IMPLEMENTATION OF MULTIPLE STATIC AND MOBILE SINK NODES FOR ENERGY BALANCING IN SENSOR NETWORKS

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Abstract— **Wireless sensor consists of spatially distributed autonomous sensors. Sensors are equipped with tiny irreplaceable batteries and it is very difficult to recharge them and sensors are more prone to hotspot phenomenon .These decreases the network lifetime so it is utmost important to design energy efficient algorithm to prolong network lifetime.**

The influence of multiple static sink nodes on energy consumption under different scale networks is first studied and CAMu-S (Clustering Algorithm for Multi Sink) is proposed and tested. Then, the influence of mobile sink velocity, position and number on network performance is studied and CAMo-S (Clustering Algorithm for Mobile Sink) is proposed and tested. Then by implementation of both static and multiple mobile sink nodes simultaneously is studied and a Clustering Algorithm for Static and Multi-mobile-sink (CASM) algorithm is proposed.

Index Terms—**Wireless sensor network, hotspot phenomenon, network lifetime**

I. Introduction

In Consumer home networks many kinds of products like biosensors, automatic light control, temperature monitoring, weather monitoring, automatic door control, Security control etc.., have been deployed in home automation networks. So that will standardize the human life style and also saves the man power.

Wireless Sensor Networks (WSNs) are suitable for the home networks because of its characteristics like infrastructure -less, self organizing, less faulty, ease of deployment[1].

Sensors are just data collecting or data sensing devices the energy provided to these sensors by tiny batteries that should be irreplaceable ones because once it's deployed it should be operate for long life.

So here communication or data collection happens like this

i) Consumer products are acts as sensors
ii) Clustering should be done
iii) Communication in between sensors is done by using wireless technologies like Bluetooth or Ultra low power technology Zigbee.

The main problem facing in sensors are
i) sensor nodes die early
ii)inter-cluster and intra-cluster communication is not possible
iii)multi-hop communication not there it leads to loss of data
iv)hot spot problems
v)Latency in data updating
vi)end to end delay

All these above problems can be optimized by using good routing algorithm and placing multiple sink node in clustering and mobile sink nodes in the cluster.This as all done by two energy efficient algorithms

1. CAMu-S (Clustering Algorithm for Multi Sink)
2. CAMo-S (Clustering Algorithm for Mobile Sink)

II.RELATED WORKS

LEACH [3] is one of the most famous hierarchical routing protocols for WSNs, which can guarantee network scalability and prolong network lifetime up to 8-fold than other ordinary routing protocols. The energy can be well balanced among sensors since each sensor takes turn to become the cluster head at different rounds. However, 5% of cluster head nodes are randomly chosen and the cluster heads use direct transmission to send their data to the sink node.

In 2003, Shah *et al* [5] first proposed the basic idea of mobile sinks for WSNs where the authors call them "Data Mules." The Mules use random walk to pick up data in their

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close range and then drop off the data to some access points.
The energy consumption for sensors can be largely reduced since the transmission range is short.

Younis *et al* [6] also investigated the potential of base station repositioning to improve network performance. The authors addressed when, where and how the base station should be moved by checking the traffic density of nodes one hop away from base station as well as their relative distance.
A Scalable Energy-efficient Asynchronous Dissemination (SEAD) protocol [7] was proposed to minimize energy consumption in both building a dissemination tree and disseminating data to mobile sinks. When the sink joined the tree, the Steiner tree was built recursively and SEAD found the minimal cost entry to the tree for the sink using unicast.

Gandham *et al* [8] tried to use an ILP (Integer Linear Program) to determine the locations of multiple base stations.
They aimed at minimizing the energy consumption per node and prolonging the network longevity.

In 2004 - 2005, the idea of multiple mobile sinks for WSNs was further investigated. Akkaya *et al* [4] stated that to find the optimal moving positions for mobile sinks was an NP-hard problem in nature. Oyman *et al* [9] focused on multiple sink location problems and they presented three problems (BSL, MSPOP and MSMNL) depending on design criteria and provided solution techniques. Luo *et al* [10] formulated lifetimemaximization as a min-max problem and jointly studied the sink mobility and routing strategy. They claimed that the overall energy is minimized when the mobile sinks were located at the periphery of the circular network. Wang *et al* [11] studied the WSNs with one mobile sink and one mobile relay individually and they claimed that the improvement in network lifetime over the all static network was upper bounded by a factor of four. However, more recently, Shi *et al* [12] proposed theoretical results on the optimal movement of a mobile base station. They showed that when base station location is un-constrained, the network lifetime can be at least (1- ε) of the maximum network lifetime under their designed joint mobile base station and flow routing algorithm. Marta *et al* [13] proposed to change mobile sinks' location when the energy of nearby sensors became low. In that case, mobile sinks had to find new zones with richer sensor energy. The authors claimed that an improvement of 4.86 times in network lifetime was achieved compared to the static sink case. Lee *et al* [14] introduced a single local sink model to minimize total energy cost during geographic routing. The optimal sink location is determined by a global sink and this model was extended to multiple local sinks model to provide scalability. Kim *et al* [15] proposed an Intelligent Agent-based Routing (IAR) protocol to guarantee efficient data delivery to sink node. Mathematical analysis and experimental results were provided to validate the superiority of their proposed protocol in terms of delay, energy consumption and throughput.

III. System Model

Fig. 1 depicts a home network consisting of various types of sensor nodes such as camera, Micaz, biosensor and RFID, as well as multiple static or mobile sink nodes which play a key role in this paper. The home network is divided into several clusters and there is a Cluster Head (CH) inside each cluster, which can perform data fusion after collecting all the raw data from its ordinary members.

Fig.1. System model

Cameras are usually installed in the main room and dining room, which is not suitable for the living room. Biosensors are attached to the body to collect human physical information. Sink nodes can be installed either on the wall (fixed) or attached on the body (mobile) to collect raw data from various sensor nodes. There is a home gateway server which will communicate with both the inside and outside devices via a wired or wireless communication. For example, it will receive commands from users and delivery requests to certain sensor or sink nodes.

The main purpose of this paper is to study the influence of fixed and mobile sink strategies on home network performance in terms of energy consumption, network lifetime as well as to mitigate the hot spot problem. When fixed sink nodes are deployed, the home network is divided into several clusters and the optimal sink number is studied. When mobile sink nodes are deployed (e.g. on human body), the influence of sink moving velocity, position and number of sink nodes on home network performance is studied.

Some assumptions should be made here:
1. Wireless links are bi-directional and symmetric.
2. Sensors are homogeneous and stationary after deployment.
3. Sink nodes are energy unconstraint and they can move freely.
4. Ideal MAC layer with no collisions is supported.

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5. Sensors can adjust their power based on the relative distance.

A traditional home network can be modeled as a graph $P(H, K)$ where H is the set of all sensor nodes and K is the set of all links (a, b). Here, a and b are neighboring nodes. Node a can communicate directly with its neighbor node b if their Euclidean distance is smaller than its transmission radius.

Here, the first order radio model [2], [3] is used as the energy model. Based on the distance between transmitter and receiver, a free space (d^2 power loss) or multi-path fading (d^4 power loss) channel models are used. Each sensor node consumes E_{Tx} amount of energy to transmit a l bits packet over distance d and E_{Rx} for reception, where E_{elec} is the energy dissipated on circuit, and fs and mp are free space and multi-path fading channel parameters respectively.

$$E_{Tx}(l,d)=\begin{cases} lE_{elec}+l\,\varepsilon_{fs}\,d^2, & d<d_o \\ lE_{elec}+l\,\varepsilon_{mp}d^4, & d>d_o \end{cases} \qquad (1)$$

$$E_{Rx}(l)=lE_{elec} \qquad (2)$$

IV. The Proposed CAMu-S and CAMo-S Algorithms

In this section, the influence of multiple static and mobile sink nodes on network performance is studied under different scale hierarchical networks. Two sink mobility based energy efficient clustering algorithms for WSNs are proposed, namely a Clustering Algorithm for Multi Sink (CAMu-S) as well as a Clustering Algorithm for Mobile Sink (CAMo-S).

A. *Clustering Algorithm for Multi-sink(CAMu-S)*

The entire network is divided into several clusters, as depicted in Fig. 2. In each cluster, there is one Cluster Head (CH) for data collection and the rest of the sensors are called ordinary nodes. The CH is determined by the residual energy among sensors and the CH sends aggregated data to the relevant sink. By adopting clustering or hierarchical routing technique, network scalability and easier management can be guaranteed. If the clustering algorithm is well designed with CHs located in a geographically more uniform way, energy consumption can be well balanced and reduced, causing a much prolonged network lifetime.

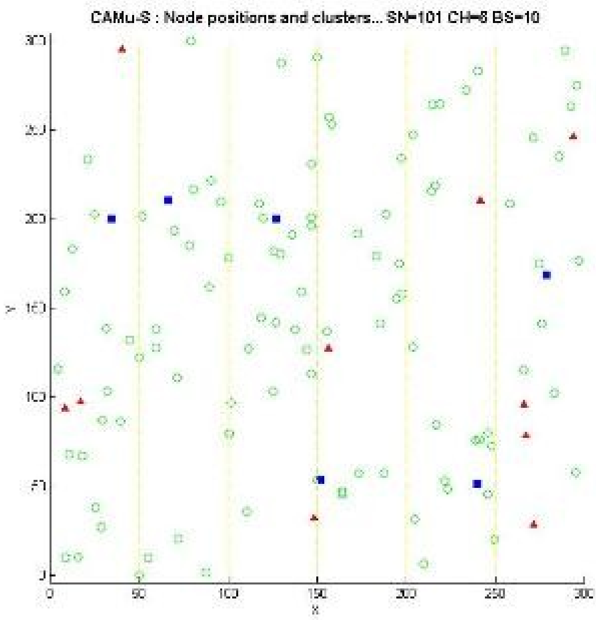

Fig.2. Node positions and clusters

Cluster Head
Sink node
Sensor node

In CAMu-S, each cluster head selects an optimal sink to send aggregated data. The reduction and the balancing of the energy consumption is the primary concern. For any CH , the energy consumption to sink node BS is represented as:

$$E(CH_n,BS_k)=\begin{cases} lE_{elec}+l\,\varepsilon_{fs}\,d(CHn,BS_k)^2, & d<d_o \\ lE_{elec}+l\,\varepsilon_{fs}\,d(CHn,BS_k)^2 & d>d_o \end{cases} \qquad (3)$$

Equ. (3) shows that the smaller $d(CH_n, BS_k)$ is, the smaller $E(CH_n,BS_k)$ will be. Inter-cluster algorithm can be formulated as to find the $Min\ (d(CH_n, BS_k))$

In many clustering algorithms, such as LEACH, some sensor nodes in the same cluster send data directly to the cluster head. Due to the fact of various locations, certain sensor nodes may consume large amount of energy based on long-distance transmission. Therefore, multi-hop routing is used here. For any member node S_i in a cluster, the energy consumption to send data to its CH_{S_i} is represented as:

$$E(S_i, CH_{S_i})=\begin{cases} lE_{elec}+l\,\varepsilon_{fs}\,d(S_i, CH_{S_i})^2, & d<d_o \\ lE_{elec}+l\,\varepsilon_{fs}\,d(S_i, CH_{S_i})^2, & d>d_o \end{cases} \qquad (4)$$

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In the mean time, S_i tries to find another sensor node S_j to relay data to save energy by avoiding directly communication with CH_{S_i}. To deliver a l-length packet to the cluster head, the energy consumption $E_2(S_i, S_j, CH_{S_i})$ calculated as (5) and the optimal relay node is determined based on the smallest value of. $E_2(S_i, S_j, CH_{S_i})$

$$E_2(S_i, S_j, CH_{S_i}) = E_{Tx}(l, d((S_i, S_j)) + E_{Rx}(l) + E_{Tx}(l, d((S_i, CH_{S_i})) \quad (5)$$

As the multiple sink nodes are randomly deployed then in practice some nodes may consume less energy through sending data directly to the sink rather than to its cluster head

B. Clustering Algorithm for Mobile Sink (CAMo-S).

1) Relocation of sink nodes

In CAMo-s, the moving velocity V of the sink is predetermined. A sink node only needs to broadcast across the network to inform all sensor nodes of its current location P_0
at the very beginning for just one time. Later on, as sensor nodes keep record of the original location of the sink, they can
reduce the changed angle θ after a time interval Δt .

$$V = \frac{\theta * R}{\Delta t}$$

$$\theta = \frac{V * \Delta t}{R} \quad (6)$$

As P_0 is known, the new location $P_{\Delta t}$ can be determined, as is shown in Fig. 3.
After the broadcasting finishes, the mobile sink is ready to collect data. Here, the mobile sink is assumed to stay at a site
for a period long enough to complete a round of data collection, and then moves to the next position.

2) Cluster formation and cluster head selection

As depicted in Fig. 4, the whole sensor network is divided into several clusters. When the CH selection begins, the sensor node that is located in the center of each cluster is motivated, like S_i and is regarded as the CH candidate. It broadcasts one message within a neighbourhood of radius R .This message aims to motivate other nodes for the competition of the cluster head. It contains the node's id and its residual energy. Only the nodes within the transmission range can receive the message and become active, whereas the outside nodes remain idle. If any node S_j has larger residual energy than S_i , it becomes the new cluster head candidate and broadcasts new message with its own information to the others. If S_j has equal residual energy with S_i , compare the ID. The node with a smaller ID wins. If S_j has smaller residual energy than S_i , it still broadcasts the message of S_i As soon as the comparison is done, the unselected node becomes idle again. All nodes in the cluster should be compared only once. In this way, the node with the largest residual energy is chosen as the cluster head.

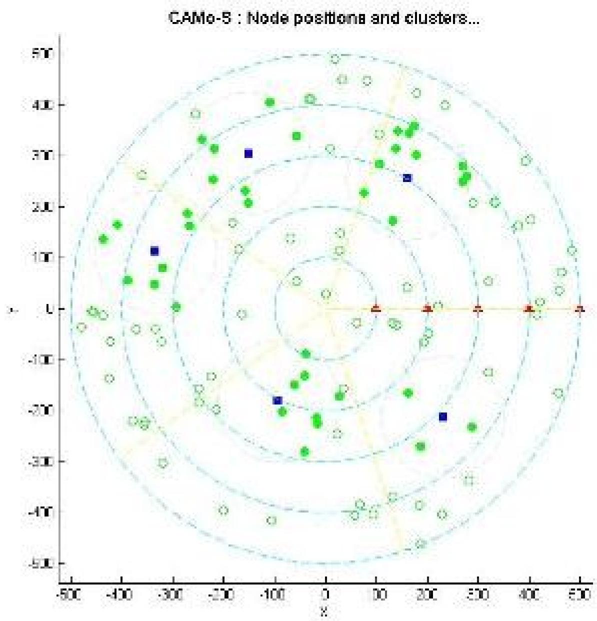

Fig.3. Node positions and clusters

- Cluster Head
- Sink node
- Sensor node
- Sensor nodes motivated for cluster head selection

3) Hierarchical routing phase

For node S_i in one cluster, the energy consumption cost to send data to its cluster head CH_{S_i} is given in Equ. (4). In the
mean time, S_i tries to find another S_j to relay data which may
consume less energy than that through directly communication
with CH_{S_i} . Since the direction of data transmission can be randomly chosen, various nodes can be chosen, which turn out
to cause various energy consumption.
Suppose S_i chooses S_j as its relay node and let S_j have direct communication with the CH_{S_i} . To deliver a l – length packet to the CH, the energy consumed by S_i and S_j is shown
in (5). Each S_i chooses S_j with the smallest $E_2(S_i, S_j, CH_{S_i})$
as the relay node if necessary:

$$E_2(S_i, CH_{S_i}) = \mathrm{Min}(E_2(S_i, S_j, CH_{S_i})) \quad (7)$$

Compare (4) and (7), and the smaller one is chosen:

$$E(S_i, CH_{S_i}) = \mathrm{Min}(E_1(S_i, CH_{S_i}), E_2(S_i, CH_{S_i}))$$

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In CAMo-S, the sink node changes its location overtime. Therefore, some nodes may consume less energy through sending data directly to the sink rather than to its cluster head. So it is necessary to compare $E\,(S_i, CH_{S_i})$ and $E(S_i, BS)$ and decide the final route. In summary, the clustering algorithms in this paper can be viewed as to find The

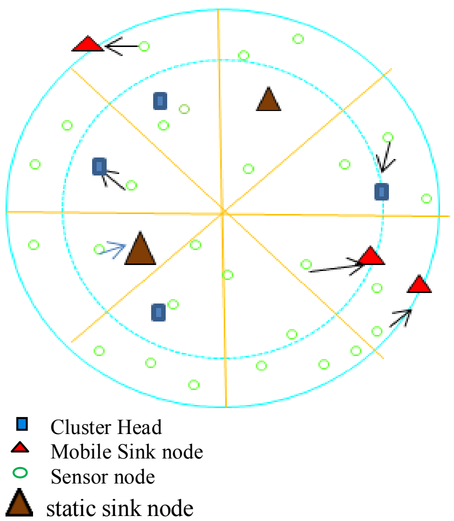
$$Min\ (E(S_i, CH), E(S_i, BS))$$

IV) PROPOSED CASM ALGORITHM

A) *Clustering Algorithm for Static and Multi-mobile-sink (CASM)*

Here both multiple mobile and static sink nodes are deployed. Suppose whenever sink node appears near to it then cluster head it can directly forward packet to sink node. IN this case sink node is both static and mobile. Thus, energy is saved. Sensor nodes will calculate least distance which is required to forward the packets. Sensor nodes calculates the minimum energy required with the help of this formula

$$Min\ (E\ (S_i, CH), E\ (S_i, BS))$$



V.PERFORMANCE EVALUATION

A. *Test Environment*

Consider the following parameters, there are 100 Sensor nodes

Deployed in a [500,500] network with multiple sink nodes placed either inside or along periphery of the area. The maximum transmission radius is assumed to be 120 meters

Each sensor node transmits the collected data to a sink either Directly or in a multi-hop fashion.

TABLE I
The following network parameters are initially assumed

Parameter name	Value
Network size	[300,300] to [500,500]
Num of nodes(N)	100
Radius(R)	120m
Packet length(l)	6 bits
Initial energy(E_0)	0.5 Joule
Energy consumption on circuit	50nJ/bit
Free space channel parameter	10pJ/bit/m^2
Multi-path channel parameter	0.0013pJ/bit/m^4

B) CAMu-S performance analysis

i) Performance analysis total energy consumption

100 sensor nodes are randomly deployed. As illustrated in the fig. 3 .Here whole network is divided into several clusters

By, changing the number of sink node and the number of cluster total energy consumption can be evaluated .It can be seen that total energy consumption units decreases as the number of sink node increases .when 3 or 4 sinks are deployed

The decreasing rate of energy consumption becomes relatively small even if more sink nodes are added later.

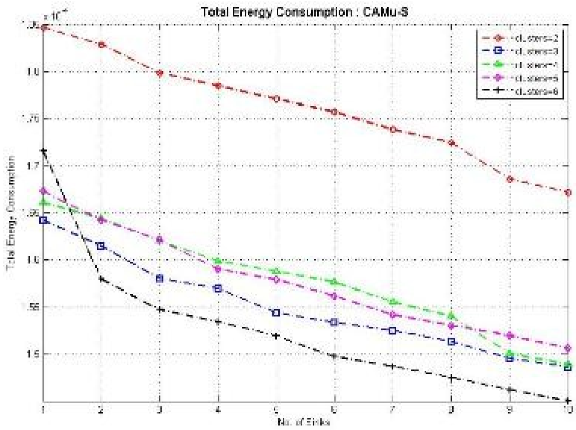


Fig.4.Total Energy Consumption : CAMu-S

C) CAMo-S performance analysis

i) performance analysis of single sink mobile node by varying its velocity

The influence of single mobile sink node moving under different strartergy is studied.

Fig. 4 illustrates, changing the velocity of sink node influences the energy consumption of the sensor network.

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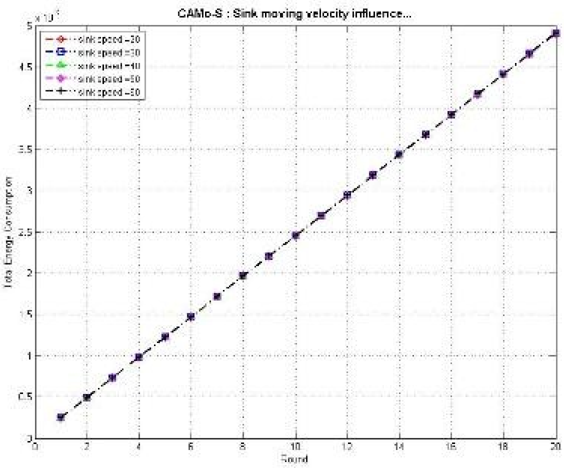

Fig.5 (a) Sink moving velocity influence

ii) performance analysis of single sink mobile node by varying its position

Fig.5 illustrates the influence of position of a sink node Moving in a different radius(1/5R,2/5R….)

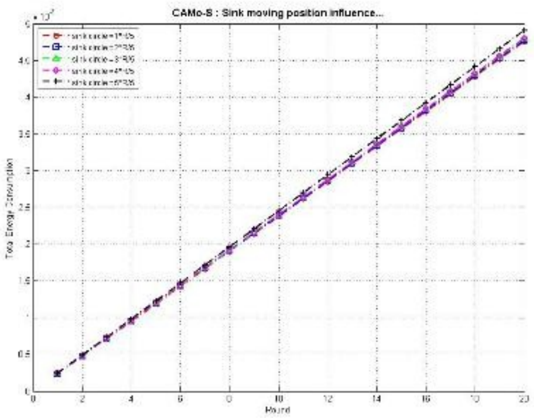

Fig.5 (b) Sink moving position influence

It can be seen that single mobile sink velocity and position have little influence on energy comsumption of sensor node due to the avarege distance square being similar to the single moving sink regarding the random sensor network topology

iii) influence of multiple mobile sink number on energy consumption by varying number of sink nodes

It can be seen from fig.6 that as the number of sink nodes increases total energy consumption decreases.but,it is necessary to find the optimal sink number for improving sensor network lifetime.

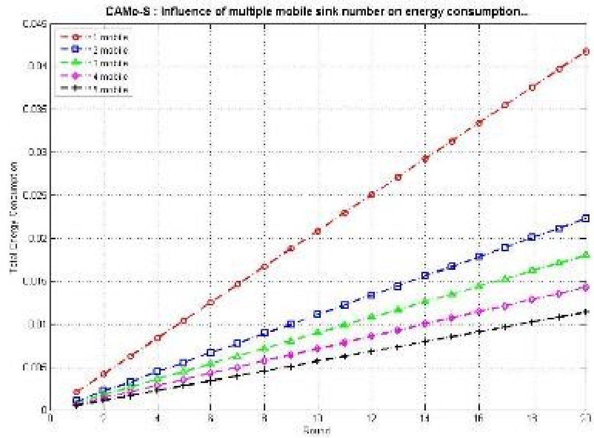

Fig.6. Influence of mobile sink number on energy consumption

VI. CONCLUSION

The main focus of this project is balancing energy among Sensor nodes and to improve the network lifetime of sensor Network. Therefore two algorithms CAMu-S and CAMo-S is Proposed and tested .the another algorithm CASM has been Proposed.

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