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A Multi-weight Based Clustering Algorithm for Wireless Sensor Networks

Abstract. *The energy supply of nodes will be limited strictly in the wireless sensor networks (WSN). Considering the characteristic, a new scheme called Multi-weight Based Clustering Algorithm(MWBCA) is presented .Based on the LEACH, MWBCA take into consideration many factors such as residual energy, have been the time as a cluster heads and the number of node's neighbors. Elects cluster head relying on the calculated weight clustering algorithm. The simulation results show that compared with LEACH the scheme effectively balance the load of cluster heads, and prevent the cluster heads from becoming the bottleneck effectively.*

Abstract. *W sieciach bez[przewodowych energia zasilania węzłów może być ograniczona. Zaprezentowano nowy schemat nazwany Multi-weight Based Clustering Algorithm(MWBCA). Wzięto pod uwagę takie parametry jak energię szczątkową, liczbę sąsiadujących węzłów. Zaproponowany algorytm równomiernie obciąża głowice klastrów. (**Wielowagowy algorytm klastrów w bezprzewodowej sieci czujników**)*

Key words: wireless sensor networks, LEACH,weight,cluster heads
Słowa kluczowe: sieć bezprzewodowa czujników, klastry.

Introduction

Wireless sensor network (WSN) is a wireless network composed of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions data such as temperature, pressure, humidity, and so on[1-4]. In recently years, WSN have been applied to widely ranging areas, Since sensors are equipped with small batteries, which are costly if not impossible to recharge or replace, sensor network operations must be energy efficient in order to maximize the network lifetime. Given the power constraints in sensors, investigations into routing protocols in order to extend the collective WSN lifetime is one of the major objectives of the sensor network research.

Clustering in WSNs is one technique that can expand the network's lifetime of the whole network through data aggregation at the cluster head, In clustering networks, sensor nodes are partitioned into smaller clusters and a cluster head(CH) for each cluster is elected. Sensor nodes in the clusters transmit their data to the respective CH. Afterward, the CH aggregates data and forward them to a central Base Station(BS)[2].

In this paper, A Multi-weight Based Clustering Algorithm (MWBCA) for wireless sensor network is presented, in order to overcome the energy limitation and imbalance consumption energy among sensor nodes.

Related work

To route data efficiently in Wireless Sensor Networks, various routing protocols have been proposed. The CH selection and clustering are very important procedure In cluster-based WSN . Low-Energy Adaptive Clustering Hierarchy(LEACH) is the first clustering algorithms proposed for sensor networks[3]. In LEACH, the time which all sensor nodes collect data with a round is called a “round” [3]. In the set up state, there are two steps including CH selection and clustering. In CH selection, the node decides by randomly generate a number between 0 and 1. In the rth round, a node whose random number is less than the threshold is selected as CH. The threshold Tn(r) for the rth round is defined as follows[4]:

$$(1) \qquad (n)=\begin{cases}\dfrac{p}{1-p*[r\,mod(1/p)]} & n=G\\ 0 & other\end{cases}$$

where p is the expectation of the probability to be selected as CH, G is the nodes set including those nodes not yet been selected a CH in recent, 1/pc rounds and m is the ID of nodes.

But the limit of the node energy did not took into account in LEACH, To solve this problem, deterministic cluster-head selection（DCHS）is proposed, the improved T (n) calculation as following[5]:

$$(2) \qquad T(n)_{new}=\frac{P}{1-P(r\,mod(1/P))}\times\frac{E_{current}}{E_{max}}$$

where Ecurrent expresses the node's current energy value ; Emax expresses the node's initial energy value. The value of $\frac{E_{current}}{E_{\max}}$ is greater, indicating the node's energy consumption more slowly, or explain the faster the node energy consumption, the new T (n) calculation preferred the slow energy cosumption as the CH.

HEED (Hybrid Energy-Efficient Distributed Clustering) [4] is a distributed clustering protocol which periodically selects cluster heads according to a hybrid of the node’s residual energy and a secondary parameter such as node degree.

HEED ensures a uniform distribution of CH across the network and adjusts the probability of CH-selection to ensure inter-CH connectivity.

Weighted Clustering Algorithm is a reactive clustering algorithm where cluster election is based on the evaluation, for every sensor, of a score function called combined weight. This function is a weighted linear combination of the degree, the mobility level, the transmission power and the residual energy of the sensor. Every sensor broadcasts its combined weight to its neighbours and the sensor having the lowest weight is elected CH.

Multi-weight Based Clustering Algorithm(MWBCA)

Network Model

First of all, we model the farmland wireless sensor networks. All sensor nodes are deployed in an irregular region A at random, and the node density is large enough. It is assumed that the nature of network is as follow:

(1) A1l of nodes are homogeneous. Each node has certain amount of initial energy E. Each node is assigned a unique identifier (ID).

(2) Communication is symmetric and sensor carl compute the approximate distance based on the received signal strength if the transmission is given.

(3) It consists of a BS, away from the nodes deployed in a square filed, through which the end user can access data from the sensor network.

We use a simplified model to compute the radio hardware energy dissipation,which is the first order radio model. The energy spent for transmission of a l-bit packet over distance d is[5-8] :

$$E(k,d)=\begin{cases} k\times E_{elec}+k\times\varepsilon_{fs}\times d^2 & d<d_0 \\ k\times E_{elec}+k\times\varepsilon_{mp}\times d^4 & d\geq d_0 \end{cases} \quad (3)$$

In this mode, E_{elec} is the base energy required to run the transmitter or receiver circuitry. ε_{fs} and ε_{mp} are the consumption energy of amplify transmission power of these models, respectively. If the distance d is lower than d_0 , consumption energy of power amplification would be the free space model. Reversely, power amplification energy would be the multi-hop model. Also in this model required energy to receive L-bit data over distance d is calculated from:

$$E_{RX}(l)=lE_{elec} \quad (4)$$

It also consumes energy during the data aggregation, thus we denote E_{DF} as the consumption energy in data aggregation.

Definition 1. Sensor Network. a sensor network consisting of N sensor, We denote that the i-th sensor by Si and the corresponding node set by v={v_1 , v_2,,,,,v_N,},|v | =N},Set of communication links E={e_1, e_2, …, e_N), Suppose that V is always connected.

Definition 2 Neighbor. For any node whose neighbor node set are defined as follows:Vi= {i∈N|d(V_i,V_j) ≤R,n≠i},N is the collection of all nodes ,d(V_i,V_j) expresses the distance between node V_i, and V_j ,r denotes the broadcasting range of nodes.

Description of MWBCA

In order to prevent early death due to excessive energy expenditure, all nodes should be alternately take turns to become CH, and nodes with higher residual energy should have greater opportunity to become cluster-head than the nodes with low-energy. CH election need to consider many factors , MWBCA use the parameter of probability, the information of remaining energy in a node and the average residual energy of its neighbor nodes to select SH,the following factors is considered:

(1) residual energy. Since the initial energy of each node is the same, the greater the node ‘s residual energy represent the less energy consumed, the more suitable is selected as the CH to balance the network energy consumption.

(2) have been the time as a CH. Longer as CH , the faster the energy consumption, all nodes should have a responsibility to share the responsibility of the CH.Therefore, as the CH has less time, more suitable to be selected as cluster head.

(3) the number of neighbors. Neighbor nodes transmit the same number, the more you can reduce the amount of information data transmission energy consumption.

Considering the above three factors, the weight of node vi can be calculated by the formula:

$$P_{v_i-ch}=\alpha\, deg(v_i)+\beta\frac{E_{v_i\_current}}{E_{v_i\_max}}+\gamma\frac{1}{T(v)} \quad (5)$$

Which deg (v_i) express the neighbor number of node v_i; $E_{vi\_current}$ node v_i is the current energy value; E_{vi_max} node v_i is the initial energy value, a lower proportion of nodes energy consumption is priority to be elected as CH. T (V) is the elected time of CH v_i , α, β and γs a weighting factor which greater than 0 and α + β +γ= 1. based on the specific application, Weights α、β and γ is to maximize the network life cycle. the node with the largest $P_{vi\text{-}ch}$ value is elected.

The message format and description of MWBCA as follows：

(1) The broadcast message of elected CH

```
Struct ch_msg{
Unsignedint Message_ID ;  /*Message ID*/
Unsignedchar ch_ID ;      /*Elected CH ID*/
} ;
```

(2) get the broadcast message of neighbor

```
Struct getneighbor_msg{
Unsignedint Message_ID ;  /*Message ID*/
Unsignedchar rmy_ID ;     /*Node ID*/
} ;
```

(3) The broadcast message of CH rotation

```
Struct competech_msg{
Unsignedint Message_ID ; /* Message ID*/
Unsignedchar ch_ID ;     /*Elected CHID*/
Unsignedchar my_ID ;     /* Node ID*/
Float Pvi-ch ;           /* NodeWeight*/
Unsignedint deg ;        /*NodeNeighbor*/
}
```

Rotation of CH election algorithm are described as follows:

```
1 While (cluster C isnot empty)
2  {node Vi in C broadcast (getneighbor_msg) ;
3   on receiving(neighboreply_msg) from Vj ;
4   compute deg(Vi), E_vi-current / E_vi_max ;
5      Send message(competech_msg) to clusterhead CH ;
6  }
7 compute max(Pvi-ch) ;
8 broadcast(ch_msg) ;
9 on receiving join_msg from Vj ;
```

Simulation Analysis

To evaluate the performance of our algorithm, we do the simulation using Network Simulator 2(NS2)[6-11] . A heterogeneous wireless sensor network with 200 nodes randomly distributed in a field with dimensions 1000m× 1000m is studied. For simplicity, we assume the sink is located in the center of the network. The impact caused by random factors such as signal collision and wireless channel interference is ignored in the process of simulation The parameters used in the simulations are summarized in Table 1.

Table 1 Main simulation parameters

Parameter	Value
LinkBandwidth	1Mbps
NetworkSize /m	1000×1000
Init_Energy /J	0,5
E_{elec}/ nJ/bit	50
ε_{fs} /pJ/bit/m^2	10
ε_{amp} /pJ/bit/m^4	0,0013
E_{DA} /nJ/bit/m^2	5
Datapacketsize /Byte	512
Route protocol	MWBCA,LEACH
NodeNumber	200

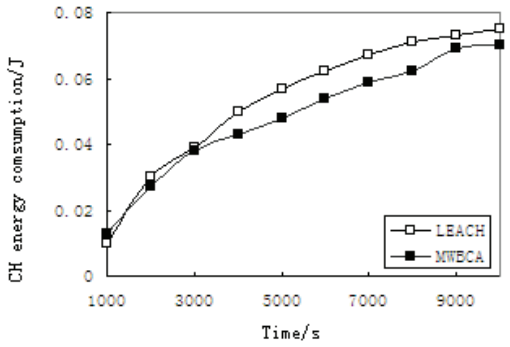

Fig.1. The cosumed energy variation of CH between MWBCA and LEACH

Fig 1 illustrates the energy consumption of CH in MWBCA and LEACH. We can seen that the consumption energy of CH with MWBCA is obviously lower than the LEACH. The reason is that MWBCA elects cluster head relying on the calculated muti-weight such as residual energy, have been the time as a cluster heads and the number of node's neighbors. The mechanism of MWBCA enable to avoid CH lost too much energy. So that under the same conditions, MWBCA has effectively balance the load of CH.

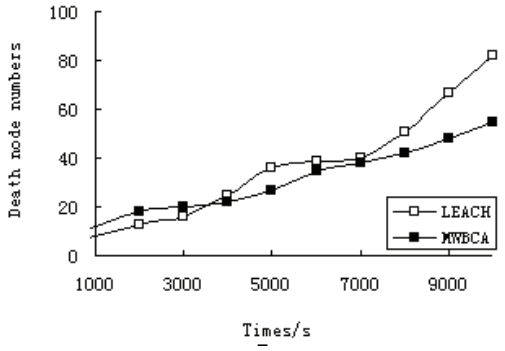

Fig.2. Number of death nodes over time

Fig.2 is the Number of nodes with LEACH and MWBCA routing protocol. As shown in Fig.2, the number of last dead node of LEACH is higher than MWBCA. Since the consumption power in LEACH is becoming unbalanced with the increasing of the time of network. However, the consumption energy of MWBCA is balanced . Thus, the MWBCA avoid generating more death sensor nodes than LEACH.

Conclusions and Future Work

Routing algorithm in wireless sensor networks is a very hot research topic, because it has great research significance in saving energy and prolonging network life·cycle. In this paper we propose a new cluster routing scheme-MWBCA for energy efficient in Wireless Sensor Networks. We have shown in our simulation results that our proposed scheme is very effective in terms Of CH energy efficiency.

Our future plans include extending our proposed routing scheme to the mobility scenarios in Wireless Sensor Networks. Achieving energy efficient in mobility environment will further increase the capability of Wireless Sensor Networks.

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