Location-Based Sleep Scheduling of Event Driven Sensor Node in Wireless Sensor Networks

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Abstract: *Wireless Sensor Networks (WSNs) contains of sensor nodes and the sensor nodes are capable collecting, sensing and gathering data from the environment. These networks have broad application in disaster management, habitat monitoring, security, and military, etc. Wireless sensor nodes are tiny in size and small battery power and have limited processing capability. Sleep scheduling is a very important technique in WSNs and helps in reducing the energy consumption by reducing use of sensor nodes. The main aim of sleep schedule to collect data in an energy efficient manner and due to this, the network lifetime is improved. Sleep scheduling plays a significant role in extending network lifetime. Existing sleep scheduling algorithms cause an extremely unbalanced energy usage, and due to this, some sensors reduce the overall network's lifetime. The proposed system uses a sensor node to which event occurs and transmits data to base station and its neighbor nodes in a particular area of WSN and which improves energy efficiency. The sleep scheduling based on the location of node minimizes the power consumption of WSN. The simulation result shows that the resulting representative data achieved using the proposed algorithm have better throughput and average energy consumption than those achieved using CLSS1 and CLSS2 algorithms.*

Keywords—*Sleep scheduling, energy efficiency, wireless sensor networks.*

I. Introduction

Wireless Sensor Network (WSN) consists of a spatially distributed autonomous sensor to monitor environmental or physical conditions, such as sound, temperature, pressure as well as cooperatively moving their data through the network to a destination. Wireless sensor network composed of self-organized wireless sensor nodes distributed in a monitored area and which gathers processes and transmits data obtained from the environment. The primary goal of a WSN is accurately evaluating and reliably detecting the occurrences in the monitored area with the gathered data. If every sensor node transfers collected data to the sink node, then the sensor nodes would consume much more energy.

The wireless sensor network is the gathering of wireless sensors which communicates each other by sending and receiving data. These sensors are little devices and are distributed in a large geographical area called as a sensing field. It has the sensing ability to sense some environmental conditions, processing capacity and also has memory to store the data. The role of the sensors is to identify the environmental conditions, process the data and send that information to the base station [1]. There are different kinds of sensors such as seismic, visual, infrared and thermal sensors. These sensors monitor a variety of conditions such as humidity, temperature, characteristic of the object and their motion. These different sorts of sensors are used in many applications like the flood or fire detection, measuring temperature, smoke detectors, soil makeup, humidity in the air, pressure, vehicular movement, noise levels or mechanical stress levels. It can also be used in military, chemical processing, and disaster, health, relief scenarios. There are many issues related to the sensor network. For example- transmission policies, orderly transfer, flow and congestion control, power consumption, fairness, loss recovery, quality of service, energy efficiency, reliability. Congestion and transmission policies are a major issue on which the rate of power consumption depends [1].

Sleep scheduling in a WSN is the method of deciding which nodes are appropriate to sleep (enter power-Saving mode) after casual deployment to conserve energy. Sleep Scheduling is an important technique in WSNs and helps in reducing the power consumption is one of the simple procedures for saving the energy of node and is an efficient way to save the limited resources. The primary purpose of Sleep Scheduling is to gather, collect and transmit the data in an energy efficient manner so that the network life is improved. Sleep Scheduling enhances the lifetime of sensor nodes by sleeping them for some time.

The remainder of the paper is arranged as follows: Section II gives an overview of related work already done on sleep scheduling. Section III includes proposed methodology. Section IV includes experimental setup and required parameters for simulation. Section V includes results and discussion. Section VI involves a conclusion and future scope.

II. RELATED WORK

The primary constraints of WSN are little power and minimum processing. The nodes in WSN have to self-organize as per the user's requirements to monitor environments. The sensor nodes deployed in an unreachable location for the particular mission. It is hard to exchange or recharge the node's battery. Well-organized utilization of power is required to increase the lifespan of Wireless Sensor Network. Thus Harshal D. Misalkar at al. proposed the mechanism for Cluster head selection using basic information of node and objective function in [2]. In all algorithms, data processing can do at the Cluster Head(CH), which use the huge amount of energy because power consumption depends on the length of the packet which is transmitted and the distance between nodes to CH's and CH to BS. The proposed work reduces the length of the packet by processing the data at the node. Three steps presented: 1) A collection of the sensed data from all the nodes in the cluster. 2) Data Aggregation. 3) Send this aggregated data to the Base Station using single hop or multi-hop.

In [3], there are some natural restrictions of WSNs (e.g., network connectivity, network life) due to the static system style in WSNs. Moreover, more and more application scenarios need the sensors in WSNs to be movable rather than static so as to create traditional works in WSNs are smarter and allows some new applications. All this lead the mobile wireless sensor networks which can significantly promote the growth and usage of WSNs. MWSNs are the types of wireless networks where small sensors move in space over time. There are four possible mobile subjects in MWSNs such as free base stations, are sensor nodes, cellular relay nodes, and mobile cluster heads. There are three mobile paradigms in MWSNs: 1) Controllable movement is the action which is determined is the easy change. 2) Predictable response: If the mobility of a mobile node has a track (e.g., sensors transfer data on moving cars), then predictable movement comes in picture. 3) Unpredictable motion: random motion. The features: 1) More dynamic topology. The topology is dynamic because nodes are movable in MWSNs. New routing and Medium access control protocols needed in MWSNs. 2) High power requirement: The additional energy for sensors to be portable will maximize the necessity of the power. Sensors have a larger power center or can be chargeable or replaced with fresh ones. 3) Unreliable communication links. Dynamic topology, transmission failures, battery depletions, and so on will result in weak communication links, especially in hostile and remote areas. 4) More accurate localization. The mobility of nodes requires a more accurate location estimation of the base station or other sensors.

Working in [4] is WSN provides data to the cloud, and mobile users request data from the cloud. A novel WSN-Mobile Cloud Computing integration scheme named TPSS implemented which comprised of two main parts: 1) Time and priority-based selective data transfer for WSN gateway to selectively transfer sensory data that are more needed to the cloud, considering the time and priority features of the data requested by the mobile user. 2) Priority-based sleep scheduling (PSS) algorithm for WSN that keep energy consumption less so that it can collect and transfer data in a more reliable way. PSS first considers the time and priority characteristics of the data needed by the user into the WSN sleep scheduling process.

Two geographical distances based connected-k neighborhood (GCKN), sleep scheduling algorithms, and are described in [5]. The first one is the geographic distance based connected-k neighborhood for first path sleep scheduling algorithm. The second one is the geographic range based connected-k neighborhood for all paths sleeps scheduling algorithm.

In [6], to minimize the delay of alarm sending from any sensor node it is a sleep scheduling technique in WSNs. Specifically; they perform two traffic paths for transmitting the alarm message, respectively. When a critical event happens, an alarm quickly goes with one of the traffic paths to a central node, and then it broadcast by the central node along another path with no the collision

The area around the sink creates a bottleneck zone due to heavy traffic, which restricts the network lifetime in WSN. This work in [7] attempts to improve the energy efficiency of the bottleneck area which leads to an overall increase the network lifetime by considering a duty cycled WSN. An efficient transmission paradigm has adopted in the bottleneck area by combining network coding and duty cycle. The relay nodes simply pass the received data. Whereas, using the network coding based algorithm the network coder nodes transmit the data. Energy efficiency of the bottleneck zone improves because more volume of data will send to the primary node with the same number of transmissions. This in-turn improves the overall lifetime of the network. A duty cycled WSN can loosely classify into two main types: random duty-cycled WSN and coordinated duty cycled WSN. In the former, the sensor nodes are kept on and off independently in the random fashion. The random duty-cycled WSNs are easy to design as no additional overhead is required.

Time Division Multiple Access (TDMA) focuses on the minimization of energy consumption. The given technique adjusts the monitoring timeslot of the sensors according to the environmental changes. Environmental changes can increase or decrease the time slot employed for sensing and computing and transmitting physical data. The sensed environment remains stable for a long time (i.e., little environmental variations). When the environment is stable, the sensor node may spend more time in the sleep state, increasing the timeslot of the TDMA in [8]. The energy consumption will reduce transitorily, and the saved energy may be employed to fulfill the sensing in the future, when necessary. Oppositely, when the environment variation increases, the frequency of sensing has to be improved to avoid data loss, which means that the frame size of the TDMA has to reduce. A.K.M. Azad and JoarderKamruzzaman [9], suggests a transmission design and defines the optimal ring thickness and hop size by providing network lifetime as an optimization problem. Two other variations also presented by redefining the optimization problem considering: associated jump size difference by sensors over life along with optimal duty cycles, and the particular set of hop sizes for sensors in each ring.

In [10] they have presented and compared several state of the art algorithms and techniques that aim to address the sleep/wake scheduling issue, which is divided into distributed and centralized manners. The advantages and disadvantages of these programming models and algorithms are also discussed.

In [11] they have proposed a wake-up scheduling protocol to save the energy through which some nodes visit active whereas the others enter sleep state so as to conserve their energy. This study has presented an original algorithm for node self-scheduling to make a decision which ones have to switch to the sleep state. They took into account the remaining energy at every node in the decision of turning off redundant nodes. Hence, the node with a little residual energy has priority over its neighbors to enter the sleep state. The judgment is based on a local neighborhood knowledge that minimizes the algorithm overhead.

In [12] they have proposed a network design solution for managing the energy consumption of wireless sensor network, in which sleep scheduling and forwarding set choosing are improved. Network nodes choose their sleep scheduling parameters. Nodes also select individual forwarding set according to a set of priority criteria. Also, nodes have their backup nodes determined by a set of rules to handle critical events and in the case of node failure. Overall, this scheme enhances network node energy consumption, leading to increased lifetime for the entire network but overhead on nodes.

In [13] they attempt to settle the problem of keeping rechargeable Wireless Sensor Networks operating for a long time. So they put forward a distributed heuristic range-based sleep scheduling algorithm which integrates the residual energy of nodes with the recharging frequency constraint. It aimed to find out a small set of nodes running in the active mode whose energy evaluation functions are higher than their neighbors within the r^{th}-range. This algorithm does not consider location information while guaranteeing area coverage.

In [14], two collaborative location-based sleep scheduling (CLSS) schemes are proposed. The awake or asleep state of sensor nodes in the WSN are dynamically replacing by the CLSS schemes assuming the locations of mobile users, to minimize the energy consumption. Especially, CLSS1 focuses on maximizing savings in power consumption of the WSN and CLSS2 also considers the scalability and robustness of the WSN. Two novel CLSS schemes aimed at sleep scheduling of WSNs. Both the location-based characteristic of mobile applications as well as the energy concern of WSNs taken into account by the CLSS schemes. CLSS1 focuses on the power consumption of the WSN, while CLSS2 further considers the scalability and robustness of the WSN.

In [15], a routing algorithm is given. To reduce both objectives such as energy and delay, Energy Delay Index for Trade-off (EDIT) is introduced. To select Cluster Heads (CHs) and next hop EDIT is used. Proposed method has used two different aspects of distances between a node and the sink named Euclidean distance and Hop count.

The aim of the proposed system is to reduce the energy consumption and find out the network lifetime of the scheme. The proposed system uses a sleep scheduling which works among the sensor nodes in a particular area of WSN and which improves transmission as well as energy efficiency.

III. PROPOSED METHODOLOGY

A. Overview

The multi-hop WSN is uniformly randomly deployed with N sensor nodes in a two dimensions area A. The whole network is modelled by a graph G = (I, B), where I = {i1, i2, ⋯, iN} is the set of sensor nodes and B = {b(1,2), b(2,3), ⋯, b(N−1,N)} is the set of links. The antenna of sensor node i (i ϵ I) is an Omni-directional antenna. Each node has the same transmission radius tr i.e. 50m. Any two sensors i_i and i_j are neighbours if they are within the transmission range of each other. In location-based event driven sleep scheduling, every sensor node sends data to the base station by one hop or multi-hops. Figure 1 shows the architecture of proposed system.

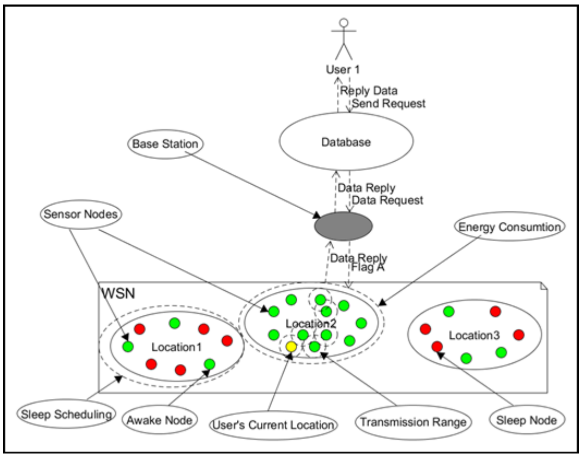

Fig 1: Proposed system architecture

In figure 1, the entire wireless sensor network is dividing into some systems that mean in different locations (as 3 locations in figure 1). In above architecture, there is one base station. Each base station collects sensed data from sensors deployed in its region and on request from a server it sends data back to it. On receiving a request from a server, it broadcasts the request to sensors in respective location and makes them active for the transaction. If no such request, it makes all sensors in sleep mode.

B. ProposedSystem

The proposed system contains sensor nodes in three locations (i.e. location 1, location 2, location 3), and these nodes send data to base station. Then it calculates the energy of sensor nodes when three algorithms such as existing algorithms: CLSS1, CLSS2, and proposed algorithm: CLSS3are implemented on the system.

Algorithm 1: Proposed Algorithm

1: Obtain mobile user's current location *lu*.
2: If *lu*€ *L*, send flag *A* to base station *s*.
   Otherwise, send flag *Z*.
3: Base station *s* broadcasts flags to sensor nodes those are in transmission range t_r of user.
4: If node *i* receives flag *A*, remain awake.
   Otherwise, run EC-CKN algorithm.
5: Find out the residual energy of nodes which are in its transmission range t_r and check whether it is above threshold or not. Make them active.
6: According to user's current location, data is sent to base station through active nodes and as data goes to sensor node changes their state from sleep to active until in range of user.
7: Nodes those are not in transmission range changes their state dynamically.
8: Repeat step 6.

In this algorithm, sensors are dynamically kept awake or sleep. But as the user will not require all the sensor nodes from the particular location (say Location 2 from figure 1), nearby sensors will be kept active. For this, user's distance from the base station is taken by algorithm and EC-CKN is performed. Flag A will be sent to sensors if they are connected k-neighbours of the user and their residual energy also considered.

C. Mathematical model

One WSN with *N* sensor nodes is modeled by a graph.

- Set of sensor nodes,

$$I = \{i_1, i_2, ..., i_N\}.$$

- The expected distance to the nearest neighbor for each sensor in *I*is as follows:

$$Ed = \frac{1}{2\sqrt{\rho}} \qquad (1)$$

We can determine that for a uniformly randomly deployed WSN with *N* nodes in

- The node density is,

$$\rho = \frac{N}{A} \qquad (2)$$

where, A is a two dimensional area of deployed sensors.

- The expected number of events that occur in time interval t at node i,

$$Ene = \lambda \cdot \rho_{ei} \quad From\ 2\ (3)$$

where, λavg. event rate,$ei$is energy of node$i$.

- The expected number of neighbors for each sensor,

$$Enb = \rho \cdot tr^2 From\ 2(4)$$

where, tr is transmission range.

Let q be the number of packets transmitted from a node to each neighbor node if an event is detected.

- Expected total number of transmitted packets for a node i is as follows:

$$Q = Ene \cdot q \cdot Enb \qquad (5)$$

$$= \lambda \cdot \rho_{ei} \cdot q \cdot Enb\ From\ 3{,}4$$

For proposed scheme, during each time t, the base station sends the flags to sensor nodes in the multi-hop distance.

The energy consumption of the base station,.

- The energy consumption of the base station,

$$(E_T \cdot Enb + E_R) \cdot Ed$$

where, $E_T$is transmission energy,E_R is reception energy.

- The energy consumption of a sensor node being awake for transmitting data packets,

$$(E_T + E_R) \cdot Q From\ 5$$

- The average power consumption for a sensor node during each time t is,

$$E = (E_T \cdot \mathrm{Enb} + E_R) \cdot Ed + \frac{(E_T + E_R) \cdot Q}{2} (6)$$

- The network lifetime of proposed algorithm is:

$$NL = \frac{E_0}{E} \cdot t$$

$$= \frac{E_0}{E_T \cdot Enb + E_R} \cdot Ed + \frac{(E_T + E_R) \cdot Q}{2} \cdot t\ From\ 6$$

IV. EXPERIMENTAL SETUP

In the network research field, it is very expensive to deploy a complete test bed including multiple networked computers, and data links to prove and verify a certain network protocol or a particular network algorithm. The network simulators in these circumstances conserve a lot of money and time in completing this task. The result of research and development is nothing but an elegant product name WSN Localization Simulator. To build WSN Localization Simulator system needs a computer and a C# Net.WSN Localization Simulator can install on several versions of Windows (Windows 7, Windows 8.1 and Windows 10). The WSN Localization simulation parameters are: Network is- 600x600 m2, Topology-Flat grid, k in EC-CKN is 1, No. of nodes-100, Initial energy-100 Joules, No. of base station-1 and Time interval t is 1 minute.

V. RESULTS AND DISCUSSION

In the proposed method, the sensor node goes into sleep mode when the event does not occur in their location and wakes up after the fixed time. The performance of proposed system is calculated by using residual energy, the number of nodes and average energy consumption on node and time.

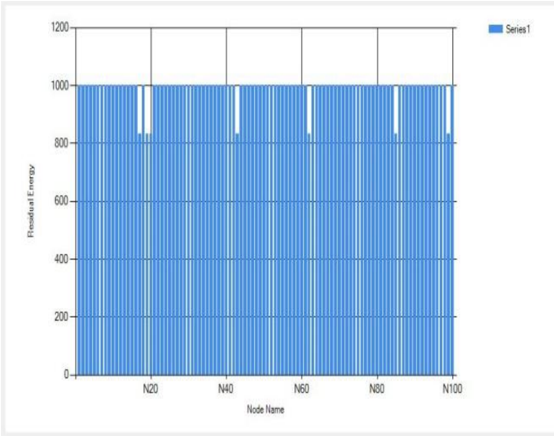

Figure 2: Energy Consumption for CLSS1 Node v/s Residual Energy graph.

In figure 2, the graph of energy consumption of a node on residual energy is given. The energy consumption for proposed algorithms ishigher than collaborative location-based sleep scheduling algorithm 1 algorithm in a graph. But even if energy consumption is higher we get real-time data from proposed algorithm. Fig. 2 shows node v/s residual energy graph of CLSS1.

In figure 3, the graph of energy consumption of a node on residual energy is given. The energy consumption for proposed algorithm is lower than collaborative location-based sleep scheduling 2 algorithms in a graph. Fig. 3 shows node v/s residual energy graph of CLSS2.

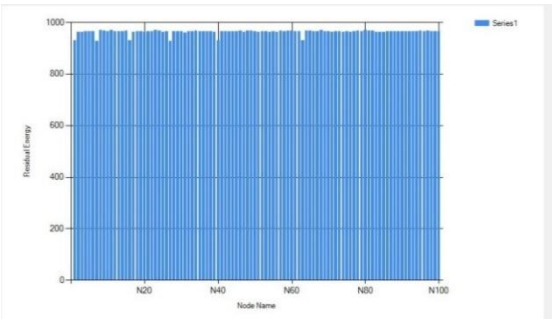

Figure 3: Energy Consumption for CLSS2 Node v/s Residual Energy graph.

In figure 4, the graph of energy consumption of a node on residual energy is given. The energy consumption for proposed algorithm is lower than collaborative location-based sleep scheduling 2 algorithms in a graph. Also, event driven sensor sends data using transmission range. Thus energy consumption is much lower than CLSS2 and CLSS1. Fig. 4 shows node v/s residual energy graph of CLSS2.

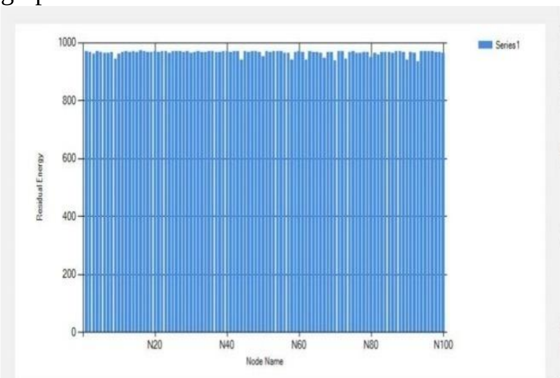

Figure 4: Energy Consumption for CLSS3 Node v/s Residual Energy graph.

This system is related to some of the WSN applications such as event tracking may need sensor nodes to periodically conduct observation and transmission of the sensed event features.

VI. CONCLUSION AND FUTURE SCOPE

The proposed system reduces energy consumption with the use of sleep scheduling of event-driven sensor nodes without affecting the other performance parameters. It achieves less consumption of power of sensor nodes by sleeping them for the particular time when they are not in use and thus increases overall lifetime of wireless sensor network, normalized overhead and balanced energy consumption than the normal scenario i.e. without considering the range of sensor node. The performance optimization can be achieved in WSN using simulations. The proposed system uses event-driven sensor nodes which sends data to their neighbors coming in transmission range and which improves transmission policies as well as energy efficiency. In future work, the system should focus on the transaction with trusted sensors. Security may provide in WSNs for preventing attacks like DoS.

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