Young Scientist- Tomorrow's Science Begins Today
Vol. 1, Issue – 2015
ISSN: 2581-4737

IMPROVEMENT IN LEACH PROTOCOL USING SWARM INTELLIGENCE OPTIMIZATION

AMIT DIXIT, CHANDAN BAJPAI

ABSTRACT

Popularity of wireless sensor networks (WSNs) is increasing incessantly in diverse domains of daily life, because they endow with efficient process of collecting valuable data from the environs for use in different applications. Routing in WSNs is the very important functionality that permits the flow of information generated with sensor nodes to the base station, while considering the severe energy restraint and the limitations of computational and storage resources.

KEYWORDS: Wireless sensor networks, Hierarchical routing protocols, Swarm intelligence.

INTRODUCTION

OVERVIEW OF WSN

Wireless Sensor Networks (WSNs) have been widely considered as one of the most important technologies for the twenty-first century [1]. Enabled by recent advances in microelectronic mechanical systems (MEMS) and wireless communication technologies, tiny, cheap, and smart sensors deployed in a physical area and networked through wireless links and the Internet provide unprecedented opportunities for a variety of civilian and military applications, for example, environmental monitoring, battle field surveillance, and industry process control [2] . Distinguished from traditional wireless communication networks, for example, cellular systems and mobile ad hoc networks (MANET), WSNs have unique characteristics, for example, denser level of node deployment, higher unreliability of sensor nodes, and severe energy, computation, and storage constraints [3], which present many new challenges in the development and application of WSNs. In the past decade, WSNs have received tremendous attention from both academia and industry all over the world. A large amount of research activities have been carried out to explore and solve various design and application issues, and signify cant advances have been made in the development and deployment of WSNs. It is envisioned that in the near future WSNs will be widely used in various civilian and military fields, and revolutionize the way we live, work, and interact with the physical world [4]. WSNs consist of large number of sensor nodes which are small in size, inexpensive and battery powered. These WSNs can be used in various applications such as Military surveillance, environment monitoring, border protection, health care monitoring, weather monitoring. These applications require data without delay and energy consumed by them should be small.

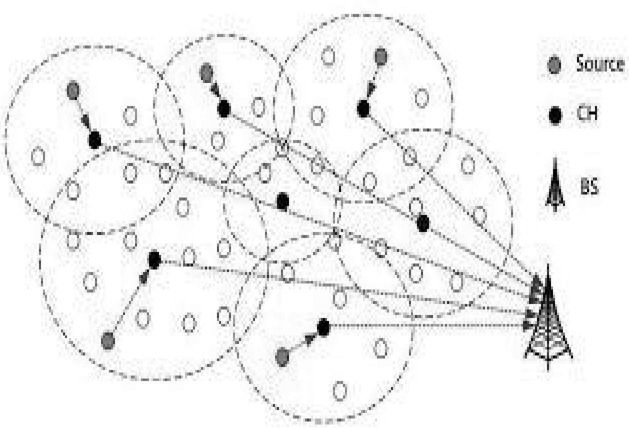


Figure 1.Wireless Sensor Network

WSNs are deployed in harsh environment. Since it is not possible to replace or charge battery of sensor nodes, so it is desirable to design communication protocols such that energy source is used effectively and the delay in the network in minimum. Sensor nodes senses the environment, gathers the data from its surrounding(computation) and communicates it to the base station(BS) .Out of the three tasks communication takes large amount of battery power of a sensor node, so the major concern is the communication task. We have to minimize the communication cost in order to save battery power. Wireless sensor networks [3] consists of thousands of sensor nodes which are deployed randomly environment or space. In sensor network there is a BS (base station) which is located far away from the sensor field. Sensor nodes send the sensed data to the B.S.For. sending the sensed data to BS directly a lot of energy is consumed. So it is desirable to develop some protocols to minimize this communication cost. Energy conservation and maximization of network lifetime are the key challenges in the design and implementation of WSNs.

APPLICATIONS OF WSN

WSNs were designed to perform high level information processing task. Sensor nodes are deployed in harsh environment .Sensor nodes senses the environmental conditions such as temperature, pressure etc. and then it sends the sensed data to the BS. Application of sensor networks is very vast. Some of the applications of sensor networks are:

- Environmental conditions monitoring: It include sensing volcano, oceans glaciers, forest.
- Industrial monitoring: It includes Machine health monitoring, Factory.
- Agriculture: Irrigation management, green houses.
- Battlefield awareness.

Challenges in WSN

The design of a sensor network is influenced by many factors, such as its characteristics and other physical constraints. Here, we highlight some of the issues that must be taken into

ISSN: 2581-4737

consideration when designing protocols for use in wireless sensor networks.

- **Self-Configuration and Self-Maintenance:** One of the main rationales for deploying sensor networks is to enable remote sensing with minimal human intervention. In addition, sensor networks are usually randomly deployed in hostile terrains in large numbers. As such, it is almost impossible to manually configure each and every one of the sensor nodes; these nodes must thus be equipped with self-configuration and self-maintenance capabilities.
- **Scalability:** As sensor nodes are often deployed in large numbers over very large physical terrains, protocols for sensor networks must be able to scale; the performance of the network must not deteriorate significantly even if the number of nodes in the network increases.
- **Energy Efficiency:** Sensor nodes expend energy during data sensing and communication with the other nodes in the network.

When the energy of a node depreciates, the node will die and this may cause the network to become partitioned-a situation whereby communication gaps exist in the network such that some nodes may be unable to communicate with each other. The presence of network partitions will usually render a sensor network useless, because some parts of the network will no longer be under coverage; hence, some researchers consider that the sensor network lifetime has expired when the network becomes partitioned. Sensor network protocols must therefore be energy-efficient so as to extend the network lifetime and usefulness of the network [7].

- **Fault Tolerance***:* Due to the limited energy of then odes, as well as harshness and hostility of the environment in which the nodes are deployed in, the sensor nodes are prone to failures. With fault tolerance, the sensor network should be able to continue with its network functionalities (such as sensing and communication) even in the presence of node failures. This helps to increase the robustness of the sensor network and improves its QoS delivery to the applications.
- **Adaptability:** The network topology and characteristics of a sensor node may be quite dynamic due to the influence of the physical environment that the network is deployed in. As such, the sensor network should demonstrate adaptability to the prevailing network conditions and physical environment in order to provide good network performance.
- **Security:** The openness of the physical environment and the transmission media subjects sensor networks to a multitude of security attacks ranging from Denial of Service (DoS) to malicious attempts to modify sensitive data information. Consequently, it is quintessential to ensure that sensor networks incorporate security mechanisms into their protocols to protect the integrity of the data collected.

HIERARCHICAL ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS

Nowadays researchers are working towards the energy efficient routing protocol. Hierarchical routing protocols are the most energy efficient among rest of the protocols for WSNs this is the one of the optimal solutions to cope up the requirements of large scale WSNs. In hierarchical routing protocol, network is divided into clusters and cluster head is assigned to each cluster. These cluster heads are higher energy nodes, which aggregate, process and transmit the information to the BS, while the lower energy nodes used to sense the targeted area and send the data to CH. Hierarchical routing is an efficient way to reduce the total energy consumption of the network. Data aggregation and processing in the CH greatly reduce total number of sent messages to the BS. Actually, the goal of developing hierarchical routing protocol is to minimize the network traffic towards the base station. Generally, security issue in Hierarchical routing protocol have not given much attention, since most of the routing protocol in WSNs have not been developed with security in mind. Many hierarchical routing protocols have been developed, where energy efficiency is the main goal.

HIERARCHICAL ROUTING PROTOCOLS

- **LEACH Protocol:** LEACH is a cluster-based protocol, which includes distributed cluster formation. LEACH randomly selects a few sensor nodes as cluster heads (CHs) and rotates this role to evenly distribute the energy load among the sensors in the network. In LEACH, the CH nodes compress data arriving from nodes that belong to the respective cluster, and send an aggregated packet to the BS in order to reduce the amount of information that must be transmitted to the BS.
- **PEGASIS Protocol:** Power-Efficient Gathering in Sensor Information Systems (PEGASIS), is a near optimal chain-based protocol. The basic idea of the protocol is that in order to extend network life-time, nodes need only communicate with their closest neighbors, and they take turns in communicating with the BS. When the round of all nodes communicating with the BS ends, a new round starts, and so on. This reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes. Hence, PEGASIS has two main objectives. First, increase the lifetime of each node by using collaborative techniques. Second, allow only local coordination between nodes that are close together so that the bandwidth consumed in communication is reduced.
- **Threshold-Sensitive Energy Efficient Protocols:** Two hierarchical routing protocols called Threshold-Sensitive Energy Efficient Sensor Network Protocol (TEEN) and Adaptive Periodic TEEN. These protocols were proposed for time-critical applications. In TEEN, sensor nodes sense the medium continuously, but data transmission is done less frequently. A CH sensor sends its members a hard threshold, which is the thresh-old value of the sensed attribute, and a soft threshold, which is a small change in the value of the sensed attribute that triggers the node to switch on its transmitter and transmit. Thus, the hard threshold tries to reduce the number of transmissions by allowing the nodes to transmit only when the sensed attribute is in the range of interest. The soft threshold further reduces the number of transmissions that might otherwise occur when there is little or no change in the sensed attribute.

PROBLEM STATEMENT

Wireless sensor networks (WSNs) have appeared as one of the emerging technologies that combine automated sensing, embedded computing and wireless networking into tiny embedded devices. LEACH (Low Energy Adaptive Clustering Hierarchy) is a classic clustering algorithm, which is widely used in wireless sensor networks. LEACH randomly selects cluster head node circularly to balance energy of each sensor node in the whole network. In the original LEACH algorithm, it only manages cluster-head nodes by taking classification of cluster, and cluster-head nodes can consume energy in the process of data transmission between cluster and base station. Due to the random cluster head selection process, LEACH does not guarantee the optimization for the number and position of cluster heads [1]. Because cluster-head nodes in wireless sensor networks may be far away from the base station, or there exists many obstacles in deployment environments of wireless sensor networks to affect the data transmission performance, they would consume excessive energy in the process of the massive data transmission, which may lead to their earlier death and even shorten network lifetime [2]. System lifetime is one of the most important design factors in wireless sensor network [3-8]. So, how to optimize the number of clusters is an essential problem in wireless sensor networks.

RESEARCH GAPS

MODLEACH minimize network energy consumption by efficient cluster head replacement after very first round and dual transmitting power levels for intra cluster and cluster head to base station communication. In MODLEACH, a cluster head will only be replaced when its energy falls below certain threshold minimizing routing load of protocol. Hence, cluster head replacement procedure involves residual energy of cluster head at the start of each round. Further, soft and hard thresholds are implemented on MODLEACH [16]. During cluster formation in MODLEACH individual nodes can become a member of any cluster during next cluster formation and some other node may become as individual nodes. Though the percentage of individual nodes varies from one time slot to other, it is a major drawback while considering the network lifetime. Such nodes may die earlier as it has to transmit the sensed data either directly to the Base station or after finding the best next hop, this may leads to data lost or consumes more energy by sending many control messages. These individual nodes in WSN are eliminated by using Particle Swarm Optimization in the proposed work [17].

BASIC METHODOLOGY

The basic motivation to the proposed approach is to improve various QoS parameter to make or sensor node work well in stipulated environment. For this a two stage parameter analysis system for WSN is imposed. In the first stage, various existing routing protocol are analyzed along with different QoS parameters. Second stage confirms the deviation that, it is due to implementing minimum distance between two Cluster Heads by applying Multiple Particle Swarm Optimization based Clustering by Preventing Residual Nodes in Wireless Sensor Networks in LEACH protocol.

ISSN: 2581-4737

TECHNIQUE AND TOOLS FOR DATA COLLECTION & ANALYSIS

Swarm Intelligence: Particle Swarm Optimization (PSO) can be referred to as a random optimization technique based on population and was devised by Kennedy and Eberhart in 1995 [18]. They have developed PSO through the inspiration of social behavior of fish schooling or bird flocking. They have demonstrated a solution to a problem of complex non-linear optimization by means of imitating the bird flocks' behavior. Also they have devised the function-optimization concept from a specific swarm.

PSO can be referred as a computational technique that optimizes an issue by using a series of iterations attempting to enhance a candidate solution regarding given quality measure or application. PSO generally optimizes an issue based on candidate population in the search-space in conformity with the mathematical formula. PSO encompasses swarm of particles. In general, each and every particle occupies position in the search space. The position's quality is generally being demonstrated by the fitness of each particle.

PSO is generally initialized with a random particles' group and in turn explores for optimal solution by means of updating generations [19]. This is shown in Fig. 2. In the context of iterations, every particle is being updated by the maximum values. In which the first maximum value can be referred to as the fitness i.e. the best solution accomplished so far and is known as p best. The second "best" value could be tracked by means of the particle swarm optimizer and is the best value found so far in the whole swarm population and it could be referred to as g best i.e. global best. Likewise, when a particle assumes in the population of swarm as its topological neighbours, it could be known as l best i.e. local best

PREDICTION OF NUMBER OF CLUSTERS IN THE NETWORK

Let (X, Y) be the sensing region and r be the coverage of any sensor node. Figure shows a sample sensor network. It is divided into smaller portions called cluster with radius r.

Let (x,y) be the coordinates of a cluster in a sensing region. The total Number of Clusters formed NC can be calculated based on the whole network area and size of a cluster.

$NC = XY / xy$ where,

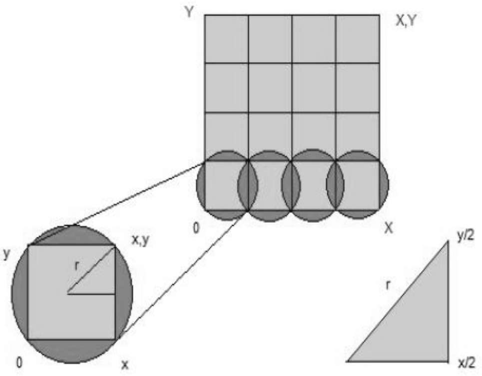
XY be the network area and xy be the area of the cluster Let the value of $x=y=t$

Eq. 3 can be written as: $NC = XY / t^2$

From the right angled triangle shown in Fig , the value of r can be written as,

$r = t / \sqrt{2}$

So the total number of clusters formed can be given as, $NC = XY / 2r^2$



This is for the lower bound. The same value is calculated for the upper bound region also. Equation 6 is used for calculating the number of clusters formed in upper bound as,

NC = {(XY / xy) +(X / x) + (Y / y)}

If x=y=t, & X=Y, t=r√2, the above equation becomes, NCAvg = $\{(X^2 + 2\sqrt{2}x*r)/2r^2\}$ and to choose the Cluster Head it uses fitness value of each node which depends upon various parameters such as:

- Energy of the particle or node EN
- Energy of particles or sensors with in a radio range from a particular particle (p)
- Distance of those particles within the radio range from a particular particle (p)

PSO ALGORITHM

- Initialize S particles to contain K randomly selected cluster heads among the eligible cluster head candidates.
- Evaluate the cost function of each node:
    - ➢ For each node ni, i = 1,2,…,N
        - ▪ Calculate distance d (ni,CHp,k) between node ni and all cluster heads CHp, k.
        - ▪ Assign node ni to cluster head CHp, k where;
    - ➢ Calculate the cost function using equations cost = β * f1 + (1- β) f...............................
- Find the personal and global best for each node.
- Map the new updated position with the closest (x,y) coordinates.
- Repeat steps 2 to 4 until the maximum number of iterations is reached

MOD LEACH

LEACH protocol changes the cluster head at every round and once a cluster head is formed, it will not get another chance for next 1/p rounds. For every round, cluster heads are replaced and whole cluster formation process is undertaken. in this protocol, modify LEACH by introducing "efficient cluster head replacement scheme". It is a threshold in cluster head formation for very

ISSN: 2581-4737

next round. If existing cluster has not spent much energy during its tenure and has more energy than required threshold, it will remain cluster head for the next round as well. This is how, energy wasted in routing packets for new cluster head and cluster formation can be saved. If cluster head has less energy than required threshold, it will be replaced according to LEACH algorithm.

CONCLUSION

In this article, we are presented the improvement in LEACH Protocol using Swarm Intelligence Optimization. Because LEACH protocol does not guarantee the optimization for the number and position of cluster head. The Swarm Intelligence Optimization technique is presented in this article which improved the LEACH protocol.

REFERENCES

1. Vinay Kumar, Sanjeev Jain, Sudarshan Tiwari, "Energy efficient clustering algorithm in Wireless Sensor Network: A survey" International Journal of Computer Science, (2011), Vol. 8, No. 05, pp 259-268.
2. R. Sumati, R.Srinivasan, "QoS aware Routing for End-to-End Reliability of Delay Sensitive Events in Wireless Sensor Networks" ACM (2009).
3. Rob Hoes, Twan Basten, Chen-KhongTham, Marc Geilen and Hank Corporaal, "Analysis QoS Trade-offs in Wireless Sensor Networks", ACM International Symposium on Modeling, Analysis and Simulation of Wireless and Mobile Systems, (2007) pp 60-69.
4. Trong Thua Huyuh, Anh-vu Dinh-Due, Cong Hung Tran, "Balancing Latency and energy efficiency in wireless sensor networks: A Comparative Study", IEEE International Conference on Computing, Management and Telecommunication (2013), pp 181-186.
5. Deepak Goyal, Malay Ranjan Tripathy, "Routing Protocols in Wireless Sensor Networks: A Survey", IEEE International Conference on Advanced Computing & Communication Technologies (2012), pp 474-480.
6. Feilong Tang, Ilsun You, Song Guo, Minyi Guo, Yonggong Ma, "A chain-cluster based routing algorithm for Wireless Sensor Networks", Journal of Intelligent Manufacturing (2012), Vol.23, No. 24, pp 1305-1313.
7. Sudhir G. Akojwar, Rajendra M. Patrikar, "Improving Life Time of Wireless Sensor Networks using Neural Network Based Classification Technique with cooperative routing", International Journal of Communication (2008), Vol. 2, No. 1, pp 75-86.
8. Jamal N. Al -Karaki, Ahmad E Kamal "Routing Techniques in Wireless Sensor Networks: A Survey", IEEE Wireless Communications (2014).
9. Somia Sahraoui, Souheila Bouam "Secure Routing Optimization in Hierarchical Cluster-Based Wireless Sensor Networks", International Journal of Communication Networks and Information Security (2013), Vol. 5, No. 3, pp 178-185.
10. Nojeong Heo, Varshney P.K, "Energy efficient deployment of Intelligent Mobile Sensor Networks", IEEE Transaction on Systems, Man and Cybernetics (2005) Vol. 35, No. 1, pp

78-92.
11. Xiaohri Chen, Liu Du, Yuanyuan Fu, "Wireless Sensor Networks: A Survey", ACM The International Journal of Computer and Telecommunications Networking (2002), Vol. 38, No. 4, pp 393-422.
12. Sumaiya Begum D, Nithya R, Prasanth K,, "Energy Efficient Hierarchical Cluster Based Routing Protocols In WSN-A Survey",-International Journal for Innovative Research in Science & Technology Volume 1(Issue 7) December 2014 ISSN (online): 2349-6010, pp 261-266.
13. Xue Wang, Sheng Wang, and Daowei Bi, "Dynamic Sensor Nodes Selection Strategy for Wireless Sensor Networks", IEEE International Symposium on Communications and Information Technologies, (ISCIT'07), pp 1137-1142.
14. Suraj Sharma, Sanjay Kumar Jena, "A Survey on Secure Hierarchical Routing Protocols in Wireless Sensor Networks", ICCCS'11 February 12-14, 2011 pp 146-151.
15. Parminder Kaur, Mrs. Mamta Katiyar, "The Energy-Efficient Hierarchical Routing Protocols for WSN: A Review" International Journal of Advanced Research in Computer Science and Software Engineering, Volume 2, Issue 11, November 2012 ISSN: 2277 128X, pp 194-199.
16. D. Mahmood, N. Javaid, S. Mahmood, S. Qureshi, A. M. Memon, T. Zaman "MODLEACH: A Variant of LEACH for WSNs" July 2013.
17. Rejina Parvin , Vasanthanayaki C "Particle Swarm Optimization based Clustering by Preventing Residual Nodes in Wireless Sensor Networks" DOI 10.1109/JSEN. 2015.2416208, IEEE Sensors Journal 2015 p 1-11.
18. J. Kennedy, and R.C. Eberhart, "Particle Swarm Optimization," in Proc IEEE International Conference on Neural Networks, NJ: Piscataway, pp.1942-1948, 1995.
19. Raghavendra V. Kulkarni, and Ganesh Kumar Venayagamoorthy, "Particle Swarm Optimization in Wireless-Sensor Networks: A Brief Survey IEEE Trans. on Systems, Man, and Cybernetics-Part C: Applications and Reviews, vol. 41, no. 2, pp. 262-267, Mar. 2011.

