Node and Network Level Scheduling Algorithm for Wireless Sensor Network

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Abstract— **In Wireless Sensor Network (WSNs) application, ample amount of data is generated, which is processed and used for decision makings. The large amount of data generated is from nodes at lower level and aggregated at cluster head (CH) uses more resources which are scares and network lifetime decreases. To minimize the utilization of resources causing increased life time node and network level conflict –free scheduling Algorithm (NNS) is proposed which may increases the utilization of slot for transfer of aggregated packets at node to CH to sink with minimum delay and reduced energy consumption. It considers TDMA as basic MAC. Slots are scheduled to transfer data from static nodes in the cluster at lower level and from CH to sink at network level. It reduces conflicts occurring for transfer of packets. Two levels functioning in allocating the collision–free slots improves QoS parameters and hence the performance of the network as compared to state of the art solutions.**

Keywords- WSN;MAC; Scheduling; Energy Consumpton;Dely.

I. Introduction

In wireless era of technological developments, collection of appropriate and accurate information plays important role with number of sources spread over the area. The sources used are resource constrained with energy and communication bandwidth to transfer the aggraded information in terms of packet to the destination as sink. If energy required collecting information packets and communicating to sink directly increases, then network will not sustain more and loss of information may degrade the performance. One way to reduce the energy commutation is structured network with in-network agnation of packets and other is to schedule the activities of the node (sources) and Cluster head (CH) to reduce the communication delay and required energy during ideal state. The scare resources can be better utilized by in-network processing which reduces the transmission load along with reduced packet count [1-4].

The main objective of proposed algorithms is to provide the collision-free packet transmission with reduced utilization of scare resources. Sensor flood the data packets to cluster head at lower half of network for data gathering and may cause collision due to transmission by nodes once at a time [3-4] , The packets colliding due to unavailability of slot are discarded during transmission process. If retransmission of these packets is initiated it consumes more energy in retransmission degrades the performance of complete network. The re-transmitted or superfluous packets need more energy and increase the delay with reduced network life time. Also other sources of energy waste and delay are first, node and CH are idle for scheduled time due to non availability of information. Secondly, flooding of sensed and aggregated packets at CH in Cluster periphery and then at sink network wide. The collision of data packets is serious consideration in terms of loss of information, and increased resource utilization. Third, Predication of next state of transmission of packets specifically at network layer increases the transmission time, also nodes not participating will engage the slots for dummy packet transmission. All above consideration demands for the dynamic and effective scheduling algorithm at node as well as at network level, which takes into account the current and future state of network.

In every scheduling algorithm delay and conflicts are the major consideration which occurs either due to more number of packets generated by nodes or discarded packets are retransmitted using more energy with less available slot for communication.

The paper has sex section is planned in different sections as: Section II describes the related work of WSN scheduling and its limitations. Section III defines considered system model and assumptions for cluster-based TDMA scheduling algorithm. Section IV explains the proposed mechanism with energy model used. Section V discusses and presents the comparative results of NNS, GCF, SMNS and A-DRAND, Finally, Section VI concludes with remarks on proposal.

II. Related Works

Time division multiplexing plays an important role in different scheduling algorithm with and without mobility concerns indifferent layers of network. This section gives in-depth analysis and gives formulation of network used for reduced delay and energy consumption and increased throughput.

The Efficient Schedule-based Data Aggregation Algorithm proposed in [3] use node mobility with distributed link between the nodes and CH. It has communication latency in multi-hop wireless networks. The limitation of algorithm is to have constant topology.

Cluster based using myopic and non-myopic scheduling algorithm (CMNS) [4] is a distributed algorithm for assigning TDMA schedule on the condition of available channel and free slot to the node requesting access for transfer of packets. The nodes at initial level and CH at network level takes decision of transferring the aggragted packets on myopic and

Non-mayopic way according to the information from state of channel. This definetly improves the delay requirement with increased throughput. Decisions are taken by predicting the next state and data traffic tries to minimize the overhead cost to assign the schedule.

In [5], activities of the node are scheduled in consecutive time slots to transfer the available packets from the sources to sink. It is useful for low traffic networks since most of the energy of node is consumed in idle state and transition between the states from idle to active to sleep. With proper scheduling maximum energy can be saved so that required throughput is achieved.

Adaptive Distributed Randomized Scheduling (A-DRAND) [6] algorithm reduces collision by using reliable data transmission but its overheads increases with scalability and mobility. It applies schedule according to density of traffic in one hop. The GCF [7] algorithm finds the single conflict free slot for each node across three hops. It shows reduced energy consumption, delay, and increased throughput with maximum reuse of slots and minimum conflict in the network the adaptive slot distribution algorithm is based on feedback mechanism [8].

It depends on collision feedback by the local nodes. It shows reduced interference under light load situation and also shows better efficiency in case of overlapping of clusters. Five-Phase Reservation Protocol (FPRP) [9] chooses the slot for each node by working in five phases and leads to increase in the overheads of the protocols

In [10], Nodes are scheduled in periodic manner with dense network of nodes which improves the lifetime of the network. Also nodes are selected according to coverage range to send the packets with reduced delay and energy. The selected nodes act as representatives for transmission of aggregated packets in scheduled slots. The problem occurs when intermediate representative node fails. [11] Proposes the hybrid approach of link scheduling with in-network aggregation for improvement of delay. By allocating the conflict-free slots, improves the accuracy for collecting the packets from random sources.

TDMA scheduling algorithms used in WSN are differentiated according to the mechanism used to schedule the nodes at lower level and cluster based at network level. The different ways of classification are centralized- vs. distributed-scheduling, flat vs. cluster network based scheduling and primitive and Non-primitive scheduling algorithms.

The major restraint of scheduling algorithm for flat network is that, with dense network scenario, slot allocation and re-use requires more energy and do not have good scalability. On the other hand cluster-based scheduling algorithms have high energy efficiency and scalability. The main drive in paper is to reduce the energy consumption and delay by allocating the multi-level conflict- free slots for transfer of aggregated packets from node to sink

Level by level scheduling of nodes and CH reduces the transmission load by effectively managing the states of the sensors to wake up or Sleep.

III. PROPOSED NETWORK MODEL

A. Node and Network assumptions

Every node has its own identity and capacity to transfer the packets. All nods and base station (sink) is stationary and are synchronized with each other, identical characteristics. Every node is not aware of location. Every node acquire slot from CH at lower level CH from Sink at network. Node requires single slot for performing multi-hop communication

B. Network Model

In wireless sensor networks nodes are distributed in random manner and organized into the cluster by use of clustering algorithms. The network considers one base station (BS) or sink node. It is partitioned in clusters; every cluster has normal nodes and a CH. Here, for achieving an energy efficiency and scalability of network, the clusters are assumed to be multi-hop. The plane formed with in the cluster and network has the set of nodes *'V'* nodes with $V= \{S_1, S_2, S_3, - - - S_n\}$ deployed in two dimensional regions. Node V_{bs} acts as Sink which collects the network wide data by forming graph *G (V, E)* between the nodes at lower level to CH at network level.

Node V_i at lower level can communicate to cluster head V_{ch} at regular interval with connecting links as '*E*'. The multi-hop communication saves the energy and reduces the delay in transmitting the aggregated packets. Here, each node needs a slot to do communication. In this model the CH and gateway nodes will get the slots from sink and sources from CH.

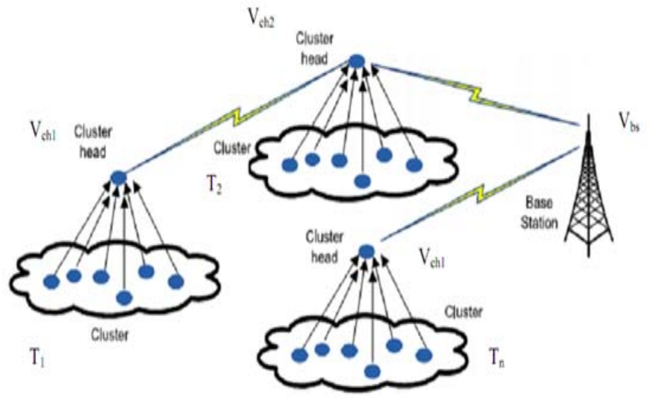

Figure 1. Cluster-based Network Model

With proposed scheduling algorithm single node will transmit, multiple packets with steady environment in one slot. During Transmission of packets from V_i node V_{ch}, the nodes in close vicinity and in listening state consumes the energy and network performance reduces. Also, the information generation rate from source node is variable and one slot may not be sufficient to transmit the aggregated packets to CH, at the same time other node V_x will try to acquire the slot and results in collision causing retransmission delay, energy and bandwidth waste. The process of transmission is repeated for each time slot till Sink receives the finally aggregated message.

IV. PROPOSED MECHANISM

In dense network it is necessary to reduce the overheads occurred due to computation and communication a method is proposed which schedules the activities of node at lower level and CH at Network level. It uses the Myopic and Non-myopic scheduling [4] respectively to reduce the required energy consumption and delay in allocation of Collision-free Slots for communication of aggregated packets from node to CH to sink.

The structure of proposed mechanism is shown in Figure2 along with frame used in synchronization of collision-free Slots in Figure 3

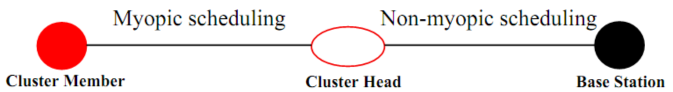

Figure 2. Structure of Proposed Mechanism

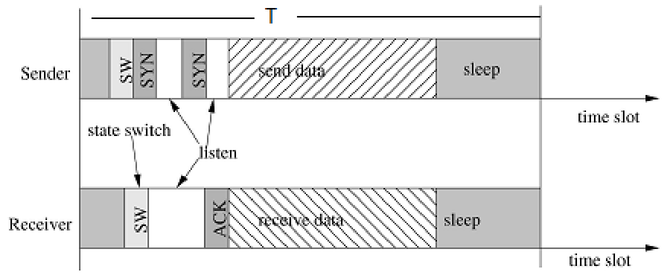

Figure 3. State switch from lower to upper layer

The paper uses the Time division Multiplesing technique (TDMA) for scheduling the activites ogf the node Ch in orde to reduce the delay and energy consumprtion . The time slots 'L' allocated are logically divieded into eual halfs for transmsiion and receiption with time Ts and Tr and these slots are synchronized though out the Netwok nodes. The total Time period 'T" is composed of T=Tr+Ts, Node vi will generate the variable number of packets rvi and thes packets are transmitted to CH by Node level and to sink by CH in the scheduling Time 'T'.

The alogorithm is applied for conflict-free scheduling that consider the state of channel and number of slots 'L' allocated to each node at the time instance t=0. If 'm' number of packets are generated by nodes without collision then the scheduled function for transmission of message is given by

$$f(f(t),S) = \sum_{m \in M} w_m \{f_m(t) \notin S, f_m(t) \neq V_{ch}\} [4] \qquad (1)$$

Where '*Wm*' weight of collegeted message, $f(t)=\{f_m(t)\}$ is state of channel and '*S*' possible schedule for each node to be active for transmission of aggregated packets. After Time slot 'T' the state of channel changes and is represented in Eq(2)

$$f_m(t+1) = \begin{cases} f(f_m(t)) & \text{if } f_m \in S(t) \\ fm(t) & \text{otherwise} \end{cases} \qquad (2)$$

Energy Model

The paper mainly focus on the energy utilization in allocation of slots and along with the different states of the radio used by nodes as transmitting from lower level , receiving at CH and network wide sink, idle listening and sleep mode Ptx; Prcv; Plst, and Pslp, respectively.

The amount of energy consumed in transmission of 'm' packets through 'L' slots over the'd' distance is represented by $P_{tx}(d)$ and E_{rx} is energy required for the reception is given by.

$$P_{tx}(d) = m*(\varepsilon d^{\alpha} + E_a)L, \text{ and } \quad E_{rx} = m*{}_{Ea.}L \qquad (3)$$

Where E_a is the electronics energy, and 'ε' is the transmitter amplifier in the free space. For multipath model, 'α' is the path loss exponent, with 2≤α≤4.

Delay Analysis for clustered network

The consecutive slots allocated for transfer of packets from node to CH and and fromCH to sink takes myopic and non-myopic scheduling mechanism. The time required for 'n' source nodes and 'N' CH nodes to schedule the 'm' packets in 'L' slots are obtained from equation (4)

$$T_{ch} = ((n/k)-1)\ L \qquad (4)$$

With consideration of available slots for node and CH to take part in tranfser of packets to sink is calculated with equation (5)

$$T_{Vbs} = m*L*L' \qquad (5)$$

Where L′ are available slots for CH to transfer packets to bae station Hence, total time required for the aggregated packet to reach to sink from source node is

$$T_{total} = Tv_{ch} + T_{Vbs} = [((n,N/m)-1) + M]\ L*L' \qquad (6)$$

All the activities of each node and CH are scheduled and Synchronized in the time slot 1≤ L, L′≤ T_{total}.

V. SIMULATION RESULTS

A. Simulation Details

The comparative analysis of NNS with state-of-the-art algorithms as A-DRAND [6], GCF [7], and CMNS [14] is given in this section. The evaluation parameters used for nodes and network getting simulation results are presented in Table I. The decision of slots allocation for transfer of packets is taken on the basis of Myopic and Non-myopic scheduling mechanisms.

TABLE I. SIMULATION AND NODE PARAMETERS

Parameters	Value
Network diamentions	100 x100 meters
Cluster head	25,50,75 and 100
Source Nodes	24, 49, 74 and 99
Sinks (Bae Station)	1

Parameters	Value
Network diamentions	100 x100 meters
Node Placement	Random
Energy of Each Node	100J
Communication Model	Two Ray- Ground
Traffic model	Constant bit rate
Idle power used by Nodes	14.4 mW
Receive power	12.06 mW
Transmit power	36.0mW
Itterations for each run	20

B. Result and discussionDiscussion

The number of conflicts is more important in the wireless sensor networks since it decides the overall performance of the network. The conflicts occur due to availability of less slots or flooding of more redundant packets from the node in when listening. The number of conflicts occurred in NNS 15.85%, 25.35%, 41.11% less as compared to SMNS, GCF and A-DRAND. It is due to decentralized approach used for allocating the slots for one hope and two hop nodes in the network. It is due to mobility of a sink in the predefined path. Also node and CH will take part in transmission with predefined time and active only for allocated slot reducing false transmission probability as shown in Figure 3.

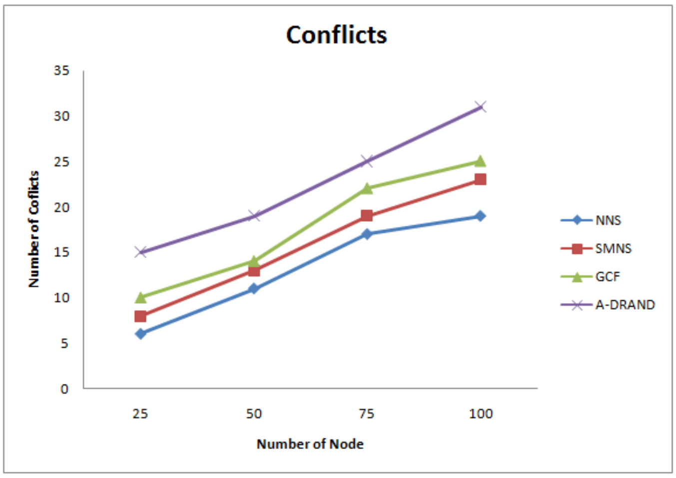

Figure 4. Comparison of Number of Conflicts

Figure 5, illustrates the comparative results NNS with CMNS, GCF and A-DRAND. The results shows that the improvement of energy utilization of NNS is very less (21.48% and 34.52% and 54.80%) in allocating the conflict free slots in scheduling the nodes and CH at network wide consideration. The SMNS considers the mobility of sink, GCF reuses the slot and A-DRAND has uneven allocation of slots for transfer of data. According to fig if participating nodes are less all algorithms behaves uniform consumption but trend changes with more number of nodes. This extra traffic in the network requires the extra energy to generate and transmit it, which leads to increase in energy consumption.

The comparative graph shown in Figure 6 explains the trend in average throughput of NNS. Throughput is the measure of percentage amount of packets reached sink after successful transmission of packets without any conflicts and proper allocation of slots to node and CH at network level. NNS has marginal improvement in throughput with A-DRAND a randomized algorithm but less as compared to GCF and SMNS using stable nodes and moveable sink respectively (7.29% and 15.36% and 45.45 over SMNS, GCF and A-DRAND). The improvement is dependent on the scheduling decision as myopic at node level and non-myopic at network level.

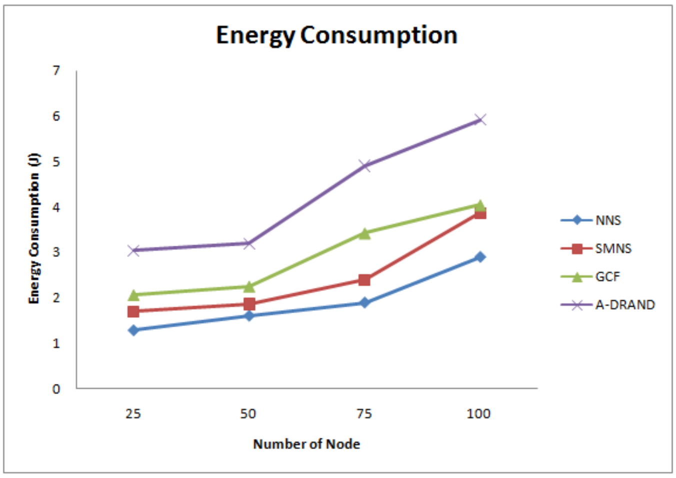

Figure 5. Comparison of Average Energy Consumption

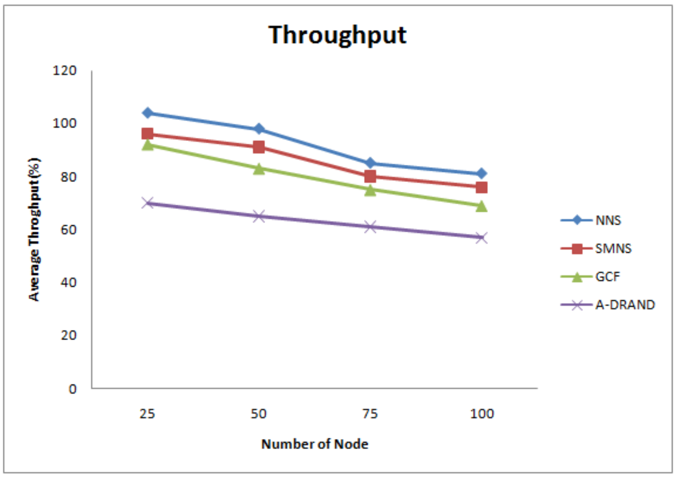

Figure 6. Comparison of Average Throughput

Figure 7 presents the average delay measured by the network in allocating the slots by considering the present and next state of available channel used for transmission of aggregated packets. Delay incurred by NNS as compared to SMNS is high due to mobile sink in aggregating the as compared to GCF using reuse The average improvement is 26.95% 2.68% and 14.15 with different algorithms as compared to the CMNS GCF and A-DRAND, The random distribution of nodes and mobility of sink causes the changes in network dynamics and increases the delay in communicating packets.

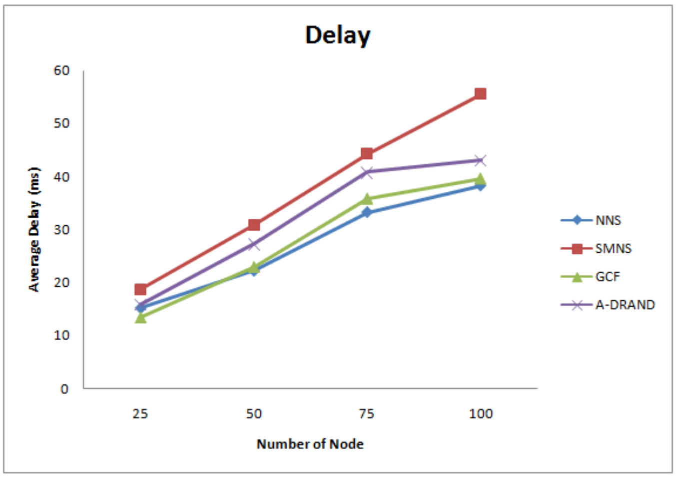

Figure 7. Comparison of Average Delay

VI. CONCLUSIONS

The proposed NSS algorithm takes care of allocating the Conflict-free scheduling slots by considering the TDMA as base. It shows better performance with reduced energy consumption, average communication delay, by allocating the schedule to nodes within the cluster and CH at network level reduces the random and redundant data used for communication to sink. The increased throughput itself indicated that the proposed NNS is superior as compared to GCF, A-DRAD and SMNS. The algorithm can be extended for adding security in allocation of slots

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