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An Energy Efficient Multihop Routing Protocol for Wireless Sensor Networks

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Abstract: **Wireless sensor networks comprise of numerous sensor nodes which are randomly distributed in an observing region. These nodes are not only supervised the surrounding but also gathered the data from it. Various routing protocols have been aimed for wireless sensor networks to effective and efficient utilization of energy since SNs are powered with limited and non-rechargeable batteries. In this paper, an enhanced version of K-LEACH routing protocol is proposed i.e. Multihop K-LEACH to minimize the power depletion for WSNs. The proposed technique utilizes the k-medoid clustering method to uniform clustering of nodes and multihop routing approach to reduce the power depletion, which leads to prolonging the lifespan of network. The performance of the proposed technique is compared with K-LEACH using NS2. The simulation shows the better results of multihop K-LEACH over the previous technique.**

Keywords: Wireless sensor networks, K-LEACH, Routing techniques, Multihop K-LEACH

I. INTRODUCTION

Wireless sensor networks are practiced in numerous applications including woodland fire discovery, climate observing, military, seismic activity discovery etc. [1].

WSNs usually consist of large number of sensor nodes deployed in the observing arena. Fig. 1 shows the architecture of the wireless sensor network, which contains the sensor nodes, a Base Station (BS) and an end-user. These sensor nodes are deployed either randomly (in catastrophic situation) or manually (in security alarm system). These nodes sense the nearby environment and gather the data from it; and these SNs are capable of communicating either with other sensor nodes or with base station. SNs have ability to sense, process and communicate the data [2].

A Wireless sensor node includes mobility unit, positioning unit, sensing module, processing module, transceiver module and power module [3] as shown in fig. 2. Mobility and positioning modules are optional and are used when nodes are mobile and position-aware respectively. Sensing unit comprises of sensor and ADC (Analog-to-Digital Converter).

Sensor senses the nearby environment and gathers the data from it. It produces an analog signals, which are digitized by ADC converter for further processing, and it is fed to the processing unit. Processor process the digitized data and forwards it to the transceiver unit. Processor also keeps an eye on the functions of the other components in a sensor node. Transceiver is the combination of both the transmitter and the receiver in the same unit. The transmitter sends the data to the other sensor nodes or to the BS directly. Power unit provides the energy supply to the components of a sensor node.

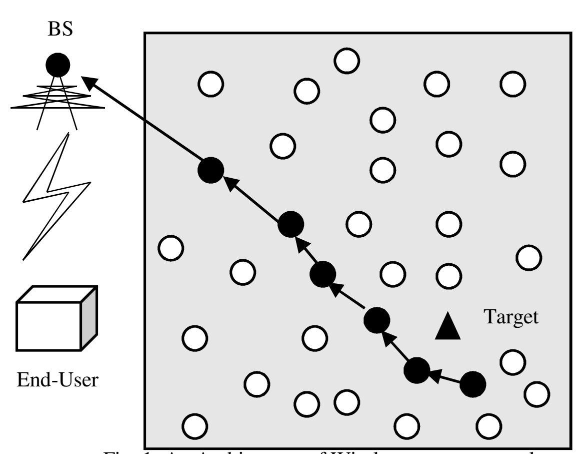

Fig. 1: An Architecture of Wireless sensor network

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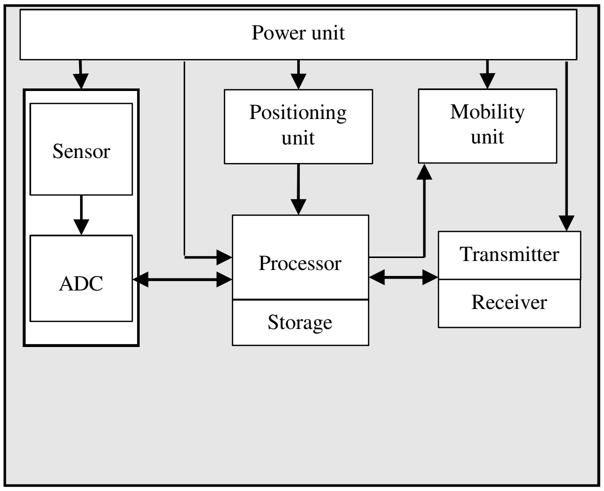

Fig. 2: Systematic view of sensor node

There should be such routing protocols that utilize the limited energy of the sensor node optimally for extending the lifetime of the network. Rest of the paper is organized as follows: In section II related works have been presented. Section III introduces the K-LEACH routing protocol, while the section IV dedicated to our proposal work multi-hop K-LEACH protocol. Section V presents the selective packet drop attack. Section VI shows the simulation and results comparison of different routing protocols. Section VII presents the conclusion and the future work.

II. RELATED WORKS

In wireless sensor network, numerous hierarchical clustering algorithms have been proposed to reduce the power depletion and enhance the network lifespan of the network. Low energy adaptive clustering hierarchy is the most common cluster-based approach used to cluster the nodes [4]. Heinzelman, et al [5] presented LEACH for WSNs, which performs a distributed cluster formation. It is a self-configuring and adaptive cluster-based method that utilize equal load distribution among the sensor nodes.

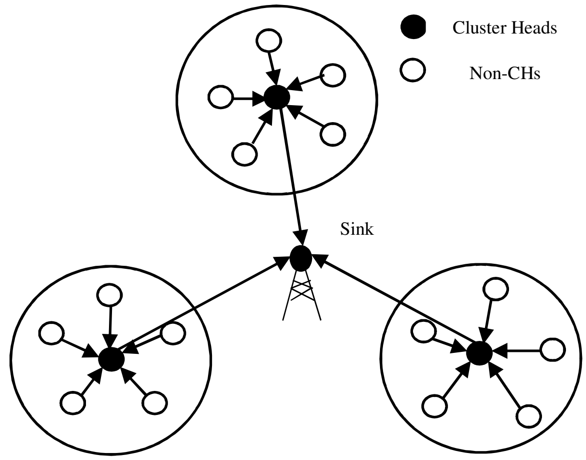

Fig. 3: Cluster-based single-hop routing

The operations of LEACH is performed in two rounds: the set-up phase and the data transmission phase. The data transmission phase is longer than the set-up phase that minimizes the overhead in the network. The SNs are randomly deployed in an observing field formed the clusters by configuring themselves. The SNs performs the different roles; few of these nodes are designated as CH nodes and rest are non-CH nodes. In the LEACH, 5% of the total sensor nodes are selected as CH nodes [6]. Non-CH nodes sense the surrounding and capture the data from it. These nodes forwards the data to the CHs. CHs combines the data received from the non-CHs, eliminates the redundant data and sends it to the BS, sometimes called as Sink. If the CH is far-off from the BS, only CH's energy is affected since it sends directly data to the BS. Thus, lifespan of the whole network is affected. Fig 3 shows the graphical view of the cluster-based single-hop LEACH protocol. LEACH allows the SNs to send the data to CH, which further directs the data to the BS.

LEACH is divided into two phases: the set-up phase and the data transmission phase. The duration of both phases is termed as a round. In the set-up phase, the SNs generate a number from 0 to 1 randomly. If the generated number is less than the threshold value T(n), then node becomes a CH for that round.

$$T(n) = \begin{cases} \frac{p}{1-p*(r \bmod \frac{1}{p})} & if \;\; n \in G \\ 0 & otherwise \end{cases} \qquad \text{(i)}$$

In the above equation, p represents the probability of a node to be elected as CH, r represents the number of current round, and G represents the selection of the non-CH nodes [9]. Now, CHs broadcast an advertisement message to the non-CH nodes. Non-CH nodes receives the advertisements from one or more CHs. The non-CH nodes reply back the join request to the CH according to the signal strength they receive. After receiving the join request from the non-CHs, CHs set the time slots using TDMA to its non-CH nodes for avoiding collision within the cluster. During the data transmission phase, the SNs sense the surroundings, capture the data and transmit it to their CHs. CHs aggregate that data and forward it to the BS using CDMA to avoid collision in the clusters.

LEACH has many advantages: the SNs are scattered randomly and dynamic clustering, which leads to an enhancement of lifespan of network As compared to the direct communication, LEACH reduce the energy depletion of the SNs. It is distributed protocol and not needed the knowledge about the entire network. Despite of many advantages, LEACH has various shortcomings: 5% of the total SNs are selected as the CHs, this amount of CHs are not adequate to cover the entire network. LEACH is a single-hop protocol, which is not applicable to WSNs deployed over the wide area. Moreover, the dynamic cluster-based approach increases the network overhead since CHs selection process consumes the large energy [7].

There are various variants of LEACH for WSNs, which have been introduced to reduce the energy consumption and to enhance the lifespan of the network. Some of them are K-LEACH, V-LEACH, C-LEACH, TL-LEACH etc.

III. K-LEACH

K-leach is an enhanced version of LEACH, which uses the k-medoid clustering algorithm for uniform clustering and uniform cluster head selection [8]. It also has two phases: the set-up phase and the data transmission phase. In the set-up phase, K medoid algorithm is used for uniform clustering of the nodes. The cluster formation by K-medoid ensures uniform selection of CHs using Euclidian distance that gives the most energy efficient solution in the WSN. From the second rounds onwards, CHs are selected based on the next nearest node to the first round's CH and so on. This method is applied until smallest SNs are not considered. After the CHs selection process, advertisement messages broadcast by the CHs. Non-CH nodes reply back with the join messages. Then CHs form the clusters and assign the time slots to the non-CHs nodes. The data transmission phase is similar as the traditional LEACH protocol.

A. RADIO MODEL

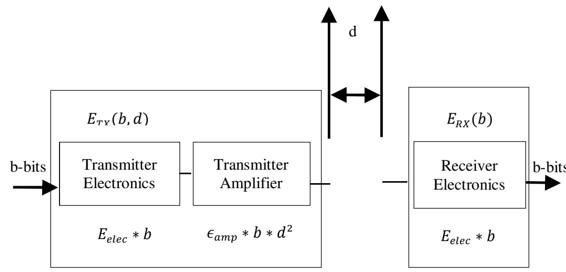

Fig. 4: Energy dissemination model

Energy dissipation used by every node during transmitting the b number of bits to distance d is:

$$E_{TX}(b,d) = E_{TX\,elec}(b) + E_{TX\,amp}(b,d)$$

$$E_{TX}(b,d) = E_{elec} * b + \epsilon_{amp} * b * d^2 \qquad \text{(ii)}$$

Energy dissipation used by every node during receiving the K number of bits is:

$$E_{RX}(b) = E_{RX\,elec}(b)$$

$$E_{RX}(b) = E_{elec} * b \qquad \text{(iii)}$$

E_{elec} is the energy consumed by electronic device of nodes to transmitting and receiving the K number of bits and ϵ_{amp} signifies the amplification factor that is used by the transmitter to forward K number of bits.

B. CLUSTERING ALGORITHM

Clustering algorithm used for multihop k-medoid technique for the development of the clusters, as shown in fig 5, follows:

Stage 1: Start: Select, randomly, k as medoid of n data objects.

Stage 2: Associate every data point to Euclidean distance and figure medoid.

Distance from s to t is:

$$d(s,t) = d(t,s) = \sqrt{(t_1 - s_1)^2 + (t_2 - s_2)^2 + \cdots + (t_n - s_n)^2} = \sqrt{\sum_{i=1}^{n}(t_i - s_i)^2}$$

{Euclidean distance between s and t is the length of line segment, which connects them (st) if coordinates are $s = (s_1, s_2, s_3, \cdots, s_n)$ and $t = (t_1, t_2, t_3, \cdots, t_n)$.

Stage 3: For every medoid m

For every non-medoid data point o

Exchange m and o and compute the lowest cost of the configuration.

Stage 4: Select the configuration with the lowest cost.

Stage 5: Repeat stage 2 to 4 until there is no change in medoid.

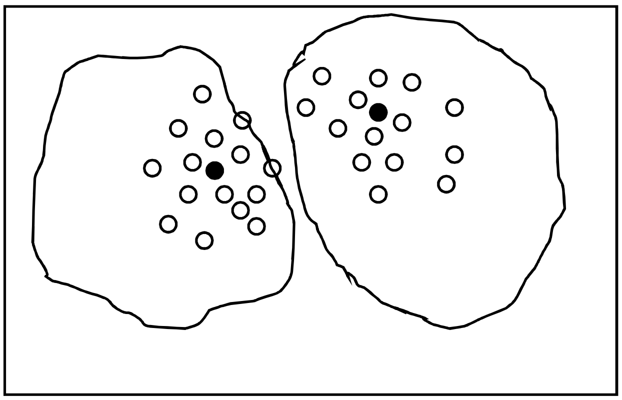

Fig. 5: Clustering using K-medoid

IV. PROPOSAL OF MULTIHOP K-LEACH

After the survey we conducted on the K-LEACH, we found that K-LEACH has various advantages, which includes uniform clustering and uniform cluster head selection. Despite of all these advantages, it is subjected to certain constrictions and assumptions that develop some de-efficiencies. For instance, single-hop routing technique is used by the CHs to direct the data to the BS. But if BS is far-off from the CH, energy of CH is affected since it directly communicate with the BS. It leads to rapid depletion of energy.

To overcome this problem, we propose an enhanced version of K-LEACH, which utilizes the multihop routing to send the data from CHs to the BS. So that CHs consume less energy as used in the previous approach.

A. BASIC CONCEPT OF PROPOSED ALGORITHM

Multihop cluster-based approach is used in the network to reduce the energy depletion.

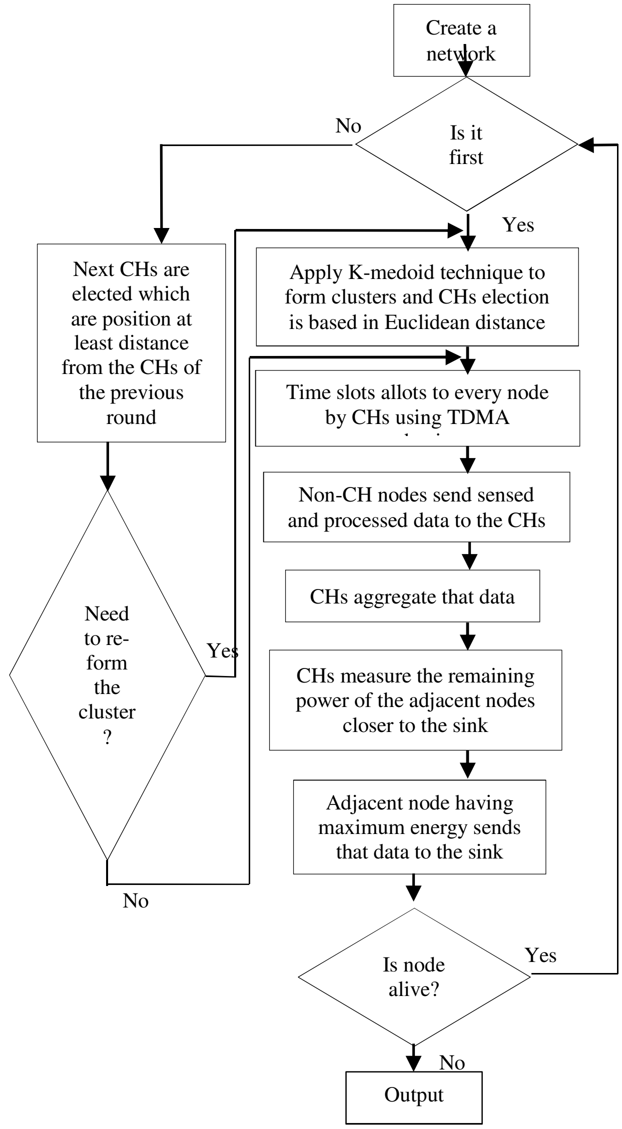

Fig. 6: Flow chart of proposed algorithm

B. DESCRIPTION OF MULTIHOP K-LEACH PROTOCOL

As in the K-LEACH, each round has two phases: the set-up phase and the data transmission phase. The set-up phase of multihop K-LEACH is similar as the K-leach. During the data transmission phase, CH finds the immediate node having maximum residual energy. If this node is the nearest node to the BS than it sends the data to the BS. It this node is not the nearest nodes to the BS than it finds its immediate node having maximum residual energy and send the data to it and this process continues until reaching the node nearest to the BS.

V. SELECTIVE PACKET DROP ATTACK

A selective packet drop attack is applied to the proposed technique to evaluate the performance of the network in the presence of selfish node. Selective Packet dropping attack is the type of DoS attack. Packet dropping attack is launched on the forward phase. So it is very complex and difficult to isolate. This attack is very easy to perform but very difficult to detect it. A malicious node drops the packets in many modes. It drops the packet just to conserve its resources but not to destruct another nodes. This attacks might spoil the objectives of an application. In this kind of attack, selfish nodes behave like a non-malicious node all the time but drop the packets, for instance, the packets containing confidential information in the military applications. It is difficult to identify the malicious node.

VI. SIMULATION AND RESULTS

To evaluate the performance of our proposed technique, we perform the simulation on the two routing protocols: K-LEACH and multihop K-LEACH. Multihop K-leach with selfish node is also simulated to evaluate the performance of the network. These are simulates in the NS2 software and results are compared using three parameters: Throughput, Packet loss, and Energy consumption. Table 1 shows the wireless sensor network settings.

TABLE 1: WIRELESS SENSOR NETWORK SETTINGS

Parameters	***Value***
Number of Cluster Heads	2
Number of Sensor nodes	25
Bandwidth	1 Mbps
Initial energy of each node	2 J
Radio range	150m
Area	800*800 m^2
MAC type	802.11

Fig. 7 shows the wireless sensor network deployment with the help of multihop K-LEACH protocol. From the experimental results, K-LEACH with malicious node performs worse in case of each parameter. It shows more energy consumption, more packet loss and minimum throughput.

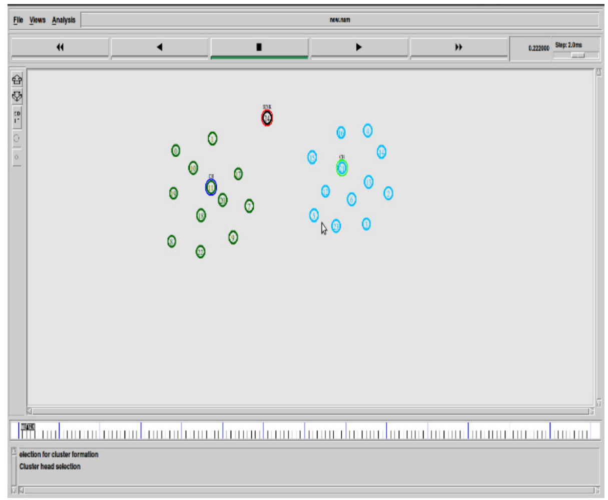

Fig. 7: Wireless sensor network using Multihop K-LEACH

K-LEACH shows more energy depletion than the multi-hop K-LEACH protocol as shown in the fig 8. Multihop K-LEACH consumes the less energy, represent as new energy. Multihop K-LEACH with attack shows the less consumption of energy initially but when attack is triggered by the selfish node, then it consumes more energy and shows the worst performance, which leads to the rapid depletion of the energy and nodes will die early.

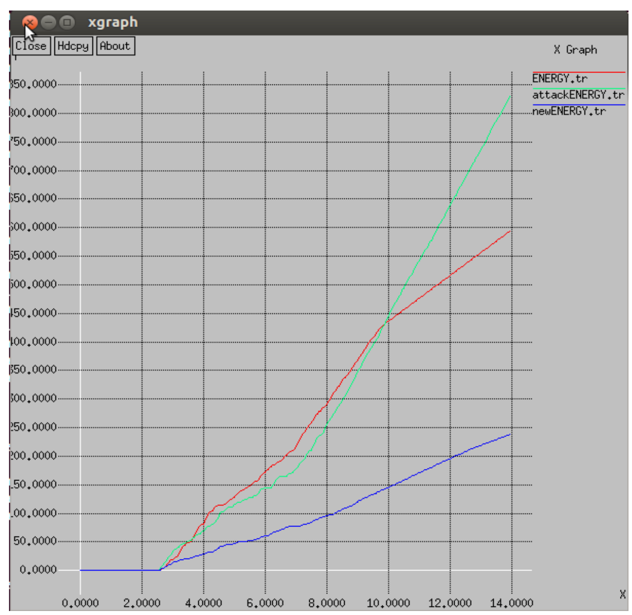

Fig. 8: Energy consumption vs Simulation time

In case of throughput, multihop K-LEACH shows the better performance than the K-LEACH as illustrated in the fig 9. Multihop K-LEACH shows the higher throughput while with the attack it shows worse performance.

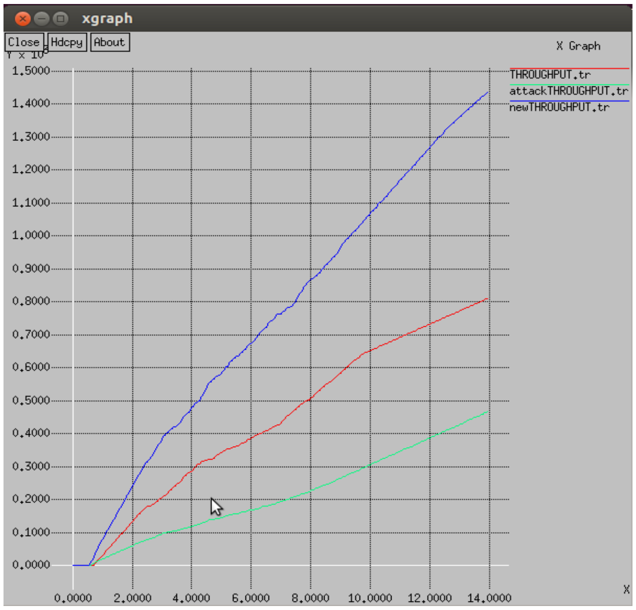

Fig. 9: Throughput vs Simulation time

K-LEACH performs worse in care of packet loss as compared to the multihop K-LEACH protocol as shown in the fig 10. Multihop K-LEACH with attack performs worse since the selfish node starts dropping some the packet, which increases the packet loss value. As compared to Multihop K-LEACH, K-LEACH shows the poor results, since it uses the single hop routing technique.

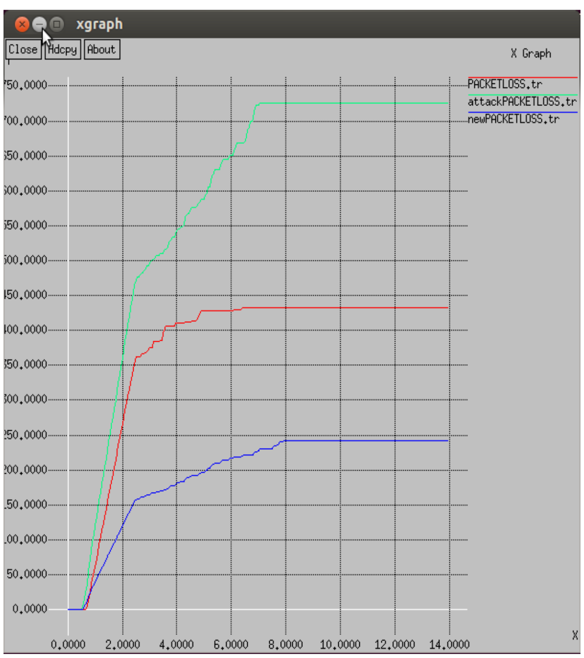

Fig. 10: Packet loss vs Simulation time

VII. CONCLUSION

In this paper, an energy efficient routing algorithm has been proposed for the WSNs. The multihop k-medoid algorithm has been implemented in the WSN, which is compared with the single-hop k-medoid routing technique based on various parameters such as energy consumption, throughput and packet loss. A selective packet drop attack has triggered by the malicious node in the network and analyses the results with the traditional and the proposed technique. Multihop k-medoid showed the better throughput and effectively consumes the energy than the other scenarios. It has also found that it minimizes the packet loss in the network as compared to the single hop k-medoid and scenario with the attack. The proposed algorithm proves that as compared to the other algorithms, it dissipates the less energy to accomplish its tasks and hence increases the network lifetime.

As there is no routing protocol that is perfect and complete. The future scope of the thesis is to minimize the fault tolerance in terms of QoS.

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