to 10 times, that comparing with it is seen that the SA for a point coverage network has identical condition and in some cases also has the advantages to 10 percent.

Table 1. Used values in simulation

PARAMETER	VALUE
Network Size	500 * 500 m
SNodes Location	Uniform Distribution
Nodes Location	Uniform Distribution
Nodes Initial Energy	0.1 J
Super Node Initial Energy	0.5 J
Communication Range	90 m
Sensing Range	60 m
Number of Nodes	25
Number of Targets	20
Elect	50 nJ/bit

As it is shown in Table 1, this experiment was performed on a 500 x 500 environment; we distribute 300 nodes and 250 super nodes in this environment evenly to cover 20 targets which are distributed in the environment randomly. Communication range of each node is 90 m and its sensing range is 60 m also the amount of super nodes primary energy are 5 times greater than nodes. In this paper, to reduce the energy consumption and get smart sensor, two conditions have been considered:

- If the target is observed by several sensors, the sensor that sees more targets is selected for sensing.

- To reduce the activation interface nodes between target observer node and the nearest super node, Dijistra algorithm is used.

Calculations done are based on the algorithm in 10 times and averaging the values of the lifetime of this number. The test has reached to 130 rounds for 450 sensors and similar condition with Table 1. According to increase in lifetime factor, the increase has also seen to 14 percent compared to other researches.

5. CONCLUSION

Here the present method is used to select active sensors in each round in asymmetrical wireless covering networks. In previous methods, this selection was dependent on the parameters of each sensor. In the proposed algorithm, this selection is according to the contest between neighboring nodes. Energy consumption in this method is more balanced than other similar methods. Generally, diagrams illustrate that the proposed method for the selection of monitoring sensors in point coverage is more energy-efficient. According to simulation results, it is observed that this algorithm is well acted to solve this problem and optimization of a wireless sensor network in large-scale and it is able to provide a good and implementable response for network design and we can achieve better energy efficiency by organizing the network nodes and classifying them. Higher performance of network leads to increasing network life time

Using SA algorithm, the categories were chosen so that the energy consumption in the network is minimized. Creating balance and uniformity in energy consumption of nodes and prolonging network life time is the Outcome of using the algorithm. In the proposed work the life time of network is more extended. Further improvements can be done as follows. Extended the simulation by considering large sensor network with large communication range. Improve the clustering in terms of energy efficiency to eliminate all overhead associated not only with cluster head selection process, but also with node associated to their respective cluster head. Improve the security level by using secure routing protocols for wireless sensor network.

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