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A New Multiple Access Scheduling Scheme for Maximum Energy Efficiency in WSN

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Abstract: Wireless Sensor Networks consists of sensor nodes which moves randomly. Routing in the wireless sensor networks is a demanding assignment Energy efficiency is a major issue in Wireless Sensor Networks. Due to path failure, sensor nodes consume high energy. Therefore, the performance of the networks is totally degraded. In order to determine the secure and energy efficient routing, we proposed Multiple Access Scheduling (MAS). It attains both throughput and network connectivity while keeping the nodes moving in dynamic manner. The scheme consists of 4 phases. In first phase, the multipath routing is constructed. In second phase, the CDMA based scheduling algorithm is proposed. Here the sensor nodes are assigned with the constant codewords and different time slots. In third phase, energy consumption model of sensor nodes is proposed. In fourth phase, new packet format of proposed scheme introduced. It consists of scheduling status and connectivity status. By using the extensive simulation results using the discrete event simulator, the proposed MAS achieves higher packet delivery ratio, connectivity ratio, less overhead and delay than the existing scheme like NMRA, SBYaoGG and AFTMR.

Key words: Scheduling Status · Scheduling Priority · Congestion Status · WSN · MAS · Energy Consumption End to end delay · Connectivity ratio · Code words

INTRODUCTION

Wireless Sensor Networks: Wireless sensor network generally composed of a large number of distributed sensor nodes that organize themselves into a multi-hop wireless network. Each network is equipped with more than one sensors, processing units, controlling units, transmitting units etc. Sensor nodes or motes in WSNs are small sized and are capable of sensing, gathering and processing data while communicating with other connected nodes in the network, via radio frequency (RF) channel.

Need for scheduling in WSNs: Sensor node lifetime shows a strong dependence on the battery lifetime. The malfunctioning of some sensor nodes due to power failure can cause significant topological changes and might require rerouting of packets and reorganization of the network. The sensor node has to sustain itself on its battery's limited energy resources and without power management; it can last only for a short period.

To minimize the energy consumption, there is a need of scheduling in sensor networks. Here, we proposed multipath routing based scheduling mechanism to make a correct balance between the network connectivity and energy efficiency.

Previous Work: Tapiwa *et. al* [1] proposed the new distributed topology to enhance the energy efficiency and radio interference to preserve the global connectivity. The drawback of the approach is lack of balancing the energy consumption and security. It does not provide better authentications to the information carried by the packets. To overcome this issue, our scheme enhances the cross layer based multipath routing to achieve the correct balance between the energy consumption and network connectivity.

K. Vanaja and R. Umarani [2] introduced the fault management to resolve the mobility induced link break. The proposed protocol is the adaptive fault tolerant multipath routing (AFTMR) protocol, which reduces the packet loss due to mobility induced link break. In this

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fault tolerant protocol, battery power and residual energy is taken into account to determine multiple disjoint routes to every active destination. When there is link break in the existing path, AFTMR initiates Local Route Recovery Process Ming.

Ming Liu *et. al* [3] proposed a mathematical method for calculating the coverage fraction in WSNs. According to the method, each active node can evaluate its sensing area whether covered by its active neighbours.

It is assumed that the network is sufficiently dense and the deployed nodes can cover the whole monitored area.In this scenario, if a node's sensing area is covered by its active neighbour nodes, it can be treated as a redundant node. Based on this idea, it is proposed a lightweight node scheduling (LNS) algorithm that prolongs the network lifetime of the sensor network by turning off redundant nodes without using location information.. According to the desired coverage fraction required by application, LNS can dynamically adjust the density of active sensor nodes so that it will significant prolong the network lifetime.

Tian *et. al* [4] proposed a node-scheduling scheme, which can reduce system overall energy consumption, therefore increasing system lifetime, by turning off some redundant nodes. The coverage-based off duty eligibility rule and backoff-based node-scheduling scheme guarantees that the original sensing coverage is maintained after turning off redundant nodes. Eligible nodes turn off their communication unit and sensing unit to save energy. Non-eligible nodes perform sensing tasks during the sensing phase. To minimize the energy consumed in the self-scheduling phase, the sensing phase should be long compared to the self- scheduling phase.

Ram Kumar Singh and Akanksha Balyan [5] mainly focussed on the energy efficient communication with the help of Adjacency Matrix in the Wireless Sensor Networks. The energy efficient scheduling can be done by putting the idle node in to sleep node so energy at the idle node can be saved. The proposed model in this work first forms the adjacency matrix and broadcasts the information about the total number of existing nodes with depths to the other nodes in the same cluster from controller node.

Babar Nazir *et. al* [6] presented a sleep/wake schedule protocol for minimizing end-to-end delay for event driven multi-hop wireless sensor networks. In contrast to generic sleep/wake scheduling schemes, the proposed algorithm performs scheduling that is dependent on traffic loads. Nodes adapt their sleep/wake schedule based on traffic loads in response to three important factors like the distance of the node from the sink node, the importance of the node's location from connectivity's perspective and if the node is in the proximity, where an event occurs.

Saqueeyan and M.Roshanzadeh [7] proposed the reliable and energy aware packet delivery mechanism to ensure quality of service in wireless sensor networks. In the proposed algorithm, to ensure that a packet of information has sent to the destination, the multi-path forwarding method is used. Several copies of an information packet via separate routes are sent to the destination, also routing decisions in this way occurs by considering the remaining energy in the neighbourhood of nodes that are located in two hop of sender node.

Jungeun Choi *et. al* [8] proposed the Fault-tolerant Adaptive Node Scheduling (FANS) that gives an efficient way to handle the degradation of the sensing level caused by sensor node failures, has not been considered in the existing sensor node scheduling algorithms. For this purpose, the proposed FANS algorithm designates a set of backup nodes for each active node in advance. If an active sensor node fails, the set of backup nodes pre-designated for the active node will activate themselves to replace it, enabling to restore the lowered sensing level for the coverage of the failed node.

In my previous work [9] a New Multipath Routing Approach is developed which attains energy model, maintenance of optimal energy path, multipath construction phase to make a correct balance between network life time, energy consumption and throughput to the sensor nodes. In this scheme, construction of multipath, optimal energy path is implemented. It uses following factors called distance, residual energy, mobility factor, mobility factor and data correlation to favor packet forwarding by maintaining high residual energy consumption for each node

Implementation of MAS Algorithm: In our proposed scheme Multiple Access Scheduling, CDMA based scheduling is used to provide energy optimization. The schemes are explained below.

Multipath Routing: The concept of proposed multipath feature is towards broadcasting the traffic load among two or more routes.. The proposed multipath system uses multi-path routing in order to select the route with the best maximum data throughput rate. Node supports with number of mobile nodes in its neighbourhood without relying on a single node to forward a message. If any failure of message arrival, it can be sent on alternative path or on multipath in parallel. In the proposed scheme, multipath routing has been used mostly for fault tolerance and load balancing and for failure recovery. The communication between mobile node and its neighbor node happens either through a direct communication path or through at most one neighbor. The following procedure is for message forwarding in multipath routing. Consider a message travelling a path A0; A1, A2…….Ak is authenticated twice before it is forwarded. A0 creates Message Authentication Code (MAC) intended for nodes A1 and A2. A0 can only reach A1 directly and relies on S1 to transmit the MAC intended for S2. Before S1 forwards the message, it creates two new authentication codes itself for A2 and A3. It continues until the message reaches its final destination. Before a node forwards a message, it checks the authentication codes from the two preceding nodes.

CDMA Based Scheduling Algorithm: Let us consider the CDMA based scheduling procedure to divide the transmitter receiver pairs into subset and this is done through energy optimisation problem as follows:

$$\min F(K,M) = M\sum_{i=1}^{N} K_i \tag{1}$$

$$\frac{P_{kl}G_{kl}}{\frac{1}{L}\sum_{n=1,n\neq l}^{L} P_{kn}G_{kl} + \frac{1}{L}\sum_{q=1,q\neq k}^{L}\sum_{n=1}^{L} P_{qn}G_{nl} + \sigma^2} \geq \chi \tag{2}$$

The solution of the above optimisation problem results in 2M + 1 equations with 2E + 1 unknowns, which we can solve for P and L.

$$\frac{-1}{\varphi^2}\sum_{e=1}^{E} P_e + \alpha\sum_{e=1}^{E}\lambda_e \sum_{d=1,d\neq e}^{E} P_d G_{de} = 0 \tag{3}$$

The solution provides the optimum spreading gain and the transmitter powers for all transmitters. Here, it is worth to be mansion that transmission power control is automatically taken care by the optimisation problem as we optimise total network energy. The algorithm starts finding minimum spreading gain for the network and individual transmission powers for all transmitters in the network following the above optimisation problem. If spreading gain of the optimisation problem results lesser than some positive value then all nodes can transmit at the same time, otherwise the first node has to be eliminated from transmission Elimination of this transmitter receiver pair will decrease the required spreading gain. This loop with this algorithm will be executed unless a set of transmitter receiver pair is found where the spreading gain upper limit is satisfied. All eliminated nodes will be considered for the next consecutive time slots. As a result, all transmitter receiver pairs in the network will be divided into different subset and nodes in each subset will transmit in one time slot with spreading gain less than some positive value.

This algorithm could be invoked at the beginning of every time slot in order to cope with the interference level or at the end of all transmitters from all subset finishes transmission. Theoretically, the later gives the optimal solution. The invocation time of this algorithm is very important. Let us first consider that a set of n nodes is dividing into m subsets according to the Scheduling-Spreading gain. The result is true for m consecutive time slots and within this period no mobility, addition or deletion of nodes are considered within the network. In this case this algorithm will find a subset from all transmitters to transmit in the next time slot, where spreading gain is less than some positive value. Mobility, addition and deletion of nodes can be taken into account at the beginning of every time slot.

Determination of Remaining Energy: After periodical time t, the energy consumed by the node Ej, remaining is calculated as follows.

$$Ej = \chi_{\text{ x Tnx}} + \lambda_{\text{ x Rnx}} \tag{4}$$

Where Tnx = Number of data packets transmitted by the node after periodical time t. Rnx =Number of data packets received by the node after time t χ and λ are constants. Its value ranges between 0 and 1. If EINIT is the initial energy of a node, the remaining energy Eremaining of a node at periodical time t, can be calculated as:

Ej, remaining = Ej, INIT-Ej

Proposed Packet Format:

Source ID	Destination ID	Scheduling Status	Network Connectivity Status	Energy Conservation Ratio	CRC
2	2	4	4	4	2

Fig. 1: Proposed Packet format

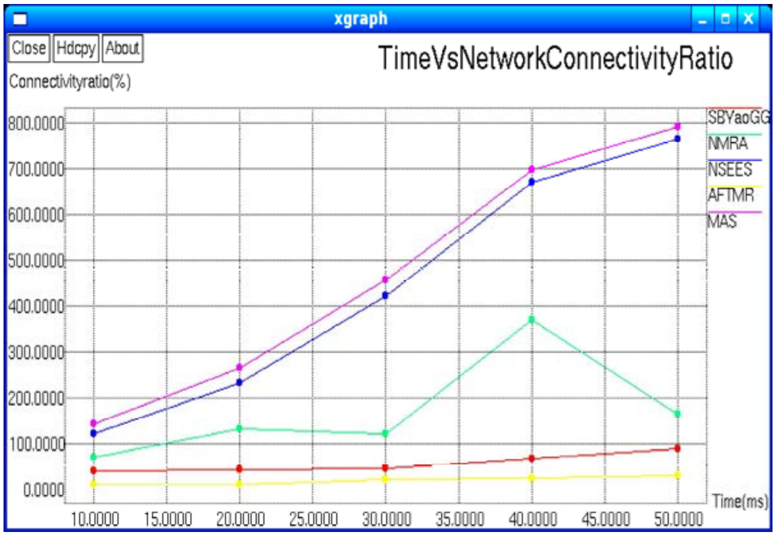

Fig. 2: Time Vs Network Connectivity Ratio

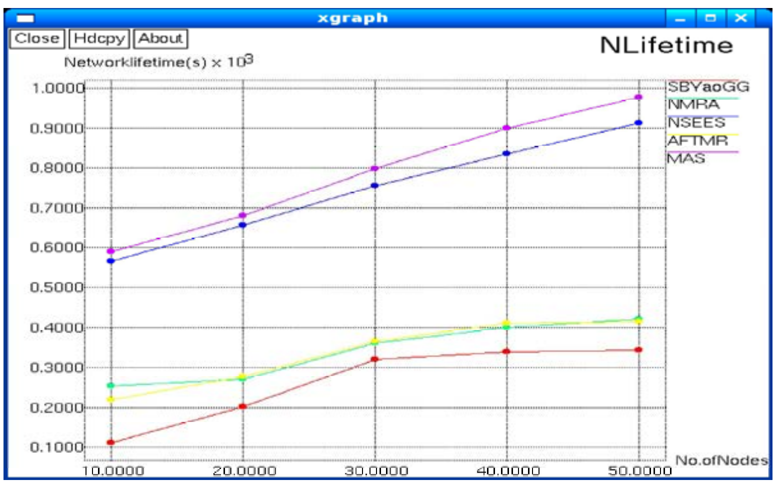

Fig. 3: No.of nodes Vs Network Lifetime

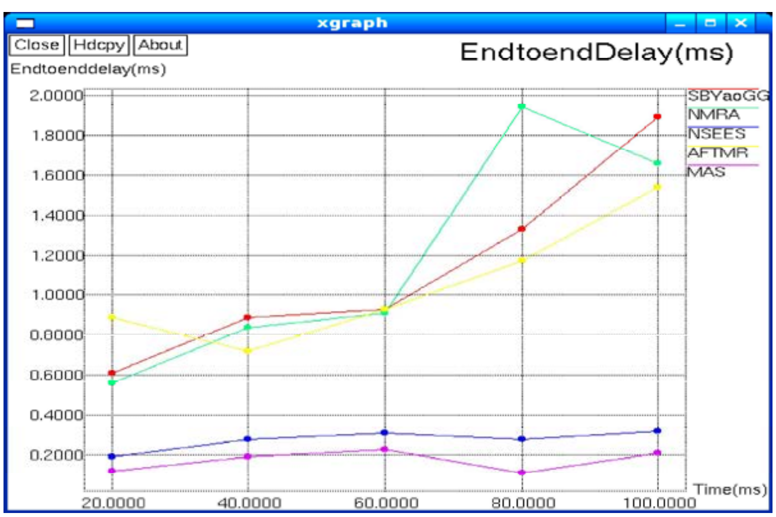

Fig. 4: Time Vs End to end delay

Fig. 5: Mobility Vs Energy Consumption

In fig 1. the proposed packet format is shown. Here the source and destination node ID carries 2 bytes. Third one is scheduling status of the node. The scheduling status induces the whether the transmission of packets are travelled with highest link priority and least hop distance. In fourth field, the network connectivity status is indicated. It determines how much of the connection status between various clusters with the current cluster.In fifth, the energy conservation ratio is allotted to ensure minimum energy consumption.

The last filed CRC i.e. Cyclic Redundancy Check which is for error correction and detection in the packet while transmission and reception.

Performance Analysis: We use Network Simulator (NS 2.34) to simulate our proposed NSEES algorithm. Network Simulator-2(NS2.34) is used in this work for simulation.

In our simulation, 200 mobile nodes move in a 1200 meter x 1200 meter square region for 60 seconds simulation time. All nodes have the same transmission range of 500 meters.

The simulation results are presented. We compare our proposed algorithm MAS with existing schemes like AFTMR [2], SBYaoGG [1] and our previously proposed scheme NSEES, NMRA [9] in the presence of energy consumption.

From figure 2 to figure 5 it shows that the Network Connectivity, Network lifetime, End to end delay, overhead and energy consumption are better compared to the previous scheme NMRA, NSEES and existing schemes such as SBYaoGG, AFTMR

CONCLUSION

In WSNs, the nodes are totally distributed in a random manner. The control may be issued by base station or without any base station. Here we focussed on to improve the scheduling link priority to avoid the packet drop and to improve energy efficiency. So we proposed MAS scheme to provide the multipath routing based scheduling to maximize the network connectivity ratio and throughput. The multipath routing and CDMA based scheduling are proposed. Here the load balancing is well improved. The energy consumption model is proposed to attain maximum energy efficiency. Each packet attains the time slots which are sent through the highest link scheduling priority. The scheduling status, connectivity status and energy conservation ratio is verified using our proposed scheme. By using NS2, a discrete event simulator, our scheme achieves high connectivity ratio and delivery ratio, low overhead, low end to end delay and minimum energy consumption while varying the time, throughput, number of nodes and mobility than the existing scheme NSEES, NMRA, SBYaoGG and AFTMR

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