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OpteLoc: An Optimal Energy Consumption Model for Localization in Wireless Sensor Network Using Multi-Hop Cluster Routing and Discrete Power Control

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Abstract: This study is meant for optimal utilization and control of energy with discrete power control works during internodes communication in wireless sensor network. In this communication process the main goal to be achieved is localization which is meant for determining the position of a particular node inside a cluster or the whole network in relation with the neighbouring nodes. To determine this location there are some aspects like getting the position with respect to other nodes and the second is extracting the position information from the node itself. In both the cases the resultant should be accurate and should be operated at minimal cost of resource consumption. To achieve the optimal cost we propose OpteLoc Model which works with hop based localization technique and experimental results are obtained under ideal condition with help from Network Simulator Version 2.27 that forms the energy model.

Key words: Clustering, localization, discrete power control, multihop, resource consumption

INTRODUCTION

Cluster analysis or clustering is the task of assigning a set of objects into groups (called clusters) so that the objects in the same cluster are more similar (in some sense or another) to each other than to those in other clusters to relate their position and arrive location information or to proceed localization. Here, in this proposal researchers are going to make use of this clustering with some other parameters to construct a framework that works with minimal energy consumption in terms of Jules (Aslam *et al*., 2009). Several kinds of multi-hop wireless networks have been proposed in the research literature: wireless mesh networks, an attractive choice for network access in rural communities, office buildings, etc., mobile ad hoc networks that may be intermittently-connected, useful to connect vehicles, underwater monitoring stations, handhelds, etc. and wireless sensor networks with various scientific and industrial applications. Despite the plethora of applications of such networks, low performance issues have prevented them from being widely adopted (Guo *et al*., 2007). Then, the next vital parameter radio transmission which after collecting the data a preliminary analysis of the measurements was made.

It was found that the average received power in logarithmic scale tends to a straight line using the method of least square errors (log-distance attenuation). This trend is shown in Fig. 1 where the results for one run in the first scenario according to the methodology explained earlier (time averaged received power) are shown. The same behaviour was found in the other measurements and scenarios. In addition, there was a slightly fading (shadowing) that is the received power randomly fluctuated around the average power. In radio propagation, a logarithmic distance decay of the received power (Martinez-Sala *et al*., 2005) is generally accepted. So, the first step was to consider a log-normal path loss model in order to characterize propagation. Routing in ad-hoc wireless networks has been an active area of research for many years.

Much of the original research in the area was motivated by mobile application environments such as

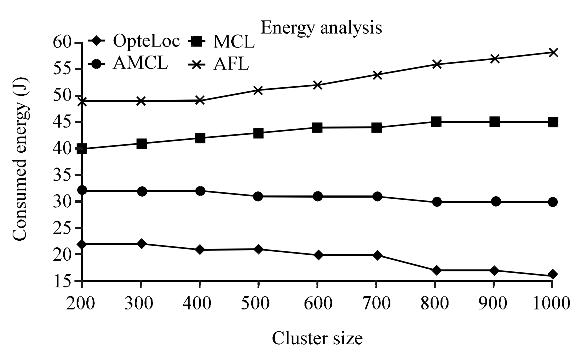

Fig. 1: Cluster size vs. consumed energy

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battlefield ad-hoc networks. The primary focus in such environments is to provide scalable routing in the presence of mobile nodes. Recently, interesting commercial applications of multi-hop wireless networks have emerged. One example of such applications is community wireless networks several companies (Martinez-Sala *et al*., 2005) are field-testing wireless networks to provide broadband Internet access to communities that earlier did not have such access. In such networks, most of the nodes are either stationary or minimally mobile and do not rely on batteries. Hence, the focus of routing algorithms is on improving the network capacity or the performance of individual transfers, instead of coping with mobility or minimizing power usage. One of the main problems facing such networks is the reduction in total capacity due to interference between multiple simultaneous transmissions (Gupta and Kumar, 2000). Providing each node with multiple radios offers a promising avenue for improving the capacity of these networks. First, it enables nodes to transmit and receive simultaneously. Otherwise with only one radio, the capacity of relay nodes is halved. Second, the network can utilize more of the radio spectrum. With two radios, a node may transmit on two channels simultaneously. Third, radios that operate on different frequency bands (for example, 802.11a at 5 GHz and 802.11b g^{-1} at 2.4 GHz) have different bandwidth, range and fading characteristics. Using multiple heterogeneous radios offers tradeoffs that can improve robustness, connectivity and performance. Finally, 802.11 radios are off-themself commodity parts with rapidly diminishing prices.

This makes it natural to consider the use of multiple inexpensive radios per node. In (Dasgupta *et al*., 2003; Barberis *et al*., 2007) the energy consumption model takes into account the discrete transmit power levels of the CC2420 radio chip used by MICAz sensor nodes is discussed. The radio propagation path loss is modelled by using the Lognormal Shadowing Model. There are other promising approaches for improving the capacity of multi-hop wireless networks such as directional antennas, improved MACs and channel switching (Li *et al*., 2007). Researchers believe that these alternative approaches are complementary to the use of multiple radios. Most of the clustering protocols developed for WSNs contain simplistic assumptions that are far from reality. Examples of such assumptions include use of infinite transmit power levels, no consideration of radio propagation loss and irregularities. These assumptions lead to an incorrect estimation of performance metrics such as network lifetime, energy consumed per bit, and connectivity. In most cases, the energy model originally proposed by LEACH (Heinzelman *et al*., 2002) or its slight variation is used. This study takes into account the fact that sensor nodes are limited to a few discrete power levels. For example, Crossbow MICAz motes use Chipcon CC2240 radio chip which is limited to only seven transmit power levels.

Literature review: Recent relevant studies (Aslam *et al*., 2009) have focused on incorporating the realistic radio and energy consumption models in WSNs. The researchers in presented an energy model for calculating the transmission and reception cost. This model is based on the first order model presented by Yi *et al*. (2007). Research results shown by Mallinson *et al*. (2007) are collected from field experiments involving few sensor motes. These experiments were performed to collect Link Quality Index (LQI) and Received Signal Strength Indication (RSSI). The investigations show that transmission power costs do not always increase as the distance increases. This research in closely related to earlier research which is focused on the CC2420 radio chips.

This research focuses on the clustering protocols. Each cluster has a coordinator, referred to as a Cluster Head (CH) and a number of member nodes. Clustering results in a hierarchical network in which the CHs form the upper level and member nodes form the lower level.

In contrast to flat architectures, clustering provides distinct advantages with respect to energy conservation by facilitating localized control and reducing the volume of inter-node communication. Moreover, the coordination provided by the CH allows sensor nodes to sleep for an extended period thus allowing significant energy savings. By adapting to a clustered topology, WSNs can share many advantages that result in a direct or indirect impact on the energy efficiency. Some of the advantages as the result of using clustering include network scalability, local route set up, bandwidth management, minimizing communication overhead and data aggregation. As a result of the advantages offered by clustered topology, a number of clustering protocols were developed for WSNs. Most of the clustering protocols developed for WSNs contain simplistic assumptions that are far from reality.

Cluster head selection, cluster formation and data transmission are the three key techniques in cluster-based routing protocols. The recent representative cluster-based routing protocols involving these three techniques are presented by Guo *et al*. (2007). Figure 2 single hop and multi-hop with clustering Comparing their characteristics and application areas, the study of Low-Energy Adaptive Clustering Hierarchy (LEACH) proposes the cluster based routing protocol for WSNs firstly in which the cluster heads are selected randomly in each round and the cluster head selection process is its focus.

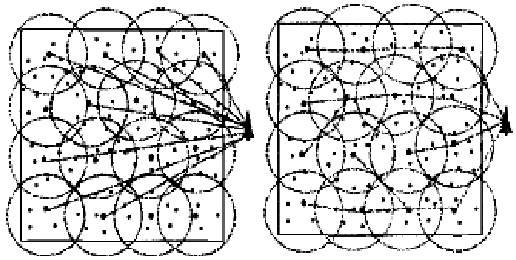

Fig. 2: Single hop and multi-hop with clustering

Examples of such assumptions include use of infinite transmit power levels, no consideration of radio propagation loss and irregularities. These assumptions lead to an incorrect estimation of performance metrics such as network lifetime, energy consumed per bit and connectivity. In most cases, the energy model originally proposed by LEACH or its slight variation is used. This study takes into account the fact that sensor nodes are limited to a few discrete power levels. For example, Crossbow MICAz motes use Chipcon CC2240 radio chip which is limited to only seven transmit power levels. In this research, the radio propagation path loss is calculated using the Lognormal Shadowing Model. Earlier studies have shown that this model is more accurate for cellular system, making it a favorable and realistic option as compared to the free Space Model. Moreover, a simple scheme is proposed that allows sensor nodes to adapt to correct output power level based on distance from the transmitter and path loss.

Finally, most sensor hardware platforms use discrete power levels. Therefore, incorporating such models into simulations would bridge the gap between simulation and experimentation results. Researchers proposed a simple algorithm that allows sensor nodes to choose appropriate power level based on inducted path loss and distance. Researchers evaluated four clustering protocols (MOECS, EECS, LEACH and HEED) using metric relevant to the energy conservation following both discrete power and conventional models. The results showed that estimates of network life using Discrete Power Model differ significantly than that of conventional model. This research will be followed by research that is focused on the effects of controlled mobility and realistic deployment strategies (Aslam *et al*., 2009).

MATERIALS AND METHODS

In the proposed system the process minimum energy utilization starts with the discovery of closely located neighbor nodes uses the Neighbor Discovery Protocol that operates in the internet layer of the Internet Model and is responsible for address auto configuration of nodes, discovery of other nodes on the link, determining the link layer addresses of other nodes, duplicate address detection, finding available routers and cluster head, address prefix discovery and maintain the reaching ability information about the paths to other active neighbor nodes.

It provides many improvements over its clustering node counterparts. For example, it includes Neighbor Under reaching ability Detection (NUD) thus improving robustness of packet delivery in the presence of failing routers or links or mobile nodes. Similarly, the remaining energy is estimated because in ad hoc network is a special peer to peer network with a wide range of application that has no infrastructure, multi-hop, self-organizing, dynamically reconfiguration and mobile. People are now paying more and more attention to the using of ad hoc network in the emergence area such as battlefield and disaster rescue. The research on its energy and security are one of the most important aspects of practicality in ad hoc network. In this study, researchers construct an Integrated Mathematical Model based on the residual energy and security. This energy is then subject to conduct inter cluster broadcast where all the nodes inside the cluster utilizes requires high amount of external resource to attain active state. As shown in Fig. 3 once all the nodes inside the cluster receive energy sufficient to be in contact with the cluster head, grouping is initiated thus forming cluster under guidance of their cluster head.

Each cluster having a cluster heads only involve in the neighbour discovery process instead of all node communication in network as that of existing system. So, cluster head plays a vital role in the system thus it is important to declare a node in the cluster as a head. This election process is done on the basis of resource availability and active life time of the nodes hence the node have least failure rate and with maximum resource availability will be elected as cluster head. All this analysis is done probability basis as when dealing with experiments that are random and well-defined in a purely theoretical setting (like tossing a fair coin), probabilities describe the statistical number of outcomes considered divided by the number of all outcomes. Here, nodes with maximum residual energy and maximum average intra-cellular broadcast power is given high priority and taken into probability consideration.

$$C_{head} = \text{(Available node)} - \text{(node of least residual energy)} \quad (1)$$

Parallel process of discrete power controlling is done at the next level where transmitter power control has

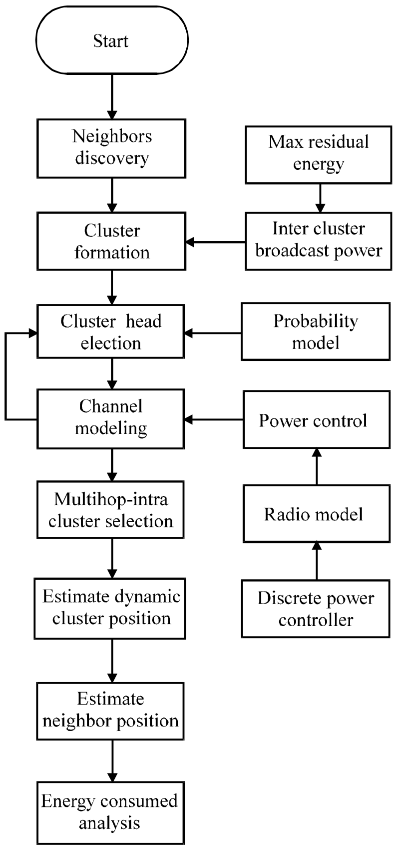

Fig. 3: OpteLoc Optimal Energy Consuming Localization Model

proven to be an efficient method to control co channel interference in wireless nodes and to increase bandwidth utilization. Power control can also improve channel network management functions such as mobile removals, hand-off and admission control. Most of the earlier studies have assumed that the transmitter power level is controlled in a continuous domain whereas in Digitally Power Controlled Systems, power levels are discrete and follows radio model which makes use of Lognormal Shadowing Model which is also called as slow-fading that accounts for random variations in received power observed over distances comparable to the widths of buildings and extra transmit power (a fading margin) must be provided to compensate for these fades.

Finally, local averages in dB of received power (or path loss) tend to be Gaussian when the ensemble is all locations with the same distance in the same type of environment are received. The mean local average path loss follows the standard power control (proportional to 10logdn) mechanism forming transmission channels.

Then, researchers introduce an irregular clustering mechanism that makes the cluster heads which are closer to all the internodes to do the multi hopping process having smaller inter node space than those farther from thus they can preserve some energy for the purpose of inter-cluster data forwarding. For the Dynamic Cluster Head Rotation System, the sensor nodes carry out cluster head utility in turn which balances energy consumption well among CHs. Researchers propose an energy-efficient multi-hop routing protocol executed by cluster head for inter-cluster communication with discrete power control mechanism. The strategy is making the most of CH's energy so the node energy in the network is saved furthest. Simulation results show that energy is clearly prolongs the network lifetime over some related routing protocols. This process is followed by localization where all the information that corresponds to all nodes inside the whole network will be shared among cluster heads. This information had been gathered from the cluster nodes hierarchically which makes data transmission always active and faster with least energy consumption. The experimental analysis of energy consumption is done using network simulator.

SYSTEM IMPLEMENTATION

The proposed system OpteLoc is having the transmission control under minimum energy utilization is implemented in terms of earlier mentioned cluster routing standards. The following flow will show the entire process in terms of codes with cluster head administration mechanism, Discrete Power controller and radio model.

```
OpteLoc Optimal Energy Consuming Localization Model:
    Claim: Handoff cluster head administrator, discrete power controller,
radio model
        Step1: Admission access (neighbour presence ack)
            if (ack == positive)
          do (calculate max residual energy && inter cluster bc power)
             for (index cluster node = 0 to end cluster node n)
                 do (formation of cluster with available energy)
             if (cluster head == 0)
        Step 2:        do (probability model && cluster head election)
             else if (cluster head == 1)
             do (activate Discrete Power Control && radio model)
                  for (index cluster node = 0 to end cluster node n)
                   form (channel modelling)
             if head cluster premises go to step 2.
                 else (maintain record of multihop)
                 do(localization with optimal energy)
        Step 3: if (ack == negative)
                do (search next neighbour in network)
                   for (index cluster = 0 to end cluster n)
              if (ack == positive)
                do (transmission ) go to Step 1.
              else (show neighbour cluster not available)
           End.
```

The whole system is constructed on the basis of above flow where essentiality is maintained at the cluster head to optimally allocate the routing path to search of neighbour cluster available with handful energy resource to keep maximum active nodes for efficient data transmission.

RESULTS AND DISCUSSION

Experimental study: In this study, researchers compare the proposed OpteLoc Method with the MCL, AMCL and AFL algorithms under various network configurations. The conceptual arguments are put forth to prove efficiency standards in OpteLoc is exponent when compared to the predecessors. Researchers have presented more accuracy in terms of efficiency statistically. The consideration is made in order to show the advancement of every parameter like time, throughput, cluster size, consumed energy, location error, PDR, time/round, number of active nodes and average hop count.

In the proposed system OpteLoc during the data transmission the exactness is calculated with that of amount of energy consumed in the mean interval of time and cluster size the following graphs showing line indicates the analysis resultant of proposed OpteLoc and measurement of earlier algorithm standard. When the time measurement is at equal interval of seconds in both the cases and the throughput in the inter communication networks, like 802.16 is the average rate of successful data delivery over a communication channel. This data may be delivered over a physical or logical link or pass through a certain network node. The throughput is usually measured in bits per second (bit/s or bps) and sometimes in data packets per second or data packets per time slot. This slot is drastically improved with a variance rate of more the twice the packets mention as packet delivery ratio which is having a study linearity than the existing system with respect to increase in time/round is shown in Fig. 4.

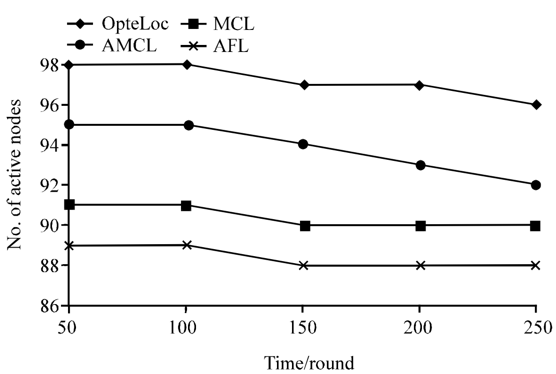

Fig. 4: PDR vs. time/round

The vital energy consumption rate analysis results are shown in Fig. 1 which incurs values of the sensor node that consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process. The energy cost of transmitting 1 kb a distance of 100 m (330 ft) is approximately the same as that used for the execution of 3 million instructions by a 100 million instructions per sec/W processor. Power is stored either in batteries or capacitors. This energy consumption is reduced more than twice of existing algorithms and shows a stream line even the cluster size increases.

Figure 5 shows the reduction in failure rate that is the location error which leads to misconception that makes the whole system utter waste because many wireless sensor network datasets suffer from the effects of acquisition noise, channel noise, fading and fusion of different nodes with huge amounts of data. At the fusion centre where decisions relevant to these data are taken, any deviation from real values could affect the decisions made. In existing system this error rate is high till the mid half of the cycle and only at 800th node it gets minimised because of having larger number of supportive neighbouring nodes but the proposed model has the capacity to overcome this issue the proposal is allocating a separate cluster head of inter cluster transmission and energy consumption analysis got positive result.

In Fig. 6, researchers have shown the increase of active node number in terms of cluster size with respect to energy utilization. In earlier standard there is a gradual decline in the node activeness as the time and size of cluster increases incurring the conclusion that when the system begins its transaction with least number of nodes it has least node failure rate and when the traffic increases (size of cluster) node failure increases because of insufficiency of energy forming inverse proportionality. In the standard node failure is not linear researchers have slight deviations and minimum failure because of optimal energy utilization and cluster head routing information

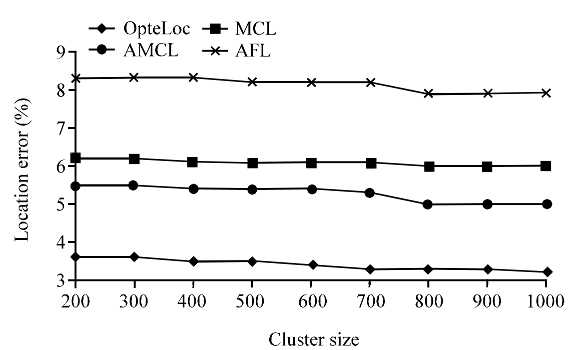

Fig. 5: Cluster size vs. location error

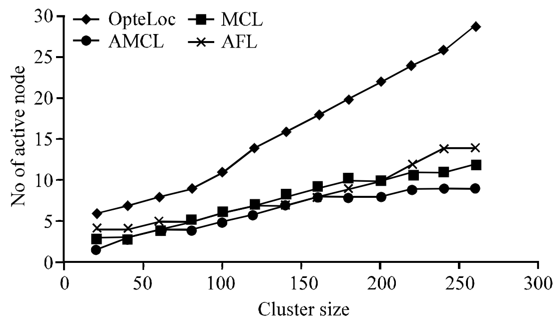

Fig. 6: Cluster size vs. No of active nodes

that gives optimal hopping. Through admission blocking probability to all nodes the transmission is done only through the cluster head proving drastic improvement in availability of maximum active nodes with minimum power consumption. Table 1 shows the overall simulation parameter of this method.

The average hop count though which the range within a band of frequencies or wavelengths is taken into consideration of the next test case where it is compared with packet delay rate and cluster size. The amount of data that can be transmitted in a fixed amount of time is measured. Due to imprecise increase in the number of average hop count handoff is done easily among the cluster heads alone of base transmission clusters the packet delayed rate is enhanced transmission to achieve faster and accurate with intelligent Cluster Header Election System. Thereby increasing efficiency of OpteLoc and is shown in Fig. 7.

Figure 8 plots as the network size increases, the network lifetime for the four protocols and shows that OpleLoc achieves better performances compared to the three others.

Table 2 shows distance between the layers is varied keeping the radio range constant. The effect of interlayer spacing does not affect much of success rate but for the other three methods it varies at a considerable mount.

All these researches of experimental studies were carried out with NS-2 which is a Network Simulator kit Version 2.27 where the energy model standards have verified through code and the parameters of the resultant graph is extracted through NS-2. The area of operation with initial energy of 20 J and base station analysis are made under coverage region of 1500×300 consisting of 100 mobile nodes and their data size of 512 bytes packet size sent between those cluster heads shown in Table 1. Thus, all the values which are necessary for the study is collected and simulation is made according to the outcome for the experiment and accuracy in performance evolution are given evidently.

Table 1: Simulation parameter

Parameters	Values
No. of nodes N	100
Network coverage	1500×300
Initial energy	20 J
Data packet size	512 bytes
Simulation time	50-100
Cluster size	200-1000

Table 2: Effect of distance between the layer

Radio range (m)	Distance between layer	Success in OpteLoca Method (target sensed) (%)	Success in other method (target sensed) (%) AMCL	MCL	AFL	Total time (sec)
5	4.0	89.6	75.1	73.1	70.0	5.324
7	5.0	88.2	74.3	70.0	69.3	5.132
10	5.5	88.0	71.0	69.3	68.0	5.043
12	6.4	87.0	68.0	67.0	65.0	5.432
14	6.8	85.3	65.0	66.0	61.2	5.254

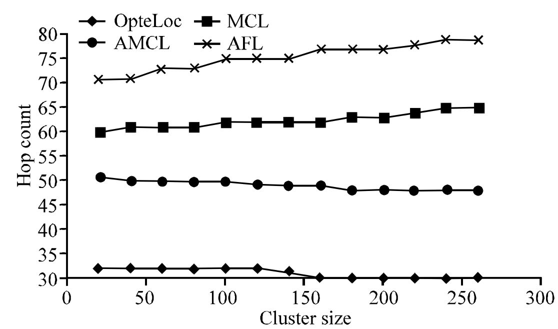

Fig. 7: Cluster size vs. avg hop count

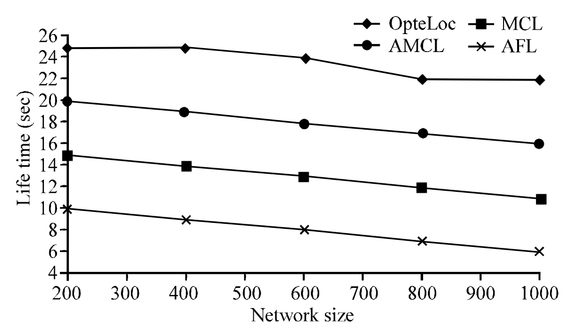

Fig. 8: Network lifetime

CONCLUSION

OpteLoc delivers an optimal energy consumption model for localization in wireless sensor network using multi-hop cluster routing in terms of elevated liveliness of bandwidth across the transmission medium with efforts from cluster head mechanism and probability model. Hence, researchers can achieve optimal energy consumption for the failure recovery of inactive nodes inside the cluster. This suggests that the proposed model and utilization of optimal routing by cluster head is useful in terms of dynamically altering routing and handoff thereby increasing profitability of increased throughput, efficient usage of energy with discrete power controller, reduced overall delay transmission. Thus, data transmission with cluster head basis is proved more efficient than the existing system that follows mesh network formation for data transmission and minimum energy consumption analysis is conduction with NS-2.

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