Designing and Comparative Analysis of Advanced SEP for Heterogeneous Wireless Sensor Networks

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ABSTRACT
Wireless Sensor Networks (WSNs) are comprised of thousands of sensor nodes, with restricted energy, that cooperate to accomplish a sensing task. In Wireless Sensor Network, the energy efficiency is the key issue for designing the protocol because sensor nodes have one time battery backup. There are many modern protocols which extend the lifetime of the wireless sensor network by efficiently using battery power of the sensor node. In this research work, a new strategy and protocol based on Stable Election Protocol (SEP) in Wireless Sensor Network have been proposed. For proposed system, we have assumed heterogeneous of environment i.e. the impact of heterogeneity of nodes, in terms of their energy, in wireless sensor networks that are hierarchically clustered. In these networks some of the nodes become cluster heads, aggregate the data of their cluster members and transmit it to the sink. We assume that a percentage of the population of sensor nodes is equipped with additional energy resources. We also assume that the sensors are randomly (uniformly) distributed and are not mobile, the coordinates of the sink and the dimensions of the sensor field are known. Firstly, all the nodes has been categorized as Normal Nodes and Advanced Nodes. Than Advanced nodes are further categoried as Alive Advanced nodes and Dead Advanced Node. Cluster head is selected among advanced nodes only. Cluster head collect data from member nodes, aggregate it and transmit it to base station. Cluster head selection is most important. Once the cluster head is selected then the cluster head broadcasts an advertisement message to the nodes. The nodes receive the message and decide to which cluster head it will belong for the current round. An advanced-SEP has been implemented and compared with existing SEP. Three parameters i.e. number of dead nodes; number of alive nodes and packets transmitted to base station has been taken as performance parameters. The simulation result shows that performance and throughput of our proposed protocol gives the effective and significant energy efficiency as well as more network lifetime compared to other protocols. MATLAB R2013a has been taken as implementation platform.

Keywords
Wireless Sensor Networks; SEP; ESEP; LEACH; Sensor Nodes etc.

1. INTRODUCTION
A sensor network is defined as composition of a large number of low cost, low power multi functional sensor nodes [1] which are highly distributed either inside the system or very close to it [4]. Wireless Sensor Networks are networks of tiny, battery powered sensor nodes with limited on-board processing, storage and radio capabilities. The energy cost is more in term of transmission of data than processing data [5]. Nodes sense and send their reports toward a processing center which is called "sink." The design of protocols and applications for such networks has to be energy aware in order to prolong the lifetime of the network, because the replacement of the embedded batteries is a very difficult process once these nodes have been deployed. Classical approaches like Direct Transmission and Minimum Transmission Energy do not guarantee well balanced distribution of the energy load among nodes of the sensor network [7]. Using Direct Transmission (DT), sensor nodes transmit directly to the sink, as a result nodes that are far away from the sink would die first [1].

2. WIRELESS SENSOR NETWORK PROTOCOLS
1.2.1 SEP (Stable Election Protocol)
SEP [2] protocol is an improvement and enhancement of LEACH [3] protocol which uses cluster based routing strategy based on the node heterogeneity of the sensor node in the networks. In this protocol and technique, some of the sensor nodes have high energy they are referred to as the advanced nodes and the probability of the advanced nodes to become CHs is more as compared to the normal nodes and the normal nodes have lower energy as compared to the advanced nodes in the network. SEP strategy uses a distributed method to select a CH in WSNs. It is heterogeneity-aware protocol and CH selection probabilities of nodes are weighted by initial energy of each node compared to the other nodes in WSN. So basically, SEP protocol is based on two levels of node heterogeneity as normal nodes and advanced nodes.

Advantage of SEP:

Any identification or global knowledge of energy of sensor node is not required in SEP [2] technique at each selection round of cluster head.

Limitations of SEP:
The cluster head (CH) selection among sensor nodes are not dynamic, which results that nodes that are far away from the powerful nodes will die first [6].

1.2.2 ESEP (Enhanced Stable Election Protocol)
ESEP [2] is improvement and enhancement of SEP technique. Three type of sensor nodes are considered in ESEP method, as normal, advance and intermediate nodes on the basis of their energy levels. The purpose of ESEP is to build a self-configured WSN which enhances network lifetime and stability period. Each sensor node in a network, continuously sense environment and transmits data to their associated CH, whereas, CH aggregates data to reduce data redundancy and sends that data to base station. In ESEP, advance nodes are certain of total nodes having additional energy as in SEP.

Intermediate nodes are certain nodes having some extra energy greater than normal nodes but less than advance nodes, and normal nodes are the residual nodes. In ESEP, CHs are selected on probability based method for each type of node.

Advantage of ESEP:

Due to three levels of heterogeneity in ESEP [2], the power saving advantage is little enhanced as compared to SEP.

The limitation of ESEP is same as SEP.

3. PROPOSED METHODOLOGY

A new strategy and protocol based on Stable Election Protocol (SEP) in Wireless Sensor Network have been proposed. It is assumed that the environment is heterogeneous i.e. the impact of heterogeneity of nodes, in terms of their energy, in wireless sensor networks that are hierarchically clustered. In these networks some of the nodes become cluster heads, aggregate the data of their cluster members and transmit it to the sink. It is assumed that a percentage of the population of sensor nodes is equipped with additional energy resources and sensors are randomly (uniformly) distributed and are not mobile, the coordinates of the sink and the dimensions of the sensor field are known. Firstly, all the nodes has been categorized as Normal Nodes and Advanced Nodes. The Advanced nodes are further categoried as Alive Advanced nodes and Dead Advanced Node. Cluster head is selected among advanced nodes only. Cluster head collect data from member nodes, aggregate it and transmit it to base station. Cluster head selection is most important. Once the cluster head is selected then the cluster head broadcasts an advertisement message to the nodes. The nodes receive the message and decide to which cluster head it will belong for the current round.

We have simulated the proposed protocol in a field with dimensions 100m×100m and 100 nodes are deployed in specific zones with respect to their energy. Some of the other parameters are:

Exiting SEP and Advanced SEP (proposed) has been implemented and compared through their performance parameters. These parameters are:

1. Number of Dead nodes in accordance with increasing number of rounds.
2. Number of alive nodes in accordance with increasing number of rounds.
3. Number of Packets transferred to base station in accordance with increasing number of rounds.

Implementation of SEP

Declaration of a loop according to number of rounds.

- Calculation of Election Probability for Normal Nodes
- Calculation of Election Probability for Advanced Nodes
- Assignment of nodes which have not been cluster heads or operation of heterogeneous epochs
- Operations for sub-epochs
- Declaration of counter of Number of dead nodes
- Declaration of counter of Number of dead Advanced Nodes
- Declaration of counter of Number of dead Normal Nodes
- Declaration of a loop according to number of nodes
- Checking if there is a dead node
- Updation of dead node counter
- Checking if node is advanced
- Checking if node is normal
- Checking if there is an alive node
- Assignment of total dead nodes and alive nodes for each round to new variable
- Checking of first node dead or alive
- Declaration of a loop according to number of nodes
- Checking if there is an alive node
- Checking if the node cluster head or not

Election of Cluster Heads for normal nodes

- Updation of cluster head counter
- Updation of counter of packets to the base stations
- Assigning of particular node as cluster head
- Assigning of selected node dimensions to other variable
- Calculation of average distance between a cluster member and its cluster head
- Assignment of calculated distance to new variable
- Updation of cluster counter

Calculation of Energy dissipated where

Eelec = (ETX + EDA) is the energy dissipated per bit to run the transmitter or the receiver circuit.

- Checking if average distance between a cluster member and its cluster head is greater than initial distance
- Checking if average distance between a cluster member and its cluster head is lesser than initial distance

Election of Cluster Heads for Advanced nodes

- Updation of cluster head counter
- Updation of counter of packets to the base stations
- Assigning of particular node as cluster head
- Assigning of selected node dimensions to other variable
- Calculation of average distance between a cluster member and its cluster head
- Assignment of calculated distance to new variable
- Calculation of Energy dissipated where Eelec =(ETX + EDA) is the energy dissipated per bit to run the transmitter or the receiver
- Checking if average distance between a cluster member and its cluster head is greater than initial distance
- Checking if average distance between a cluster member and its cluster head is lesser than initial distance

- Updation of counter of packets to the base station
- Assignment of updated variable to new variable
- Election of Associated Cluster Head for Normal Nodes
- Declaration of a loop according to number of nodes
- Checking if there is any normal and alive node
- Checking if number of cluster more than one
- Calculation of average distance between a cluster member and alive node
- Initialization of loop according to total number of clusters
- Calculation of average distance between a cluster head and alive node and comparison with average distance between a cluster member and alive node
- Calculation of Energy dissipated where ETX is the energy dissipated per bit to run the transmitter or the receiver circuit or Energy dissipated by associated Cluster Head
- Again checking if associated Cluster head distance is greater than initial distance
- Again checking if associated Cluster head distance is greater than initial distance
- Calculation of Energy dissipated
- Checking if minimum distance is positive
- Calculation of energy dissipated by cluster head with minimum distance
- Updation of counter cluster head per round

Display of alive nodes in accordance with number of rounds

Display of dead nodes in accordance with number of rounds

Display of number of packet transmitted to base station in accordance with number of rounds

4. RESULT & DISCUSSION

An effective protocol for Wireless sensor network has been designed and implemented using Advanced Stable Election Protocol for transmission of packets to the base station through an efficient cluster head. Firstly, all the nodes has been categorized as Normal Nodes and Advanced Nodes. Than Advanced nodes are further categoried as Alive Advanced nodes and Dead Advanced Node. Cluster head is selected among advanced nodes only. Cluster head collect data from member nodes, aggregate it and transmit it to base station. Cluster head selection is most important. Once the cluster head is selected then the cluster head broadcasts an advertisement message to the nodes. The nodes receive the message and decide to which cluster head it will belong for the current round. This phase is called as cluster formation phase. On the basis of received signal strength, nodes respond to cluster head and become member of cluster head. Cluster head then assign a TDMA schedule for the nodes during which nodes can send data to cluster head. After the clusters formation, every node data and sends it to the cluster head in the time slot allocated by the cluster head to the node. When data is received from nodes, Cluster head then aggregates this data and send it to the base station this phase is called as transmission phase. We have simulated the proposed protocol in a field with dimensions 100m×100m and 100 nodes are deployed in specific zones with respect to their energy. Some of the other parameters are:

Parameters of WSN	**values**
Number of rounds	9000
Alpha (α)	2
Initial energy (Eo)	0.5 J
Initial energy of advance nodes	Eo(1+α)
Energy for data aggregation (EDA)	5 nJ/bit/signal
Number of nodes	100
Transmitting and receiving energy (Eelec)	5 nJ/bit
Amplification energy for short distance (Efs)	10 Pj/bit/m2
Amplification energy for long distance (Eamp)	0.013 pJ/bit/m4
Probability (Popt)	0.1
Filed dimension	100 x 100 square meters

In this work, exiting SEP and Advanced SEP (proposed) has been implemented and compared through their performance parameters. These parameters are:

1. Number of Dead nodes in accordance with increasing number of rounds.
2. Number of alive nodes in accordance with increasing number of rounds.
3. Number of Packets transferred to base station in accordance with increasing number of rounds.

The performance of existing SEP are compared with Advanced SEP. Figure 1 is the snapshot of placement of all the Normal Nodes with ‘O’ sign, Advanced Nodes with ‘+’ sign and base station or sink in middle of field with ‘x’. Figure 2 is the snapshot of selected normal nodes and advanced nodes for a cluster with ‘*’. Figure 3 is the snapshot of all the nodes at the completion of all the rounds in red color with ‘.’ sign. Figure 4 is the snapshot of graph of alive nodes in accordance with number of rounds. Figure 5 is the snapshot of graph of dead nodes in accordance with number of rounds. Figure 6 is the snapshot of graph of number of packet transmitted to base station in accordance with number of rounds.

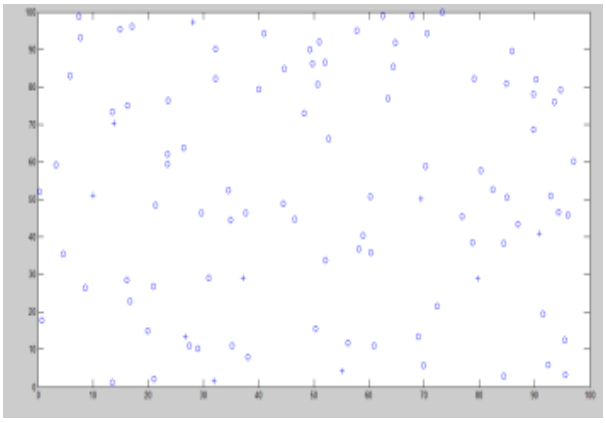

Figure 1: Snapshot of placement of all the Normal Nodes with 'O' sign, Advanced Nodes with '+' sign and base station or sink in middle of field with 'x'

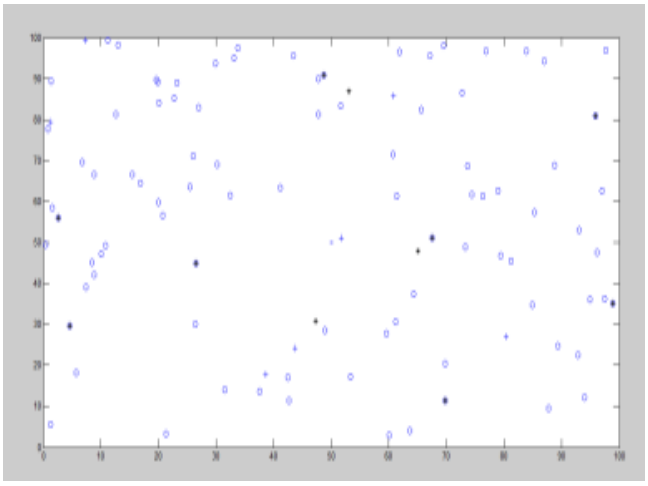

Figure 2: Snapshot of selected normal nodes and advanced nodes for a cluster with '*'

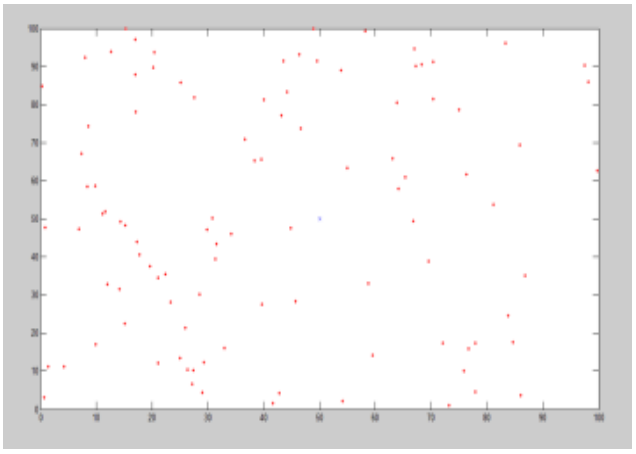

Figure 3: Snapshot of all the nodes at the completion of all the rounds in red color with '.' Sign

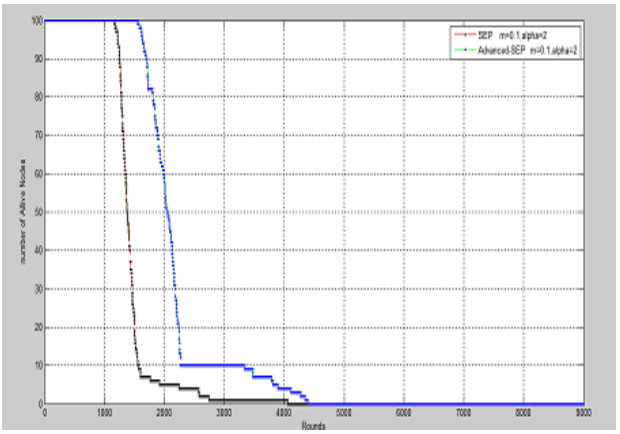

Figure 4: Snapshot of comparison of alive nodes in SEP and ASEP

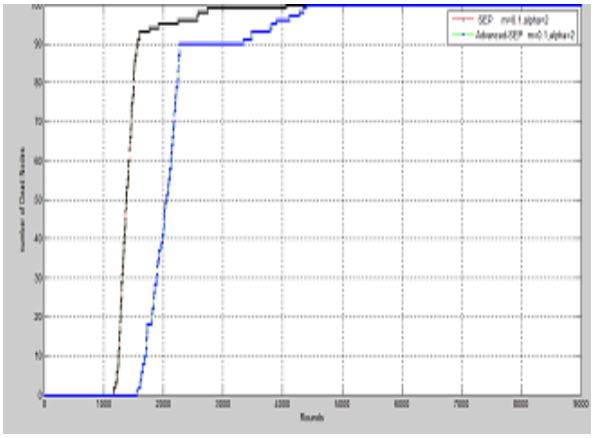

Figure 5: Snapshot of comparison of dead nodes in SEP and ASEP

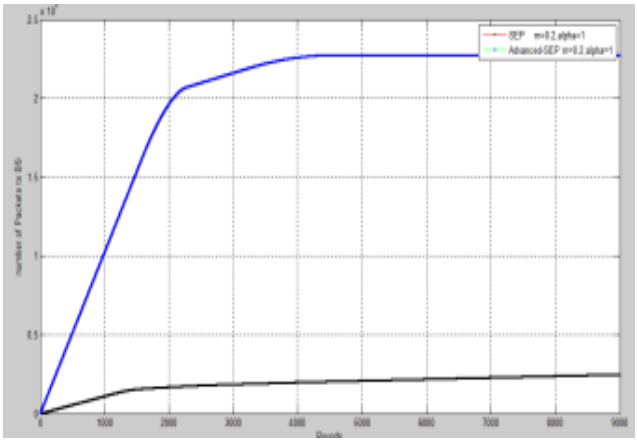

Figure 6: Snapshot of comparison of packets delivered to BS in SEP and ASEP

5. CONCLUSION AND FUTURE SCOPE

The Advanced Stable Election based routing Protocol for WSNs has been proposed, examined and compared with existing SEP routing protocols. In this work, we have proposed Advanced-SEP for heterogeneous environment. The field is divided in to three regions. Normal nodes are only deployed in central region to reduce the energy consumption and they transmit data directly to base station. Half of advanced nodes are placed in the top most regions (above the normal nodes) and other half are placed in bottom most regions (below the normal nodes). Advanced nodes use

clustering technique to transmit data to base station. Simulation results show that the proposed Advanced Stable Election based routing Protocol shows better performance in terms of energy saving, alive nodes, dead nodes and packet transmission. Also, the stability period is increased approximately 50%, by just altering the deployment of the different type of nodes in different regions according to their energy requirement. The proof of above statements is the value of packets transmitted to base stations at last round in both the cases. Packets transmitted in case of existing SEP at last round are 24613 and that for proposed method are 231438. Also, all alive nodes becomes dead before completion of 4000 rounds and that for proposed method is after 5000 rounds, which increase the stability period significantly. Throughput of Advanced-SEP is also increased compared with Existing SEP.

However Advanced-SEP is not suitable where frequent information is received from wireless sensor network. Our future direction will be to overcome this limitation in this protocol. Finally, in future, the concept and implementation of mobile base station can be introduced in proposed system to perform the next level of technology of wireless sensor network.

6. REFERENCES

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