International Journal of Multimedia and Ubiquitous Engineering
Vol. 9, No. 11 (2014), pp. 283-292
http://dx.doi.org/10.14257/ijmue.2014.9.11.28

Study on Cluster Based Routing Method in a Wireless Sensor Networks

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Abstract

In a wireless sensor network, energy efficiency is critical issue on several topics. For sending sensed data to the sink node, many upstream sensor nodes are role as relaying node. Direct transmission is not proper in a wireless sensor network. We propose hop-based cluster head selection method. This method provides small number of cluster heads and connectivity to the sink node with these cluster heads. By providing shortest path to the sink node, wireless sensor network prolongs the life time. We also compared with other method with simulation.

Keywords: *cluster based routing, energy efficient, wireless sensor network*

1. Introduction

Wireless sensor network is used for ubiquitous environment. Many advanced applications such as earth-quake, forest fire, battlefield surveillance, machine failure diagnosis, biological detection, home security, smart spaces and inventory tracking are available with the development of smart sensor technology and wireless communication technology [1-3]. Wireless sensor network can be used for many applications such as monitoring for wide area, mobile health care and smart spaces [1-3]. Smart sensor technology and wireless communication technology make these applications stable. In sensor net-works, many topics have been researched in several fields such as MAC, topology, query dissemination, data routing and aggregation, and QoS. Many applications of WSN consider energy efficiency because it has a difficulty of recharging battery [4-5].

Sensor node detects some phenomena and delivers data to the sink node. To deliver data to the sink node, sensor node communicates to the sink node directly or by multi-hop. Limited power of sensors makes several routing methods for energy efficiency. Energy efficient routings for wireless sensor network have been researched several papers [6-8]. LEACH(Low Energy Adaptive Clustering Hierarchy)[9] uses single hop clustering algorithm in which cluster head communicates with the sink directly. However this algorithm is inefficient for cluster head which is located at a distance greater than one hop from the sink. Multi-hop based clustering methods (EEHCA, MCBT, Min-Distance Hop Count Clustering) proposed recently [10-12]. Multi-hop based method would be more efficient than single hop method, but it also increases communication overhead and costs required to obtain routing information [11]. Cluster based models also have drawback that cluster head consumes more energy for data gathering and relaying. We also proposed multi-hop based routing with cluster head selection in a same hop count.

The rest of this paper is organized as follows. In section 2, we investigate related work and we introduce our proposed method in section 3. We simply have a simulation in section 4, and finally conclude this paper in section 5.

ISSN: 1975-0080 IJMUE

2. Related Work

Several clustering algorithms are proposed through many years and some papers examine these proposed algorithms [13-19]. Figure 1 shows the classification of proposed clustering algorithms [24].

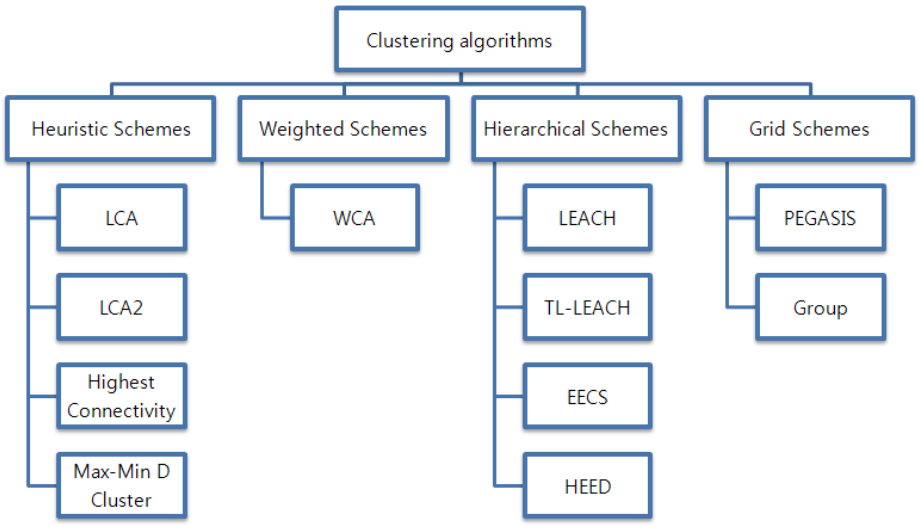


Figure 1. Classification of Proposed Clustering Algorithms

In this section, we investigate related work such as LEACH and MCBT. LEACH is a representative method of Cluster based routing and many other papers reference it. MCBT is recently proposed method that proposes a stable backbone tree construction algorithm using multi-hop clusters for wireless sensor network [11].

2.1. LEACH

LEACH provides a simple hierarchical routing protocol. Sensor nodes transmit its sensed data to cluster head and cluster head aggregate and transmit it to the sink node. It is energy efficient method compared with direct transmission of all sensor nodes. Sensor node just transmits data to the cluster head which is located in a close area. Cluster heads use more energy to receive data from its member nodes and transmit it to the sink directly. For this drawback, cluster heads are selected each round with rotation using probability algorithm. However cluster heads waste energy by communication to the sink directly.

LEACH is energy efficient method considering cluster based routing. However direct communication with sink node is not proper with energy saving. LEACH-C, HEED, PEGASIS are made up with weak points in LEACH method [21-23].

As shown in Figure 2, cluster head aggregates sensed data and transmit it to the sink node directly.

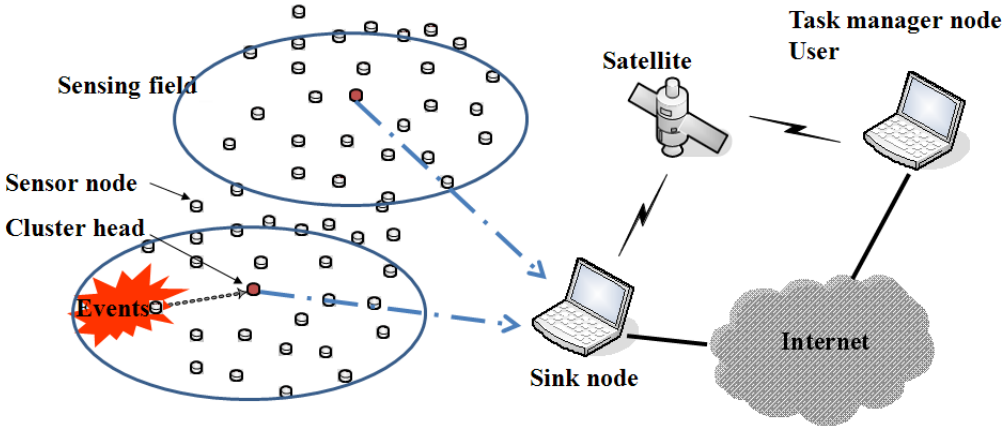


Figure 2. Cluster Configuration and Data Relaying in LEACH

2.2. MCBT

Recently multi-hop based clustering methods are proposed such as EEHCA, MCBT, Min-Distance Hop Count clustering method. MCBT(Multi-Hop Cluster Based Stable Backbone Trees for Data Collection and Dissemination in WSNs) proposes cluster based data collection and backbone nodes are responsible for multi-hop communication. For election of cluster head, each sensor takes into account with two factors, the sensor node's residual energy and degree. The flooding value are calculated with two factor [11]:

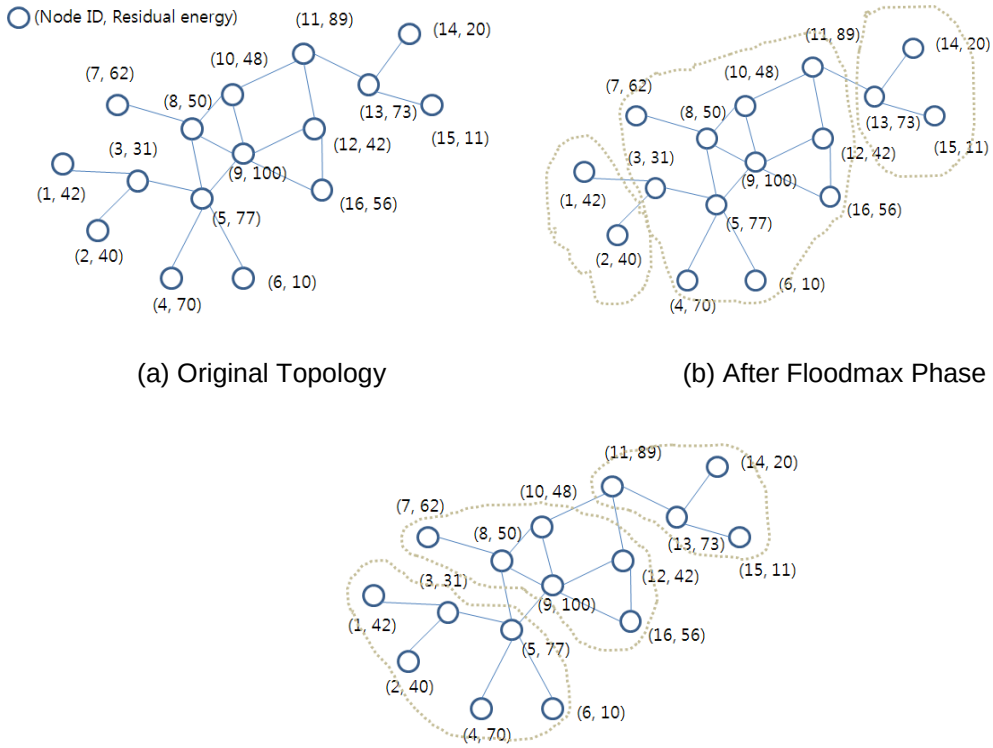
$$f(i,w) = w(\frac{E_{res}}{E_{ini}}) + (1 - \mathrm{w})(\frac{deg_i}{max_{j \in S_i}(deg_i)})$$

where w is weight factor that adjust the priority between residual energy and degree.

This flooding factor is calculated in round 0 at each sensor nodes and propagated to its d-hop neighbors. Propagation of flooding factor is progress two stages, Floodmax and Floodmin. Through Floodmax stage, each sensor node checks its role of cluster head. For the balanced load for cluster head, Floodmin stage is used.

Figure 3 shows clustering phases of MCBT, Floodmax and Floodmin phase[11]. This example uses 2-hop clustering that propagates flooding factor to 2-hop neighbor. Figure 3(a) shows original topology in which each sensor node is denoted its residual energy and degree of neighbors. During Floodmax phase, each sensor node broadcasts its max neighbor flooding factor and organizes into cluster as shown in Figure 3(b). Becase Floodmax is greedy method, cluster conformation is not balanced. After Floodmin phase as shown in Figure 3(c), Cluster member is divided to appropriate group with load balancing.

MCBT constructs the backbone of network with load balanced cluster head. However it cannot provide connectivity to the sink node with cluster heads. This method needs additional relaying nodes to the sink node for routing.



(a) Original Topology

(b) After Floodmax Phase

(c) After Floodmin Phase

Figure 3. 2-hop clustering – Floodmax and Floodmin Phase

3. Hop-based Cluster Head Selection

In a wireless sensor network, sensor node senses some data and relays data to the sink node. From sensor node to the sink node, direct transmission is difficult for energy efficiency in a wide area. Many other papers propose multi-hop based routing protocols [10-12].

We suggest hop count based disjoint cluster head selection method. With same hop count, cluster head is selected with disjoint method. One sensor node declares to neighbor sensor nodes its head election and the other neighbor nodes postpone its cluster head competition. Declaring is depends on factor which is calculated from remaining energy. Cluster head is role for data aggregation in a cluster group and data relaying from downstream cluster heads to the sink node.

The cluster head selection in a same hop count can be simplified as shown in Figure 4. This method provides small number of cluster head in a same hop count. However some cluster head cannot connect to the sink node by other upstream cluster head. Additionally relaying nodes are selected by downstream cluster head. This additional work is done just one time because relaying node is also included in a cluster having upstream hop count.

Hop count provides the shortest path to the sink node by multi-hop method. If we cannot use direct transmission from sensor node to sink node, the shortest path with multi-hop is just using a direct upstream cluster head. Upstream cluster head is relaying node with one less hop count. It may not exist upstream cluster head and its probability is about 0.36 [20]. Additionally we select relaying node for connectivity in this case.

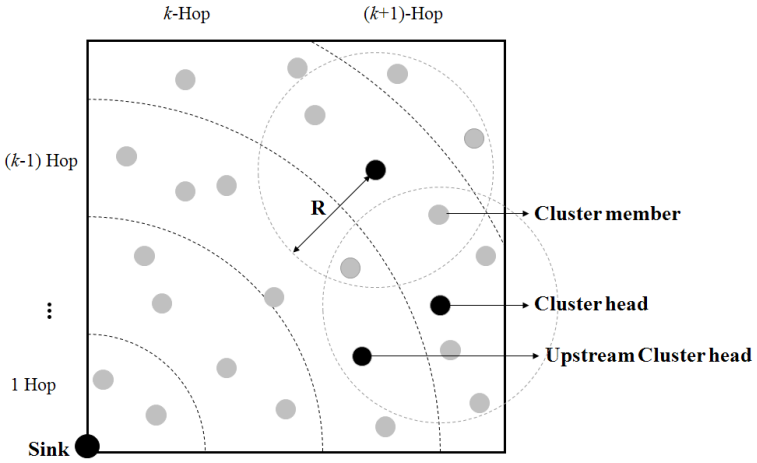


Figure 4. Head Selection in a Same Hop Count

As shown in Figure 5, this proposed method configures the formation of routing tree. Proposed method provides a little more cluster head than that of LEACH, MCBT. However, LEACH consumes more energy through direct transmission to the sink node and MCBT uses more relaying nodes for routing to the sink node.

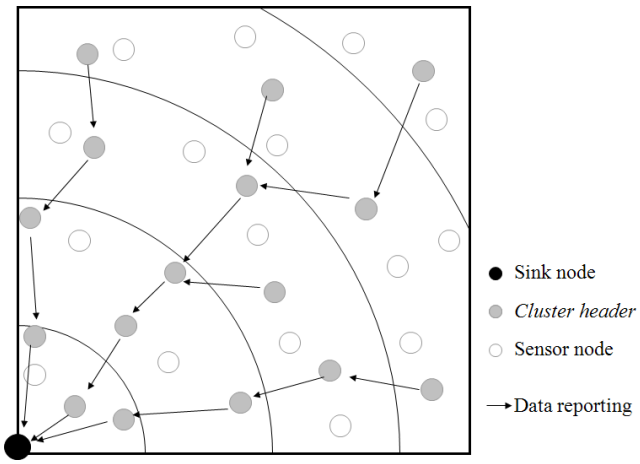


Figure 5. Data Relaying to the Sink Node by Routing Tree

4. Performance Evaluation

In this section, we report results from experiments to measure the performance of cluster head selection. In this paper, we simply calculate the performance and compared with related work such as LEACH and MCBT. Experiments are carried out on a simulator implemented in C.

4.1. Simulation Parameters

To evaluate the proposed scheme, we form sensing field in that sensor nodes is scattered over a square region in a uniformly random fashion. The sink node is located at the corner of the sensing field as shown in Figure 6. The parameter sets used for simulation are listed in Table 1.

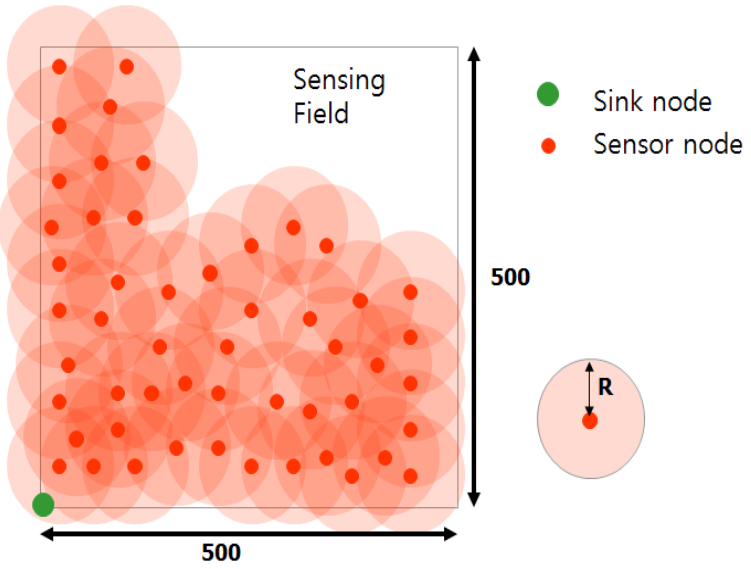


Figure 6. Wireless Sensor Network

Table 1. Simulation Parameters

Parameter	Notation	Value
Network size	*A*	500 * 500
Number of sensor nodes	*N*	200 ~ 1000
Transmission radio radius	*R*	100

4.2. Simulation Results

Figure 7 shows selected cluster head in a same hop count and connectivity to the sink node. Selected node marking 'A' is additional node for data relaying to upstream cluster head. A sensor node which detects some sensing data sends to cluster head and this cluster head relays data to the sink node by multi-hop using upstream cluster head. Figure 7(a) shows the shortest routing tree with cluster head and additional relaying node. And Figure 7(b) shows cluster formation based on hop count.

Sensor node can be included in cluster with downstream hop count as shown in Figure 7(b). This simulation just calculates the selection of cluster head with initial energy. So we will consider more parameter in future work and complement it.

MCBT has many cell head in initial topology in which sensor nodes have same energy. As shown in Figure 8, MCBT do not work well initial same energy, but shows good performance in the environment that sensor nodes have different energy. And hop count-based cell head selection method also performs well as MCBT. So considering the flooding overhead, hop count-based clustering method can be used in initial stages. LEACH has cluster heads smaller

than MCBT, hop count-based method. However it consumes more energy by transmitting data to the sink directly. MCBT shows well performances using 2-hop flooding than that of 1-hop.

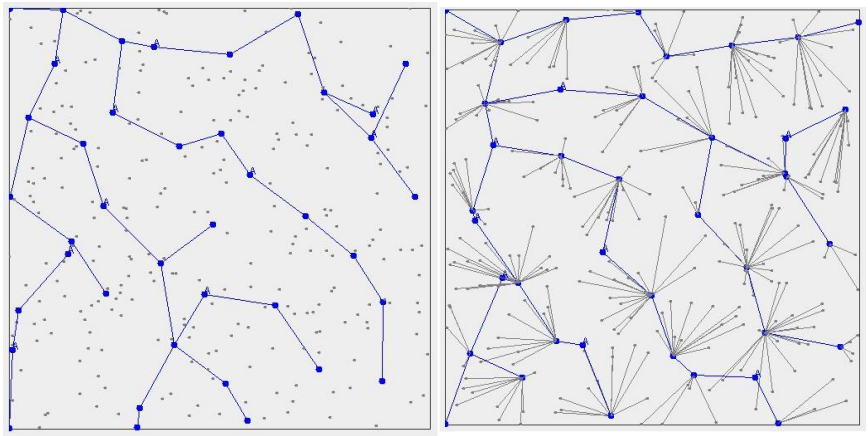
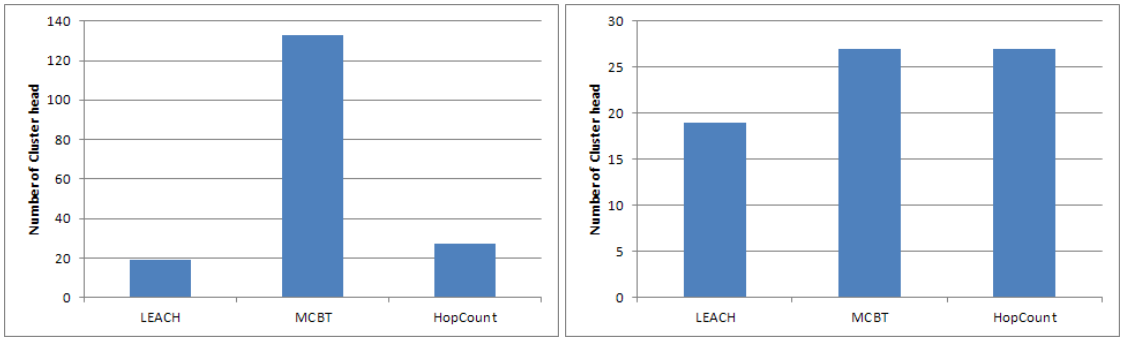


Figure 7. Cluster Head Selection in a Same Hop Count and Connectivity to the Sink Node.
(*Network Area* =500*500, *Radius*=100, *Nodes* =300)



(a) Initial topology(same energy) (b) Random Energy

Figure 8. Comparison of LEACH, MCBT, Hop Count-based Method
(*Network Area* =500*500, *Radius*=100, *Nodes* =300)

5. Conclusion

In this paper, we propose a cluster head selection method to preserve the energy by selecting cluster header with same hop count in a wireless sensor network field. Clustering method can provide small set of cluster head in a same hop count but cannot satisfy connectivity to the sink node by multi-hop. With additional selection of relaying nodes, it provides simple way to communication with upstream cluster header.

Our proposed scheme use one-hop count for disjoint cluster head selection. However it can scale up hop count greater than one to applying large-scale network. And we will consider more parameters in the future work like as residual energy, degree, size of hop radius and so on.

References

[1] F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, "Wireless Sensor Networks: A Survey", Computer Networks, vol. 38, **(2002)** March, pp. 393-422.
[2] C. Chong and S. P. Kumar, "Sensor Networks: Evolution, Opportunities, and Challenges", Proceedings of the IEEE, vol. 91, **(2003)** August, pp. 1247-1256.
[3] N. Ahmad, N. Riaz and M. Hussain, "Ad hoc wireless Sensor Network Architecture for Disaster Survivor Detection", Int'l Journal of Advanced Science and Technology, vol. 34, **(2011)**, pp. 9-16.
[4] Md. Zair Hussain, M. P. Singh and R. K. Singh, "Analysis of Lifetime of Wireless Sensor Network", International Journal of Advanced Science and Technology, vol. 53, **(2013)** April, pp. 117-126.
[5] K. H. Eom, M. C. Kim, S. Y. Park and G. H. Hyum, "The Reduction Method of Power Consumption for the Wireless Sensor Network System", Int'l Journal of u- and e- Service, Science and Technology (IJUNESST), vol. 6, no. 2, **(2013)**, pp. 63-76.
[6] F. Ye, G. Zhong, S. Lu and L. Zhang, "PEAS: A Robust Energy Conserving Protocol for Long-Lived Sensor Networks", Proceedings of IEEE Network Protocols, **(2002)** November, pp. 200-201.
[7] H. Huang, G. Hu and F. Yu, "Energy-aware geographic routing in wireless sensor networks with anchor nodes", Int'l. Journal of Communication Systems, **(2011)**, pp. 100-113.
[8] E. Park and K. Cho, "Energy Efficient and Reliable Geographic Routing in Wireless Sensor Networks", World Academy of Science, Engineering and Technology, **(2010)**, pp. 631-636.
[9] W Heizelman, A Chandrakasan and H. Balakrishman, "Energy efficient Routing protocols for wireless microsensor networks", Proc 33rd Hawaii International Conferences on System Sciences, **(2000)**.
[10] X. Guan, H. Y. Wu and D. G. Bi, "EEHCA: An Energy-Efficient Hierarchical Clustering Algorithm for Wireless Sensor Networks", Information Technology Journal, **(2008)**, vol. 7, no. 2, pp. 245-252.
[11] I. Shin, M. Kim, M. W. Mutka, H. Choo and T. Lee, "MCBT: Multi-Hop Cluster Based Stable Backbone Trees for Data Collection and Dissemination in WSNs", Sensors, vol. 9, **(2009)**, pp. 6028-6045.
[12] E. Kim, D. Kim, D. Song and J. Yoo, "Min-Distance Hop Count Based Balanced Multi-Hop Clustering in Non-uniform Wireless Sensor Networks", Proc. of the KIISE Korea Computer congress 2011, vol. 38, no. 1(A), **(2011)**, pp. 416-419.
[13] R. Sheikhpour, S. Jabbehdari and A. Khadem-Zadeh, "Comparison of Energy Efficient Clustering Protocols in Heterogeneous Wireless Sensor Networks", Int'l Journal of Advanced Science and Technology(IJAST), vol. 36, **(2011)**, pp. 27-40.
[14] H. Kim, "An Efficient Clustering Scheme for Data Aggregation Considering Mobility in Mobile Wireless Sensor Networks", Int'l Journal of Control and Automation, vol. 6, no. 1, **(2013)**, pp. 221-233.
[15] M. Arshad, N. Armi, N. Kamel and N. M. Saad, "Mobile data collector based routing protocol for wireless sensor networks", Scientific Research and Essays, vol. 6, no. 29, **(2011)**, pp. 6162-6175.
[16] C. -M. Liu, C. -H. Lee and L. -C. Wang, "Distributed Clustering algorithms for data gathering in mobile wireless sensor networks", Journal of Parallel and Distributed Computing, vol. 67, **(2007)**, pp. 1187-1200.
[17] A. M. Popescu, I. G. Tudorache, B. Peng and A. H. Kemp, "Surveying Position Based Routing Protocols for Wireless Sensor and Ad-hoc Networks", Journal of Communication Networks and Information Security, vol. 4, no. 1, **(2012)**, pp. 41-67.
[18] R. Sheikhpour, S. Jabbehdari and A. khademzadeh, "A Cluster-Chain based Routing Protocol for Balancing Energy Consumption in Wireless Sensor Networks", International Journal of Multimedia and Ubiquitous Engineering, **(2012)** April, vol. 7, no. 2, pp. 1-16.
[19] C.-S. Nam, K.-S. Jang, G.-S. Choi and D.-R. Shin, "Study on Use of a Clustering Technique with Zone-Based Multi-hop Communication in Wireless Sensor Networks", International Journal of Smart Home, vol. 6, no. 2, **(2012)** April, pp. 65-70.
[20] E. Kim, "A Density Control Scheme Based on Disjoint Wakeup Scheduling in Wireless Sensor Networks", Int'l Journal of Smart Home, vol. 7, no. 5, **(2013)**, pp. 327-336.
[21] O. Younis and S. Fahmy, "HEED: A Hybrid Energy-Efficient Distributed Clustering Approach for Ad Hoc Sensor Networks", IEEE Transactions on Mobile Computing, vol. 3, no. 4, **(2004)**.
[22] S. Lindsey and C. S. Raghavendra, "PEGASIS: Power-Efficient Gathering in Sensor Information Networks", Computer Systems Research Department, the Aerospace Corporation.
[23] S. D. Muruganthan, D. C. F. Ma, B. Rollyi and A. Fapojuwo, "A centralized energy-efficient routing protocol for wireless sensor networks", IEEE Radio Communications, vol. 43, no. 3, **(2005)**, pp. 8-13.
[24] D. J. Dechene, A. El Jardali, M. Luccini and A. Sauer, "A Survey of Clustering Algorithms for Wireless Sensor Networks", http://www.dechene.ca/papers/report_635a.pdf.

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