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Simulation of Forest Fire Detection in Wireless Sensor Networks

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Abstract: *A Wireless Sensor Network (WSN) is a gathering of tiny sensor nodes with sensing computation and communication capabilities. The sensor nodes are randomly placed in distributed environment. The main goal of this paper is to form clusters of sensor nodes and perform Data Aggregation to collect the data by maintaining the energy efficiency so that the network lifetime can be increased enormously. Network lifetime is an important issue in an energy constrained sensor networks. Expectation-maximization (EM) algorithm and Neighbourhood density based clustering algorithm is used for clustering of nodes and Directed Diffusion method is used for aggregating the data. One of the major drawback in directed diffusion is the enactment of flooding diffusion which is used for discovering the routing map that leads to the decrease in the reduction of network lifetime and data latency through high energy consumption.*

Keywords: *Expectation Maximization, Directed Diffusion, Gaussian mixture model*

I. INTRODUCTION

With the advancement in modern technologies in wireless communications, processor, memory, radio, low power, highly integrated digital electronics, it becomes possible to significantly develop small size, low power, and less expensive multi-functional sensor nodes. Big data constitutes of high volume, high velocity, and high variety information assets [6] [7], which has to be grouped, retained and processes the data using the sufficient technologies Wireless sensor networks (WSNs) have been used for various applications and placed in many areas like vital signal monitoring in the homecare systems like analysing patients health, ecology sensing which are widely used for monitoring wild-life, micro-organisms, changes in the water bodies, soil surfaces during natural disasters like typhoon, tsunami, flood and soil erosion, monitoring climatic factors like temperature, structural monitoring like monitoring the conditions of a bridge after its construction, monitoring the historic monument, military surveillance, facility monitoring and environment monitoring[1,2,3]. Typically WSNs consists of huge number of sensor nodes with the ability to interact among themselves and also to an mobile sink node or base station.

In this model, base station are considered as static one where the mobile sink node travel across each clusters of nodes to gather the sensed data. The sensors could be distributed uniformly in environments such as a battlefield or progressively placed at some locations as specified by the sensors. The sensor nodes are grouped to form clusters based on clustering techniques and specialized algorithm. The sensors initiate among themselves to form a communication network such as a single multi-hop network. Otherwise the hierarchical organization with several clusters and cluster heads communication network is also formed. The sensors that occur frequently sense the data process it and transmit it to the mobile sink node. These sensor nodes can interact within clusters and associated to form a common task. The sensor nodes are energy constrained, therefore it is not that much efficient for all the sensor nodes to transmit the sensed data directly to the mobile sink node. Data that are sensed and gathered by the sensor nodes which are

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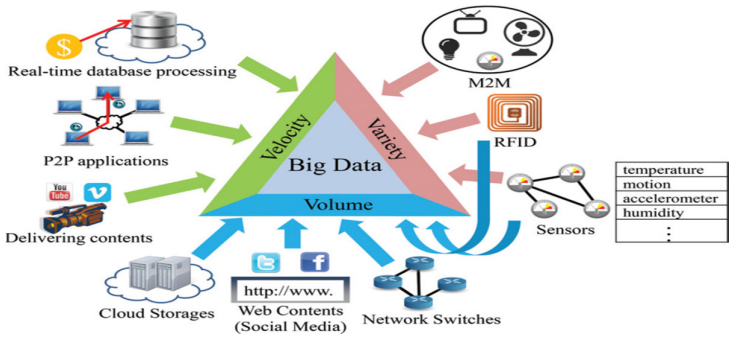
nearer to each other is expendable. Hence, there is a need for a method which merges the data from variety of sensor nodes and decreases the number of packets to be transmitted to the mobile sink node. Wireless sensor nodes needs less power for processing the data than compared to data transmission. This results in the storage of energy consumption and increase in the network lifetime rapidly. Data aggregation involves the fusion of data from different kinds of sensors at intermediate nodes and data is transmitted to the mobile sink node. Since sensor nodes may contain unnecessary data packets from multiple nodes can be combined so that the number of transmissions is reduced to a certain level. This can be implemented by data aggregation techniques. The cluster centroid attempts to gather the critical data from the nearest and intermediate sensor nodes and make it sufficient to the mobile sink node in an energy efficient manner with reduced data latency.



II. Clustering Based Data Aggregation in WSN

In this section, we figure out the clustering and data aggregation problem in wireless sensor networks and contemplation network system in WSN. The outline of EM algorithm for clustering and directed diffusion for data gathering is examined. Based on EM algorithm, we initiate our clustering method and the gathering of data procedures in WSN

A. Clustering Problem

When data gathering scheme is implemented in WSN using mobile sink, the main goal is to minimize the energy obtained by the sensor nodes. The energy exhaustion can be reduced by clustering the sensor nodes and gathering of data is done. Cluster formation should ensure that no similar node should be present in one or the other clusters. The best approach is to use clustering technique for grouping the sensor nodes and once the clustering is done, header node among the clusters has to be selected depending upon various energy constraints. EM algorithm is the most popularized method to overcome the clustering problem by calculating the sum of square of distance for each and every node and cluster centroid , we acquire EM algorithm over the 2-dimensional Gaussian mixture distribution

B. Data Aggregation Problem

Data aggregation is a process of gathering the information from the sensor data using aggregation methodology. These method uses the sensor data from the sensor nodes and aggregation algorithms are used for aggregating the data such as centralized techniques like LEACH (low energy adaptive clustering hierarchy), TAG (Tiny Aggregation) and Directed Diffusion [9] .The efficient path is selected for transferring the aggregated data to the mobile sink node. The most important data aggregation algorithms are cluster-based data aggregation algorithms, the nodes are grouped into clusters and each cluster consists of a header node that is cluster head (CH) and other nodes. Each other remaining node transmits the data to its cluster head, then each cluster head collects the data and perform aggregation and transfer the merged data to Base Station(BS). The cluster- based Wireless Sensor Networks have an inherent problem of unbalanced energy dissipation. Some nodes lose their energy faster than the other nodes and it results in the defeat in the network.

C. Data Request Flooding Problem

The data request message is send from the mobile sink node for the transmission of data from sensor nodes when it reaches the cluster centroids. The nodes transmit the data to the mobile sink node after receiving the data request message and distribute the data request message to their nearby nodes. Iteratively the data request messages are distributed until each and every nodes in the same group receives the message. Some nodes in the group may receive the message more than twice, but the data is send only for the first time at the reception of message. Due to this broadcasting technique, the energy consumption is high because the network will be immersed with dispensable wireless communication. Thus, decreasing the data request transmission is most important for mobile sink node in data gathering method

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D. Overview of Expectation Maximization Algorithm

The EM algorithm is a classical clustering algorithm, where nodes are distributed according to Gaussian mixture distribution [8],

$$p(x) = \sum_{k=1}^{K} (\pi_k N(x|\mu_k, \sum_k))$$

where K and π_k indicate the total number of clusters and the mixing co-efficient of the kth cluster. The EM algorithm seeks to find the maximum likelihood estimation of the marginal likelihood by iteratively applying the E-step and M-step.

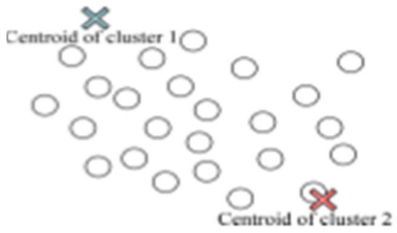

Figure1 (a) First stage of EM algorithm

Figure1 (b) Second stage of EM algorithm

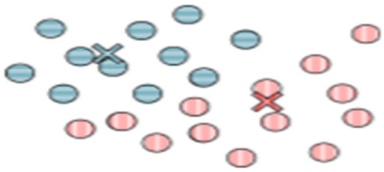

Figure1(c) Third stage of EM algorithm

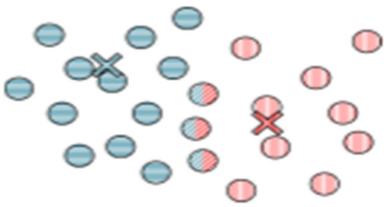

Figure1 (d) Fourth stage of EM algorithm

Figure1 (a) is the initial status of network. Every nodes do not belong to any cluster and centroids of clusters which represented by the cross are randomly decided. At the first step, shown in Figure1 (b), EM algorithm calculates each node's degree of dependence that is referred to as responsibility. The responsibility value shows how much a node depends on a cluster. This responsibility value is calculated by the nodes location and centroid location of cluster. Normally, each node depends only on one cluster. However, it is possible for nodes to depend on more than one cluster so that those nodes will not focus their energy in a single cluster. After that EM algorithm calculates the responsibility value, it calculates the centroid of the cluster by using node's location as shown in Figure1(c). The centroid of each cluster is calculated to minimize the distance between each node which belong to the cluster and the centroid.

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III. Proposed Cluster-Based Data Aggregation System

A. Considered Network Model

The system consists of large number of sensor nodes. The sensor nodes are of equal energy at the initial phase. There are two descends in the proposed system one is the static sink node and other is mobile sink node[4].The static sink node is placed in the centre of the network and in this system there are two mobile sinks. These mobile sinks travels around the header node to collect data. The header node receives data request message from the sensor nodes and redirect the message to one of the mobile sink node. When the mobile sink node gets message from more than one cluster centroid it retransmit to other mobile sink.

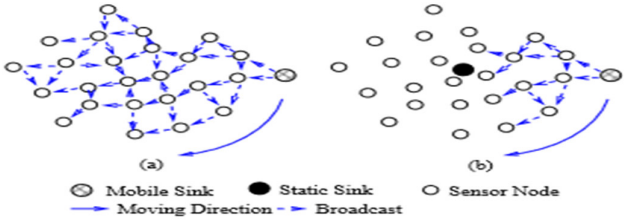

Figure2(a) The mobile sink uses network-wide broadcasting; (b) The mobile sink only broadcasts to a subset of nodes in Dual-Sink

B. Clustering Phase

The sensor nodes are placed in a physical environment for monitoring, sensing the data and gathering the information. A large number of sensor nodes of uniform energy and mobile sink of maximized energy is deployed in the sensing area. At the initial stage, the nodes are distributed and cluster centroid among the nodes is deployed at random location by using EM algorithm. Then the collections of nodes are formed by calculating the shortest distance between cluster centroid and sensor nodes. The distance is calculated by taking one-hop neighbour from each sensor node to cluster centroids. The responsible value for each node is measured. The responsibility value refers to the degree of dependency among the sensor nodes. Some sensor nodes have low degree and some nodes have high degree value. Low degree nodes are combined with high degree nodes to form groups by using Neighbourhood density based clustering algorithm. The next step is to calculate the header node location for each cluster. The header node is calculated based on location information of cluster members. The header node located in place of each cluster is the data points collected in the network .Nodes are seggregated based on constant transmission distance from the centroid. High degree sensor nodes are also taken as to be member nodes among the sensor nodes. After calculating the distance from each node, the header node location among the sensor nodes is calculated and grouped into the cluster

C. To Find Shortest Path for Mobile Sink

To find the shortest distance for data gathering path using a mobile sink node, the data structure Travelling Salesperson Problem (TSP) is used. The mobile sink node monitors around the cluster centroids to gather the information from nodes to be sensed. The sum of the square of the distance between cluster centroid and nodes are decreased to a certain level. When the broadcasting distance reduces, the energy consumed by the sensor nodes and mobile sink node, data latency can be minimized.

D. Data Gathering using Mobile Sink

The mobile sink remains insignificant till it receive data request message from cluster centroids. Directed Diffusion in addition to the specialized algorithm “Push Diffusion” is used for gathering the data. The sensor nodes sink identifies a set of attributes and propagates an interest message to the cluster centroids. Each node records the interests and establishes gradient, the state indicating the next hop direction for other nodes to report data of interest. When an interest arrives at a data producer, data are being redirected to the sink along established gradients. The cluster centroid sends request message to the mobile sink once it reaches a fixed threshold value[11].It sends the sensor nodes message id along with the request to the mobile sink. Then the sink takes the shortest path to reach the particular centroid. The mobile sink remains insane till it receives the message request. The mobile sink collects the gathered data from each cluster centroid point and sends it to the base station.

V. Conclusion

We proposed the simulation model in wireless sensor network system for forest fire detection. Nodes in the system periodically sense the environment and send the message to the base station. This Clustering-based Data aggregation algorithm for Wireless Sensor

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Networks by using two mobile sinks, which improves network lifetime and reduces the transmission distance between each nodes. By using this proposed method, the sensed data are collected efficiently which minimizes data latency. The prevention of forest fires is possible with this type of network, as it allows not only to monitor the signal, but at the same time allows more resources for energy consumption optimization and the decrease in traffic characteristics with the large networks producing significant benefits for small networks are almost similar or identical. Although it has been found that the in WSN there is no network infrastructure is proposed, to ensure communication and interaction efficiently between the sensors, perform a hierarchical mesh type connection, that while increasing the energy consumption, improves the integrity of the transmission and reception of data, a communication star topology, has been confined to major nodes . In this simulation we can conclude that when the network equipment is deployed correctly, the alarm is generated to the base station when the temperature exceeds the threshold

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