THE ANALYSIS OF ENERGY-EFFICIENT PERFORMANCE BASED ON LINEAR WIRELESS SENSOR NETWORKS

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***ABSTRACT*: *Currently, Wireless Sensor Networks have gathered attention in research themes due to its diversity in manifold sectors such as weather monitoring, health, military, civilian security systems, surveillance and logistics applications. In wireless sensor networks, core passion of researchers is to prolong lifetime of a network and minimize energy consumption. In this context, Multi hop communication has been used nowadays to send data from node to sink, consuming energies of all sensor nodes to the sink. In this paper, Linear Cluster handling technique with multiple mobile sinks has been implemented. Proactive LEACH and Network reactive TEEN protocols are used with LCH, while multiple mobile sinks are placed in linearly enhanced field. Simulations suggested improved results with network lifetime has been increased from 964 rounds to 1075 rounds in case of LEACH and LEACH-LCH and significant escalation from 1109 rounds to 4642 rounds has also been investigated in case of TEEN and TEEN-LCH protocols. Consequently, throughput has been boosted up to 13222 number of packets while implementing LEACH-LCH and up to 42040 number of packets while executing TEEN-LCH protocol.*

Keywords: TEEN, LEACH, LSNs, Throughput, Alive nodes, Dead node, LCH

1. INTRODUCTION

Wireless sensor networks have been widely used in sensing environmental phenomena and evaluating parameters at certain regions such as pressure, temperature and humidity etc. Sensor nodes are low cost and marginal powered entities which perform sensing function and transfer detected data to central point for aggregation and interpretation of information. WSNs are used in variety of applications such as military, surveillance, health care, monitoring of borders logistics, industrial applications etc. Even in hostile regions where human access is quite threatening, Sensor Networks offer effective and seamless service to the customers. Additionally, SNs have restricted supplies of energy, power, computational memory etc. [1-2].

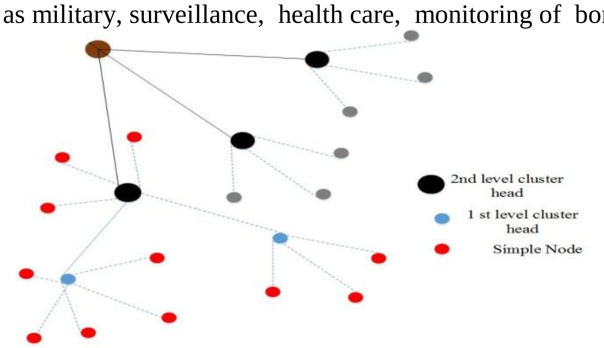

Fig.1 Cluster based hierarchical model

Earlier routing techniques such as Direct Communication (DC) and Minimum Transmission Energy (MTE) were not energy efficient as sensor nodes deplete much energy in transmitting data to Base Station (BS) and perished quickly. To overcome deficiencies of these protocols the very first cluster based routing protocol Low-Energy Adaptive Clustering Hierarchy (LEACH) was proposed that divides the whole network region into clusters and each cluster have its Cluster Head (CH). Every node transmits its data to respective CH that sends data to the sink node for energy conservation [2].

In this paper, Linear Sensor Networks(LSNs) with multihop communication has been investigated. LSNs found applications in diverse fields such as monitoring of gas, oil, water pipelines, illegal crossing of borders, monitoring of electrical power lines etc [3]. In the proposed work, cluster based multiple mobile sink routing protocol is introduced in linearly enhanced field where in each round CHs transmit data to nearby mobile sink.

This article is organized as following sections: section 2 presents the associated work, section 3 and section4 covers proposed protocol and discussion on simulation results respectively whereas, section 5 furnishes the conclusion correspondingly.

2. LITERATURE WORK

Wireless sensor networks were implemented with static nodes and static sinks in early years [1-2]. Multihop communication was used by the sensor nodes to transmit data from node to sink, all the nodes in the passage used to deplete energy. Multiple static sinks were used in order to lessen distance between nodes and sink. In [4, 5] authors used energy efficient multiple static sink approach that reduces the transmission distance for sensor nodes. In order to balance load among nodes and position of sinks, facility location solution has been proposed [6]. To overcome shortcomings of static sinks, idea of mobile sink was introduced. In order to balance energy depletion by the sensor nodes in the network , relay nodes and multi layer SNs were suggested [7] that improve the performance of overall network and results in escalation of network life time balancing routing load among nodes and error tolerance [8]. Lifetime of network, energy consumption, connectivity and coverage is considered by many experts,which has been specified the remarkable results related to Mobile Data Collectors (MDC) and implementation of mobile nodes [9]. A numbers of research contributions has been carried out related to mobile sinks such as Load Base sink Movement (LBM) locates the position of sink node by computing geographical distance [11-13] from sensor node. Similarly, another protocol Residual Energy Aware Routing (REAR) utilize residual energy of sensor nodes to establish routing path. By using Integer Linear Programming (ILP) author proposed [14], that if a base station is placed at the boundary of a network it may results in enlargement of the throughput as well as lifetime of a network. [15] in conjunction with a Random Walk strategy [16] proposed idea to deplete less energy and gathering data in a network in which sensor nodes are sparsely deployed. However, the model has not been able to predict the detecting power of sensor node and transferal of sink node towards SN to gather data, this insufficiency may lead towards delay in arrival of data packets.

In [17, 18], authors proposed a protocol-based sink mobility pattern to achieve efficient data delivery and robustness in performance of network. In [19,20], scheme of restoring of a network and controlling of transmission of mobile sink in network system is proposed, where CH is selected on the basis of residual energy and Euclidean distance, a unique protocol (Learning Automata) LA-LEACH has been illustrated in the work.

Another energy efficient routing protocol Link Aware Clustering mechanism (LCM) has been proposed [21] which gives an idea of Predetermined Count of Transmissions (PTX) to support the node and cluster formation. While consumption of energy in transmission, residual energy of nodes and quality of link derive this report quality. To use (PTX) as a key metric for determining priority of each CH, LCM selects the CH on the basis of derived priority. Status of node and condition of link are considered by LCM to ensure a reliable and regular routing path.

Akkaya, et al. [22], purposed a survey on data centric and location based protocols for WSNs. The paper ended up with open research issues associated with routing.

Zhenquan Qin, et al.[23], proposed an Overlapping Clustering Approach with Energy-awareness (OCHE) for routing in WSNs. Authors compared OCHE with the classical Greedy Perimeter Stateless Routing (GPSR) and simulation results suggested that OCHE achieves shorter recovery time than GPSR, especially with large network size. In [24] , authors proposed LEACH based protocol on mobile agents. It is a multi-hop intra-cluster routing protocol, where clustering approach control the management of mobile agents. The characteristics of mobile agents include average data calculation, information sharing among sensor nodes, redundant data reduction and alternative path discovery. Mobile agents based LEACH save more energy through ignoring repeated data and delivers the data efficiently to the BS.

3. PROPOSED PROTOCOL

In most of LSNs nodes, multi hop communication has been used to transmit information up to sink node which consume energy of each node in the passage towards sink node and decrease network life time. It is needed to replace multihop or direct transmission of data with clustering mechanism which should be dynamic i.e. high energy nodes should not to die soon. Mobile sink is to be used to make the network more energy efficient and expanding the network life time. With current scenario, Linear cluster handling technique with proactive LEACH protocol and network reactive TEEN protocol has been recommended to cope up with flaws during transmission of data.

In this section informative facts of proposed protocol TEEN-LCH and LEACH -LCH has been mentioned. Furthermore, simulation results are compared by means of simple LEACH and TEEN in conjunction with proposed linear cluster handling scheme in subsequent section.

A. Formation of linear region

A linearly enhanced region of 1000m×2m^2 has been created to analyze linear topology of network with multiple mobile sinks. Field is not divided into sub regions as utilization of mobile sinks ultimately minimize the communication distance between CH and sink; communication will be independent of cluster formation and offer sufficient support in reduction of energy depletion by the sensor nodes.

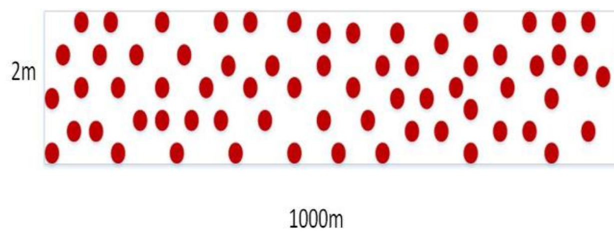

Fig.2 linearly enhanced field

B. Placement of mobile sinks and nodes deployment

After forming a linear region, the sensor nodes are arranged in such a way that maximum area would be covered by the nodes in the region. Concurrently, out of three mobile sinks couple of them occupy both ends where as one has been placed in the middle. Every time the CH will receive data from the nodes and pass it to the mobile sink which crosses near to the CH.

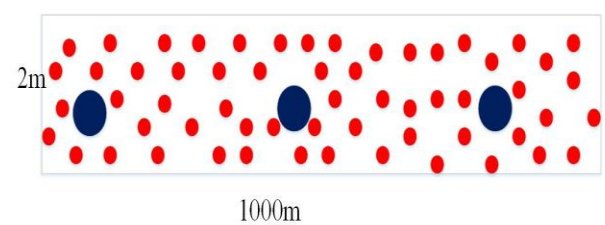

Fig.3 Placement of nodes and sinks

C. Operation of protocol

Operation of protocol will be completed in three phases

- Phase of Advertisement
- Phase of Cluster setup
- Phase of Data transmission

D. Phase of Advertisement

The proposed protocol is proficient in terms of implementation of multiple mobile sinks and cluster formation in the region, which might be helpful in boosting lifetime and throughput of the network. Every time CH sends data to the nearest mobile sink and then transfer it to BS.

E. Phase of cluster setup

Initially, when clusters are formed in a region, each node have equal probability to become a CH for current round. Total number of CHs for current round are created on predefined threshold T(n) given as

$$T(n)= \{\frac{p}{1-p\left(r*mod\left(\frac{1}{p}\right)\right)}\} \quad (1) \ [27]$$

Where, P is the number which is desired for CH, r is the current round and G is the set of nodes from which CH is to be selected in current epoch. 1/p are number of rounds after which a CH becomes eligible again to become a cluster head. Each node randomly generates a number between 0 and 1, if the number's value is less than the threshold of node, the sensor node becomes a CH. After the CHs are elected, each CH propagate its status using CSMA MAC protocol. All nodes send a message of their joining to the suitable CH, using CSMA MAC. Subsequently CHs schedule all nodes using TDMA for transmission of data. In steady-state phase, each node sends its sensed data to their respective CH in specific allocated time slots. Figure 4 gives details of CH selection in LEACH and TEEN protocols.

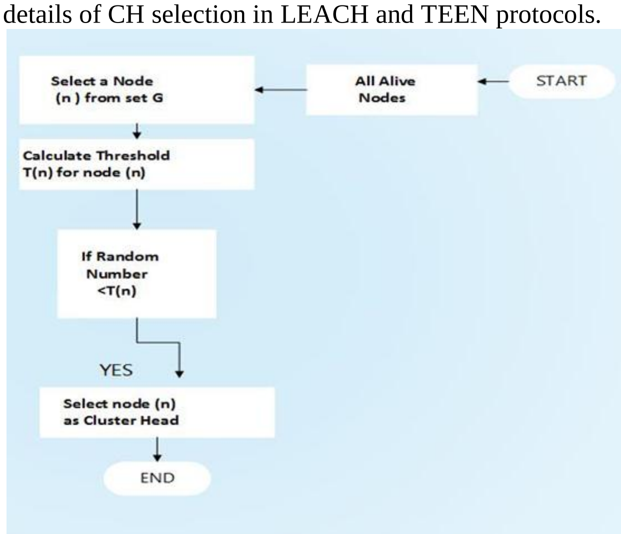

Fig.4 Flow chart of cluster head selection in LEACH and TEEN

F. Phase of data transmission

Once cluster heads are formed, data transmission is initiated subsequently. Data is received by CH from its associated nodes. When CH receives all the data from the nodes, CH performs data collection and transmits to the mobile sink. In this manner, it requires low energy for transmission. Similar mechanism is executed in each round.

4. SIMULATION RESULTS

The Performance of proposed protocol is compared with TEEN and LEACH. In this regard, whole region of 1000m × 2m^2 is deployed with random nodes. Furthermore, three mobile sinks are placed in the network at diverse positions and CH transmits data packets to its closest mobile sink respectively. Simulation parameters are indicated in the table.1.

Table.1 Parameters for simulations

Network Field	1000x2m^2
Number of nodes	100
Transmitter Electronics	50nJ/bit
Receiver Electronics	50nJ/bit
Transmitter Amplifier	100pJ/bit/m^2
Node Energy(LEACH)	0.5J
Node Energy(TEEN)	0.1J
Efs	10nJ/bit/m^2
Emp	0.0013/pJ/bit/m^4
P_{opt}	0.1

In this paper, simple model has been proposed where the radio dissipates E_{elec}= 50 nJ/bit to run the transmitter or receiver circuitry and amplifier dissipates 100 pJ/bit/m^2 to offer decent gain and tolerable Eb/No. Due to channel transmission, r^2 energy loss has been assumed. Thus, to transmit a k-bit (where k=4000) message across distance d.

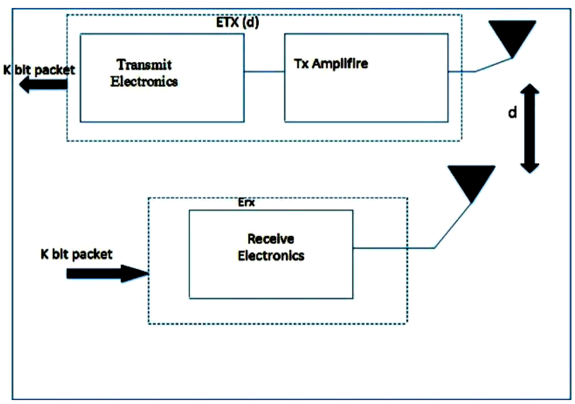

Fig.5 Energy dissipation radio model

Where to transmit message the radio expands

$$ER_x(k) = ET_x - elec(k) + ET_X - amp\ (k,d)$$

$$ET_x(k,d) = Eelec\ \times K + amp\ \times k\ \times\ d^2 \quad (2)$$

And to receive message radio expands

$$ER_x(k) = ER_x - elec(k)$$

$$ER_x(k) = Eelec\ \times k \quad (3) \quad [28, 29]$$

A. Stability period

In this section, network stability has been reported. In view of the fact that Network is considered stable from the starting period of network operation to the death of first node. The evaluation of TEEN-LCH with TEEN and LEACH-LCH with LEACH has been made on simulation basis. In case of stability, LEACH-LCH is not competent in terms of energy efficiency and many nodes die out early. LCH shows mores stability period as compared to that of TEEN.

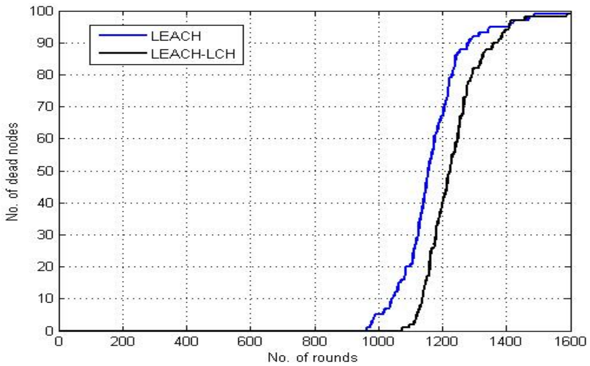

Fig.6 no. of dead nodes increase with time

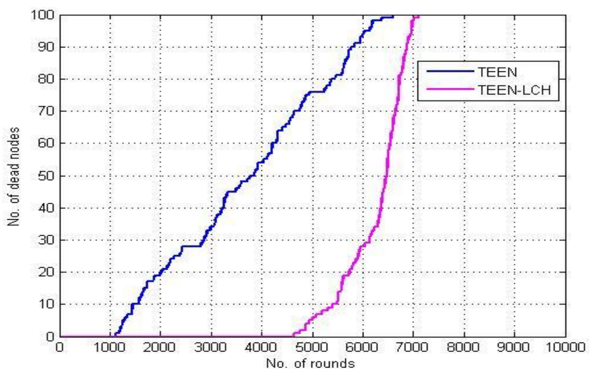

Fig.7 no. of dead nodes increase with time

B. Network lifetime

Network lifetime is defined as the time from the start of network operation to the death of last node. In comparison of LEACH-LCH and LEACH, network lifetime is increased while using proposed scheme. Since nodes save their energy due to less communication distance between node and CH afterwards between CH and sink. Consequently, TEEN-LCH shows improved network life time as compared to that of TEEN protocol. Eventually, energy consumption is also minimized due to reduced communication between multiple nodes as discussed earlier.

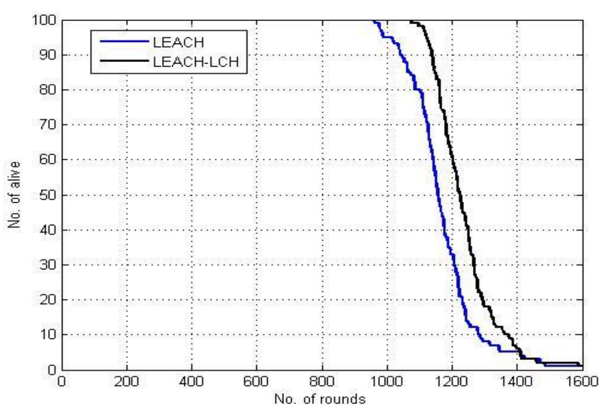

Fig.8 no. of alive nodes decrease with time

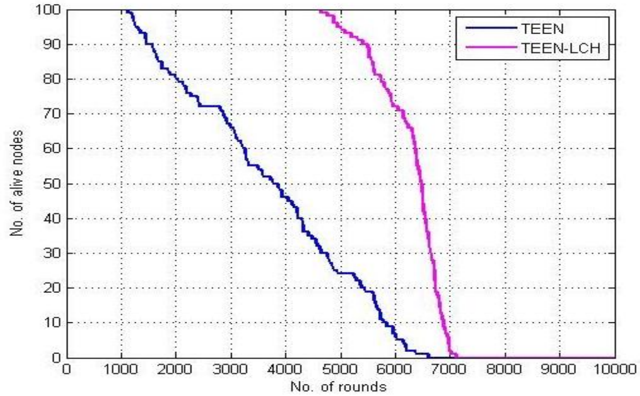

Fig.9 no. of alive nodes decrease with time

Table.2 lifetime comparison

Protocol	Number of rounds
LEACH	964
LEACH-LCH	1075
TEEN	1109
TEEN-LCH	4642

C. Throughput

Throughput is defined as number of data packets received at BS. It is clear that LEACH-LCH gives marginal improvement in throughput as compared to that TEEN-LCH. This is due to the reduction of the communication distance between sensor nodes and CH. Accordingly, LCH is efficient protocol in terms of network lifetime and increased throughput.

Table3. Throughput comparison

Protocol	Number of Packets received
LEACH	12608
LEACH-LCH	13222
TEEN	24959
TEEN-LCH	42040

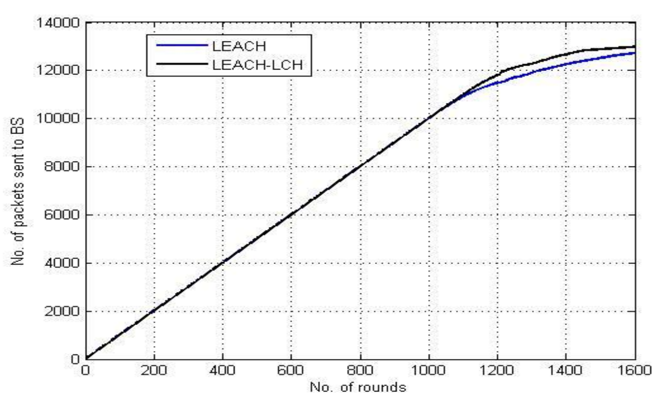

Fig.10 Throughput increase with time

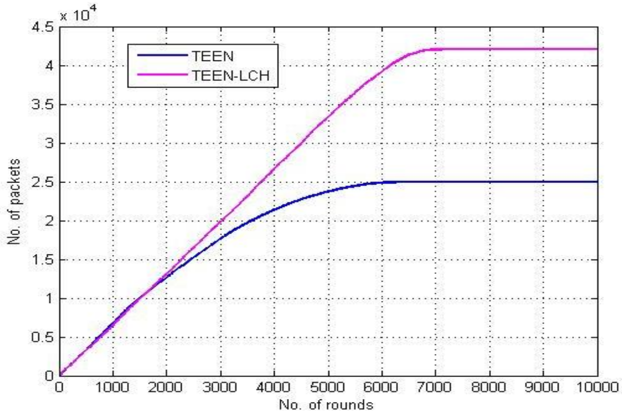

Fig.11 Throughput increase with time

5. CONCLUSION

Linear Clustering approach has been implemented with multiple mobile sinks in linearly enhanced field and improved results has been accomplished successfully. Each CH receives sensed data from its cluster members and after aggregation transmits to nearby mobile sink, which finally sends information to BS. Clustering approach reduces energy consumption in linear sensor networks, because it relieves nodes from multihop communication which reduces much energy of nodes. Thus linear clustering is better approach in terms of energy efficiency and prolonging lifetime of a network, while deployment of multiple mobile sinks enhances the performance of proposed protocol. In future work this work can be extended with chain based clustering.

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