CLUSTERING BASED ROUTING PROTOCOLS: A COMPARATIVE STUDY

Indu*

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Abstract:

A wireless sensor network consists of small low cost sensor nodes and having a limited transmission range. Their processing, storage capabilities and energy resources are limited. These networks collect information from nodes and transmit to base station for further processing. Energy and storage capabilities are a major problem to perform routing in wireless sensor network with such limitation of low power. There are many routing protocols like: location based, multipath, data centric, mobility based, hierarchical routing, hybrid routing etc. An Optimal Clustering technique can reduce the energy consumption in WSN and increase the lifetime of the network. In this paper we have studied and compared different clustering based energy efficient routing protocols of wireless sensor networks on various parameters.

Keywords: **energy conservation protocols, Network lifetime, wireless sensor network.**

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I. INTRODUCTION

Wireless Sensor Network (WSN) is a latest emerging technology during the last decades, lot of researchers doing effort to find a low cost and energy efficient wireless sensor network. WSN can connect information world with physical world together and using different applications such as remote healthcare, battlefield surveillance, land monitoring for smart farming and environmental monitoring. While designing algorithms and protocols of WSNs, several challenges occurs like maintaining connectivity and maximizing network lifetime are severe considerations [1]. A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices that use sensors to monitor physical or environmental conditions. These autonomous devices combine with routers and a gateway to create a typical WSN system. Basically a sensor node is made up of four components: a processing unit, a sensing unit, a communication unit, a power unit. A sensing unit is made up of one or many sensors and analog to digital convertor. Where the sensor nodes sense the physical phenomenon and generate the analog signal. Than these analog signals are converted into digital signals by ADC which are sensed by the sensors. They are fed into processing unit after the conversion of the signals. The processing unit has limited memory (storage) and processor (microprocessor) provides full control to sensor nodes. A communication unit use radio for data transmission b/w nodes. The sensor nodes are grouped for local aggregation i.e. clustering. When the sink is far away from the sensing region then the local aggregation is much better than direct communication. Therefore clustering works efficiently in such conditions or environments which aggregates the nodes into clusters. For a cluster, there is only one cluster head. Cluster heads can be chosen by sink or members of the clusters. For transmitting the data to the sink, cluster heads serve as relays. The cluster head of the cluster have the same transmission capacity as the sensor nodes. Data aggregation at cluster head reduces the number of data transmission to the sink and improves energy efficiency and lifetime of the network.

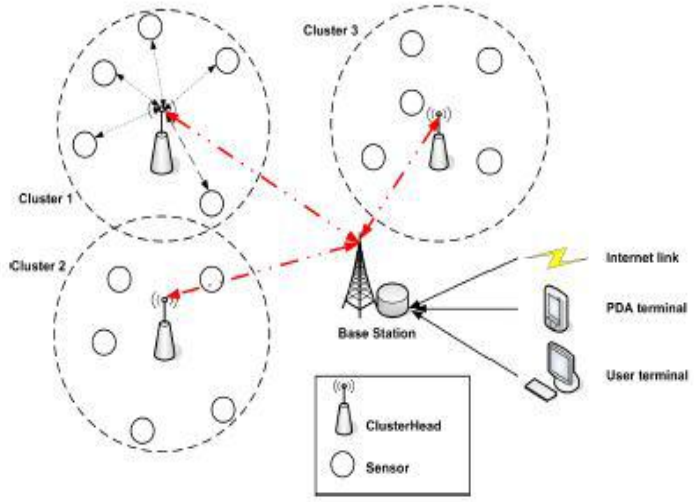

Figure1. Clustering Process in WSN

II. ENERGY-EFFICIENT CLUSTERING PROTOCOLS

Energy efficiency is a major consideration while designing WSN nodes. Most of the sensor network applications require energy autonomy for the complete lifetime of the node, which may span up to several years. These energy constraints require that the system be built such that Wireless sensor networks use battery-operated computing and sensing devices.

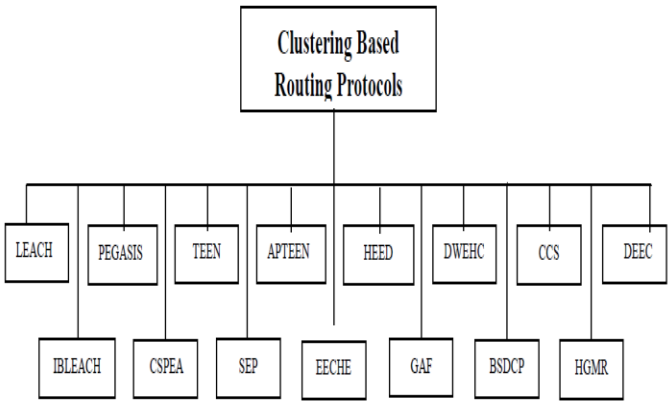

Fig2. Clustering based routing protocols

2.1 Low energy adaptive clustering hierarchical (LEACH)

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical cluster-based routing protocol for wireless sensor network, which partitions the nodes into clusters, Cluster Head (CH), a dedicated node with extra privileges in each cluster is responsible for creating and manipulating a TDMA (Time division multiple access) schedule and sending aggregated data

from nodes to the BS where these data is needed using CDMA [2]. Remaining nodes are cluster members. LEACH is divided into rounds; each round consists of two phases:

- Setup phase
- Steady phase

2.2 Threshold-sensitive energy-efficient sensor network protocol (TEEN)

TEEN (Threshold sensitive Energy Efficient sensor Network protocol) is a hierarchical clustering protocol, that groups sensors into clusters with each led by a CH (cluster head). The sensors within a cluster report their sensed data to their CH [3]. Then CH sends the aggregated data to higher level CH until the data reaches the sink. In this scheme, as every cluster in addition to the attributes, change time, the cluster-head broadcasts to its members the following:

- Hard Threshold: This is a threshold value for the sensed attribute. Hard threshold is the absolute value of the attribute beyond which, the node sensing this value should switch on its transmitter and report to its cluster head.
- Soft Threshold: Soft threshold is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit.

2.3 Constrained shortest path energy aware routing (CSPEA)

Network is divided into clusters where each cluster has a cluster head and a gateway node is used to connect them. Estimation of energy consumption can be made by calculating distance from source to destination. Energy efficiency can be achieved by choosing best path for data routing. It is the best approach as it entails less control packet overhead.

2.4 Power-efficient gathering in sensor information system (PEGASIS)

A chain of sensor nodes is made instead of clusters and all the nodes in the chain can transmit and receive data from its neighboring nodes. The node which starts transmitting data is called as an end node. Than in the chain the other nodes starts receiving data and send the data after aggregating it to its next neighbor. This whole process continues till the last node in the chain which is elected as leader node [4].

2.5 Distributed energy-efficient clustering (DEEC)

It is also based on LEACH protocol and used for heterogeneous WSN. The wireless sensor network is divided into clusters and each cluster head is chosen by a probability of ratio between residual energy of each node and average energy of the network. DEEC is better than LEACH, SEP because it has longer lifetime [5].

2.6 Distributed Weight-based Energy-efficient Hierarchical Clustering protocol (DWEHC)

DWEHC is very much similar to HEED protocol. DWEHC improves HEED by making balanced cluster sizes and also optimize the intra-cluster topology using location awareness of the nodes. DWEHC also consider residual energy in the process of CH election. It creates a multi-level structure for intra-cluster communication and limits a parent node's number of children.

2.7 Concentric Clustering Scheme (CCS)

Concentric Clustering Scheme reduces the energy consumption loopholes in PEGASIS. CCS considers the location of the BS to enhance the lifetime of the network. In CCS, whole network is divided into a variety of concentric circular tracks. Each circular track is assigned with a level. The track nearest to the base station is assigned with level-1 and the level number increases with the increase of the distance to the BS.

2.8 Energy-efficient cluster head election protocol (EECHE)

It is the improved version of Prim's algorithm. Additional energy resources are used by some sensor nodes. The cluster head broadcast the TDMA schedule to all sensor nodes and based on that TDMA schedule the sensor nodes participate in the network operations. Otherwise when they are not participating they will turn off their radio. This process minimizes the energy consumption.

2.9 Hybrid Energy-Efficient Distributed Clustering (HEED)

Hybrid Energy-Efficient Distributed clustering is different from LEACH in the manner of CH election; HEED does not select nodes as CHs randomly. Based on the hybrid combination of two parameters, cluster formation is performed. One parameter is the intra-cluster communication cost and the other parameter depends on the node's residual energy. In HEED [6], elected CHs have relatively high average residual energy compared to member nodes.

2.10 Base-Station Controlled Dynamic Clustering Protocol (BCDCP)

This is a centralized clustering routing protocol. In BCDCP the cluster formation is done and to balance cluster head overload, each CH serves an almost equal number of mobile nodes. At the beginning of cluster setup, the base station receives information on the residual energy from all the nodes in the network. Based on the information, the BS computes the average energy level of all the nodes in the network and then chooses a set of nodes whose energy levels are above the average value. CHs can be elected only from the chosen set for the current round. Based on the picked set, the base station performs the task of clustering [7].

III. COMPARISON OF CLUSTERING BASED ROUTING PROTOCOLS ON VARIOUS PARAMETERS

Protocol name	Delivery delay	Load balancing	Energy efficiency
LEACH	Very Small	Medium	Very Poor
TEEN	Small	Good	Very High
APTEEN	Small	Medium	Medium
GAF	Poor	Medium	Medium
CSPEA	Medium	Medium	High
PEGASIS	Very Large	Medium	Poor
SEP	Very Small	Good	Medium
HGMR	Medium	Poor	Poor
DEEC	Very Small	Good	High
DWEHC	Medium	Very Good	Very High
IBLEACH	Very Small	Very Good	Very High
CCS	Large	Very Poor	Poor
EECHE	Small	Very Good	Very Good
HEED	Medium	Medium	Medium
BCDCP	Small	Good	Very Poor

IV. CONCLUSION AND FUTURE RESEARCH

The main aim of energy efficient cluster based protocols is to efficiently maintain the energy usage of sensor nodes by involving their participation in multi-hop communication within a particular cluster because clustering plays an important role for energy saving in wireless sensor networks. With clustering in wireless sensor networks, energy consumption, lifetime of the network and scalability can be improved. In this paper we have surveyed the past research works which mainly focuses on energy efficient clustering based routing protocols for wireless sensor networks and we have systematically analyzed a few classical WSN clustering routing protocols, and compared these different approaches based some primary metrics. Further research would be needed to address issues related to Cluster formation, cluster head communication and data fusion etc.

V. REFERENCES

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