Available online at www.sciencedirect.com

SciVerse ScienceDirect

AASRI Procedia 3 (2012) 523 – 527

AASRI Procedia

www.elsevier.com/locate/procedia

2012 AASRI Conference on Modeling, Identification and Control

Location-based Inner-Cluster Data Aggregation for Wireless Sensor Networks

Jianghong Guo[a]*, Haifeng Zhang[a], Weijun Chen[a]

[a]*Department of Computer Science, JiaYing University, Meizhou, 514015, PR.China*

Abstract

Data aggregation is an important method to reduce energy consumption in wireless sensor networks. Cluster-based data aggregation usually consists of two phases, inner-cluster aggregation and fusion data transmission from aggregators to base station. Most of existing schemes are mainly focus on the efficiency of the second phase and all inner-cluster sensors will transmit their readings to the aggregator. Authors proposed a location-based inner-cluster data aggregation scheme to improving the efficiency of in-cluster aggregation. Agent nodes are selected with assist of nodes' location and only the nodes have different readings with agent nodes transmit their data to cluster head, therefore, the data transmissions in the first phase are reduced effectively. Simulation shows that our scheme has fewer transmissions than that of related schemes and reduces the communication overhead effectively.

Keywords: Wireless sensor networks, data aggregation, agent nodes

1. Introduction

Wireless sensor network (*WSN*) consists of a large number of low-cost sensors which are usually deployed by random scattering and energy consumption is an important consideration for the designing of wireless sensor protocols. One of the major tasks of *WSN* is measure the different environment parameters and

* Corresponding author. Tel.: +86 0138 2458 8292.
E-mail address: gjhjyu@gmail.com(J.Guo), seawindzhang@jyu.edu.cn(H. Zhang), cwj@jyu.edu.cn(W.Chen)

doi:10.1016/j.aasri.2012.11.082

transmits the sensor readings to the base station (BS). Due to the broadcasting characteristics of WSN, all neighbors of the transmitter will receive the messages transmitted by the transmitter, thus, the most effective way to reduce the energy consumption is to reduce the unnecessary transmissions. Data aggregation is such a method to prolong the lifetime of WSN by reducing the redundant transmissions.

Recently, many data aggregation schemes for *WSN* have been proposed. Al-Karaki et al. propose exact and approximate algorithms for data aggregation [1], Aonishi et al. study the impact of aggregation efficiency on GIT routing [2], Gatani et al. propose a robust and efficient data gathering method for Wireless Sensor networks [3], Considine et al. propose an approximate aggregation techniques for sensor databases [4], Villas et al. propose a scalable and dynamic data aggregation aware routing protocol for wireless sensor networks [5], Heinzelman et al. proposed LEACH [6] for the network clustering and cluster head election; Younis et al. proposed HEED[7] in which the residual energy was taken into account cluster head election.

In these schemes, the cluster-based data aggregation [6] [7] usually consist of two phases, first phase is the inner-cluster aggregation and the second, fusion data transmitted to the base station. We know that the WSN has features such as the cluster is a relatively small area and sensors will have same or similar readings if they are close, but most of cluster-based schemes pay more attention to the second phase and all sensors will transmit their readings to aggregator in the first phase. In our scheme (LBDA: Location-based inner-cluster data aggregation), the mentioned features will be utilized to reducing the inner-cluster transmissions.

2. Our work

In our scheme, the cluster was divided into four regions and each node can calculates which region it located in using location information. For each region, cluster head knows how many nodes located in and selects some agent nodes for each region. Also, the communication range of agent node should cover its region. Only the nodes located in the same region and have different readings with agent node will transmit their data to cluster head and therefore reduce certain number of inner-cluster transmissions.

2.1. Network model and assumptions

In this paper, we have some assumptions about the network. 1) The network was clustered and each inner-cluster node was 1-hop away from the cluster head. Some clustering algorithms, such as ACE [8], can fulfill this task. Fig.1 (a) and (b) show the clustering results and corresponding logic topology of the network; 2) sensors can achieve their location by GPS or some location algorithm [9] [10], any inner-cluster nodes and cluster head each know other's location and Id; 3) there are multi-type sensors deployed in the network, for example, the temperature sensors and humidity sensors, and all sensors have the same communication radius *Rc* (*Rc*=40m); 4) inner-cluster parameters are follow normal distribution with mean μ and standard deviation σ due to the features mentioned in section 1 and sensor readings are rounded to integer because the measuring errors are unavoidable.

2.2. Inner-cluster division and report nodes

For reducing the inner-cluster transmissions, the cluster is divided into four regions R1, R2, R3 and R4 counterclockwise as shown in Fig.2 (a). In Fig.2 (a), the light-colored area is region *R1* and the dark area is the report region (*RR*). If we denote *SA* as the circle with point *A* at the center and *Rc* as radius, denote *SB* as the circle with point *B* at the center and *Rc* as radius, *Rc* is the communication radius of sensors, thus, we have that $RR=R1\cap SA\cap SB$. It is obviously that the communication range of any nodes located in *RR* will cover *R1,* and these nodes are report nodes. As shown in Fig.2 (b), the nodes marked with '*' are report nodes. The proof of communication range of report node cover the located region can be deduced easily using plane geometry and we don't prove it for conciseness.

Assume that the location of cluster head *Ch* and any node *Ni* are (X_{Ch}, Y_{Ch}) and (X_{Ni}, Y_{Ni}) respectively, node *Ni* calculates which region it located as follow:

$$\theta = \arctan\left(\frac{Y_{Ni} - Y_{Ch}}{X_{Ni} - X_{Ch}}\right) \tag{1}$$

$$Ni \in \begin{cases} R1, \textit{if } \theta \in [0, \pi/2] \textit{ and } (X_{Ni} > X_{Ch}) \\ R2, \textit{if } \theta \in [-\pi/2, 0) \textit{ and } (X_{Ni} > X_{Ch}) \\ R3, \textit{if } \theta \in [0, \pi/2] \textit{ and } (X_{Ni} < X_{Ch}) \\ R4, \textit{if } \theta \in [-\pi/2, 0) \textit{ and } (X_{Ni} < X_{Ch}) \end{cases} \tag{2}$$

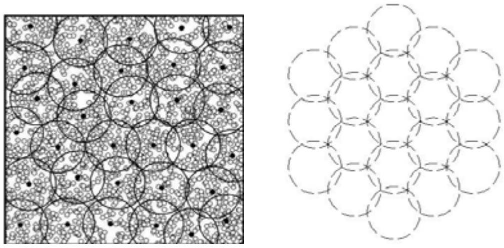

Fig. 1. (a) ACE clustering; (b) logic topology of the network

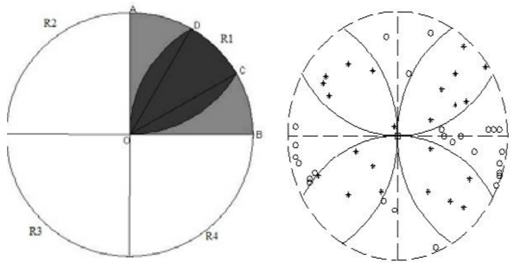

Fig. 2. (a) cluster division; (b) report nodes

2.3. agent node selection

For each type of sensors, cluster head randomly selects one of the corresponding report nodes as agent node for each region and preserve a table of agent information as shown in Table 1.

Table 1. Table of agent information

Agent node (ID)	*Type*	*Region*	*Num*
N1	*A*	*R1*	*Num_1A*
N2	*B*	*R1*	*Num_1B*
…	…	…	…
N9	*A*	*R3*	*Num_3A*
N10	*B*	*R3*	*Num_3B*
…	…	…	…

In Table 1, *A* and *B* are different sensor types, *Num_1A* denotes the number of sensors of type A located in region *R1* except *N1*, the same way to *Num_1B*. Then, the cluster head broadcasts <*N1, N2, R1*> … <*N9, N10, R3*>… to all inner-cluster nodes.

2.4. Inner-cluster data aggregation

Upon receiving the data request broadcasted by base station, all nodes measure the external parameters and the agent nodes will transmit their readings to cluster head directly. For any node *Ni* located in region *R*, will keep silent if its reading equals that of the agent node which located in the same region, otherwise, *Ni* will transmits its reading to cluster head. It is obviously that there are (*Num_1A - n*) sensors have the same reading with agent node *N1* if *n* sensors of type A located in *R1* transmit their data to *Ch*. In this way, *Ch* can achieve all data in the cluster and corresponding counter by common comparison and transmits the fusion data to base station.

Because the main concern of this paper is how to reduce the inner-cluster transmissions and many existing methods can be used for inner-cluster data comparison and data fusion if data and counter are available, therefore we don't discuss the data comparison and data fusion in detail.

3. Simulation

In our simulation, the network is clustered as shown in Fig.1 (b) and related assumptions has described in section 2.1. We evaluate the communication overhead using ns2 with wireless extensions and *802.15.4* allows a variable payload of up to 102 bytes. We assume that the average number of sensors in the cluster is $2n$, n sensors of type A and n sensors of type B, means of the data distribution in cluster are 30 and 60 for two kinds of sensors and standard deviation σ various from 0.6 to 1. Also, we use TCDA (Traditional cluster-based data aggregation) denotes most of existing cluster-based schemes which pay more attention to the transmission of fusion data from aggregator to based station and all inner-cluster nodes will transmit their data to aggregator. The comparison of inner-cluster transmissions were shown in Fig.3.

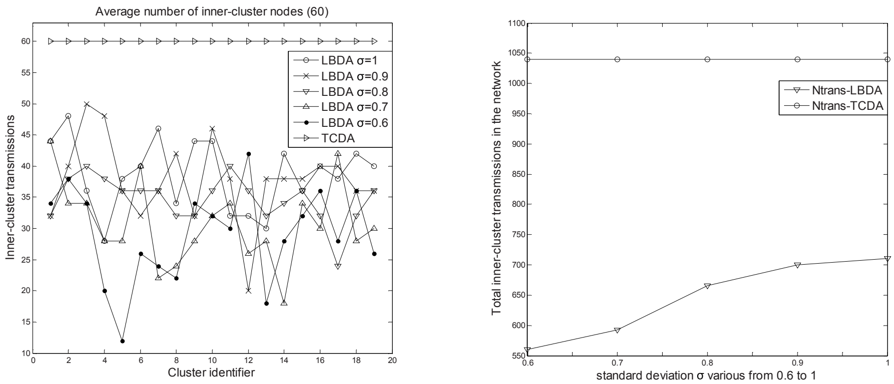

Fig. 3. (a) Inner-cluster transmissions; (b) Total inner-cluster transmissions

In Fig.3 (b), Ntrans means the total number of inner-cluster transmissions of the network. Fig.3 (a) shows that the inner-cluster transmissions in different clusters of LBDA is less than that of TCDA when σ various from 1 to 0.6 and Fig.3 (b) illustrates that the total inner-cluster transmissions of LBDA is less than that of TCDA. From Fig.3 (b) we know that the number of total transmissions has decreased follow the decrease of standard deviation σ. The reason is that the small σ makes the sensor readings more concentrated and results more sensors have same readings with the agent node, thus leads to more nodes keep silent in the processing of data aggregation.

4. Conclusion

In this paper, we proposed a location-based inner-cluster data aggregation scheme for reducing the inner-cluster transmissions for cluster-based data aggregation. Cluster was divided into regions and each node calculates which region it located in using location information. Only the nodes located in the same region and have different readings with agent node will transmit their data to cluster head. Simulation shows that our scheme has less inner-cluster transmissions than most of cluster-based data aggregation schemes, thus lowered the communication overhead and prolong the lifetime of the network.

References

[1] I. N. Al-Karaki, R. UI-Mustafa, A. E. Kamal, "Data aggregationin wireless sensor networks-exact and approximate algorithms", Computer Engineering, 2004: 241–245.

[2] T. Aonishi, T. Matsuda, S. Mikami, H. Kawaguchi, C. Ohta, M. Yoshimoto, "Impact of aggregation efficiency on git routing for wireless sensor networks", In Proceedings of the 2006 International Conference Workshops on Parallel Processing, 2006:151–158.

[3] L. Gatani, G. L. Re, M. Ortolani, Robust and efficient data gathering for wireless sensor networks, In proceedings of the 39th Annual Hawaii International Conference on System Sciences, Volume 09, Washington, DC, USA, 2006:235-240.

[4] J. Considine, F. Li, G. Kollios, J. Byers, "Approximate aggregation techniques for sensor data- bases", In Proceedings of the 20th International Conference on Data Engineering, ICDE'04, Wash- ington, DC, USA, 2004: 449–455.

[5] L. A. Villas, D. L. Guidoni, R. B. Ara´ujo, A. Boukerche, A. A. Loureiro, "A scalable and dyna- mic data aggregation aware routing protocol for wireless sensor networks", In proceedings of the 13th ACM international conference on Modeling, analysis, and simulation of wireless and mobile systems, MSWIM '10, 2010:110–117.

[6] W. R. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, An Application-Specific Protocol Architecture for Wireless Micro-sensor Networks[J], IEEE Trans Wireless Communication. 2002,10:660–670.

[7] O. Younis and S. Fahmy, HEED: a Hybrid, Energy-Efficient, Distributed Clustering Approach for Ad Hoc Sensor networks, IEEE Trans. Mobile Computing, 2004, 3(4): 366–379.

[8] H. Chan, A. Perrig, ACE: an emergent algorithm for highly uniform cluster formation [J], LNCS, 2004,2(2920):154-171.

[9] S.Capkun, J.P. Hubaux, Secure positioning of wireless devices with application to sensor networks. in *Proc. IEEE INFOCOM*, Miami, FL, Mar. 2005:1917– 1928.

[10] A. Savvides, C. Han, and M. Srivastava, Dynamic fine-grained localization in ad-hoc networks of sensors, in *Proc. ACM MobiCom*, Rome, Italy, Jul. 2001, pp. 166–179.