International Journal of Technology and Engineering System (IJTES)
©gopalax-Publisher of International Journals
ISSN: 0976-1345 pp. 20-23
available at : www.ijcns.com
Vol 3.No.1 Jan- March 2012

A Hierarchal cluster framework for wireless sensor network

Rajesh Kumar ,Uttam Kumar
IIIT-Allahabad., A.I.T chickmagalur
iiita.rajesh@gmail.com, uttam.enc@gmail.com

Abstract: **In wireless sensor networks, a cluster algorithm is a good option to reduce redundant data transfer and organize nodes effectively for long life. In this paper we implement and evaluate a new flexible, hierarchical clustering algorithm on the middleware layer based paradigm. The goal of our algorithm is to give the five features, scalability, energy efficiency, fault tolerance, load balancing and multi-level clustering. Our algorithm consists of three protocols. Flat Clustering protocol constructs a 2-level clustering network structure. Function Delegation protocol provides fault tolerance and load balancing features. Multi-Level clustering protocol builds a more than two-level clustering network structure. This research work also examines several popular simulators and clarifies the definition and implementation of our algorithm in NS2 simulator. Then we evaluate the algorithm from different angles. Based on our simulation, we optimize the key parameters for our algorithm and find that performance and energy efficiency of our algorithm is promising, especially in bridge topologies**.

1. INTRODUCTION

With the eye-catching development in Wireless Sensor Networks (WSN), there are various emerging applications, such as [1] monitoring structural health, hazardous area surveillance and disaster management. For instance, sensors could be deployed on a bridge to sample vibrations in different places and adopt algorithms such as to monitor structural health. In these applications, sensor nodes have the capability of detecting surrounding conditions, such as vibration, temperature and illumination Recently researchers have focused on grouping sensor nodes into clusters. The main idea of clustering is to organize nodes into a cluster structure. Every cluster has a leader and several members, named cluster head(CH) and cluster member(CM) respectively. Normally in a cluster, CMs communicate with its CH and the CH is responsible for the communication with nodes outside the cluster. With clusters, a WSN is able to achieve large scalability, provide reachability, conserve communication bandwidth, stabilize a network topology and aggregate data.

2. RELATED WORK

Researchers have designed and developed lots of standards and protocols to solve problems regarding to communication, scalability, energy efficiency and so on. Several ad-hoc routing protocols have been applied in WSN to provide multi- hop routing, such as Ad hoc On-Demand Distance Vector (AODV) routing [2], Destination-Sequenced Distance-Vector (DSDV) routing [3] and Dynamic Source Routing (DSR) [4]. Clustering has the following advantages. Firstly, clustering originally aims at providing great scalability for WSNs because a network cannot maintain a large number of nodes only with MAC standards and multi-hop routings. Furthermore, clustering could stabilize the network topology and also reduce the maintenance overhead. There are numerous clustering algorithms proposed for WSNs [5, 6, 7, 8, 9, 13]. Usually, these algorithms focus on the following features, scalability, fault tolerance, load balancing, energy efficiency and multi-level clustering, but few of them could provide all these features. Algorithms such as [8, 9, 10] usually use random number based mechanisms to select CHs and form clusters. For instance, [8] uses random time and Node ID together to select CHs, [9] counts down a random integer and [10] uses probability to decide CHs. However, such a way to select CHs ignores the residue energy on those nodes, thus causing a good probability of a low energy node selected as a CH.

3. PROBLEM STATEMENT

There are mainly four challenges in WSNs:

1. MAC standards and routing protocols are not enough to efficiently organize a large scale WSN with numerous nodes, especially in the condition that each node sends data to the sink node simultaneously and periodically.
2. A WSN usually contains a large number of nodes capable of sampling data at high rates and generating huge volumes of data. These huge data consume limited resources on the nodes and often result in redundant data transmission, which consumes bandwidth and battery. In most cases, network communication is the main source of power consumption in WSN [12]. 3. Nodes in WSNs usually have limited battery, which causes heavy energy constraint on WSN applications for long lifespan.
4. Large sampled data may expire during the forwarding process before they reach the sink node due to long latency in wireless transmission, thus resulting in extra consumptions on limited resources in the whole network.

4. NETWORK ARCHITECTURE

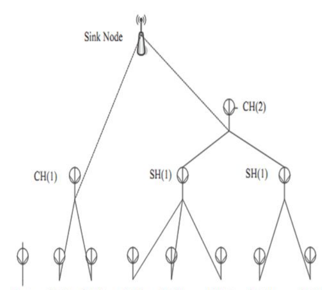

Figure1: Wsn architecture

Our algorithm aims at forming a wireless sensor networks into the following logic cluster structure shown in Figure1. The number in the brackets in the figure represents the level of a node. From left to right, first there is a single node that does not join a cluster. We consider it is a newly initiated node trying to join a cluster nearby. Then, beside that node, there is a flat (2-level) cluster which consists of a level-1 CH (Cluster Head) and two level-0 CMs (Cluster Member).

Definition: Before the introduction of the three protocols, we need to define four roles of a node, six message types and three time phases. a node in our clustered network could have 4 roles, Node, CM(Cluster Member), CH (Cluster Head) and SH (Sub Cluster Head).Node stands for a node which just starts and does not join a cluster . A SH receives data from its CMs or SHs, aggregates and sends them to its upper CH or SH.

In addition, our algorithm defines 6 types of messages:

1. ADV: ADV stands for "Advertise". ADV contains the energy, the level, the capability and the location of the sending node. The energy contains the residue energy value of the sending node. The level is the current level of the sending node.
2. SUB: SUB stands for "Subscribe". A CH usually sends SUB to recruit nodes. SUB also contains the type of data that the CH is interested in so that the receiver could send that kind of data to the CH in the future if it joins that cluster.
3. PUB: PUB stands for "Publish". There are two cases that a node sends PUB. In one case, when a node receives SUB from a CH, it immediately sends back PUB to the CH to acknowledge its participation to its cluster.
4. INV: INV stands for "Invite". When nodes form a cluster, the CH usually selects a node with the highest energy as its backup CH. Then the CH sends INV which contains all the details of its current members to that node. On receiving INV, that node stores the information and becomes BCH (Backup Cluster Head.
5. NTF: NTF stands for "Notify". It has several options, such as RETIRE etc. Generally speaking, usually this message is sending from a head to its BCH to notify a certain event.
6. ACK: ACK stands for "Acknowledge". Nodes usually send this message to acknowledge the receiving of certain messages, such as PUB, INV and NTF.

4. CLUSTER PROTOCOL

Flat cluster protocol: Flat Clustering Protocol is the basic protocol for our clustering algorithm and forms a network into a flat (2-level) clustering structure. Figure 2 shows the process of the basic flat clustering protocol. When nodes initiate, they immediately go into T1 phase.

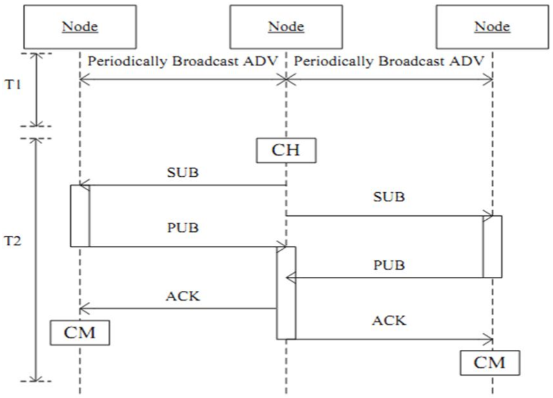

Figure2: Flat clustering Algorithm

Function Delegation Protocol: we considering the fault tolerance for CHs and the load balance for energy consumption among nodes, our clustering algorithm includes the second protocol - Function Delegation protocol as shown in Figure 3. Figure3 shows the process of the Function Delegation protocol.

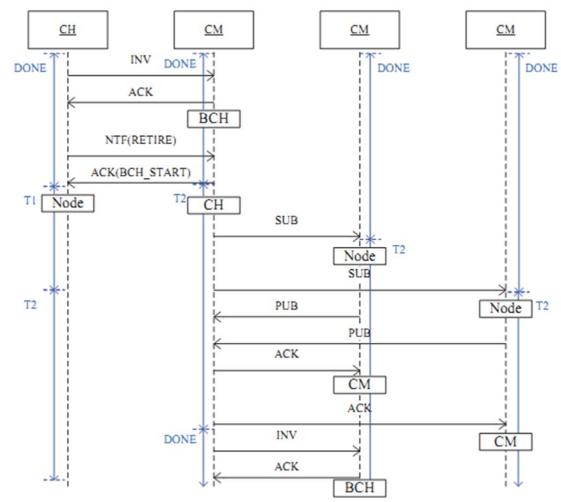

Figure3: Function Delegation Protocol

Multi-Level Clustering Protocol: In WSNs, a 2-level clustering structure has its benefits, such as fast speed of forming the structure and energy saving. However, if an algorithm could form a clustering structure with more than 2 levels, there could be more benefits. based on the above two protocols, we design the third protocol Multi-Level Clustering protocol. The basic idea is that after nodes form flat clusters and CHs select BCHs, the level-1 CHs of these clusters go through a similar process as the flat clustering protocol to form multi- level clusters.

Implementation: In this chapter, we give a detailed description of how we implement our algorithms on NS-2 platform. Our simulation has the following preconditions:

1. Each node has the initial energy of 100 + 5% Joule and starts randomly within the 1st second.
2. For each node, we set its T1 phase to 2 seconds and T2 phase to 4 seconds according to the simulation of isolated nodes.

3. A node iterates the process of trying to join a cluster if it fails in the previous round
4. The initial TTL of an ADV message is 2, which means a node can only reach its direct neighbor (one hop). And the ADV TTL increases by one per every two rounds.
6. All simulations were repeated 10 times to calculate the mean value.

5. SIMULATION ANALYSIS

1. Flat clustering:

A). Isolated Node Number: In this simulation, we simulate the conditions of 64 nodes in the matrix case. We take rounds as X axis and the percentage of isolated nodes to total nodes as Y axis. And the cluster size is 5. Figure4 show that the matrix topologies, it is obvious that the curve with (2, 4) has the best performance because with the increase of rounds, its percentage of isolated nodes decreases more dramatically than the values of other curves.

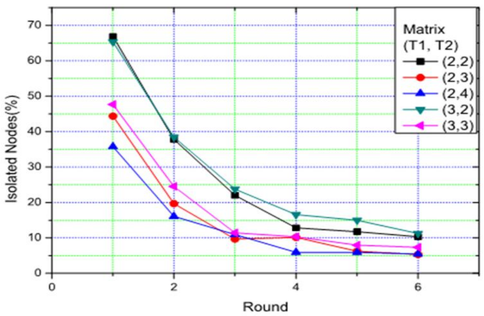

Figure 4: Isoloated Node Number in the Matrix case.

B). convergence time: The convergence time is an important factor to evaluate the speed of flat clustering process. The faster speed (short convergence time) benefits network initialization. And three parameters, total nodes number, network topology and cluster size, could influence the convergence time. In the matrix case of Figure 5, the average convergence time rises dramatically with the increase of the node number when the node number is less than 16. For more than 16 nodes matrix cases, the average convergence time reaches a plateau but still increases slightly with the increase of the node number.

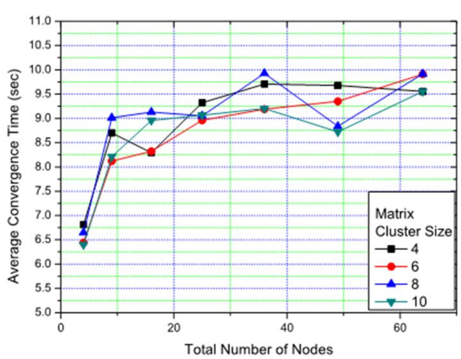

Figure 5: Convergence time in Matrix case.

C). Energy efficiency: In Figure 6, it is the case of the saved system energy percentage soars up when node are less then 40 nodes, and when nodes are more than 40, the percentage reaches a plateau of about 55%. The larger cluster size could save more energy. And with bigger network scales, for our flat clustering the saved system energy percentage tends to reach a stable value, 55% for the matrix case.

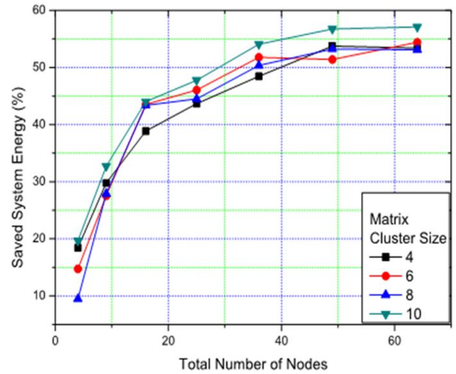

Figure6: System energy Consumption regarding to node number in the matrix case.

We can do same process for function delegation protocol and multi-level clustering protocolto find the isolated node number, convergence time and energy efficiency.

6. CONCLUSION AND FUTURE WORK

To sum up, Our work, we first review several related clustering algorithms and their laws. Then, we introduce our algorithm including 3 protocols, Flat Clustering protocol, Function Delegation protocol and Multi-Level Clustering protocol, and describe our improvements to the original design. These three protocols together could provide the following features, scalability, fault tolerance, load balancing, energy efficiency and multi-level clustering. Next, in order to evaluate our algorithm in a short time with low expense, we validate our algorithm and find it quite promising in performance and energy efficiency.

The algorithm of selecting a CH needs further improvement. Currently, our algorithm totally bases on the residue energy for the CH selection. The node with the highest residue energy among its neighbors could automatically become a CH. However, more conditions could be taken into consideration for selecting a CH. These things can be included in our future work.

REFERENCE

[1] Flowers, D., and Yang, Y. MiWi Wireless Networking Protocol Stack. Tech. rep., Micro chip Technology Inc., 2007.

[2] Perkins, C., Belding-Royer, E., and Das, S. Ad ho c On-Demand Distance Vector (AODV) Routing. RFC 3561, the Internet Engineering Task Force - Network Working Group, July 2003.

[3] Perkins, C. E., and Bhagwat, P. Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers.

[4] Johnson, D., Hu, Y., and Maltz, D. The Dynamic Source Routing Proto col (DSR) for Mobile Ad Ho c Networks for

IPv4. Tech. rep., IETF- Network Working Group, February 2007.

[5] Heinzelman, W. R., Chandrakasan, A., and Balakrishnan,H. Energy-effcient Communication Protocols for Wireless Micro sensor Networks.

[6] Demirbas, M., Arora, A., and Mittal, V. Flo c: A fast local clustering service for wireless sensor networks,DIWANS/DSN (2004).

[7] Banerjee, S., and Khuller, S. A clustering scheme for hierarchical control in multi-hop wireless networks. In Proceedings of 20th Joint Conference of the IEEE Computer and Communications Societies (IN-FOCOM 01) (April 2001)

[8] Xu, K., and Gerla, M. A heterogeneous routing proto col based on a new stable clustering scheme. In Proceeding of IEEE Military Communications Conference (MILCOM 2002) (October 2002).

[9] Nagpal, R., and Coore, D, An algorithm for group formation in anamorphous computer. In Proceedings of the Tenth International Conference on Parallel and Distributed Systems (PDCS (1998).

[10] Heinzelman, W. R., Chandrakasan, A., and Balakrishnan, H. Energy-efficient Communication Proto cols for Wireless Micro sensor Networks (January 2000).

[11] Ding, P., Holliday, J., and Celik, A. Distributed energy e-cientierarchical clustering for wireless sensor networks. In Proceedings ofhe IEEE International Conference on Distributed Computing in Sensor Systems(DCOSS05) (June 2005)

[12] Hohlt, B., Doherty, L., and Brewer, E. Flexible p owner scheduling for sensor networks. In Proceedings of the 3rd international symposium on Information processing in sensor networks (IPSN '04) (2004),CM, pp. 205-214.

[13] Youssef, A., Younis, M., Youssef, M., and Agrawala, A. Distributed formation of overlapping multi-hop clusters in wireless sensor networks. In Proceedings of the 49th Annual IEEE Global Communication Conference (Globecom 06)) November 2006).