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A Survey on Clustering Techniques for Wireless Sensor Networks

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Abstract: Wireless sensor network is energy constraint network. The lifetime of a network is defined by the life of first specified percentage of dying nodes. Load balancing is a method to equalize energy consumption of all nodes and this way all nodes will degrade together. By load balancing, the lifetime of the network does not depend only on the life of weak node but depends on the life all nodes in the network which helps to increase the life of the network. In this paper, clustering algorithm that based on uniform energy uses is examined for wireless sensor networks. Uniform energy uses can extend the lifetime of a sensor network by reducing centralized load. It also increase network scalability. Wireless sensor network with the different energy levels nodes can prolong the lifetime of the network and also its reliability. We discuss the improvement to be made for future proposed uniform energy consumption/load balancing schemes. This paper provided the reader with the basis for research in load balancing schemes for wireless sensor networks.

keywords: Wireless sensor network, aggregation, data precision, residual energy, network lifetime, chain

I. INTRODUCTION

In today's world of computing, information gathering is a fast growing and challenging field in the different area such as inhospitable and low-maintenance areas where conventional approaches prove to be very costly [1]. Sensors provide a low-priced and straightforward solution to these applications. These physical devices are small in size that is capable of gathering environment information like heat, light or motion of an object . Sensors are deploying in a simple model in the area of interest to monitor events and gather data about the surroundings. Networking of these unattended sensors is expected to have a major impact on the effectiveness of many military and civil applications, such as combat field observation, security and adversity management. Sensor motes in such systems are typically throwaway and expected to last until their energy drain. Therefore, for sensor networks power is a very inadequate resource and for the duration of a particular mission. It has to be managed wisely to extend the life of the sensor motes. The sensor networks pursue the model of a base station, where sensors relay streams of data to the base station either like periodically or based on actions. The control node/ base station may be statically allocated in the surrounding area of the sensor, or it may be mobile so that it can move around the field and collect data from the network. In either case, the base station cannot be reached strongly by all the sensor motes in the network. The motes /nodes that are located far away from the base station will consume more energy to transmit data than other nodes and therefore will die sooner [2].

In Wireless Sensor Network (WSN), it consists of a potentially large number of resource constrained sensor nodes and few relatively powerful relay nodes. The sensor node has a battery and a low-end processor, a limited amount of memory, and a low power communication module capable of short range wireless communication [3]. As sensor nodes are deployed randomly and have very limited battery power, it is impossible to recharge the dead batteries. That's why battery power is considered as a limited resource in WSN and should be efficiently used. Sensor node consumes battery in sensing data, receiving data, sending data and processing data [4]. A sensor node doesn't have enough power to send the information directly to the far away base station. Therefore, along with sensing data the sensor node act as a router to promulgate the data of its neighbour. The sensor nodes can be grouped into small clusters in a large sensor network. Each cluster has a cluster head to coordinate the nodes in the cluster. Cluster arrangement can increase the lifetime of the sensor network by making the cluster head, collect data from the nodes in the cluster, aggregate it and send to the base station. A randomly deployed sensor network requires a cluster formation protocol to partition the network into equal sized groups. There are two ways to select cluster heads: process the leader first and the cluster first. In the leader first approach, initially cluster head is chosen then the cluster is formed. In the cluster first approach, initially the cluster is formed and after that cluster head is selected. Clustering has numerous advantages like it reduces the size of the routing table, conserve communication bandwidth, prolong network lifetime, decrease the redundancy of data packets, reduces the rate of energy consumption etc. [5]. In [6], a Hybrid Multihop Partition-Based Clustering routing protocol (HMPBC) is proposed in which the area of interest is divided into a number of zones. They formed a single-chain structure in the cluster to gathers data from sensing field.

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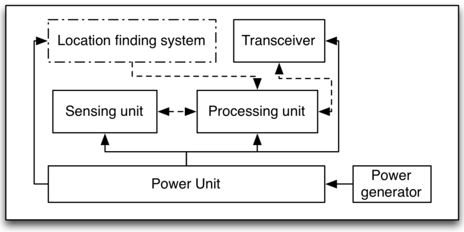

Fig. 1: Typical architecture of sensor node [9].

The rest of the paper is organized as follows. Section II discusses components of sensor nodes. Section III describes WSNs applications. Section IV provides an overview of clustering algorithms in WSNs. Section V presents load balancing techniques. Section VI concludes the paper.

II. Components of Sensor Nodes

Sensor nodes have hardware and software components.Hardware components include processors, radio-transceiver sensors, and power unit. The software's used for sensor nodes are TinyOs, Contiki, and Nano Rk. In this section, we discuss hardware components briefly.

A. Sensors

There are two types of Sensors nodes: digital sensors and analog sensors. Analog sensors gives data in continuous or in waveform. The data is further processed by the processing unit that converts it to human readable form [7].Digital sensors directly generate data in the discrete or digital form. Once the data is converted, it directly sends it to the processor for further processing [7].

B. Memory

Microprocessors use different types of memory for processing data. The memory and input/output devices are integrated on the same circuit. Random-access memory (RAM) stores data before sending it, while read-only memory (ROM) stores operating system of sensors nodes [8].

C. Processors

Microprocessors of sensor nodes are also known as small scale CPUs which is related about the CPU speed, voltage, and power consumption. Sensors operations run at low CPU speed.Most of the time, sensors remain in sleep mode. In sleep mode processor is involved in other activities like time synchronization and consumes small amount of the power [7].

D. Radio Transceiver

The transceiver receives and sends data to other sensor nodes [7]. The radio frequency is used to connect sensors with other nodes. Data transmission process consume most of the energy in transceiver section.The transceiver has four operational modes such as sleep, idle, receive, and send [8].

1) Sleep Mode: In sleep mode, nodes turn off their communication devices or modules so that there are no more transmission and reception of data frames. In sleep mode, nodes can listen to data frames. This is listening stage of sleep mode. When nodes listen to the data frame, it turn in to the active mode; otherwise, it remains in sleep mode.

2) Active Mode: In active mode, data is transmitted normally. Nodes communication devices are in active state and can send or receive data.

3) Idle Mode: It is also one of the sleep modes. In this stage, sensor nodes are in low-power mode and remain in this mode for agreed amount of time. When sensor nodes go back to the awake or active mode from the idle mode, they again connect to the networks and start communication [8].

E. Power Unit

It is the most important part of the sensor node. Sensor node cannot perform any work without this unit [8]. The lifetime of the sensor node is defines by the Power unit. Typical architecture of sensor node is given in Fig. 1.

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III. Applications

Sensor nodes gather and forward data for the particular application whenever some kind of physical change occurs, such as change in temperature, sound, and pressure. WSNs have many applications such as military, civil, and environmental applications. Some important applications are discussed below.

A. Area Monitoring

Sensor nodes are deployed in the area where some actions have to be monitored; for instance, the position of the enemy is monitored by sensor nodes, and the information is sent to the base station for further processing. Sensor nodes are also used to monitor vehicle movement.

B. Environmental Monitoring

WSNs have many applications in forests and oceans, and so forth. In forests, such networks are deployed for detecting fire.WSNs can detect when the fire is started and how it is spreading. Senor nodes also detect the movements of animals to analyses their habits. WSNs are also used to analyses plants and soil.

C. Industrial Monitoring

In industries, sensors monitor the process of making goods. For instance, in manufacturing a vehicle, sensors detect whether the process is going right. A response is produce if there is any manufacturing fault [7]. Sensor nodes also monitor the grasping of objects by robots.

D. Medical and Healthcare Monitoring

Medical sensors are used to monitor the conditions of patients. Doctor scan monitor patient's conditions, blood pressure, sugar level, and so forth,review ECG and change drugs according to their conditions[7]. Personal health-monitoring sensors have special applications. Smart phones are used to monitor health, and the response is generated if any health risk is detected. Medical sensors store health information and analyze the data obtained from many other sensors such as ECG, blood pressure, and blood sugar [8].

E. Traffic Control System

Sensor nodes monitor traffic flow and number plates of traveling vehicles and can locate their positions if needed. WSNs are used to monitor activities of drivers as well such as seat-belt monitoring [7].

F. Underwater Acoustic Sensor Networks

Underwater special sensors can monitor different applications of numerous oceanic phenomena; for instance, water pollution, underwater chemical reactions, and bioactivity. For such purposes, different types of 2D and 3D static sensors are used. 3D dynamic sensors are used to monitor autonomous underwater vehicles (AUVs) [7].

IV. Clustering Techniques

Clustering is a technique to balance load of network. There are some points need to know about clustering.

A. Cluster properties

The clustering schemes has some characteristics. Such characteristics can be associated with the internal structure of the cluster or how it relates to others. The following are the pertinent attributes:
1) Cluster Count: cluster heads are rearranged thus; the number of clusters is predefined. For randomly deployed sensors, cluster head selection algorithms pick randomly cluster heads, therefore, yield a variable number of clusters.
2) Intra-cluster Topology: direct communication between a sensor node and its respected cluster head, some clustering schemes are based on it, but multi-hop connectivity sensor to CH is required.
3) Connectivity of cluster head to the base station: sensor nodes send their data to cluster head by single or multi-hop. Cluster heads send the aggregated data to the base station directly or indirectly. It means, there exists a direct link or a multi-hop link.

B. Cluster head Capabilities

The following attributes of the CH node are differentiating factors among clustering schemes.
1) Mobility: cluster head may be stationary or mobile. In most scenarios, they are stationary. But sometimes, cluster head can move within a limited region to reposition themselves for better network performance.

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2) Node Types: Generally sensor nodes among the deployed sensors are designated as CHs, but sometimes sensor nodes equipped with significantly more computation and communication resources are selected as CHs.
3) Role: Some of the main roles of the CHs are simply relaying the traffic, aggregation or fusion of the sensed data.

C. Parameters of CH selection

Cluster head selection criteria Following are some of the parameter used for selecting the cluster head
1) Initial Energy: This is an important parameter to select the CH. Many algorithm considers the initial energy for cluster head selection.
2) Residual Energy: After some of the rounds, the cluster head selection considers remaining energy in the sensors for cluster head selection.
3) Energy Consumption Rate: This is another significant parameter that considers the energy consumption rate.
4) Average Energy of the Network: The average energy is used as the reference energy for cluster head selection. It is the ideal energy that each node should own in current round to keep the network alive.

V. UNIFORM ENERGY CONSERVATION TECHNIQUES IN WIRELESS SENSOR NETWORKS

Recently, a large number of load balancing techniques and algorithms have been proposed for WSNs, and simultaneously many studies have been done to analyze existing routing techniques and algorithms. For example,
In [2], authors selects the cluster member by considering the maximum transmission power of the nodes, its membership depends on the communication cost. In this method backup recovery is not to be consider. In paper [10], author improves the choice of the cluster member by using comprehensive weight value composed of distance between the cluster head and the member and the residual energy. To avoiding the load imbalance, it uses optimization threshold value too. For developing the balanced cluster the algorithm considers load equalization.
In this paper [11], for intra and inter-cluster communication layered approach is used. This algorithm considers similar network. In this paper [12], fairly distributed cluster heads increases the network lifetime. The cluster heads used the transmission range reconfiguration to balance the clusters that based on the number of general nodes in the cluster and the number of cluster heads. The algorithm provides effective data aggregation.
In this paper [13], for packet forwarding uses optimal scheduling algorithm in which determines the time slot for sending the packets for the nodes. The algorithm provides uniform packet loss probability for all the nodes. The algorithm uses balanced cost objective function for optimum scheduling. In this research [14], for improving data accuracy and use of bandwidth WSN to increase network lifetime pseudo-sink protocol is introduced. In this paper [15], handles the hot point problems which use the pruning mechanism in the cluster to balance the load in the network. Evaluation function in the algorithm is based on pruning mechanism and uses nodes location, residual energy and count of cluster nodes as its parameter to find its cost.
In this paper [16], by dividing the sensor network nodes into subsets, the algorithm consider sensing coverage & network connectivity. To ensure the network connectivity, it turns on some extra nodes in each subset. The problem with this approach is to find the existence of critical nodes. These nodes may be on all the time and if these nodes die the network will be partitioned In this paper [17], provides possible in- network method for adaptive distributed control of energy consumption. In this, some other methodologies like a market-based algorithm or game theoretic algorithm are used. The algorithm assumes complete connectivity.
In this paper [18], density as a key parameter, the load balancing algorithm is proposed for cluster heads in wireless sensor networks by considering the traffic load. It is supposed i.e. the traffic load supplemented by entire sensor nodes is same, which is the special case of this algorithm. It is a NP-hard method. It uses centralized approach and assumes that each node is aware of the network. In this research [19], in this paper, an algorithm is proposed that accounts the problem of positioning mobile cluster heads and balancing traffic load in hybrid sensor network which abides of static and mobile nodes. It has shown that the location of the cluster head could affect network lifetime significantly, by moving cluster head to better location network load can be balanced and lifetime is increased. In this paper [20], load balanced group clustering to balance the battery power by implementing dynamic route calculation according to the condition of energy distribution in the network.
In this paper [21], in this paper fuzzy based approach is used in distributing database for load balancing on sensor network that extends the lifetime of the network. A new approach vertical partitioning algorithm for distributing a database on sensors is used in this paper. In this approach, first clusters are formed and then distribute partitions on clusters. In this paper [22], a new clustering protocol of load balancing which isolates the entire network to the virtual circle with variable radiuses is proposed. This protocol used in such a fashion that radius of every virtual circle and the size of every cluster will rise with the augmenting distance from the base station, in such a way that cluster size of every circle would be distinct with the clusters of the other circles.In this study, theprospective protocol, network coverage after the initial node dead, first node dead, decreases harmonically and uniformly. It also raised network lifetime incomparably in such a way that the lifetime of the network increased.

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In this paper [23], planned to deal with the lifetime expansion problem, then improves a novel load balancing scheme by load balancing applying to the sub-network management in wireless sensor networks that balance the energy consumption of the sensor nodes and utmost network lifetime. In this study a scheme using analytical models and compare the results with the earlier researchers. This scheme takes into account the load balancing of individual nodes to maximize the system lifetime. In this paper [24], authors proposed a clustering approach to providing the balanced cluster by considering thresholds for cluster formation and also address to reduce cluster unevenly and load unbalanced. It shows that it reduces the death rate of nodes when it compares with the other traditional approaches with a better lifetime of the network. It provides us an impartial clusters and better quality cluster.

In this paper [25], a data aggregation methods are used which are the combination of two methods for load balancing. In the primary method, nodes which are away from the sink consume additional energy and load balancing is concluding by rising the interval of communication based on remaining energy of these nodes. In the secondary method, load balancing is concluded by tolerating the superiority of data when data is sufficient diverged from previous data.Nodes which have less energy send data only. The quality of data is based on deviation control function and this deviation control function is based on remaining energy of nodes. This method shows radically increases the lifetime of wireless sensor network. In this research [26] by using some backup nodes, a clustering technique will balance the load among the cluster. The backup high energy and high processing power nodes replace the cluster head after the cluster reaches its threshold limit. It provides high network lifetime and maximum throughput. The performance of the algorithm is compared with the original LEACH algorithm regarding the number of rounds and the dead nodes using the parameter like energy dissipation in each round per node. The result shows that it provides effective results in prolonging the network lifetime.

In this paper [27], a decentralized routing algorithm, known as a game theoretic energy balance routing protocol. It is planned to expand the network lifetime through balancing energy consumption in a larger network area with geographical routing protocols. The goal of the proposed protocol is to make sensor nodes decreases their energy at approximately the same time, which is accomplished by addressing the load balance problem at both the region and node levels. In the region level, evolutionary game theory (EGT) is used to balance the traffic load to the available subregion. In the node level, classical game theory (CGT) is used to select the best node to balance the load in the selected subregion. The combination of evolutionary and classical game-theoretic with geographical routing is shown to be effective improvement in lifetime of the network.

In this paper [6], a Hybrid Multihop Partition-Based Clustering routing protocol is proposed . In this, the area of interest is divided into a number of zones, which a single-chain structure in the cluster is used to prolong the network lifetime and the region minimum spanning tree algorithm is adopted for communication among CHs. In order to reduce the number of forwarding in information interaction and lower energy consumption, we do not select CHs before transmission and we do select CHs in the transmission based on the comparison of the remaining energy; then, the nodes with much remaining energy become the CHs in the current round.

In this paper we investigate the clustering techniques that is based on energy consumption of nodes and region density, cluster size, network traffic, network subdivision, number of chains in cluster etc. It has been found that the load balancing can be used to expand the lifetime of a sensor network. Load balancing using clustering and chaining can also increase network scalability which is best for real time application. With respect to energy requirements, a more robust energy efficient multi-hop routing protocol is need for sensor networks.

VI. CONCLUSION

In this paper, we have examined the load balancing algorithms with respect to energy requirements. In wireless sensor network, energy is the most valuable resource. The algorithms surveyed in this paper offer a promising improvement over conventional algorithms. However, there is still much work to be done. Optimal clustering in terms of energy efficiency should eliminate all the overhead of cluster head selection process as well as cluster member selection process. Again re-clustering should be done efficiently to improve the network lifetime. The conclusion is that a load balance multi-hop routing is needed for sensor network.

REFERENCES

[1] S. K. Gupta, N. Jain, and P. Sinha, "Node degree based clustering for wsn," *International Journal of Computer Applications*, vol. 40, no. 16, pp. 49–55, 2012.

[2] G. Gupta and M. Younis, "Load-balanced clustering of wireless sensor networks," in *Communications, 2003. ICC'03. IEEE International Conference on*, vol. 3, pp. 1848–1852, IEEE, 2003.

[3] K. Sun, P. Peng, P. Ning, and C. Wang, "Secure distributed cluster formation in wireless sensor networks.," in *ACSAC*, pp. 131–140, 2006.

[4] B. Nazir and H. Hasbullah, "Energy balanced clustering in wireless sensor network," in *2010 International Symposium on Information Technology*, vol. 2, pp. 569–574, IEEE, 2010.

[5] S. K. Gupta, N. Jain, and P. Sinha, "A density control energy balanced clustering technique for randomly deployed wireless sensor network," in *2012 Ninth International Conference on Wireless and Optical Communications Networks (WOCN)*, pp. 1–5, IEEE, 2012.

[6] C. Wang, Y. Zhang, X. Wang, and Z. Zhang, "Hybrid multihop partition-based clustering routing protocol for wsns," *IEEE Sensors Letters*, vol. 2, no. 1, pp. 1–4, 2018.

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[7] F. Hu and X. Cao, *Wireless sensor networks: principles and practice*. CRC Press, 2010.
[8] L. Hoesel, L. Dal Pont, and P. J. M. Havinga, *Design of an autonomous decentralized MAC protocol for wireless sensor networks*. 2003.
[9] A. Moschitta and I. Neri, "Power consumption assessment in wireless sensor networks," in *ICT-energy-concepts towards zero-power information and communication technology*, IntechOpen, 2014.
[10] H. Zhang, L. Li, X.-f. Yan, and X. Li, "A load-balancing clustering algorithm of wsn for data gathering," in *Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC), 2011 2nd International Conference on*, pp. 915–918, IEEE, 2011.
[11] N. Israr and I. Awan, "Multi-hop clustering algo. for load balancing in wsn," *International Journal of SIMULATION*, vol. 8, no. 1, 2006.
[12] N. Kim, J. Heo, H. S. Kim, and W. H. Kwon, "Reconfiguration of clusterheads for load balancing in wireless sensor networks," *Computer Communications*, vol. 31, no. 1, pp. 153–159, 2008.
[13] E. László, K. Tornai, G. Treplán, and J. Levendovszky, "Novel load balancing scheduling algorithms for wireless sensor networks," in *The Fourth Int. Conf. on Communication Theory, Reliability, and Quality of Service, Budapest*, pp. 54–49, 2011.
[14] S. Ozdemir, "Secure load balancing via hierarchical data aggregation in heterogeneous sensor networks.," *J. Inf. Sci. Eng.*, vol. 25, no. 6, pp. 1691–1705, 2009.
[15] Y. Zhang, Z. Zheng, Y. Jin, and X. Wang, "Load-balanced algorithm in wireless sensor networks based on pruning mechanism," in *Communication Software and Networks, 2009. ICCSN'09. International Conference on*, pp. 604–606, IEEE, 2009.
[16] M. Mahdavi, M. Ismail, and K. Jumari, "Load balancing in energy efficient connected coverage wireless sensor network," in *2009 International Conference on Electrical Engineering and Informatics*, vol. 2, pp. 448–452, IEEE, 2009.
[17] C. Canci, V. Trifa, and A. Martinoli, "Threshold based algo. for power aware load balancing in sensor networks," *IEEE Transaction, 0-7803-8916-6/05*, 2005.
[18] C. P. Low, C. Fang, J. M. Ng, and Y. H. Ang, "Load-balanced clustering algorithms for wireless sensor networks," in *2007 IEEE International Conference on Communications*, pp. 3485–3490, IEEE, 2007.
[19] M. Ma and Y. Yang, "Clustering and load balancing in hybrid sensor networks with mobile cluster heads," in *Proceedings of the 3rd international conference on Quality of service in heterogeneous wired/wireless networks*, p. 16, ACM, 2006.
[20] Y. Deng and Y. Hu, "A load balance clustering algorithm for heterogeneous wireless sensor networks," in *E-Product E-Service and E-Entertainment (ICEEE), 2010 International Conference on*, pp. 1–4, IEEE, 2010.
[21] M. Zeynali, L. M. Khanli, and A. Mollanejad, "Fuzzy based approach for load balanced distributing database on sensor networks," *International Journal of Future Generation Communication & Networking*, vol. 3, no. 2, 2010.
[22] Y. Kavian *et al.*, "A load-balanced energy efficient clustering protocol for wireless sensor networks," *IET Wireless Sensor Systems*, 2016.
[23] H.-Y. Kim, "An energy-efficient load balancing scheme to extend lifetime in wireless sensor networks," *Cluster Computing*, vol. 19, no. 1, pp. 279–283, 2016.
[24] V. Pal, G. Singh, and R. Yadav, "Balanced cluster size solution to extend lifetime of wireless sensor networks," *IEEE Internet of Things Journal*, vol. 2, no. 5, pp. 399–401, 2015.
[25] D. R. Gaurang and R. S. Ankit, "Load balancing to extend life of wireless sensor network," in *Computing Communication Control and Automation (ICCUBEA), 2015 International Conference on*, pp. 334–337, IEEE, 2015.
[26] D. Wajgi and N. V. Thakur, "Load balancing based approach to improve lifetime of wireless sensor network," *International Journal of Wireless & Mobile Networks*, vol. 4, no. 4, p. 155, 2012.
[27] M. A. Abd, S. F. M. Al-Rubeaai, B. K. Singh, K. E. Tepe, and R. Benlamri, "Extending wireless sensor network lifetime with global energy balance," *IEEE Sensors Journal*, vol. 15, no. 9, pp. 5053–5063, 2015.