An Approach To Wireless Nano Sensing Network Routing Protocol Based On Energy And Lifetime

Md. Syful Islam Mahfuz, Farzana Yesmin

Abstract: Recent advancement and grown up technologies has enabled the development and implementation of low-cost, energy efficient and versatile sensor networks. Sensor networks are built up with sensors that have the ability to sense physical or environmental property. Assumption can be made that Wireless Sensing Network (WSN) is able to sense environmental conditions at Nano and gaseous level. Wireless sensor network has increasingly become a research hotspot as the technology of wireless networks become gradually matured and supported by small, micro-mobile devices. WSN consists of a several number of sensor nodes ranging from few tens to thousands and base station or sink node. Each node is capable of storing, processing and relaying the data that are sensed. The quality of working properly of the nodes in WSN application consists of comprehension, gathering and distributing information in the network. Energy is a main issue as the sensors are in general tiny. In addition wireless with restricted memory and quality of working properly given the fact that the batteries have a restricted governing power. For this reason, routing system of these type of nodes sometimes depend on energy. In this paper, we have focused on the efficient routing protocols of wireless sensing network based on energy level and life time.

Index Terms: Cluster, Nano Network, Nano Node, Routing Protocol, Sensor Network, Sink Nodes, WSN

1 INTRODUCTION

Radio sensing technologies are now in an advance mode that enables to build up low cost, low-power and multiple functional tiny sensing nodes. These nodes are basically used to sense as well as to process data and communication components [1], [2]. These sensors can directly communicate with each other and also able to communicate with the base station (BS). Any wireless sensing network can contain thousands and even millions of similar operational nodes. These nodes are responsible for sensing the environments and its information about temperature, humidity, air speed/pressure, light, dust category, constraints and so on. It processes the tasks in a data aggregation process. Next it sends the data to central sink nodes for further processing. To do such tasks, sensing nodes requires high amount of energy. But this is the most important problem. In maximum cases, nodes are powered by battery which has limited power.

- *Md. Syful Islam Mahfuz received the B.Sc. degree in Computer Science and Engineering from Patuakhali Science and Technology University, Dumki, Patuakhali, Bangladesh in 2012. Currently, he is a Lecturer of Computer Science and Engineering at Bangladesh University of Business and Technology. His teaching and research areas include Data Mining, wireless transmission and embedded system design. Mr. Syful Islam may be reached at mahfuzisl@pstu.ac.bd*
- *Farzana Yesmin received the B.Sc. degree in Computer Science and Engineering from Khulna University, Khulna, Bangladesh in 2012. Her teaching and research areas include network control systems, Network Planning and wireless transmission. Ms. Farzana may be reached at farzana_cse15@yahoo.com*

2 BACKGROUND

Nano sensing nodes form a cluster of network to perform any certain purpose. In this case, networks may be of homogeneous, heterogeneous or hybrid. Homogeneous networks are formed by similar types of sensing nodes. Heterogeneous networks are formed by two or more types of nodes combined together. They may have different sizes, battery powers, sensing capabilities, workloads etc. To maintain a WSN, a main task is to find out or to select a sink node or cluster head. In a homogeneous network, a single node is selected as a cluster for a certain time and later the role will be randomly and periodically taken by other nodes. In this case, one node will be selected as cluster head only once for the entire lifetime. In heterogeneous network, node with high capabilities and powerful batteries compared to other nodes is selected as the cluster head. In hybrid sensor networks, cooperative mobile BSs work together in real time manner [3].

3 SENSOR NETWORK CLASSIFICATION

On the basis of the sensor network modes of functioning and target application type, a simple classification can be prescribed [4].

1. Proactive Networks: This type of network is used when a periodic data monitoring is required. It provides a data processing (sensing, analysis, transmitting) at regular intervals.
2. Reactive Networks: The nodes have a sudden react and a drastic change after receiving the value of sensed attributes. This scheme is well suited for critical timing applications.

4 ROUTING PROTOCOL DESIGN ISSUES

At first, WSN was used in military application for its mobile and flexible behavior. Civilian application of wireless application was later considered which includes environ-mental monitoring to smart home security system. Such WSNs may consist of mobile sensing nodes or heterogeneous nodes with different network topology such as star, bus or tree depending on network application [5]. To fulfill this diversification trends, following design issues are followed [6], [7].

1. Fault tolerance: Sometimes, several sensor nodes may fail or be damaged due to power lacking or

environmental interference. This incident should not affect the network system.

2. Scalability: The routing schemes should be scalable to respond to any events and should be able to handle a large number of sensing nodes.
3. Production cost: Every single node should be low cost to make the overall network cost effective as the network consists of thousands or millions of sensor nodes.
4. Quality of Service: Service quality refers to reliable data delivery, energy efficiency, life time, location awareness etc. These factors are most important factors that must be maintained effectively and efficiently to design a network. For example, in some cases such as military purpose, we must ensure data delivery within very short time as the data is sensed.
5. Power Consumption: Another important design issue is how much energy is consumed by the network. Transmission power is proportional to distance and obstacles. How-ever, significant overhead is introduced for topology management and MAC. If all the nodes are close to the sink or cluster head (CH), direct routing may suit well [8].
6. Data Aggregation/Fusion: Since data redundancy may be occurred by sensor nodes, similar packets may be aggregated which helps to reduce number of transmission. Data aggregation means data combination from different sources by using several functions such as min, max, average and suppression [9].

5 Related Works

Routing protocols are most important issues to build up efficient Wireless Sensing Network. Several protocols have given in this regard. Here we discuss some recently given routing protocols based on different issues. Geographic Adaptive Fidelity (GAF) [10] makes a division of the net-work and makes smaller grids where all nodes of any grid can communicate with any adjacent grid. Only one node in a grid remains awake and routes packets. But, this increases the number of hops taken by a route and so that power consumption of the network also increases. Greedy Perimeter Stateless Routing (GPSR) [11] is one of the familiar routing schemes based on geographical schemes that are proposed using face routing or perimeter to route over obstacles. If a packet stuck at an obstacle, face routing routes to the dead ends while a closer node to the destination is found. Another routing protocol is based on a 2-hop clustering algorithm instead of geographical scheme. This protocol is called The Lowest ID (LID) clustering algorithm [12]. While executing this algorithm, a single node continuously broadcast the list of nodes that can be heard by it including itself. If a node only hears the higher ID containing nodes than itself, it itself declares cluster head. Various simulation results have proved the LID algorithm as more stable in the case of frequently changing environment [13]. List Clustering Change (LCC) [14] proposes a minimization algorithm of the frequency of cluster head when cluster stability is a major concern. In those environments where topology changes frequently, LCC will be a robust algorithm having low latency and routing overhead. But a problem is the unequal load distribution for all nodes. Low Energy Adaptive Clustering Hierarchy (LEACH) is a well-known clustering based energy efficient algorithm which considers the signal strength of the received signal to form nodes and routes to the base station through local cluster heads [15]. LEACH does not ensure good cluster head and it may terminate within a finite iteration.

6 Energy Model

As discussed above, energy efficiency is the most important issue and researchers have made different types of assumption about radio characteristics which includes energy dissipation in transmission and reception. [16]. A previous energy model [17], [18] is discussed here. This model states, consumed energy in transmitting a message of k bits size over a transmission distance d is given by,

$$E_{tx}(k,d) = k(E_{elec}+\varepsilon_{amp}d^{\lambda})$$

$$=kE_{elec} + \varepsilon_{amp}kd^{\lambda}$$

Where, k=length of the message
d= transmission distance between transmitter and receiver
E_{elec}= electronic energy
ε_{amp}= transmitter amplifier
λ= path- loss component ($2 \le \lambda \le 4$)

Also, the energy consumed in the message reception is given by, $E_{rx}= E_{elec}k$. Therefore, the total energy consumed to transmit and received by another sensor is,

$$E_{total}(d) = k(2E_{elec} + \varepsilon d^{\lambda})$$

7 Motivation

Routing protocol is to be proposed considering limited energy resources of sensors. But most of current routing protocols are out of such consideration [19]. Developing an energy efficient and power aware algorithm for routing is now the requirement and so that lifetime of sensors as well as network will not be prolonged. Following criteria may be followed to do such:

1. End to end delay decrement
2. Network reliability increment
3. Power consumption reduction while data transmission and processing
4. Residual energy maximization

The algorithm will be such that it guarantees QoS. The algorithms should also obey the boundary of battery capacity. For this reason, geographic routing has a challenging situation for researchers. This work mainly focuses the energy awareness and so that the energy consumption will maintain an optimum scale.

7.1 Basic Considerations

All the nodes are connected to a common base station (BS) which we call the Cluster Head (CH) or sink node. Sensors are homogeneous i.e. they all have the same features and same energy and are obliged to transmit data to the CH. Initially, all the sensors have the same power level. The CH is located at a distant place from the sensors and immobile. Every node will be selected as a cluster head once in a cyclic process.

8 Proposed Routing Protocol Based on Energy And Lifetime

To maintain high energy level of sensor nodes is a difficult task. Energy level as well as node lifetime goes down with the increment of time. As we can't hold the energy level as the initial state, so the lifetime of the sensor nodes are also out of our hand. We can just maintain the internal routing schemes and interconnection structures to make the best utilization of those limited life sensor nodes.

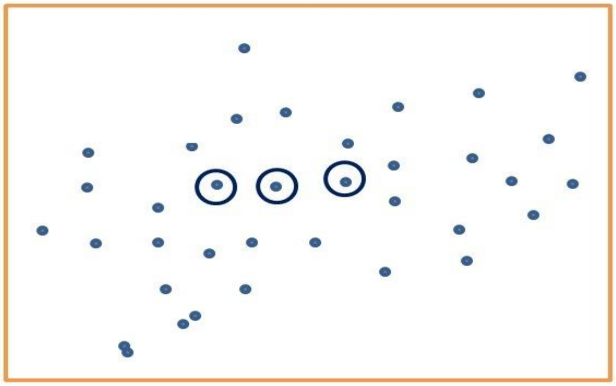

Fig. 1. Centralized nodes competing to be Sink Node

In this scheme, we have divided the total energy of any node into some levels. The whole network or small clusters are maintained by different energy levels which are decreasingly ordered with time. The minimum energy of any level will allow any node to be included in that energy level cluster and the node will be able to compete to be CHs.

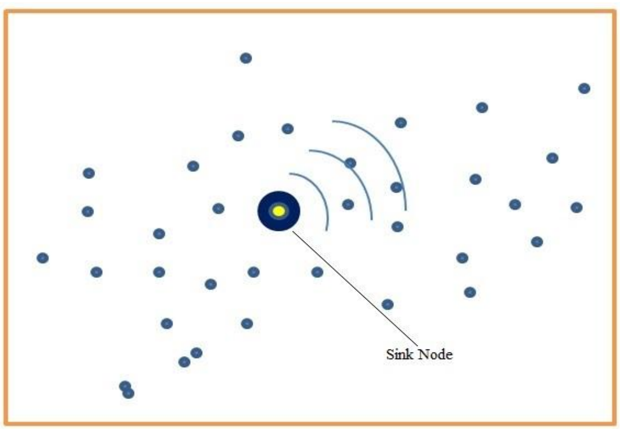

Fig. 2. Sink Node broadcast itself about its energy reduction

At first, the sensor nodes are distributed randomly in any region where we have to sense the environment or to per-form the required operation. As all the nodes are homogeneous, randomly one node is to be selected as the sink node. Here we consider some centralized nodes to take part in such randomization. This sink node will then be responsible to maintain all sorts of communication. When the energy of the sink node goes down to a certain level, it starts to broadcast itself to the sensors about its energy level. The nearest sensors then start to compete to be cluster head. The nodes having maximum energy strengths are then selected as the sink node. Energy strength includes remaining lifetime, working time, transmitted data unit and signal strength. These nodes will then perform several important tasks. Each newly selected node has now the responsibility to build up a cluster of its own, of which, that node will be the Cluster Head (CH). Now the whole network is divided into several clusters having a cluster head for every cluster. At this stage, the cluster size/volume will also decrease.

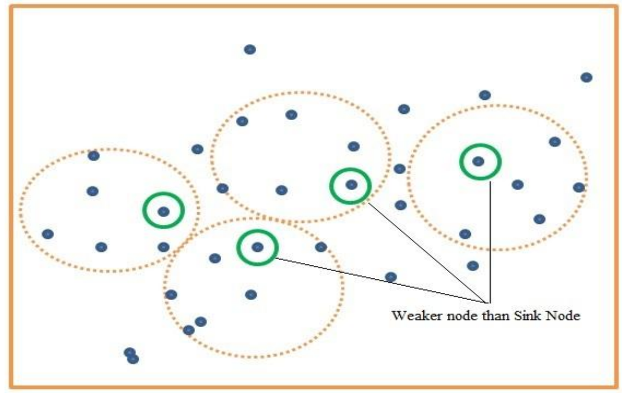

Fig. 3. Relatively weaker Nodes creating Small Clusters

As time grows up, nodes become weaker so that they slowly become less energetic and unable to maintain a large net-work. These CHs now start to broadcast themselves into their own clusters and allow competition from the remaining nodes to be the new cluster head. Any node that meets the minimum energy range of that certain cluster level can compete. This time, the cluster will be smaller than before and the weaker cluster heads can maintain such smaller network without any major difficulties.Thus, with the increment of time, this routing technique allows the base station to receive data from the weaker nodes. Also, weaker nodes can easily handle the clusters as the cluster also become small with reduction of the node energy.

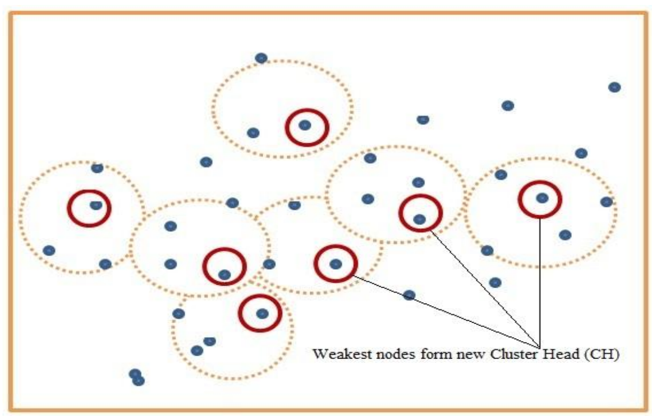

Fig. 4. Weakest nodes building Smaller Clusters after previous CH damage

This algorithm will be an efficient routing algorithm where the node lifetime or energy will have no acute effect on the network and also the Base Station (BS) will be able to handle the received data with more care with the passage of time as the network clusters become smaller with time.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E.Cayirci, "A Survey on Sensor Network", IEEE Communication Magazine 40, 8 (August 2004), pp. 102-114.

[2] G. Martin, "An Evaluation of Ad-hoc Routing Protocols for Wireless Sensor Networks", Master's thesis, School of Computing Science, Newcastle University upon Tyne, U.K., May 2004.

[3] Shio Kumar Singh 1, M P Singh 2, and D K Singh, International Journal of Wireless & Mobile Networks(IJWMN), Vol.2, No.3, August 2010, 'Energy Efficient Homogenous Clustering Algorithm for Wireless Sensor Networks'

[4] AratiManjeshwar and Dharma P. Agrawal, TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks, 2001 IEEE

[5] Rajashree.V.Biradar, V.C .Patil, Dr. S. R. Sawant, Dr. R. R. Mudholkar, UbiCC Journal – Volume 4, Classification And Comparison Of Routing Protocols In Wireless Sensor Networks, June 2007

[6] J. Pan, L. Cai, T. Hou, Y. Shi, and S. Shen, Topology control for wireless sensor networks, Proceedings of the Nineth ACM MobiCom, (2003)

[7] Kay Romer, FriedemannMattern: The Design Space of Wireless Sensor Networks, IEEE Wireless Communications, pp. 54-61 (December 2004)

[8] J. Kulik, W. R. Heinzelman, and H. Balakrishnan: Negotiation-Based Protocols for Disseminating In-formation in Wireless Sensor Networks, Wireless Networks, vol. 8, pp. 169–85 2002).

[9] B.Krishnamachari, D. Estrin, S. Wicker: Modeling data centric routing in wireless sensor networks, in the Proceedings of IEEE INFOCOM, New York, (June 2002).

[10] F. Kuhn, R. Wattenhofer, Y. Zhang, and A. Zollinger, "Geometric ad-hoc routing: Of theory and practice," in 22nd ACM Symposium on the Principles of Distributed Computing (PODC), Boston, July 2003.

[11] B. Karp and H. T. Kung. GPSR, "Greedy perimeter stateless routing for wireless networks," In IEEE/ACM MobiCom, Aug. 2000

[12] C.R. Lin, and M. Gerla, "Adaptive Clustering for Mobile Wireless Networks", IEEE Journal on Select-ed Areas in Communication, vol. 15, no. 7, Sept. 1997, pp. 11265-1275.].

[13] M. Gerla and J. T. C. Tsai. "Multi-cluster, Mobile, Multimedia Radio Network", ACM/Baltzer Journal of Wireless Networks, vol. 1, no. 3, Sept. 1995, pp. 255-265.

[14] C. Chiang, H. Wu, W. Liu, and M. Gerla, "Routing in Clustered Multi-hop, Mobile Wireless Networks with fading Channel", in Proceeding of IEEE Singapore International Conference on Networks (SICON '07), Singapore, Apr. 1997, pp. 197-211.

[15] W.R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "An Application-specific Protocol Architecture for Wireless Microsensor Networks", IEEE Transactions on Wireless Communications, vol. 1(4), Oct. '02.

[16] Shio Kumar Singh , M P Singh , and D K Singh, In-ternational Journal of Wireless & Mobile Networks(IJWMN), Energy Efficient Homogenous Clustering Algorithm for Wireless Sensor Networks, Vol.2, No.3, August 2010

[17] W.R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks" in IEEE Tmnsactions on Wireless Communications (October 2002), vol. 1(4), pp. 660-670

[18] W.R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient Communication Protocol for Wireless Microsensor Networks", in IEEE Com-puter Society Proceedings of the Thirty Third Hawaii International Conference on System Sciences (HICSS '00), Washington, DC, USA, Jan. 2000, vol. 8.

[19] Adel Gaafar A.Elrahim , Hussein A.Elsayed, Salwa El Ramly , Magdy M. Ibrahim, An Energy Aware WSN Geographic Routing Protocol, Universal Journal of Computer Science and Engineering Technology , Nov. 2010 S. D. Stearns, Digital Signal Processing with Examples in MATLAB. CRC Press.