International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

Energy Optimization in Wireless Sensor Network using Clustering and PSO Algorithm

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Abstract - *Wireless Sensor network is used nowadays almost everywhere. A sensor node, in a sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. A Sensor is a device that responds and detects some type of input from both the physical or environmental conditions, such as pressure, heat, light, etc. The output of the sensor is generally an electrical signal that is transmitted to a controller for further processing. Wireless Sensor Network (WSN) is a self-organizing network which formed with huge sensors which are located in an application specific environment to monitor the physical pheromone like temperature, fire, and pressure. Mostly sensors are equipped with battery power through which they can perform sufficient operations and communication among neighboring nodes. Researchers for WSNs face challenge that arises from limited energy. Maximizing the lifetime of the WSN, energy conservation measures are essential for improving the performance of WSNs. Particle Swarm Optimization (PSO) is used to form clustering and select cluster head with respect to minimizing the power consumption in WSN.*

Key Words: Sensor node, Wireless Sensor Network, Controller, Particle Swarm Optimization, clustering, power consumption.

I. INTRODUCTION

In recent years, with the rapid development of wireless technology, sensors are receiving important attention, which leads to the emergence of directional sensor network. Wireless Sensor Network (WSN) is a self-organized network with huge, intelligent and small sensors. These sensors can perform the data transmission among themselves within their radio range and also they are organized in a way to sense, observe and recognize the physical entity of the real world. WSNs integrate into the environment, machinery and human, coupled with the efficient delivery of sensed information, could deliver tremendous benefits to society. Some of the potential benefits are reinforced emergency response, preservation of natural resources, improved homeland security and enhanced manufacturing productivity. The significance of sensor networks have low energy consumption, sufficient intelligence for signal processing, low cost, self-organizing capability, data gathering and querying ability. Wireless sensor is equipped with a radio transceiver, a microcontroller, an interfacing electronic circuit and an energy source usually a battery. The features of these sensors include tiny, low cost, low computation power, multifunctional and easy communication within short distances. WSN consist of intelligent sensors, which has been arranged and installed based on the applications and a sink that is located very near to or within the radio range. The sink transmits the queries to the neighboring sensors which perform the sensing task and return the data to the sink as a response to the transmitted query. In WSN nodes utilized is balanced amount of energy for communication and the required energy in terms of battery power to transmit the packet will differ among the transmissions with respect to the distance between the sender and receiver nodes; therefore multi-hop communication is recommended. Data transmission using hierarchical routing which increases the lifetime of the sensor network by grouping a number of nodes into clusters. Then a high residual energy node is selected for each cluster known as cluster head to collect the data from its members and transmit to the sink with a minimum cost of multi-hop transmission. Extended network lifetime, reliable data transfer, energy conservation in sensors and scalability are the main necessities for WSN applications. Because of the several limitations in the sensors, WSN is having various issues such as coverage area, network lifetime and dynamic topology and data aggregation.

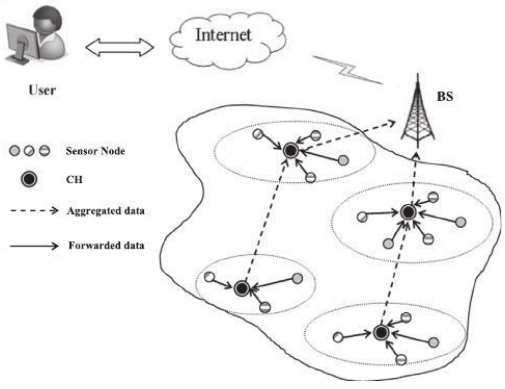

Fig.1. A clustered wireless sensor network

Clustering sensor nodes is one of the most effective techniques for the energy conservation of the sensor nodes. In the clustering process, the entire network is divided into several groups, called clusters. Each cluster has one leader node called as cluster head (CH). CHs are responsible to collect the local data from their member sensor nodes within the clusters, aggregate them and send it to a remote base station (BS) directly or through other CHs. The BS is connected to a public network such as Internet. The functionality of cluster based WSN model for communication between the target area and user via internet.

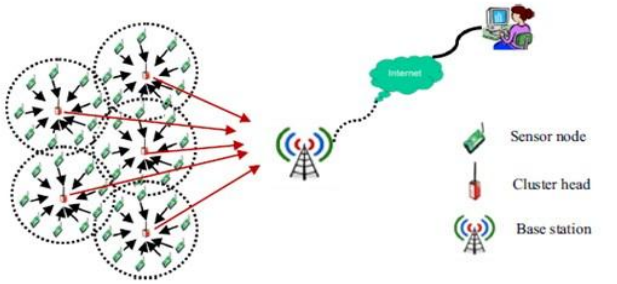

Fig2: Cluster based WSN model.

1.1.2 Wireless Sensor Network requirements

There are a few requirements that apply to most sensor network applications:

- Lifetime: it is desirable to prolong the lifetime of the network because sensor are not accessible after deployment.
- Network size: in most applications a larger network is of interest as it cover more area and therefore monitors more events.
- Minimize faults: a faulty network uses resources to generate incomplete data. At the sensor level, it means the monitoring of the environment is broken an many events may be missed. In transmission to the sink, it means packet loss is high; in both cases, the knowledge of the environment is incomplete and therefore the gathered data is not reliable. i.e. reliable collective event-to-sink is important in WSNs.

1.1.3 Routing Challenges In Wireless Sensor Networks

WSN is used in many applications. In these applications, nodes may be of heterogeneous or homogeneous or it may be mobile nodes, number of nodes deployed may be varied etc. In order to meet these criteria, the following important design issues of the sensor network have to be considered.There are various challenges which affect the wireless sensor network (WSN) these are:

1. Node deployment: Node placement in WSNs is application-dependent and can be whichever manual or randomized. In manual placement, the sensors are manually allocated and data is routed across predetermined paths. Though, in random node placement, the sensor nodes are dispersed randomly, crafting an ad hoc routing infrastructure. The node deployment in WSN should in such way that the communication between nodes never failed. So to maintain the proper communication between these nodes an excellent routing protocol is required.
2. Fault tolerance: Some sensor nodes could block due to lack of domination, physical damage, or environmental interference. Individual nodes are liable to unexpected failure with a much higher probability when compared with other type of network. The network should keep alive information dissemination in spite of failure.
3. Scalability: Sensor network is made up hundreds or thousands of nodes. The designed Protocol should be able to work to such high degree of nodes and take advantage of such high density of networks. So the routing protocol should not limit with the fixed nodes. But it should operate with large number of node and should be varies with the network size.
4. Coverage: In WSNs, every single sensor node obtains a precise think of the environment. A given sensors think of the nature is manipulated in both scope and accuracy; it can only cover a manipulated physical distance of the environment. Hence, distance coverage is additionally a vital design parameter in WSNs.
5. Power consumption: WSN is made up of thousands of nodes and these nodes are energy restricted and cannot replaceable and rechargeable. WSN lifetime depends on these nodes energy and every nodes operation consumed some energy. So an efficient energy consumption by the node is the main design issue in WSN.
6. Transmission media: In WSN the sensor nodes are wirelessly connected to each other so it is very important to maintain wireless connection between them. In WSNs transmission medium between sensor nodes is radio waves or infrared waves. The communication medium between these sensor nodes should be universally presents, it should not bound with any standards and should not require any license to operate.
7. Data Aggregation/Fusion: Data aggregation is the process of gathering of data from different sources at certain point and combined it by a certain aggregation function like suppression, min, max etc.

II. RELATED WORK

The common operation of cluster-based protocol can be understood with the help of the following phases. In cluster formation phase, Cluster Head (CH) election takes place in a random manner. Once the CH election is performed, each CH broadcast an advertisement message to all the sensors, which are in the transmission range of a particular CH receives the message. The sensors or cluster nodes which then send a reply message with request message to join under the particular CH. In information processing phase, each sensor involves in sensing the attributes depending on the application. The sensed data from each node is transmitted to their respective CH. Once CHs receive the sensed data, it performs data aggregation and this process is repeated periodically. In data dissemination phase, each CH transmits the aggregated data to the sink based on the data dissemination interval. PSO is a popular choice for WSN clustering because its optimization algorithm is simpler and the network efficiency is better. By using PSO for clustering, let us consider a sample space and deploy the particles or sensors in it. Let be the number of particles considered in the sample space. Particles are created by considering two parameters namely, position and velocity. Once the sensors are deployed in the sensor field, the sink broadcasts a request message to all the sensors in the network to collect the node's information. This in turn sends reply message to the sink which contains: position, velocity and energy of the sensor. These values are maintained and updated at the sink. Then the sink makes the sensors to perform clustering. Cluster formation is performed using PSO by allowing each sensor to find the nearest neighbor within its radio range. Likewise all the sensors in WSN are allowed to form clustering, it become a part of any of the clustering. In WSN, energy efficient routing protocols should be designed in an efficient manner in order to improve the network lifetime. The network lifetime is measured by the effective usage of the sensor in the network. Sensor in the sensing region is used to perform sensing, processing and communication. The overall network lifetime is based on the above said factors. The network lifetime can be improved by avoiding the sensor to transmit raw data. This can be achieved by aggregating the sensed data to eliminate the data redundancies, eliminating the control overhead messages and avoiding the long distance transmission. If a network is constructed by considering the above said factors, the overall network lifetime can be improved. In this section, various energy optimization using PSO based on clustering algorithms for WSN was discussed, which aims to extend network lifetime.

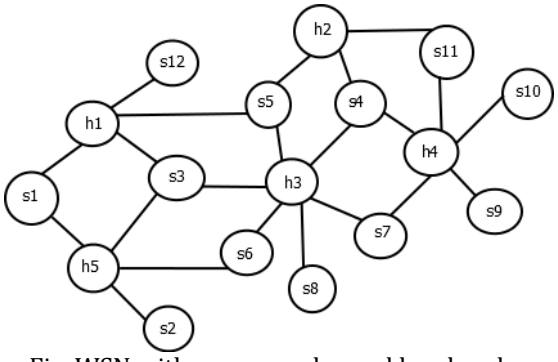

Fig .WSN with sensor nodes and head nodes

III. PROPOSED SYSTEM

Network Model: Network setup is completed in three stages: bootstrapping, route setup, clustering. During bootstrapping procedure, the entire nodes and heads are allotted unique IDs. The sensor nodes are placed in 100 × 100 m area in grid format. All the placed nodes will perform both transmission and gathering of data (messages) . Every sensor node will send the information to CH or a cluster member and further, CHs process the information and send the processed information to the base station (BS). The base station decides the CH for every round based on the clustering algorithm. The CH is responsible for data aggregation and communication.

Energy Model: In WSNs, the CHs selection depends on the fitness function. In this work, a new fitness function is designed for CHs selection. This function comprises the two-important aspect of WSNs i.e. the energy consumption between CH and sensor nodes and the amount of energy consumption for aggregating the data at CHs level plus transmitting the information to BS. Whenever a node sends or receives sensed information it has to spend some energy called free space (power loss) for the purpose of one-hop or direct transmission and the multipath fading channel (power loss) for packet transmission via multihop.

IV. Particle Swarm Optimization [PSO]

The PSO algorithm is an evolutionary computing technique, modeled after the social behavior of a flock of birds. In the context of PSO, a swarm refers to a number of potential solutions to the optimization problem, where each potential solution is referred to as a particle. The aim of the Particle Swarm Optimization is to find the particle position that results in the best evaluation of a given fitness function. In the initialization process of Particle Swarm Optimization, each particle is given initial parameters randomly and is „flown" through the multi-dimensional search space. The during each generation, each particle uses the information about its previous best individual position and global best position to maximize the probability of moving towards a better solution space that will result in a better fitness. When a fitness better than the individual best

fitness is found, it will be used to replace the individual best fitness and update its candidate

Clustering is an NP-hard optimization problem and is used for several effective energy protocols in WSN. The common operation of cluster-based protocol can be understood with the help of the following phases. In cluster formation phase, Cluster Head (CH) election takes place in a random manner. Once the CH election is performed, each CH broadcast an advertisement message toall the sensors, which arein the transmission range of a particular CH receives the message. The sensors or cluster nodes which then send a reply message with request message to join under the particular CH. In information processing phase, each sensor involves in sensing the attributes depending on the application. The sensed data from each node is transmitted to their respective CH. Once CHs receive the sensed data, it performs data aggregation and this process is repeated periodically. In data dissemination phase, each CH transmits the aggregated data to the sink based on the data dissemination interval. PSO is a popular choice for WSN clustering because its optimization algorithm is simpler and the network efficiency is better. By using PSO for clustering, let us consider a sample space and deploy the particles or sensors in it. Let be the number of particles considered in the sample space.

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V. CONCLUSION

Today, Wireless Sensor Networks (WSN's) are used at various places such as forest fire detecting system, natural disaster alert system, area monitoring, and health care system. Numbers of clustering algorithms have been developed to improve the energy balance of the WSN's because energy is the main aspect of WSN's during data transmission. These algorithms are mainly used for increasing the lifetime of these sensor networks. This paper suggests an algorithm based on Particle Swarm Optimization (PSO) technique for improving network life time. It helps in forming the clusters as well as the Cluster Head (CH) selection. From the current rate of growth of PSO-based applications, it is envisioned that PSO will continue as an important optimization technique in the field of WSNs.

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