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A genetic algorithm based distance-aware routing protocol for wireless sensor networks☆

Tarunpreet Bhatia*, Simmi Kansal, Shivani Goel, A.K. Verma

Thapar University, Bhadson Road, Patiala, Punjab 147004

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ABSTRACT

A Wireless Sensor Network (WSN) is an aggregation of sensor nodes which are remotely deployed in large numbers, operate autonomously in an unattended environment and have limited energy resource. In most of the hierarchical routing protocols, the cluster head (CH) selection is on the basis of random probability equation. There is a scope to reduce the energy dissipation by improving CH selection procedure. The proposed scheme, coined as GADA-LEACH, makes use of evolutionary genetic algorithm for improving CH selection in legacy LEACH routing protocol in sensor networks. The concept of relay node is introduced which acts as an intermediary between CH and base station (BS) to ease the communication between the CH and BS. The simulation results obtained supports that our proposed algorithm is efficient in terms of network lifetime.

1. Introduction to wireless sensor networks (WSNs)

Wireless Sensor Networks (WSNs) consist of mobile or stationary sensor nodes which are spatially distributed for sensing and processesing the data. Sensor nodes sense the event according to the intended application. WSN is used for monitoring physical and environmental conditions such as temperature, sound, pressure etc. Some of its applications include area monitoring, air pollution monitoring, disaster management, security surveillance, healthcare monitoring, industrial monitoring, forest fire monitoring, landslide monitoring etc [1]. Due to mobility in sensor nodes, the topology of network changes dynamically [2,3]. The architecture of WSN is shown in Fig 1.

Some of the limitations from which WSNs suffer are limited battery source, lower data rates, slower computing speeds, smaller memory and limited communication range. Sensor nodes are battery powered and have to operate in an unattended environment for a longer period of time so it becomes cumbersome to change or recharge their batteries. Due to resource constrained nature of WSNs, routing has become a challenging task. These limitations should be given due weightage while designing the routing protocols for WSNs as they directly impact functioning of whole network [4]. The focus of routing protocols in WSN should be more in finding out the routes that may result in prolonged lifetime of the network apart from considering other parameters such as shortest distance, minimum delay or maximum bandwidth.

There are various types of routing protocols proposed in literature for WSNs such as flat, hierarchical and location based protocols. Among all, hierarchical or cluster based routing protocols are one of the most efficient due to high network scalability, energy efficiency, low data retransmission, efficient sharing and optimum use of constrained resources [5]. The major

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* Corresponding author. Fax: 0175 2393005.
E-mail addresses: tarunpreetbhatia@gmail.com (T. Bhatia), simmikansal877@gmail.com (S. Kansal), shivani@thapar.edu (S. Goel), akverma@thapar.edu (A.K. Verma).

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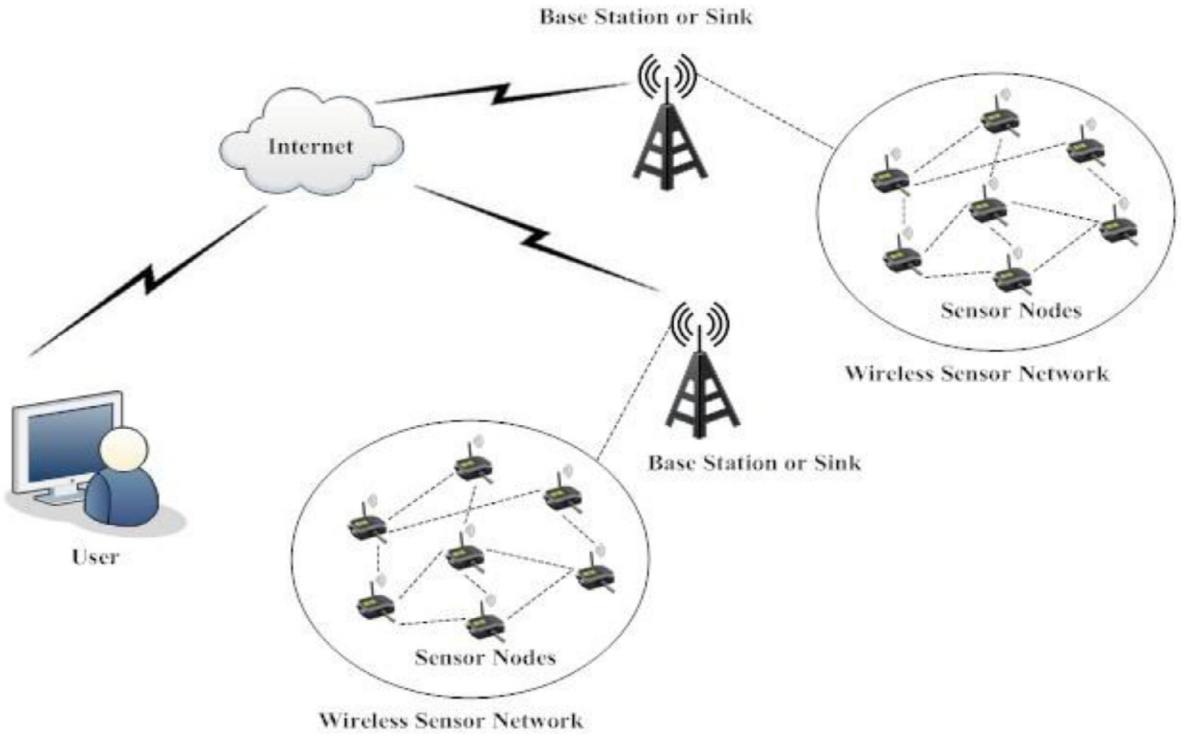

Fig. 1. Wireless sensor network architecture.

design issue for such protocols is formation of clusters and selection of CHs to reduce the energy consumption. LEACH, one of the popular hierarchical routing protocols [6], though uses cluster based routing to maximize energy consumption distributes energy consumption non-uniformly as CH selection doesn't consider residual energy and distance of nodes selected as CH. The major challenge in the design of routing protocols for WSNs are minimizing energy dissipation and maximizing network lifetime. In the proposed work, the cluster formation and CHs communication procedure of LEACH protocol has been modified in order to improve network lifetime. The proposed algorithm makes use of Genetic Algorithm (GA) for optimized CH selection and relay node for Distance Aware (DA) routing. It is named as GADA-LEACH.

This paper is organized as follows: Section 2 discusses related work. Section 3 gives an overview of Genetic Algorithm. Section 4 discusses the proposed algorithm GADA-LEACH followed by Section 5 presenting the simulation environment and experimental results of GADA-LEACH in comparison to various LEACH based protocols such as LEACH, LEACH-E, LEACH-EX, M2NGA, GP-LEACH and LEACH-H and finally conclusion and future scope is presented in Section 6.

2. Related work

Recent advances in WSNs have led to designing many new routing protocols specifically clustering or hierarchical protocols, supporting longer network life. The energy efficiency of routing protocols in WSN still remains an open challenge for the research community [6]. There are several hierarchical routing protocols proposed in the literature for sensor networks [7–10], their main objective is to generate stable clusters in mobile environment. Many of such techniques focus on node reachability and route stability leaving other critical factors such as network longevity and coverage. The energy consumption of the sensor nodes is mainly dominated by data transmission and reception. Therefore, routing protocols for WSNs should focus on energy efficient routing for extending the lifetime of individual sensors and thus network.

LEACH, one of the first hierarchical routing protocols, was proposed by Heinzelman [11] in the year 2000. The process of generating clusters of nodes where one node acts as a cluster head is performed in periodical manner, dividing every round into two phases: a) Cluster Building Phase: One of the node is elected as a cluster head by following cluster head election process. Then this CH sends message to non-cluster nodes informing about its new role. The non-cluster nodes sends joining request to the Cluster head on the basis of received signal strength. b) Stable Data Communication Phase: Cluster member's sends data to the CH, and then CH aggregates the received data and forwards it to the sink node.

Kumar et al. [12] proposed a protocol EEHC (Energy Efficient heterogeneous clustered scheme for WSN) that aims at increasing the stability and network lifetime in presence of heterogeneous nodes. Nodes in the network are divided into three categories: normal nodes, advanced nodes and super nodes which are referred to as heterogeneous nodes. In this, it is assumed that energy of advanced nodes is more than energy of normal nodes and energy of super nodes is more than

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