Energy Efficient Packet Transmission For Wireless Sensor Networks

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Abstract- *In this research work a solution for packet collision problem with energy efficient approach is proposed. The proposed algorithm uses a grid based prediction system. The grid uses a time slot method for avoiding the packet collision and the prediction approach is used for the selection of the cluster head. By using the history information, the cluster predicts the energy consumption of node, nodes with high residual energy and low energy consumption ratio. This algorithm can effectively prolong the life of network.*

Keywords- Prediction, Grid searching, Clustering, Routing, WSN

I. INTRODUCTION

Packet collision in Wireless Sensor Networks is one of the major problems which can even affect the whole system performance. Excessive packet collisions lead to packet losses and retransmissions, resulting in significant overhead costs and latency. Under an idle event-driven sensor networks operate and then it becomes suddenly active in response to a monitored or detected event. As a result, collisions between packets can be a considerable obstacle to achieving the required throughput and delay for such applications. As the data load increases, there is a severe degradation of network performance. Packet success ratio drops due to frequent collisions and retransmissions.

II. LITERATURE REVIEW

Rhee et al (2006) propose a distributed randomized time slot scheduling algorithm, called DRAND that is used within a MAC protocol called Zebra-MAC (Z-MAC) to improve performance in sensor networks by relating the power of listed access during high loads and unplanned access during low loads.

Van Hoesel (2004) introduces Lightweight MAC which divides time into slots and sensor nodes broadcast information about time-slots they believe that they control. Nearby sensor nodes will prevent picking such slots and pick the remaining to control. The collision avoidance is attained at the rate of additional listen time and control overhead. Lin (2007) proposed a hybrid protocol, Neighbor Aware Probabilistic Transmission (NAPT). It combines the features of randomized transmission and heuristic scheduling where the schedule feature is used to avoid possible packet collisions and the randomized transmission is applied to the sensor with less contention.

Related scheduling schemes introduced by H. Zhang(2006) considerably control the message overhead for building data delivery schedules. In addition, generating and delivering an optimal schedule for data transmissions is complex in a large network.

Heinzelman W R (2002) introduces Low-Energy Adaptive Clustering Hierarchy (LEACH), which applies randomized rotation of the cluster head to distribute the energy load among the sensor nodes evenly in the entire network.

Younis O proposed a Hybrid Energy-Efficient, Distributed Clustering approach (HEED) that does not select CHs randomly. Only sensor nodes that remain high residual energy and lower intra-communication costs can become CHs. Those algorithms pay close attention to the residual energy, but do not make full use of the history information

III. GRID BASED PREDICTIONAPPROACH

In this section a new proposed system contributes a solution for the avoidance of packet collisions and an energy efficient approach in the wireless sensor networks. The Grid based Latin Squares Scheduling (GLASS) protocol and the Prediction Based Energy Efficient Clustering (PBEEC) is combined to get a well-organized model for the WSN. Though the time slot methodology plays a role in energy savings, the results are not so prominent when the network grows larger. So, the proposed work incorporates the algorithm PBEEC which makes full use of the information to cluster the network. A node with high residual energy and low energy consumption ratio is selected as cluster heads. The proposed model uses the energy dissipation ratio, which means the percentage of energy consumption per unit time, generated from the history information to predict the time the node may survive. The cluster head selection is primary based on the parameter, Predicted Survival Time (PST) of the node. The proposed algorithm is simple enough to load on sensor nodes which have limited memory and computing ability.

In this section, Grid Based Latin Squares Scheduling Protocol (GLASS) is proposed. GLASS is a decentralized technique that addresses the issue of collision and is robust in the presence of mobility. In GLASS, sensors use location information to improve channel access. Sensors virtually divide the monitoring area into a grid. Then, each sensor associates itself with one virtual grid cell. This design allows neighboring sensors to maintain spatial and temporal separation between potentially colliding packets while keeping channel access distributed. In addition, the Latin Squares function is used to facilitate the assignment of time slots for transmission among sensors within a grid cell thus reducing the number of colliding transmissions.

A. Grid Searching

The implementation of the GLASS protocol comprises of three phases. The first phase of the GLASS deals with the Grid Searching (GS). A GS algorithm assigns sensors in a monitoring area to grid cells. The monitoring area is splitted into square grid cells with uniform shapes and sizes. The length of one edge is R and it ranges between 2r and 2.1r, where r is the sensor's transmission range. Each grid cell is identified by an ID along with its location. GS_Xi and GS_Yi are the vertical and horizontal coordinates of a grid cell.

B. Transmission Frame Assignment

The second phase of the Glass protocol is Transmission Frame (TF) Assignment. A TF is a group of continuous time slots. The TF structure repeats to handle sensors' transmit, idle, or receive states. The TF is divided into multiple equal Sub Transmission Frames (STFs) that are orthogonal. The proposed work uses a configuration with two STFs. The sensor uses the GS result from the first phase to independently assign itself an STF. As a result, sensors in adjacent grid cells operate at different STFs, reducing the potential for collisions.

$$Length\ of\ TF = 2 * STF \qquad (1)$$

$$= 2 * \left(\left[\frac{No\ of\ \ deployed\ Sensors}{No\ of\ \ Grids\ in\ the\ Network} \right] + \alpha \right) \qquad (2)$$

Where α is an adjustable variable. If sensors in the network are evenly distributed then α is small. If sensors are not evenly distributed then α is large. To avoid uncertainty in sensor deployment, α should not be too small, but this may slightly impact packet delay due to longer transmission cycle or frames.

C. Time Slots Assignment

The third phase of the GLASS protocol is to determine a time slot for the transmission state of each sensor. Latin Squares Matrix (LSM) is used to assign time slots for sensors by avoiding collisions between neighbors. Each sensor performs neighborhood discovery to prepare for time slots scheduling. The neighborhood discovery requires all sensors to broadcast their GS and STF to one-hop neighbors. In this way, every sensor is aware of its neighbors and maintains a neighbor table which records neighbors' ID, distance or hop count, GS, and STF.

Likewise, sensors must keep precise and complete neighbors' statistics in the interior of grid cells, such that each sensor can broadcast recently received data and update its neighbor table. The sensor needs two or three broadcast messages to announce it and discover neighbor's presence within a grid cell if one of the messages is lost.

IV. PREDICTION BASED ENERGY EFFICIENT CLUSTERING

An alignment of nodes into clusters and electing a CH is known as Clustering in WSNs (i.e)

- In a cluster members can connect with their CH straightly.
- A CH can forward the aggregated data to the central base station through other CHs.

A. Clustering and Head Selection

The typical model for clustered Wireless Sensor Network is depicted in Figure 1 and consists of cluster members and Cluster Heads (CH).In a clustered Wireless Sensor Network, all members of the clusters are directly connected to the CHs. Sensor nodes in the same cluster can communicate directly with their CH. CH can transmit gathered information to the Sink as shown in Figure. Each sensor node is assigned a unique ID number by the base station. Node ID number are saved in the Sink. A Cluster Head is a sensor node with better resources and may be used to collect and merge local traffic and send it to the base station. During the network operation, the CH is responsible for the integration of all cluster node data and transmitting the data to the sink. The Sink is typically a gateway to another network for data processing or storage center, or an access point for human interface and to collects the sensor readings.

Intra-cluster transmission: The source node transmits the packet to the Cluster Head within the same cluster, the distance between cluster member and the Cluster Head is small. Inter-cluster transmission: The Cluster Head transmits the packet to the sink node or Cluster Head via the relay transmission. In this relay transmission cooperative sending and receiving nodes are used because the distance between the Inter cluster transmissions is large when compared to intra cluster transmission.

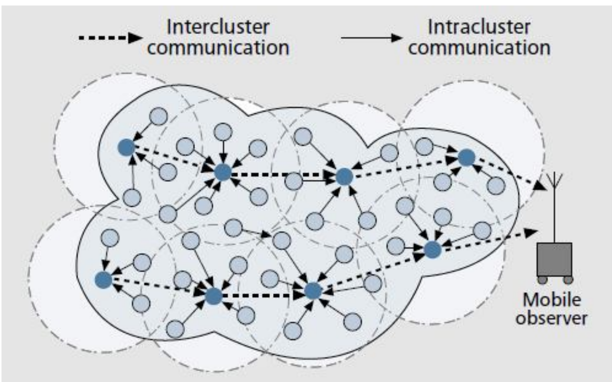

Fig -1: Data flow in clustering network

B. Neighbor Cluster Information Exchange

Clusters are formed for the purpose of transferring information to the base station. In this section a cluster head relay techniques is used to exchange the information. It is an efficient algorithm for neighbor cluster information exchange. Every node sends information to the cluster head who broadcasts the packet to all the nodes in the cluster. This cluster head relay algorithm is very simple and effective. Each node just sends own information directly to the head without knowing any other information such as topology, geography, etc. The cluster head is responsible to exchange information between the cluster members. Each node maintains a table with the information of its ID, neighboring ID and the routing information. Whenever there is change in the neighboring information the changed or the altered information is updated to its table.

C. Multi Hop Routing

Multi hop routing in wireless sensor network is one of the major requirements for the improvement in performance of the network. There are two main ideologies in this concern, namely, inter-cluster and intra-cluster multi-hop communication

1. Multihop inter-cluster operation

The network is grouped into different clusters. Each cluster is composed of one CH and cluster member nodes. The individual CH received the sensed data from its member nodes in a cluster, collects the sensed data and it sends to the Base Station through an ideal multihop tree formed between CHs with base station as root.

2.Multi-hop intra-cluster operation

In general using single hop communication within a cluster for communication between the sensor nodes and the cluster heads may not be the optimum choice. When the sensor nodes are arranged in sections of dark vegetation or rough terrain, it is helpful to use multi-hop communication among the cluster nodes to reach the cluster head. As it is possible for nodes to remain disconnected from the network due to a cluster head not being in range, each node is able to request another connected node to become a cluster head. This occurs after a timeout period and is done through a normal advertisement message.

D. Prediction Algorithm

All sensor nodes cannot move after being deployed. So the network topology changes mainly due to node failures and energy depletion. There is only one base station which lies outside the network to collect the data through the network. Each node has the ability to aggregate data. Node can perform data fusion when it is elected as CH and compress the collected data in the cluster into an own signal which then transmits the composite signal to the BS. The network serves multiple observers, which implies that energy consumption is not uniform for all nodes. And the initial energy allocation of node could vary from each other. Every node has power control capability and stable number of transmission power levels to differ their transmission power.

The algorithm that is loaded on the node should be simple enough due to the limited computing capability and memory. In this section a prediction based algorithm is used. The algorithm uses the energy dissipation ratio, which means the percentage of energy consumption per unit time, generated from the history information to predict the time the node may survival. All the nodes deplete its energy at the same time. So the average energy consumption ratio of the node is equal in the network regardless of the initial energy. Assume that n nodes are deployed randomly in a r x r region to compose a

WSN. The initial energy of node i (1≤i≤ n) is E^i_{Ini} , which is uniformed. E^i_{Res} is node's residual energy. Each node has a clock, and the survival time T^i_{Sur} of each node is known. Based on the history information, the average energy dissipation ratio of node i (1≤i≤ n) is

$$R^i_{Ee} = \frac{E^i_{Ini} - E^i_{Res}}{T^i_{Sur} \times E^i_{Ini}} \qquad (1 \le i \le n) \qquad (3)$$

The dissipation ratio is used to predict the time the node to live. Then the predicted survival time of the node is given by:

$$T^i_{pst} = \frac{E^i_{Res}}{R^i_{EC}} \qquad (1 \le i \le n) \qquad (4)$$

in which T^i_{pst} describe the duration of the node that live with the dissipation ratio generated by history information. T^i_{pst} is proportional to the residual energy and inversely proportional to the energy dissipating ratio. The dissipation ratio is used to choose nodes not only with high residual energy but also consume energy slowly as cluster head.

V. SIMULATION AND DISCUSSIONS

In the proposed scheme 80 nodes is placed randomly with a BS in centre.

Chart 1 shows the success rate of the packets. The result is consistently reliable because of the conflict free time slots assignment schedules. The transmission efficiency of CSMA is acceptable for high contention scenarios whereas the transmission efficiency of the proposed algorithm is satisfactory for all traffic loads. This proposed algorithm maintains collision resolution around intersection of grid cells and it has high transmission efficiency in different traffic loads.

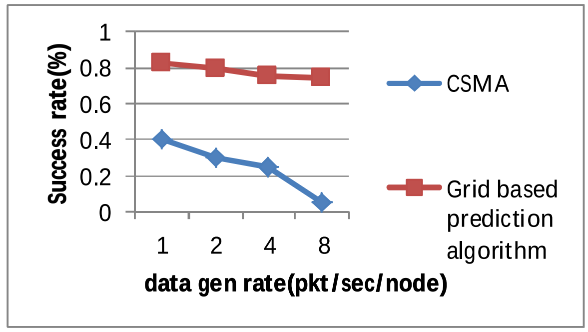

Chart -1: Performance of Success Rate

Chart 2 shows the throughput of the network. The performance is high because it overcomes the challenges of data intensive traffic. The CSMA/CA degrades as the load increases. CSMA is inefficient in the network with higher channel contention. In the proposed algorithm each node is aware of its geographical location. The proposed algorithm is designed to overcome challenges of data intensive traffic scenario and so its performance is better. As the traffic load increases the throughput is high because of shorter TF.

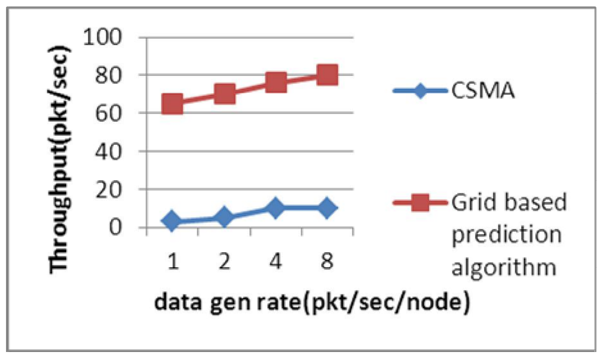

Chart -2: Performance of Throughput

Chart 3 shows the latency performance. Because of the TF size, the average delay increases as the data generation rate increases. The tuning parameter influences the length of TF. With longer TF average packet delay is affected. If the sensor in the network is evenly distributed then the tuning parameter will be at the minimum. If it is not evenly distributed then the tuning parameter will increase. To avoid uncertainty in sensor deployment, tuning parameter should not be too small, but this slightly impacts the packet delay due to longer transmission cycle/frame.

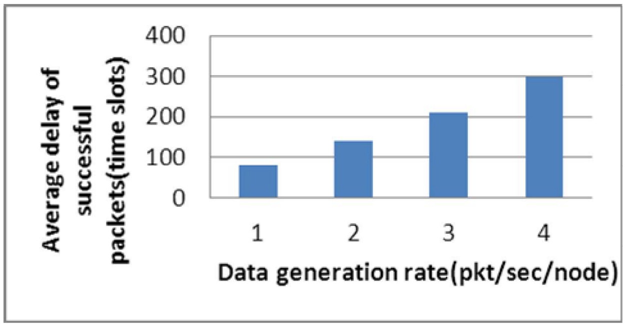

Chart -3: Performance of Latency

Chart 4 shows the collision effect. The collision avoidance improves as the tuning parameter α increase. In large dense network, the proposed algorithm adapts better to changing topology according to the statistical results. This is because it adapts the two STF configurations. When the node moves from one location to another its STF changes, so potential collision is avoided.

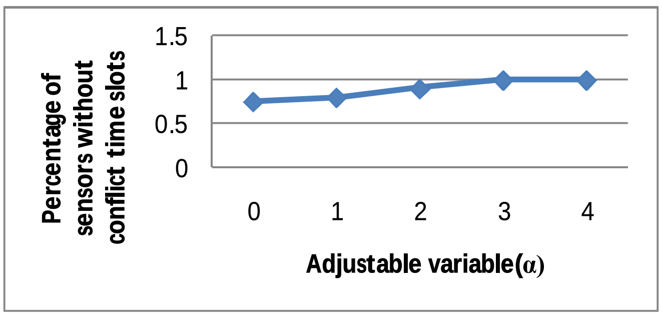

Chart -5: Performance of Collision Avoidance

VI. CONCLUSIONS

In this paper a solution for packet collision problem with energy efficient approach for wireless sensor networks is proposed. The proposed ideology has two major modules, namely GLASS protocol and PBEEC. The GLASS protocol has the methodology of avoiding the packet collision by exploiting the time slots and grids for the sensor nodes. A PBEEC approach is used for the selection of the cluster head. By using the history information, PBEEC predict the energy consumption of node, and nodes with high residual energy and low energy consumption ratio is elected as CH to bear more jobs. This algorithm can effectively prolong the life of network.

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