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Sleep-Distance Based Sleep-Awake Mechanisms in Wireless Sensor Network

Sanjeev Indora[1], Dinesh Singh[2]
sanjeev.cse@dcrustm.org[1], dineshsingh.cse@dcrustm.org [2]
[1,2] Deenbandhu Chhotu Ram University of Science and Technology, Murthal, India

Abstract: Wireless Sensor Networks (WSNs) are special types of networks, which are popular these days and find themselves suitable for variety of applications. Energy conservation is always needed in WSNs to make them survive for longer duration. The present article proposes a unique sleep-awake mechanism where, firstly, Cluster heads are selected considering the factors like random probabilities, remaining energy of sensor nodes and node degree. Sleep distance is used to decide the SNs, which goes to sleep for a particular round. The proposed mechanism is evaluated based on alive nodes, packets sent to base station and total energy depletion in the network and it performs very effectively when compared to DEEC and LEACH.

Introduction:

Wireless Sensor Networks (WSNs) are energy scarce networks. Sensor Nodes (SNs), which are at the heart of WSNs are use and throw types of commodities having limited processing capabilities, very limited battery capacity and uses low capability links for communicating between SNs. Considering the scarcity of these resources, researchers have proposed various taxonomies for optimum use of these limited resources especially, the battery i.e. energy source.

Clustering is the most common of the methods utilized for the purpose where, in spite of individual SNs only the nodes with better resources are allowed to communicate with the base station, whereas, the low resourced SNs are used only for communicating data between SNs and cluster heads. Different factors considered for clustering are SNs residual energy, the average energy of the network, CH-to-CH distance, node degree etc.

Besides clustering, the energy of the network still needs to be conserved to prolong the network lifetime further. To explore it further, the selected SNs can be allowed to go to sleep for the time their operation is insignificant. To explore the same, the researchers around the globe have also explored different sleep-awake mechanism in WSNs.

The traditional sleep-awake process involves preparing a TDMA schedule which is communicated to all the participate SNs. SNs whose turns falls next wakes up and all else SNs goes to sleep mode.

Such sleep-awake mechanisms in WSNs are always application specific and only where one can afford the ignorance of data of few SNs can apply such sleep-awake schemes. However, when the data of individual SNs cannot be ignored, sleep-awake proposal are not suitable for such situations.

The present research article proposes a unique sleep-awake methodology where the TDMA schedules is communicated with least energy consumption and hence conserving the overall network energy at first instance. Secondly, the clustering has been done in an efficient manner so that the nodes with higher residual energy and higher node degree are selected, hence further harnessing the energy of the network.

The performance of the algorithm is compared with established protocols like LEACH and DEEC[2]. The performance of the proposed mechanism is analyzed on various parameters like alive nodes, total energy of the network and number of packets communicated between CHs and Base station and performs very well in all the mentioned parameters.

Literature Review:

Sleep-awake mechanisms have been explored a lot by the researcher. The present section presents a review of such popular proposals.

Sleep-awake Energy Efficient Distributed (SEED) an algorithm proposed by Ahmed et al[1]. It divides the network field into three different regions. High-energy region cluster heads takes the responsibility of communicating with the base station and conserves the energy of low energy region cluster heads. SEED outperformed various previously proposed energy-efficient mechanisms in the field.

In [2], Qing et al proposed DEEC, where the cluster heads are selected based on a probability index derived from remaining energy of individual nodes and average energy of the whole network. The sensor nodes of high energy will be selected prior to the nodes with lesser remaining energy.

LEACH-CS, proposed by Hady, El-kader and Eissa [3] is an intelligent protocol, which prioritizes that whether data is of significance, or not. Based on the prioritization, the significant Cluster Heads are allowed to communicate whereas, insignificant cluster heads are allowed to sleep.

Zhu et al [4] proposed CLSS scheme, which dynamically determines the awake or asleep status of sensor nodes to optimize energy of the network.

In [5], Chen et al. proposed a cross-layer clustering protocol, which considered various properties of different layers of network. Various nodes are grouped so that the nearby nodes can communicate with the same neighbors. The proposed mechanism enhanced the lifetime of the network to great extent.

Chen, Niu and Zou [6] proposed a protocol where, network is divided into different streams. Simultaneously, the congestion control mechanism detects the congestion using queue length. The proposed protocol balances the energy consumption of lower hierarchy nodes by utilizing the nodes with highest remaining energy. The protocol is very effective in managing the energy of the network in whole.

In [7], stress has been laid in proposing a sleep scheduling technique. Few nodes are prioritized to go to sleep and hence conserving the energy.

Ghadimi et al [8] suggested an algorithm to find the EDC-optimal forwarding. The outcome of the proposed algorithm is much better than the previous protocols.

In [9], Hester et al introduced Ekho, an emulator. Using this emulator, the experimenting is much closer to real circumstances. It supported a large volume of facilities for conducting experiments. Different types of frequencies can be generated using the present tool.

Keeler and Taylor in [10] presented a stochastic model to study the advancements using greedy routing in WSNs with a power-saving mechanism. They examined an uncoordinated power-saving scheme with its effects on local node density. The proposed scheme was very energy efficient and prolonging network lifetime.

System Model:

- SNs are stationary.
- Communication can occur between SNs and SNs to CHs.
- Only CHs will communicate with Base Station.
- Energy heterogeneity is considered for SNs.
- SNs use energy model of EECH.
- Clustering is done in two phases, where first phase is used to nominate the SNs based on random probabilities.
- In second phase, SNs compete to become CH based upon their residual energy.

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Proposed Algorithm:

- Phase 1: Setup Phase
  - Nodes deployment and initialization
  - Repeat the same for different types of nodes

- Phase 2: Cluster Head Selection
  - SNs gets nominated based on random probabilities as in case of LEACH
  - Remaining energy of the nominated SNs is compared to select the CHs for the current round in second stage

  Clusters are formed by the selected CHs by advertisements

- Phase 3: Sleep-awake scheduling phase
  - CH node asks the nodes lying in its sensing environment range to go to sleep for that particular round.
  - CH schedules a TDMA scheme only for those associates which are farther than the sleep-distance.
  - The non-sleeping associates shares the TDMA schedule that has a total duration of T time units, and to the other associates its sends a SLEEP_UNTIL packet with sleeping time equal to T+1.

Results and Conclusion:

Simulation Parameters:
Number of Sensor Nodes: 100
Types of SNs based on Energy Heterogeneity: Three (Normal, Advanced & Super Nodes)
Sensing Field Dimension: 100m x 100m
Sensor Range of SNs: 10 m
Base Station Coordinates: (100, 50)
No. of rounds: 3000

Alive Nodes statistics:

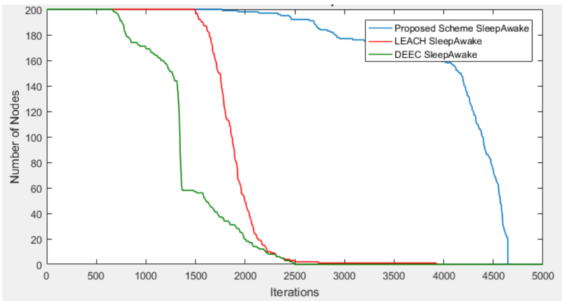

Fig 1: Comparison of Alive nodes v/s Iterations)

Dead Nodes statistics:

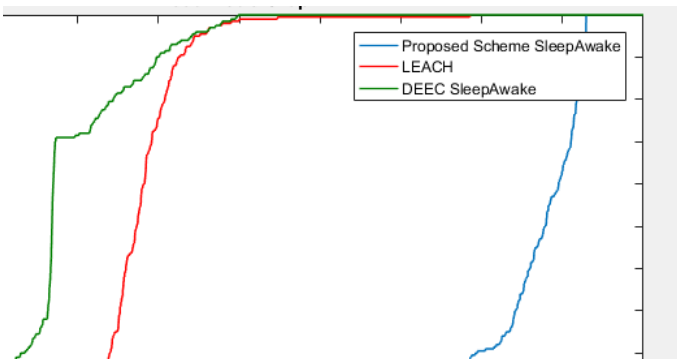

Fig 2: Comparison of Dead nodes v/s Iterations

Cluster Heads Counts:

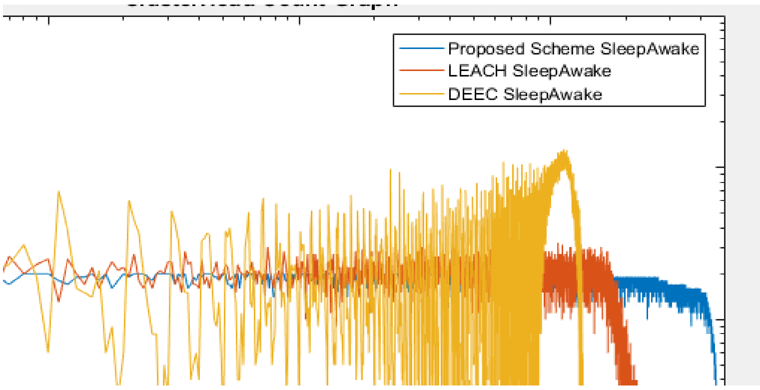

Fig 3: Cluster Heads selected in different protocols

Data sent to Base Station by CHs:

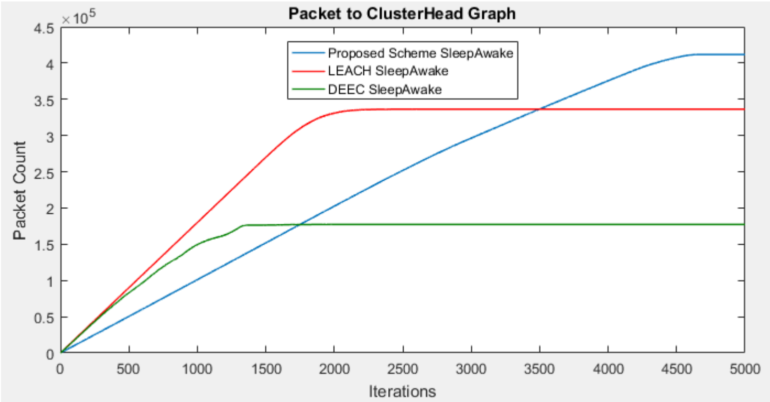

Fig 4: Number of Packets sent to Base Station

Total Energy of the Network:

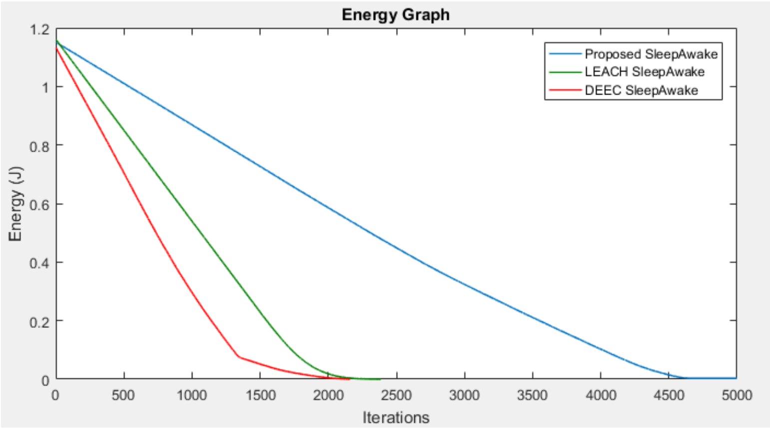

Fig 5: Energy spent in the network

The sleep-awake mechanism proposed is very energy efficient and is low complex as compared to earlier sleep-awake mechanisms. As the TDMA schedule is communicated only once, the communications required are least, which directly reduces the amount of energy consumed in the network.

Conclusion and Future prospects:

The proposed sleep-awake mechanism is based on the unique methodology where, firstly the CHs are selected by phased process using the random probabilities, residual energy of SNs and Node degree of selected CHs. Later, a sleep-distance is used to select the number of SNs to go to sleep for certain duration of time. The results for the proposed mechanism are very satisfactory as it outperforms the established protocols like LEACH and DEEC. The proposed protocol is application specific for the problems where data from certain SNs can be ignored. In future, more optimized mechanisms can be explored for further conserving the energy of the network.

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