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Recharging of Wireless Sensor Nodes for Real Time Transmission

G.Swapna, A.Naveena

PG Scholar, M. Tech, Dept. of ETM, G.Narayanamma Institute of Technologies and Sciences, Shaikpet, Hyderabad, India.

Assistant Professor, Dept. of ETM, G.Narayanamma Institute of Technologies and Sciences, Shaikpet , Hyderabad, India.

ABSTRACT: In this rapid growing technological world, wireless sensor networks play a crucial role. The performance of the WSN depends on the lifetime of the sensor nodes. In this paper energy harvester technique is used to capture the energy and recharge the sensor nodes. To ensure sustainable operation of WSN, charging in timely fashion in very important, since lack of energy of even a single sensor node could result in serious outcomes. If energy of the sensor nodes is completely drained off, it can be replaced using Unmanned Aerial Vehicles(UAV) is also proposed in this paper. By using these techniques, it can be observed that there is an improvement in packet delivery ratio, energy consumption, delay and can be observed in simulation outputs.

KEYWORDS: Recharging, Energy, Throughput, Mobile access point, Packet delivery ratio.

I. INTRODUCTION

In wireless sensor networks, nodes spread electromagnetic waves into the atmosphere to sense the surrounding environment. Earlier this sensed information was collected by the cluster head and it forwarded the data to the base station. But now mobile access point travel in the network to collect and forward the data to base station. In wireless sensor networks sensing nodes are placed very densely in different environment and mostly with no defined network topology. Energy of individual sensor node is lot of concern, it needs to be recharged or replaced to keep node active in the network. So that connectivity is maintained and the network lifetime will be increased. Wireless recharging is not that much easy without any wire or switch. For that we have to install energy converters on around the sensor nodes. There are different sources of energies(e.g solar, wind, vibration, light, thermal, electrostatic).

Energy harvesting is a process that captures small amounts of energy that would otherwise be lost as heat, light and sound. This captured energy is used to power lower electronic devices like sensors. Wireless sensor nodes are central elements in a wireless sensor network, these does sensing, processing and communication. It stores and executes the communication protocols and data processing algorithms. Energy is the most important parameter for WSN. Batteries are installed in a sensor to power the sensor node. UAV's are the flying robots to deploy number of sensor in an area like forest and military areas. UAVs can fly in air with altitude and these can move on the earth to collect the data.

II. LITERATURE SURVEY

Earlier sensor network with mobile access point is an architecture for low power nodes and large scale networks. Whenever there is no ongoing information, the network will goes to sleep state. A wake up scheme is developed to bring the network to active state[1]. The approach is to wake up nodes by using radio frequency signals. But the major limitation, in flat ad-hoc network sensors are woken up by the neighbouring nodes which are actually not needed to be in a active mode..

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A mobility assisted data collection model was proposed in [2] mainly to maximize network lifetime. In the network k locations are specified first. Each sensor chooses a rendezvous point and selects a sensor node as a cache node which is one hop distance from rendezvous point. A mobile sink visits an RP and waits for certain amount of time. Each sensor node forwards its data to cache node through multi hop path [2]. This cache node stores the data for some time and then it forwards data to mobile sink, when mobile sink stays at RP which is nearer to cache node. The main factors affect performance of wireless sensor network are, the number of RPs present in the network, visiting time period of RP, speed of mobile sink, effect of interference.

Main focus on network deployment, repair and connectivity was discussed in[3]. Flying helicopters are used to node deployment where a human cannot enter into such environment. This flying helicopter can detect network failure and node failure. The helicopter consist of sensor node so that it is a mobile node of the sensor network and that can communicate to the ground [3]. The node deployment is done on demand. We can determine the location where additional nodes are required with the help of connectivity map. We develop an algorithm which is used to deploy a network with specified network topology with the limited communication range.

Explanation about the two examples of spectrum sensing applications are discussed in[4]. This spectrum sensing is used in cognitive radio to find the unused frequency bands[4]. These frequency bands are used for own transmission and these frequency bands are licensed bands, allocated for primary users. Primary users inserts guard bands in their spectrum and guard bands are used for cognitive radio. Spectrum sensing performs the radio location by spreading the RF signals to find out the location of particular object.

MRADC model was proposed to investigate the throughput capacity of large scale networks. The network consists of mobile relays, they responsible for storing the data for certain amount of time and to forward the collected data [5]. The network is divided into clusters and each cluster has a mobile relay. This relay travels in specified locations they are the data can forward to sink in one hop. The sensor nodes are one hop away from cache nodes. Wireless sensor networks, which treat sensor devices as network nodes, serve as critical enablers of the IoT [5], carrying out missions of monitoring, localization, tracking of objects by seamless transfer of data in real time between sensor nodes. Wireless rechargeable sensor networks consisting of sensor nodes with batteries to prolong the network lifetime without compromising the sensing performance.

III. PROPOSED SYSTEM

To overcome the limitations of the existing techniques, recharging of sensor nodes is proposed. In this proposed system, the recharging of sensor nodes is discussed in detail. Initially fix the power to each sensor node to sense, process and communication. Each sensor node have a threshold level energy before going to dead. Whenever energy reaches threshold level the sensor node spreads beacon signal. To recharge node we are going to energy harvesting , it is process that captures external energy(e.g. solar) and stores temporarily. Solar energy is converted into electrical energy with the help of photovoltaic panels that we can observe in Fig.1. These photovoltaic panels are installed on or around the sensor nodes for conversion of solar energy to electrical energy(both indoor and outdoor). Solar panels composed of a number of cells containing a photovoltaic material to generate photovitaic power. Energy harvesting devices converting ambient energy to electrical energy have attached to reach interests in both military and commercial sectors. In general energy can be stored in stored capacitor, super capacitor or battery. Capacitors are used when application needs to provide huge energy. Batteries leak less energy and are therefore used when the device needs to provide a steady flow of energy.

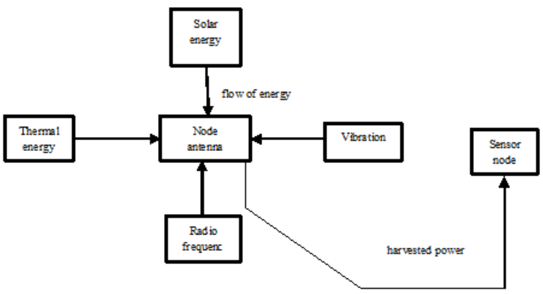

Fig.1 Different Types of Sources for Energy Harvesting By Sensor Device.

Electrostatic energy, this is type of harvesting, it is based on charging capacitance of vibration dependent on capacitors. Vibration separates the plate of charged variable capacitor and mechanical energy is converted into

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electrical energy. To convert thermal (heat) energy to electrical energy we can install thermoelectric converters. To convert vibrational energy to electrical energy piezoelectric sensors are used as transducers

In wireless chargeable sensor network, nunber of sensors are deployed in an area. This network consist of one mobile charger, base station and sensor nodes. In general every node fixed energy to do their job and also has a threshold level. Whenever a node continuously sensing, processing and communication the energy of individual node will decrease. The energy of node reaches threshold level, node spread out the signal(i.e it needs to recharge). These signal will recieved by base station and base station will give message to the mobile charger. To find out the location of sensor node it has some notations and to calculate some parameters. The following are the notations of sensor nodes.

Notations	Explanation
$S_i(x_{i,y_i})$	Position in Euclidean coordinates
r^c	Communication range
F_i	Information sampling rate
$T_i(t)$	Trasmission rate in instant t
P_i^s	Sensing power consumption
P_i^t	Transmission power consumption
$L_i(t)$	Expected lifetime at instant t
$E_i(t)$	Residual energy at time t
$Emax_i$	Maximum energy that can be stored in the battery
$Emin_i$	Minimum energy threshold for being active
R^{ch}	Battery recharging rate (assumed equal for all sensors)
$P_i(t)$	Total power consumption equal to:$P_i^s F_i + P_i^t T_i(t)$

Table1. Notations for sensor nodes

A mobile charger is capable of moving across the positions of target sensor node. In this mobile charger is represented with R and assume that the network is considered in XY coordinate system and assume that mobile charger is placed at coordinate R(x, y). Assume that mobile charger is charged directly by visiting the base station.

Notations	Explanation
R(x,y)	Position in Euclidean coordinates
$Emax_m$	Total energy available for movement
$E_m(t)$	Reamaining energy for movement at time t
$Emax_r$	Total energy available for recharging
$E_r(t)$	Remaining energy for recharging at time t
$Nmax_r$	Maximum number of sensor nodes for replacement
T_r	Time needed to replace a sensor node
P_m	Power consumption for movement
V_m	Movement speed
P_r	Power consumption for recharging
$T_{replace}$	Time needed for own battery recharging or replacing
r_s	Sensing range

Table2. Notations for mobile charger

Assume that the movement speed of mobile charger is reprsented as V^m and power consumption for movement $P^m$and when recharging a node the mobile charger has a power consumption P^r. Mobile charger has two

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separate amount of energies to recharge node and for movement of it and they are represented as $Emax^r$ and $Emax^m$. P^m and P^r are the power consumption for movement and power consumption for recharging. In particular, we will consider the total available time to the charger to move the fraction of maximum energy available for movement and power consumption for movement is represented as $Emax^m / P^m$. Evaluation of total time available to recharge sensor node is the division of maximum energy available to recharge and power consumption to recharge is represented as $Emax^r / P^r$.

Based on the collected information base station identifies the set sensors that need to be recharge in the next window duration T and these set of nodes are denoted as V^*. A sensor node is considered as that in next two time duration it will drop to threshold level and then it is added to V^*. After finding the which are need to recharge, the path to visit all the selected nodes with in the time frame T. There are three possibilities to choose the path, they are random, closest, TSP.

- Random: Mobile charger randomly chooses the path that we can seen in Fig.2.
- Closest: The nodes which are nearer to charger, this is shown in the Fig.3
- TSP: In Fig.4, the path to cover is defined by Travelling salesman problem.

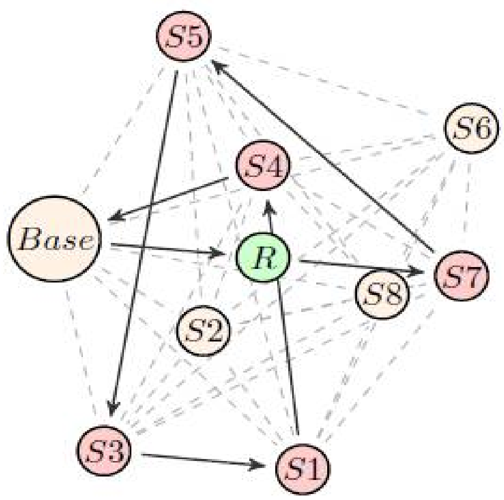

Fig.2 Random path selection

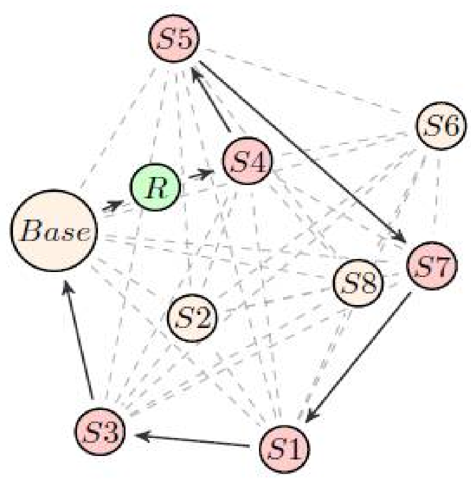

Fig.3 Path selection based on closest node

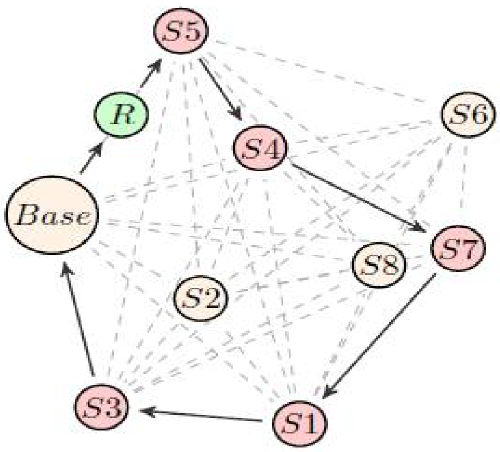

Fig.4 Path selection based on TSP solution

Initially all the selected nodes need minimum energy to stay alive during next time cycle duration in the network. We propose three algorithms to select which is node is to recharge next. They are random, minimum energy and minimum life.

- Random: Charger randomly chooses the node to recharge.
- Minimum energy: The node which has minimum energy level.
- Minimum life: The node minimum lifetime in the network.

IV. SIMULATION RESULTS

The below Fig.4 shows, graphs are drawn with the help of network simulator by writing the code to proposed work. The Fig shows residual energy comparison of previous technology and proposed technology. Time taken on X-axis and residual energy is taken on Y-axis. Green colour line indicates the proposed technique and the red colour indicates existing work. By comparing the both we can observe that, initially at time 1ms residual energy of existing and proposed are same. As the time increases residual energy of both existing and proposed are differed. Proposed has more residual energy because in proposed system we implemented advanced techniques. Because of this network lifetime increased.

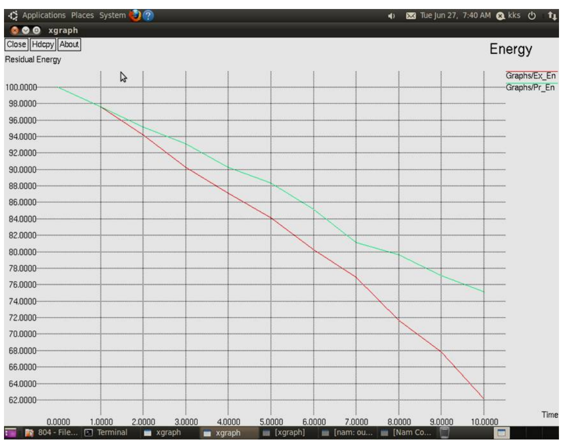

Fig.5 Residual energy

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The below Fig.6 shows the packet delivery ratio of existing and proposed. Time is taken on X-axis and packet delivery ratio on Y-axis. PDR is fraction of number of packets send at the sender side and number of packets received at the receiver end. Green line indicates the proposed and the red line indicates the existing work. Initially on X-axis at time 1ms both proposed and existing are overlapped. As the time increases PDR is slightly differed. PDR is calculated by taking the average of packets at what time and how many packets send and received. This gives the actual packet delivery ratio. Packet delivery ratio is improves the network lifetime. The calculation of PDR is based on the generated packets as recorded in the trace file. PDR is calculated using awk script which processes the trace file and produces the result.

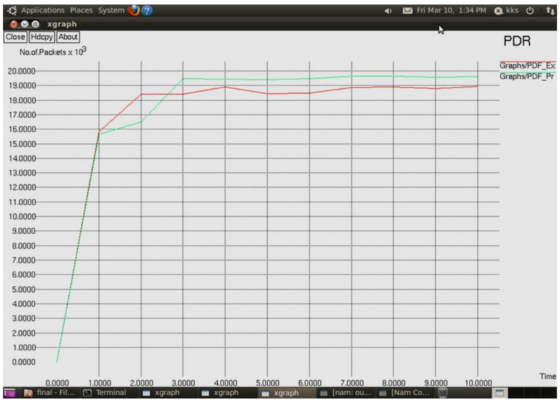

Fig.6 Packet delivery ratio

The below Fig.7 shows delay comparison of existing and proposed. By comparing existing and proposed we can observe that delay is more in proposed. Red colour indicates existing system and green colour indicates the proposed system.

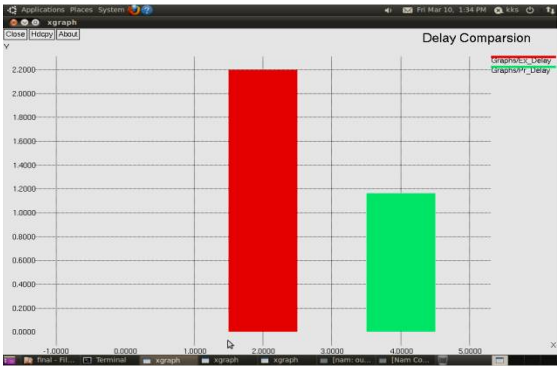

Fig.7 Delay comparison

V. CONCLUSION

In this paper we discuss about the recharging of sensor node with advanced technology. Finally in this we achieve low power consumption for sensor nodes. Packet delivery ratio is high than the previous technology. As the energy consumption of individual sensor node is decreased then the network lifetime is increased and also reduces the delay in network communication. The residual energy in existing is less than the proposed system. It is an energy efficient scheme for real time transmissions. For future work we can use directional antennas to recharge in particular direction so that coverage area of will decrease.

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