Vigilant Cluster Head based Routing in Sleep Wake Scheduling and Opportunistic Routing

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Abstract

Wireless sensor network is composed of sensor nodes and multiple sink in which each sensor node is capable of detecting events. The main problem arise in the network is it remains unattended for long duration because these networks are placed in remote areas. So to extend the network lifetime of a network, node energy must be efficiently used. So in order to efficiently use energy of the network sleep wake scheduling method is used. Asynchronous sleep wake scheduling arrange sensor node to sleep mode when transmission or reception is not required. It allows sensor nodes wake up independently with the given rate. But it has got a disadvantage that additional delay may occur in each node along the path to sink node. So to minimize this problem opportunistic routing is used. In this method it selects some nodes as forwarding nodes and through these nodes it sends the packet. In the above methods it has got some limitations that sink node has to wait for long time to receive the transmitted signal. So clustering method is used. clustering enables efficient resource allocation and thus help in better designing of power control and other advantage is due to the fact that any changes of nodes behavior within a cluster affect only that cluster but not the entire network, which will therefore be robust to these changes. The main objective of this project is to reduce the energy consumption and to increase the packet delivery ratio (ie, ratio between received packet by destination and generated packet by source)

Keywords: Wireless Network, Opportunistic Routing, Sleep Wake Scheduling, Forwarding Set, Network Lifetime

I. INTRODUCTION

Wireless sensor network has got a unique ability to remotely sense the environment, as the networks are placed in remote areas it is difficult to recharge batteries of large number of sensors. Sleep wake scheduling is an efficient method to extend the lifetime of a network as it arranges sensor nodes to sleep mode when data transmission or reception is not needed. But in this method it has got some limitations, as here we are using asynchronous sleep wake scheduling it may cause additional delay in each node along the path of sink node. So to minimize this problem opportunistic routing packet is used. In this method it selects some nodes as forwarding nodes and through these nodes it sends the packet.

In sleep wake scheduling method sink node has to wait for long time to receive its corresponding transmission signal. Energy is not efficiently used here so inorder to enhance network lifetime, efficient energy usage, and to obtain high packet delivery ratio a new method called cluster head based sleep wake scheduling is used.

In this approach, some nodes are considered as initiator nodes through which the cluster heads are decided. In each cluster, the cluster head selects a node with the highest energy and keep it in active mode and sends the remaining nodes into the sleep mode. Through this way it is possible to decrease the energy consumption of the network and increase the network's life time [10].

In this paper analysis and evaluation of various sleep wake scheduling method are done. System model is included in Section 1. Section 2 describes the cluster head based method. Simulation results are done in Section 3. Conclusion and Future discussions are done in Section 4.

Various protocols related to sleep wake scheduling have been proposed in the literature. In the case of synchronized sleep wake scheduling sensor nodes periodically or a periodically exchange synchronization information with neighboring nodes thus it incurs additional overheads and consume consumable amount of energy. So it is not an efficient method to be used. In the case of on demand sleep wake scheduling, nodes turn off most of the time and turn on using a low powered receiver to listen to wake up calls sending by the neighboring nodes. Since additional receiver is using cost of this method will increase significantly. So it is better to use asynchronous sleep wake scheduling because in this method each node wakes up independent without considering its neighboring nodes. This independence of wake up process may cause additional delay in each node along the path of sink node so the main problem that lies here is each node has to wait for its next hop node to wake up before transmitting a packet and is time consuming. So by involving multiple forwarders called forwarding set, to overhear the packet opportunistic routing is an efficient method to reduce the energy consumption by considering actual reception conditions of forwarding nodes. So by considering both the advantages of sleep wake scheduling and opportunistic routing ASSORT is used to prolong the network lifetime. ASSORT allows sensor nodes to switch in to sleep mode when there is no transmission and to wake mode at the time of transmission also it forwards data or consumed energy to neighboring nodes hence by prolong lifetime of a network.

In deterministic routing method [2], [3], [4], [5] each node considers residual energy for selecting a path and also it selects a specific route to send a packet from source to destination. The main aim of this method is to select a path with less residual energy by providing traffic load to another path. Retransmission scheme is widely used in multi hop networks because of channel fading data transmission cannot be done. Some existing methods applied the idea of opportunistic routing in the network among them one of the methods is EFFORT [6]. This method helps to prevent some nodes from draining out of energy and the main disadvantage of this method is that it consumes energy even if the state is idle.

II. SYSTEM MODEL

A. Asynchronous Sleep Wake Scheduling

Sleep wake scheduling allows sensor nodes to switch in to sleep mode when transmission or reception is not required. In sleep mode, the communication medium of sensor node is turned off thus by it reduces the energy consumption. Among different sleep wake scheduling here asynchronous sleep wake scheduling [7] is used because it allows sensor nodes to wake up independently within a given rate so that it does not wait for its neighboring nodes.

In sleep wake scheduling it allows sensor nodes to either go to sleep mode or wake mode. When there is no transmission or reception is required the sensors nodes will switch in to sleep mode and wake up for a small period of time T_{active}.

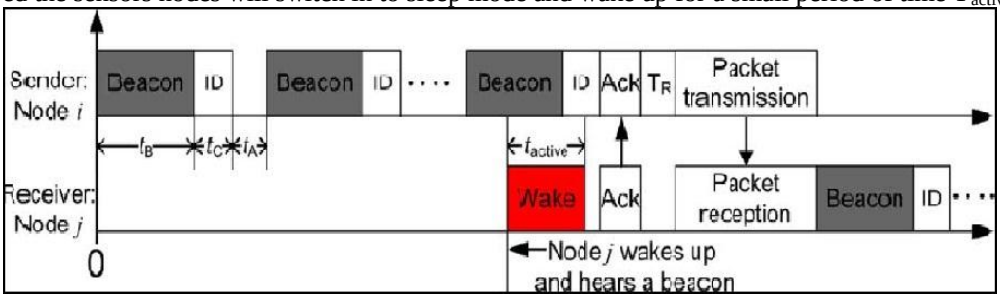

Fig. 1: Sleep wake scheduling model

Figure 1 explains how sleep wake scheduling is processed [1]. When a node i has a packet to send to the receiver node j it will send a beacon signal along with ID signal (carrying sender information) with in a time period of t_B and t_C. Node waits for acknowledgement signal for a time period of t_A from its neighboring nodes. If the node does not hear any acknowledgement signal from its neighboring nodes it repeats the signaling procedure. When neighboring node j wakes up and hears the beacon signal it keeps awake and waiting for ID signal to recognize the sender. When node j wakes up in the middle of signaling procedure it keeps awake and waits for the next ID signal. If node j successfully identifies its sender and recognizes it is a next hop node of I, then it will communicate with node to receive the packet. Node j uses this similar procedure to wake up its own next hop node and if it does not sense a beacon signal it will then go back to sleep mode.

The flowchart of sleep wake scheduling [8] is shown in Figure 2. This can be easily explained using an example. Suppose a node want to transmit a signal to its destination and the sender node is named as node 2 and receiver node is named as node 10. Initially node 2 is in wake mode. It will send the beacon and ID signal in to its neighboring nodes. If one node hears the signal it will send an acknowledgement signal to node 2 then it will transmit the packet to that node. Then the node 2 goes to sleep mode and this process repeats until it reaches node 10. If more than one node hears the signal it makes the node to go to wake mode and the based on priori the packet is send to destination.

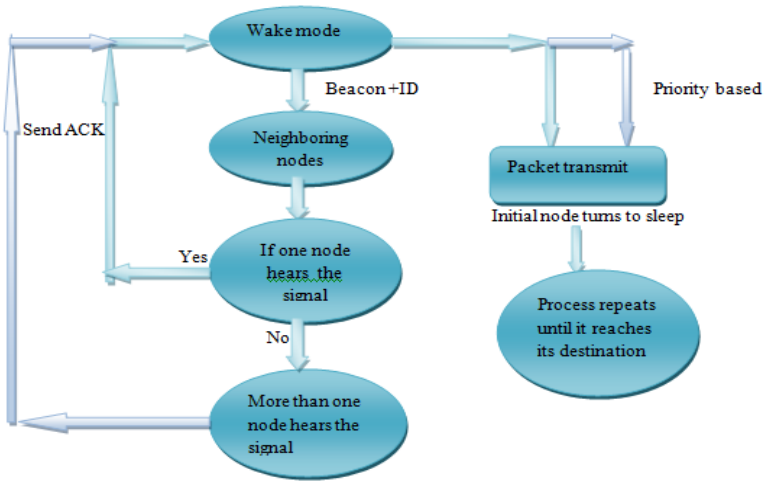

Fig. 2: Flowchart of sleep wake scheduling

But a main problem arises in this method is that an additional delay is incurred while transmitting a packet from source to sink thereby each node along the transmission path has to wait for its next hop node to wake up. So to reduce this delay problem opportunistic routing method is used. Sleep wake scheduling model considers a wake up rate and it follows a poison process.

B. Opportunistic Routing Framework

Opportunistic routing involves multiple forwarders as forwarding set to overhear the packet thus it reduces the energy consumption of retransmission based on actual reception conditions at forwarding nodes. Wireless sensor networks uses retransmission scheme to provide reliable data delivery and it has got a main disadvantage that certain poor links has to spend much time in the network. So by using opportunistic routing method this problem can be minimized up to a limit. The Figure 3 shows the algorithm of opportunistic routing.

The wake up rate follows a Poisson random process and priority is set to all the nodes. The letters A, B, C, D, E, F denotes the priority of the nodes with respect to forwarding nodes. Suppose node 2 needs to send a packet to node 10 in that case it will send that packet to its first forwarding set and using the priority it will send that packet to its destination node.

The Beacon and ID signal is transmitted with in a time period of Ta and Tb, and any forwarding node within that route hears the packet will receive that packet as well and will respond by sending an acknowledgement to that node. If node 2 receives an acknowledgement form neighboring nodes it will send the packet and the node 2 will goes to sleep mode. The process gets repeated until it reaches its destination and based on priority the packet is send to the destination.

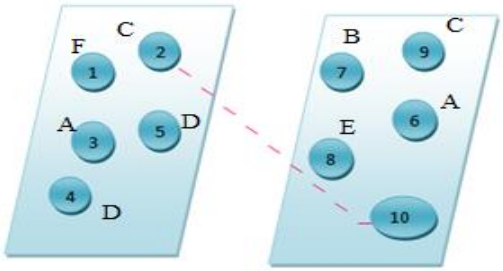

Fig. 3: Algorithm of opportunistic routing

The same amount of energy consumption has got different impact on sensor nodes with various residual energy means that the sensor nodes with less residual energy should more conservatively manipulate its energy. Opportunistic routing has got a main advantage that when the energy level of a sensor node goes low, another nodes can disperse energy to the group of forwarders. For example consider two nodes u and v and its residual energy is 8 and 2 respectively. After some time the energy level of node v will be drained out at that time a small energy consumed by node u will be significant for node v [9]. Here, energy cost is defined and calculated for that OECS (Opportunistic Energy Cost with Sleep wake schedules) metric is used. Its main goal is to minimize energy cost caused by each data transmission and also to balance energy usage to maximize the network lifetime.

Every sensor node has to take all the forwarder nodes OECS value in to consideration when computing its own OECS value so that end to end energy cost from a sensor node to sink can be calculated. By using this method, every sensor node considers the expected energy cost of the forwarding nodes from sensor node to sink. More specifically, the OECS value of node u is the expected energy calculated from node u to sink which is the summation of energy cost of its forwarders, energy cost at the time forwarding node receives data, energy cost of transmitting data from u, energy cost of receiving data by all awake forwarders, expected OECS value of node u's forwarders to sink, and the energy cost of retransmission.

$$OECS_u(F_u, P_u) = C_{prob} + C_{wake} + C_{tx} + C_{rx} + C_{fwd\text{-}sink} / P_{TS}$$

Once a sensor node receives the metric of its neighboring node it first calculates its own OECS metric and forwards that value to one hop neighboring node. Through this propagation each neighboring nodes in the network gets the OECS metric value. While a sensor node determines its forwarding set, the OECS metric of its neighboring nodes are given and by using greedy selection method the value is calculated.

Initially sensor node u sets it forwarding set to be empty. Then node u adds the neighboring nodes with less OECS value in to account and if there are more than nodes have the same value then based on priority the data is relayed. The sensor node's OECS value depends up on the residual energy and the OECS metric value of its forwarding set, so each nodes OECS metric value depends up on time.

By combining this two metrics a new method called ASSORT is introduced. The main problem that relies in this network is the nodes are placed in scattered mode. So it is difficult for sink node to identify a specific node and also it is difficult to form a routing path which is time consuming. By using this method energy saving can be done up to some imit.

III. CLUSTER HEAD BASED SLEEP WAKE SCHEDULING

In wireless networks cluster is a group of nodes which is generally considered to be a scalable method to manage large sensor networks and each cluster consists of a single cluster head (CH). The network sensors nodes can be managed locally by a cluster head in a cluster – a node elected to coordinate the nodes within the cluster and is responsible for communication between the

cluster and the base station or other cluster heads. Clusters provide a convenient framework for resource management, data fusion, and local decision making. Since in a cluster all the nodes will be wake state to communicate with the cluster head. In order to improve the energy saving and get a high packet delivery ratio (PDR), we use sleep & wakeup scheduling.

In WSN, each sensor nodes can aggregate all the clustering information which gives accurate results and is called as data aggregation. Then they are partition in to small groups like clusters and each cluster has a head known as C-H. Finally the packet transmission will taken place in between C-H as well as base station. Figure 4 shows the WSN architecture [11].

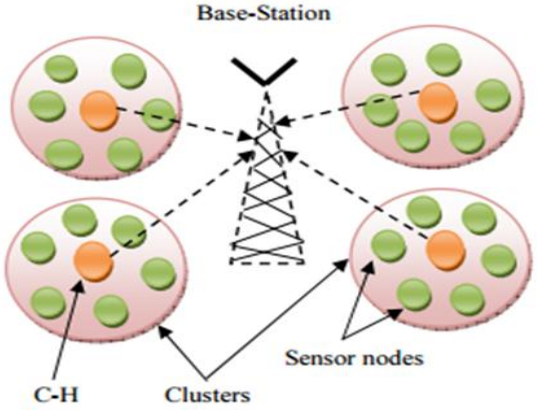

Fig. 4: WSN Architecture

So, in order to reduce this consuming energy by the nodes which are not capable of transmitting data or to communicate with in the cluster to the cluster head a sleep/wake scheduling technique is implemented in the network. Through this sleep/wake scheduling process, it is possible to conserve energy in the network. This is possible by dividing the node of a cluster into active nodes and the inactive nodes. The active nodes are the nodes which are with the high energy and which are capable of communicate with the cluster head and the inactive nodes are the nodes which are with the low energy and these nodes are not capable of communicating with the cluster head. These inactive nodes with the low energy are sent to the sleep mode. And the remaining nodes are kept in the wake mode which is capable of communication to the cluster head. Through this way it is possible to conserve the network energy and also it is possible to increase the network's lifetime[11].

In this approach, some nodes are considered as initiator nodes through which the cluster heads are decided. In each cluster, the cluster head selects a node with the highest energy and keep it in active mode and sends the remaining nodes into the sleep mode. Then again the initiator nodes collect the residual energies details of these clusters and compare with the standard threshold value. If the cluster energy is less than the threshold value then that particular cluster will be sent into the sleep mode. At the last, the transmission will be done by the active clusters to the sink node. Through this way it is possible to decrease the energy consumption of the network and increase the network's life time. By simulation results, it is proved that the proposed technique reduces the energy consumption and increases the packet delivery ratio.

IV. SIMULATION RESULTS

In this section, sleep wake scheduling and cluster head based method is evaluated. Simulation results shows that the energy is minimized and high packet delivery ratio is obtained by using cluster head based method. The simulation results obtained from scenarios is shown below.

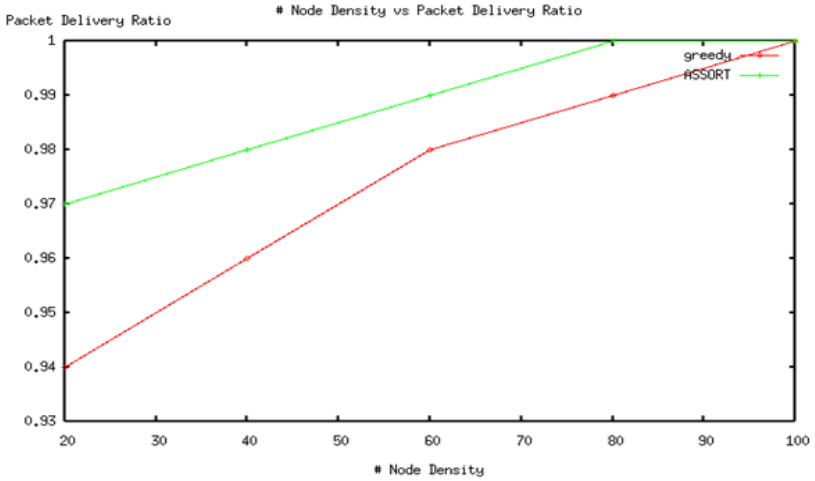

Fig. 5: Node density Vs Packet delivery ratio

In Figure 5 and Figure 6, we plot packet delivery ratio (ie, packets that are successfully delivered to destination with respect to number of packet that have been generated by the sender) of ASSORT and cluster based method. Figure 6 shows that packet delivery ratio of cluster head based method is higher than ASSORT method.

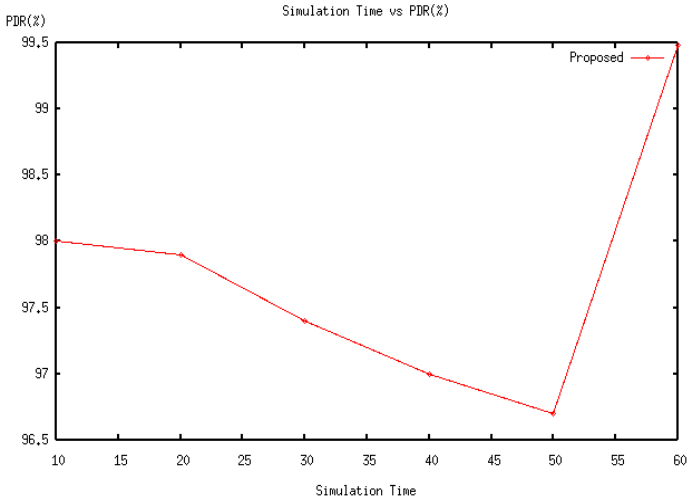

Fig. 6: Node density Vs Packet delivery ratio

In Figure 7, we plot initial energy versus network lifetime is plotted. It shows proposed method ie, cluster head based method is having higher network lifetime than ASSORT method. By simulation results, it is proved that the proposed technique reduces the energy consumption and increases packet delivery ratio.

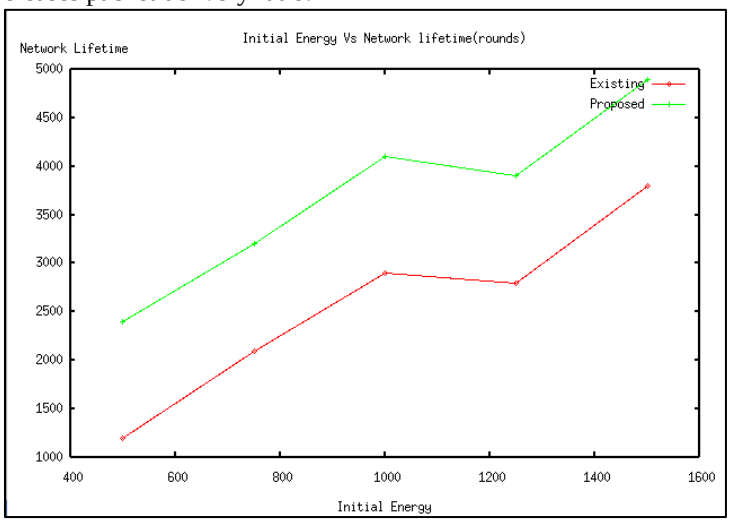

Fig. 7: Initial energy Vs Network lifetime

V. CONCLUSION AND FUTURE DIRECTIONS

To maximize the network lifetime of the network the path is selected in such a way that total energy consumed along the path is minimized and also lifetime of the network depends up on residual energy also. To support high scalability and better data aggregation, sensor nodes are often grouped in to clusters which create hierarchical WSNs which incorporate efficient utilization of limited resources of sensor nodes and thus extends network lifetime. Clusters even provides network scalability, efficient use of constrained resources that gives network topology stability and energy saving attributes and also reduce communication overheads thus decreasing the overall energy consumption and reducing the interferences among sensor nodes. A large number of clusters will combine in to small size clusters thus minimizes the area and small number of clusters will exhaust the cluster head with large amount of messages transmitted from cluster members.

By simulation results, it is proved that the proposed technique reduces the energy consumption and increases packet delivery ratio.

ACKNOWLEDGEMENT

We express our sincere gratitude to God Almighty for giving us strength and blessing us with his grace. We also thank the faculty members and students of our college for their valuable support. We also express our heartfelt thanks to C.-C. Hsu, M.-S. Kuo, S.-C.Wang, and C.-F. Chou, whose work inspired us to put forward the system.

REFERENCES

[1] Hsu C C, Kuo M S, Wang S C, and Chou C F, "Joint design of asynchronous sleep-wake scheduling, and opportunistic routing in wireless sensor networks," Tech. Rep. 09-2012, 2012 [Online]. Available: http://www.cmlab. csie.ntu.edu.tw/~kenneth/NTU-CSIE-09-2012.
[2] Park J and Sahni S, "An online heuristic for maximum lifetime routing in wireless sensor networks," IEEE Trans. on computer., 55(8), pp. 1048–1056.
[3] Wu Y, Fahmy S, and Shroff N, "On the construction of a maximum-lifetime data gathering tree in sensor networks: NP-completeness and approximation algorithm," in Proc. IEEE Conf. Comput. Commun. (INFOCOM), 2008, pp. 1013–1021.
[4] Chang J H and Tassiulas L, "Maximum lifetime routing in wireless sensor networks," IEEE/ACM Trans. Netw., 2004, 12(4), pp. 609–619.
[5] Kar K, Kodialam M, Lakshman T, and Tassiulas L, "Routing for network capacity maximization in energy-constrained ad-hoc networks," in Proc. IEEE Conf. Comput. Commun. (INFOCOM), 2003, Mar/apr 3, 1, pp. 673–681.
[6] Hung M C C , Lin K C J, Chou C F, and Hsu C C, "EFFORT: Energy efficient opportunistic routing technology in wireless sensor networks," Wireless Commun. Mobile Comput., 2013.13(8), pp. 760–773.
[7] Kim J, Lin X, Shroff N, and Sinha P, "On maximizing the lifetime of delay sensitive wireless sensor networks with any cast," in Proc. IEEE Conf. Comput. Commun. (INFOCOM), 2008, pp. 807–815.
[8] Diwakaran, "Energy efficient scheduling in wireless sensor networks," in International Journal of scientific engineering and research," ISSN (2347-3878), 2014, 2(1).
[9] Priyanka Lokande M and Thakare A P, "Maximization of Lifetime and minimization of delay for performance enhancement of WSN," in International Journal of Technology and Management, ISSN 1927-9000,2013, 2(1), pp 9-16.
[10] Sasikala V, Chandrasekar C, "Cluster based Sleep Wake up scheduling technique for WSN, " in International Journal of computer applications (0975-8887,2013, 72(8), PP. 15-20.
[11] Senthil M, Sivakumar P, "Sleep and wake up technique based clustering protocol performance evaluation in wireless sensor network, " in Journal of theoretical and applied information technology, ISSN 1992-8645, 2014.68(3).PP.572-78.