Volume 2, No. 4, April 2011
Journal of Global Research in Computer Science
ISSN-2229-371X
RESEARCH PAPER
Available Online at www.jgrcs.info

Energy-Efficient Target Monitoring Algorithm for Wireless Sensor Networks

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Abstract: In this paper, an energy-efficient target monitoring algorithm for wireless sensor networks have been reported. Here, we have proposed new energy efficient algorithms HADEEPS, based on the scheduling that allow sensor nodes can interchange its state into idle, sleep and active modes. The network lifetime increases with the number of sensors at different targets and sensing range. The simulation results for target supervising protocol, HADEEPS verify that with the adjustable sensing range, heterogeneous nodes and different targets, the overall network lifetime improved as compared with existing protocols.
Keywords: WAN, HADEEPS, network model, heterogeneous nodes

INTRODUCTION

WSN are distributed systems or a computer network, in which a large number of little and inexpensive devices, sometimes called Motes or sensor nodes that collect environmental data more recently, medical data. The sense data is collected across the wireless network via multiple hops relaying, aggregated and fed into business applications.

When compared WSNs with traditional ad hoc networks, the most detectable point are that they are limited in memory, power and computational capacities. A node of the WSNs consists of the battery, transceiver, sensing hardware and embedded processor & memory. The primary metric for measuring functioning of WSN protocols is the sensor network lifetime measured by total time during which the network perform its monitoring duties without recharging batteries. Power saving mechanism can be classified into two general ways: adjusting the transmission or sensing range and scheduling the sensor nodes to alternate between active and sleep mode [1, 2, 3, 4].

In this paper, sensor network is consisting of few heterogeneous nodes which are deployed in an effective manner to prolonging the network lifetime. We indicate on the operation of a heterogeneous sensor network with three types of nodes such as normal, advance and super nodes [5, 6, 7]. Advance and super nodes are equipped with more battery energy than normal nodes. Under this model, we have developed HADEEPS, new protocol with adjustable range, scheduling and new heterogeneous model that significantly increases the lifetime of the network. Our simulation results show HADEEPS provide longer lifetime than existing protocols.

The remainder of the paper is prepared as follows: In Section 2, we present some related work. In Section 3, we discuss network model. In Section 4, we provide details of distributed algorithms for SNLP and its simulation. We present results and discussion in Section 5. The paper has been concluded in Section 6.

RELATED WORK

In this section we look the existing approaches to prolonging the lifetime of WSNs. The existing approaches divided into two categories such as centralized and distributed algorithms. In centralized approaches single node has access the entire network information and in the distributed approaches sensor can exchange information with its neighbors with in a fixed ranges.

In [8] the authors introduce energy efficient data structure to represent the monitoring area, efficiently provable good centralized algorithms for sensor monitoring schedule prolonging the total lifetime and a family of efficient distributed protocol with trade-off between communication and monitoring power consumption.

In [3] authors propose reliable distributed algorithms for target-monitoring and using LEACH protocol for data delivery to the base-station as a communication protocol.

M. Cardei at el [2] address the adjustable range set-cover problem, objective of that problem is to finding a maximum number of set covers and ranges for all the targets. Sensor can be participated in multiple sensor sets but the energy spent in every cover set is constrained by the initial energy resources.

In [1], investigate a problem of maximizing the duration of time for which the network meets its coverage objective. In this a subset of sensors need to be in “sense” or “on” mode at any given time to meet the coverage objective, while others can go into a power conserving “sleep” mode and these active set of sensors is known as a cover.

In [9] propose a distributed algorithmic framework for coverage problems in wireless sensor networks. It is an extension of distributed algorithms in [10] with a distributed algorithmic framework to enable sensors to determine their sleep-sense cycles based on specific coverage goals.

In [5, 6, 7] we have studied three type of nodes heterogeneity and implemented that node heterogeneity in target-supervising algorithm.

NETWORK MODEL

Sensor Network Model

Our network model is similar to the models described in [1, 3, 4, 8, 11]. We assume that sensors are deployed over the monitored region R and each sensor knows its IDs, battery power and its own coordinates as well as coordinates of all the covered targets. Each sensor S has its own monitoring targets T where S can collect the information for the target T without the help of any other sensor.

Sensor Network Lifetime Problem with range appointment

Given a monitored region R, a set of sensors $S_1, S_2, \ldots, S_m$ and a set of targets $T_1, T_2, \ldots, T_n$ and battery power supply bi for each sensor, find a monitoring schedule ($C1, t1$), ($C2, t2$), ………, (Ck, tk) and a range assignment for each sensor in a set Ci such that

a. $t1 + t2 + \ldots + tk$ is maximized,

b. each set cover monitors all target $T_1, T_2, \ldots, T_n$ and

c. each sensor Si does not appear in the set $C1 \ldots Ck$ for a time more than bi where bi is the initial energy of sensor of Si.

DISTRIBUTED ALGORITHMS FOR SNLP AND ITS SIMULATION

In this section first, we discussed heterogeneous distributed algorithm after that we present simulation setup and simulation steps for HADEEPS.

Heterogeneous Distributed Energy Efficient Protocol for Adjustable Range Sensing (HADEEPS)

In this section HADEEPS protocol has been characterized for heterogeneity and adjustable range.

Sensor nodes networks are divided into three categories of the sensor such as advance nodes, super nodes and normal nodes. In the HADEEPS each sensor at any moment is in one of three states.

- ***active state***: the sensor is active and monitors the targets
- ***idle state***: In idle state sensor listens to other sensors, but does not monitor targets
- ***deciding state***: the sensor monitors targets, but will alter its state to either active or idle state soon

In this algorithm, which targets will be sinks and which will be hills have been decided by us before defining the transition rules and for each target T at least one sensor placed as an in-charge. The description of lifetime of a sensor and maximum lifetime of a target as follows. Let Lt (b, r, e) be the lifetime of a sensor, here b is the battery, r is sensing range where r ≤ maximum sensing range and e is the energy mode. Then, the maximum lifetime of a target would be Lt ($b1, r1, e$) + Lt ($b2, r2, e$) + Lt ($b3, r3, e$) + …, assuming it can be covered by neighborhood sensors with batteries bi at a distance ri for i = 1, 2 , …

Let ***sink*** be a target T which is poorest in maximum lifetime for at any rate one sensor covering T. The deserted target is a ***hill,*** i.e., a target which is not the poorest in maximum lifetime for any of its covering sensors.

Finally, the network fails if there is a target which is not covered by any sensor.

Simulation Setup

For wide range of physical sensor network sizes with varying node densities this simulator is designed. For the simulation purpose, we created a static network of sensors in a 100m x 100m area. The adjustable parameters are:

- S, number of sensor nodes. We vary this from 40 to 200.
- Consider some values as m=0.2, m_0=0.5, α=2, β=1
- T, number of targets. We vary this to 25 and 50.
- The initial energy of each sensor node is 2 J.
- P sensing ranges $r_1, r_2, \ldots, r_P$. We vary this to 30m and 60m and each sensor has P = 2 sensing ranges with values 30m and 60m.
- The linear model defined as $ep = c1rp$,where the energy ep needed to cover a target at distance rp , $c1$ is constant and quadratic model is defined as $ep = c2r_p^2$, where $c2$ is a constant. In order to make comparison, we used the same simulations parameters used in [1].

In this paper we defined constants $c1 = E / \left(\sum_{r=1}^{P} rp\right)$ and $c2 = E / \left(\sum_{r=1}^{P} r_p^2\right)$, Where $E=$

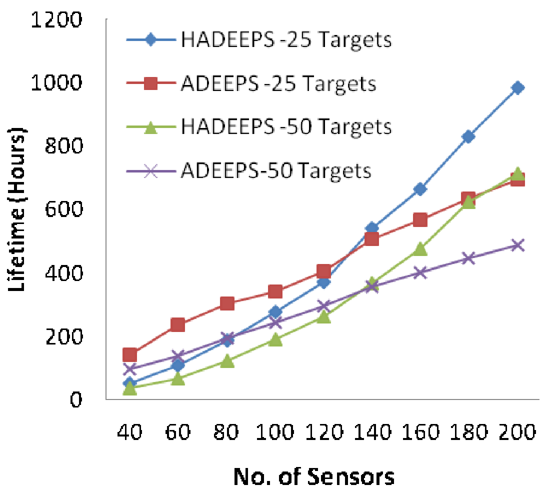
$n*(1-m)*E_0 + n*m*(1-m_0)*E_0*(1+\alpha) + n*m*m_0*E_0*(1+\beta)$

$= n*E_0*(1+m*(\alpha+m_0*\beta))$ is the sensor initial energy of the new heterogeneous network in [5, 6, 7].

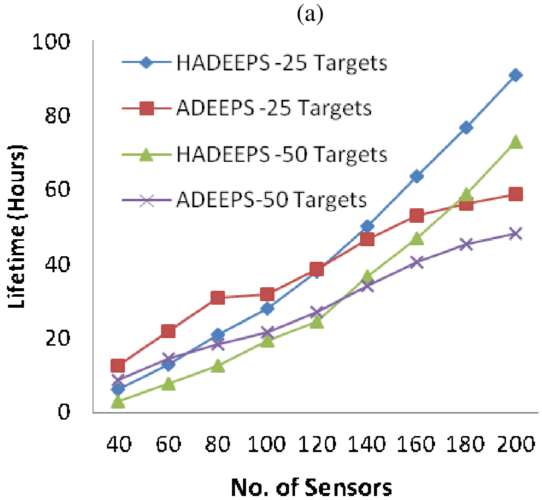
Let m be the fraction of the total number of nodes n, and m_o is the percentage of the total number of nodes m which are equipped with β times more energy than the normal nodes, we call these nodes as super nodes. The rest $n*m*(1-m_0)$ nodes are equipped with α times more energy than the normal nodes; we refer to these nodes as advanced nodes and remaining $n*(1-m)$ as normal nodes. We suppose that all nodes are distributed uniformly over the sensor region R. Suppose E_0 is the initial energy of each normal node. The energy of each super node is then $E_0(1+\beta)$ and each advanced node is then $E_0(1+\alpha)$.

RESULTS AND DISCUSSION

Figure 1 (a&b) indicates the lifetime for sensor nodes in case of linear and quadratic energy model with adjustable sensing range of 50M and number of targets 25 and 50.



(a)

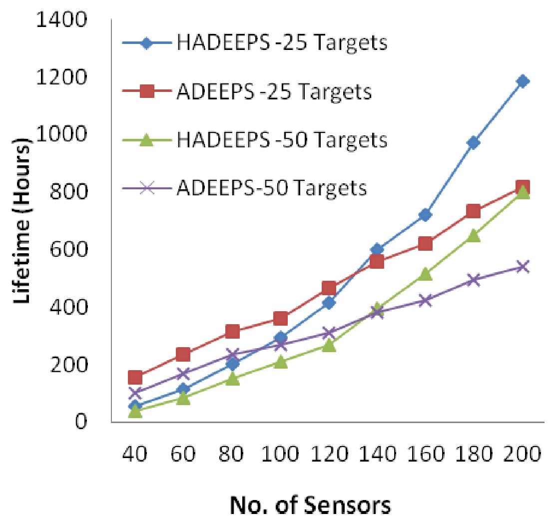


(b)

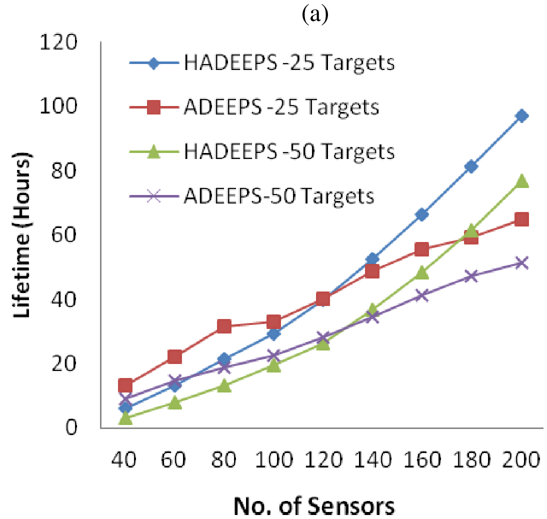
Figure 1 lifetime for sensor networks in case of (a) Linear Energy Model (b) Quadratic Energy Model.

The results have been obtained for modified HADEEPS and their comparison has been reported for lifetime with ADEEPS. It is evident from the results that for 200 numbers of sensors the lifetime obtained is [984, 694, 712, 487] and [91, 58, 72, 48] hours respectively for both energy models at the different number of targets. In case of linear and quadratic energy model with heterogeneity there is enhancement of [893, 639, 640, 439] hours in lifetime at different number of targets.

Figure 2 (a&b) mentioned the lifetime for sensor nodes in case of linear and quadratic energy model with adjustable sensing range of 100M and numbers of targets 25 and 50.



(a)



(b)

Figure 2 lifetime for sensor networks in case of (a) Linear Energy Model (b) Quadratic Energy Model.

The results have been found for modified HADEEPS and their comparison has been reported for lifetime with ADEEPS. It is evident from the results that for 200 numbers of sensors the lifetime obtained is [1184, 815, 799, 542] and [96, 64, 76, 51] hours respectively for both energy models at the different number of targets. In case of linear and quadratic energy model with heterogeneity there is enhancement of [1088, 751, 723, 491] hours in lifetime at different number of targets.

CONCLUSIONS

In this paper, we have presented a distributed algorithm for increasing the lifetime of WSNs at different number of targets and sensors. The total lifetime of the sensor network has been reported when all the targets are covered by the sensor cover sets during the simulation. Results have been shown that the overall network lifetime improved with HADEEPS in comparison of existing protocol ADEEPS in linear and quadratic energy models.

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