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ETEEC: Enhanced Threshold Energy Efficient Clustering Algorithm for Dynamic Wireless Sensor Networks

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Abstract- **A sensor may be deployed in an open space; on a battle field in front of, or beyond, enemy lines; in the interior of industrial machinery; at the bottom of water Body; in a biologically and chemically contaminated field; in a commercial building; in a home; or in on a human body. It is not possible to recharge the batteries in all environments and hence lifetime of a sensor is very crucial. So to increase the lifetime, the sensors are grouped into clusters and information is exchanged with base station via cluster head. An energy efficient cluster head selection technique is required to increase the lifetime of WSN. The traditional LEACH protocol selects the cluster head by random time which may select low energy sensors as cluster head. In this paper, the cluster head selection is based on energy variable and mean distance of neighboring nodes. This methodology is implemented using both CDMA and TDMA approaches and results show that using the CDMA approach reduces the energy consumption and improves the network lifetime compared to TDMA approach.**

Keywords-CDMA, cluster-head, wireless sensor networks, TDMA.

I. INTRODUCTION

The important issues of WSNs are sensor type, sensor placement, and sensor power consumption, operating environment, connectivity and telemetry. Sensor networks require sensing systems that are long-lived and environmentally resilient. Untethered, unattended, self-powered low-duty-cycle systems are typical. The design, implementation and operation of a sensor network requires the confluence of many disciples, including signal processing, networking and protocols and so on and these networks are often deployed in resource-constrained environments such as energy and bandwidth. All the nodes of wireless sensor network have to sense data in the network and must be transmitted to the base station through the cluster head. Since all the nodes are involved in transmitting the sensed information their energy gradually reduces. One of the major reasons is the limited energy supplied for each node. Therefore an effective energy efficient cluster-head selection (ETEEC) algorithm is required for wireless sensor networks. By using the CDMA approach over the TDMA approach it is possible to increase the lifetime of the network. The lifetime is evaluated by considering the time taken to be the time at which the first node or the last node dies out of energy (application specific)

The LEACH protocol elects the cluster head randomly through a fixed probability which means all the nodes have equal probability of becoming a cluster head. In this protocol there is no effective mechanism for locating the leader in the network. There is possibility of low energy nodes becoming a cluster-head leading losing its energy soon when it communicates with all other nodes and base station. In PEGASIS, the protocol aims at extending the lifetime of a network by achieving a high level of energy efficiency and uniform energy consumption across all network nodes. This protocol also reduces delay that occur on their way to sink. Here we use the concept of selecting cluster-head by considering the energy variable, delay and distance between neighboring nodes to maintain the uniform energy among the nodes. The CDMA approach can further increase the life time of the network which reduces the interference between the communicating nodes.

II. CHALLENGES AND HURDLES OF WSN

The WSNs face the following challenges and limitations.

A. Size

Sensor consists of four components namely power unit, sensing unit, processing unit and a transceiver unit. It also

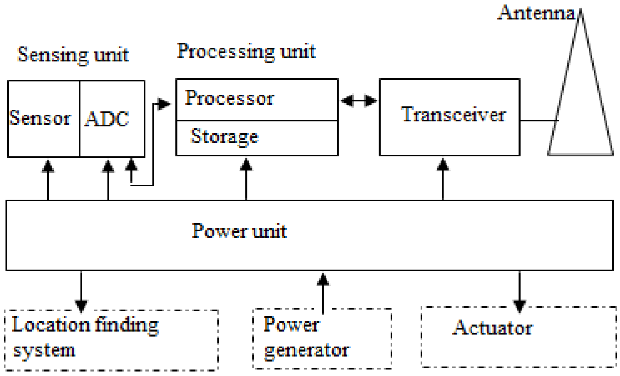

Fig 1 Sensing node architecture

includes optional components such as location-finding system, a power generator, a control actuator and other application dependent elements. Sensor should include all these components in the order 2cm × 5cm × 1cm or even as small as 1cm × 1cm × 1cm

B. Power Consumption

Wireless sensor node has limited power supply. Applications such as sensing, communication and data processing utilize the maximum power.

C. Node Architecture

Architecture depends on the type of application. Some applications require separate sensing, processing and communication units as shown in the fig. 1. Other applications may require fully integrated sensing, processing, and communication units.

D. Environment

Sensor nodes operate in dispersed and remote geographical locations. Nodes may be deployed in harsh, hostile or widely scattered environments.

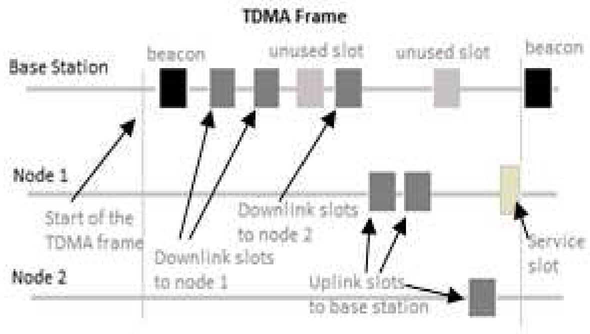

Fig. 2 Time division multiple access

E. Connectivity and Topology

Connecting the dispersed nodes requires special techniques. Nodes can communicate using point-to point, star, multi-hop, client-server or full peer to peer.

III. CHANNEL ACCESS METHODS

A. TDMA

TDMA is a channel access method for shared medium networks. Time is broken into frames and each node is given a specific time-slot within the frame in which each nodes transmit the sensed data. Only one node can transmit in a particular time slot. TDMA requires guard slots to separate different nodes and it requires all nodes to be time-synchronized as shown in fig. (1). The disadvantage of TDMA systems is that they create interference at a frequency which is directly connected to the time slot length

.B. FDMA

In FDMA type channel access method the entire bandwidth is divided frequency components such that each node gets a unique part of the total bandwidth

No other node can use the same frequency part to transmit data. In FDMA the energy dissipation is more compared to TDMA as it requires the transmitter to be on at all times. To avoid interference FDMA requires good filtering technique. In FDMA the energy dissipation is more compared to TDMA as it requires the transmitter to be on at all times. To avoid interference FDMA requires good filtering technique. Bandwidth is pre-allocated in TDMA and FDMA. Pre-allocation bandwidth leads wastage of resources

C. CDMA

Code division multiple access (CDMA) is a channel access method used by various radio communication technologies.

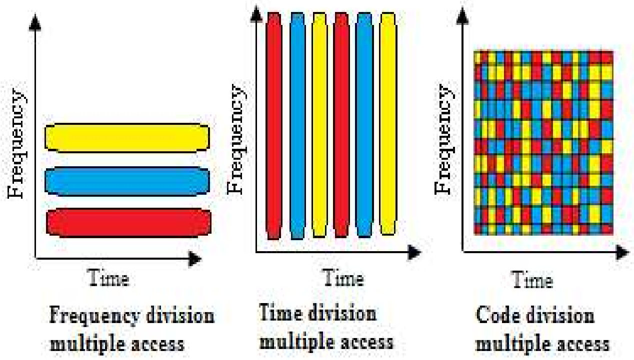

Fig. 3 Channel access methods

As shown in fig (2) in CDMA several nodes can transmit at the same time using the same bandwidth by spreading their data using a unique spreading code. CDMA eliminates need for tight synchronization among many different users along with expensive analog filters. Receivers may be received with very different powers, receivers near the base station may high power and receivers far from the base station may receive low power. So power control should be used. CDMA reduces interference among different signals and using the power control it minimizes energy dissipation at the nodes.

IV.ETEEC Algorithm

A. Deployment of sensor

The application specific sensors are randomly spread across the required geographical area by hand are by means any transport to monitor remote or dangerous area. The Sensors are spread across fixed base station to transmit all sensed information as shown in fig (3).

B. Formation of clusters

Cluster formation is based on K-means algorithm.The algorithm will start assuming 'n' sensors to be placed in 'k' clusters with an initial set of k centroid points. The algorithm does multiple rounds of the processing and redefines this centroid location until the iteration max-limit criterion is reached or until the centroids converge to a fixed point from which it doesn't move very much. There are two steps in this algorithm. The first step finds the sensors, which are nearest to each centroid point, and assigns them to that specific cluster. The second step recalculates the centroid point using the average of the coordinates of all the sensors in that cluster.

C. Selection of cluster-head

All sensor nodes obtain the location of every other sensor node using their GPS. Information of every sensor node in the cluster is exchanged with base station.

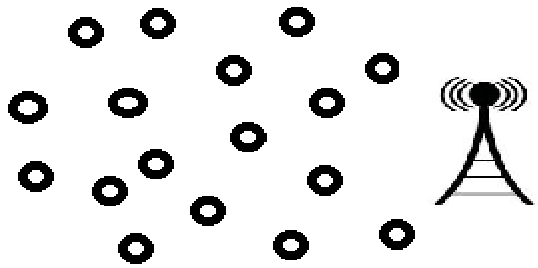

Fig. 4 Sensor node deployment

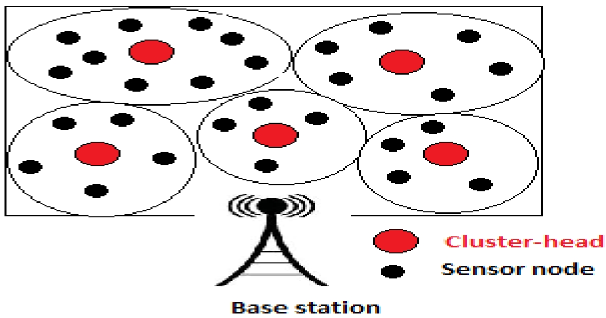

Fig. 5 Communication between cluster-head and base station

Assuming all sensor nodes having same energy the sensor node with minimum mean distance to all other sensor nodes is chosen as cluster-head and will remain as cluster-head for a specific round. In the subsequent round. The 'X' factor is calculated for each sensor node in the corresponding cluster and sensor node with highest 'X' factor is elected as cluster-head for next round. In the following round if the same node has highest "X' value then it continues to be the cluster-head.

'X' factor is the ratio of total remaining energy in the sensor node to the square of mean distance to all sensor nodes in that particular cluster.

$$X_i = \frac{E_{irem}}{D_{imean}^2} \quad (1)$$

WhereX_i is 'X' factor of i^{th} sensor node, E_{irem} is the remaining energy in thei^{th} sensor node and D_{imean}^2 is the square of mean distance of i^{th} to all other sensor nodes. Mean distance (D_{imean}) of sensor node 'i' is calculated using the formula,

$$D_{imean} = \frac{\sum_{j-1}^{clustn} dij}{clustn} \quad (2)$$

Where dij is distance between sensor nodes 'i' and 'j', clustn is the number of sensor nodes in the cluster.

D. Communication

All the sensor nodes sense the information and transmit the sensed information to the cluster-head of that particular cluster. Cluster-head collects all the information from the cluster nodes and aggregate the information and send it to the base station as shown in the fig (4). Only the cluster-head communicates with the base station whereas communication of all other sensor nodes is limited to cluster-head. The sensor nodes in the cluster can transmit the sensed information to the cluster-head using the TDMA schedule assigned by cluster-head. Using TDMA approach the sensor node can transmit any sensed information only in the allocated time-slot. The CDMA approach allows all the sensor nodes to transmit

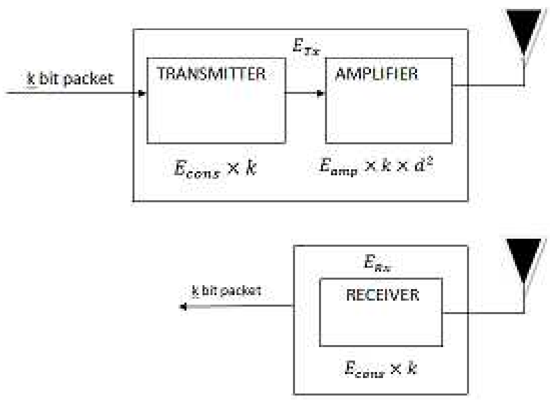

Fig. 6 Physical model

sensed information at the same time and using same bandwidth which will reduce the wastage of time-slots.

V. Physical model

The physical model of transceiver is shown. The transmitter and receiver is separated by distance'd'. Sensing unit includes sensors and analog to digital converters (ADCs) the analog signals produced by the sensors based on the observed phenomenon are converted to digital signals by the ADC, and then fed into the processing unit. The processing unit, which is generally associated with a small storage unit, manages the procedures that make the sensor node collaborate with the other nodes to carry out the assigned sensing tasks. A transceiver unit connects the node to the network.

To send k information bits the energy consumed by the cluster-head is,

$$E_{TX}=k.E_{cons}+k.\epsilon_{fs}.d^2 \quad (3)$$

To receive k-bit information the energy consumed by cluster head is,

$$E_{RX}=k.E_{cons} \quad (4)$$

Energy consumed by cluster head in one round is,

$$E_{ch}=E_{cons} \times k \times (n-1) + n \times k \times E_{DA}+E_{cons} \times k + \epsilon_{fs} \times k \times d_{to\ BS}^2 \quad (5)$$

where 'k' is the number of bits transmitted, 'n' is number of alive nodes, E_{cons} isenergy required for transmission or reception of one bit, ϵ_{fs} is Free space loss, 'd' distance between nodes, E_{DA} is energy for data aggregation and compression and $d_{to\ BS}^2$ is the square of the mean distance between the cluster-head and base station.

VI. Simulation and Results

NS-2.34 is used for simulation. The simulation is carried out by considering 10 sensor nodes and a fixed base station. C++ language is used as a front end and otcl (object oriented tool command language) is used as a backend language. Simulation of LEACH and TEACH (Threshold energy aware cluster head) protocol have been recorded using MATLAB code. ETEEC algorithm is used for both TDMA and CDMA approach using network simulator platform. The simulation parameters are shown below.

TABLE I
Simulation parameters

No. of nodes	10
Area(cm)	100 × 100
Placement of Base station	Located at (50,120)

The network lifetime can be tested by considering the death of first sensor node or last sensor node in the clusters. The network lifetime, data aggregation and data transmitted to the base stationare compared in TDMA and CDMA. Fig. 7 shows random deployment of sensor nodes using nam(network animator) tool.

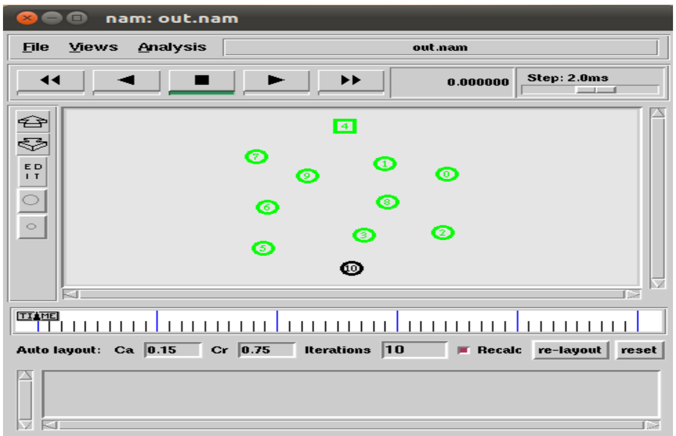

Fig. 7 Random deployment of nodes

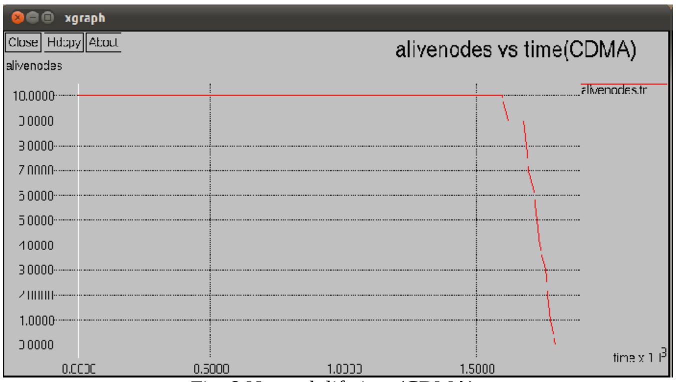

Fig. 8 Network lifetime (CDMA)

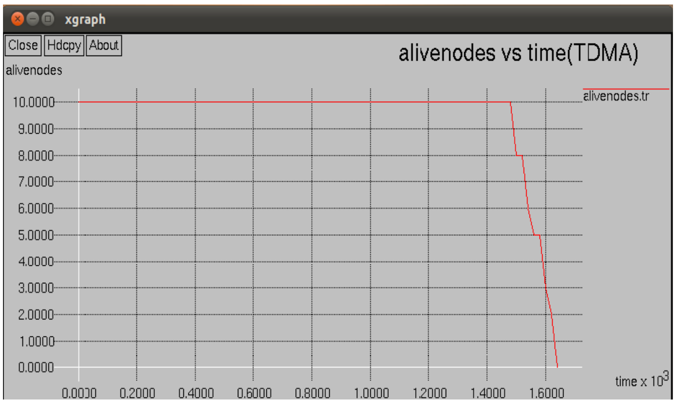

Fig. 9 Network lifetime (TDMA)

TABLE 2
Comparison of Death of Nodes in CDMA and TDMA

	CDMA	TDMA
First node death(ms)	1620	1500
Last node Death(ms)	1800	1640

Fig. 10 Bits from cluster versus time (CDMA)

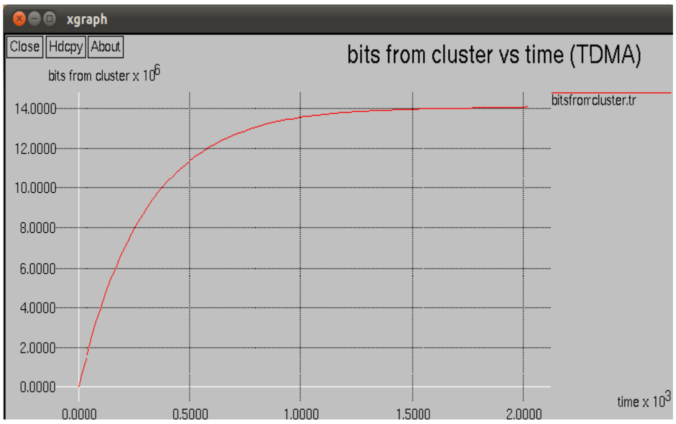

Fig.11 Bits from cluster versus time (TDMA)

TABLE 2
Comparison of Bits transmitted versus time

	Time	Bits transmitted
CDMA	1640(ms)	13868000 (bits)
TDMA	1640(ms)	13740000 (bits)

From fig.(7) and fig.(8) we can conclude that using CDMA approach increases the lifetime of the network compared to TDMA approach. Fig.(9) and fig(10) shows the throughput of CDMA and TDMA approaches. From table 2 we can observe that more bits can be transmitted using CDMA for same time as with TDMA.

7. Conclusion

In LEACH protocol there is no logical rule on nodes being elected as a leader as selection is completely random. The cluster-head is rotated randomly. There are chances of lower energy nodes becoming cluster-head which loses out energy sooner. By considering the energy parameter of sensor node along with the mean distance to all other sensor nodes the cluster-head loses its energy very slowly. In TDMA approach sensor nodes can only transmit in their allocated time slot and the time slot will be wasted if the current sensor node doesn't have any information to send. Here amplitude and frequency will be constant changing only the time. So all nodes require same power level even though they are placed closer which drains the energy sooner. In CDMA, sensor nodes can transmit the information to cluster-head using the same frequency in the same time-slot. Here frequency and time remains constant and amplitude varies. Varying the amplitude leads to less energy drain as closer nodes require less power. In CDMA cluster-head requires channel access only once whereas in TDMA cluster-head needs to access the channel for every nodes present in the cluster. Cluster-head selection completely depends on the X factor of each sensor node.

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