Increase The Network Lifetime in WSN Using Clustering Algorithm

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A wireless sensor network consists of spatially distributed autonomous sensors to monitor physical or environmental conditions and to cooperatively pass their data through the network to a main location. Utilizing Mobi-clustering algorithms to form a hierarchical network topology is a common method of implementing network management and data aggregation in wireless sensor networks. Mobi-clustering algorithm is used minimizing the overall network overhead and energy. Power consumption and maximizing the life time are the important aspects of wireless sensor networks. The proposed protocol aims at minimizing the overall network overhead and energy Distribution associated with the multi-hop data retrieval process while also ensuring balanced energy consumption among Sensor Nodes and extended network lifetime. Arranging cluster sizes and transmission ranges (ACT), reduces the size of clusters near the base station and provides energy consumption. But it does not concentrate on coverage problem and maximizing the life time. In this project is developed similar to, the Integer Linear Programming (ILP) problem that formulates the coverage problem and maximizes life network time of the sensor nodes. It implement the optimization problem, with the objective function and several constraints of this problem can be solved to optimality by using CPLEX solver.

Index Terms: Cluster, Energy consumption, Energy-Balancing, Routing protocol, Wireless sensor networks.

1. INTRODUCTION

1.1 Overview of Wireless Sensor Networks

Wireless Sensor Networks have emerged as research areas with an overwhelming effect on practical application development. They permit fine grain observation of the ambient environment at

an economical cost much lower than currently possible. In hostile environments where human participation may be too dangerous in sensor network which may provide a robust service. Sensor networks are designed to transmit data from an array of sensor nodes to a data repository on a server. WSN has potential to design many new applications for handling emergency, military and disaster relief operations that requires real time information for efficient coordination and planning. Sensors are devices that produce a measurable response to a change in a physical condition like temperature, humidity, pressure etc.

WSNs may consist of many different types of sensor such as seismic, magnetic, thermal, visual, infrared, and acoustic and radar capable to monitor a wide variety of ambient conditions. Through each individual sensor may have severe resource constraint in terms of energy, memory, communication and computation capabilities; large number of them may collectively monitor the physical world and process the information on the fly environment. In a WSN, sensor nodes monitor the environment, detect events of interest, produce data and collaborate in forwarding the data towards a sink, which could be a gateway, base station, storage node, or querying user. A sensor network is often deployed in an unattended and hostile environment to perform the monitoring and data collection tasks. When it is deployed in such an environment, it lacks physical protection and is subject to node compromise. After compromising one or multiple sensor nodes, an adversary may launch various attacks to disrupt the in-network communication.

1.2 Wireless Sensor Networks Characteristics

A WSN is different from other popular wireless networks like cellular network, WLAN and Bluetooth in many ways. Compared to other wireless networks, a WSN has much more nodes in a network, distance between the neighboring nodes is much shorter and application data rate is much lower also. Due to these characteristics, power consumption in a sensor network will be minimized. To keep the cost of the entire sensor network down, cost of each sensor needs to be reduced. It is also important to use tiny sensor nodes. A smaller size makes it easier for a sensor to be embedded in the environment it is in. WSNs may also have a lot of redundant data since multiple sensors can sense similar information. The sensed data therefore need to be aggregated to decrease the number of transmission in the network, reducing bandwidth usage and eliminating unnecessary energy consumption in both transmission and reception.

The main characteristics of a WSN include,

- Power consumption using batteries or energy harvesting
- Ability to cope with node failure
- Mobility of nodes
- Heterogeneity of nodes
- Scalability to large scale deployment
- Ease of use

1.3 Benefits of Wireless Sensor Network

The two primary motivations for choosing a wireless network over a wired approach are the flexibility and the cost-savings associated with eliminating cables and wires.

- Flexibility
- Low cost
- Lifetime maximization

1.4 Overview of Clustering

The large-scale deployment of wireless sensor networks (WSNs) and the need for data aggregation necessitate efficient organization of the network topology for the purpose of balancing the load and prolonging the network lifetime. Clustering has proven to be an effective approach for organizing the network into a connected hierarchy. In this article, we highlight the challenges of clustering in a WSN, discuss the design rationale of the different clustering approaches, and classify the proposed approaches based on their objectives and design principles. We further discuss several key issues that affect the practical deployment of clustering techniques in sensor network applications. In order to support data aggregation through efficient network organization, nodes can be partitioned into a number of small groups called clusters. Each cluster has a coordinator, referred to as a cluster head, and a number of member nodes.

Clustering results in a two-tier hierarchy in which cluster heads (CHs) form the higher tier while member nodes form the lower tier. The member nodes report their data to the respective CHs. Research on clustering in WSNs has focused on developing centralized and distributed algorithms to compute connected dominating sets. The CHs aggregate the data and send them to the central base through other CHs. Because CHs often transmit data over longer distances, they lose more energy compared to member nodes. The network may be clustered periodically in order to select energy-abundant nodes to serve as CHs, thus distributing the load uniformly on all the nodes. Besides achieving energy efficiency, clustering reduces channel contention and packet collisions, resulting in better network throughput under high load.

1.5 Cluster Network Characteristics

A basic cluster has the following characteristics:

- Multiple computing nodes
- Low cost
- A fully functioning computer with its own memory, CPU, possibly storage

- Own instance of operating system
- Computing nodes are connected by interconnects
- Typically low cost, high bandwidth and low latency
- Permanent, high performance data storage
- A resource manager to distribute and schedule jobs
- The middleware that allows the computers act as a distributed or parallel system
- Parallel applications designed to run on it

1.6 Benefits of Clusters

Benefits and reasons for popularity of clusters can be listed as follows:

- **No expensive and long development projects**. Building clusters is easy, compared to building a dedicated supercomputer.
- **Price performance benefit**: Highly available COTS products are used.
- **Flexibility of configuration**: Number of nodes, nodes' performance, and inter-connection topology can be upgraded. System can be modified without loss of prior work. Two types of scaling can be defined.
- **Scale up**: Increasing the throughput of each computing node.
- **Scale out**: Increase the number of computing nodes. Requires efficient I/O between nodes and cost effective management of large number of nodes.

2. RELATED WORK

Wireless distributed micro sensor systems will enable the reliable monitoring of a variety of environments for both civil and military applications. In this paper, we look at announcement protocols, which can have important impact on the overall energy dissipation of these networks [2]. Based on our findings that the conventional protocols of direct broadcast, minimum-communication-energy, multi-hop routing, and stationary clustering may not be most favorable for sensor networks, we recommend LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilize randomized revolution of local cluster base stations (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH uses limited to a small area organization to enable scalability and robustness for go-ahead networks, and incorporate data union into the routing protocol to reduce the amount of information that must be transmit to the base station. Simulations show that LEACH can attain as much as a factor of 8 reduction in energy dissipation compared with conventional direction-finding protocols. In addition, LEACH is able to share out energy debauchery evenly throughout the sensors, replication the useful system life span for the networks we simulated.

Wireless sensor networks (WSNs) are composed of a large number of inexpensive power-constrained wireless sensor nodes, which sense and watch physical parameter around them from beginning to end self-association. Utilizing clustering algorithms to form a hierarchical network topology is a common method of implementing network management and data aggregation in WSNs [3]. Assuming that the residual energy of nodes follows the random allocation, we suggest a load-balanced clustering algorithm for WSNs on the basis of their distance and thickness allocation, creation it fundamentally different from the previous clustering algorithms. Imitation tests specify that the new algorithm can build more balanceable clustering structure and enhance the network life cycle. A new method is proposed in this paper to improve Low Energy Adaptive Clustering Hierarchy(LEACH) by electing cluster heads according to the residual energy of the nodes dynamically[4].

A sliding window is set up to adjust the electing probability and keep stable the expected number of the cluster heads using two parameters in this method, one is the initial energy information of the nodes and the other is the average energy information of those that have not already been cluster heads in the network. Meanwhile, the number of cluster heads which is fixed in the entire network lifetime in LEACH is modified to be a variable according to the number of the living nodes. Simulations show that the improvement for First Node Dies (FND) and Half of the Nodes Alive (HNA) is 41% and 36%, respectively over LEACH, 17% and 26% for Low

Energy Adaptive Clustering Hierarchy with Deterministic Cluster-Head Selection (LEACH-DCHS), 22% and 21% for Advanced Low Energy Adaptive Clustering Hierarchy (ALEACH).

Networking together hundreds or thousands of cheap micro-sensor nodes allows users to accurately monitor a remote environment by intelligently combine the data from the personality nodes. These networks require robust wireless communication protocols that are energy efficient and provide low latency [5]. In this paper, they developed and analyze low-energy adaptive clustering hierarchy(LEACH), a protocol architecture for micro-sensor networks that combines the ideas of energy-efficient cluster-based routing and media access together with application-specific data aggregation to achieve good performance in terms of system natural life, latency, and application-supposed quality. LEACH includes a new, distributed cluster arrangement technique that enables self-organization of large statistics of nodes, algorithms for adapting clusters and turning cluster head positions to evenly allocate the energy load among all the nodes, and technique to enable disseminated signal dispensation to save announcement resources. Our results show that LEACH can recover system lifetime by an order of extent compared with general-purpose multi-hop approaches.

3. PROPOSED WORK

In a WSN, the sensor network is often deployed in an unattended and hostile environment to perform data collection tasks. It lacks of physical protection and is subject to node compromise when it is deployed in such an environment. An important objective of any clustering technique is network connectivity. For intra-cluster communication, a cluster member communicates with its CH either directly. Connectivity in this case is a result of the success of cluster formation. Network density has to be sufficiently high in order to ensure that enough gateways are present at the intersection areas between clusters. After compromising one or multiple sensor nodes, an challenger may launch various attacks to disrupt the in-network communication. compromised nodes drop or modify the packets that they are supposed to forward.

Utilizing Mobi-clustering algorithms to form a hierarchical network topology is a common method of implementing network management and data aggregation in wireless sensor networks. Power consumption and maximizing the life time are the important aspects of wireless sensor networks. The proposed protocol aims at minimizing the overall network overhead and energy Distribution associated with the multi-hop data retrieval process while also ensuring balanced energy consumption among Sensor Nodes and extended network lifetime. Arranging cluster sizes and transmission ranges (ACT), reduces the size of clusters near the base station and provides energy consumption. But it does not concentrate on coverage problem and maximizing the life time. ACT consists of the cluster formation phase, data forwarding phase and cluster maintenance phase. The following conditionsare assumed

- The positions of Base Station and sensor nodes is fixed.
- The power of all sensor nodes is the same in the beginning.
- Each sensor node transmits one unit of data to the CH in each round.
- A CH aggregates data and then forwards them to BS.
- Energy uniformly distributed in the sensor field with density dn.
- Sensor nodes can adjust power levels. The maximum power level can be used in transmitting data to BS directly.
- The covered area is a WL rectangle, where W is the width and L is the length. Note that the area considered in LEACH and BCDCP are also rectangular.

The proposed work consist of the list of modules which describes the network life time and coverage area.

- Node Creation.
- Cluster head selection.
- Cluster building phase.
- Cluster maintenance phase.

3.1 Node Creation

In this module, wireless sensor nodes are created and information collected from the sensor nodes. Various information from the sensor nodes collected though multi hop communication. Calculate the distance from base station to each sensor node and individual node to node distance also calculate using the cluster radius .According to the radio energy dissipation model [4], the energy consumed by sensor nodes for transmitting k bits of data at a distance d is:

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$

That is ,

$$E_{Tx}(k,d) = E_{elec} \times k \times \varepsilon_{amp} \times k \times d^2 \qquad (1)$$

Where E_{elec} is the energy used in a sensor node for a transmitting one bit of message.ε_{amp} is the energy consumed by the transceiver during its transmission of one bit data through amplifier.

Eq. (1) is simplified into eq. (2):

$$E_{Tx}(k,d) = k \times (E_{elec} + \varepsilon_{amp} \times d^2 \qquad (2)$$

Eq. (2) to calculate the radius of the each cluster.

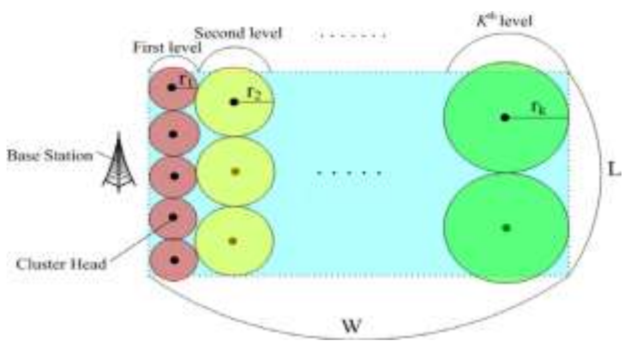

Fig.1: Level structure

3.2 Cluster Head Selection

Cluster head is selected by comparing the remaining power of the nodes. This approach helps to prolong the lifetime of the nodes. If the power of sensor node is higher than other sensor nodes in a group that will be selected as a cluster head. DSBCA follows a distributed approach to establish hierarchical structure in self-organizing mode without central control. DSBCA selects the random nodes to trigger clustering process first. Then the trigger node calculates its connected density and distance from the base station to determine cluster radius and became the temporary cluster head selection.

3.3 Cluster Building Phase

DSBCA sets the threshold of cluster size. The number of cluster nodes cannot exceed the threshold to avoid forming large clusters, which will cause extra overhead and thus reduce network lifetime. When the cluster head node receives Join message sent by the ordinary node, it will compare the size of cluster with threshold to accept new member and update the count of cluster nodes if the size is smaller than threshold, or reject the request. If the rejected node has cluster head already, the clustering process cases. Otherwise, it finds another suitable cluster to join. Each member node of cluster maintains a cluster information table, which saves the HID, HD, SID and other information.

For example, the node checks HD in a newly received packet, if HD is smaller, then it updates the value of HD in table, with SID updated. That is to say, it has found a shorter path to cluster head and sets the new SID as its forwarding node. The overlapping cluster node has multiple HID information entries for different clusters. DSBCA algorithm avoids the fixed cluster head scheme(cluster head manages cluster and forwards data, so it consumes energy faster than other nodes), with periodic substitution to balance the node energy utilization.

3.3.1 Data forwarding

The data forwarding phase consists of intra-cluster data forwarding and inter-cluster data forwarding.,

- **Intra-cluster data forwarding**:

After cluster setup, CHs collect data transmitted from cluster members and perform data aggregation. If a CH adopts single-hop for intra-cluster data forwarding, the sensor nodes farthest from the CH consume much more energy in larger clusters. To avoid this, we employ the concept of the MST to reduce the distance between the sensor nodes and CHs for data transmission.

In a network with a high density of sensor nodes, the transmitted information may go far before reaching the targeted CHs if the MST is applied. Therefore, we assign a hop count H. At the time the data transmission begins, the data forwarding from one sensor node to another causes the value of H to be decreased by one. When the value H is equal to zero but the data fails to reach the targeted CH, the sensor node that holds the data at the moment passes the data to the CH directly to avoid time-consuming routing.

- **Inter-cluster data forwarding**:

The inter-cluster data forwarding refers to transmissions of CHs' collected data from cluster members in the ith level to the next CH in the (i-1)th level closest to the BS until the transmitted data reach the BS.

3.4 Cluster Maintenance Phase

The power of a CH may be exhausted after going through cluster setup and several data transmissions. At this time cluster maintenance, such as picking out a new CH and merging clusters, should be performed to continue data transmissions from sensor nodes to the BS. Cluster maintenance is also required when a CH is away from its original cluster due to the mobility of sensor nodes. In the traditional cluster-based routing protocol, the cluster maintenance phase is very important because the loads imposed on the CHs are much larger than those imposed on the sensor nodes; as a result, the power of CHs may be exhausted quickly. In case the power of the CH approaches depletion, a new CH is elected. In ACT, the cluster maintenance phase consists of CH rotations within a cluster and cross-level data transmission to the BS.

CH rotations in a cluster:

Define the threshold of CH power as T (15% of initial energy). When the remaining power of a CH is under T, a new CH is selected from among the sensor nodes, usually the one closest to the CH within its cluster group, while a change msg is broadcast to inform cluster members of the change of CH.

Cross-level data transmission to BS:

In ACT, clusters in the 1st level are the smallest in size, and thus, fewer cluster members are found in the 1st level. If the sensor nodes within a cluster take turns serving as CHs, the process may finish quickly as there are not enough sensor nodes. When the BS is aware that each sensor node in the 1st level can no longer serve as a CH, it broadcasts a message to allow the CHs in the 2nd level to transmit data to BS directly . Let the network topology be divided into K levels with the CHs in the 1st level transmitting data to BS. When the power of each sensor node in the 1st level is exhausted after a while, the CHs in the 2nd level assume the process of data transmission (the same for 3rd level, 4th level,…Kth level). In this way, the network lifetime can be extended.

Cluster head selection, cluster setup and intra-cluster communications are the fundamental methods of forming a cluster. Moreover, while ACT does consider ‘‘cross-level data transmission to BS’’ and ‘‘communication load balance for each cluster,’’ LEACH, BCDCP and MRLEACH do not.

4. SIMULATION RESULTS AND PERFORMANCE ANALYSIS

We conduct simulations to study the performance of the proposed ACT and the other three schemes, LEACH, BCDCP and MR-LEACH.

4.1 Simulation setup

We use a combination of the NS-2 [6] and the Mannasim [7] in simulations.We apply the first order radio model [5] to evaluate the energy dissipation in sensor nodes. We average the results based on 300 runs for each scenario. In addition, we are interested in the following performance metrics: (1) average energy dissipation; (2) standard deviation of energy consumption of CHs (utilizing standard deviation to observe the scattering of values); (3) the number of sensors alive; and (4) network lifetime (which is defined as the number of rounds in which the first sensor node uses up its energy).

4.2 Simulation results

The average energy dissipation in sensor nodes in four types of routing protocols, namely LEACH, BCDCP, MRLEACH and ACT, within a range of 80 _ 120 m2. The energy dissipation found in LEACH is greater than that in BCDCP, MRLEACH and ACT as a whole. This is because LEACH adopts single-hop communications with the CH sending its data directly to the BS; BCDCP, MR-LEACH and ACT utilize multi-hop communications that require less energy consumption from each sensor node.

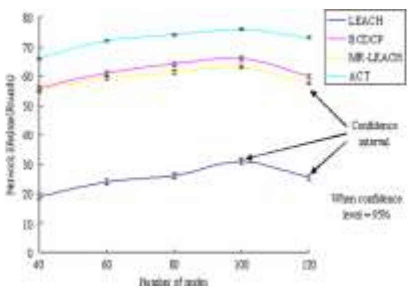

Fig.2: Network lifetime of different node densities

Table.1: The simulation parameters

PARAMETER	VALUE
Network size	$80\times 120m^2$
Base station location	(0,40)m
Number of sensor nodes	96 nodes
Density	1 node/ $100m^2$
Initial energy of each sensor node	0.5J
Data packet size	500 bytes
E_{elec}	50 nJ/bit
E_{amp}	100 pJ/bit/m^2
K	3 for ACT ,4 for MR-LEACH

The network lifetime for different node densities of 40, 60, 80, 100 and 120 nodes. We define network lifetime as the number of rounds before the first sensor node uses up its energy in the network.

5. CONCLUSION

Mobi-clustering algorithm can form more stable and reasonable clusters, and also improve the network life cycle. Wireless sensor network requires sensor node to work for a long period of time without human intervention. Using Integer Linear Programming(ILP) problem to avoids the coverage problem and increases the network lifetime, that cannot be achieved in existing system. The clusters formed by DSBCA is based on the distance from base station, distribution of nodes and residual energy accord with actual network. Hence, it achieves a better performance even when the number of nodes changes As a result, the energy consumption decreases effectively. The cluster structure changes in each round in LEACH, but DSBCA maintains relatively stable clustering structure in which switching of cluster head often occurs in the same cluster.

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