Study of Energy Efficient Cluster Based Routing Protocols in Wireless Sensor Networks

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Abstract— Wireless sensor network (WSN) consists of a large number of small, cheap, low power, limited memory, smart devices called sensors that can be deployed inside or near a physical area that is to be observed. They are networked through the use of wireless links and the internet, and provide unprecedented opportunities for a variety of applications. The sensor nodes are communicated through routing protocols. The routing protocol can be classified into flat, cluster based and location based routing protocols. The routing protocols must be designed energy efficient to improve the network performance such as throughput, lifetime, end-to-end delay and transmission time. This paper focus on study of cluster based routing protocols, underline methodology, advantages and limitation of each protocol.

Key words: Wireless sensor networks, energy efficient routing, clustering protocols, sensors, communication strategy

I. INTRODUCTION

The reinforcement of wireless sensor network was formally occupied by military applications such as monitoring militant movement in remote area, force protection, opponent tracking and battleground surveillance. But these days, wireless sensor networks are used in many other applications, including environmental observation, health application, habitat monitoring, industrial automation, home automation, and traffic control [1]. Thus, WSNs have organized to form the connection between the physical world, human society and the computing world. WSN is a collection of vast number of tiny, smart, low cost, low power electronic devices called sensors which have the facility of sensing information, performing computations, self-organizing and communicating the sensed/processed information to the other sensor nodes or to the sink or base station.

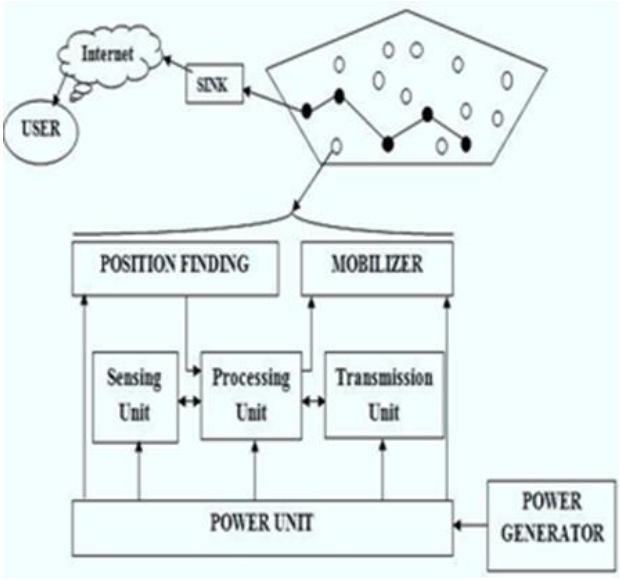

Fig. 1: Sensor node architecture

Fig. 1 shows the architecture of sensor node. Nodes key components are micro sensor, micro processor, memory and transceiver to communicate with the rest of the network [2]. Because of the limitation of power supply, the processing capability and transmission bandwidth and efficient routing becomes a critical issue in wireless sensor network. Routing protocols [3,4] are responsible for discovering and maintaining energy efficient routes and in order to make communication efficient and reliable.WSN routing protocols are divided into flat routing, location based routing and hierarchical routing.

II. ROUTING PROTOCOL IN WSN

Routing is used to find the path between source and destination node [4,6]. The design of routing protocols in WSN is affected by several factors such as node deployment, energy consumption, quality of service, nature of node, scalability, coverage and application. For energy efficient communication WSN need to overcome these factors.

III. CLUSTER BASED ROUTING PROTOCOL IN WSN

Cluster based routing is one of the energy efficient method in which nodes with high energies are initially selected for processing and sending data as well as nodes with low energies are used for sensing and sending information to the cluster heads(CH) [5,8]. Cluster based routing is used to achieve the scalability, energy minimization and network lifetime maximization [7,9]. The cluster based routing protocols are used to achieve the application specific goals.

IV. CLUSTERING TECHNIQUES

Dividing the sensor networks into small manageable groups is called as clustering [10,16,17,18]. The main purpose for the implementation of the clustering scheme is to boost the scalability of the network, it is a main reason for achieving energy efficient routing of data within the network. Apart from achieving scalability of the network, it has more benefits like conserving communication bandwidth within the clusters, localizing energy efficient route setup within the clusters and avoiding redundant message transfer between the sensor nodes. Some of the energy efficient routing protocols based on clustering are HEER, LEACH, MZ-LEACH etc.

A. LEACH with fuzzy descriptors:

The protocol consists of mobile sink and static sensors [11]. The cluster formation is based on the LEACH protocol. Sensor node sense the data and forward the data towards the CH. CH collects these data, aggregates it and send to the SCH. SCH node can send the data towards the mobile sink or mobile sink can collect the data from SCH node. Instead of multiple CHs, one SCH can deliver the message to sink that can reduce energy consumption and enhances energy

efficiency. SCH node is elected from group of cluster head (CH) nodes by using fuzzy descriptors.

The fuzzy descriptors are remaining battery power, mobility of sink, and centrality of the clusters. Depending on the application, mobility of the sink can be considered as low or medium or high. Centrality focuses on the location of SCH how much it is central to other CH's for communication purpose. Equation (1.1) is used to calculate the chance to be the SCH that can deliver the message to the sink.

Chance = (BatteryPower −1) + Mobility + Centrality (1.1)

Due to mobility of the sink, it can take many different paths to collect the data from SCH. The sink mobility is used to increases or decreases distance between the sink and SCH.

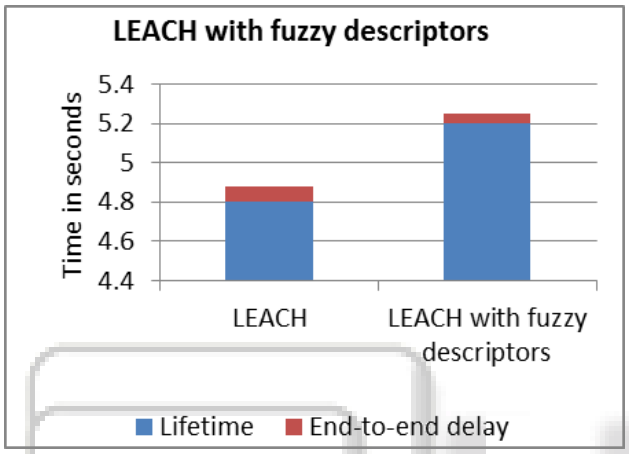

Fig. 2: LEACH with Fuzzy Descriptors Performance

Fig. 2 shows the lifetime and end-to-end delay of LEACH with fuzzy descriptors model. The lifetime of the network depends on the lifetime of individual node. It is seen from Fig. 4 that first node dies in LEACH very fast whereas it survives almost double time in the LEACH with fuzzy descriptors model. Fig. 2. Shows the end-to-end delay. It is reduced by 62% in the LEACH with fuzzy descriptors protocol compared to LEACH.

B. CBCCP Protocol:

CBCCP protocol follows a proximity based hierarchical clustering method [12]. From each cluster one node is assigned to the role of Cluster Head (CH) randomly. Each cluster consists of one CH and varied number of Cluster Coordinator (CCO). Each CH transmits the data to next level cluster and received by the node which acts as the CCO. These CCO send the data to the next level CCO in the next cluster. This process is continued until data reaches the sink. Number of CCOs depend the number of clusters beneath the cluster in which CCOs are located. It is the responsibility of cluster to have one CCO for each cluster for the data of lying below to it.

For example if there are six clusters below to the one cluster then there will be six CCOs in that cluster to handle the data of each cluster. CBCCP follows a cooperative and chain communication. Intra cluster communication using the relay nodes and it follows a multi hop approach for energy efficiency. Inter cluster communication by using the CCO nodes. CCO nodes are used to minimize the distance between the CH and sink.

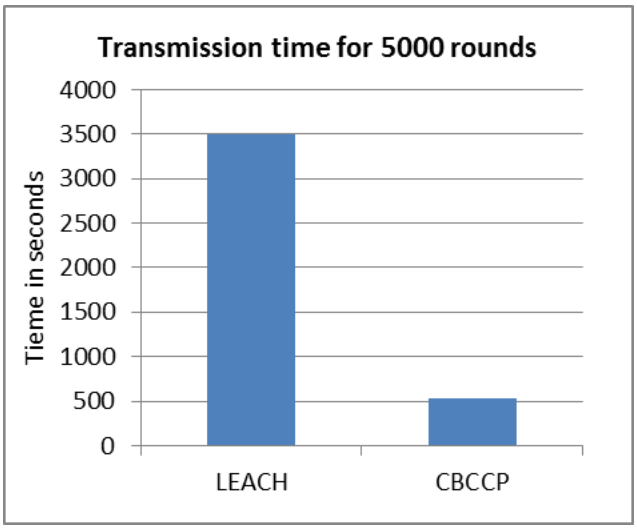

Fig. 3: CBCCP protocol transmission time

Fig. 3 shows the transmission time of CBCCP protocol. . Transmission time is defined as the time taken to transmit data packet from source to destination. Transmission time of CBBCP is 524 s, for transmitting data for 5000 times. CBCCP protocol outperforms LEACH protocol in terms of transmission time.

C. HEER protocol:

HEER protocol follows LEACH clustering method. Clusters are formed by using LEACH protocol [13]. The sensor nodes in the cluster form a single hop fully connected graph. The data transmission is performed by using Hamilton path that traverses a graph and ends at CH rather than all the nodes are transmitting data to the CH. This design is used to reduce the distance between the sensor nodes and CH. A sample path in a graph that passes through every vertex exactly once is called a Hamilton path. The Hamilton path is established by using greedy algorithm.

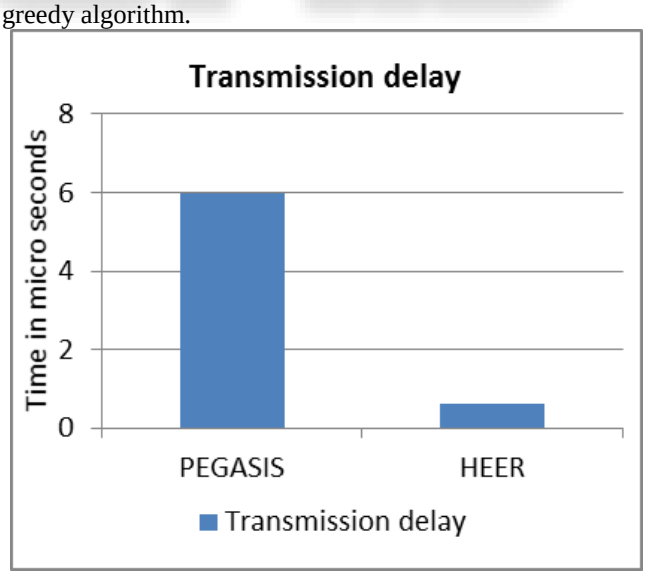

Fig. 4: HEER protocol transmission delay

Fig. 4 shows the transmission delay of HEER protocol. HEER protocol is used to reduce transmission delay by 90% compared to PEGASIS protocol.

D. MZ-LEACH protocol:

The multiple zonal approach MZ-LEACH protocol is based on LEACH protocol [14]. It creates Cluster Heads according to the LEACH protocol. This approach creates properly

partitioned triangle zones and provides appropriately a well CH repartition in the network in order to maximize the efficiency of communication.

The zones creation is based on the position of the sink, the distance between the CH and sink, as well as area dimension of the deployed network. In this approach, the network is divided into six zones; each triangle-zone contains the equal number of nodes. The sensor nodes in each zone are distributed randomly as the same approaches employed in LEACH protocol.

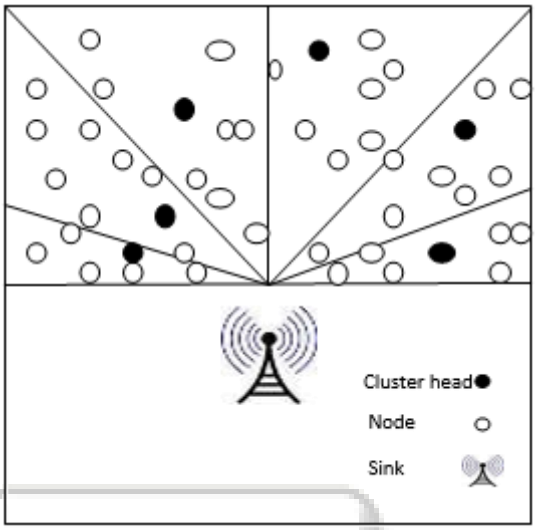

Fig. 5: Formation of multiple triangle zones

Fig. 5 illustrates the formation of multiple triangle zones in the proposed approach. Nodes in the zone 1 and zone 6 are distant from the sink by a distance less than the threshold value. Therefore, the CH's of the zone 1 and 6 use less energy than other zone's CH's. So the other zones use multi path energy model.

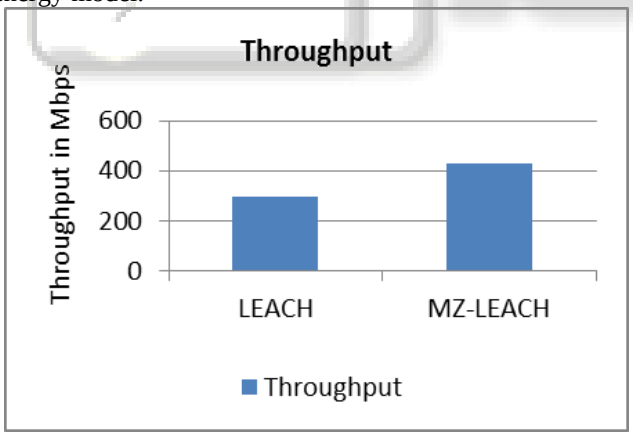

Fig. 6: MZ-LEACH Protocol Throughput

Fig. 6 shows the throughput of MZ-LEACH and LEACH protocol. In MZ-LEACH, the number of packets transmitted to the sink is significantly larger than transmitted packets in LEACH protocol.

E. NEAHC protocol:

NEAHC protocol used to maximize the network life time or minimize the total energy consumption [15]. The protocol consists of set up phase and steady state phase.

In setup phase, clusters are organized and nodes with low remaining energy are picked from each cluster, these nodes will fall asleep till next round. CHs are rotated in each round depending on the residual energy of nodes

In setup phase, each node chooses the random number from 0 to 1 and compares to a threshold value. If the chosen random number less than threshold value, then the node becomes the CH for the current round . Nodes with more residual energy have a better chance to become a CH.

Data transmission occurs in the steady state phase. Each non-cluster head node collects sensed data and directly send it to the cluster head within its unique time-slot comply with TDMA schedule of the cluster. After the cluster head finishes receiving all data from its all member nodes at the end of each frame it will aggregate the data, reduce redundant data and then choose a neighbor cluster head node as its next hop node. In this way the data reaches the sink.

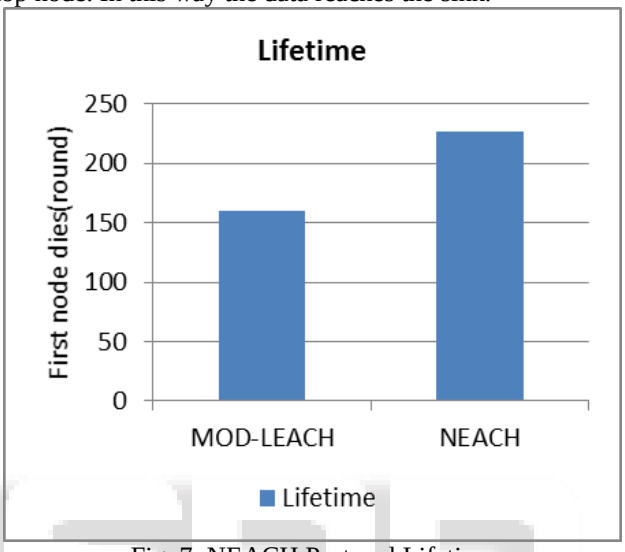

Fig. 7: NEACH Protocol Lifetime

Fig. 7 Shows The Lifetime Of NEACH Protocol. NEACH Protocol Has 39% Improved Lifetime Compared To MOD-LEACH Protocol.

Protocol	Advantages	Drawbacks
LEACH with fuzzy descriptors [11]	1. BS adopts many different paths to collect the information from the Super Cluster Head. 2. BS can relax collision by collecting the data from SCH. 3. SCH utilize bandwidth efficiently. 4. Fuzzy Logic is used to overcome the overheads of collecting and calculating energy and location information of each node.	1. Fault tolerance is not achieved. 2. Sensors are not scheduled to dormant state, it always in active state. 3. Data aggregation is not present.

CBCCP [12]	1. Cluster heads can use multi-hop communication for energy efficient routing. 2. Cluster heads and cluster coordinators use efficient path during data transmission. 3. Load is balanced to maximize the energy efficiency. 4. Number of nodes can be increased without any additional cost.	1. This protocol is developed only for limited applications.
HEER [13]	1. Cluster reformation is not required and the members on the path will take turns to become cluster head. 2. Cluster size control is introduced. 3. Minimize network management overhead.	1. The protocol is not applicable for mobile WSN. 2. Fault tolerance is not achieved.
MZ-LEACH [14]	1. It generates more cluster heads. 2. Energy consumption of cluster head is less. 3. Number of packets transmitted to the base station is large.	1. It is not applicable for mobile WSN. 2. Fault tolerance is not achieved.
NEAHC [15]	1. Minimum communication cost is utilized. 2. Direct data transfer by nodes. 3. CM nodes with low energy switches between sleep and active modes in order to balance energy consumption.	1. Some data packets are lost because certain cluster heads are not in the range of others.

Table 1: Summary of Advantages And Drawbacks Of Various Protocols

V. CONCLUSION

Wireless sensor networks have fascinated much concern for both civil and military applications. In this application, vast numbers of sensors are needed, it needs cautious architecture and network management. To support scalability, grouping of nodes into clusters has been important method in WSNs. In this paper, we focus a survey of few clustering based routing protocols in WSNs with highlighting their methodologies, advantages and disadvantages and also various performance metrics such as throughput, lifetime, end-to-end delay and transmission time are analyzed.

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