International Journal of communication and computer Technologies, ISSN: 2278-9723
Available at http://www.ijccts.org

# A Survey of Energy-Efficient Communication Protocol for Wireless Sensor Networks

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**Received:** 18-06-2015, **Revised:** 21-08-2015, **Accepted:** 11-09-2015, **Published online:** 16-11-2015

**Abstract -** Recent advancement in wireless communications and electronics has enabled the development of low-cost sensor networks. The sensor networks can be used for various application areas (e.g., health, military, home). In this paper, communication protocols, this can have significant impact on the overall energy dissipation of these networks. For this, Here, discuss the operations of various Energy-Efficient Communication Protocol, as well as comparisons on the performance with different parameters such as the throughput and network lifetime. This paper contains survey of different these algorithms for WSNs; highlighting their objectives, features, complexity, etc. and also discuss improvements to be made for future proposed Communication Protocol. This article also points out the open research issues and intends to spark new interests and developments in this field.

**Keywords:** Wireless sensor networks; clustered routing; received signal strength; network lifetime; energy efficiency; throughput maximization.

## I. INTRODUCTION

Wireless sensor networks (WSN) are envisioned as autonomous and self-organizing systems consisting of a large number of small, inexpensive, battery-powered communication devices densely deployed throughout a physical space [1], [2]. These networks are mainly to be used for the systematic gathering of useful information related to the surrounding environment (e.g. temperature, humidity, seismic and acoustic data, etc.), and for the transmission of the gathered data to a base station, i.e. sink, for further processing. Due to the above features, WSNs are expected to find use in a wide range of real-world applications, including habitat monitoring, structural monitoring, surveillance, disaster management, inventory management, target tracking, etc. It should be noted, however, that the anticipated application potential of wireless sensor networks can, and will be, fully utilized only after the main technological challenges faced by WSNs have been properly addressed.

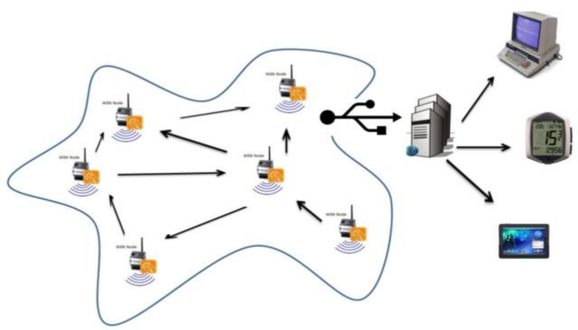

Fig.1 Architecting platform for WSN

Realization of these and other sensor network applications require wireless ad hoc networking techniques [3]. Although many protocols and algorithms have been proposed



for traditional wireless ad hoc networks, they are not well suited to the unique features and application requirements of sensor networks. [10], [11], [12] to illustrate this point, the differences between sensor networks and ad hoc networks are:

- The number of sensor nodes in a sensor network can be several orders of magnitude higher than the nodes in an ad hoc network.
- Sensor nodes are densely deployed.
- Sensor nodes are prone to failures.
- The topology of a sensor network changes very frequently.
- Sensor nodes mainly use a broadcast communication paradigm, whereas most ad hoc networks are based on point-to-point communications.
- Sensor nodes are limited in power, computational capacities, and memory.
- Sensor nodes may not have global *identification* (ID) because of the large amount of overhead and large number of sensors.
- Many researchers are currently engaged in developing schemes that fulfill these requirements.

## II. OVERVIEW OF ENERGY-EFFICIENT COMMUNICATION PROTOCOL ALGORITHMS

LEACH [8] is a self-organizing, adaptive clustering protocol. It uses randomization for distributing the energy load among the sensors in the network. The following are the z made in the LEACH protocol:

- All nodes can transmit with enough power to reach the base station.
- Each node has enough computational power to support different MAC protocols.
- Nodes located close to each other have correlated data.

According to this protocol, the base station is fixed and located far from the sensor nodes and the nodes are homogeneous and energy constrained. Here, one node called cluster-head (CH) acts as the local base station. LEACH randomly rotates the high-energy cluster-head so that the activities are equally shared among the sensors and the sensors consume battery power equally. LEACH also performs data fusion, *i.e.* compression of data when data is sent from the clusters to the base station thus reducing energy dissipation and enhancing system lifetime. LEACH divides the total operation into rounds—each round consisting of two phases: set-up phase and steady phase.

In the set-up phase, clusters are formed and a CH is selected for each cluster. The CH is selected from the sensor nodes at a time with a certain probability. Each node generates a random number from 0 to 1. If this number is lower than the threshold node [T (n)] then this particular node becomes a CH. T (n) is given as follows:

$$T(n) = \begin{cases} p/(1 - p \times \left(r \times mod\left(\frac{1}{p}\right)\right) & if\ n \in G \\ 0 & otherwise \end{cases}$$

Where p is the percentage of nodes that are CHs, r is the current round and G is the set of nodes that have not served as cluster head in the past 1/p rounds. Then the CH allocates time slots to nodes within its cluster.

In steady state phase, nodes send data to their CH during their allocated time slot using TDMA. When the cluster head gets data from its cluster, it aggregates the data and sends the compressed data to the BS. Since the BS is far away from the CH, it needs high energy for transmitting the data. This affects only the nodes which are CHs and that are why the selection of a CH depends on the remaining energy of that node.

TEEN [13] is a cluster based hierarchical routing protocol based on LEACH. This protocol is used for time-critical applications. It has two assumptions [14]:

- The BS and the sensor nodes have same initial energy
- The BS can transmit data to all nodes in the network directly.

In this protocol, nodes sense the medium continuously, but the data transmission is done less frequently. The network consists of simple nodes, first-level cluster heads and second-level cluster heads. TEEN uses LEACH's strategy to form cluster. First level CHs are formed away from the BS and second level cluster heads are formed near to the BS.

A CH sends two types of data to its neighbors—one is the hard threshold (HT) and other is soft threshold (ST). In the hard threshold, the nodes transmit data if the sensed attribute is in the range of interest and thus it reduces the number of transmissions. On the other hand, in soft threshold mode, any small change in the value of the sensed attribute is transmitted. The nodes sense their environment continuously and store the sensed value for transmission. Thereafter the node transmits the sensed value if one of the following conditions satisfied:

- Sensed value > hard threshold (HT).
- Sensed value ~ hard threshold >= soft threshold (ST).

TEEN has the following drawbacks:

- A node may wait for their time slot for data transmission. Again time slot may be wasted if a node has no data for transmission.
- Cluster heads always wait for data from nodes by keeping its transmitter on.

However, in TEEN, when a node has data to send, there are checks of hard and soft thresholds. Nodes first time transmit, when the sensed value reaches its hard threshold. Next time transmissions occur, only when, the sensed value is greater than hard threshold and the current value of the sensed attribute differs from soft threshold by an amount greater than or equal to the soft threshold. However, in addition to the drawbacks of LEACH this protocol has decreased network throughput.

SEP [14] is heterogeneous-aware, in the sense that election probabilities are weighted by the initial energy of a node relative to that of other nodes in the network. This prolongs the time interval before the death of the first node (*stability period*), which is crucial for many applications where the feedback from the sensor network must be reliable.

The simulation that SEP provides longer stability period and higher average throughput than current clustering heterogeneous-oblivious protocols. And also study the sensitivity of SEP protocol to heterogeneity parameters capturing energy imbalance in the network. That SEP is more resilient than LEACH in judiciously consuming the extra energy of advanced nodes—SEP yields longer stability region for higher values of extra energy.



SEP defines two energy levels. Based on these energy levels, nodes are categorized into two types i.e., normal and advanced. Nodes having $\alpha$ times more energy in comparison to normal ones are called advanced nodes. Thus, the advanced nodes are more preferred for the selection of CHs due to their assigned probability weights. However, the nodes always send the sensed data to the CH(s) even if these lie at comparatively shorter distance from the BS. Thus, extra energy is consumed which causes shrinkage in the network lifetime.

Li Qing *et al.* in [17] propose DEEC routing protocol for heterogeneous WSNs. In this protocol, nodes are equipped with different energy levels as the network operation starts. The CHs selection is based on the ratio of the residual energy of a node to average energy of the network. The nodes with higher residual energy have more chances to be CHs for a particular round. This makes the energy distribution even among the nodes. DEEC prolongs stability period as nodes with more residual energy become CHs frequently. The CH formation in DEEC is similar as in LEACH, however, the probability for nodes to become CHs is different However, the clusters formed due to random selection of CHs are of different sizes. Thus, leading to quick energy depletion of the CHs belonging to the cluster with dense concentration of nodes as compared to that of the sparse ones.

Sheng-Shih Wang [15] proposed the passive clustering technique, proposes a link-aware clustering mechanism (LCM) to support energy-efficient routing in WSNs. The main

goal of the LCM is to establish a persistent and reliable routing path by determining proper

nodes to become clusterheads and gateways. In the LCM, clusterhead and gateway candidates use the node status (e.g., residual energy) and link condition (e.g., quality) to determine a clustering metric, called the predicted transmission count. The predicted transmission count is defined as the number of transmissions that a clusterhead and gateway candidate conducts. This metric can be determined by measuring the transmit power consumption, residual energy, and link quality.

The clusterhead or gateway candidate depends on a priority, derived from its predicted transmission count, to evaluate its qualification for a clusterhead or a gateway. The clusterhead or gateway candidate having the highest priority is elected as a clusterhead or a gateway, respectively. To the best knowledge, this study is the first to investigate the routing issue based on the passive clustering technique in WSNs. CHs selection depends on priority, and candidates with highest priority are selected as CHs. The deficiencies of LCM include; unbalanced cluster size and non optimum number of CHs.

Ashfaq Ahmad [18] proposed away cluster heads (CHs) with adaptive clustering habit ($(ACH)^2$) scheme for WSNs. This scheme increases the stability period, network lifetime, and throughput of the WSN. The beauty of this scheme is its away CHs formation, and free association mechanisms. The proposed routing scheme aims to maximize the lifetime, and throughput of the network. After nodes' deployment, information sharing among the nodes and BS is carried out with the help of HELLO messages broadcast mechanism.

BS first elects the candidate set for the selection of CHs and then finalizes this set by removing the candidates remained with less than average residual energy of individual nodes' in the network. The central control, calculates optimal number of CHs from the available resources in the network, and compares it with the finalized candidate set. If these elected CHs are found to be more than the optimal value, then, the extra candidates are unmarked by selecting away CHs based on received signal strengths. The away CHs mechanism results in clusters of almost similar size and optimum in number. In this way the unbalanced load problem of CHs is solved.

Furthermore, with balanced cluster size, the contending nodes for channel access are minimized in number. There by leading to relatively less number of packets being dropped. Moreover, the *(ACH)*$^2$ associates nodes with CHs in an adaptive free manner such that back transmissions are removed and the overall length of the path traversed by locally gathered data is reduced. As the association mechanism of *(ACH)*$^2$ minimize the overall communication distance, so energy consumption is reduced which means increased network lifetime.

## III.CONCLUSION

The past few years have witnessed a lot of attention on routing for wireless sensor networks and introduced unique challenges compared to traditional data routing in wired networks. Routing in sensor networks is a new area of research. Since sensor networks are designed for specific applications, designing efficient routing protocols for sensor networks is very important. First work has gone through a comprehensive survey of routing techniques in wireless sensor networks. This document discussed eight routing protocols These eight protocols are LEACH, TEEN, SEP, DEEC, LCM and (ACH)$^2$. Future perspectives of this work are focused towards modifying one of the above routing protocols such that the modified protocol could minimize more energy for the entire system.

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