

Integrated Gateway Node (IGN) Routing Protocol in WSN (Wireless Sensor Networks)

Anand Nayyar*

Abstract

The Sensor nodes are equipped with small, often irreplaceable, batteries with limited power capacity, it is essential than the network be energy efficient in order to maximize its lifetime. The scheme is to increase the life time of the sensor network with the integrated gateway node. The IGN increases the life time of the network to integrate the multiple gateway nodes. IGN is divided into two classes: the primary class was to set a gateway-selection level and the secondary class was to propose an offer of a home automation using a routing technique centered on a sensor network to set a flooding level. In the degree, mobility and energy based approach proposed in this paper, cluster formation mechanism is considered with respect to node speed, residual energy and degree of the node. With this scheme, a node with the highest F value will be named cluster head.

Keywords: Wireless Sensor Networks, Sensor Routing, Home Automation, Home Network, Integrated Gateway Node.

Introduction

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance. They are now used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation, and traffic control. In addition to one to more sensors, each node in a sensor network is typically equipped with a radio transceiver or the other wireless communications device, a small microcontroller, and an energy source, usually a battery. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motives" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few pennies, depending on the size of the sensor network and the complexity required of

*Assistant Professor, Department of Computer Applications & IT, KCL Institute of Management and Technology, Jalandhar, Punjab, INDIA

individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and bandwidth. A sensor network normally constitutes a wireless ad-hoc network, meaning that each sensor supports a multi-hop routing algorithm.

As mobile communication devices and communication technology are developing, the demand for wireless communication network on a small scale is increasing besides existing network of infra-structure. Especially, the need for wireless network on a small scale is increasing in environments such as inside buildings and mountain area, where wired facilities are unavailable. Wireless sensor network is one example. Unlike network of infra-structure, there is no router that relays packet transport in wireless sensor, but each sensor node performs both the roles of host and router. Since the transport range of each node's wireless frequency is limited in wireless sensor network, there are times when event packets are unavailable to be sent from the start node to the end node. In such case, event packets are transported via multiple sensor nodes that work as a router. Such method is called multi-hop and routing protocol is required for multi-hop method in wireless sensor network.

The most important thing in wireless sensor network is an efficient energy use in network environment and there are efficient routing and MAC protocols introduced. Routing can be largely classified into flat structure and hierarchical structure. In hierarchical structure, although energy data aggregation and data-aggregation is very efficient as well as in network processing is easy, there are problems that the overhead to make hierarchical structure is large and hierarchical structure is not maintained and needs to be created again because energy use is focused on nodes like cluster head. In addition, it is energy-efficient because all sensor nodes are not used in communication but it intensively uses energy because of a large amount of data processing in header node as well as it is hard to synchronize between header node and other nodes.

Flat structure Routing protocol has easier multi-hop communication hierarchical structure and each sensor node uses even amount of energy because there are no nodes that intensively use energy like cluster header in hierarchical structure. However, it is energy inefficient than hierarchical structure because there are frequent packet collisions if event packets for interest take place a lot and the number of re-transports increase due to the loss through multi-hop and all sensor nodes are always used to communicate. And there is also a problem that each node uses a lot of energy since sensor nodes installed in the same area perform sensing as well as most flat-structure protocols have to have all sensor nodes in network routable for communication.

Applications of Wireless Sensor Networks

- Structural Health Monitoring - Smart Structures
- Industrial Automation
- Civil Structure Monitoring

Related Work

IGCP- Integrated Gateway-Node Control Protocol

Although the hierarchical structure is energy efficient and great in data-aggregation as well as in network processing is easy, the hierarchical-structure cannot be maintained for a long time and needs to be created again because of intense energy use in nodes like cluster head. The flat-structure has easier multi-hop communication than that of the hierarchical-structure and allows even energy use of each node. However the most important aspect of wireless sensor network, energy use, is very inefficient because all sensor nodes should always be used for communication. This study suggests the IGN (Integrated Gateway Node) Algorithm to compensate the vulnerability of two structures. It is an Algorithm in which virtual gateway nodes consisting of several nodes like the cluster of hierarchical-structure routing protocol and allows the flat-structure routing protocols between virtual nodes.

The initial flooding process:

Routing Information is flooded from the sink nodes. The procedure of each node to set the routing information for each sink node is similar to the distance vector algorithm. In the routing information packet, the number of hops to a specific sink node and the address of transmitting node are included. When a node receives routing information from a neighbor node, it increases the number of hops by one and uses the number as its own number of hops to the sink node, and then, retransmit this information with its own address. When different number of hops is received from different neighbor nodes, the smallest number of them is used. If a node receives smaller number after it has retransmitted routing information, the smaller number should be again retransmitted to correct the propagated errors. Through this procedure, each node can know its own number of hops to a specific sink and the address of the next hop node to the sink.

Clustering:

The initial clustering occurs during the initial routing information distribution. In a routing information packet, energy state information of the transmitting node should be included. When a node has transmitted routing information, every neighbor of the node, except those who have previously transmitted the information, will retransmit the information. The node can gather information about the energy states of every neighbor node with the routing information packet, and compare them with its own energy state. When a node has found that it has the local maximum amount of energy, it becomes cluster head and broadcast a cluster head advertisement (CHAD) message to its neighbors. Before a node decides to be a cluster head, it has to wait for a sufficient time to gather the energy state information from all the neighbor nodes.

The nodes that decided not to be a cluster head wait for a CHAD message from any other node. If a node waiting for a CHAD message cannot receive one for a pre-determined time period, it repeats the exchange procedure of energy state information with other non affiliated nodes. This procedure is repeated until every node is affiliated with one cluster head. Any non-affiliated node affiliates with the node whose CHAD message it first receives.

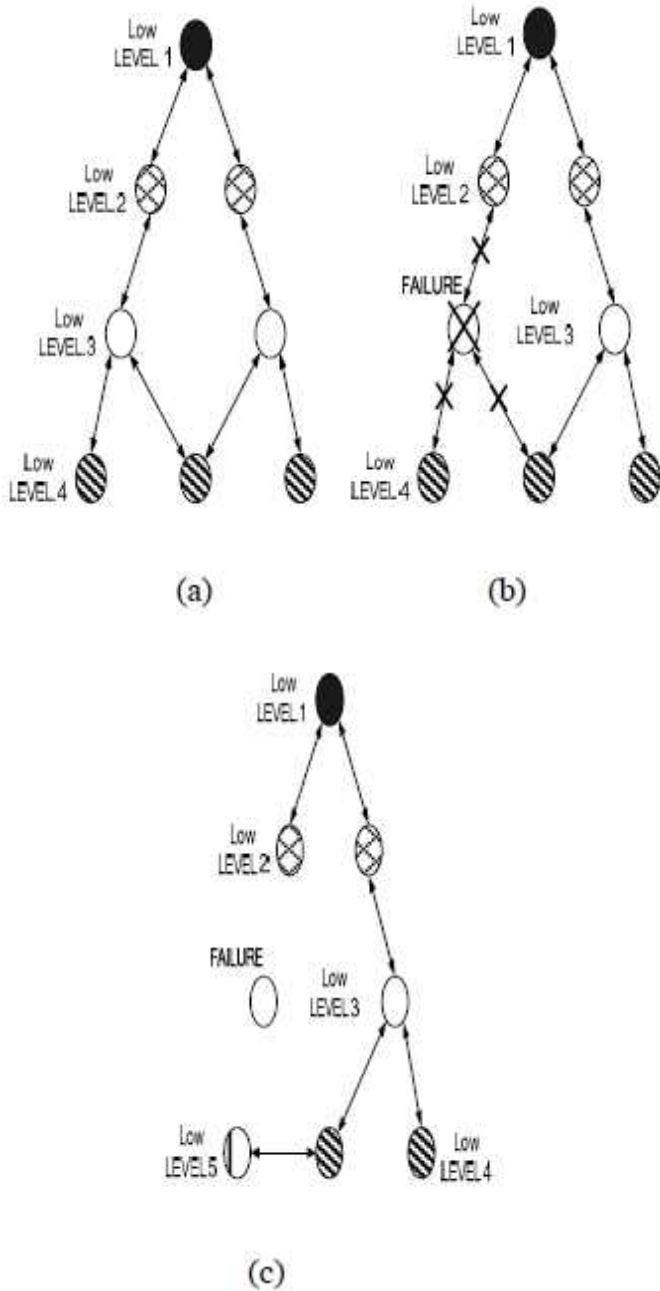


Figure 2: The level-updating procedure

In this figure, (a) indicate the levels of child nodes if the root (or parent) node equals level 1. This figure shows available connections between individual nodes and root or child nodes. However, in the event that the node with level 3 malfunctions, of child nodes detecting that, the node whose upstream connection has relied only on a connection with the faulty node finds out a node with the highest-layer level, i.e., with the lowest level value among its adjacent nodes. This node, then, sets its own level to the result of adding 1 to the existing level. These processes are happen for a level update. The processes (a), (b), and (c) represent level dependent data transmission from usual low-layer sensor nodes to a high layer gateway node.

Data transmission:

Once a cluster has been formed, as a rule, all of its operations are controlled by the gateway node. The information, detected and obtained in the cluster, is transmitted to the gateway node. Then, the gateway node transmits the data via data aggregation to the relay node. Next, the relay node simply transmits the data to a selected upper link. This facilitates significantly in setting upper links. Most interestingly, the upstream nodes of a cluster go towards the sink node.

Proposed Methodology

Scheme: DEMAC

In the degree, mobility and energy based approach proposed; cluster formation mechanism is considered F-value will be named cluster head.

Priority function (F)

The algorithm considers three factors for selection of cluster head namely-node speed, residual energy and degree of node. The node speed is important for selection of a cluster head. This is because, if a highly mobile node is elected as cluster head, there is a higher possibility of the cluster head to move out of the neighborhood of the respective cluster which lead to election of a new cluster head. Similarly, the energy is taken into consideration because if a poor energy node is elected as cluster head, the node will be dead shortly and an initiation of cluster head election process will take place more frequently. Degree of the node is taken into consideration so that a cluster contains good number of nodes as member node. Our algorithm uses a function of these three factors to assign a priority level to a node for election of cluster head. The function used for estimation of priority level for cluster head election is given as-

$$F = (\text{residual energy} * \text{degree}) / 2X * \text{speed} \tag{1}$$

Where X is a constant which represents the degree by which the speed affects the priority. With large X, nodes moving at low speed would be preferred to be selected as cluster heads.

Hello message and neighbor table

To keep track of neighborhood, each node maintains a neighbor table having fields for ID of the neighboring nodes, link status, and role of neighboring nodes and value of F. Continuous updating of the neighboring table is done by periodic transmission and reception of the hello message to the, from the neighborhood of a node. Hello message will carry important information regarding the sender such as nodes ID, node status, neighbor table, cluster adjacency table and value of F.

Methodology

In order to use the priority given in Eq. (1) for clustering, a two step clustering algorithm is proposed which uses the priority as a basis for cluster head selection. In DEMAC all the nodes send (receive) hello message to (from) their neighbors. On receiving the hello message from its neighbors a node will count number of neighbors it has. Then it calculates the value of F using Eq. (1). All the nodes start in Cluster-Undeclared state. Every node broadcasts its priority in a "hello" message to its 1-hop neighbors, once in every Broadcast Interval (BI) period. If the node is not already in the neighbor table of each neighboring

node, it will be stored in the neighbor table of them along with a timeout period (TP) seconds as new neighbor. Otherwise neighboring node's entry in neighbor table is updated.

Cluster formation algorithm for DEMAC shows the algorithm in details.

The algorithm is distributed. Thus, a node receives the F-value from its neighbor then compares them with its own. If a node has highest value of F among all its neighbors, it assumes that it has status of cluster head. Then the node broadcasts "hello" packet to introduce itself as cluster head. In case, the priority of two nodes are same, the cluster head selection is base on the lowest ID algorithm, the node with cluster member or cluster undecided status moves into the range of another cluster head node with higher mobility, a clustering process will not be triggered because this decreases the stability of the network and overlay for the topology control increases.

Algorithm

```

A node x receives a "hello" packet from y;
x searches its neighbor table;
if (y is already in the neighbor table of x) then
-calculate the F-value of node x using (1);
-update neighbor table's field of node x for node y;
-update the cluster adjacency table of node x;
-update 2-hop database of node x;
-update the number of cluster head related to x;
if (x is a cluster head in proximity of other cluster head)
then
if (F-value of x is greater than node y) then
-node x remains cluster head;
-node y gives up cluster head role and becomes a member node
of x;
-return;
else if (F-value of node x is equal to node y) then
if(x has a lower Id) then
-x remains cluster head;
-y becomes a member of x;
-return;
else
-x is member of neighbor cluster head;
-return;

```

In DEMAC, each node transmits some packets named "Hello message" to announce its presence to its neighbor nodes. In the example Fig 3 when node 1 receives a hello message from its neighbor node 2 it updates its neighbor table's entry corresponding to node 2. Node 1 also updates its cluster adjacency table and 2-hop neighbor database. Upon receiving a hello message, node 1 counts the number of neighbor nodes. It also measures its speed and residual energy. Then it computes its F-value using Eq. (1) and compares it with F-value of its neighbors. Let node 1 has highest value of F among its neighbor's nodes (2, 3, 4, 5) and none of its neighbor is cluster head and sends a hello message to its neighbors. Node 2,3,4,5 will become the member of the cluster whose cluster head is node 1. Node 2 is also the member of cluster 6. Therefore, in the example node 2 is a gateway node. Node 3 and 9 maintains connectivity between cluster 1 and 8. Therefore node 3 and 9 are also gateway nodes.

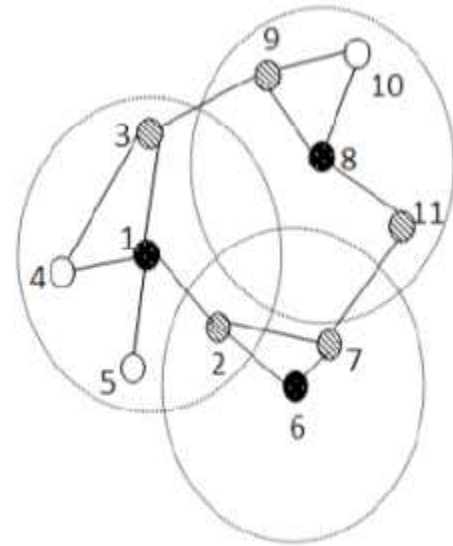


Fig. 3: Example of DEMAC

Conclusion

In this paper DEMAC is proposed as a degree, energy, mobility aware clustering scheme in WSN. Due to its improved cluster head selection algorithm DEMAC outperforms CBRP with respect to number of cluster head changes, throughput, delay and routing overhead. In which includes both the advantages of existing hierarchical-structure algorithm and flat-structure algorithm in wireless sensor network.

The suggested algorithm communicates with application of flat structure type protocols after bundling up several nodes like the hierarchical-structure cluster and making them work as one node. The algorithm suggested in this study is expected to be used in a number of application fields of sensor network since it has many characteristics and advantages.

In the future, it will be necessary to have more studies on many types of algorithm that can work in many more application fields with more efficient energy use. If we look at infinite possibilities of sensor network used in numerous fields with numerous environment and application factors.

References

1. Sung-Hwa Hong, and Byong-Kug Kim(2010) , "An Efficient Data Gathering Routing Protocol in Sensor Networks Using the Integrated Gateway Node", *IEEE Transactions on Consumer Electronics*, Vol. 56, No. 2, May.
2. Praveen Rentala, Ravi Musunnuri, Shashidhar Gandham and Udit Saxena, "Survey on Sensor Networks".
3. Heinzelman, W., RChandrasekaran, A., Balakrishnan, H.(2000), "Energy- Efficient Communication Protocol for Wireless Micro sensor Networks", *Proceedings of the Hawaii International Conference on System Science*, page 1-10, Jan.
4. Lindsey, S. and Raghavendra, C. S. (2002), "Pegasis: Power-efficient gathering in sensor information systems," *IEEE Aerospace Conference*, March.

5. Haas, Z. and Tabrizi, S. (1998), "On Some Challenges and Design Choices in Ad-Hoc Communications," in IEEE MILCOM'98, October.
6. Huseyin Ozgur Tan and Ibrahim Korpeoglu (2003), "Power Efficient Data Gathering and Aggregation in Wireless Sensor Networks", ACM SIGMOD Record, Vol. 32, No. 4, Pages 66-71, December.
7. Sohrabi, K., Gao, J., Ailawadhi, V. and Pottie, G. J. (2000), "Protocols for Self- Organization of a Wireless Sensor Network," IEEE Personal Comm. Mag., vol. 7, no. 5, October.
8. Manjeshwar, A., Agrawal, D. P. (2001), "TEEN: a routing protocols for enhanced efficiency on wireless sensor networks", International Proceedings of 15th Parallel and Distributed Processing Symposium, page 2009-2015.
9. Pottie, G. J. and Kaiser, W. J. (2000), "Wireless Integrated Network Sensors", Communications of the ACM, vol. 43, no. 5, pp. 51-58, May.
10. Gao, J. L. (2000), "Energy Efficient Routing for Wireless Sensor Networks," Ph.D. Dissertation, Department of Electrical Engineering, UCLA, June.
11. Jiang, M., Li, J., and Tay, Y.C., (1999), "Cluster Based Routing Protocol," IETF Draft, August.
12. Mingliang, J., Tay, Y.C. and Long P., "CBRP: A Cluster based Routing Protocol for Mobile Ad hoc Networks", National University of Singapore.
13. Manjeshwar, A., Agrawal, D. P. (2002), "APTEEN: A Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks," Proceedings of the 2nd Int. Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, April.
14. Intanagonwiwat, C., Govindan, R., and Estrin, D. (2000), "Directed Diffusion: A Scalable and Robust Communication Paradigm for Sensor Networks," in Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking (MOBICOM).
15. Kulik, J., Heinzelman, W. R., and Balakrishnan H. (2002), "Negotiation-Based Protocols for Disseminating Information in Wireless Sensor Networks", ACM Wireless Networks, vol. 8, no. 2-3, pp. 169-185.
16. Heinzelman, W. R., Kulik, J. and Balakrishnan, H. (1999), "Adaptive Protocols for Information Dissemination in Wireless Sensor Networks," Proc. ACM MobiCom '99, Seattle, WA, pp. 174-85.