View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by CiteSeerX

International Journal of Science, Technology & Management www.ijstm.com
Volume No 04, Special Issue No. 01, March 2015 ISSN (online): 2394-1537

CLUSTERING SOLUTION TO MAXIMIZE LIFETIME OF WIRELESS SENSOR NETWORK: A SURVEY

Zaheeruddin[1], D.K. Lobiyal[2] and Aruna Pathak[3]

[1]Professor , Department of Electrical Engineering,
Jamia Millia Islamia Central University,New Delhi, (India).
[2]Professor , School of Computer and Systems Sciences,
Jawaharlal Nehru University, New Delhi, (India)
[3]Ph.D. scholar ,Department of Electrical Engineering,
Jamia Millia Islamia Central University,New Delhi, (India)

ABSTRACT

Wireless sensor networks consist of small nodes with sensing, computation, and wireless communications capabilities. The purpose of the network is to sense the environment and report what happens in the area it is deployed in. The sensor networks can be used for various application areas (e.g., health, military, home) Moreover, most of the Wireless Sensor Network (WSN) applications render it impossible to charge or replace the battery of sensor nodes. Therefore, optimal use of node energy is a major challenge in wireless sensor networks to enhance the lifetime of whole network. Clustering of sensor nodes is an effective method to use the node energy optimally and prolong the lifetime of energy constrained wireless sensor network. .In the paper we give out the survey of clustering solution to lifetime maximization in wireless sensor network. In this paper we also points out the open research issues and intends to spark new interests and developments in this field.

Keywords-Wireless sensor network, Lifetime, Clustering

I INTRODUCTION

A Wireless Sensor Networks (WSNs) contains hundreds or thousands of sensor nodes. These sensors have the ability to communicate either among each other or directly to an external Base-station (BS). A greater number of sensors allows for sensing over larger geographical regions with greater accuracy. Sensor nodes coordinate among themselves to produce high- quality information about the physical environment. Each sensor node bases its decisions on its mission, the information it currently has, and its knowledge of its computing, communication, and energy resources. Each of these scattered sensor nodes has the capability to collect and route data either to other sensors or back to an external base station(s)[1].Traditionally sensor networks have been employed for monitoring environmental conditions such as temperature, pressure, moisture contents etc. But with technological advances sophisticated sensor nodes are being produced capable of transmitting real-time data (video/images) and critical data (outages/leaks). A base station may be a fixed node or a mobile node capable of connecting the sensor network to an existing communications infrastructure or to the Internet where a user can have access to the reported data. The applications of sensor networks in various fields vary from environment monitoring, military applications to monitoring patients in hospitals[2]. Basically nodes are driven by batteries and in many applications it is not easy to replace the batteries or sometimes not even recharge the batteries so each node has a limited energy supply. Lifetime is very important factor in wireless sensor network. Due to power-constrained nature of sensor nodes, long-distance communications should be kept to least in order to enhance the network lifetime [3]. So, direct communications between nodes and the base station are not encouraged. An effective approach to improve efficiency is to arrange the network into several clusters, with each cluster electing one node as its leader called as cluster head [4]. A cluster head collects data from other wireless sensor nodes in its cluster, directly or through a multihop manner. Typically, data collected from nodes of the same cluster are highly correlated. Data can be fused during the data aggregation process [5]. The fused data will then be transmitted to the base station directly. In such an arrangement, only cluster heads are required to transmit data over a long distance. The rest of the nodes will need to do only short-distance transmission. Energy consumption of wireless sensor nodes is greatly reduced and the overall network lifetime can thus be prolonged. Grouping sensor nodes into clusters has been widely pursued by the research community in order to achieve network lifetime enhancement.

This paper is organized as follows. In Section II, we focus on General architecture of Clustering. In Section III, we present cluster properties. In Section IV, we brief the abilities of cluster head. In Section V, we define motives of clustering. Survey of some basic clustering protocols is given in Section VI. Finally, we conclude in Section VII.

II GENERAL ARCHITECTURE OF CLUSTERING

In Fig. 1, we can see the architecture of a generic Wireless Sensor Network [1], and examine how the clustering phenomenon is an essential part of the organizational structure.

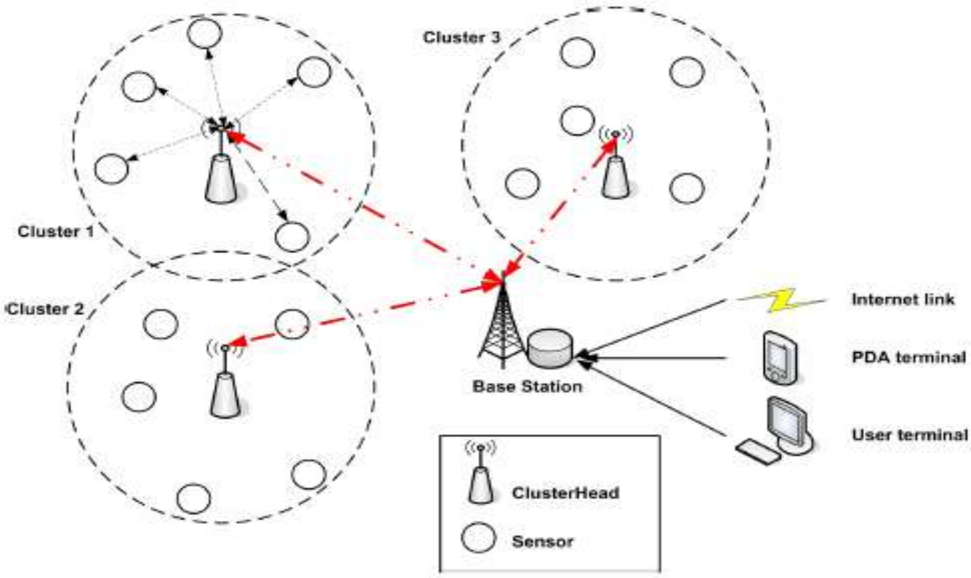

Fig1. General architecture of clustering

- **Sensor Node:** Sensor nodes can take on multiple roles in a network, such as simple sensing; data storage; routing; and data processing.
- **Clusters:.** The dense nature of these networks require the need for them to be broken down into clusters to simplify tasks such a communication.
- **Cluster heads:** Cluster heads (CHs) are the organization leader of a cluster. They often are required to organize activities in the cluster. And send data to next cluster head or base station as needed.
- **Base Station:** The base station is at the upper level of the hierarchical WSN. It provides the communication link between the sensor network and the user.
- **End User:** For a particular application user may make use of the network data over the internet, using a PDA, or even a desktop computer. In a queried sensor network (where the required data is gathered from a query sent through the network). This query is generated by the end user.

III CLUSTER PROPERTIES

Cluster properties are following-

- **Number of Clusters** : Number of clusters may be fixed or variable. If set of Cluster Heads(CH) are predetermined and thus the number of clusters are preset. Randomly picking CHs from the deployed sensors usually yields variable number of clusters.
- **Cluster Stability:** When the member of clusters varies over the time, the clustering scheme is said to be adaptive. Otherwise, it is considered fixed since sensors do not switch among clusters and the number of clusters stays the same throughout the network lifespan.
- **Intra-cluster topology:** Some clustering schemes are based on direct communication between a sensor and its designated CH. However, multi-hop sensor-to-CH connectivity is sometimes required depends on communication range.
- **Inter-CH connectivity:** When the CH does not have long haul communication capabilities, CHs connectivity to the base-station has to be provisioned. In that case, the clustering scheme has to ensure the feasibility of establishing an inter-CH route from every CH to the base-station.

IV. CLUSTER-HEAD ABILITIES

- **More Resource type:** In some networks deployed sensors are selected as CHs while in others CHs are equipped with significantly more computation and communication resources.
- **Mobility:** When a CH is mobile, sensor's membership dynamically changes and the clusters would need to be continuously maintained. On the other hand, stationary CH tends to yield stable clusters and facilitate intra- and inter-cluster network management. Sometimes, CHs can travel for limited distances to reposition itself for better network performance.
- **Responsibility:** A CH can simply act as a relay for the traffic generated by the sensors in its cluster or perform aggregation/ fusion of collected sensors' data. Sometime, a CH acts as a sink or a base-station that takes actions based on the detected phenomena or targets.

V. MOTIVES OF CLUSTERING

Motives of clustering depends on objective the applications requirements[5]. The following discussion highlights popular motives for network clustering:

- **Load balancing:** Load balancing is a more pressing issue in WSNs where CHs are picked from the available sensors[6]. CHs more work burden then other nodes in this case because all nodes have same capabilities but CHs have to combined data report becomes ready almost at the same time for further processing at the base-station or at the next tier in the network. Rotating the role of CHs among nodes in the cluster can give load balancing advantage .
- **Fault-tolerance:** In many applications, WSNs will be operational in harsh environments and thus nodes are usually exposed to increased risk of malfunction and physical damage. Tolerating the failure of CHs is usually necessary in such applications in order to avoid the loss of important sensors' data. The most intuitive way to recover from a CH failure is to re-cluster the network. However, re-clustering is not only a resource burden on the nodes, it is often very disruptive to the on-going operation Assigning backup CHs is the most notable scheme pursued in the literature for recovery from a CH failure.
- **Improved connectivity:** Unless CHs have very long-haul communication capabilities, e.g. a satellite link, inter-CH connectivity is an important requirement in many applications. The connectivity goal can be just limited to ensuring the availability of a path from every CH to the base-station[7] or be more restrictive by imposing a bound on the length of the path[8] . When some of the sensors assume the CH role, the connectivity objective makes network clustering one of the many variant of the connected dominating set problem.
- **Data latency:** On the other hand, when data latency is a concern, intra-cluster connectivity becomes a design objective or constraint. Delay is usually factored in by setting a maximum number of hops ''K'' allowed on a data path. K-hop clustering is K-dominating set problem[9].
- **Prolonging network lifetime:** The energy limitation on nodes results in a limited network lifetime for nodes in a network. Combined clustering and route setup has also been considered for maximizing network's lifetime[10]. Adaptive clustering is also a viable choice for achieving network longevity[11].

VI. SOME BASIC CLUSTERING PROTOCOLS

LEACH [12] proposed initially is a distributed and single-hop clustering algorithm. Each clustering cycle consists of cluster forming phase and data communicating phase. Election of cluster head depends on the selected threshold *T (n)* as follows.

$$T(n) = \begin{cases} \frac{P}{1-P*[r \mod (1/p)]}, & n \in G \\ 0, & \text{else} \end{cases} \qquad (1)$$

where *P* is the percent of cluster head nodes in all nodes, *n* is the token of the node, and *r* is the number of rounds for the election. *r* mod *(1/p)* is the number of nodes elected as cluster head in a cycle, and *G* is the set of nodes not elected as a cluster head, while each node is elected as the cluster head with the same probability. In each circle, first the threshold *T (n)* of the node elected as cluster head is set to 0, and then the probability of the remaining nodes increases. Thus this process can guarantee that the node with the equal probability is elected as the cluster head.

By taking overhead of communication within a cluster into account, HEED [13] algorithm overcomes the shortcoming of unevenly distributed cluster heads as enjoyed by the LEACH algorithm. And the residual energy of node as a parameter is introduced to elect cluster head with more energy to undertake data forwarding tasks. In initialization phase, nodes send the messages to compete with the initialized probability of *CHprob*. When the election of cluster head is completed, other nodes join into clusters by means of the information gathered in competing phase. Here, *CHprob* is described as

$$CH_{prob} = \max(C_{prob} + E_{resident}/E_{\max}, p_{\min}) \qquad (2)$$

where *Cprob* and *p*min are the whole network parameters affecting the convergence speed of the algorithm, the recommended values of which are given in simulation experiments; *Eresident* /*E*max is the ratio of the node residual energy and initial energy.

WCA [14] is a classical algorithm based on node degree, the number of single-hop neighbors. The election of cluster head relies upon the factors of node degree, send-receive energy and residual energy.

Energy Efficient Hierarchical Clustering—EEHC[7] is a distributed, *k*-hop hierarchical clustering algorithm aiming at the maximization of the network lifetime. The main objective of this algorithm was to address the shortcomings of one-hop random selection algorithms such as LEACH by extending the cluster architecture to multiple hops.

In [15], the mobile sink (aircraft) flies and collects the data from the cluster-heads. Each sensor node transmits data packets to its cluster-head in a single/multi-hop path and cluster-heads forward packets to the aircraft.

Energy Efficient Clustering Scheme—EECS[16] has a constant number of CHs are elected (i) based on their residual energy (as the main criterion) and (ii) using localized competition process without iteration to complete the cluster formation process. The corresponding algorithm can effectively lead to better energy consumption and uniform load distribution based on the fact that clusters at a greater distance from the BS require more energy for transmission than those that are closer.

Protocol	**Mobility**	**No. of clusters**	**Cluster head selection criteria**	**Objective**
LEACH	Fixed BS	Variable	Probability criteria	Lifetime longevity
HEED	Stationary	Variable	Residual energy	Save Energy
WCA	Yes	Variable	Node degree, Residual energy	Load Balancing
EEHC	No	Variable	Hop distance	Maximize lifetime
Hetro n/w	Mobile BS	Variable	Distance	Lifetime longevity
EECS	Static	Constant	Residual energy	Better energy consumption

VII. CONCLUSION

WSN is a promising future technology and presently used in range of application that requires minimum human intervention.. Researchers have already designed a number of clustering techniques. In this paper we have surveyed the clustering solution to maximize lifetime of WSN technology. paper we also points out the open research issues and intends to spark new interests and developments in this field.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless Sensor Networks: A Survey," IEEE Trans on Computer Networks, 38(4), 2002, 393-422.

[2]J. N. AL-Karaki and A. E. Kamal, **"**Routing Techniques in Wireless Sensor Networks: A Survey", IEEE Trans on Wireless Communications, 11(6) ,2004, 6-28.

[3] J. Ai, D. Turgut, and L. Bölöni, "A cluster-based energy balancing scheme in heterogeneous wireless sensor networks," in Proc. 4th Int. Conf. Networking, (ICN 2005), Reunion Is., France, Apr. 2005, vol. 1, 467–474.

[4] K. Akkaya and M. Younis, "A survey on routing protocols for wireless sensor networks," Ad hoc Netw., 3(3) , 2005, 325–349.

[5] A. A. Abbasi and M. Younis, "A survey on clustering algorithms for wireless sensor networks," Comput. Commun., 30(14),2007, 2826–2841.

[6] O. Younis, S. Fahmy, HEED: A Hybrid, Energy-Efficient, Distributed clustering approach for Ad Hoc sensor networks, IEEE Transactions on Mobile Computing 3 (4) ,2004, 366–379.

[7] S. Bandyopadhyay, E. Coyle, An energy efficient hierarchical clustering algorithm for wireless sensor networks, in: Proceedings of the 22nd Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM 2003), San Francisco, California, April 2003,123-128.

[8] F. Dai, J. Wu, On constructing k-connected k-dominating set in wireless networks, in: Proceedings of the 19th IEEE International Parallel and Distributed Processing Symposium (IPDPS'05), Denver, Colorado, April 2005, 22-29.

[9] F. Garcia, J. Solano, I. Stojmenovic, Connectivity based k-hop clustering in wireless networks, Telecommunication Systems 22 (1) ,2003, 205–220.

[10] K. Dasgupta, M. Kukreja, K. Kalpakis, Topology-aware placement and role assignment for energy-efficient information gathering in sensor networks, in: Proceedings of 8th IEEE Symposium on Computers and Communication (ISCC'03), Kemer-Antalya, Turkey, July 2003, 54-59.

[11] T. Moscibroda, R. Wattenhofer, Maximizing the lifetime of dominating sets, in: Proceedings of the 19th IEEE International Parallel and Distributed Processing Symposium (IPDPS'05), Denver, Colorado, April 2005.

[12] W.B. Heinzelman, A.P. Chandrakasan, H. Balakrishnan, Application specific protocol architecture for wireless microsensor networks, IEEE Transactions on Wireless Networking ,4(1),2002,660-670.

[13] O. Younis and S. Fahmy, "HEED: A hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks," IEEE Trans. Mobile Comput., 3(4),2004, 366–379.

[14] M. Chatterjee, S. K. Das, and D. Turgut, "WCA: A weighted clustering algorithms for mobile ad hoc networks," Cluster Comput., 5(2),2002, 193–204.

[15] V. P. Mhatre, C. Rosenberg, D. Kofman, R. Mazumdar, and N. Shroff, "A Minimum Cost Heterogeneous Sensor Network with a Lifetime Constraint", IEEE Transactions on Mobile Computing, 4(1),2005, 4-15.

[16] M. Ye, C. Li, G. Chen, and J. Wu, EECS: An energy efficient clustering scheme in wireless sensor networks, in Proceedings of IEEE Intl. Performance Computing and Communications Conference (IPCCC),2005, 535–540.