Energy-Efficient Enhanced Hierarchical Routing Chain Based Clustering for Wireless Sensor Networks

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Abstract— Wireless Sensor Networks (WSN) constitute a wide range of applications. In most applications, sensor nodes are distributed in harsh environments and WSN nodes are power-limited, so once installed it will be difficult to charge those sensor nodes. In this article, combined with clusters, we propose a routing scheme that saves energy. First, the entire surface of the sensor is divided into parts, and then the sensor is divided by weighing the elements. Each section selects a Cluster Head (CH).Clustering is one of the common methods to maximize energy production. All sensor hubs are assembled into a number of groups in the clustering technique and each group is assigned a group head called the Cluster Head (CH). The CH absorbs high energy as they are responsible for data processing and data transmission compared to the remainingSensor Nodes (SNs). The heads of the cluster are usually overwhelmed with a large number of sensing nodes, resulting in faster death. We propose an enhanced hierarchical routing chain-based clustering (EHRCC) algorithm based on the LEACH algorithm. The EHRCCalgorithm uses E-LEACH, PEGASIS-E,LEACH-1R PEGASIS and P-LEACH algorithm to investigate the creation of clusters, cluster head choice, chain creation, as well as the data transmission mechanism. Simulation results show that, EHRCC is better consumption of energy compared to HEED, E- LEACH,E- PEGASIS In addition, we evaluate the impact of various network parameters on network efficiency and further improve its performance.

Keywords: Cluster Head(CH), enhancedhierarchical routing chain-based clustering(EHRCC), LEACH, Cluster-Chain Mobile Agent Routing (CCMAR), Energy-efficient Cluster-based Dynamic Routing Algorithm (ECDRA)

I.INTRODUCTION

There are many small, lightweight, low-power nodes in a wireless sensor network. The number of sensor nodes in each WSN is application specific, and the program used in a specific wireless sensor network is built by combining multiple sensor nodes. Many programs include the implementation of WSNs, including military, smart home, environmental and health programs. In most of these applications, the sensor node is difficult to charge and may not be able to charge the sensor node battery. So the main problem with WSN continuity could be power limitation.

Generally, there are two methods to control the transmission distance, namely the routing algorithm and the network topology. Using the correct routing algorithm for certain network topologies will significantly affect the power consumption of the WSN, affecting the life of the network. There are different categories of routing algorithms and each category in WSN is related to a specific problem. Hierarchical routing algorithms are types of routing algorithms that are concerned with power consumption and network life. This project provides an improved and energy efficient routing algorithm.

Battery replacement is not common because sensors are usually powered by a limited battery, the number of sensors is high, and the cost is high. In the event of a power outage in the WSN, it is recommended to install a large-capacity battery in the sensor. However, battery performance has reached its limit and is difficult to improve. So, the only way to solve the WSN outage problem is to implement a low-power routing protocol[6,7].A number of local and international studies on the WSN routing protocol [15–28] have shown that better routes improve network lifetime and reliability. For many sensor nodes, hierarchical routing protocols provide excellent scalability and can include aggregation of data for each group via the Cluster Head (CH) [29].

Each sensor owns its monitoring range and fade zones will appear once a node dies and the network output will also decrease rapidly. The uneven performance phenomenon in WSN is close to the performance range. Both are the result of the "hotspot" problem. The "hotspot" problem usually occurs in fixed pool WSN and fixed network topologies.

Storage nodes usually load a lot of traffic because they need to move data packets from the outer layer to storage and extract resources faster. Because the pit is rigid and the lattice structure does not change, the energy becomes more and more uneven over time. Network lifetime is an important metric for estimating network performance and is usually defined as the downtime of the first node.

Issues related to energy efficiency and energy balance have been the subject of much work and excellent results have been obtained [10-13]. By dividing the sensors into multiple groups according to some special rules, the grouping technology can significantly reduce the power consumption of WSN. One or one cluster in each cluster is its member, and more cluster heads (CHs) are selected as relay nodes.

The Low Energy Adaptive Clustering Algorithm (LEACH) is one of the classic routing protocols that uses clustering. However, the method for choosing CH is not reasonable and more work is being done on the basis of LEACH. Sink Mobility Technology is an effective method to address WSN's energy imbalance.

An E-LEACH protocol was, for instance, proposed to balance network loads and adjust the round time[30], the residual power of the sensor nodes and the optimum cluster size are taken. The PEGASIS-E protocol was proposed using the average distance between sensor nodes as a chaining criterion[29].

Second, by abridging, the overallenergy consumption can be significantly decreased.Assuming that the sink mobility pattern is well built, the transmission distance between the contact pairs. Second, by using a mobile sink, the latency of the network can be decreased and the throughput of the network can be increased. Eventually, even under sparse or disconnected sensor networks, network access can be assured.

In this paper, we present an energy-efficient routing schema combined with clustering to solve the aforementioned issues.. In this paper ,an improved chain-based clustering, based on the LEACH algorithm,It is proposed to include enhanced hierarchical routing chain-based clustering ((EHRCC) for utilizing better energy efficiency.

II. RELATED WORKS

Much attention has been paid to energy- efficient routing protocols in recent years. The energy-efficient dynamic routing algorithmbased on clusters (ECDRA)[13] is a mobilesink-based routing scheme. The mobile sink is deployed on the outer side of the circular sensor area in ECDRA and revolvesIn a circular way. According to the location of the mobile sink, the topology of the network changes dynamically.

One of the most well-known and representative hierarchical routing protocols first proposed is LEACH[15]. All sensors in LEACH are broken down into two groups, cluster heads (CHs) and ordinary nodes (ONs).An ON will supply its monitored data to its corresponding CH, and the CH will fuse the monitored data to the base station (BS) and forward it. In terms of expanding the network lifespan, LEACH is far superior to conventionalrouting protocols. However, CHs are frequentlyunevenly distributed due to the random choice of CHs, and CHs interact directly with the BS, causing big dissipation of electricity.

An improved version of LEACH, which is achain-based hierarchical protocol, is power- efficient collection in sensor information systems (PEGASIS)[16]. In PEGASIS, each node only needs to send to its nearest neighbour a data package that is closer to the BS than the source node. CHs are attached By the greedy intercluster communication algorithm, into a chain. Then, it is the duty of each chain leader, who is closest to the BS, to forward the data packages to the BS. By avoiding long-distance communication, chain construction allows aneconomical use of electricity. Meanwhile, a serious network delay may be triggered due to the use of multi-hop propagation. Hence, for delay-sensitive applications, this protocol is not suitable.

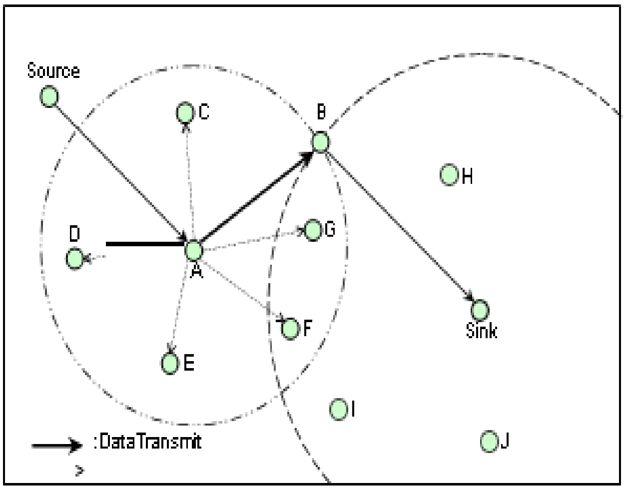
There have been several studies recently focused on investigating the protocols forenergy-efcient routing. For example , a new protocol called ECHERP was proposed in [32], which can pursue energy conservation by balanced clustering. The proposed protocol has been found to be effective in terms of energy consumption.

Compared to LEACH, the hybrid, energy- efficient, distributed clustering method (HEED)[17] is a substantially improved alternative with regard to aspects of CH selection. It uses residual energy as a key parameter and the CHs are more likely to be nodes with higher energy. In this way, it was possible to substantially delay the time when the first node dies, and to produce more uniform CHs. The secondary parameter for deciding which cluster a node should participate in is intracluster communication cost.

Recently, we are focusing on designing energy-saving algorithms that route data received from fixed sensor nodes in the target area and transmit them in a fixed manner. The latest developments in energy saving control algorithms are the product of two well-known routing algorithms, LEACH and PEGASIS.

WSN implemented to protect the lifetime of the network. However, the cluster nodes are not well distributed and most of the network performance is loaded by the overload algorithm. Therefore, PEGASIS based on a single chain topology was introduced to reduce power consumption by using a coverage algorithm during the data transmission and configuration process. However, there is a long delay because Pegasus forms long chains to propagate the observed data. Therefore, the PEGASIS algorithm is not suitable for long delays in long transmission paths.

With the original LEACH[29], the E- LEACH algorithm adopts the same round principle and each round can be split into a clustering phase and a stable transmission phase. Each node which has not served as theCH produces a random number between 0and 1. in the clustering stage. If the random generated The number is lower than the threshold value T(n) provided, and the nodeis elected as the Cluster Head(CH).



PEGASIS-E is an improved routing algorithm based on the chain that operates in the round[30], and each round can be dividedinto the process of chain creation, the selection stage of the leader, and the process of data transmission. In the construction process of the chain, the node farthest from BS joins the first chain before all the nodes complete the chain.

The leader in each round of communication is at the random place on the chain in the leader selection process , ensuring network robustness against failures[30]. Each node delivers its own sensed data to its neighbour in the data transmission process, and the neighbour nodes fuse the neighbour further. The data was received with their own data and forwarded further to the leader[30].

III. EHRCC ALGORITHM

3.1 Network Model and Assumptions

There are N sensor nodes randomly arranged in a square M-M region in this paper. In addition, some assumptions are made as follows: the sensor nodes and BS are static; the sink node energy is unlimited and the energy of common nodes is restricted; the position of all sensor nodes is known; the links are symmetric.

3.2 Energy Consumption Model

The sensor nodes all have small batteries and it is difficult to recharge the batteries. Energy conservation requires an efficient energy-aware clustering protocol. Links are symmetrical, i.e., using the same

Fig. 1. An example of packet transmission on WSN.

transmission power, two nodes can communicate. All sensor nodes (data process-ing, wireless communication, battery power) have equivalent capabilities.All sensor nodes have different levels of transmission power and each node can dynamically alter the power level.

Fig. 1 gives an example of packet transmission on wireless sensor networks from node A to node B. Just in Fig. 1, Node A transmits its data packet to Node B and to all nodes that can overhear the packet within the transmission range.

This is one of the wireless sensor network features, and excessive receiving packets will dissipate each sensor node's residual energy.Nonetheless, the overhearing nodes willseparate the transmitter and the packet receiver. EHRCC is designed to make use of this information that is overheard.

3.3 ClusterFormation

The primary objective of the protocols for energy-aware clustering is to optimise thelifetime of the network under defined energy limitations. Long-term network access, low and balanced energy consumption for each node must be supported by the clusteringprotocols even if the networks consist of sparsely or densely deployed nodes. These requirements are closely linked to the lifetime of the wireless sensor networks on the network.

Algorithm 1: Functions of cluster formation andjoining

Function:
Create cluster with time delay:
Nm.createCluster(Tdelay):
Initially set timer with time delay:
Nm.setTimer(T_{delay})
Until timer not expired check
while Nm.timerExpired() = false do
N_{des} ← Nm.receivePacket() //receive packet
if N_{des} = Nm then Nm.aggregatePack()//aggregate packet
else if Nm.distanceFrom(N_{des}) ⩽ Nm.
***distanceFrom(Nm. nextHop)** then*
Nm.joinCluster(N_{dest})
end if
end while
end function
function Nm.joinCluster(N_{des}):
N_i.nextHop ← N_{dest}
end function

In the function Nm.formCluster(Tdelay), the Nm sets the timer to wait for Tdelay, and receives and aggregates multiple packets until the timer expires. If a packet is overheard by the Nm, it checks whether the distance from the Ndes node is smaller than that of the next hop already selected. In the Nm.joinCluster(Ndes) function, the Nm's next hop is modified to the Ndes node. Therefore, on wireless sensor networks, EHRCC offers multi-level clustering.

IV Performance Analysis

The sensing field is assumed to be 100 m • 100m in this simulation. The centre of the sensingfield and the number of nodes on the sensing field is 100 are the position of the sink node. One is the sink, and 99 other sensor nodes arenodes. Periodically, all sensor nodes senseevents and transmit the data packet to the sinknode. Every sensor node 's initial energy is 0.1J, and the sink node has unlimited energy.It isassumed that the packet length is 256 bits, T_{delay} is set as 20 · T_{slot} where the T_{slot} is the time slot required for transmitting a single packet over the wireless channel.

Fig. 2 presents the clustering protocols' energy consumption when the maximum transmission range is 20 m and 40 m respectively. The x-axisindicates the number of rounds, while the y-axis indicates each node 's average residual energy. The results show that EEHRC energy consumption is generally smaller than that of, HEED, LEACH,E-PEAGISIS

4.1 Network lifetime

Represents the time interval from when the sensor node is deployed until it is considered that the sensor network cannot function normally. Non-functional situations can occur in WSN, depending on the application requirements. For example, it can be defined as the period of time from the first detection round to the death of the first sensor node, from the first detection round to the death of some part of the node, or from the first detection round to the WSN . time period of all sensor nodes.

4.2 FND and LND (First Node and Last Node Died)

This indicates that the first node of each algorithm stops in the sensor cycle and the last node stops in the sensor cycle.

4.3 Network stability

This is one of the major problems with running WSN. Many WSN applications require secure connectivity, detection and coverage during uptime. When nodes start to disappear, network performance can become unstable. To get the most out of your WSN network, you need to keep all network nodes active for as long as possible. In other words, the network is optimally stable when all nodes are active. Therefore, the period of network instability between the shutdown of the first node and the loss of all sensor nodes is taken into account.

4.4 Energy consumption

This measurement measures energy consumption over its useful life. There are three factors that consume power when routing data. Send, receive and add data packets. Stable consumption extends the service life of the entire network. In addition, this reduction in power consumption and maintenance of consistency in consumption has a positive effect on load balancing between sensor nodes and stable time throughout the life of the network.

Average Energy Consumption

Number of nodes	HEED	LEACH	E- PEAGISIS	EHRCC
1000	55	52	51	49
2000	76	71	69	67
3000	142	130	121	119
4000	189	176	168	164
5000	238	224	210	208
6000	292	239	251	249

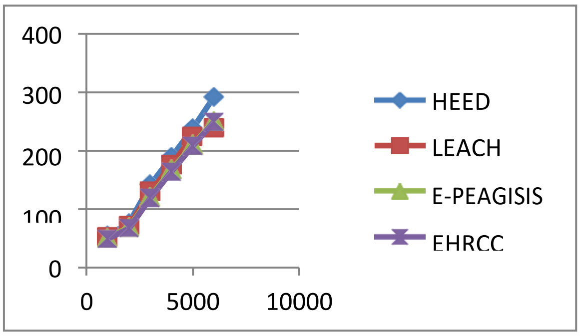


Fig2:Number of nodes Vs Average EnergyConsumption

V. CONCLUSION

WSNS' energy efficient routing algorithm design has attracted the attention of many researchers because it has little impact on the performance and stability of the WSN network. It is a chain-based routing algorithm called clustering that uses EHRCC designed to improve network durability and network stability, two key elements of WSN performance. The EHRCC algorithm can execute three processes to achieve key design goals. This allows you to distribute excessive traffic load to all nodes, reduce transmission distance, and implement excellent performance by selecting CH nodes in a simple and efficient system. However, EHRCC compared several features in terms of power consumption, longevity and grid stability. The next task is to select the best power consumption and best EHRCC domain, implement the network routing protocol and high energy efficiency.

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