Survey on Clustering Approach for Wireless Sensor Networks

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Abstract— Wireless sensor network is emerging field because of its wide applications and least cost. It is a wireless network which subsist a group of small sensor nodes which communicate through radio interface. These sensor nodes are composed of sensing, computation, communication and power as four basic elements. But limited energy, communication capability, storage and bandwidth are the main resource constraints. Our survey is based on various aspects of wireless sensor networks. In this paper we also focused various Architectures of wireless sensor networks, Clustering Approach, and Different versions of LEACH Protocol.

Key words: Multi-Hopping, Intra- Cluster, Inter-Cluster, Data –Fusion, Fusing

I. INTRODUCTION

Wireless sensor networking is an emerging technology that promises unprecedented ability to monitor and manipulate the physical world via a network of densely distributed wireless sensor nodes. Recent advancement in Micro-electronic-mechanical-systems (MEMS) and wireless communication system, tiny, cheap and smart sensor nodes collaborated with wireless links and the internet deployed in physical area which provide many opportunities in various applications, for example battle field surveillance, environment monitoring, and health care applications.

Wireless Sensor Network is a special kind of non-infrastructure networks capable of wireless communication having large number of low-cost sensor nodes with limited power and multi-functional capability. A typical sensor node includes four basic components: a sensing unit,a processing unit, a communication unit, and a power unit as in figure 1.

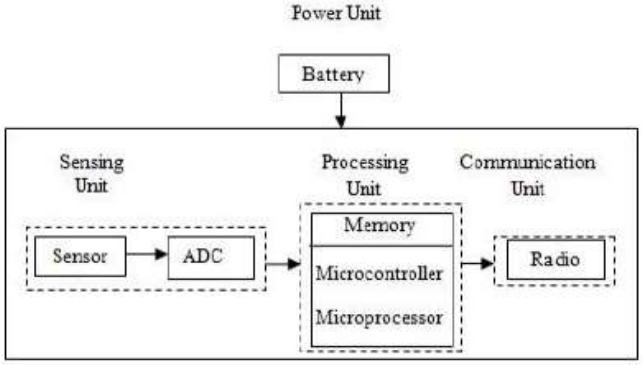

Fig. 1: Sensor Node Structure [1]

WSNs are not centralized one as no static infrastructure exists. Peer-to-peer communication exists between nodes. Multi-hopping can cause a sensor node to communicate with a node that is not in radio range of each other via intermediate nodes. So WSN provides flexibility of adding or removing nodes in the network [1].

A. *Architectures of Wireless sensor Networks*

- Data-centric architectures
- Hierarchical architectures
- Location-based architectures
- Mobility-based architectures
- Quality of Service (QoS) architectures
- Network flow architectures
- Multipath-based architectures
- Heterogeneity-based architectures

B. *Hierarchical Architectures*

The main goal is to efficiently maintain network power consumption even in large-scale networks.

Most hierarchical architectures consist of sensor nodes grouped into cluster heads. Cluster heads build intra-cluster communication with other nodes within the same cluster, but they also build inter-cluster communicate with other cluster heads. Cluster heads aggregate data obtained individual sensors and then transfer the same information mostly in a multi-hop approach to the base.

II. CLUSTERING APPROACH

In This Clustering approach, In order to support data aggregation through efficient network organization, nodes can be partitioned into a number of small groups called clusters. This phenomenon of grouping sensor nodes into clusters is called clustering. Every cluster would have a leader, commonly referred to as cluster-head (CH). A CH may be elected by the sensor nodes in the cluster or preassigned by the network designer. A CH may also be just one of the sensors or a node that is generally richer in resources. The cluster membership may be fixed or variable.

There are several advantages in clustering phenomenon. The basic advantage is that, it supports network scalability. It can localize the route setup within the cluster. Clustering can also conserve communication bandwidth. Moreover, clustering can stabilize the network topology at the level of sensors and thus cuts on topology maintenance overhead. The CH can also implement optimized management strategies to prolong the battery life of the individual sensors and to maximize the network lifetime [2].

A. *Various types of Clustering Algorithms*

In Hierarchical topology, nodes perform different tasks in WSNs and organized as clusters based on different metrics. Generally, each cluster contains one or more Cluster Heads and the CHs can be organized into further hierarchical levels. The Popular clustering routings protocols in WSNs include Low-energy Adaptive Clustering Hierarchy (LEACH), Hybrid Energy-Efficient Distributed clustering (HEED), Energy Efficient Clustering Scheme (EECS), Energy-Efficient Uneven Clustering (EEUC) algorithm, Threshold sensitive Energy Efficient sensor Network protocol (TEEN), The Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN), *etc*. Clustering routing is becoming an active branch of routing technology in WSNs on account of a variety of advantages,

such as more scalability, data aggregation/fusion, less load, less energy consumption, more robustness, *etc*. Among these clustering algorithms, Low Energy Adaptive Clustering Hierarchy (LEACH) is the First energy efficient routing protocol for Hierarchical clustering. It reduces the energy significantly [3].

B. LEACH

Low-Energy Adaptive Clustering Hierarchy (or LEACH) was one of the first major improvements on conventional clustering approaches in wireless sensor networks. Conventional approaches algorithms such as MTE (Minimum-Transmission-Energy) or direct-transmission do not lead to even energy dissipation throughout a network.

LEACH provides a balancing of energy usage by random rotation of cluster heads. The algorithm is also organized in such a manner that data-fusion can be used to reduce the amount of data transmission.

The decision of whether a node elevates to cluster head is made dynamically at each interval. The elevation decision is made solely by each node independent of other nodes to minimize overhead in cluster head establishment. This decision is a function of the percentage of optimal cluster heads in a network (determined a priori on application), in combination with how often and the last time a given node.

Distributed clustering is the mechanism in which, there is no fixed central CH and the CH keeps on changing from node to node based on some pre-assigned parameters. distributed clustering algorithms for WSNs is presented, based on some advantages like efficient utilization of communication bandwidth within the clusters, avoiding redundant message transfer between the sensor nodes, localizing energy efficient route setup within the clusters, reduction in energy consumption, etc.

LEACH is a clustering mechanism that distributes energy consumption all along its network, the network being divided into clusters and CHs which are purely distributed in manner and the randomly elected CHs, collect the information from the nodes which are coming under its cluster.

LEACH protocol involves four main steps for each round: Advertisement phase, cluster set-up phase, schedule creation and data transmission.

In the first step, the advertisement phase the eligible CH nodes will be issuing a notification to the nodes coming under them to become a cluster member in its cluster. The nodes will be accepting the offer based on received signal strength (RSS).

In the cluster set-up phase the nodes will be responding to their selected CHs.

In schedule creation step, as the CH receives response from the nodes it have to make a TDMA scheme and send back to its cluster members to intimate them when they have to pass the information to it.

In the data transmission step, the data collected by the individual sensors will be given to the CH during their time intervals. The main constraint here is that, the radio of the cluster members will be turned off to reduce energy consumption after the data transmission during particular slot is finished. Here in LEACH protocol, multi-cluster interference problem was solved by using unique CDMA codes for each cluster. The energy drain is prevented for the same sensor nodes which have been elected as the cluster leader using randomization, for each time CH would be changed. The CH is responsible for collecting data from the cluster members and fusing it. Finally each CH will be forwarding the fused data to the base station. When compared with the previous protocols, LEACH has shown a considerable improvement mainly in terms of energy-efficiency [4].

III. DESCENDANTS OF LEACH ROUTING PROTOCOL

A. LEACH-C (Centralized Low Energy Adaptive Clustering Hierarchy)

Centralized LEACH has steady-state same as basic LEACH protocol but varies in set-up phase. The cluster head nodes are chosen by base station. Each node send its current location and energy level to the base station and the base station uses this global knowledge via GPS or other tracking methods to produce better clusters require less transmission energy. The base station will choose only those nodes to become cluster head nodes which have enough energy level and broadcast this information to all nodes in the network.

Advantage of this protocol over basic LEACH is the deterministic approach of choosing number of cluster head nodes in each round which is predetermined at the time of deployment. LEACH-C causes better distribution of cluster head nodes in the network. But LEACH-C requires current location information of all nodes using GPS which is not robust [6].

B. LEACH-F (Fixed number of cluster Low Energy Adaptive Clustering Hierarchy):

This LEACH-F protocol uses centralized approach for cluster formation Like LEACH-C protocol. Once the cluster formation process is done, then there is no re-clustering phase in next round. The clusters are fixed and only rotation of cluster head nodes within its clusters. The steady-state is same as classical LEACH.

The overhead of re-clustering in basic LEACH is removed by LEACH-F protocol as once the fixed number of clusters is formed; they are maintained throughout the network. But this protocol provides no flexibility of adding or removing the nodes once clusters are formed and nodes cannot adjust their behaviour on node dying [7].

C. LEACH-B (Balanced Low Energy Adaptive Clustering Hierarchy):

LEACH-B uses decentralized approach of cluster formation in which each sensor node knows about its own position and position of final destination irrespective of position of rest of the nodes in the network. LEACH-B works in three stages: Cluster head selection, Cluster formation and data transmission with multiple accesses. According to energy dissipated in the path between a node and final receiver, each node chooses its cluster head. LEACH-B has better energy efficiency than basic LEACH protocol [8][9].

D. TL-LEACH (Two level Low Energy Adaptive Clustering Hierarchy):

Unlike LEACH protocol where cluster heads send data to the base station directly in a single hop, TL-LEACH

protocol works in two-level hierarchy. The aggregated data from each cluster head is collected by a cluster head lies between cluster heads and the base station, instead of sending directly to the base station.

Advancement of this protocol reduces data transmission energy. Cluster head nodes die early compared to other nodes, far away from base station and TL-LEACH improves energy efficiency by using a cluster head node as relay node in between cluster head nodes [10].

E. LEACH-E (Energy Low Energy Adaptive Clustering Hierarchy):

In LEACH-E protocol, initially all nodes have same energy and same probability of becoming the cluster head. After the first round, energy level of each node changes. Then the amount of residual energy of each node is used to select cluster head nodes. The nodes with highest residual energy are preferred on rest of the nodes. LEACH-E enhance lifetime of network by balancing energy load among all nodes in the network [11].

F. MH-LEACH (Multi-Hop Low Energy Adaptive Clustering Hierarchy):

In LEACH protocol, the cluster head nodes send data to the base station directly irrespective of distance between them. This will cause high energy dissipation of cluster head node if base station is located far away from it. As the network diameter increases, the distance between base station and cluster head nodes increases. To increase energy efficiency of the protocol, multi-hoping communication is introduced. Firstly cluster member nodes send data to their respective cluster head nodes which further transfer data to cluster head rather than base station directly. This protocol adopts an optimal path between cluster head and the base station [12].

G. LEACH-M (Mobile Low Energy Adaptive Clustering Hierarchy):

LEACH-M protocol was proposed for mobility issue in LEACH protocol. This protocol provides mobility to the both non-cluster head nodes and cluster head nodes while the set-up and the steady-state. Nodes are homogeneous and location of each node is calculated by GPS. The nodes with minimum mobility and the lowest attenuation are being selected as cluster head nodes and the role of cluster head nodes is broadcasted to all nodes within its transmission range [13].

H. I-LEACH (Improved Low Energy Adaptive Clustering Hierarchy):

Detection of Twin nodes and assignment of Sub-Cluster Head (SCH) nodes are the two functions served by Improved-LEACH protocol. Randomly deployment of nodes results in high probability of two nodes located very close to each other called Twin nodes. It is necessary to keep one node sleep until the energy of another node depletes. Therefore I-LEACH has uniform distribution of cluster head so that it doesn't run out of energy when longer distance transmission takes place. This protocol uses threshold approach for managing number of cluster members for each cluster head in the network at a time [9][11].

I. LEACH-A (Advanced Low Energy Adaptive Clustering Hierarchy):

LEACH protocol has a problem that the cluster head node consumes more energy than normal nodes. Advanced-LEACH protocol, a heterogeneous protocol used to decrease probability of failure nodes and for extending the time interval before the death of the first node (called stability period). Each sensor knows the starting of each round using synchronized clock. Let n be the total number of nodes and m be the fraction of n that have energy more than other nodes called CGA nodes (nodes selected as gateways or cluster heads). The rest of (1-m)*n nodes act as normal nodes.

Advantages of using LEACH-A protocol are:

- Distributed Algorithm where clusters configuration is independent of the base station.
- TDMA/CDMA techniques save maximum energy by allowing clusters' hierarchy on different levels.
- CAG nodes will continue to send data even after failure of all normal nodes [14][13][15].

J. Cell-LEACH (Cell Low Energy Adaptive Clustering Hierarchy):

In Cell-LEACH, WSN is divided into number of clusters where each cluster is further divided into 7 sections called cells. Several sensors are included within each cell from which one sensor node is selected as cell-head. No re-clustering and re-celling is done once formed. Each cell node sends data to the cell head at its designated time given by TDM. Data aggregation function is performed by cell heads and processed data is sent to cluster heads. Cluster heads perform the same function as cell heads and transfer data to the base station.

After first round, the cell head and the cluster head will be determined randomly [16][11].

K. V-LEACH (Vice Cluster Head Low Energy Adaptive Clustering Hierarchy):

In classical LEACH protocol, the cluster head node consumed more energy as compared to normal nodes in sending aggregated data to the base station (located far away). Therefore the cluster head node dies early and the whole cluster will become useless, results data loss.

V-LEACH improves this drawback having vice-cluster head in each cluster that takes the role of cluster head when cluster head dies. In this way, this protocol reduces overhead of selecting new cluster head each time when a cluster head dies and the data will always reach to the base station. Hence network lifetime increases [17][10].

L. LEACH ERE (Low Energy Adaptive Clustering Hierarchy Expected Residual Energy):

A Fuzzy Logic based Approach with a extension to the Energy predication to prolong the Lifetime of wireless sensor Networks for fixed nodes is proposed by Jin-Shyan Lee et.al.(2012) . The expected residual energy and residual energy introduced as Fuzzy descriptors during the on-line Cluster Head selection process.

LEACH ERE is more efficient than other distributed Algorithms [5][18].

IV. CONCLUSION

Wireless Sensor Network is one of the emerging fields in research area. Wireless sensor network has a feature to monitor environmental and physical conditions. In this paper we discussed various Architectures of wireless sensor networks, Clustering Approach, and also discussed descendants of LEACH Protocol.

In the future, the wide range of application areas will make sensor networks an integral part of our lives. Wireless sensor network has bright future in the field of networking because it continuingly providing us solutions for many monitoring problems. Also we can conclude that to make the Wireless sensor network energy efficient is one of the great areas for future work.

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