Modified Passive Clustering Algorithm for Wireless Sensor Network

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Abstract

Energy efficiency is the most challenging issue in wireless sensor network to prolong the life time of the network, as the sensors has to be unattended. Cluster based communication can reduce the traffic on the network and gives the opportunity to other sensors for periodic sleep and thus save energy. Passive clustering (PC) can perform a significant role to minimize the network load as it is less computational and light weight. First declaration wins method of PC without any priority generates severe collision in the network and forms the clusters very dense with large amount of overlapping region. We have proposed several modifications for the existing passive clustering algorithm to prolong the life time of the network with better cluster formation.

1. Introduction

Sensor network can be envisaged as a collection of thousands of small tiny sensor nodes deployed for unattended operations. Each node is equipped with a sensing circuitry, a processor, a radio transceiver for short range communication and a limited battery-supplied power. Typical applications of sensor networks are environmental monitoring which detects several environmental parameters such as fire, oil slicks, water pollution, or animal herds. Unattended and hostile environment are two basic characteristics of sensor network which instigate the deployment of huge sensor nodes to ensure standard operation of network which in turn, necessitate the design of low cost nodes.

Various definitions exist for network lifetime. Network lifetime can be defined as the time elapsed until the first node (or the last node) in the network depletes its energy (dies). For example, in a military avoid potential long set-up time and reduce the cost of initial interest propagation of Directed Diffusion. But passive clustering does not consider residual energy for becoming cluster head. As a result network life time is reduces if the low energy nodes become cluster head. Another problem is PC is not aware of distance between the nodes as the result clusters are form with high density and generates unnecessary transmission field where sensors are monitoring chemical activity, the lifetime of a sensor is critical for maximum field coverage. Energy consumption in a sensor node can be due to either "useful" or "wasteful" sources. Useful energy consumption can be due to (i) transmitting/receiving data, (ii) processing query requests, and (iii) forwarding queries/data to neighboring nodes. Wasteful energy consumption can be due to (i) idle listening to the media, (ii) retransmitting due to packet collisions, (iii) overhearing, and (iv) generating / handling control packets. Several MAC protocols attempt to reduce energy consumption due to wasteful sources, e.g., [3], [4]. A number of protocols have also been proposed to reduce useful energy consumption.

The noble idea of Directed Diffusion (DD) is improved in [1] combining the idea of Passive Clustering (PC) by proposed by Kwon and Gerla [2]. Passive clustering is an on demand creation and maintenance of the cluster substrate which can
Considering the above points we proposed a modified passive clustering algorithm which takes account of both residual energy and distance for becoming a cluster head and cluster creation. Our algorithm reduces the number of cluster and works well under high network load.

Overview of passive clustering:
Several unique properties of passive clustering include increased viability as a flooding overhead control mechanism for on-demand wireless networking protocols. Passive clustering is a kind of on demand clustering and the formation of cluster here is dynamic and is initiated by the first data message to be flooded. Which in turn reduces the significant long initial set-up period, and the benefits of the reduction of the forwarding set can be felt after a very small number of data message rounds. Because the main function of the clusters is to optimize the exchange of flooded messages, there

is no point in wasting valuable resources to pro-actively maintain such an elaborate structure between floods, when there is no traffic that can make use of it. Consequently, passive clustering refrains from using explicit control messages to support its functionality and all protocol-specific information is piggybacked on the exchanged data messages.

In passive clustering nodes can have four status: (1)Initial, (2) Cluster head, (3) Gateway and (4) Ordinary. For cluster creation passive clustering has a simple novel rule, called first declaration wins. Under this rule, the first aspirer to become a cluster head is immediately and without further neighborhood checks declared as such and allowed to dominate the radio coverage area. The node who is receiving request from a node turns to be initial node. Only initial nodes can be the candidate for cluster head. One node become cluster head using the "first declaration wins" rule. Any node receiving packets from two cluster head will change its status to gateway. Rest of the nodes assigned as ordinary node. For detailed understanding we refer [2].

Proposal - Modified Passive Clustering:

In wireless sensor network energy efficiency is one of the most challenging issues to prolong the life time of individual sensors as well as the total network. Passive clustering can be used in WSN to form the clusters as it is less computational and light weight.

Generally in a cluster based approach, cluster heads and gateways have to have the maximum energy as it performs all the communication. But the existing passive clustering algorithm does not consider any criteria to be the cluster head or gateway. Moreover the first declaration method without any priority will generate severe collision in the network. And can form very dense cluster with huge number of overlapping sensor nodes. As a result huge number of nodes will be the gateway which is simply wastage of energy.

We have proposed several modifications for the existing passive clustering algorithm to prolong the life time of the network with better cluster formation.

Cluster Head: Residual energy can be considered with highest priority to be the cluster head as it requires sufficient energy to survive his turn properly. The distance is also considered with less priority (compared to residual energy) to form better clusters. Without considering distance the resulting clusters might be very dense. With this end in view, a threshold value R_{th} should be assigned to be a cluster head. Nodes having more residual energy than R_{th} will wait for t_i time and then claim as a Cluster head. The waiting time t_i can be calculated as follows:

$t_i = T/(X*R_i * Y* D_i)$

where, T= constant value based on application. X and Y are priority where X > Y [simulation result shows that 3 to 4 times greater value of X than Y gives expected result]. R_i (must greater than R_{th}) and D_i are the residual energy and distance respectively of node I.

According to the above equation distant nodes with more energy will claim first. There will be a timeout period. No claim within the period indicates that there is no node having sufficient residual energy. In that case the restriction of $R_i > R_{th}$ will be withdrawn.

Suppose in the following figure node 1 initiates the search. Let N_2,N_3,N_4,N_5 nodes have the residual energy respectively 100,80,80 and 40 unit with the distance of 2,6,8 and 10 unit respectively from node 1. And the value of X, Y are 4 and 1.

So their waiting times are as follows:

$T_2 = t/(400*2) = t/800$, $T_3 = t/(320 * 6) = t/1920$,

$T_4 = t/(320*8) = t/2560$

$T_5 = t/(160*10)=t/1600$

Thus considering residual energy and distance node 4 will claim first. And according to the first declarations win method it will be the cluster head. Here is a typical example of forming cluster considering distance and without considering distance.

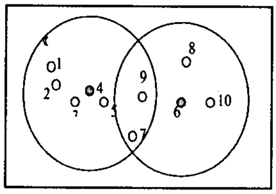


Fig: a

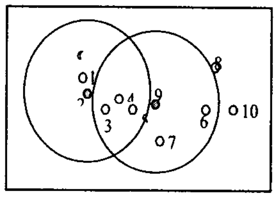


Fig: b

Considering distance (Fig a): Resultant clusters have less overlapping area.

Without Considering distance(Fig b): Resultant clusters have more overlapping area

Gateway: Sensor nodes in the overlapping region of two or more clusters can claim themselves as a gateway. The number of gateway is directly proportional to the network performance and

So the maximum number of gateway should be specified to save the energy as well as getting stable network performance. Moreover priority should be given to the nodes with more residual energy and serving number of clusters. So we proposed all the candidate gateways will wait for t_i time. The waiting time t_i can be calculated as follows:

$t_i = T/(N*R_i)$

where, T= constant value based on application. N is the number of cluster. R_i is the residual energy I.

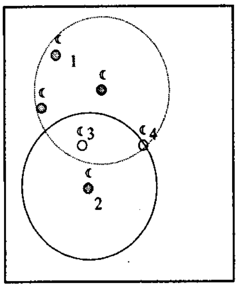


Fig: a

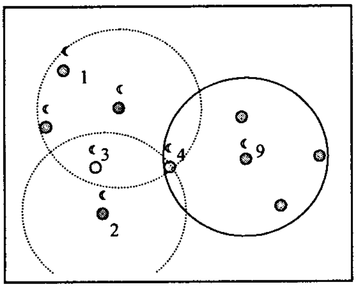


Fig: b

Suppose node 3 and 4 having the energy 15 and 12 respectively.

In figure a: node 3 and 4 will claim as a gateway with the following waiting time.

$T_3 = t/(2*15) = t/30$, $T_4 = t/(2*12) = t/24$

So node 3 will get higher priority and claim first as it is having more residual energy.

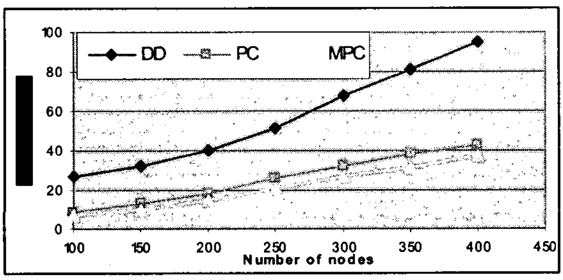
In figure b: node 3 and 4 will claim as a gateway with the following waiting time.

$T_3 = t/(2*15) = t/30$, $T_4 = t/(3*12) = t/36$

So node 4 will get higher priority and claim first considering number of cluster and residual energy.

Simulation:

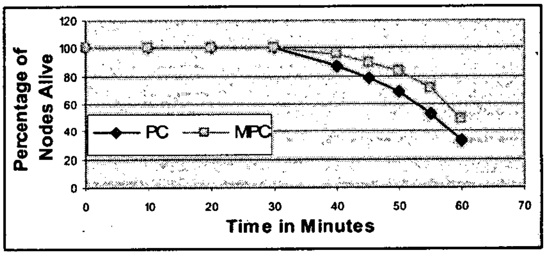
We perform our experiment in the NS2 environment to verify the network load under varying network size and also verify the life time of the network in terms of percentage of nodes alive



inversely proportional to energy efficiency.

In the first experiment our proposed modified passive clustering (MPC) algorithm is compared with directed diffusion (DD) and passive clustering (PC). From the results we can claim our proposed algorithm performs better than other two algorithms. MPC algorithm works better with large network size as the ratio of network load increases linearly with number of nodes

Second experiment shows the better performance than PC in terms of network life time. We perform the experiment with 200 nodes with a moderate network load. MPC is better in cluster creation as it tries to limit the number of gateway and clusters based on network stability and thus save energy significantly.



Conclusion: We have proposed MPC for WSN to make the network energy efficient and thus prolonging the life time. We considered residual energy with maximum priority for consistent performance and distance with less priority to form better cluster.

Reference:

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