Optimizing Energy Consumption Using Cluster based Approach for Collision Avoidance in Wireless Sensor Network

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Abstract* — In wireless sensor networks, congestion happens when the traffic load being offered exceeds the obtainable capability of sensing element nodes. In most applications, each sensing element node will send the event it's detected to a sink node. This operation makes the sensors nearer to the sink, leading to congestion. Congestion could cause packets loss, lower throughput and sensing element energy waste. The proposed system contributes a solution for the avoidance of packet collisions and energy efficient approach in the wireless sensor networks. The GLASS protocol and the PBEEC (Prediction Based Energy Efficient Clustering) are 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 (Prediction Based Energy Efficient Clustering) which makes full use of the history information is developed to clustering the network. The results show that the performance of the proposed scheme for saving resources in wireless sensor network is best. Traditional AODV process scheme provide good solution for communication but proposed scheme have much better performance in saving resources and to reduce energy consumption. The energy consumption is less in case of mobile sinks communication in wireless sensor network as compared to the normal AODV process.

Keywords— **Congestion Control, Clusters, PBEEC, Wireless Sensor Network.**

I. Introduction

A wireless sensor network is a network which consists of a number of sensor nodes that are wirelessly connected to each other. This small, low-cost, low-power, multifunctional sensor nodes can communicate in short distances. Each sensor node consists of sensing, data processing, and communication components. A large number of these sensor nodes collaborate form wireless sensor networks [1]. A WSN usually consists of tens to thousands of such nodes that communicate through wireless channels for information sharing and cooperative processing. To ensure scalability and to increase the efficiency of the network operation, sensor nodes are often grouped into clusters [2][3].

The sensors must be placed in exact locations, since there are a limited number of nodes extracting information from the environment. Furthermore, deployment of these nodes and cables is costly and awkward, requiring helicopters to transport the system and bulldozers to ensure the sensors can be placed in exact positions. There would be large economic and environmental gains if these large, bulky, expensive macro-sensor nodes could be replaced with hundreds of cheap micro-sensor nodes that can be easily deployed. This would save significant costs in the nodes themselves as well as in the deployment of these nodes. These micro-sensor networks would be fault-tolerant, as their sheer number of nodes can ensure that there is enough redundancy in data acquisition that not all nodes need to be functional. Using wireless communication between the nodes would eliminate the need for a fixed infrastructure.

Wireless micro-sensor networks represent a new paradigm for extracting data from the environment. Conventional systems use large, expensive macro-sensors that are often wired directly to an end-user and need to be accurately placed to obtain the data. For example, the oil industry uses large arrays of geophone sensors attached to huge cables to perform seismic exploration for oil. These sensor nodes are very expensive and require large amounts of energy for operation. The most difficult resource constraint to meet is power consumption in wireless sensor networks. The use of wireless sensor networks is increasing day by day and at the same time it faces the problem of energy constraints in terms of limited battery lifetime. As each node depends on energy for its activities, this has become a major issue in wireless sensor networks. The failure of one node can interrupt the entire system or application. Every sensing node can be in active, idle and sleep modes. In active mode, nodes consume energy when receiving or transmitting data. In idle mode, the nodes consume almost the same amount of energy as in active mode. While in sleep mode, the nodes shutdown the radio to save the energy. Energy constraints end up creating computational and storage limitations that lead to a new set of architectural issues. A wireless sensor network platform must provide support for a suite of application-specific protocols that drastically reduce node size, cost, and power consumption for their target application.

The following steps can be taken to save energy caused by communication in wireless sensor networks.

- To schedule the state of the nodes (i.e. transmitting, receiving, idle or sleep).
- Changing the transmission range between the sensing nodes.
- Using efficient routing and data collecting methods.
- Avoiding the handling of unwanted data as in the case of overhearing.

In WSNs, the only source of life for the nodes is the battery. Communicating with other nodes or sensing activities consumes a lot of energy in processing the data and transmitting the collected data to the sink. In many cases (e.g. surveillance applications), it is undesirable to replace the batteries that are depleted or drained of energy [4]. Many researchers are therefore trying to find energy-aware protocols for wireless sensor networks in order to overcome such energy efficiency problems as those stated above.

All the protocols that are designed and implemented in WSNs should provide some real-time support as they are applied in areas where data is sensed, processed and transmitted based on an event that leads to an immediate action. A protocol is said to have real-time support if and only if, it is fast and reliable in its reactions to the changes prevailing in the network. It should provide redundant data to the base station. The base station or sink using the data that is collected among all the sensing nodes in the network. The delay in transmission of data to the sink from the sensing nodes should be small, which leads to a fast response.

II. REVIEW OF RELATED WORK

A sensor network consists of huge number of small sensors nodes, whose aim in 'field of interest' region to observe a single or multiple phenomena [12]. These nodes have limited battery power. Data routed from source to destination may follow many possible routes. Suppose source node generates data and is delivered to destination node. If the node has sufficient battery power only then it will transmit data to the distance node. If the node lies in its transmission range, then only data can transmit between two nodes without any failure. If the node is situated far away from the source node, where data is transferred, then large battery power is required to transmit the data. After few transmissions, a stage will reached when a node eliminated from the network path because it reached to its threshold battery level. A situation will be reached when no node will be available for transmission of data and the overall lifetime of a network decrease [13]. For enhancing the lifetime of network, there should be balance between energy consumption used by nodes and their energy reserved.

Shio Kumar Singh et al. in [14] proposed Homogenous Clustering Algorithm for wireless sensor networks to improve the energy efficiency and scalability of wireless sensor network. In this algorithm, firstly the sensor nodes are randomly clustered and then to balance the size of the clusters, they conduct self adaptive optimization. The algorithm is divided into rounds. At each round, the current cluster heads selects cluster member's node as the next cluster head. The rotation of cluster head is transparent to other cluster members.

Yash Pall et al. in [15] Proposed an energy saving scheme named as maximize the lifetime of Object tracking senor Network with node-to-node Activation Scheme (MLONAS) in which some nodes remain in sleep mode while some nodes are involved in tracking of an object. In this algorithm, when an object enter the other node's region it will activate that node and when that node start tracking the object previous one will go to sleep mode. Thus, this algorithm increases the lifetime of sensor network.

S M Lambor et al. in [16] evaluate the relationship between network lifetime and the energy consumption in a multi-hop wireless sensor network to enhance the performance. In evaluation, they had shown that as the network lifetime raised, the energy consumption decreased with the increment in number of hops and attain the minimum at critical hops. After the critical hops, the energy consumption gradually raised due to increase in cumulative energy consumption of intermediate nodes.

Soysal Onur et al. in [17] Proposed sleep/wake-up protocol POWERNAP, Which prevent the overhead of distributing complex and large sleep/wake-up scheduling information to the nodes. The pseudorandom generator encodes the scheduling information and enables snoopers/recipient to calculate its sleep/wake-up schedule from this seed. In order to avoid expensive control packet transmissions, POWERNAP trades off doing extra computation. POWERNAP removes the idle-listening problem and achieves self-stabilizing, low-latency, and low-cost relaying of data packets for random routing protocols.

Sandip Kumar Chaurasiya et al. in [18] urged an energy-efficient routing scheme named as Enhanced Energy-Efficient Protocol with Static Clustering (E3PSC) which is the extension of an existing routing scheme, Energy-Efficient Protocol with Static Clustering (EEPSC).The proposed work divide the network into distance-based static clusters. To reduce the intra-cluster communication overhead among the nodes making the scheme more energy-efficient, cluster-head selection is performed by taking account both the spatial distribution of sensors nodes in network and their residual energy.

Senouci et al. in [19] study the lifetime of flat and hierarchical sensor network routing protocols, namely : DIRECT, FLOODING, GOSSIPING, LEACH and HEED. To increase the HEED's lifetime, they introduced a new technique EHEED. The new technique is compared to other protocols and comes to the conclusion that EHEED is very effective for long-lived sensor network.

R.S.Rajesh et al. in [20] implements the three random based mobility models such as Random waypoint, Random walk and Random Directions. The two parameters constraints like packet-delivery fraction and end-to-end packet delivery delay are compared with mobility speed, traffic and Network size. The simulation results show that the AODV((ad-hoc on demand) protocol in Random Waypoint mobility model performs better than DSDV(distance sequencing), TORA(temporary ordered) and DSR(dynamic source routing) in Random walk and random Direction mobility model.

III. Improved Cluster Based Approach

In existing protocol, sensing field was divided into grids (particular defined area) and after that they consider the transmission frame (particular time slot used to handle different states of sensor node such as idle, active, transmit, dead). Further for collision avoidance, latin square matrix has been used for providing time window to the sensing grid which will avoid collision. At initial state sensor will perform neighbour discovery and form a neighbour table for future. For inter cluster communication prediction based clustering algorithm has been used (history based on initial discovery).

In this proposed work, we proposed an improvement in inter cluster communication by improving cluster based clustering approach. In our proposed work we checked the energy level of the sensors and judged the participation of the sensor in different tasks accordingly. This improved the quality and saved resources too.

3.1 Proposed Model

The research proceeded with implementation of time slot to avoid congestion status in the sensor network to obtain the better results. Some of the milestones which need to be fulfilling to simulate research proposed concept is given below:

- Find the solution for better communication in between sensor and sink.
- To minimize the congestion in communication.
- Increase the throughput with congestion avoidance.
- Increase network lifetime while communication by saving resources.

A proposed concept of congestion avoidance is used to avoid the battery drain of the wireless sensor network by avoiding resources wastage to solve the congestion issues. For experimentation we have used network simulator version 2 with animation for the concept of congestion avoidance. Various parameters used for experimentation is below table 1:

Table 1: Parameters used for the experimentation

Parameters	Value
Simulator	NS2
Simulation Time	30 sec
No of nodes	5 Logical subnets
Routing Protocol	AODV
Traffic Model	CBR
Pause Time	100 sec
Speed	11 mps
Number of sources	2
Sub-packet size	256 bytes
Transmit Power	15mW
Receiving Power	13 mW
Initial battery power	100j
MAC layer	802.11
Time Slots	Grid Distribution

3.2 Proposed Methodology

The proposed system contributes a solution for the avoidance of packet collisions and energy efficient approach in the wireless sensor networks. The GLASS protocol and the PBEEC (Prediction Based Energy Efficient Clustering) are 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 (Prediction Based Energy Efficient Clustering) which makes full use of the history information is developed to clustering the network. The inter-cluster communication cost and cluster size are also considered when clustering.

Nodes with high residual energy and low energy consumption ratio have more possibility to be 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. To increase energy efficiency and further prolong network lifetime, cluster communication cost as a secondary clustering parameter. The proposed algorithm is simple enough to load on sensor nodes which have limited memory and computing ability.

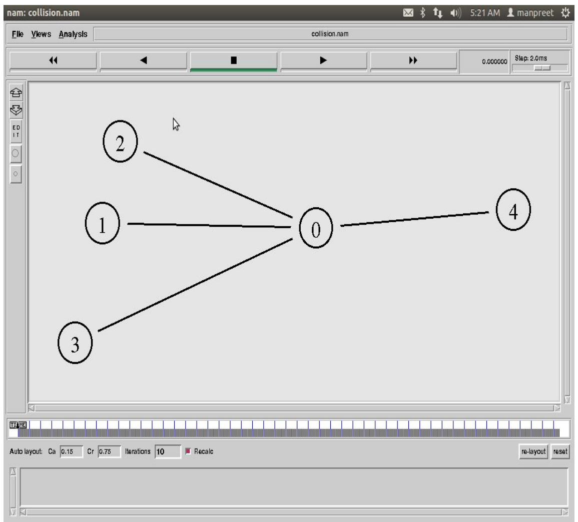

Fig 1: Simulation scenario for experimentation

The proposed work use to simulate sensor network implementation and proceeded with saving energy for sensors. At initial phase basic functionality and collection of information (simulator, basic sensor functions etc) has been done. Network simulator has been used to provide the simulation and results of the proposed work. Grid area considered as logical based on network grid area nodes which represent the different area for the sensing ground. In fig 1, overview of the simulation has been shown. Various parameters for experimentation are shown in table 1. The transmitting and receiving power has been configured with basic energy carried by sensor nodes.

The initial state is for selecting cluster heads based on the residual energy of the nodes. Further we have implemented a simple scenario for sensor nodes and divided the grid area into equal parts. Sensing process starts with computation and communication later on. After this we have implemented the time slices based on the time sot availability for avoiding congestion in the network. Basic GLASS protocol has been implemented and proposed work has been tested as compared to the GLASS protocol. Finally we have done comparison for GLASS and proposed work with delay, overhead, packet delivery ratio and throughput as base parameters for performance variation. Fig 1, shows the concept as described above in network simulation.

IV. RESULTS

The results are based on the simulation of congestion avoidance concept in sensing field for wireless sensor network. Fig 2 shows the throughput comparison for the proposed work and GLASS protocol in sensor network. The comparison shows the throughput in case of Glass protocol is less as compared to the throughput of the proposed work. The throughput of proposed work is increased by 5.2%.

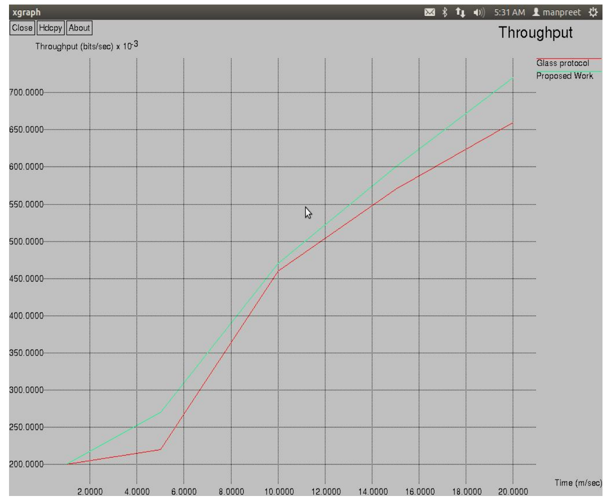

Fig 2: Comparison of GLASS and proposed work in term of throughput

Fig 3 shows the packet delivery ratio comparison for the proposed work and GLASS protocol in sensor network. The comparison shows the number of packets is more in case of proposed time slot concept scenario as compared to normal GLASS protocol. The packet delivery ratio is increased by 20%.

Fig 3: Comparison of proposed scheme and GLASS protocol in term of Packet Delivery Ratio

Fig 4 shows the energy consumption comparison for the proposed work and GLASS protocol in sensor network. The comparison shows the consumption is less in case of proposed time slot concept scenario as compared to normal GLASS protocol. The consumption is reduced by 18%.

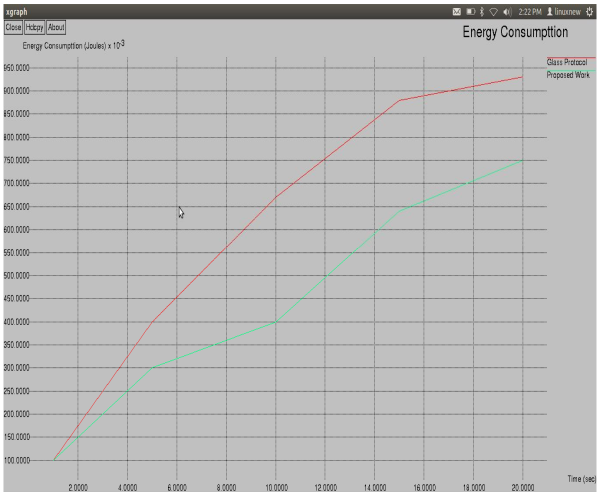

Fig 4: Comparison of proposed scheme and GLASS protocol in term of energy consumption

Fig 5 shows the end to end delay comparison for the proposed work and GLASS protocol in sensor network. The comparison shows the delay is less in case of proposed time slot concept scenario as compared to normal GLASS protocol. The delay is reduced by 8%.

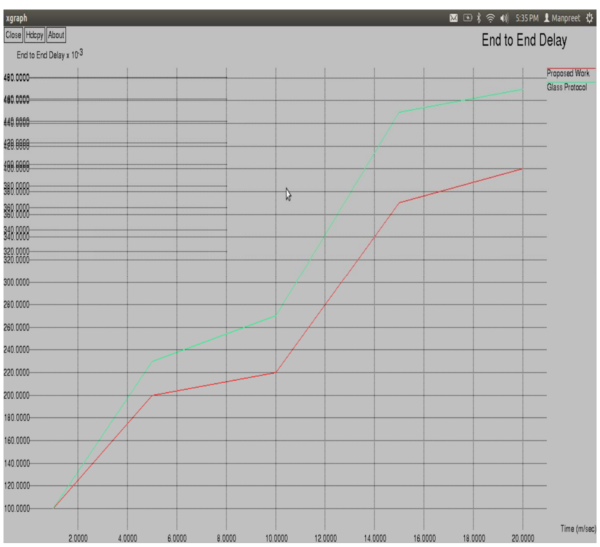

Fig 5: Comparison of proposed scheme and GLASS protocol in term of end to end delay

The results shown above summarized the performance of the proposed scheme for saving resources in wireless sensor network. Traditional AODV process scheme provide good solution for communication but proposed scheme have much better performance in saving resources and to reduce energy consumption. The energy consumption is less in case of mobile sinks communication in wireless sensor network as compared to the normal AODV process..

IV. CONCLUSION

This proposed work is based on the concept of saving of resources in the wireless sensor network area by bringing concept of time slot variation and grid distribution with congestion avoidance schemes. This work is very useful in saving resources and in process to improve the lifetime of the wireless sensor network. The 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 efficient time slot congestion avoidance technique. The GLASS protocol has the methodology of avoiding the packet collision which comprises of three phases- Grid Searching (GS), Transmission Frame (TF) Assignment and Assignment of Time slots. It is evident that this GLASS protocol reduces packet collision by exploiting the time slots and grids for the sensor nodes. The results shown that the GLASS protocol is showing good results and our proposed work over perform the GLASS protocol for packet collision avoidance strategies.

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