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A Cluster based Data Collection Method for Wireless Sensor Networks

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***Abstract*—The wireless Sensor Network (WSN) plays an important role in many applications. The performance of the WSN purely depends on the data collection schemes. One of the important factors to determine the performance of WSN is data collection. Topology management plays a vital role in reducing various constraints such as energy consumption, life time, node failure, long-range communication within a network etc. The data collection scheme such as flat, chain, tree, cluster and cluster tree are available for collecting data in WSNs. In this paper, a new data collection method is proposed. It is based on cluster topology. As compared to static sensor nodes, the mobile sensors have many advantages to gather and collect the data. The proposed data collection method has a Data Gathering Node (DGN).The DGN is made as a mobile node, which moves towards the cluster and collects the data and forwards to the sink. The DGN does not participate on sensing in this particular round, however, it simply gathers the data packet from the cluster and delivers it to the sink. The designed method minimizes the energy consumption, traffic and delay. The simulation results have demonstrated that proposed data collection method has better performance in terms of energy consumption, end-to-end delay, and throughput and network lifetime of WSNs.**

Key word— Cluster Topology; Data Gathering Node; Energy Consumption; Lifetime; Wireless Sensor Network

I.INTRODUCTION

The Wireless Sensor Networks (WSNs) composed of huge amount of sensor nodes that are randomly deployed into a sensing field without any preconfigured infrastructure [2]. The goal of the sensor node is to collect the data periodically and finally send the gathered data to the sink or base station. Before monitoring the environment, the sensor nodes are identify their neighbor nodes and grouped to form a network. Some of the design challenges of WSNs are power consumption, reliability, scalability, production cost, mobility, bandwidth and responsiveness [15]. WSN has wide range of application in environmental monitoring, mining, meteorology, health care applications, military application etc[7] [12].Several network topology management routing protocols have been proposed for collection of data to increase the effectiveness of WSN [1**].**Data collection is one of the important task of the sensor nodes. Data aggregation is the process of collecting the data from all sensors and transmitted to the base station [13]. Choosing the right topology improves the performance of WSN. Flat, chain, tree, cluster and hybrid topologies are used in WSNs. One of the important parameter in WSN is energy consumption. Energy consumption is directly related to the distance between the sensor nodes. If the energy consumption is less, then the lifetime of the network will be more.

In this paper, we propose a cluster based data collection method. The proposed method overcomes the existing limitation such as delay, traffic, energy consumption, network lifetime of WSNs. We use NS2 simulator to implement the proposed method. Section II describes the background information about the data collection schemes. Section III discuss about the new proposed method. Finally simulation and results are discussed in Section IV.

II.RELATED WORKS

In this section, we discuss about the background information of the network topologies. There are several topology methods to collect the data. The topologies can be classified into flat, chain, tree, cluster and cluster tree [11]. This topology determines the efficiency of the sensor nodes in WSN.

A. Flat Topology

Flat Topology or unstructured topology is a very easy method to gather the data from the remote location to sink [5]. Here, each sensor nodes forwards the data packet to the neighbor nodes by one hob distance. Flat topology does not have any predefined structure. The following authors discussed their paper by using various network topologies for the data collection.

Kulik et al [8] discussed about SPIN (Sensor Protocol for Information via Negotiation) to overcome the problems in flooding, gossiping and resource blindness etc [6]. It is a data centric routing mechanism. The idea behind SPIN protocol is to name the data using meta-data. The meta-data are exchanged all over the sensors before transmission by using data advertisement mechanism, which is the key feature of SPIN. Each node will receive the meta-data and advertises it to its neighbors. The interested neighbors are retrieved the data by sending the request message, The advantage of SPIN gives a factor of 3.5 less than flooding in terms of energy dissipation.

Shah et al. [14] designed EAR (Energy Aware Routing) to resolve the problems in SPIN. The author discovers suboptimal paths instead of multiple paths. The paths are chosen based on probability function by using minimum energy consumption on each path to increase the lifetime of

the network. However, path recovery on single path may become very difficult in this EAR.

B. Chain Topology

In chain topology, all the sensor nodes forms a chain and one of the nodes acts as a chain leader and all the remaining nodes communicate with each other along the chain path. The limitation of chain topology is if the sensor nodes have high mobility it leads to chain link breakage.

Lindsey et al [10] discussed PEGASIS (Power-Efficient GAthering in Sensor Information Systems), an improved version of LEACH protocol. In this PEGASIS, all the sensor nodes are in chain form. One of the sensor nodes along the chain link is selected as chain leader; it collects the data from remaining sensor nodes and broadcasts it to the sink.

Tabassum et al. [16] designed COSEN (Chain Oriented SEnsor Network), it is a chain based protocol to improve the performance. The idea behind this COSEN is the entire sensor node grouped to form chain and select a leader with different levels. The lower level chain gathers the data from chain members and sends it to higher level chain. This high level leader forwards the data to the sink. As compared to PEGASIS, COSEN have better performance.

C. Tree Topology

In tree topology, all the sensor nodes construct a tree which means entire data forwards the packet from leaf nodes to parent nodes. The advantage of this topology is energy efficient.

Li et al. [9] designed TBDCS (Tree Based Data Collection Scheme) which is used for data aggregation. It constructs a tree with minimum intermediate node that selects an appropriate time to collect the received data. TBDCS improves the network lifetime. As compared to chain topology, it can save more energy. One of the limitations is link failure when the node is in mobility environment. Thepvilojanapong et al [17] developed EDGE (Efficiency Data GathEring) to overcome the limitations in existing protocols. EDGE achieves better performance than directed diffusion, AODV, DSR in terms of data rate and delay.

D. Cluster Topology

Cluster Topology is widely used in various targets such as data collection, tracking etc. It is a popular topology and more proficient method used for data collection. In this topology all the sensor nodes grouped to form cluster and one of the cluster member acts as a cluster head. The advantage of this cluster topology is energy consumption and increase the lifetime of the WSN.

Heinzelman et al. [6] proposed LEACH (Low Energy Adaptive Clustering Hierarchy), one of the popular protocol used for data collection. In this protocol, First cluster head is elected by all sensor nodes based on threshold value, coverage distance etc. The cluster head collects all the data from cluster members and broadcast to the sink. Energy consumption is the advantage of this protocol. Disadvantage of LEACH is does not applied to large mobile WSNs. This topology has more energy consumption as compared to other topology.

Deng et al. [4] discussed MBC (Mobility Based Clustering protocol), that is all the sensor nodes elects the cluster head based on threshold value on each round. The cluster member forwards the sensed data to the cluster head. MBC provides better performance than LEACH, HEED and other existing protocols on mobility-based environment, but MBC fails to address the critical node occurrence problem which causes link breakage, packet dropping and reduces the network utilization.

III.PROPOSED METHOD

To increase the network lifetime of the wireless sensor network, a new data collection method is proposed. The proposed method consists of setup phase and steady state phase. In setup phase, cluster formation and Data Gathering Node is selected. After the completion of setup phase, steady state phase is initiated. In steady state phase, data collection is performed. The Fig. 1 shows the simple outline of our proposed method which helps to improve the network lifetime. On mobility-based environments, it provides better performance than other methods.

A. setup phase

In set up phase, a large number of sensor nodes are randomly deployed over a sensor field. The sensor nodes are grouped to form a cluster and then cluster head is elected over the entire network. To identify the location and position of the sensor nodes beacon signals are used. Once the nearby nodes are identified, cluster head is elected by using cluster head election algorithm based on threshold valueU_{th}, coverage time $G_{\omega\vartheta}(t, t+s)$ .After that data gathering node is selected. The subscript(ω, ϑ) corresponds to sensor node ϑ and cluster head ω respectively.

In our proposed method, the threshold value U_{th} has been calculated in the equation (1) by adding the multiplication of factors such as number of nodes, residual energy, coverage time etc.

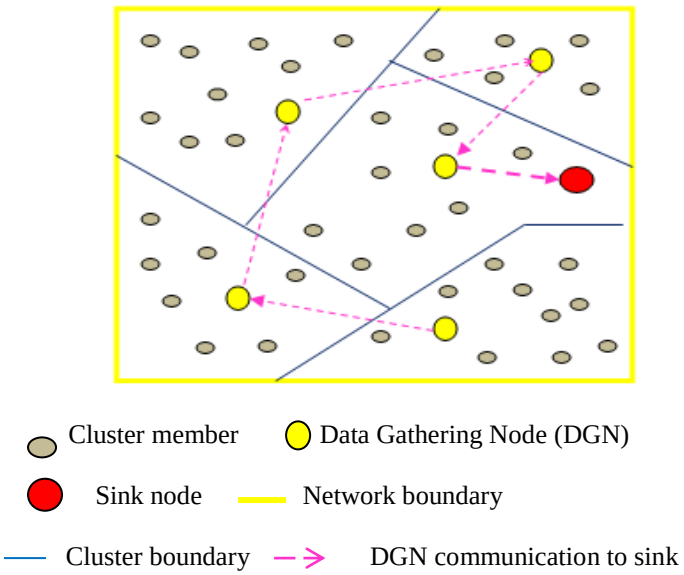

Fig 1.Proposed Structure

$$U_{th} = F_c + \left(\frac{N_\omega^c}{N_N^m - N_\omega^c} \times \frac{E_N^m - E_\omega^c}{E_N^m} \times \frac{V_N^m - V_\omega^c}{V_N^m + V_\omega^c} \times \frac{R_N^m - R_\omega^c}{R_N^m + R_\omega^c}\right) \quad (1)$$

F_c is the flag. Let set $F_c = 1$ for previous round cluster head and set $F_c = 0$ for sensor node which is act as the current round cluster head. The number of cluster members on this round is denoted by N_ω^c, the current sensor node energy is E_ω^c, the current speed of the sensor node is V_ω^c, current coverage radius of the sensor node is R_ω^c, the maximum number of cluster members on each round is N_N^m, the initial energy is E_N^m, the maximum speed of the sensor node is V_N^m and the maximum coverage radius of the sensor node is R_N^m.And then coverage time $G_{\omega\vartheta}(t, t+s)$ is calculated in the equation (2).

$$G_{\omega\vartheta}(t, t+s) = G_{\omega\vartheta}(t) - G_{\omega\vartheta}(t+s), \ \forall S \in t \quad (2)$$

Where, $G_{\omega\vartheta}(t, t+s) \leq 0$ the cluster member is far away from the cluster head and $G_{\omega\vartheta}(t, t+s) \geq 0$ the cluster member is moving towards the cluster head. After the cluster head formation, the DGN is selected based on residual energy. The DGN is made as mobile node and all other nodes are static nodes.

B. steady state phase

The steady state phase is initiated after the completion of set-up phase. In this phase, the selected DGN moves towards the cluster head and collects the sensed data. However the DGN does not participate on sensing in this particular round, it only collects the sensed data from the entire cluster group and finally send it to the sink node.

IV.RESULTS AND DISCUSSION

In this section, our new proposed method is simulated by using Network Simulator (NS2).The performance of our proposed method is compared with the existing method in terms of energy consumption, throughput and delay. The following parameters are assumed for simulation. Table 1 shows the simulation parameters for the proposed data collection method.

Table. 1 Simulation Parameters

Parameter	value
Field size	1400×1400 m^2
Number of sensor nodes	21
Propagation type	Two ray ground
Routing type	AODV
Packet size	5000
Velocity of mobile node	20 m/s
Sensing range	20 m
Channel	Wireless
Simulation time	7 seconds

The 21 number of sensors are randomly dropped in the field of $1400\times1400m^2$. The Data Gathering Node (DGN) is selected using the procedure adopted in existing method. All 21 nodes are considered as one group, out of which one data gathering node is selected. Now, the Data Gathering Node is made as a mobile node, which moves towards each sensor and collects the data and forwards to the sink. As compared to existing scheme, our proposed scheme has better performance. Fig 2 gives the number of packets Vs throughput. The graph shows the performance of the proposed method is better than the existing method.

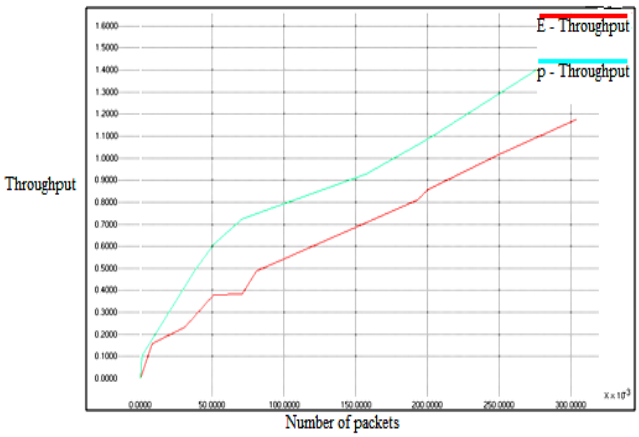

Fig. 2 Number of packets Vs Throughput

Fig.3 shows the performance of delay with respect to total number of packets. The simulation shows that our proposed method has minimum delay when compared to the other existing protocol. Fig. 4 gives the number of packets Vs total energy. Our proposed data collection method consumes more energy.

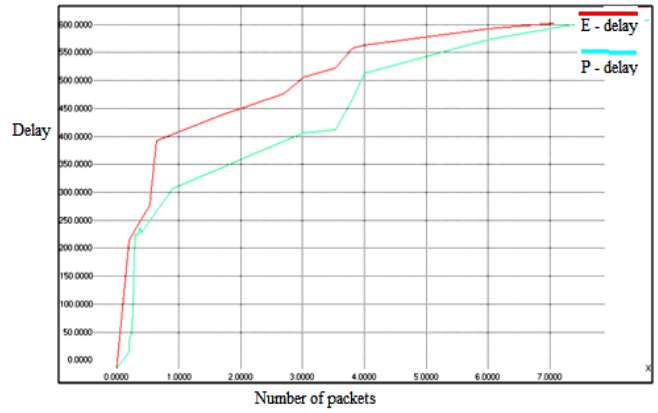

Fig. 3 Number of packets Vs Delay

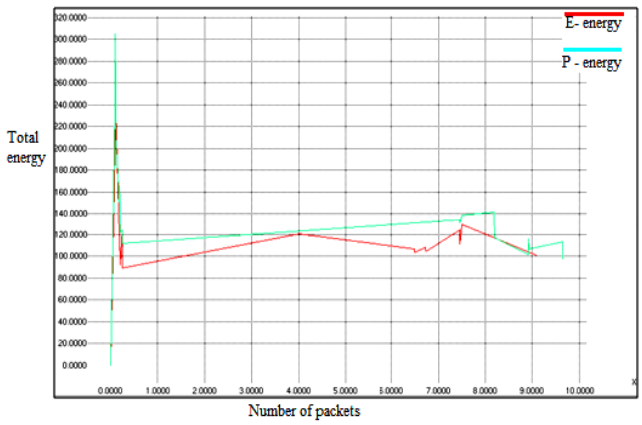

Fig.4 Number of packets Vs Total energy

It is observed that our proposed method can save the sensor node residual energy and increase the lifetime of sensor networks.

IV.CONCLUSION

In this paper, a new data collection method is proposed. It is based on cluster topology. In proposed method, the DGN made as mobile node which moves towards the cluster and collects the data from cluster members and send it to the sink. The selection of cluster is based on coverage distance, threshold value etc. The DGN is selected based on residual energy. The DGN does not participate on sensing in this particular round. However, it simply collects the data from the cluster members. The proposed data collection method increases the life time of the network and reduce the energy consumption and delay.

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