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Saranya . N

Anna University of Technology, Coimbatore, saranit45@gmail.com

Mr. S.V. Manisekaran

Anna University of Technology, Coimbatore, svmanisekaran@yahoo.co.in

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Delay Tolerant Cluster Based Routing For Wireless Sensor Networks

Saranya . N¹ and Mr. S.V. Manisekaran²

M.Tech -IT , Anna University of Technology, Coimbatore, saranit45@gmail.com

Assistant Professor-IT, Anna University of Technology, Coimbatore, svmanisekaran@yahoo.co.in

Abstract- In a dynamic Wireless Sensor Network (WSN) the movement of each sensor node affects the structure of network which may result in inefficient routing. Various difficulties in a dynamic network may include lack of communication between the nodes, end to end delay and transmission overhead. Transmitting data in a dynamic network to the destination node with less delay is the major problem to be addressed. Sensed data can be transmitted using flooding scheme, where the end to end delay can be minimized but results in transmission overhead. In this scheme sensed data is broadcasted to all the nearby nodes until it reaches the sink node. The proposed system make use of cluster based routing protocol, where the sensor nodes with similar mobility pattern are grouped into cluster. Exponentially weighted moving average (EWMA) scheme is used for updating the nodal contact probability of each cluster node. Two Gateway nodes are selected for routing which performs data transmission. The simulation result shows that cluster based routing protocol implemented for a dynamic wireless sensor network result in less end to end delay.

KeyTerms -Clustering, delay tolerant network, routing, wireless sensor networks.

I. INTRODUCTION

A Wireless Sensor Network (WSN) is a collection of sensor nodes, which consists of transceiver and sensors in it. WSN is used in surveillance, environmental monitoring, traffic monitoring and also in many real world applications. These sensor nodes gather information about the environment through measuring the mechanical, thermal, biological, chemical & magnetic phenomena. A sensor node consists of sensor to capture the data and transceiver to transmit data and a small battery to accomplish these tasks. The sensed data must be transferred to sink, which act as base station. But the data cannot be directly transmitted to sink because transmission range of a sensor node is very short. Thus the sensor nodes are grouped to form a cluster, in which sensed data in a cluster get transmitted through a gateway node. This gateway node in turns transmits the data to the sink node.

In a dynamic WSN the sensor node should be grouped into cluster based on the mobility pattern. Delay may occur in the dynamic network due to lack of continuous communication between the sensor nodes. This delay can be eliminated by grouping the sensor nodes into clusters, based on its pair-wise contact probability. Cluster table is maintained for each node listing the cluster-id, contact probability & time stamp. Gateway node is selected based on the highest contact

probability which act as a bridge between the clusters. Sensed data can be transferred through gateway node and routing can be performed to transmit the data to the sink node. Two gateway nodes are used to transmit the data to the sink node which minimize the delay in the network. Gateway nodes exchanges network information for data transmission.

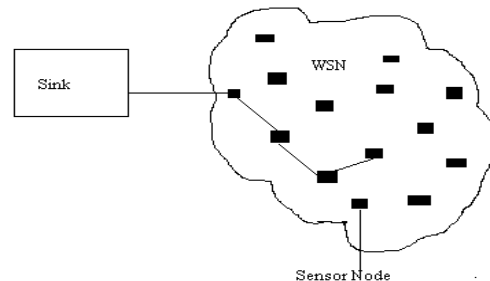


Figure-1 A Typical Representation of WSN

II. RELATED WORKS

In this distributed clustering algorithm is used to form the cluster of mobile node, which can be done based on pair-wise contact probability of each node. Node may join or leave the cluster based on the current contact probability. Exponentially Weighted Moving Average (EWMA) is used to update the cluster table. Cluster table contains the details of pair-wise contact probability and a gateway node is selected based on the contact probability. Gateway node is used to transfer the data to the destination node. This can be done by performing cluster based routing in the mobile network [3].

Flooding scheme is used for data transmission from a sensed node to the sink node. This system is mainly used to improve delivery ratio and to reduce transmission overhead and delay in a system [7]. It transmits data through the node based on its delivery probability to the sink. Fault tolerance can be achieved by storing the data in the buffer for further transmission.

A queue management scheme is used for data transmission. Each node consists of its own data queue. The data may be of its own sensed data or data from other sensor node and also data which is transmitted to the sink node. Transmitted data are also stored in the queue to achieve fault tolerance. Sensed data is first transmitted to the node which has highest probability of data transmission to the sink [7]. The cross layer data delivery protocol may also be used for an intermittent network [8]. It consists of two working modes. They are sleep mode and working mode, where these states are dynamic. The data can be transmitted through two phases. They are asynchronous and synchronous phase. In the asynchronous phase sender contacts its neighbor to identify the receiver, where in the next phase sender gains channel control and transmits its data to the receiver [8]. Cluster based hierarchical structure is used for collecting sensor related data [1]. In this paper the cluster node may pose any one of three states. They are sleep, active and cluster head state. Data related to sensor nodes are collected in the same way as sensed data collection. Active sensors send the collected data to the processing node (PN) through cluster head (CH).

During this transmission the state and energy of the node is also sent. PN broadcasts this information to all the remaining nodes through CH [1]. This approach shows the increased lifetime with average energy consumption. Instead of transmitting the node information along with the data we can broadcast the information to every node in the network [7]. This can minimize the overhead of data transmission. Energy efficient dynamic clustering can be used to minimize total energy consumption. This method is used to find the number of active nodes in the network [10]. It devises an algorithm for transmission of the data using intra cluster routing and for multi hop routing protocol. The cost of the data transmission can be calculated based on the number of hops from CH to the sink node. Number of active nodes information in the network can be calculated by using the total signal power received from the cluster member [10].

Multi hop routing is done to transfer the data to the sink, which is far away from the current position of the node [3]. The cost of this kind of routing is high when compared with one hop routing. It can be minimized by sending the data to the nearby node and which in turn again transmits the data to the base station. With this several requests the base station calculates the low cost path and receives the data from that node [10]. By making use of this technique the total cost for data transmission can be reduced. By transmitting the data through the cluster head the burden on CH gets increased. This can be minimized by making use of the optimization formulation [6]. Load balancing scheme is used to control the traffic in intra cluster routing. It mainly

makes use of two schemes. They are routing aware optimal cluster planning and clustering aware optimal random relay. The maximum cluster size can be found from the routing aware optimal cluster planning [6].

Cluster formation is based on contact probability of each node in cluster based routing [3]. The optimized flooding scheme [7] makes use of broadcasting the information only within the cluster, where it overcomes the disadvantages of broadcasting the information to all nodes in the network. This scheme reduces the transmitting time but increases the transmission overhead.

The design of a proper DFT-MSN data delivery system will help to improve the delivery delay/ratio and transmission overhead/energy. This can be achieved by considering correct source, message and destination [7]. While designing the protocol for DFT-MSN the parameters to be taken into account are nodal delivery probability and message fault tolerance. The states of the radio transceiver may be in one of four states. They are transmitting, receiving, listening and sleeping. The tradeoff may be effective by assigning the states according to the position of the network [8].

III. STUDIES OF BASIC APPROACHES

The data in the dynamic wireless sensor network get transmitted to the sink node through various ways. The sensed data should be transmitted to the sink node as soon as possible. Thus a delay tolerant network should be designed. This can be done by just broadcasting the data and by designing effective routing techniques.

A. Flooding

In flooding scheme the data get broadcasted to all the nodes in the network until it reaches the sink node. This method reduces the delay in the network but increases the transmission overhead. Thus the data sent to all the nodes in the network may result in overhead, where the destination node or the sink node may get the same data from various nodes.

B. Cluster Based Routing Scheme with one gateway

In this scheme sensed data get transmitted to the destination based on routing. It consists of a gateway node which is used to transfer the data from one cluster to another cluster or from cluster to sink node. The cluster formation is based on contact probability between the nodes. Cluster table is maintained to gather the details about the node movement and the cluster members. Exponentially Weighted Moving Average (EWMA) scheme is used to update the table. Based on

the contact probability between the nodes routing done within and outside the cluster to reach the sink node.

$$\xi_{ij} = \begin{cases} (1 - \alpha)\xi_{ij} + \alpha, & i \text{ meets } j \\ (1 - \alpha)[\xi_{ij}], & \text{otherwise} \end{cases}$$

ξ_{ij} . Contact probability between node i and j. α -constant

C. Routing with Two Gateway Node:

In the cluster based routing protocol two gateway nodes is used to transmit the data from one cluster to the other or to the sink node. The gateway chooses for transmitting the data is highly based on contact probability of the nodes. Choose the gateway from any two opposite ends where it can be done by choosing the nodes which have low contact probability. This helps in transferring data from one end to the other quickly. Sensed data get transferred to the nearer gateway node and which in turns get transferred to the sink node.

D. Pseudo code:

N_1, N_2, \dots, N_k = sensor nodes;

Function CF (N_1, N_2, \dots, N_k)

{
For every node N

$$\xi_{ij} = \begin{cases} (1 - \alpha)\xi_{ij} + \alpha, & i \text{ meets } j \\ (1 - \alpha)[\xi_{ij}], & \text{otherwise} \end{cases}$$

Each node is with node id, cluster id;
}

Function GWG ($\xi_{ij}(N_1, N_2, \dots, N_k)$)

{
For every node N
For every node M
If $\xi_{ij}(N) > \xi_{ij}(M)$
Add N to Set of GW; // {GW}
}

Repeat GWG ($\xi_{ij}(N_1, N_2, \dots, N_k)$) for all nearby clusters;

Function routing

{
If data from node to GWP
Flooding with TTL as $N/2$;
If data from node to Sink
Gateway checks its table for contact probability of the sending node
If CP > threshold
Forwards to nearby cluster with cluster id;
Else

Drop packet

Repeat routing until packet reaches Sink;
}

GWP – gate way point

CP – contact probability

GWG – gateway generation

Two gateway nodes get selected based on the contact probability between the nodes. Gateway nodes have high contact probability between the other nodes in the cluster but where the contact probability between the two gateway nodes should be very low.

IV SIMULATION AND RESULT

The simulation result shows that the delay while using two gateway nodes get reduced when compared to the existing one gateway cluster based routing and broadcast method. The sensed data from a particular node get transmitted to the sink node using three algorithms. In the flooding the data get transferred through broadcasting where each node broadcast the data until it reaches the sink. In the cluster based routing protocol a cluster formed and a gateway is used to transfer the data.

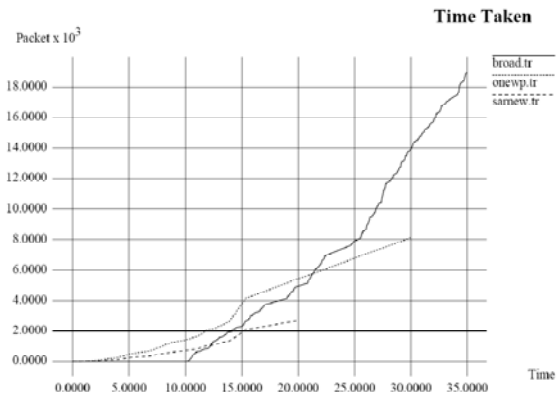


Figure-2: No of packets Vs Time Taken

In the delay tolerant cluster based routing protocol two gateway nodes are used to transfer the data. The result shows that the two gateway method reduces the end to end delay comparatively.

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