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Simulation of Low Energy Adaptive Clustering Hierarchy Protocol for Wireless Sensor Network

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Abstract- Recent advances in wireless sensor networks have settled into an important part of one's everyday life and gained attention from both the research community and actual users. In wireless sensor networks energy alertness is an essential consideration & it explored to many new protocols specifically designed for sensor networks. Most of rank, given to hierarchical routing protocols based on clustering because of scalability .In this paper we analyze the routing challenges & design issues involved in the wireless sensor networks and present the overall working of LEACH protocol and its SIMULATION .As a result, it reveals & provides not only a measure for performance calculation of sensor networks but also a guideline while designing & evaluating new protocol for wireless sensor networks.

Keywords- Wireless Sensor network, Low Energy Adaptive Clustering Hierarchy, Cluster head, Routing Challenges, Simulation

I. INTRODUCTION

WSN (wireless sensor network) is in demand from recent years; it emerged as a promising tool for monitoring the physical world where wired network can't reach such as under water, remote areas, machinery etc. In WSN sensors are integrated into structure, machinery, and deliver the sensed information. A wireless sensor networks (WSN) consists of spatially distributed tiny autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location.[1][2]. The network must possess self-organizing capabilities since the positions of individual nodes are not predetermined. Cooperation among nodes is the dominant feature of this type of network. WSN has various features like it consumes very little power, smart & software programmable , scalable and capable of fast data acquisition, installation cost is less last but not the least no real maintenance is required.

Some of the important application [3][4][5] domains of WSNs are listed below:

- Emergency Situations
- Health & Medical
- Habitat monitoring
- Biological, nuclear, radiological and explosive material
- Home networks, Industrial fields
- Military environment etc.

II. ROUTING CHALLENGES & DESIGN ISSUES IN WSN

Firstly sensor networks was mainly motivated by military applications but later on civilian applications have been considered such as environmental monitoring, health monitoring etc.[2] A sensor network design is influenced by many factors, which include fault tolerance; scalability; production costs; operating environment; sensor network topology; hardware constraints; transmission media; and power consumption. To meet the performance, following design issues [5] [6] [7] of the sensor networks have to be measured.

A. *Fault Tolerant Communication*

Some sensor nodes may fail or be blocked due to lack of power, have physical damage or environmental interference. Due to faulty and unreliable nodes some nodes cannot communicate other nodes. Thus, the framework can be resilient to the advent of faulty nodes. Therefore failure of sensor nodes should not affect the overall task of the sensor network.

B. Low Latency

The events which are urgent should be recognized immediately by the operator. Therefore, the framework has to detect and notify the events quickly as soon as possible. Latency should be minimum for WSN

C. Scalability

A system, whose performance improves after adding hardware, proportionally to the capacity added, is said to be a scalable system. In this network the number of sensor nodes may vary in the order of hundreds, thousands or more. The new schemes must be able to work with this number of nodes.

D. Power Consumption

Power may be either stored (e.g., in batteries) or scavenged from the environment (e.g., by solar cells). Transmission power is directly proportional to distance squared or even higher order in presence of obstacles. Nodes lifetime is strongly dependent on its battery lifetime.

E. Operating Environment

We use sensor network in home or large buildings, in battle field, at the bottom of an ocean, in machinery, in vehicles, in forest for habitat monitoring.

F. Data Delivery Models

It determines when the collected data has to be delivered. Depending on the application the delivery model can be classified into Continuous, Event-Driven, Query-Driven and Hybrid [8]. In continuous delivery model, sensor sends data periodically. In event driven delivery model, occurrence of event trigger the transmission of data. In query driven model, transmission of data is triggered when query is generated by sink. Hybrid delivery model is the combination of continuous, event-driven and query-driven data delivery models.

G. Transmission Media

In a multihop sensor network, communicating nodes are linked by a wireless medium. These links can be formed by radio, infrared or optical media. To enable global operation of these networks, the chosen transmission medium must be available worldwide.

H. Data Aggregation/Data Fusion

Data aggregation is the combination of data from different sources. Data aggregation is done to remove redundancy and to minimize the number of transmissions. Data aggregation is done locally. This technique is used to solve the implosion and overlap problems in data centric routing

I. Node Deployment

Node deployment is application dependent. The deployment is either deterministic or self-organizing. In deterministic situation, the sensor nodes are manually placed and routing of data is done through predetermined path. In self-organizing situation, the sensor nodes are scattered randomly creating an infrastructure in adhoc manner. In this situation the position of sink is also crucial in term of energy and performance.

III. LEACH PROTOCOL PHASES

Low –Energy Adaptive Clustering Hierarchy (LEACH) protocol for sensor networks is proposed by W. R. Heinzelman et. al [9] [10] which minimizes the energy dissipation in wireless sensor networks. LEACH is one of the first hierarchical routing approaches for sensor networks. In this algorithm formation of clusters is done on the basis of the received signal strength. The main objective of LEACH is to provide data aggregation for sensor networks. [11]. In LEACH protocol the total nodes are divided into many small groups or cluster for equal distribution of power consumption inside the network as shown in Fig. 1 [5].

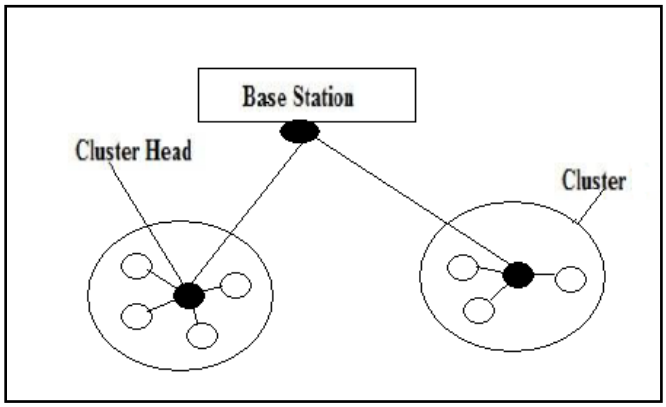

Fig. 1: cluster based mechanism of LEACH in WSN

The cluster head can be selected randomly and then rotate this role to evenly distribute the energy load among the sensors in the network. The node n chooses a random number between 0 and 1 and the nodes becomes a cluster head for the current round if the number is less than the threshold T (n).

$$T(n) = \begin{cases} \frac{p}{1-p*(r \bmod \frac{1}{p})} & \text{If } n \in G \\ 0 & \text{otheriwse} \end{cases}$$

Where *p* is the desired percentage of cluster heads (e.g. 0.05), *r* is the current round and *G* is the set of nodes that have not been cluster heads in last 1/p rounds. There is only 5% of the nodes need to act as cluster head which act as a router to the base station.

The clusterhead (CH) nodes compress all the data arriving from nodes that belong to the respective cluster, and send an aggregate data to the base station. Data aggregation is done to reduce the amount of information that must be transmitted to the base station. Data aggregation is local to the cluster [10]. This protocol is divided into rounds and each round consists of two phases [10] [12]:

A. SET-UP PHASE
1. Advertisement Phase
2. Cluster Set-up Phase

B. STEADY PHASE
1. Schedule Creation
2. Data Transmission

In setup phase, the clusters are organized and cluster heads are selected. Each node decides independent of other nodes if it will become a CH or not. This decision is based on when the node served as cluster head for last time; the node that has not been cluster head for long time has more probability to elect.

In advertisement phase cluster head send the advertisement packet to inform their neighbors that they become cluster head. Non cluster head nodes pick the advertisement packet on the basis of received signal strength. As shown in Fig. 2

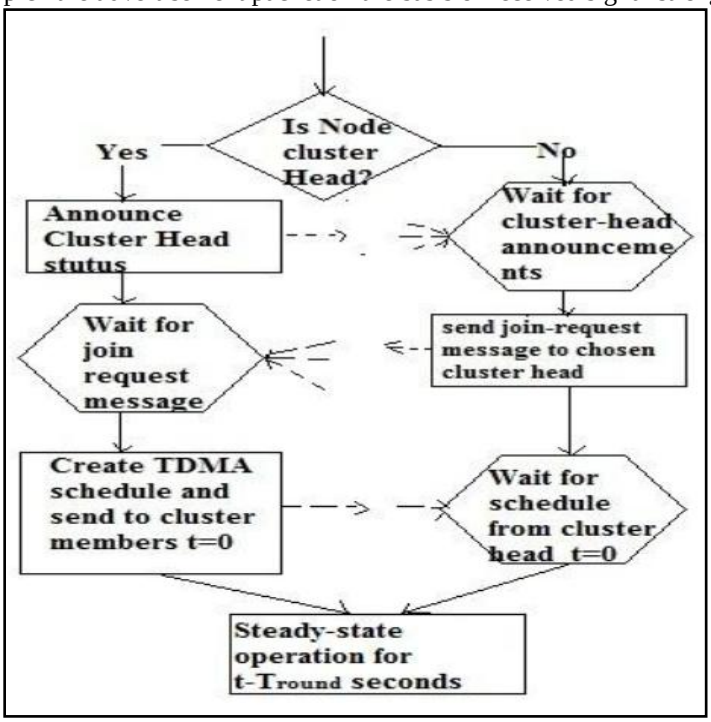

Fig. 2 Flowchart of Set-up phase of LEACH Protocol

In Cluster setup phase, the non-cluster head nodes inform the cluster head by sending the "join packet" which contains their IDS using CSMA that they a member to that cluster. After knowing the number of member nodes and their IDs, the cluster head creates a TDMA schedule, pick CSMA code randomly and transmit the TDMA table to member nodes.

In Steady phase the data is actually transfer to the base station. The duration of steady phase is longer than setup phase in order to minimize overhead. In steady phase nodes send their data to cluster head during their allocated TDMA slot as shown in Fig. 3.

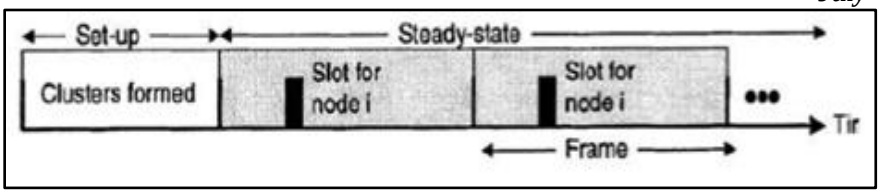

Fig. 3 Time Line operation of LEACH [10]

This transmission uses a minimal amount of energy (chosen based on the received strength of the cluster-head advertisement).The radio of each member can be turned off until the nodes allocated TDMA slot, for minimizing the energy dissipation in nodes. After reception of all the data cluster head aggregate the data and send it to the base station. LEACH reduces the amount of data by performing local aggregation. When n k-bit of messages has collected by cluster head in its cluster then it compresses the data to a μ (n * k) – bit message and transmit this message to base station, where $\mu \leq 1$ is the compression coefficient [12].

IV. ADVANTAGES & DISAVANTAGES OF LEACH PROTOCOL

Various advantages of LEACH [13] are as follow:

- Outperforms conventional routing protocols
- LEACH is completely distributed, requiring no control information from the base station
- No global knowledge of network required.

Besides these advantages LEACH suffers from many drawbacks [13] [14] such as:

- Extra overhead to do dynamic clustering.
- Cluster head selection is randomly that doesn't take into account energy consumption
- LEACH is not able to cover large area.
- Cluster heads are not uniformly distributed

V. SIMULATION

In simulation we evaluated the performance of LEACH protocol in terms of number of dead nodes. With this simulation the life time of LEACH protocol is revealed.

The graph in the fig. 4 shows the number of dead nodes in the network. Initially there was zero number of dead nodes in the network. But when transmission begun the number of dead nodes increases rapidly. The energy consumption of nodes increases and finally approaches to zero.

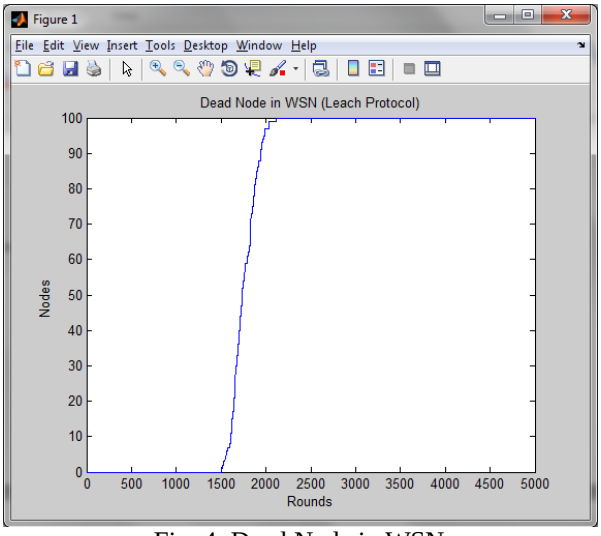

Fig. 4: Dead Node in WSN

As we can see the first node dead at round 1500 and till 2200 rounds all nodes get dead.

VI. CONCLUSION

This paper presents the overview of wireless sensor networks and their routing challenges and design issues that is faced in designing a protocol for sensor networks. After that well-known hierarchical protocol for wireless sensor networks called LEACH protocol which is the first and the most important protocol in wireless sensor network, which uses cluster based broadcasting technique is discussed. Then given LEACH's advantage & disadvantages & its simulation which simulate the dead nodes in the network.

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