고정 전파 파장 반경에 의한 무선 센서네트워크에서의 다단계 에너지 효율적인 라우팅 알고리즘

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요 약

무선 센서 네트워크에서 에너지 효율성을 높이려는 연구가 많이 진행되어 왔다. 그러나 현재 이루어지고 있는 대부분의 연구는 클러스터 헤드와 싱크 노드들 사이의 직접적인 통신에 바탕을 두고 있다. 앞에서 이루어진 연구들은 노드들 사이의 거리에 따라 에너지를 계산하는 방식에 기초를 두고 있다. 거리에 따라 에너지를 계산하여 알고리즘을 구현하는 것은 어려운 문제가 된다. 이 논문에서는 싱크 노드에서 다른 모든 노드들까지 고정된 전파 파장의 반경을 갖는 다단계 라우팅 알고리즘을 제안한다. 이 논문에서는 시뮬레이션을 이용하여 WSN이 에너지를 효율적으로 줄이는 것과 WSNdp 활용 방안을 제시한다.

A Multi-level Energy Efficient Routing Algorithm on Fixed Radio Wave Radius in Wireless Sensor Network

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ABSTRACT

A lot of researches have been done to improve the energy efficiency of Wireless Sensor Networks. But all the current researches are based on the idea of direct communication between cluster head and sink node. Previous results assume that node can intelligently regulate signal energy according to the distance between nodes. It is difficult to implement algorithms based on this assumption. We present a multi-level routing algorithm from the sink node to all other nodes which have fixed radio wave radius. We also show the energy saving efficiency and the implementation in real WSN using the simulation result.

Key words : WSN, Radio Wave Radius, Multi-hop, Sink node, Routing, Cluster head

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1. Introduction

WSN(Wireless Sensor Network) technology has developed sensor nodes with small size, low price and low electricity due to the development of the information technology. Wireless Sensor Network has been studied for the military service, but recently it applied for a variety areas such as environment / ecology supervision, energy management, physical distribution / stockpile management, battle area management, medical monitoring and so on[1, 2].

Wireless Sensor Network has some problems such as low speed, fallacy, limited electric power, and replacement difficulty due to random sensor node distribution of wireless products. To overcome these kinds of problems, we should design to extend the life span of the whole network and distribute the energy which is concentrated on a few sensor nodes to the whole network.

Recently a variety of researches have been done for improving the energy efficiency. However, the existing techniques did not applied to the real sensor network construction. The reason is because the performance of the sensor node has been highly idealized. For example, to represent Wireless Sensor Network, LEACH assumes that the collected and integrated data communicate with sink node directly. And the sensor nodes also can control the sending energy actively according to the distance between the adjacent nodes. Therefore, to apply the wireless sensor network to the real sensor network, we have to consider not only simple network technique, but also restriction of the Electromagnetic Engineering.

If the structure of hardware does not change in the Electromagnetic Engineering, the sensor nodes are operated in current of electric power rate. When all the sensor nodes are operated as a current electric power rate, the energy and the scope of radio wave are maintained steadily.

In this paper, we compare and analyze the advantages and disadvantages of the existing techniques. Then, we will propose the routing algorithm which substitutes the existing technique. We consider the multi-level as well as the remaining energy of the node centered on the sink node.

2. Hierarchical Routing Protocols

Hierarchical or cluster-based routing, originally originated in wired networks well-known techniques with special advantages related to scalability and efficient communication. Therefore, the concept of hierarchical routing is also utilized to perform energy efficient routing in WSNs[3, 4]. In a hierarchical architecture, high energy nodes can be used to process and send the information while low energy nodes perform the sensing the proximity of the target. This means that creation of clusters and assigning special tasks to cluster heads can greatly contribute to overall system scalability, lifetime and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster and perform data aggregation and fusion in order to decrease the number of transmitted messages to the BS. Hierarchical routing is two-layer routing method where one layer is used to select cluster heads and the other layer is used for routing. However, most techniques in this category do not consider routing, but consider "who and when to send or process/aggregate" the information, channel allocation etc., which can be orthogonal to the multi-hop routing function [10].

The typical methods of the hierarchical routing protocol can be found in LEACH [5, 6], TEEN [7], APTEEN [8], and PEGASIS [9]. LEACH

(Low-Energy Adaptive Clustering Hierarchy) [4] is a clustering-based routing scheme in which the cluster head collects data from member nodes, gathers data through "data fusion" and directly sends them to the sink. This scheme is characterized by randomly circulating the cluster head which performs energy concentrative function to fairly distribute energy consumption to all sensors in network and by making local fusion of data collected in the cluster head from cluster to decrease total communication cost. Performance of LEACH depends on the fixed number of clusters in each round and it allows the cluster heads to be equally arranged, but it cannot be ensured with self-selecting method. Therefore, LEACH-C scheme was proposed to determine cluster head and cluster, depend on the location information on sensor nodes and amounts of preserved energy in the sink.

TEEN (Threshold sensitive Energy Efficient sensor Network protocol) [7] operates like LEACH, but the sensor nodes don't have data which are periodically transmitted. TEEN is suitable for reactive sensor network, in the sense that it processes time-critical data, while LEACH has the characteristics that are suitable for proactive sensor network. TEEN has the functions which enable users to control the correct decision on energy consumption and state of network. Time-critical data such as earthquake and explosion are transmitted in real time and the critical value which is broadcasted in cluster generates decision time. When the sensed data does not reach critical value, it cannot determine the state of network although life spans of all the nodes are finished since it cannot obtain data from network. Resources may be wasted because the report for time-critical data may be delayed due to use of TDMA scheduling and all the nodes may not have data to be transmitted to the corresponding slot.

APTEEN (Adaptive Periodic Threshold-sensitive Energy Efficient sensor Network) [8] provides a hybrid network that combines the advantages of proactive and reactive sensor networks, while minimizing their limits. In a APTEEN hybrid network, sensor nodes not only periodically transmit data, but also react to a sudden change of observed data. ATPEEN processes time-critical data like TEEN, and when a sensor node does not transmit data during count time for proactive operation, it sensors data and transmit them to the cluster head. This improves the problems of TEEN.

In APTEEN, the characteristics of adjacent nodes sensor similar data and two adjacent nodes are compared in pair wise. Then one node respond to question, while the other node is in "sleep mode" thereby decreasing consumption of electric power. Similar to LEACH, APTEEN adopts the methods that use TDMA within a cluster to avoid interference between nodes and that each cluster uses different diffusion code to avoid interference between clusters. In APTEEN, periodic data transmission provide users the entire state of network and enable them to immediately react to a sudden change of network state and get time-critical state. In addition, it allows the users to set critical values for time and properties. Therefore it allows them to control energy consumption. However, it needs additional cost to implement critical value function and count time.

PEGASIS (Power-Efficient Gathering in Sensor Information Systems) [9] tried to decrease energy consumption by improving cluster configuration and data transmission methods in LEACH. Each node transmits data to the nearest adjacent node, one of them plays a role of head node that transmits them to the sink. In LEACH, sensor nodes in a cluster transmit data to the head node when the cluster is configured but in PEGASIS, it transmits data to the most adjacent node, instead of the head node. Nodes are composed of one chain and adjacent

nodes and start with a randomly selected node. PEGASIS tried to decrease transmit distance between the head node and general node in cluster configuration and cluster using chain-based data transmission method. However, it has the transmission delay occurs in transmitting data to a single chain when network is expanded and it is difficult to deal with errors made by a node in the middle of a chain.

3. The Proposed Algorithm

The existing routing techniques, the sensor node has the intelligence and the energy of the radio wave can be operated ideally according to the random distance between sensor nodes. Therefore it is difficult to construct the real wireless sensor network. In this paper, we assume that all the sensor nodes maintain the scope of radio wave and the transmission rate. Based on the assumption, we propose the multi-level routing technique which has the scope of the radio wave centering in the sink node. The proposed routing technique has three steps such as initial step, clustering step and data transmission step.

In the initial stage, the interest message is broadcast from the sink node through multi-level and then all the nodes in the network make the routing table using the attribute information of their own and attribute information of nodes in the scope of radio wave. In the clustering stage, clusters are formed centering in the head node of the assigned numbers and the data transmission stage is the step that data collected from the nodes which are transmitted to the cluster head. Then the data are merged and the merged data are transmitted to the sink node using the routing algorithm.

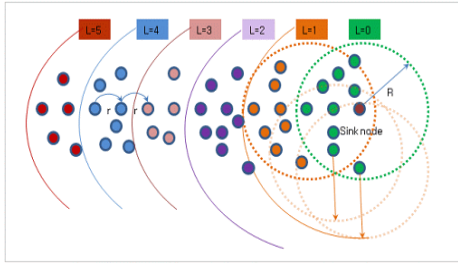
3.1 Initialization of the Node Attributes

In this step, all the nodes consisting of the network are constructing the routing table based on the nodes and the attribute information of the nodes from the sink node to the last node.

<Table 1> attributes of routing table

Attribute name	Explanation
N_ID	uniquely node identity
Level	sink to sensor node level
E_residue	Residual energy
PS	Received Signal strength
Link	Data link control
CH_ID	Cluster Header Identity
S_ID	Source node Identity
D_ID	Destination node Identity
Data	Sensing data

The node attribute information is initialized in theh the procedure of Figure 1.



(Figure 1) Routing table

1) First in the sink node, interesting message (node identifier, level information, remaining energy and so on) is broadcast to all the nodes in the circle with radius r, based on the assigned scope of the radio wave of general nodes. Nodes which receive the interest message from sink node will have the level 0.
2) Then the nodes which have level 0 broadcast the interesting message to the second level. The nodes which receive interesting message assign

to level 1 and then it writes a new interesting message. The assigned level is maintained and the routing table is constructed based on the received interesting message.

3) Using the previous method, the interesting message is broadcast incrementally and then all the network nodes initialize the level value as well as the routing table.

3.2 Network Clustering

In this paper the cluster header is selected according to the fixed scale, after single sensor node is distributed into the sensor field. This implies that all the sensors have a uniform probability p that will be cluster header. And each sensor selects the random number between 0 and 1 and then if the number is less than and equal to probability p, it is selected to header. Namely, we use the same method with cluster header selection method in Leach technique.

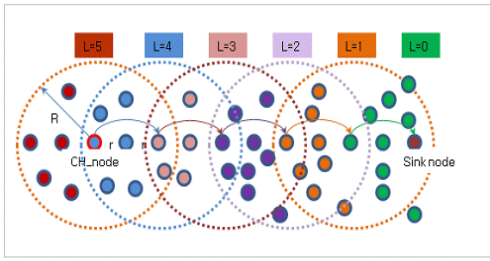
If the number of the sensor node in the entire network is N, then Np cluster headers will be selected on average. After sensor node is selected as a cluster header by the previous procedure, it broadcasts the message that it is the cluster header to the sensor nodes in the scope of the communication. Sensor nodes which received the message confirm if they are cluster headers. If they are not the cluster headers, they will be the cluster members of the nearest cluster headers.

In some case, if the sensors are not the cluster header and also don't belong to any cluster, they are the unconnected cluster heads. Also, even though they are selected as the cluster headers but they can't transmit the merged data to the sink node through sensor nodes in the scope of the communication, they are also the unconnected cluster heads. Because the unconnected cluster header can't transmit the collected data to the sink node, the energy use of the unconnected cluster head is regarded as 0.

3.3 Data Transmission Stage

In the proposed technique, data transmission consider only routing procedure for transmitting the data of inter process from the cluster header to sink node which is the data destination. And in the intra process data transmission from member nodes to cluster header is processed using the existing multi-hop of Leach technique.

The routing algorithm transmits the data of the merged data in the cluster header by using the routing table information generated in the initialization procedure. The algorithm makes the data packet as in the Table 1 and then transmits the data to the sink node based on the routing table stored in the node through the following procedure as Figure 2.



(Figure 2) Data transmission in procedure

1) First, header information of the data packet in the cluster header (NID, Level, E_residue, PS, Link, CHID) is renewed as their own attribute information, and the next node to broadcast the data is chosen from the stored routing table.

2) The standard to choose the next node is to select the node which has the small information of level. And if there are several nodes with the same level, select the information with the largest remaining energy from the residues. If there are the nodes with the same remaining energy, select the nodes with the short distance

between the nodes, PS.

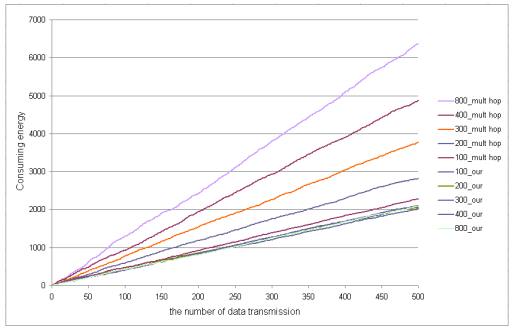
3) After the next node is selected, the header information of the data packet (NID, Level, E-residue, PS, Link, CHID) is renewed and then the data packet is unicast to the next broadcast node.
4) The node which receives the data packet repeats the procedure (2) and (3) and then transmits it to the node with level 0.
5) In the node of level 0, data packet is transmitted to the sink node directly and the data transmission stage is ended.

4. Simulation

4.1 Simulation Environment Setting

In this paper, we implemented the program using C++ and compared the proposed technique with LEACH technique with the multi-hop method to evaluate the performance of the hierarchical sensor network of the proposed technique. In the experiment the assigned sensor field size is 100m * 100m and the number of the sensor nodes varies from 100 to 1000 to evaluate the energy performance. We assume that each node has the same initial energy and the same energy is used every time the data are transmitted. And also the scope of the radio wave is uniform. Accordingly, the energy use is in the direct proportion to the degree of the data sending. If the amount of energy use for data sending each time is assumed as 1 unit, the amount of energy use for the degree of the data sending can be replaced. And in the experiment we ignore the amount of the energy use in data receiving because it is less than the amount of the energy use in data sending.

Analysis of the Result



(Figure 3) Consuming energy of multi-hop protocol

Figure 3 shows the total number of the data packet broadcast according to the density of the sensor network node. Our model is little influenced by the density of the node and the energy efficiency is raised because the transmission number of the data packet is reduced greatly. As the density of the node is huge, the energy efficiency is reduced noticeably in the existing multi-hop technique. That is because the packet transmission in the multi-hop is passed through several nodes in the scope of the transmission and the energy use occurs redundantly.

5. Conclusions

Due to the development of the wireless communication technique, the sensor network adapts the wireless technique. And a lot of researches have been done on the wireless sensor network using hardware and software. However, most researches on the software areas are difficult to apply to wireless sensor network because they are based on the idealized environment setting. For example, the highly representative hierarchical routing technique, Leach, assumed that the data are transmitted from the cluster header to the sink

node. The routing technique using the multi-hop method assumed that it can control the sending energy according to the assigned distance because the general node has the intelligence. They ignore the limited efficiency of the node and assume good result.

In this paper, we analyze the routing techniques of the existing wireless sensor network and propose the technique to construct and realize the real wireless sensor network. We propose the multi-level routing technique centering in the sink node to solve the problems. We estimate the amount of the energy use based on the scope of the radio wave of the nodes. Therefore, it is possible to optimize the energy usage and also it can be used for constructing and realizing the real wireless sensor network.

We simulate our method and analyze it. Then compare the performance of it with that of existing technique. We also prove that the proposed method improve the performance and can be used to realize the real wireless sensor network.

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