Efficient Energy Harvesting in WSN Devices

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ABSTRACT

Wireless Sensor Networks are starting to become more and more integrated into domestic and industrial means such as mobility, hands-free use, and more. However, because of their own symptoms, you may experience many concerns that affect their performance. Although there will be a greater focus on energy bans, many of these problems are temporarily given up. Energy harvesting as a source of energy received by WSNs has been found to have the highest reliability, and this assessment is all about energy management systems because of this source. Power management systems are designed for efficient use of harvested electricity. This assessment sets out a power management system specifically for art classes representing different program requirements. In this agreement we fight for a strategy of unwanted energy harvesting to develop and emulate a more efficient way by using Markov to select the advances and technologies that MAKE to use energy efficiently. Data is transferred within the good course set by WARPWING for new technologies and what about the power itself used to transmit information.

Keywords  
WSN, MDP, WARPWING, Rf energy, EH-WSN, Piezo Electricity, GINA board.

1. INTRODUCTION

A classic sensor node comprises of CPU, flash memory, wireless transceiver, power supply, the sensing device and a tiny OS that manages its hardware these devices monitor ambient condition such as temperature, pressure, humidity, stress level, light intensity, etc. Wireless technologies are utilised to organise a large number of these nodes into WSNs. Infrastructure and ad-hoc are the two modes of wireless network communication. WSNs use the ad-hoc mode, and nodes act as a router to forward packets of one another to a base station. The base station usually serves as a gateway to private IP networks and internet.

WSNs see their application in variety of industries such as military surveillance, home automation, environmental monitoring, etc.

These WSNs devices face several issues that affect their performance such as energy constraint. Application of these devices over a long span of time can be tedious and inflexible as we have to change the batteries when they run dry. The solution is to use energy harvesting technologies to convert ambient energy into the power required to charge the battery. The efficiency of this conversion is insufficient that’s why we need to deploy certain energy management schemes to efficiently utilize the harvested energy.

- Some of the problem that EH-WSN has to tackle are: Nodes Synchronization – traditional EH-WSNs lose node synchronization and lose efficiency of network communication due to lack of energy and needs to be restarted that requires extra energy to be synchronized.
- all the intermittent operation connected to the WSNs up to the computation and communication phase may sometime be halt due to lack of energy causing wastage and failure of energy that’s why proper energy management schemes and policies need to be implemented.

For most EH-WSNs existing algorithm the nodes are assumed to be in sync and the harvested energy in each time and phase is known. These energy management techniques require energy models which is not completely accurate, as it does not consider various factors, which causes significant error.

2. LITERATURE SURVEY

2.1 Review Stage

As shown in fig. 1 a WSN network has many nodes connected to each other in a sensing field each sensing data and communicating with the other nodes and then transferring data to a common sink node which transfers the data to the internet, which are connected through a gateway and then an user can access it from the internet.
Based on preceding works and discussion this paper proposes an energy aware energy harvesting WSN system that implements certain energy harvesting and energy conservation policies to achieve node synchronization and counter energy shortage problem to aid in completion of intermitted operation.

In this review we cover about the energy sources of nodes, issues in previous models, ways of managing energy in a WSN node and network of these nodes and conclusion of our review.

2.2 Energy Sources in WSN

There are two ways of supplying energy to nodes in WSN devices by using batteries and by harvesting [1]. Many of the existing nodes like mica, telos and iris are battery powered. These nodes have low power consumption and short life span which made batteries as viable source for WSNs. However, they have low capacity, in long term application they will drain out quickly, so they require a regular maintenance. One of the solutions of this is to use human resources to replace batteries. But this is also not feasible when the nodes are placed at a harsh geometrical and ecological environment. Thus, focus is being shifted from batteries to finding alternative energy sources such as energy harvesting [2].

Energy harvesting is being implemented for providing energy to nodes where batteries replacement is not possible. Solar technologies provide energy to sensors with very high efficiency. The total energy output is determined by the size of solar panel which is influenced by the size constraint associated with the sensor nodes.

Beside solar energy other sources which have energy in wave form or energy from vibration have also been used, but these sources have less energy output in comparison with solar energy. Node synchronization is possible as each node receives energy based on their size constraint and thus being in sync with other nodes. Fig. 2 shows the need of power inside a node [7].

Harvesting can be done from other sources like by using piezo electric materials for making sensors. Sensors made of gallium phosphate, tourmaline have higher stability and are stronger that is they are more effective in places where forces of nature do physical high damage to the sensors. Piezo material works on these physical deformations, they produce energy from these changes in their physical structure and while restoring to the original structure. Thus, making them work in every kind of climate [15].

2.3 Issues and Challenges in WSN

The main issues and challenges faced while setting up WSNs are as follows-

- Energy is consumed by sensor nodes to accomplish numerous functions such as sensing, processing and transmission. Even in idle state large amount of energy is being disbursed in the continuous listening of the wireless medium. Hence energy conservation is required to provide a better performance.
- In real time applications like structural monitoring WSN’s require good guidance of data, quality of service and to reduce bit error rate in data forwarding to ensure minimum end to end delay, optimal pathing and to reduce packet loss.
- For long term applications sensor nodes should have a long-lifespan, for this the node should be robust, can tolerate harsh condition at their ecological location and have a sufficient amount of energy for working and synchronisation.

Nodes in a single network can be different quality so they will require different energy and have different efficiency of working so in the networks the nodes will go out of sync.

3. RELATED WORK

The author proposed new queries to calculate maximal and minimal inflection point in continuous time in changing climate. to monitor the changes in climate with time is quite hard as it has discrete values that cannot be described. This paper investigates curve query processing for WSN as an effective way to represent continuous sensed data. The cognitive allerrithm turns the algorithm to support for solving the curve question first. See show that energy costs are approximate the clustering algorithm is completely given [3].

Proposed that all the holistic aggregations require a lot energy to send sensory data from one node to another to
a sink. In this paper the author studies about the approximated holistic aggregation algorithm based on uniform sampling. Four holistic aggregation operation are investigated in which the mathematical methods to construct their estimators and determine the optimal sample size are proposed and the correctness is proved [4].

Proposed an efficient harvesting system based on rechargeable batteries. Duty-cycle scheduling is an effective way to balance energy consumption and elongate network lifetime which requires connected dominating set (CDS) [5]. This paper deals with identifying largest number of CDSs in energy harvesting network (EHN), to prolong network life. They proposed four approximate algorithms to investigate novel problems which are proved to be NP-complete. Both the solid theoretical analysis and expensive simulations are performed to evaluate these results. To prolong network lifetime multiple CDSs are expected in a WSN so that they can take turn to serve as a virtual back bone [10].

The existing EH-WSN platforms are incapable of providing various types of energy data. The traditional WSN can determine the energy state by measuring the battery voltage. For EH-WSN with a capacitor, most of the platforms can calculate the stored energy by $E=CV^2/2$. However, the method can perceive only the current residual energy but not the specific harvested and consumed energy, while the capacitance offset of the capacitor seriously affects the accuracy of the calculated energy. Few of the existing EH-WSN platforms have energy measurement functions [6]. The EnHANT nodes designed by adopt a current-sensing amplifier to amplify the current of the energy-harvesting circuit, whereas, the method by is only able to measure the instantaneous value of the current [8]. To sense the energy harvested for a period, the instantaneous current has to be sampled and summed up to calculate the total charge, thereby requiring a large amount of CPU time and energy and interrupting the node operation seriously. Moreover, the discrete sampling leads to errors. Proposed an energy harvesting platform called UR-Solar Cap with moderate power systems based on solar energy [12]. The platform uses a current-sensing amplifier circuit and collects discrete current value with a PIC controller to calculate energy; unfortunately, the energy consumption is only up to 10mW, which is not applicable for EH-WSN.

Each of these is an effective way of harvesting energy but none of them gave a proper way for utilizing energy efficiently. Gave the use of duty cycle scheduling but in different nodes the same duty cycle cannot be maintained without a proper learning algorithm thus causing loss of synchronizations [9].

These works also don’t show how in a network energy can be conserved while transmission of data from one node to another. In the long run from one node to another node which are not directly connected to each other, an optimized path is to be found were usage of energy is also conserved.

4. PROPOSED SOLUTION

In this paper we are proposed ways to overcome some major problems in the current ways.

- Nodes need to be durable or they will not work properly in harsh conditions, so we proposed to use piezo electric material for making durable and strong nodes. Piezo materials also will harvest energy for every deformation along with other sources like solar energy, thus piezo electric materials like gallium phosphate, tourmaline which are durable and can harvest energy very effectively.

- Energy needs to be conserved and a lot of energy is wasted in a node as it does not have an efficient energy management protocol to manage energy in the WSN node. We propose the use of markov decision process (MDP) protocols to manage the usage of energy inside a node, to determine which part of node will work at what time, so that energy is used only at those part of the node to save energy and thus increasing efficiency [13].

- In a network we need to transfer data from one node to another in a WSN network, the transfer must be fast and consume less energy with less loss of data and low bit error rate. To transfer data efficiently we propose the use of WARPWING (wireless autonomous robot platform with initial navigation and guidance), as it will find the most optimal path for data transfer and to do that it will consume energy of nodes need in the transfer only.

These are the methods proposed in this paper.

4.1 Piezo Electric Materials

Piezoelectricity is the amount of electricity that accumulates solid objects in response to operating pressure. The term piezoelectricity refers to the electricity created by pressure and latent heat. French physicist Jacques and Pierre Curie discovered piezoelectricity in the 1880s. Piezoelectric Effect of effects in line electronic communication between the mechanical and electrical properties in the crystalline things that cannot be internalized. The piezoelectric effect is transition process: piezoelectric material the result (internal generation of electric charge generated used mehendi) also signifies revenge piezoelectric effect, the internal generation of machinery difficulties due to the electric field used [11]. For example, lead zirconate titanate crystals will produce measurable piezoelectricity in which their identity formation is
virtually destroyed 0.1% of actual size. On the other hand, those same particles will change about 0.1% of their static size if the external electric field is applied to the material. The opposite the piezoelectric effect is used in the production of ultrasonic noise the waves.

The piezoelectric effect type is strongly related to the emergence of electric currents of the. Last but not least may be ionized at asymmetric Crystal lattice sites charging around or can be carried directly by cells groups [14]. The density of a dipole or polarization can occur easily is calculated by the crystals by summarizing the dipole moments with Crystallographic unit cell volume. Since all dipoles are a Vector, density P is a vector field. Dipoles next to each other some are usually directed to regions called Weiss domains.

The domains are often randomized, but can be manipulated voting process, a process with a strong electric field used across the content, usually at elevated temperatures.

4.2 Markov Decision Process

A Markov choice procedure is a discrete period stochastic management procedure. A mathematical framework for modelling choice producing inside cases whereby results tend to be partially arbitrary &amp; partially underneath the control over a choice developer are provided by it. MDPs are helpful for examining seo concerns resolved via dynamic programming and reinforcement learning. Machines are allowed by it as well as cd representatives to immediately figure out the perfect behaviour within a particular context, to be able to optimize the performance of its. Easy incentive responses is necessary for the representative to master the behaviour of its; this’s referred to as the reinforcement signal. You will find numerous diverse algorithms which deal with the problem. As a situation of reality, Reinforcement Learning is identified by a certain problem type, plus most its treatments are classified as Reinforcement Learning algorithms. Within the issue, a representative really should determine the right steps to pick according to the current state of his. If this move is repeated, the issue is recognized as a Markov Decision Process.

A Markov decision process is a 4-tuple \((S, A, P_a, R_a)\), where

- \(S\) is a finite set of states,
- \(A\) is a finite set of actions (alternatively, \(A_x\) is the finite set of actions available from state \(S\)),
- \(P_a\) is the probability that action \(A\) in state \(S\),
- \(R_a\) is the immediate reward (or expected immediate received due to the action \(A\)).

In our research states are sensor, actuators, transmitter and receiver the components of a node. Actions are to providing energy to which part is being used at the time, which is determined by probability of occurrence of that action which will be initially entered, and reward is the energy provided to the node.

4.3 WARPWING

WARPWING (Wireless Autonomous Robot Platform with Inertial Navigation and Guidance) is used to read the location the network of nodes is placed at and which node is connected to which node, i.e. which node can transmit data to which node and what path it will take. WARPWING works well on any topological location while knowing the location of every node and the working condition of every node. So, it will tell which node is to be used for the transmission of data in the network. It defines the most optimum path on which the nodes to be used for transmission so that energy is used only by those nodes and energy is conserved, while the data is received quickly.

It reads live location of every node and checks which node is working more better than other, which node will require less energy than other node. In this technology the location and stats of each node is filed into its software so the it can design the optimal path from each node to each other node.
general-purpose robot controller, especially for micro air vehicles (MAVs) shown in fig. 4. It comprises inertial sensors for angular rate and linear acceleration along with a general-purpose feature-laden microprocessor. It can interface to additional sensors or drive several actuators via an expansion header and provides built-in communication over a 2.4GHz wireless link.

WARPWING keeps the track of every node in the network and how they are connected to other nodes, which node they are connected to and the working condition of heterogeneous nodes. Since it can manage nodes of different types, so it will reduce the bit error rate, it can find the most optimal path for data transfer from one node to other node or the sink node, so the transmission is fast and less energy will be used in this transfer as only those nodes will use their energy who are needed for the transmission in the network.

5. RESULT
As the principle and structure of energy-harvesting measurement and energy consumption measurement are identical, we compared only the measured harvested energy with real values. IEA is powered by a solar battery and the piezo electric materials and works 100 seconds continuously with the implementation of the MDP protocols and WARPWING protocol for the conservation of energy. The node wakes up per second to measure current energy, receive 50 ms of data, send a 10-byte data packet, and then falls asleep. In circuit, \( R_1=R_2=10 \, K\Omega \), \( R_3=R_4=R_5=R_6=R_7=R_8=2 \, M\Omega \), \( C_3=1 \, \mu F \). The resistor \( R_s \) refers to 10 \( \Omega \) in the energy measurement; when the sampling period is one second, the amplification factor is 1000, and the measuring range is 1 mA. Fig. 5 show a comparison between the measured results and real values of the IEA platform. In Figure 7, we can observe the comparison of the energy measurement between the IEA platform and the actual value, and the measuring error for each time. As shown in Fig. 6, the current measured by IEA is very close to the real value with an average error of \(-0.16\%\), and the standard deviation of error is 0.32%.

Fig. 7 compares the energy measured by IEA with that of the actual value. As shown in Fig. 8, the average error is 0.11% and the standard deviation of error is 0.35%. We can see that the energy measurement accuracy of IEA is high enough to support further network routing algorithm and promote the energy efficiency significantly.

The power of the IEA energy measurement is approximately 157 \( \mu W \), which can be further reduced by a low-power operational amplifier such as TSU104. The power of TSU104 may be less than 10 \( \mu W \), but the measurement accuracy may decrease as well.
6. CONCLUSION
In our paper we have discussed the various methodology used to generate an efficient energy harvesting mechanism system. Our paper deals with introduction of artificial intelligence in the WSN network that will help in optimizing the duty cycle. This introduced artificial intelligence helps in energy prediction, optimal energy usage in steps of duty cycle and prediction of future energy constraints based on the historical data. We also introduced the use of WARPWING technology or the conservation of energy while transmission and the utilization of energy in the network efficiently.

REFERENCES