iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VIII **Month of publication:** August 2017

DOI: http://doi.org/10.22214/ijraset.2017.8010

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

A review on Clustering and Routing Techniques Based upon LEACH Protocol for Wireless Sensor Network

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Abstract: In recent years Wireless Sensor Networks (WSNs) have emerged as a new powerful technology used in many applications such as military operations, surveillance system, Intelligent Transport Systems (ITS) etc. These networks consist of many Sensor Nodes (SNs), which are not only used for monitoring but also capturing the required data from the environment. Most of the research proposals on WSNs have been developed keeping in view of minimization of energy during the process of extracting the essential data from the environment where SNs are deployed. The primary reason for this is the fact that the SNs are operated on battery which discharges quickly after each operation. It has been found in literature that clustering is the most common technique used for energy aware routing in WSNs. The most popular protocol for clustering in WSNs is Low Energy Adaptive Clustering Hierarchy (LEACH) which is based on adaptive clustering technique. This paper provides the taxonomy of various clustering and routing techniques in WSNs based upon metrics such as power management, energy management, network lifetime, optimal cluster head selection, multihop data transmission. A comprehensive discussion is provided in the text highlighting the relative advantages and disadvantages of many of the prominent proposals in this category which helps the designers to select a particular proposal based upon its merits over the others.
Keywords: Clustering, WSN, Energy dissipation, Sensor nodes.

I. INTRODUCTION

Recent technological advancement in micro-electronic-mechanical systems (MEMS), wireless communication and digital electronics technologies have enabled the development of low-cost, low-power and multifunctional sensor nodes that are tiny in size in WSN [1]. These smart sensor nodes are deployed over a geographical area for monitoring the physical phenomena. WSNs become widely useful in variety of applications such as environment monitoring, field surveillance, military and civilian applications [2].

WSN is different from traditional wireless communication network such as cellular networks and mobile ad-hoc networks (MANET) [3]. WSNs have unique characteristics such as higher node density, higher unreliability of sensor nodes and prone to failure which show many challenges in development of WSN. Sensor nodes in WSN are tiny in size but include three basic components- a sensing unit, a processing unit and a wireless unit. In addition, a power unit called battery supplies the energy needed by device as shown in fig.1. Sensor node may include location finding system to find out their position and a mobilizer to change their location or configuration. Sensor nodes must:-

A. Consume extremely little power
B. work in high volumetric densities
C. have low production cost
D. be autonomous and adaptive to the environment

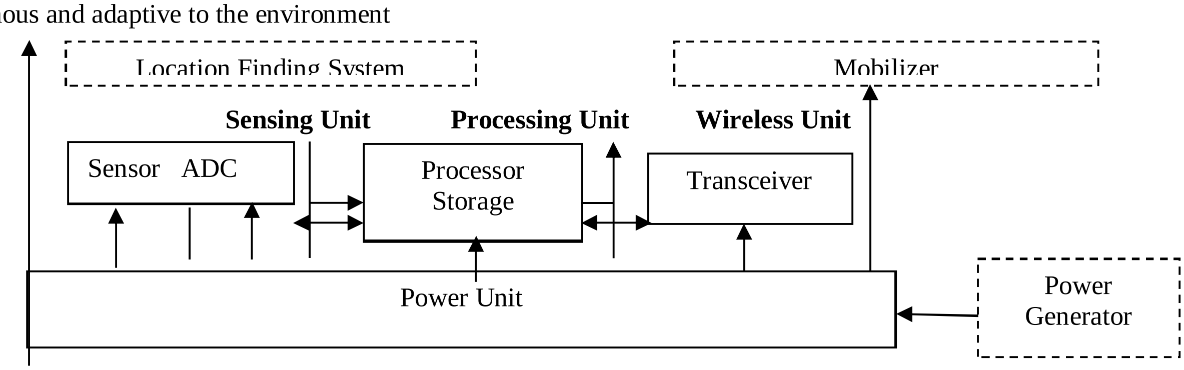

Fig. 1 Components of Wireless Sensor Node

Fig. (2) Represents Sensor Network Model consists of one sink or Base Station (BS) and large number of sensor nodes deployed over a geographical area called Sensing field [2].

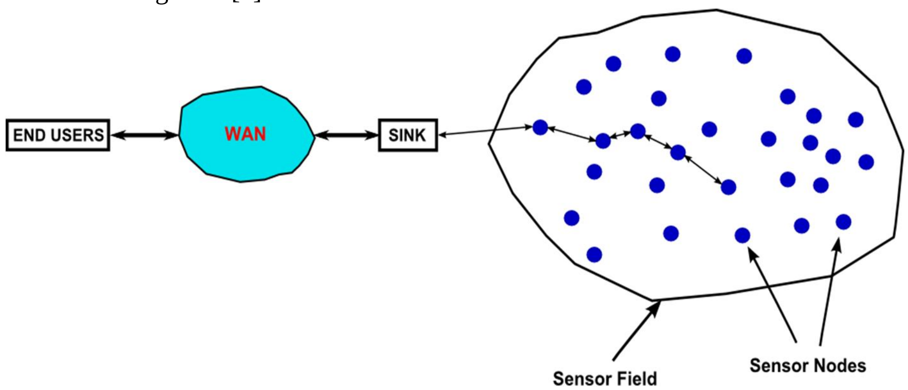

Fig. 2 Working of WSN

A variety of protocols were proposed for extending the lifetime of WSN and for routing the correct information to the sink or BS. In this paper, various Energy-Efficient Cluster-Based Routing Protocols for WSN are discussed. This paper is organized in following way: Section 2 describes the Energy Efficient Clustering Structures in WSN. Section 3 describes Energy-Efficient Cluster-Based Routing Protocols for Homogeneous and Heterogeneous WSN. Section 4 includes conclusion of survey and section 5 consists of references.

E. Clustering Technique in WSN

Wireless sensor networks have plenty of advantages. The deployment of WSNs is easier and faster than the wired sensor networks or any other wireless networks, because they do not need any fixed infrastructure. Since sensor nodes are densely deployed in most of the cases, they are able to tolerate the network failures. Wireless sensor networks do not require a central organization and they are self-configuring.

There are several types of wireless sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, and acoustic and radar sensors. These sensor nodes can monitor various environmental conditions. Some of these conditions are temperature, pressure, humidity, soil makeup, vehicular movement, noise levels, lighting conditions, the presence or absence of certain kinds of objects and mechanical stress levels on attached objects. Wireless Sensor Networks provide unforeseen applications in this new field of design.

F. Clique Technique in WSN

SNs used for monitoring applications have to be designed to meet the specific requirements and characteristics of the application environments. This fact is strongly reflected in the indoor systems where operating constraints can vary significantly from one application scenario to another. The particularly harsh environments, like tunnels, impose constraints on the possible network topology. For such long structures, the WSN represents a linear topology. This limits the usability of certain localization methods or reduces dramatically their accuracy. In fact, the public literature has few studies about methods dedicated to localization in tunnels and thus the challenges for accurate localization techniques remain to be addressed.

Introduction to LEACH &CBCR for WSN

The core idea of LEACH protocol is to divide the whole wireless sensor networks into several clusters. The cluster head node is randomly selected, the opportunity of each node to be selected as cluster head is equal, and energy consumption of the whole network is averaged. Therefore, LEACH can prolong the network life-cycle. LEACH algorithm is cyclical; it provides a conception of round. LEACH protocol runs with many rounds. Each round contains two states: cluster set-up state and steady state. In cluster set-up state, it forms clusters of self-adaptive mode; in steady state, it transfers data. The time of second state is usually longer than the time of the first state for saving the protocol payload. The selection of cluster head depends on decisions made 0 and 1. If the number is less than a threshold, the node becomes a cluster head for the current round. Using this threshold, each node will be a cluster head at some point within 1/p rounds. Nodes that have been clusters heads cannot become cluster heads for a second time for

1/p -1 rounds. After that, each node has a 1/p probability of becoming a cluster head in every round. At the end of every round, every normal node that is not a cluster head select the nearest cluster head and joins that cluster to transmit data. The cluster heads combine and compress the data and forward it to the base station, therefore it extends the life span of major nodes.
Disadvantages of LEACH**:** (i) LEACH is not applicable to network deployed in large region because it uses single-hop routing. (ii) The idea of dynamic clustering brings extra overhead eg. Head change, ADV etc. that can increase the energy consumption. (iii) LEACH does not guarantee good CH distribution & assume CH consume same amount of energy.

G. Existed Technique

The aim of cluster formation in LEACH is to have k number of clusters per round. The LEACH protocol determines the optimal value of k, which is a system parameter, using the communication energy model based on radio energy dissipation model as in [12]. The research work derived the total energy consumption for transmitting -bit message at a distance d for a frame and is given by the following:

$$E_{\text{total}} = l\left(E_{\text{elec}}N + E_{\text{DA}}N + k\varepsilon_{\text{mp}}d_{\text{toBS}}^{4} + E_{\text{elec}}N + \varepsilon_{\text{fs}}\frac{1}{2\pi}\frac{M^2}{k}N\right),$$

where Elect = 50 nJ/bit is the energy consumption per bit for the transmitter and receiver circuits to operate, Efs=10 pJ/bit/m^2 and Emp=0.0013pJ/bit/m^4 are the amplifier energy, and is the number of nodes in the network distributed in M*M region. E_{DA}da is the energy consumed for data aggregation, and D $_{tobs}$ is the distance from the cluster head to base station. From (1) the optimum number of clusters K_{opt} is determined by setting the derivative of E_{Total} with respect to to zero which gives the following:

$$k_{\text{opt}} = \frac{\sqrt{N}}{\sqrt{2\pi}}\sqrt{\frac{\varepsilon_{\text{fs}}}{\varepsilon_{\text{mp}}}\frac{M}{d_{\text{toBS}}^{2}}}.$$

II. ENERGY DISSIPATION FOR WSN

In the network model assumed in recent literature, nodes can join a cluster after the cluster heads election based on strongest signal strength, node degree, or distance of cluster heads to base station [12, 16–18]. During cluster formation if the cluster heads do not maintain a certain cluster head degree, the connectivity of the network may be lost. The connectivity depends mainly on the number of nodes per unit area and their radio transmission range. Our goals in this paper are that (1) small node degree will result in reduced average distance between cluster members to cluster heads and vice versa, (2) connectivity can be conserved by maintaining cluster head degree to certain value, (3) controlling the node degree we can create both equal and unequal cluster sizes, and (4) addressing the question of whether or not the network connectivity can be achieved at minimum energy dissipation
The placement of sensor nodes on a monitored field may influence the general performance of the network. Taking into account the placement of nodes in the field, there are three main categories of placement of nodes in a network including the deterministic node placement (grid), the semi- deterministic node placement (e.g., Biased Random), and the nondeterministic (stochastic) node placement (e.g., Simple Diffusion and Random). Long range transmission by sensor nodes is not energy efficient as it needs more energy than a linear function of transmission distance does. Clearly, node density is just one element in network topology as the placement of the node is another key factor. The placement of nodes influences the capacity of a network to correctly sense an event as well as the number of possible disjoint paths towards the sink(s).
Under the deterministic node placement, the nodes are placed on exact, preset points on a grid or in specific parts of the grid. Commonly, deterministic or controlled node placement dictates the type of nodes, the environment that nodes will be placed, and

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
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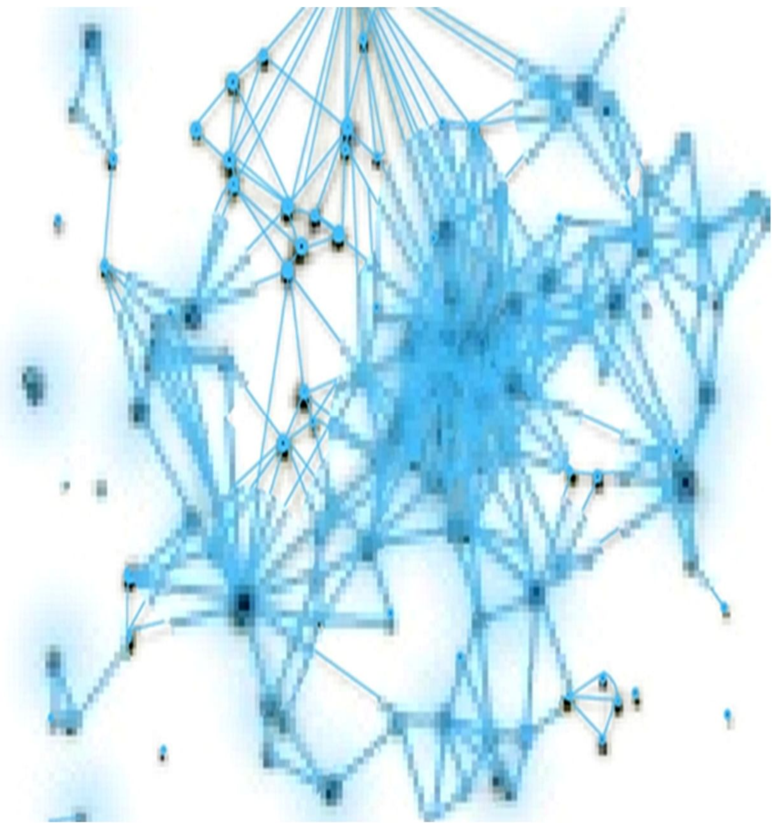
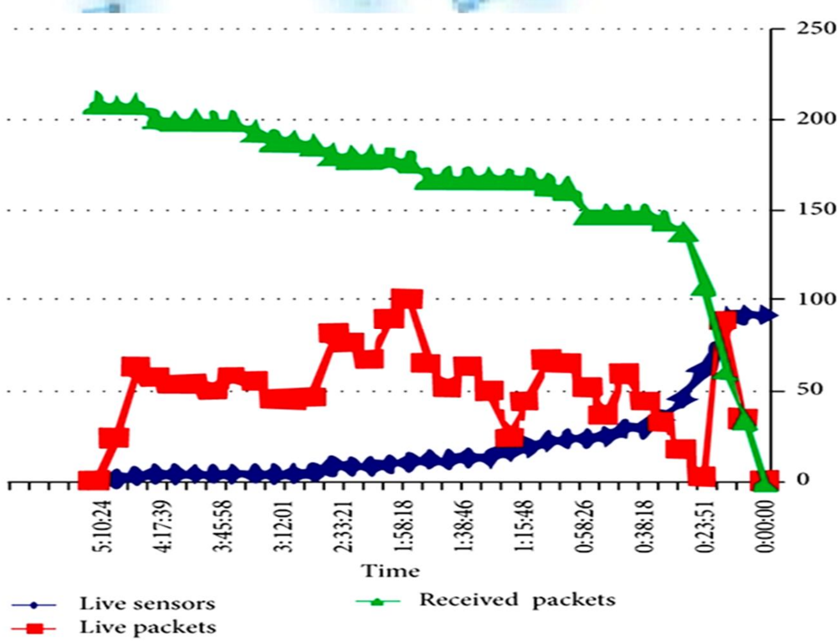
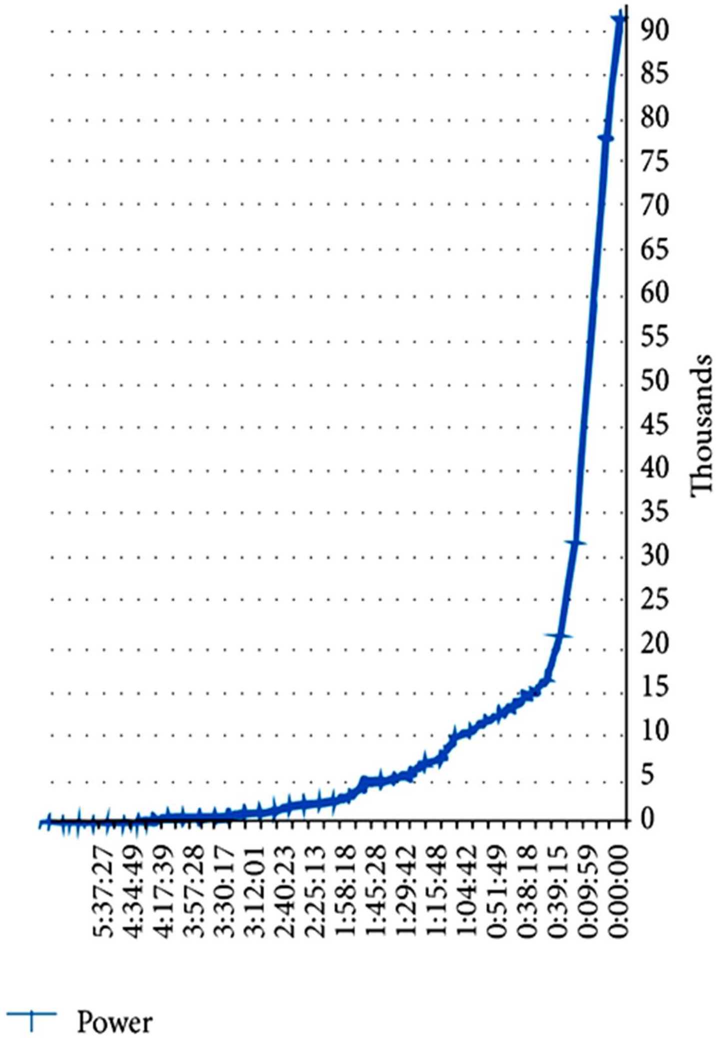
the application. Thus, in Sensor Indoor Surveillance Systems or Building Monitoring application nodes must be placed manually [13]. Under semi- deterministic placement, on the other hand, individual nodes are positioned in a nondeterministic way on the grid (e.g., random) which covers the areas nodes must be spread. That is, microscopic and macroscopic ways of placement of nodes are nondeterministic and deterministic, respectively.

To make sure that network runs with the highest feasible performance, the nodes are positioned on the campus network. Along with balanced energy consumption of all nodes, a preferred node placement protocol is supposed to supply a better network throughput through attenuating contention of channel and collision of packet under high load. An instance of a node placement scheme is pictured in Figure 3(a).







The common advantages of proper sensor propagation in WSNs are listed below [14].

A. *Scalability:* A high number of nodes can be deployed in the network; this is suitable when transmissions between the nodes are not unlimited.

B. *Collision Reduction:* Since the cluster head (CH) functions as a coordinator, a limited number of nodes gain access to the channel and cluster members and head communicate locally.

C. *Energy Efficiency:* High energy consumption is a consequence of the periodic relocation. Still, duties of CH may be distributed among all other nodes through periodic relocation, which results in lower energy consumption.

D. *Low Cost:* The excess costs can be avoided by deploying sensors at proper locations.

Routing Backbone. The data collected by cluster members are aggregated in CH and sent to the sink. Thus, using a little route-thru traffic and routing backbone with enough efficiency one can build the network.

III. CONCLUSION

Due to proposed a several energy efficient hierarchical routing protocols among this LEACH is famous protocol, we have simulated LEACH in NS2 and analyzed performance of LEACH in terms of energy, throughput and lifetime. Sensor nodes are equipped with small, often irreplaceable batteries with limited power capacities. They can be deployed manually or be randomly dropped. They are self-configuring, containing one or more sensors, with embedded wireless communications and data processing components and a limited energy source. The use of wireless sensor networks is increasing day by day but the problem of energy constraints prevails as there is limited battery life. In order to save energy dissipation caused by communication in wireless sensor networks, it is necessary to schedule the state of the nodes, changing the transmission range between the sensing nodes, use of efficient routing and data routing methods and avoiding the handling of unwanted data.

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