Volume 5, Issue 8, August 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Weighted Adaptive Clustering Algorithm for Wireless Sensor Networks

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Abstract -- Wireless sensor networks (WSNs) are an emerging, fast-growing technology, and the growing interest can be attributed to new applications enabled by large-scale networks. WSN applications are used in both industrial and commercial environments, some of the applications are object tracking, habitat monitoring, fire detection, traffic monitoring, and area monitoring. We concern adaptive clustering approaches to extended the life time of sensor nodes and increases the network lifetime To implement this approach we used cluster head mechanism in computing of the weight of each node in the network is one of the proposed techniques to deal with this problem. In this we propose an energy efficient and safe weighted adaptive clustering algorithm (WACA) for WSNs using a combination of five metrics. Among these metrics lie the behavioral level metric which promotes a safe choice of a cluster head in the sense where this last one will never be a malicious node. We use simulation study to demonstrate the performance of the proposed algorithm.

Keywords— WSN, Adaptive clustering, Weighted Adaptive Clustering Algorithm, Malicious node.

I. INTRODUCTION

A modern wireless sensor network consists of individual sensor nodes which measure various environmental variables. Most of the variables depend on the application and can range from physical parameters, such as temperature or humidity, to more abstract parameters. This information can be stored as data at the node or relayed through the network, using wireless communications, for access by the user. Recent advancements made in the miniaturization of electronics have sparked a growing interest into the vast possibilities and applications of wireless sensor networks. This reduction of size, energy consumption and cost of the wireless sensor node components i.e. sensors, circuits, wireless communication; has made the vision of autonomous sensor networks deployed throughout the environment, a near reality.

Clustering means grouping nodes that are close to each other, largely in ad-hoc networks and recently in WSNs is to reduce useful energy consumption and routing overhead. we have defined two kinds of nodes can be found inside the cluster, one node is called cluster head (CH) or coordinator (CH1, CH2 and CH3) that is responsible to coordinate the cluster activities, and several ordinary nodes are called cluster members (CMs) (CM1 and CM2) that have direct access only to one CH. An ordinary node that is able to hear two or more CHs and it acts a gateway. For each communication initiated by a cluster member to a destination inside the cluster must pass by CH. If the destination is outside the cluster, the communication must be forwarded by a gateway and consequently consume more energy compared with CMs during the network operations and this will lead to untimely death causing network partition and therefore failure in communication link.

II. RELATED WORK

In our research problems is to search for the best way to elect CH for each cluster and CH can be selected by computing quality of nodes are depend on several metrics such as connectivity degree, residual energy and distance of a node from its neighbors. Significant improvement in performance of this quality can be achieved by combining these metrics. In this paper, we propose an energy efficient and safe weighted clustering algorithm for WSNs using a combination of metrics to added a behavioral level metric. The latter metric is decisive and allows to the proposed clustering algorithm to avoid any malicious node in the neighborhood to become a CH, even if the remaining metrics are in its favor. The election of CHs is carrying out using weights of neighboring nodes which are computed based on selected metrics. In this process we ensures the election of legitimate CHs with high weights. The results obtained through NS2 simulation study reveal that our approach is very suitable if we plan to use in network layer reactive routing protocols instead of proactive ones after the clustering mechanism was launched.

The behavior level of a node n_i is a key metric in our contribution. Initially, each node is assigned an equal static behavior level “0” and dynamic behavior level "1". We estimate the level can be decreased by the anomaly detection algorithm if a node has misbehavior. For computing the behavior level of each node, nodes with a behavior level less than threshold behavior will not be accepted as CH candidates even if they have other interesting characteristics such as high energy, high degree of connectivity or low.

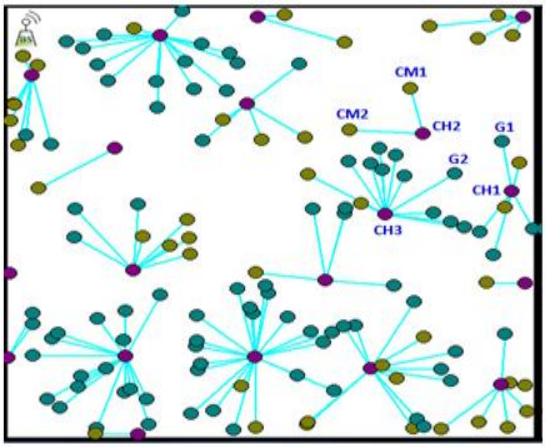


Figure 1 : Clustering formation of WSNs

The behavior of the malicious node by moving frequently inside a same Cluster or from a cluster to another is a normal behavior to not attract attention of the neighborhood and therefore be detected. The idea of our algorithm to ensure the choice of a CH is to never elect a node that moves frequently even it has the best performance metrics. In this paper, clustering mechanism before and after moving operations by considering only one cluster. In the situation before movement the node 3 acts as CH and nodes 1, 2, 5 and 6 as CMs including the malicious node 4 which is assumed to belong to the cluster. Nodes 1 and 5 perform one movement for each of them due to external forces, whereas malicious node 4 by nature performs several movements and a new cluster is formed with a new CH (node 1) and new CMs (2, 3 and 6), without the presence of a malicious node 4 as a CM.

Although a suspect node can always belong to a cluster as a CM but never as a CH, it can become malicious if it continues to move around the deployment space, that is to say it exaggerates in its movements. The aim is to have stable clusters, so it should be an election of node with low relative mobility as a CHs. In order to characterize the instantaneous nodal mobility, there should be use of a simple heuristic mechanism as presented in the formula

$$\text{Cluster Head Node} = \frac{1}{t}\sum_{w}^{\sqrt{(x1-x2+y1-y2)}} p$$

The distance *Di* of node *ni* from its neighbors is given

$$\text{Min Node Distance } D_i = \sum_{i=0}^{n}(node \text{ min} \quad distance\ of\ i,j\ )$$

$$\text{Max Node Distance } D_i = \sum_{i=0}^{n}(node \text{ max} \quad distance\ of\ i,j\ )$$

The residual energy of a node *ni*, after transmitting a message of *k* bits at distance *d* from the receiver, is calculated according to Where *E*: The node’s current energy. *E* (*k*, *d*) *k E K E d* 2 *Tx = elec + amp* : refers to the energy required to transmit a message; where *amp E* is the required amplifier energy, (k) *Rx elec elec E K = k E* : refers to the energy consumed while receiving a message.

For each node, we calculate cluster node weight *Pi*, according to the below equation:

$$CNW = P\ w\ {*}BL\ w\ {*}Er\ w\ {*}M\ w\ {*}C\ w\ {*}D$$

Where: *w1, w2, w3, w4, w5*, are the coefficients corresponding to the system criteria, so that

$w1 + w2 + w3 + w4 + w5 = 1$

The weight *Pi* calculated for each sensor is based on the parameters (*BLi, Mi, Di, Eri, and Ci*), each node in the network. So, a node with a high weight *Pi* is considered as trustworthy to be a legitimate CH, otherwise we considered as a malicious node and risk can never be chosen as CH. The values of coefficients *wi* should be chosen depending on the importance of each metric in considered WSNs applications. In few scenarios we assign a greater value to the metric *BLi* compared to other metrics if there is promotion of the safety aspect in the clustering mechanism. It is possible also to assign the same value for each coefficient *wi* weight of the node.

Assumptions

a) The network formed by the nodes and the links can be represented by an undirected graph *G=(U,E)*, where *U* represents the set of node *ni* and *E* represents the set of links *ei*.
b) All sensor nodes are deployed randomly in a plane of two dimensions *2D*.
c) A malicious node can join the network during a random deployment of sensor nodes or during network operation, the radio coverage of sensor nodes is a circular region centered at this node with radius *R*.
d) Each node has unique identifier.
e) Number of nodes in the system is finite. Two sensor nodes cannot be deployed in exactly the same position *(x, y)* in *2D* space.
f) No node will leave its neighborhood area while in CS. If a node executing in CS wants to exit the neighborhood, it will come out of CS before leaving the neighborhood.
g) All sensor nodes are identical or homogeneous. For example, they have the same radio coverage radius R. Each node can determine its position at any moment in 2D space.

h) The Sink is a node having sufficient capacity in terms of computation, communication, memory of storage and energy autonomy.
i) Underlying ad hoc network is of quasi stable nature.
j) Message delivery is ensured between two connected nodes via a routing protocol.

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={v1,v2,,,,,vN,},|v | =N},Set of communication links E={e1, e2, …, eN), Suppose that V is always connected.
Definition 2 : Neighbor. For any node whose neighbor node set are defined as follows:Vi= {i∈N|d(Vi,Vj) ≤R,n≠i},N is the collection of all nodes ,d(Vi,Vj) expresses the distance between node Vi, and Vj ,r denotes the broadcasting range of nodes.
The CH message that is sent in the network by the sensor node has the greatest weight. The second one is the JOIN message that is sent by the neighbors of *CH* If it wants to join this cluster. Finally, a *CH* must send a response ACCEPT message The node which has the greatest weight begins the procedure by broadcasting CH message to their 1-hop neighbors to confirm its role as a leader of the cluster. The neighbors confirm their role as being member nodes by broadcasting a JOIN message. The nodes that have the same maximum weight, the CH is the node that has the best criteria ordered by their importance (*BLi, Eri, Ci, Di and Mi,*). If all criteria of nodes are equal, the choose the random nodes.
Algorithm -1
Inputs : Min weights , Max weights
Outputs : Assigning weights to all sensor nodes in network
Step 1: Assign the CH to all sensor nodes based on the nearest neighbour node
Step 2 : Unsignedint Message_ID ; /*Message ID*/
Step 3 : Unsignedchar ch_ID ; /*Elected CH ID*/v} ;
Step 4 : get the broadcast message of neighbor

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

Step 5 : The broadcast message of CH rotation

```
    Struct competech_msg
    {
        Unsignedint Message_ID ; /* Message ID*/
        Unsignedchar ch_ID ; /*Elected CHID*/
        Unsignedchar my_ID ; /* Node ID*/
        Assigned min weight to the nodes ; /* NodeWeight*/
        Unsignedint deg ; /*NodeNeighbor*/
        }
```

Step 6 : CH election algorithm

6. 1 While (cluster C isnot empty)
6. 2 {node Vi in C broadcast (get neighbor_msg) ;
6. 3 on receiving(neighboreply_msg) from Vj ;
6.4 Compute the nodes weights based on the shortest path then
6. 4 Compute deg(Vi) = $\frac{Min\ weights\ of\ nodes}{Total\ number\ \ of\ nodes}$
6.5 vi _ min,vi_ max, vi current.

Step 7 : Send message(competech_msg) to clusterhead CH ;
}
Step 8 : compute min weighted nodes and max weighted nodes ;
Step 9 : broadcast(ch_msg) ; on receiving join_msg from Vj ;
Step 10 : End

III. SIMULATION RESULTS

To evaluate the performance of our algorithm, we do the simulation using Network Simulator 2(NS2). A heterogeneous wireless sensor network with 100 and 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 interface In all simulation experiments, N was varied between 10 and 100 sensor nodes. The nodes moved randomly in all possible directions. To measure the performance of our algorithm, we identify weights to sensor nodes, w1 = 0.3, w2 = 0.2, w3 = 0.2, w4 = 0.2 and w5 = 0.1 To evaluate the performance of the our algorithm, we implemented the transmission range on the average number of sensor nodes and limited number of clusters.

Parameter	Value
LinkBandwidth	1Mbps
NetworkSize /m	1000×1000
Cluster Head (CH)	15
ƛsn	1 node (20X 20)
R sn	5-25 m
R ch	25-120 m
E elec	50 nj/bit
Number of bits	50 bits
M.Nodes	6
Init_Energy /J- SN	0.25
Init_Energy /J- CH	0.9
εfs /pJ/bit/m2	10
εamp /pJ/bit/m4	13
EDA /nJ/bit/m2	5
Datapacketsize /Byte	512
Route protocol	MACWWS,LEACH
Number of nodes	100

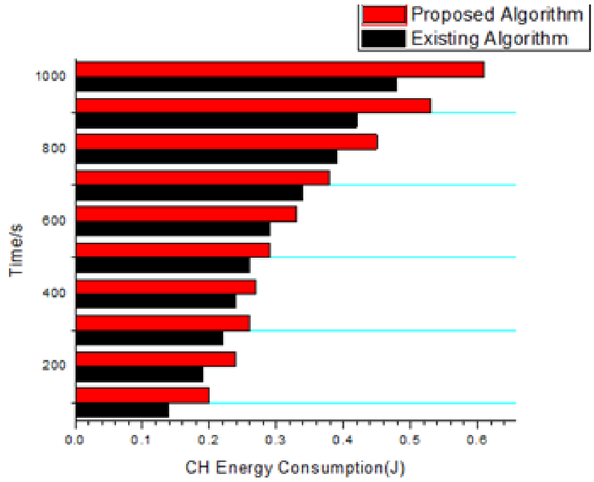
NS2 Simulation for 100 nodes

Parameter	Value
LinkBandwidth	1Mbps
NetworkSize /m	1000×1000
Cluster Head (CH)	15
ƛsn	1 node (20X 20)
R sn	5-25 m
R ch	25-120 m
E elec	50 nj/bit
Number of bits	50 bits
M.Nodes	18
Init_Energy /J- SN	0.5
Init_Energy /J- CH	1.8
εfs /pJ/bit/m2	10
εamp /pJ/bit/m4	13
EDA /nJ/bit/m2	5
Datapacketsize /Byte	512
Route protocol	MACWWS,LEACH
Number of nodes	200

NS2 Simulation for 200 nodes.

Time/s	Existing Algorithm CH Energy Consumption(J)	Proposed Algorithm CH Energy Consumption(J)
100	0.14	0.2
200	0.19	0.24
300	0.22	0.26
400	0.24	0.27
500	0.26	0.29
600	0.29	0.33
700	0.34	0.38
800	0.39	0.45
900	0.42	0.53
1000	0.48	0.61

Cluster Head - Energy per node using MACWWS



IV. CONCLUSION

In this paper, we proposed a new algorithm called "MACWWSN " is proposed for the specificities and constraints of sensor networks. Using MACWWSN we aimed at creating a virtual topology to minimize frequent re-election and avoid overall restructuring of the entire network. Our first objective is to reduce energy consumption in all levels . As a result of this work, we plan to exploit the concept of redundancy to enhance results that are related to energy conservation. Another interesting work that remains to do is to provide in-network processing by aggregating correlated data in the routing protocol and reduces the amount of data that are transported in the network.

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