Energy Efficiency Under Cluster Based Lifetime Maximization Using S-MAC Protocol in Wireless Sensor Networks

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Abstract- **WSN application is rapidly increasing in a few decade years based on their capability for detecting and sending the data to one or more collection points in a network system comprised of spatially distributed devices such as sensor nodes to monitor physical or environmental conditions such as sound, temperature and motion. In WSN the data is gathered at a point called sink, based on various factors the energy utilized by each node at different paths may vary largely thus affecting the overall network lifetime. This becomes an major issue of a network system which can be obtained by Randomizingly switching the nodes and further enhanced using Scheduling techniques that adopts different listen and sleep schedules by using an S-MAC protocol.**

Index Terms- **wireless sensor network(wsn), network lifetime, s-mac protocol, clusters, energy efficient**

I. INTRODUCTION

A WSN comprises of several hundreds to thousands of nodes, capable of sensing the data, processing the information data locally and sending data to one or more collection points in a WSN. Efficient data transmission is one of the major issue for WSN, while they are deployed in a severe condition, neglected and often adversarial physical environments for certain applications such as health care monitoring chemical agent detection, Data logging, military domains and sensing task with trust less surrounding. Sensor nodes are small battery-powered devices with wireless communication capabilities and very limited resources. They operate unattended, as they may be randomly deployed over the sensing area due to the roughness of the terrain or even the inaccessibility of the physical environment. In most scenarios, sensed data are reported to a data collection point (called sink) by organizing the WSN into a data collection tree[1].As these sensor nodes are normally powered by batteries, there can only provide small and limited processing capabilities. The problem becomes very critical when these batteries are non rechargeable in practical errors and significant amount of power is spent for processing of required information. Thus a variant rate of depleted energy of the nodes are seriously hamper the networks efficiency and therefore its lifetime. The major case for energy loss are corruption during broadcasting of packets, idle listening i.e. listening to an idle channel in order to receive any possible traffic, overhearing of a node to receive some packets that are destined for other nodes, control packet overhead for data transmission set up, over emitting while transmission of a message when the destination node is not all ready for the changes.

Several type of protocols like TDMA and MAC [2] protocols are proposed to prolong the lifetime of WSN. Sensor-MAC protocol [S-MAC][3] is considered as the best performance in minimizing the power consumption. So the limitations by suing the synchronization of sensor nodes under a unified scheduled is been surmount by broadcasting the constant synchronized packets to the overall network so that all the nodes are updated with the data and can be communicated with each other under a single schedule. In this way, the network lifetime of all the nodes can be efficiently increased for a good performance.

II. RELATED WORK

Energy-efficient communication in WSNs has received significant attention in recent years. The following summarizes the research literature that is more closely related to our proposed solution. We first present general approaches related to lifetime maximization and load balancing, then focus on schemes specifically targeted to data collection trees. The main purpose of this paper is energy conservation which can be retained by a contention-based protocol which is exactly similar to IEEE 802.11. The flexibility of using this protocol is major concern or the efficient energy utilization in a network. The S-MAC protocol is a medium access control protocol identifies 3 major energy consumptions. These are: a) Collision which results in energy waste due to retransmission of collided packets. b) Overhearing that occurs when a node listens to transmissions which are not intended for it. c) Idle listening which occurs when a node listens to receive any possible data that is not sent.

A. Scheduling

Scheduling is done to minimize energy consumption. Minimizing energy in highly dense WSN needs to maximize off duty nodes. Scheduling is when to activate a sensor node and when to keep it idle. One approach based on sensor activity scheduling is to divide all sensors into disjoint sensor subset or sensor cover and each sensor cover need to satisfy the coverage constraints. Only one sensor cover is active to provide the functionality and the remaining sensors are in the sleeping mode. Once the active sensor runs out of energy then another sensor cover is selected to enter the active mode and provide the functionality and remaining sensor nodes are in the sleeping mode. The network activity can be divided in rounds, and at the beginning of each round active sensor nodes are decided. The objective was to minimize the number of active nodes in each time period. A Genetic Algorithm [4] is introduced for point coverage problems. An enhanced GA is proposed, aiming at solving disjoint set cover s problem for maximizing the lifetime. The Schedule Transition Hybrid Genetic Algorithm (STHGA) can be applied to both point coverage and area coverage disjoint set cover problem for maximizing lifetime of network. STHGA has a special feature that it adopts a forward encoding scheme for the representation of chromosomes in the population and uses some effective genetic and sensor schedule transition operations.

B. Energy efficient routing

Extensive research has been done on energy efficient data gathering and information dissemination in sensor networks. Some well-known energy efficient protocols were developed, such as Directed Diffusion [5] and LEACH [6]. Recently, a clustering architecture is used to improve the lifetime of two-tiered sensor networks. The proposed approximation algorithm [8] starts with an arbitrary tree. And iteratively reduces the load on overloaded nodes. Constructing data gathering trees in both grid and general graphs was studied in [7]. Authors proposed a Minimal Steiner Tree based algorithm which provides a constant approximation ratio for grid graphs, and a randomized algorithm which guarantees a poly logarithmic performance bound for general graphs.

C. On/off scheduling

Another important technique used to prolong the lifetime of sensor networks is the introduction of switch on/off modes for sensors. The best method for conserving energy is to turn off as many sensors as possible, while still keeping the system functioning. An analytical model was proposed in [9] to analyse network capacity and data delivery delay, against the sensor dynamics in on/off modes. The proposed algorithm [8] achieves 0.73 of the maximal lifetime. The on/off scheduling was studied in target (point) coverage in wireless sensor networks. The problem is to find the maximum number of subsets of sensors (a sensor can appear in several subsets), such that each subset can sufficiently cover all targets in the region. Existing work has studied scheduling sensors into a sleepsense cycle based on simple greedy criteria or by using centralized optimization techniques. The improved distributed algorithms can be designed by paying attention to the inherent dependency that exists between different cover sets since they share sensors in common. These heuristics represent a 20-30% increase in the network lifetime over the existing work which uses greedy criteria to make scheduling decisions. In [10] a node scheduling scheme is proposed which can reduce system overall energy consumption by turning off some redundant nodes. A framework [11] is proposed to maximize the lifetime of the wireless sensor network (WSN) by using a mobile sink when the underlying applications tolerate delayed information delivery to the sink. Within a prescribed delay tolerance level, each node does not need to send the data immediately as they become available. Instead, the node can store the data temporarily and transmit them when the mobile sink is at the most favourable location for achieving the longest WSN lifetime. To find the best solution within the proposed framework, we formulate optimization problems that maximize the lifetime of the WSN subject to the delay bound constraints, node energy constraints and flow conservation constraints.

III. PROBLEM FORMULATION

Network lifetime can be defined as the capability of a network to serve its design purpose or the lifetime of the network is defined as the amount of time that the network can satisfy its coverage objective, i.e., the amount of time that the network can cover its area or targets of interest. Having all the sensors remain "on" would ensure coverage but this would also significantly reduce the lifetime of the network as the nodes would discharge quickly. There can be mainly two approaches to maximizing network lifetime. An indirect approach to minimize energy consumption. Another one is direct approach to maximizing network lifetime.

A. Indirect approach

This approach focuses on minimize energy consumption, and help in extending the network lifetime but it does not precisely address the problem of maximizing lifetime. Recharging of a node battery is generally possible. Although solar and wind energy can be used, such energy supplies are not reliable. So we use indirect methods by reducing energy consumption. Scheduling the sensing activity mean when to activate a sensor activity for sensing and when to keep it idle. One approach based on the sensor activity scheduling techniques is to divide all sensors into disjoint sensor subsets or sensor covers and each sensor cover need to satisfy the coverage constraints. Only one sensor cover is to activate to provide the functionality and the remaining sensor covers are in the sleeping mode.

1. Packet based model

In this model we assume that power only consumed when transmitting packets in Wireless network. Wireless nodes are powered to receive incoming packets and decode to decide if the packet should be accepted, forwarded or discarded. Although many packets turn out to be simply discarded, their reception has already consumed a significant amount of energy. In packet based model network lifetime is considered as number of packet that can be delivered by the network.

2. Time based model

This model states the energy is also consumed in overhearing and idle periods. In some extreme cases where Wireless nodes stay idle and no communication happens at all energy is consumed in idle period on a per time unit basis. So we need to turn off as many transceivers as much as possible. To put it off means to switch to sleep mode. In sleep mode we can avoid energy in overhearing and idle state. Communication is done by a backbone composed of nodes that are not in sleep mode .A sleeping node awakes when needed, that part of energy consumption can be handled by packet based model. In this model network lifetime is defined as the time until no such backbone can be formed.

B. Direct approach

This approach directly focus on maximize network lifetime by considering battery allocation.WSN lifetime depends on the distribution of power among nodes in addition to average power consumption. The locations of sensor nodes are often carefully controlled in real deployment in order to reduce the cost. It is feasible to equip nodes with battery packs with different capacities based on their computation and communication requirements. In [12] author proposed the motivation towards battery allocation for WSN with arbitrary topologies, node configuration and power distribution. WSN lifetime depends on the distribution of power among nodes in addition to average power consumption. There is a large body of work on reducing node power consumption.

The most frequently described techniques are power state control [13], hardware –software co-design [14], as well as clustering and compression [15].Work attempting to spatially balance power consumption and communication tasks more evenly among sensor nodes. However real WSN deployment may use heterogeneous sensor nodes.

For example Hou.et. al [16] deployed heterogeneous sensor nodes to construct a two tier infrastructure to prolong WSN lifetime. Furthermore the locations of sensor nodes are often carefully controlled in real deployment in order to reduce the cost. It is feasible to equip nodes with battery packs with different capacities, based on their computation and communication requirements.

IV. DATA TRANSMISSION AFTER SYNCHRONIZATION OF BORDER NODE

The scheduling mechanism of S-MAC illustrates that each node has its own schedule generated randomly. It will then wait for a given time and if it fails to receive a SYNC packet, it will set its own schedule and broadcast its SYNC packet to the neighbour nodes. The neighbour nodes will receive the SYNC packet and use that schedule to get synchronized, but the whole network is not unified under same schedule. Therefore an independent schedule cluster having an independent schedule gets to be made and a node between heterogeneous schedules gets to receive SYNC packets which are different from one another and work as a border node [17]. As shown in the figure, the border node adopts and handles both the schedules and creates a link between the virtual clusters. Therefore, it has to be in the listen state twice and the power consumption will be twice of a general node. If the border node dies out quickly, the clusters will not be able to interact with each other and no data transmission will take place between them. Thus the power consumption of the border node will increase in proportion to the number of different schedules adopted by it. In the existing S- MAC code, this problem is somewhat minimized as the border node will only adopt one schedule depending upon the SYNC packet received first. However, this does not change the longevity of the border node as it stays in the listen state for a longer time.

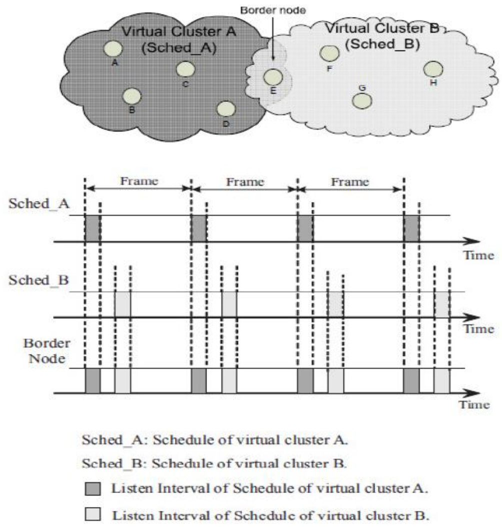

Fig.-1: Border Node adopting and handling both the schedules

V. EXISTING SYSTEM

Source authentication schemes found in the literature can be classified into three categories: The asymmetry property denotes that a receiver can verify the message origin using the MAC in a packet without knowing how to generate the MAC. This property is the key for preventing impersonation of data sources.

- Secret information asymmetry,
- Time asymmetry, and
- Hybrid asymmetry

Secret information asymmetry

In secret information asymmetry every node is assigned a share in a secret, e.g., a set of keys. A source appends MACs for the multicast keys so that a receiver verifies the authenticity of the message without being able to forge the MACs for the other nodes. The challenge in using this category of approaches is striking the balance between collusion resilience and performance impact. While the use of a distinct MAC per node imposes prohibitive bandwidth overhead, relying on the uniqueness of the key combinations risks susceptibility to node collusion.

Time asymmetry

The main idea behind time asymmetry is to tie the validity of the MAC to a specific duration so that a forged packet can be discarded. One-way hash chains are usually employed to generate a series of keys so that a receiver can verify the current key based on an old key without being able to guess the future key. However, it requires clock synchronization among the communicating parties in order to prevent accepting forged packets, or discarding authentic packets.

The communication between nodes takes place when S-MAC protocol exchange packets that starts with Carrier Sense (CS) to avoid collision. Then followed by Read to Send and Clear to Send (RTS/CTS) packets exchanged for unicast type data packets shown in the Fig-2. Upon successful transmission of these packets data communication takes place.

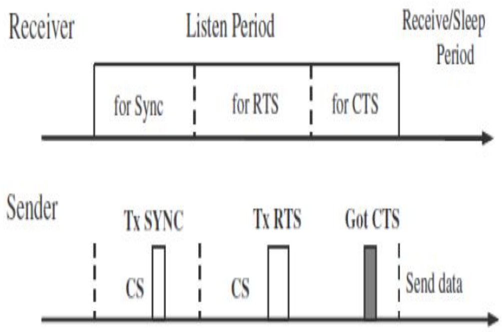

Fig.-2: S-MAC Messaging Mechanism

In [17], the nodes in WSN with S -MAC protocol keep on the listen state for 10 seconds in every 2 minutes. The node is not engaged in transmission or reception if S-MAC is in the sleep state or if its neighbours are involved in communication. The sleep state exits in S-MAC protocol to reduce collision and overhearing. The node wakes up at the end of its neighbour's transmission to relay the packets. This task is performed by overhearing neighbour's RTS and CTS exchanges and then the node goes to sleep and serve the purpose of reducing latency. This behaviour of S-MAC protocol is called *adaptive listening* and the technique for optimizing power consumption is *message passing*. Since all the immediate nodes have their own sleep schedules, periodic sleep may results in high latency. The latency caused by periodic sleep is called *sleep delay*. Schedules are periodically exchanged by broadcasting SYNC packets among neighbouring nodes. The SYNC packet is very small and includes the address of the sender and the time of its next sleep. As soon as, a receiver gets the time from the SYNC packet it subtracts the packet transmission time and use the new value to adjust its timer. Due to the inconsistent of time cycle, different virtual clusters are formed. The communication between these virtual clusters takes place when a common node between them adopts both the schedules. In this way, the border nodes are listening for a longer period of time and die out quickly. There are two main reasons of multiple scheduling in a single network. Firstly, when nodes establish their own schedules, some nodes are situated far away and cannot hear each other's schedules. Secondly, if two nodes broadcast their schedules at the same time, collisions may take place. In both the situations, the nodes must now choose their own schedules.

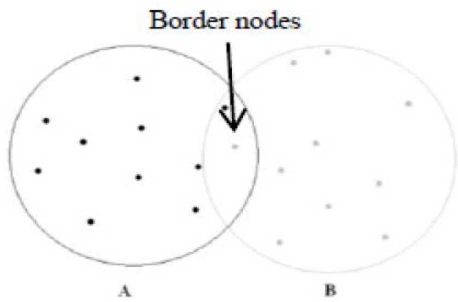

Fig-3: Border node and Virtual Cluster

VI. PROPOSED SYSTEM

We propose a Sleeping schedule algorithm with an S-MAC protocol which minimizes the energy more efficiently. Whenever the sensor node is not utilized by Wireless Sensor Network system the node will go to a sleep mode and when it is utilized it uses its energy very efficiently so the maximum network lifetime is achieved by randomly switching the nodes in a network design and adds appropriate reads to reveal as many violations as possible. Our key contributions are as follows: 1) We present a novel energy efficient as a S-MAC protocol with a test bed where a group of nodes in a network identifies which node is in sleep mode rather than utilizing its energy unnecessarily. 2) We have highlighted the challenges of wireless sensor network which will increase the network lifetime that as lifetime can be considered as the time model, or as packet model 3) We design algorithms to randomly switching the nodes in a network with an minimum energy utitlized by using an S-MAC protocol and some of the various direct and indirect approaches for maximizing network lifetime.

a) Advantages:

1. As a rising subject Wireless Sensor Network, the energy of each sensor node is playing an increasingly important role in maximizing the lifetime of the whole network which will increase the performance of the network and the throughput is achieved with the lower convergence time and also the lower overhead.
2. The increase in the network lifetime with a lower time complexity than the current state of the art in a wide range of operating conditions by considering different network parameters like density, degree etc.

VII. SYSTEM ARCHITECTURE

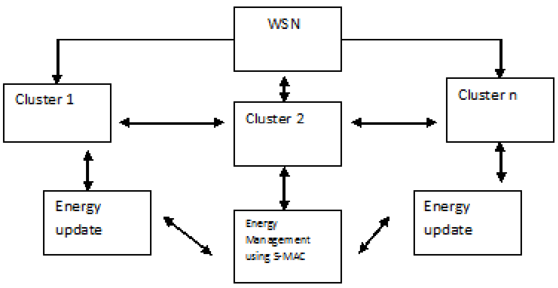

Fig-4: System Architecture

A. Network design

An ad-hoc network is a collection of autonomous nodes that together set up a topology without the support of a physical networking infrastructure. Depending on the applications, an ad-hoc network may include up to a few hundreds or even a thousand nodes. Communications among nodes are via multihop routes using omni directional wireless broadcasts with limited transmission range. It is assumed that clusters are established securely by using pre-distributed public keys, employing a robust trust model, or applying identity based asymmetric key-pair cryptographic methods, and that a proper key management protocol is followed in order to perform re-clustering when needed. Clustering is a popular architectural mechanism for enabling scalability of network management functions.

- **Cluster Head Election using Energy Efficiency**

This is used to choose one among a set of nodes in each cluster as a cluster head based on the remaining battery power. If all nodes have the same battery power then the node which is closer to the destination is chosen as the cluster head.

B. Cluster head design

Each cluster is controlled by a cluster-head, which is reachable to all nodes in its cluster, either directly or over multi-hop paths. Nodes that have links to peers in other clusters would serve as gateways. The presence of gateways between two clusters implies that the heads of these clusters are reachable to each other over multi-hop path and that these two clusters are considered neighbours. If a node moves out its current cluster and joins another, it is assumed that the associated cluster-heads will conduct a handoff to update each other about the change in membership of their clusters; other cluster-heads will not be involved in the handoff events outside their clusters.

Level 0:

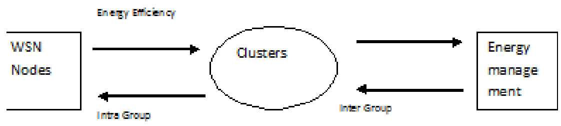

Fig-5: Level 0 data flow diagram

Level 1:

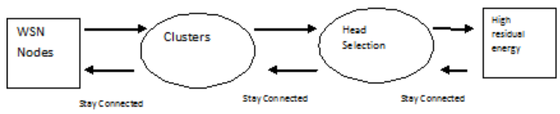

Fig-6: Level 1 data flow diagram

As shown in the above fig.5 each node in a WSN have some initial energy that can be utilized based on the packet transmission under a specified path. So the clusters would be formed with a minimum of 2 nodes and maximum of 6 nodes and the cost of each node is been calculated. In a Cluster a Cluster Head is been selected based on their energy constraint ie the High Residual Energy as in fig.6.

C. ENERGY MODULE

The energy model updates the total energy consumed by the entire network but does not maintain the radio states. The old energy model indeed was maintaining some of the radio sates, and had some methods to manipulate them accordingly, and they were mainly used by the adaptive fidelity module. So this approach had a problem with inconsistency in wireless-phy. To keep adaptive fidelity work, we did not remove it from the energy model, but it is obsolete, and should not be used further. Now all access to the energy model should go through wireless-phy.

VIII. EVALUATION STUDY

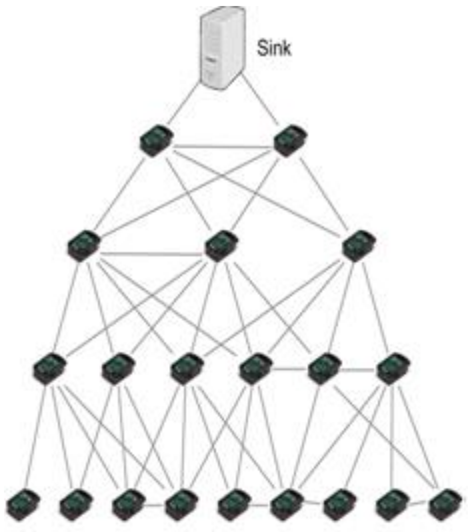

Fig-7: Connectivity graph of the network

The physical topology of the sensor nodes, along with the corresponding connectivity graph, is illustrated in fig.7. The sink was represented by a workstation using a wireless sensor node as a gateway. The sink collected the data from the whole network and processed them to obtain the metrics of interest of interest. The sensor nodes used their default Medium Access Control(MAC) protocol, namely, a carrier-sense multiple access scheme with collision avoidance and a duty-cycle mechanism for energy conservation. The latest version of MAC ie S-MAC is been used for better utilization of energy.

IX. CONCLUSION

In this paper, we present an energy efficiency of each sensor node in a Wireless Senor Network using S-MAC protocol under the concept of Clusters and the problem of diversified scheduling in WSN is been overcome. The border nodes in between Virtual Clusters broadcast Uni-Scheduling packets which synchronize the network under a single schedule. The energy is efficiently being utilized as shown in the connectivity graph using S-MAC protocol.

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