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A Novel Study on Data Forwarding Mechanism with Improved Sleep Scheduling in WSN

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Abstract: Power saving is an important issue in WSN now days. For minimizing the power usage, the nodes get switching to sleep mode. So, the main objective of this work is to design an improved algorithm for sleep scheduling in WSN. It will provide the concept of synchronous and asynchronous sleep scheduling. It will also provide the concept of adaptive duty cycle and also provides optimization of energy. In this, it will formulate the routing problem as shortest path problem. The proposed mechanism will be implemented with MATLAB.

Keywords: WSN System, Sleep awake cycle, Route Management, Sleep Scheduling etc.

I. INTRODUCTION

Consider a wireless sensor network deployed for the detection of rare events, e.g., forest fires, intrusion in border areas, etc. To conserve energy, the nodes in the network sleep-wake cycle whereby they alternate between an ON state and a low power OFF state. An important class of wireless sensor network applications is the class of continuous monitoring applications. These applications employ a large number of sensor nodes for continuous sensing and data gathering. Each sensor periodically produces a small amount of data and reports to one (or several) base station(s). This application class includes many typical sensor network applications such as habitat monitoring [1] and civil structure monitoring.

A sensor dies when its energy source gets depleted and thus a WSN may be structurally damaged if many sensors exhaust their onboard energy supply. So the deployment of sensor node should be done in an optimal manner such that full coverage of the monitored area should be ensured. Although sensor nodes are identical devices but their characteristics varies with the network structures. Sensor deployment, coverage, transmission power, computation, reporting, addressing and communication pattern greatly affects the routing protocol operation both at nodes and at base stations [2].

There are several major sources of energy wastage in the MAC layer of WSNs which should be minimised to achieve greater energy efficiency. The first is idle listening, which occurs when the radio transceiver is active while there is no data to transmit or receive. It has been studied that sending and receiving packets of various sizes indicate that the power consumed when the interface is active or idle is virtually identical [4].

A usage scenario commonly analyzed for wireless sensor networks is the tracing of a tagged object through a region of space controlled by a sensor network.

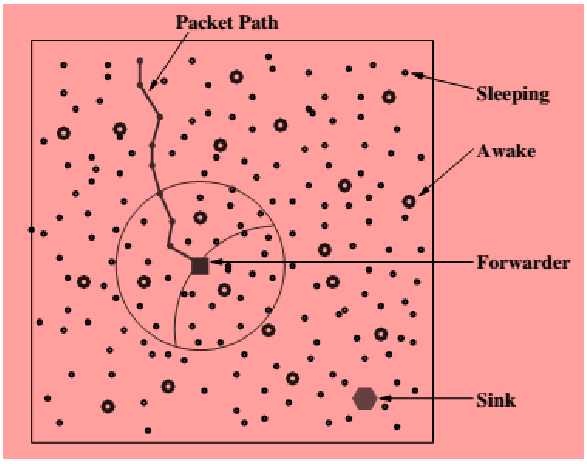

Fig 1: Packet Forwarding by Sleep Awake Cycling in Network [1]

There are various situations where one would like to trace the location of valuable possessions or personnel. Current control systems attempt to track objects by recording the last check point which an object passed through [5].
Duty cycling is a technique that increases energy efficiency by allowing a node to turn off part or all of its systems for periods of time. Encompassing a range of techniques from peripheral management to almost complete system shutdown, duty cycling extends node lifetime and reduces maintenance. It has been shown that duty cycling can extend battery life by an order of magnitude or more. In WSN, duty cycling is pervasive and almost all deployed systems integrate it.

The rest of paper is ordered as follows. In section II, we discuss the related work of dynamic reconfiguration system in WSN networks. In Section III, It defines general reconfiguration scheme. In Section IV, it describes proposed work of system. Finally, conclusion is explained in Section V.

II. LITERATURE REVIEW

Some authors investigated how to optimize the network lifetime of delay-sensitive WSNs with respect to energy efficient routing and sleep scheduling. Instead of treating routing and sleep scheduling as two separate approaches, they have a joint consideration of them, and mathematically devise the lifetime maximization problem under multiple constraint (i.e. routing, end-to-end delay bounds, sleep scheduling, energy consumption of transmission, receiving and listening, etc.). Since the formulated problem is a mixed integer non-linear programming (MINLP) problem and NP-hard to solve, they relax it into a linear programming (LP) problem and solve the relaxed problem for the upper bound.

Some proposed routing algorithm (Resistance Distance Routing algorithm, RDR algorithm) which optimizes the routing path based on the theory of resistance distance in electricity. This paper describes the whole process of RDR algorithm in detail, and simulates it with MATLAB. Simulation results show that RDR algorithm is superior to the GEAR (Geographical and Energy Aware Routing) algorithm both in the efficiency of energy consuming and the sturdiness of the network.

Some presented an approach for scheduling of sensing nodes using a tree and proposed an energy aware routing protocol in this scheme. The tree was acted as a sink node. The tree could be reconstructed with consideration of energy balance and can remove any failure nodes from that tree. The proposed scheme also reduced average energy consumption rate of nodes since they were able to put more number of nodes in sleep with comparison to other schemes.

Some presented a new protocol for routing taking the concept of swarm intelligence. In this, they provided many investigation schemes for routing protocols using different swarm intelligence. After this, they provided a comparison on the basis of energy efficiency, lifetime, fault detection, scalability, success rate etc. These swam based protocols can remove several problems like battery life, maintainability, survivability, adaptability etc.

Some proposed an energy efficient protocol called Enhanced Energy Efficient Chain-based Routing Protocol in WSN. In this work, they minimized energy consumption and transmission delay. They organised these sensing nodes as horizontal chains & vertical chains. The Head was selected on the basis of remaining energy of nodes and distance from head of upper level. In this scheme, each sensing node transmitted its data to its head. The simulation results showed that EECRP outperforms PEGASIS, ECCP and EECRP in terms of network lifetime, energy consumption.

Some presented some general data forwarding algorithm that can be set so that delay can be minimized. To provide a solution, each node provided a route to sink node. The main metric used for this problem is based on the end-to-end total cost objective. The starting node that forwards the data is uncertain about its no. of relays, their wake up time and rewards but only knew about probability distribution of these quantities. At each wake up point, when relay shows its rewards, the node was to forward its data or to wait for other relay to wake up.

Some presented routing performance in duty-cycled wireless sensor networks. They focussed on improving the performance of greedy forwarding under sleep scheduling. They provided simulations and results that showed that they can shorten the length of transmission path of greedy forwarding as compared to other connected sleep algorithms.

III. SLEEP AWAKE CYCLE IN WSN

A sensor node consumes battery power in the following four operations: sensing data, receiving data, sending data, and processing data. Generally, the most energy consuming component is the RF module that provides wireless communications. Consequently, out of all the sensor node operations, sending/receiving data consumes more energy than any other operations. The energy consumption for transmitting 1 bit of data on the wireless channel is equivalent to the energy required to execute thousands of cycles of CPU instructions. Therefore, efficient use of energy in WSN communication protocols extends the network lifetime.

The major design objective for wireless sensor network applications is to minimize the energy consumption in order to maximize network lifetime. To improve a sensor network's reliability and extend its longevity, sensor networks are deployed with high densities. However, if all sensor nodes in such a dense deployment scenario operate at the same time, energy will be consumed excessively. Also, packet collisions will increase as a result of the large number of packets being forwarded in the network. In addition, most of the data forwarded in the network will be redundant since when node density is high, sensing regions of the nodes will overlap and the data of adjacent sensor nodes will be highly correlated.

A practical sleep scheduling algorithm should both choose the minimum number of active nodes and satisfy user defined constraints. The non-sleeping nodes must be chosen so that they are connected to the sink and they provide some minimum coverage of the network field. User defined constraints may vary depending on the application type. F or instance, the user may want the network to be connected and provide some minimum coverage for as long as possible or the user may want the network to be connected and provide full coverage of the network field while ensuring some minimum delay in gathering data.

Besides, the sleep scheduling algorithm must be simple, distributed and localized. It must be applicable to many kinds of networks with minor modifications. Due to the distributed nature of sensor networks, it must be a distributed approach and it should only use local information since each node has a limited transmission range. It is also desirable not to require any location information since it is very costly for a sensor network. Although sleep scheduling is not a new approach to

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extending network lifetime, there is almost no work satisfying all these requirements simultaneously.

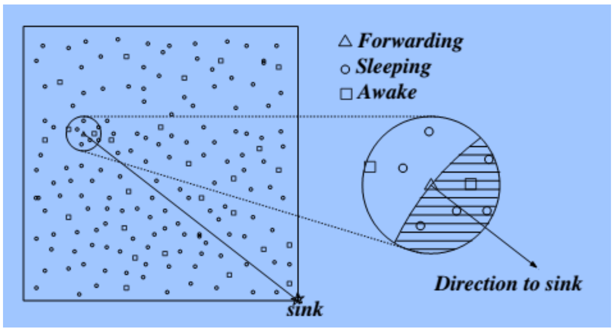

Fig 2: Description of Local Forwarding in Network

The purpose of sleep scheduling techniques is to save energy and prolong network lifetime. Several protocols have been proposed to reduce the energy consumption using sleep scheduling methods. This section describes the fundamental asynchronous and scheduled sleep techniques. Asynchronous sleep techniques aim to keep the radio in default sleep mode and wake-up briefly to check for traffic or send/receive messages. In the design, each sensor node is equipped with two radio transceivers. The primary (data) radio remains asleep by default. The secondary radio is a low-power wake-up radio that remains on at all times. When the secondary radio receives a wake-up signal from another node, it instructs the primary radio to wake up for data transmission. This method assumes that an extremely low power radio can be used as a secondary radio.

Sleep scheduling techniques aim to reduce energy consumption by synchronizing sleep schedules and enable lower duty cycles. S-MAC, T-MAC, and D-MAC are the most well-known WSN sleep scheduling techniques. Sensor MAC (S-MAC) provides a tunable, non-adaptive, periodic active/sleep cycle for sensor nodes. During sleep periods nodes turn off their radios to conserve energy. During active periods nodes turn on their radios to exchange data. During the initialization phase nodes remain awake and listen for sleep schedules from neighbours. If they do not receive a sleep schedule, they create their own schedule and start broadcasting it.

It is assumed that each sensor node has Ns − 1 neighbouring sensor nodes within its maximum transmission range of a total of Ns sensor nodes that are present within the WSN. The duty cycle of the sensor node shall be denoted as d. Where Pr is denoted as the probability that the preamble and the duty cycle overlap with each other is p + d when p + d<1, the probability that the preamble and the duty cycle overlap with each other is 1 when p + d >1. This is given by

$$\Pr(X = n) = \binom{N}{n}(p + d)^n(1 - p - d)^{N-n}$$

With the expected value of X equal to

$$E[X] = N_S . \min(p + d, 1)$$

Where Ns is the total number of sensor nodes within the transmission range

$$N_S = \lambda\pi R^2$$

Where λ is the estimated sensor node density. Therefore, the duty cycle d can be expressed as

$$d = \frac{n - \lambda\pi R^2 p}{\lambda\pi R^2} \; (p + d < 1)$$

IV. PROPOSED SYSTEM IN WSN

Sensor nodes are assumed to be stationary in most of the network architecture. If not it is more challenging to route messages between moving nodes depending on the application: the sense event can be dynamic or static. Traffic is generated only when reporting has to be done in static events; on the other hand most application periodic reporting is required in dynamic events, resulting in the generation of significant traffic that has to be routed to the base station. One of the factors that affect the performance of routing protocols is the deployment of sensor nodes, which is either deterministic or self-organizing.

In WSN, all nodes consume energy while data transmission. So, due to this mostly nodes gets dead after some time and it causes less throughput and increase energy wastage. So, there is a scope of energy efficiency under sleep awake cycle in WSN. Also in synchronous sleep protocol, all nodes gets awake at a time so it causes amount of energy is wasted. So, there is a need to develop improved on demand sleep scheduling routing algorithm for energy conservation in WSN using MATLAB. To improve the synchronization precision and reduce the communication overhead in large sensor networks, we propose to deploy multiple source nodes in the network, so that the sensor nodes can synchronize to the nearest source node. Our goal is to provide secure synchronization so that even if a certain number of malicious nodes collude together to disrupt clock synchronization, each normal node can still synchronize its local clock to the source node. The basic idea is that each node is allowed to wake up independently of the others by guaranteeing that neighbouring sensor nodes always have overlapped active periods of time within a specified number of cycles. One of the advantages of this protocol is that a sensor node can wake up at any-time when it wants to communicate with its neighbouring sensor nodes. There is no need to exchange extra synchronization information unlike in the synchronous protocols so that the energy efficiency is improved. In order to reduce the end-to-end latency with energy efficient data transmission proposed an Asynchronous Wakeup Schedule in WSNs.

In this scenario the following assumptions are also made: Each sensor node with a asynchronous sleep/wake scheduling wakes up for a active period and enter into the sleep mode of length ts, the scheduling of the sleep and awake periods of each sensor node is independent. The general scheme for the sleep &wakeup procedure is that each sensor node selects a starting time between 0 and Tperiod randomly and each node follows its own wakeup schedule for the succeeding periods. For ease let's assume that Tperiod is equal to 1. The duty cycle is defined as the percentage of time a node is active compared the time for one period Tperiod.

The On-demand Protocol

The on demand protocol is one of the types of power management protocol. This protocol is based on the fact that a sensing node should be in the sleep mode or off when there is no data packet to transmit or receive. As soon as there is a data packet that needs to be transmitted or received the sensor node will become active and will be in on state. In this way sensor nodes interchange between sleep & active periods depending on network action. The outcome is that sensor do not waste energy by unnecessary transmissions and unnecessary sensing & hence the energy consumption is minimized.

The Scheduled Rendezvous Protocol

The second power management protocol is called scheduled rendezvous protocol. It belongs to the synchronous protocols since it requires all neighbouring sensing nodes to wake up at the same time. In Figure, the sleep scheduling of sensor nodes using a scheduled rendezvous protocol is shown. In this approach sensor nodes wake up according to a wakeup schedule and remain active for a short time interval to communicate with their neighbours. After the transmission of the data the senor nodes will go to sleep until the next time. The main advantage of this protocol is that it is definite that if a sensor node is awake that all its neighbouring sensor nodes are awake as well. It is very convenient for data aggregation and allows sending broadcast messages to all neighbours.

The Asynchronous Protocol

The last algorithm that is used is the asynchronous protocol. In this, each node is allowed to wake up independently of the others by providing assurance that neighbouring sensor nodes always have overlapped active periods of time within a specified number of cycles. The main advantages of this protocol are that a sensing node can wake up at anytime when it wants to speak with its adjacent sensing nodes. Therefore, in these protocols there is no need to exchange extra management information unlike in the synchronous protocols so that the energy efficiency is enhanced. In contrast with the scheduled protocol, it is not possible to broadcast a message to all neighbouring sensor nodes in one period of time. Though each sensor node is able to get in touch with any of its adjacent sensing nodes in a finite amount of time, it almost never happens that neighbours are simultaneously active.

V. CONCLUSION

Wireless Sensor Networks (WSNs) have progressively changed the way to monitor the environmental and industrial phenomena over the last two decades. Since these networks use wireless channels, the medium access control is of pivotal importance. Asynchronous protocols are widely used for relaxed traffic load conditions in multi-hop WSN, notably for periodic, on-demand, and event-driven applications. All nodes consume energy while data transmission. So, due to this mostly nodes gets dead after some time and it causes less throughput and increase energy wastage. So, there is a scope of energy efficiency under sleep awake cycle in WSN. Also in synchronous sleep protocol, all nodes gets awake at a time so it causes amount of energy is wasted. So, there is a need to develop improved on demand sleep scheduling routing algorithm for energy conservation in WSN using MATLAB.

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