***I.J. Wireless and Microwave Technologies* 2012, 4, 46-51**
Published Online August 2012 in MECS (http://www.mecs-press.net)
DOI: 10.5815/ijwmt.2012. 04.07

Available online at http://www.mecs-press.net/ ijwmt

Data Collection Method with A Mobile Sink Node in Wireless Sensor Network

Hu Chang Jun, Yao Shan Hua

School of Electric and Information AnHui University of Science and Technology HuaiNan China

Abstract

this paper resent a data collection method of using mobile sink and static sink together against “thermal region” in wireless sensor network. The mobile sink visits the remote-cluster and communicates with the head node directly, thus reducing both the energy cost of multi-hop transmission in long distance and the frequency of data forwarding in clusters near the static sink. Simulation results showed that the added mobile sink extended the network lifetime and expanded the capacity of network.

Index Terms: thermal region; wireless sensor network(WSN); remote-clustere; mobile sink (MS); static sink;

1. Introduction

Wireless sensor networks have become a major research focus. The network consists of tiny sensor nodes including sink node and sensor nodes connected through wireless communication [9]. The sink node receives data from sensor nodes and has no energy restriction while the sensor node uses battery with limited energy supply and it is hard to supplement energy after deployment. So for the WSN protocol the primary factor is concerning how to improve energy efficiency and extend the lifetime of network [8].

In order to improve energy efficiency and balance the network load, most WSN use clustering: the whole network is divided into several clusters. Each cluster consists of some member nodes and a cluster head in charge of receiving data from other members and making data fusion, sending to the sink node by other cluster head. For the cluster heads near the sink, they are responsible for forwarding the data to the sink from remoter cluster besides they own data, thus consuming more energy than remote heads. As a result the nodes near the sink become invalid earlier than the remote and cause network segmentation. That is called “thermal region” problem. This paper presents a data collection method of using mobile sink and static sink. With the mobile sink functioning, the data forward frequency of proximal cluster nodes reduces, transmission delay shortens, and the network lifetime is prolonged.

Corresponding author:
E-mail address: 601254090@qq.com

2. RELATED WORK

Reference [1] proposes unequal clusters of routing algorithm based on divided virtual region for“thermal region”in the wireless sensor network. The routing algorithm gives the task of clusters divided to sink node with non-limited energy, therefore, the scale of inside cluster layer which near the sink node is smaller than outer layer cluster. To realized the distributional election work of cluster head and avoided energy consumption in each wheel, the algorithm takes main and vice cluster head into the structure of clusters. However, the protocol requires that each node maintains routing information, thus aggrandizing overhead for communication and storage.

In [2], a low-power hierarchical wireless sensor network topology control algorithm, which is called LPH, is presented. The topology control is divided into two phases: network building and network maintaining. LPH provides solutions to reduce energy consumption in every phase and every task. It also provides a solution to balance the distribution of the cluster head nodes. Yet the protocol is much complex.

Reference [3] proposes an energy-efficient uneven clustering (EEUC) algorithm for network topology organization, in which tentative cluster heads use uneven competition ranges to construct clusters of uneven sizes. The clusters closer to the sink have smaller sizes than those farther away from the sink, thus the cluster heads closer to the sink can preserve some energy for the inter cluster data forwarding. The parameters used in the algorithm need to be further optimized.

Reference [4] presents an operating mode with static and mobile sinks. The MS periodically spreads information within a small range and the sensor nodes send or forward packets to the MS with the minimum number of hops away. The node within single-hop region of MS ensures the reliable transmission by send-response mechanism. With MS the success rate of data transfer increased and the network lifetime was prolonged. But the overhead also grew up. This paper adopts the hybrid sink pattern, simplifies the work process of MS and extends the network lifetime with appropriate communication overhead.

3. DATA COLLECTION METHOD

3. 1 Design philosophy

This article assumes that network can operates with a static node and the move path of MS can be controlled. For the nodes near the static sink (proximal cluster) can transmits packets to it. The MS is responsible for the data from remote clusters, thus reducing the pressure of forwarding packets in the proximal clusters and expanding the network capacity. Because of the communication delay between MS and sensor node, transmit failure may occur when sending packet to MS by intermediate nodes. To simplify the process, in this paper the MS only communicates with the remote-cluster heads within one hop and visits the remote cluster repeatedly until all heads of remote-cluster become invalid.

3. 2 Implementation of process

Assuming the sensor nodes are random distributed among a circular area of radius R with the static sink at the center and a MS running. Each node has a unique ID. The MS is free to communication with static sink and can visit node according to its ID and location. The process runs as follows:

1) *After running the network generate the clusters and cluster head using LEACH protocol[7]*
2) *The sink node obtain the number of hops from each node*

The static sink broadcasts a message with TTL and set distance value zero. Nodes receiving the message increase the distance value by 1 and subtract TTL by 1, then forward the message. For message from the same node only the minimum distance value is adopted. Finally each node obtains a number of minimum hops from the static sink and notifies the sink node by multi-hop transmitting.

3) *The MS obtain the head list of remote clusters according to the distance from the head to static sink*

The sink node take those as remote-cluster heads which distance (hop counter) greater than D. (D>1 and can be adjusted in experiment according to network state) assuming D_{max} is the maximum distance, set

$$D \in \max(2, D_{\max} / 2)$$

4) The MS visit the head list of nodes in cycles until the list become empty

The process of visit a remote-cluster head:

a) The MS send message periodically when moving
b) The head received message marks its packet as ”to MS” and sends the packet, starting timer to get response from MS
c) The MS response to the head. And if the head does not get any response, meaning packet transmitting fail, it marks the packet as “to static sink” and pass the data through multi-hop way.

The cluster follow the rules while network running:

a) When no MS come, the remote-cluster send packets to static sink by multi-hop way
b) When a node is selected as new head in remote-cluster, it tells the static sink its ID and location by multi-hop way, the MS update the heads list
c) Before a remote-cluster demise, its node inform the static sink before joining in other cluster, the MS update its heads list

It can be seen from above process, in addition to the flooding method at beginning, the added communication only occurs between MS and remote-cluster heads. Compared with [4], the communication overhead lessens obviously.

4. SIMULATION AND ANALYSIS

Take NS2 and MATLAB as simulation environment, assuming sensor nodes randomly distribute in a circle with static sink at the center. IEEE802.15 protocol is used as MAC protocol. Other parameters list in table 1:

TABLE I. PARAMETER TABLE

name	***identification***	***value***
Radius of area	R	100m
Radius of sink	R0	15m
Radius of sensor node	R1	10m
Number of nodes	N	50~200
Initial energy of node	E0	2J
Speed of MS	V	1~5m/s

Other parameters reference [5], assuming scheme 1 signifies multi-hop communication without MS, scheme 2 signifies method used in [4] and scheme 3 signifies method in this paper.

4. 1 Comparison of the network lifetime

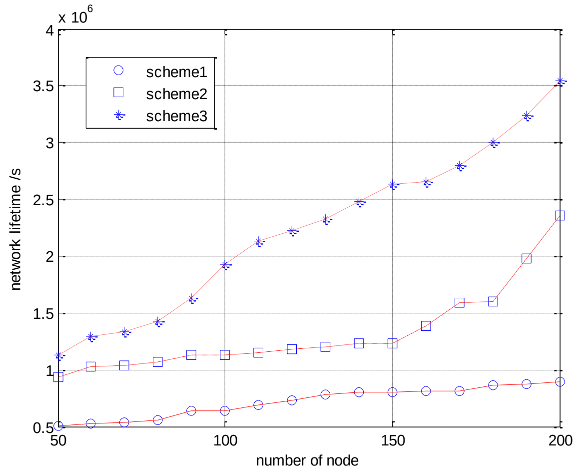

Figure 1. Network lifetime

It can be seen from Fig. 1 that with the increase of node number, network lifetime extends for all three schemes. For scheme 2 and 3, because of the function of MS, network lifetime is longer than it in scheme 1, and scheme 3 is best in three schemes for the same number of nodes.

4. 2 Comparison of the success rate of data transfer

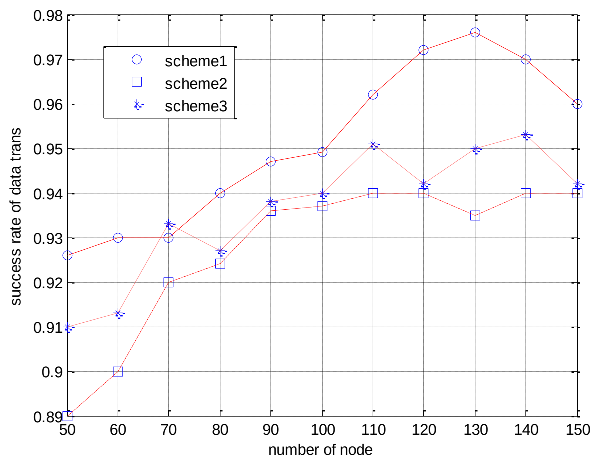

Figure 2. Success rate of data trandsfer

For all three themes, the success rate of data transfer grows with the node number increase until it reaches a certain value. After that, in scheme 1 and 2, the numerical value drops a little while in scheme 3 it tends to stable. Generally speaking, scheme 1 has a better success rate than other two. For in scheme 2 and 3, When a MS communication with a cluster head, there will be a certain probability of transmitting failure. In scheme 3, the head communication with the MS directly without an intermediate node while in scheme 2 intermediate nodes often participate in communication, which may cause more transfer failure, thus scheme 3 has a better rate than scheme 2.

4. 3 Comparison of the average packet delay

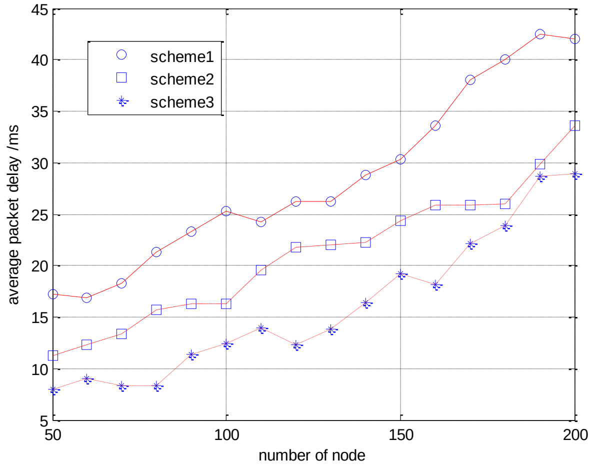

Figure 3. Average packet delay

From Fig. 3, the average packet delay grows with the number of nodes and it is clear that the effect of MS to packet delay. With MS in scheme 2 and 3, the duration of delay is shortened. And in scheme 3, the remote-cluster head send packet directly to MS without an intermediate node so the average packet delay is shorter than that in scheme 2.

5. CONCLUSION

In this paper a data collection method is proposed to support hybrid sink mode in wireless sensor networks where static and mobile sinks coexist. With the work of MS, the head in promote-cluster can transmit packets directly to mobile sink. Simulation results showed that the added mobile sink extended the network lifetime and expanded the capacity of network.

References

[1] HAN Zhijie, WANG Ruchuan , FAN Gaojuan , XIAO Fu . “An Unequal Clustering Algorithm in Wireless Sensor Networks Based on ARMA,” ACTA ELECTRONICA SINICA, vol. 38, April 2010, pp. 865-869(in Chinese)

[2] KANG YiMei, LI ZhiJun, HU Jiang, DONG JiChang . “A Low-power Hierarchical Wireless Sensor Network Topology Control Algorithm,” ACTA AUTOMATICA SINICA, vol. 36, April 2010, pp. 543-549(in Chinese)

[3] LI ChengFa, CHEN GuiHai, YE Mao, WU Jie. “An Uneven Cluster-Based Routing Protocol for Wireless Sensor Networks,” CHINESE JOURNAL OF COMPUTERS, vol. 30,January 2007, pp. 27-36(in Chinese)

[4] MA Kui, HUANG Heqin, SHEN Jie, YAO Daoyuan, LIU Haitao, YIN Zejie. “A Data Collection Method with Hybrid Sinks in Wireless Sensor Networks,” Opties and Precision Engineering, vol. 16, September 2008, pp. 1752-1758(in Chinese)

[5] BANDYOPADHYAY S, COYLE E J. “An energy efficient hierarchical clustering algorithm for wireless sensor networks ,” INFOCOM 2003, the 22nd Annual Joint Conference of the IEEE Computer and Communications Societies[C]. IEEE, 2003. 1713-1723.

[6] HEINZELMAN W R, CHANDRAKASAN A, BALAKRISHNAN H. “An application-specific protocol architecture for wireless microsensor networks ,”. IEEE Trans on Wireless Communications, 2002,1(4):660-670.

[7] Heinzelman W, Chandrakasan A, Balakrishnan H. “Energy-Efficient communication protocol for wireless microsensor networks,”. In : Proe. ofthe 33rd Annual Hawaii Int’1 Conf. on System Sciences. Maui : IEEE Computer Society. 2000. 3005-3014

[8] Wang FuBao, Shi Long, Ren FengYuan “Self-Localization Systems and Algorithms for Wireless Sensor Networks,” Journal of software, vol. 16, May 2005, pp. 857-868(in Chinese)

[9] Sun LiMin, Li JianZhong, Chen Yu. Wireless Sensor Networks[M]. Tsinghua University Press,2005(in Chinese)