A Survey on Clustering, Energy Efficiency in Wireless Sensor Networks

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Abstract—this is the survey paper about the sensor networks and their issues mainly energy efficiency and which technique is efficient in balancing the energy consumption and how clustering can be useful in Wireless sensor network. Clustering comes under the category of hierarchical based routing which organizes the network in hierarchy of two levels: at upper level Cluster-head and at low level hierarchy which includes non cluster-head sensor nodes. Energy efficiency is coupled with the lifetime of the network.

Keywords—WSN, Clustering, LEACH, heterogeneous, network lifetime

I. INTRODUCTION

Sensor networks are highly distributed network of small light weight wireless sensor node which is deployed in large number to monitor the system and collect the information of various physical parameters like temperature, radiation, pressure, light etc. Each node of sensor network consists of three subsystems:
1) Sensor Subsystem which senses the environment.
2) Processing System perform local computations on the sensed data.
3) Communication Subsystem is responsible for message exchange with neighbouring sensor nodes.

Sensor networks are used for the following purposes:
(i) data acquisition – the collection of data from the environment
(ii) data dissemination – the delivery of information to other nodes in the network;
(iii) Data distribution – the delivery of information or instructions from the centralized sink to one or more sensor nodes in the network.

Characteristics of Network:
1) Autonomous: sensor network can be deployed anywhere without the requirement of existing infrastructure [3].
2) Mobility: the nodes can be placed in any geographical area to sense the information regarding climate [3].
3) Heterogeneity: In heterogeneous wireless network each node of the network can perform different task [3].
4) Scalability: A new node can be added in the existing network without affecting the sensor network [3].
5) Changes in topology: due to the environment conditions the small light weighed sensor nodes can be deviated from its current position to another location which cause change in topology of the network [3].
6) Data Centric Networking: sensor networks are data centric in which flow of data take place towards central sink

Issues related to wireless sensor network:
1) Self-maintaining: mostly sensor nodes are deployed in difficult geographical areas which cannot be configured manually. Sensor nodes must be equipped with self-configure and self-maintenance.
2) Energy Efficiency: If there is increase in efficiency of energy automatically the network life of sensor network will increase.

II. RELATED WORK AND MOTIVATION

An. Muhamad et al. [9] analyses energy consumption of three different protocols direct communication, minimum energy consumption, low energy adaptive clustering hierarchy for maximizing the network lifetime of wireless sensor network. It is found that LEACH is best among these three protocols for prolonging the network lifetime.

Boyinbode et al. [10] provides an overview on clustering algorithm for wireless sensor networks .This paper presented that small sensor nodes of wireless sensor network is an effective way of gathering the data in different environment and increase the scalability of wireless sensor network, the gathered data is communicated to the sink and then transmitted to the end user, and survey paper also focuses on challenges of clustering.
Dalei Wei et al. [11] proposes how size of cluster is determined by distributed clustering algorithm, energy efficient clustering and also evaluates the end to end energy consumption.

Vipin Pal et al. [12] focus on classification of clustering scheme and how they can increase the lifetime of the network by limiting the long distance communication.

Arvind et al. [13] presents survey on improving the lifetime of wireless sensor network and objectives and features of various clustering algorithm.

SC Sharma et al. [14] wireless sensor network have different strategies of communication and routing protocols on which communication strategies work. There are pros and cons of clustering schemes in wireless sensor network and give an overview of taxonomy of clustering routing methods.

Smaragdakis et al. [15] this paper proposes stable election protocol (heterogeneous aware protocol) which increases the stable period of the network by increasing high energy nodes.

Energy conservation is very important part of sensor network and has direct influence on network lifetime. There are two types of Routing protocols in wireless sensor network flat routing and hierarchical routing.

Flat routing: All nodes in the network have same functionalities and perform same task.

Hierarchical routing: In this type routing every node in the sensor network can perform different tasks according to the requirement of the situation [1].

In clustering, the created group of nodes are known as cluster and in each cluster there is one cluster head (CH) which can communicate with Base Station /sink and with other clusters of the sensor network. Clustering is an effective technique for organizing the network in hierarchy.

As compare to flat routing, hierarchical routing is beneficial for more scalability, robustness, and energy efficiency and less load [1].

Data aggregation reduces the energy consumption during transmission of data in sensor network. The process of data transmission is performed by cluster head in clustering which save energy. There are two types of clustering schemes: fixed and variable. In fixed, number of clusters and their cluster head is fixed.

In other one cluster head is selected randomly on the basis of some rules. The node selected as cluster-head in the cluster should have these characteristics mobility, capability, and energy efficiency etc. If cluster-head or nodes are mobile, then cluster membership should be dynamically change and need to be change periodically. Cluster head can aggregate the data directly or through the intermediate node. CH can transmit the data to base station through intermediate node.

The main objectives of clustering are: data aggregation, increase in network lifetime and, fault tolerance and load balancing.

Data Communication in clustered network:

Intra-cluster communication: The communication between the cluster-head and members in the cluster [2].

Inter-cluster communication: The communication between the cluster-head and base station/sink in the network [2].

Clustering routing method:

Centralized: in this global information of the network is required by the CH or sink [2].

Distributed: sensor node can become the cluster head on basis of its own capability without the need of global information.

Hybrid: It is the combination of centralized and distributed.

Due to the limitation of sensor nodes such as battery, power and memory, Energy efficiency is the major challenge in WSN. Energy efficiency has direct effect on network lifetime.

The network lifetime is measured by the time between the first node and last node dies. In this period of time network provides the service.

III. CLUSTERING PROTOCOL

A. LEACH

(Low energy adequate clustering hierarchy) is one of the important techniques of cluster based routing. In LEACH the cluster head and base station can be randomly rotated due to this, load of energy is evenly distributed among the sensor nodes of the network.

Leach is one-hop protocol, hierarchical, probabilistic and distributed. Distributed algorithm forms cluster where sensor nodes can take independent decision without the need of centralized control [4].

Balancing of energy consumption can be achieved by rotation of Cluster-head (CH) randomly and formation of cluster in each round dynamically.

\[ T(i) = \frac{p}{1-p^*(r \mod 1/p)} \quad \text{if } i \in G \quad \text{otherwise } T(i) = 0 \]

Here in this expression

- \( T \): random number chosen by node at rotation
- \( p \): round number
- \( G \): set of nodes that have not become Cluster-heads yet

Energy dissipation of the sensor network is minimized by turning off the radio components of the non CH sensor nodes, turn-on during the transmitting period data in the cluster. Cluster-head collects all the data and transmits the compressed data to the base station.
B. HEED:
Hybrid energy efficient distributed clustering. This clustering construction algorithm is energy efficient. The process of selecting the cluster head (CH) is different from LEACH. It depends on hybrid combination of two parameters: residual energy and intra-cluster communication cost.
Probability of node for cluster head: CHprob = Cprob (Eresidual/Emax)
Eresidual: current energy of the node
Emax: reference maximum energy

C. DWEHC:
Dien et al. [5] proposed Distributed weight-based energy-efficient hierarchical clustering protocol which is an improved version of HEED by constructing size of cluster in balance and consume low energy. Multi-level structure is formed for communication of intra-cluster.

D. EECS:
Ye at al. [6] proposed energy efficient clustering scheme. This scheme is efficient for an application which gathers the data periodically. In this scheme every node tries to become cluster head but node which have high residual energy will be selected as cluster head. It creates dynamic size of clusters based on the distance from base station.

E. BCDCP:
Base station controlled dynamic protocol forms the cluster in which each cluster head communicates with the equal number of member nodes. Every node of the network sends the information of their residual energy to the Base station and then base station evaluates the average energy of the nodes. The nodes with optimum energy are selected as cluster head and the nodes which are below the value average can perform as ordinary node. This protocol is centralized protocol in which task of clustering is performed by base station [7].

F. EEHC:
Energy efficiency Hierarchical clustering is a randomized, distributed protocol with the aim of increasing the lifetime of network. This approach is divided on two stages: initial and extended. In initial stage every node communicates itself as a cluster head to the neighbouring nodes through messages which fall under the range of k-hops. In extended stage cluster is extended to multi-level clustering [8].

G. EAP:
In this energy aware routing protocol which is heterogeneous every node of the cluster maintains the table of neighbouring node’s residual energy and then calculates the average residual energy of the nodes. The node which has residual energy higher than the average residual energy can be selected as cluster head with high probability. At set-up phase each node of the cluster update its table containing information of residual energy of neighbouring nodes. At steady-phase the cluster head transmit sensed data to the base station [12].

H. SEP:
Stable election protocol is heterogeneous aware protocol. There are two types of nodes which are considered as normal and advanced node. The heterogeneous parameters used in SEP are m and α. Here m represents the fraction of advance node and α is the energy factor by which advance node is compared with normal node [16].

IV. CONCLUSION
We have studied various clustering algorithm and protocols in wireless sensor network.

REFERENCES
[3] [Hwee Xian Tan, Quality of Service in Wireless Sensor Networks.


