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A Study on Energy Routing Algorithms Using Clustering in Wireless Sensor Networks

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Abstract- WSN is an upcoming technology that is predicted to change the human life in future. This technology is composed of tiny sensing objects called sensors that are widely scattered in the environment. Clustering is a key technique which is used to extend the lifetime of sensor network. In this paper, survey on different clustering algorithms for increasing energy efficient has been performed and highlighted their objectives and feature.

Keywords: sensor nodes, lifetime, clustering, routing algorithms

I. INTRODUCTION

The latest developments in time critical, low cost, long battery life and low data rate wireless application have led to work on WSN. These have considered for work in certain areas of applications with limited power, reliable data transfer, short communication range, monitoring, military applications, healthcare [1].

The power of wireless sensor networks lies in the ability to deploy large numbers of tiny nodes that assemble and configure themselves. Sensor network initially consists of small or large nodes called as sensor nodes. These nodes are varying in size and totally depend on the size because different sizes of sensor nodes work efficiently in different fields.

Wireless sensor networking have such sensor nodes which are specially designed in such a typical way that they have a microcontroller which controls the monitoring, a radio transceiver for generating radio waves, different type of wireless communicating devices and also equipped with an energy source such as battery. The entire network worked simultaneously by using different dimensions of sensors and worked on the phenomenon of multi routing algorithm which is also termed as wireless ad hoc networking. The sensors are typically battery-powered and have limited wireless communication bandwidth. Therefore, energy efficient target tracking systems are needed for less consumption of important energy from sensors [8].

One of the advantages of WSN is their ability to operate unattended in harsh environment in which contemporary human–in-loop monitoring schemes are risky, inefficient and sometimes infeasible. Therefore sensors are expected to be deployed randomly in the area of interest by a relatively uncontrolled means eg. Sensors are dropped by a helicopter and to collectively form a network in an ad-hoc manner.

[2, 3]. Several applications need only aggregated value. In such cases, sensors in different regions can collaborate to aggregate their information and provide more accurate results. For e.g. in a habitat monitoring application [4], the average reported humidity value is sufficient. In military field where chemical activity or radiation is measured the maximum value may be required to alert. In order to support the data aggregation through efficient way, the nodes can be partitioned into groups called clusters. Clustering is a key technique which is used to extend the lifetime of a sensor network by dropping the energy consumption. [3].Every cluster has a cluster head (CH), which can be fixed or varied. Lot of clustering algorithms have been designed for WSN for scalability and efficient communication.

II. ROUTING MODELS IN SENSOR NETWORKS

Lot of research work has been done in this field to make this technology more scalable, energy efficient and robust. Ibriq and Mahgoub in [7] described different routing models used for WSN. There are three models routing in WSN including:

- One Hop Model
- Multi Hop Model
- Cluster Based Model

A. One Hop Model

In this model, each individual sensor node sends the data directly to the base station.

Fig.1 One hop model [7]

B. Multi-Hop Model

In this model, the sensor nodes choose their nearby nodes to forward their data to the base station.

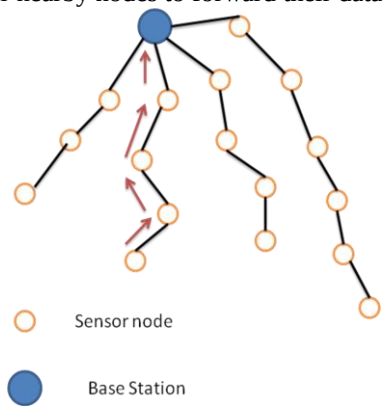

Fig 2. Multi-hop model [7]

C. Cluster Based Model

In this model, the network is grouped into clusters. In each cluster, one node is elected as cluster head (CH) and the remaining nodes act as the member nodes. The CH collects all the information from the member nodes and then sends it to the base station. Each cluster can have equal or unequal number of member nodes.

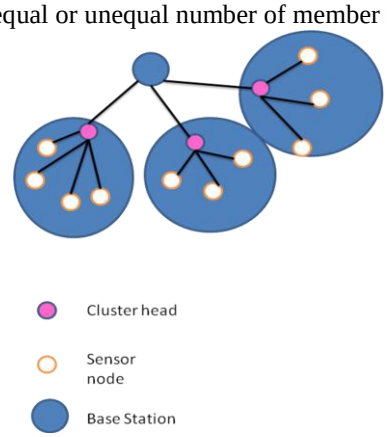

Fig. 3 Cluster based model [7]

Many routing protocols have developed based on the above models. But cluster routing is an energy efficient routing model when compared to direct and multihop routing.

III. CLUSTERING

In a sensor network, the sensor nodes are divided into different groups, and they are allocated geographically adjacent into the same cluster according to their communication range. Every cluster would have a leader, often named as cluster head (CH). The role of CH is to organize the clusters, including data aggregation, data forwarding, communication between base station and the sensor nodes. Cluster heads can consolidate the data and send it to the base station as a single packet, which helps to reduce the overhead. Within the cluster organization there can be both intracluster communication and intercluster communication.

Clustering is essential for sensor network applications, where a large number of sensors are deployed for sensing purposes. If each sensor nodes starts to transmit data in the network, large amount of data congestion and collisions may exhibit. This leads to loss of energy rapidly from the sensors. Clustering is a method which is used to overcome these issues. In other words, clustering improves the scalability of wireless sensor networks [17]. It reduces the communication overheads among the sensor nodes.

Nowadays, many clustering algorithms have been proposed for sensor networks aiming to improve the lifetime of the nodes. To achieve maximizing network lifetime the whole network is divided into different clusters.

A. Benefits of Clustering

The foremost benefits of clustering in wireless sensor networks are:

1. Clustering provides the spatial reuse of resources to increase system capacity. For example, if the clusters are not neighbors, they can use the same frequency for wireless communication [15].
2. It reduces collisions caused by contention for the channel.
3. It provides resource utilization and reduces energy consumption in the network by reducing the sensor nodes that take part in long distance transmissions.
4. Clustering reduces the size of the routing table stored at the individual nodes by localizing the route set up within the cluster. [5]

5. The CH can prolong the battery life of the individual sensors and the network lifetime as well by implementing optimized management strategies [5]
6. A CH can minimize the rate of energy utilization by scheduling activities in the cluster (can make the nodes to sleep mode).
7. Clustering can also conserve communication bandwidth since it limits the scope of inter-cluster interactions to CHs and avoids redundant exchange of messages among sensor nodes [5]

B. Design goals of Clustering

Design goals targeted in traditional networking provide little more than a basis for the design in wireless sensor networks [6]. Clustering algorithms plays an important role in achieving the targeted design. There are several attributes which are to be considered while designing the clusters namely,

1. formation of clusters
2. section of cluster head and its capabilities
3. synchronization
4. data aggregation
5. error recovery and maintenance
6. quality of service
7. real time application using clusters

IV. EXISTING ENERGY ROUTING ALGORITHMS USING CLUSTERING

Many energy efficient routing techniques have been proposed by different researchers to help route data within the sensor network with the hope of minimizing duplicated packets, minimizing the number of hops needed to deliver the data in due course conserving the energy of the network.

Recently, a number of clustering algorithms have been designed for WSN. Clustering is very effective in reducing communications i.e., sensor nodes periodically send the gathered information to the base station through the cluster head [9] The clustering technique can provide more benefit to the network lifetime; it conserves bandwidth, helps to reduce the size of the routing table, and reduces the delay in sending the data packets.

The clustering methods in sensor networks can be categorized into static and dynamic ones. The static clustering methods aims only at minimizing the energy spend during the formation of the clusters for the given network parameters [10]. The parameters are not changed. The dynamic clustering method also aims to minimize the energy by changing the network parameters, such as the number of active nodes, sleep nodes, or the available energy levels in the network.

A number of contributions were made by researchers to increase the network lifetime by using clustering and multipath routing. One such is by reducing the redundant information, the energy can be conserved. Such work is carried out by Anh Tuan Hoang and Mehul Motani [11]. It considered the broadcast nature of sensor node. Whenever data is broadcasted it is known by all the nodes present within the communication range, so a node can eliminate the redundant information transmitted by the sending node. This property can compress the node's information while transmitting and the energy conservation is also achieved.

The selection of cluster head forms a main role in the clustered network. Many different ways has been proposed by different authors. In some cases, the election of cluster head is not done properly. Taewook Kang *et al.,* [19] put forward a distributed scheme of cluster heads to reduce the energy dissipation by avoiding unnecessary redundancy. This process helps to select the cluster head in an evenly manner. It avoids creating redundant cluster heads within a small network range.

The author Taruna *et al.,* [20] proposes a new protocol named PECP (Power Efficient Clustering Protocol) to improve the stable region of the clustering hierarchy process using the characteristics parameters of heterogeneity, namely the fraction of powerful nodes (with more energy) more suitable to become a cluster head. It creates clusters based on zone and establishes connections between sensor nodes. This algorithm reduces the number of communication between the sensor nodes for cluster head selection, so that the energy consumption for cluster head selection is reduced.

Ping *et al.,* [12] formulated a distributed weight based energy efficient hierarchical clustering scheme in which each node after discovering its neighbors calculates its weight, based on their residual energy and the distance to its neighbors. The largest weight node becomes a cluster head. Basagni (1999) used a Distributed Clustering Algorithm to elect the cluster heads. It elects the node that has the highest weight among its 1-hop neighbors. But it is suitable only for the networks in which the nodes are static or moving at a very low speed.

Jaffery *et al.,* [13] proposes a same type of energy optimized clustering protocol for wireless sensor network. The cluster head selection criteria are based on which clusters are formed. The role of the cluster head is rotated so that the energy consumption can be evenly distributed. For the first round, the cluster head is selected randomly and for the subsequent rounds, the residual energy of nodes is considered and hence it increases the lifetime of sensor network to some extent.

Chiasserini *et al.,* [14] used a combination of determining the optimal cluster size and cluster heads to achieve the maximum lifetime. By prior knowing the location of the nodes, the cluster head is elected, which is not possible in all scenarios. Moreover it requires that each node to know the complete topology of the network, which is generally not possible in the large sensor networks.

Siva Ranjani *et al.,* [15] proposes a data aggregation method to enhance the network's lifetime. In ECBDA (Energy Efficient Cluster Based Data Aggregation for Wireless Sensor Networks) cluster formation phase is used to split the network into set of cluster. *K* clusters are formed in each layer then each layer is divided into a set of clusters. In Cluster

Head election process, one node is selected as cluster head from each cluster by using its residual energy and the communication cost factor. Once a node is elected as a cluster head, it broadcasts the cluster head message to its cluster members, other cluster heads and base station. Data forwarding is performed in the third phase.

In the Data aggregation phase, all cluster members send its sensed data during its allotted time slot. The cluster head waits until its TDMA (Time Division Multiple Access) frame ends. After receiving its data from its entire cluster member, cluster head starts the aggregation process. Each cluster head eliminates the duplicates and forwards the packet to BS via the forwarding nodes. Maintenance phase checks the cluster head's residual energy at each round. If the residual energy is less than the required threshold value, a new cluster head is elected from the same cluster. Re-clustering is also performed in the maintenance phase. This protocol leads to small sized cluster which lead to more amount of data transfer form cluster head to base station it is energy consumable.

Feng Li and Liuhong Huang [16] suggested a connected graph as Clustering Routing Protocol based on Connected Graph (CRPCG), which controls electing the cluster head and ordinary nodes joining into the cluster based on residual energy, node density and intra-cluster communication cost. The base station and all cluster heads form a connected graph structure. But, when the cluster head is elected, it leads to recursive path and leads to energy loss of the nodes.

Mohammad Mehrani *et al.,* [17] formulate another clustering algorithm to cover numerous nodes in both inter and intra cluster levels. The network is divided into clusters and selects a node for each cluster to work as the router of the corresponding cluster, which is named as pivot node. All the cluster heads and pivot nodes together make a group called dominating set which covers all over the entire region. This pivot node is responsible for receiving data from the nodes existing in the corresponding cluster and then forwards it to the cluster head. Using this technique, it reduces existing load of cluster head in huge networks and considerably decreases energy consumption of the regular nodes.

An energy efficient scheduling algorithm for clustered wireless sensor networks is presented by Murthy *et al.,* [18]. The main objective is to provide optimized Time Division Multiple Access (TDMA) schedules that can acquire high power efficiency, reduced interference, reduced conflict and reduced end-to-end delay over a wide network. To obtain this objective, a joint optimal design of network, Medium Access Control (MAC) and physical layers is considered to reduce the overall energy consumption. The slot reuse concept is applied to derive the TDMA schedule to minimize the frame length.

To minimize the cluster formation the author Meenakshi Diwakar and Sushil Kumar [19] has introduced a protocol named as Energy-Efficient Level Based Clustering Routing Protocol (EELBCRP) in which the network is partitioned into annular rings by using various power levels at base station and each ring having various sensor nodes. It has also considered the residual energy of each node and the distance from the BS of nodes as the principle of cluster-head election. It has reduced the number of dead nodes and the energy consumption to extend the network lifetime.

An Energy-Aware Clustering Algorithm (EADC) was proposed by Jiguo Yu *et al.,* [20], using competition range to construct clusters of even sizes. The routing algorithm of EADC increases forwarding tasks of the nodes in scarcely covered areas by forcing cluster heads to choose nodes with higher energy. But by choose only the higher energy nodes can lead the nodes to die faster and again reformation of clusters has to be performed which leads lesser lifetime of the network.

The energy aware protocols work well; sometimes it may lead to route failure. To avoid such failures Getsy *et al.,* [21] proposes a novel hybrid routing algorithm. The Energy Aware (EA) selection mechanism and the Maximal Node Surplus Energy estimation technique incorporated in this algorithm improves the energy performance during routing. The author uses Bayer's rule to choose the node with highest surplus energy, least mobility and best transmission range. It maintains a route list which consists of multipath with maximal nodal residual energy, so in case of link failure and route breaks; new route discovery can be avoided.

Another novel approach is EECS (Energy Efficient Clustering Scheme) suggested by Mao Ye *et al.,* [22], in which the CHs is distributed uniformly across the network through a localized single hop communication. A competitive algorithm is suggested for CHs selection phase and a fixed competition range is specified to each volunteer node. A weighted cost function is also introduced to manage the number of cluster members. Every node, which finds a more powerful node in its competition set, will give up the competition immediately and broadcast its QUIT acknowledgment message. Any node that finds itself more powerful than the others in its competition radius will introduce itself as a CH and broadcast its advertisement message. The message complexity in this algorithm makes trouble in the dense networks for having too many nodes competing for being CH.

The researcher Shalli Rani *et al.,* [23] proposes an EEICP (Energy Efficient Inter Cluster Coordination Protocol) which uses a uniform distributing load of energy among all the sensor nodes. In this, layers of clusters are formed in such a way that there is always one cluster coordinator for every lowest cluster. The division of clusters is done from top to bottom. The protocol depends upon the fact that some cluster head sends data directly to the base station and use the multi hop approach for the CHs. Each node is given equal responsibility to receive data from all other nodes in the cluster and to transmit the aggregating signal to the base station. But this can lead all the nodes to die at the same time, where there will be no chance for using any nodes in case of route failure.

Sanjeev Kumar Gupta *et al.,* [24] developed a protocol DECBC (A Density Control Energy Balanced Clustering Technique for Randomly Deployed Wireless Sensor Network) to enhance the life time of heterogeneous wireless sensor networks. In this paper authors select cluster heads based on probability threshold and current energy level. Authors also work on redundant node identification and deactivation. It achieves longer lifetime and stability period.

The formation of clusters can be done in two ways namely static or in a dynamic manner. Yoshitsugu *et al.,* [25] proposes an energy aware routing scheme in which the sensor network is grouped into clusters dynamically. The cluster

heads positioned near to the network base station are assigned the role of cluster head for direct transmission with the base station with less energy consumption. These cluster heads are supposed to be the Upper Level cluster heads. In a similar way, cluster heads located distant away from the network base station, are considered to be the Lower Level cluster heads. Due to random selection of cluster-heads all the cluster-heads might be chosen from one part of the level. But the upper level cluster heads will lose its energy soon and leads to decreased network lifetime.

Elbhiri *et al.,* [26] proposed an EDEEC algorithm (Equitable Distributed Energy-Efficient Clustering) which is used for heterogeneous network, using an intermediate cluster based hierarchical solution. But this protocol is suitable only if the base station is far away from the network. The clustering of the network can be equal or unequal.

Soro and Heinzelman [27] propose an unequal clustering model which focuses on heterogeneous network where cluster heads are deterministically deployed at some pre-computed locations. But cluster heads farther away from the base station have to transmit the packets over longer distance than the cluster head closer to the base station. But the longer cluster heads loses its energy soon, which automatically effects the network lifetime.

The Wei *et al.,* [28] determines a suitable cluster sizes depending on the hop distance to the data sink. It achieves approximate equalization of node lifetimes and reduced energy consumption levels. However, too many clusters around the sink will produce a significant number of summary packets. In result, it will cause heavy traffic load.

V. CONCLUSION

Node clustering is a useful way to reduce the communication overhead and send the data. In this paper, we have summarized recent research results on energy routing algorithms in sensor networks using clusters. We have highlighted some of the pitfalls in the current algorithms. Further research is necessary for handling life time of sensor networks based on their mobility and more number of nodes.

REFERENCES

[1] I.F. Akyildiz, W.Su.Y.Sankarasubramaniam and E.Cayirci, "A survey on sensor networks", IEEE Comm.. Magazines, Vol.40, no.8, pp.102-114, Aug 2002.

[2] K.Sohrabi et.al. "Protocols for self organization of a wireless sensor network", IEEE Personal Communications 7(5), pp.16-27, 2000.

[3] R.Min.et.al, "Low Power Wireless Sensor networks", *Proceedings of International Conference on VLSI Design*, Bangalore, India, Jan 2001.

[4] "Habitat Monitoring on Great Duck Island", http://www.greatdeckisland.net/2006

[5] Akkaya.K and Younis.M, "A survey on routing protocols for wireless sensor networks", Elsevier Journal of Ad.Hoc Networks, 3(3) pp.325-249

[6] A.Amir, R.Prakash, T.Vuong and D.Huynh, "Max-Min D-Cluster Formation in Wireless Ad Hoc Networks", *IEEE INFOCOM*, March 2000.

[7] J. Ibriq and I. Mahgoub. "Cluster-based routing in wireless sensor networks: Issues and challenges", Department of computer science and Engineering, Florida Atlantic University.

[8] C. Schurgers and M.B. Srivastava, "Energy efficient routing in wireless sensor networks", *MILCOM Proceedings on Communications for Network-Centric Operations: Creating the Information Force, McLean, VA, 2001*.

[9] Asfandyar Khan, Nurul Hasan, Azween Abdullah, Maximizing Lifetime of Homogenous Wireless Sensor networks through Energy Efficient Clustering Method, International Journal of Computer Science and Security (IJCSS), 3(6): 448 – 594, 2010.

[10] Bandyopadhyay, S and E.J.Coyle, Minimizing communication Costs in hierarchically clustered networks of wireless sensors, Computer Networks, 44(1): 1-16, 2004

[11] Anh Tuan Hoang and Mehul Motani, Collaborative broadcasting and compression in cluster based wireless sensor networks, ACM Transactions on Sensor Networks. 3(3), 17, 2007.

[12] Ping Ding., JoAnne Holliday and Aslihan Celik, Distributed energy-efficient hierarchical clustering for wireless sensor networks, Lecture notes in Computer Science, Springer Berlin Heidelberg, 322 – 339, 2005.

[13] Jaffery Z.A., Moinuddin and Munish Kumar, Adaptive Clustering based on Residual Energy on Sensor Nodes in Wireless Sensor Network for Multimedia Data, International Journal of Computer Applications, 33(1): 25 – 29, 2011.

[14] Chiasserini C.F., I. Chlamtac, P. Monti and A. Nucci, Energy Efficient design of Wireless Ad Hoc Networks, Proceedings of Networking, Springer-Verlag, 376 -386, 2002.

[15] Siva Ranjani, S and S. Radha Krishnan, Energy-Efficient Cluster Based Data Aggregation for Wireless Sensor Networks, IEEE Recent Advances in Computing and Software Systems (RACSS), 174 –179, 2012.

[16] Feng Li and Liuhong Huang, CRPCG—Clustering Routing Protocol based on Connected Graph, International Journal on Intelligent Systems and Applications, 3: 11 – 18, 2011.

[17] Mohammad Mehrani, Ali Shaeidi and Mohammad Hasannejad, A New Network Coverage Algorithm for Enormous Clustered Wireless Sensor Networks, Global Journal of Computer Science and Technology, 11(4): 59 – 66, 2011.

[18] Murthy J.K., S. Kumar and A. Srinivas, Energy Efficient Scheduling in Cross Layer Optimized Clustered Wireless Sensor Networks, International Journal of Computer Science and Communication, 3(1): 149-153, 2012.

[19] Meenakshi Diwakar and Sushil Kumar, An Energy Efficient Level Based Clustering Routing Protocol For Wireless Sensor Networks, International Journal Of Advanced Smart Sensor Network Systems (IJASSN), 2(2): 55 – 65, 2012.

[20] Jiguo Yu., Yingying Qi, Guanghui Wang and Xin Gu, A cluster-based routing protocol for wireless sensor networks with Nonuniform node distribution, International Journal of Electronics and Communications, 66(1): 54 – 61, 2012.

[21] Getsy S Sara, R. Kalaiarasi, S. Neelavathy Pari and D. Sridharan, Energy Efficient Clustering and Routing In Mobile Wireless Sensor Network, International Journal of Wireless & Mobile Networks (IJWMN) 2(4): 106 – 114, 2010.

[22] Mao Ye., Chengfa Li, Guihai Chen and Jie Wu, EECS: An Energy Efficient Clustering Scheme in Wireless Sensor Networks, Proceedings of IEEE International Performance Computing and Communications Conference (IPCCC), 535 – 540, 2005.

[23] Shalli Rani, Jyoteesh Malhotra and Rajneesh Talwar, EEICCP—Energy Efficient Protocol for Wireless Sensor Networks, Wireless Sensor Network, 5: 127 – 136, 2013.

[24] Sanjeev Kumar Gupta, Neeraj Jain and Poonam Sinha, A Density Control Energy Balanced Clustering Technique for Randomly Deployed Wireless Sensor Network, IEEE Conference on Wireless and Optical Communication Networks (WOCN), 1 – 5, 2012.

[25] Yoshitsugu Obashi, Huifang Chen, Hiroshi Mineno and Tadanori Mizuno, An Energy-Aware Routing Scheme With Node Relay Willingness In Wireless Sensor Networks, International Journal of Innovative Computing, Information and Control, 3(3): 565 – 574, 2007.

[26] Elbhiri B., R. Saadane, A. Pagés-Zamora, Driss Aboutajdine, Equitable Distributed Energy- Efficient Clustering (EDEEC) for heterogeneous wireless sensor networks, International conference on Next Generation Networks and Services (NGNS'09), 2009..

[27] Soro S and W. Heinzelman, Prolonging the Lifetime of Wireless Sensor Networks via Unequal Clustering, Proceedings of 19th IEEE International Parallel and Distributed Processing Symposium, 2005.

[28] Wei D., Y. C. Jin, S. Vural, K. Moessner and R. Tafazolli, An Energy-Efficient Clustering Solutions for Wireless Sensor Networks, IEEE Transactions on Wireless Communications, 10(11): 3973 – 3983, 2011.

