Recharging Mechanism of Wireless Sensor Network: A Survey

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Abstract— WSN have been extensively researched during recent years helping in diverse employment of sensor networks in various systems and applications. One of the key challenges that preclude the sustained operation of these networks is their limited energy resources. One of the most critical limiting factors for a Wireless Sensor Network (WSN) is its battery life. Therefore, a very desirable feature of WSN would be its rechargability to remain operational over longer period of times. The wireless sensor node, being a limited form factor device, can only be equipped with a limited power source. In this paper, we have presented several existing techniques for recharging a sensor node in wireless sensor networks.

I. INTRODUCTION

Wireless Sensor Network is an emerging field with lot of applications. Due to its wide applications in the field of defense security, civilian applications and medical research, there is lot of research going on. With rapid advancement in electronics industry, small inexpensive battery powered wireless sensors have started to hit the market for communication purpose. Small, inexpensive, low-power, intelligent, disposable sensors can be deployed in large numbers, in possibly in accessible environments such as disaster areas or battlefields. They can be deployed manually or from an airplane. The deployment can be random, periodic or with specific positions according to the application.

These sensor nodes are self-configuring and contain one or more sensors, embedded wireless communications and data processing components and a limited energy source. Due to the large number of nodes and the possibly hazardous environment in which these nodes are deployed, their batteries cannot be replaced. The failure of a single node in the network could possibly cause network partition and cut a part of the WSN off from the rest of the network. Network lifetime is therefore dependent on the lifetime of individual nodes. This necessitates energy efficient design of the network.

Sensor nodes with hardware constraints in energy source, computational speed, memory capacity, and communication bandwidth have to achieve low energy consumption, short data reporting delay, reliable data communication, and scalable sensor network. The concept of wireless sensor networks is based on a simple equation:

Sensing + CPU + Radio = Thousands of potential applications

Recent advances in perfect theory and hetero-geneous algorithms are regularly at odds with B-trees. In this position paper, we prove the evaluation of checksums, which embodies the key principles of machine learning. In order to surmount this question, we disprove not only that extreme programming and multi-cast algorithms can synchronize to overcome this riddle, but that the same is true for wide area networks.

II. DESIGN CONSIDERATION FOR WSN

The wireless sensor networks with different applications have several drawbacks, such as limited energy at node, limited computation power, and limited bandwidth of the wireless links connecting sensor nodes. The main aim of designing the goals for WSNs is to try to prolong the lifetime of the network by using different efficient energy management techniques. The design of routing protocols in WSNs is influenced by many challenging factors. Node deployment in WSNs is application-dependent. It can be manual or randomized. In manual node deployment, the sensors are manually placed at preplanned locations. However, in random node deployment, the sensor nodes are scattered randomly.

III. STATE OF THE ART SENSOR NODE PLATFORMS

Currently, there are several state-of-the-art sensor node platforms available on the market, which separately target different applications as shown in Table 1

Node Type	Intel Telos	Berkeley Mica2	Sun SPOT	Crossbow Imote2
Example Picture				
MCU Type	8 MHz, 8 bit	8 MHz, 8 bit	180 MHz, 32 bits	13-416 MHz, 16 bits
RAM	2 KB	4 KB	512 KB	256 KB
ROM	256 KB	512 KB	4 MB	32 MB
Bandwidth	250 kbps	38.4 kbps	250 kbps	250 kbps
Battery Capacity	Coin cell 1000 mAh	2xAA 5700 mAh	Rechargeable 750 mAh	3xAAA 3750 mAh

Table 1: State of the art sensor node platforms

IV. BATTERY TECHNOLOGIES

There are three common battery technologies that are applicable for wireless sensor networks – Alkaline, Lithium, and Nickel Metal Hydride. An AA Alkaline battery is rated at 1.5 V, but during operation it ranges from 1.65 to .8 V and is rated at 2850 mAh. With a volume of just 8.5 cm3, it has an energy density of approx 1500 Joules/cm3. While providing a cheap, high capacity, energy source, the major drawbacks of alkaline batteries are the wide voltage range that must be tolerated and their large physical size. Additionally, lifetimes beyond 5 years cannot be achieved because of battery self-discharge. The shelf-life of an alkaline battery is approximately 5 years.

Lithium batteries provide an incredibly compact power source. The smallest versions are just a few millimeters across. Additionally, they provide a constant voltage supply that decays little as the battery is drained. Devices that operate off of lithium batteries do not have to be as tolerant to voltage changes as devices that operate off of alkaline batteries. Additionally, unlike alkaline batteries, lithium batteries are able to operate at temperatures down to -40 C. The most common lithium battery is the CR2032. It is rated at 3V, 255 mAh and sells for just 16 cents. With a volume of 1 cm3, it has and energy density of 2400 J/cm3. In addition to traditional lithium batteries, there are also specialized Tadiran lithium batteries that have densities as high as 4000 J/cm3 and tolerate a wide temperature range. One of the drawbacks of lithium batteries is that they often have very low nominal discharge currents.

Nickel Metal Hydride batteries are the third major battery type. They have the benefit of being easily rechargeable. The downside to rechargeable batteries is a significant decrease in energy density. An AA size NiMH battery has approximately half the energy density of an alkaline battery at approximately 5 times the cost. Before considering the use of NiMH batteries it is important to note that they only produce 1.2 V. Because many system components require 2.7 volts or more, they it may not be possible to operate directly off of rechargeable batteries.

An alternative to relying on batteries with enough energy to last for years is to use renewable energy. Modern solar cells can produce up to 10 mW per square inch in direct sunlight. If stored properly, the energy collected during the day can be enough energy to last through the night. In indoor lighting environments between 10 and 100 uW per square inch can be produced depending on the type of lighting. For solar powered application scenarios, the key to successfully harnessing solar energy lies in the ability to store the energy.

V. Related Work

In recent years, there has been a considerable degree of interest in energy management issues in individual sensors, sensor systems, and wireless ad-hoc networks. There have been approaches suggested to extend the network lifetime in the presence of coverage and/or connectivity constraints, and energy-constrained sensor nodes. A large number of sensor network applications involve monitoring of a geographically vast area over an extended period of time. Since the deployment region is vast, and often inaccessible, periodic replacement of sensor batteries may not be a viable solution. For long term monitoring of such environments, sensors can be deployed with rechargeable batteries which are capable of harnessing the energy from renewable sources. The following are the some methods of recharging battery.

A. *Photovoltaic Cell Battery Model* [1]

Solar energy is a major source of energy especially for outdoor wireless sensor applications. This is primarily due to the periodicity and reliability of solar energy systems. Several years ago, photovoltaic cells (PV), as a means of an endless source of energy, are viewed as an expensive alternative to the customary and limited Lithium batteries. Due this cost issue, engineers opted to use the limited battery source arguing that it would be cheaper to let the nodes “die” than to employ photovoltaic cells to recharge the power source. Recent developments have changed this tough scenario into a favorable one for solar energy. With the increase in the need for longer lasting nodes, solar energy is one of the alternatives.

Despite currently being disadvantaged in terms of cost, photovoltaic cell attributes and its great potential to reduce its current price gives it advantage, motivating manufacturers and engineers to design sensor an unlimited source, solar energy from photovoltaic cells is a environmentally clean and safe source of energy. The amount of solar energy that a certain photovoltaic cell can provide is dependent on several factors. Since solar energy is a natural resource, it is heavily dependent on the environmental conditions which are generally random in nature.

B. *Remote Power Charging (RF Source) Model* [2]

The author has focus on developing a wireless sensor node that can be remotely charged by harvesting microwave energy. The current system implementation allows a user to access information from a remote sensor via their mobile computing device. These sensors are limited in complexity due to the limited power available, and are cumbersome since manual intervention is required to replace its batteries. The author has proposed a system where battery powered wireless sensor nodes can be recharged by harvesting energy from a microwave Radio Frequency (RF) signal source. The remote power charging module of the wireless sensor node architecture consisted of an antenna array and a rectification circuit. A prototype of the antenna array and rectification circuit of the remote power charging module for the wireless sensor node was presented in [2]

C. *Laser Recharged Wireless Sensor Network* [3,4]

In this paper, the author has adopted the strategy to devise a model that optically recharges RF sensor nodes equipped with the recharging facility. Recharging of sensor node is done using an IR- laser (Infrared-laser). In the model, the main nodes communicate with the Base Station (BS) using their beam steering lasers, either directly when in the Line of Sight (LoS), or indirectly through other main nodes using CCRs (Corner Cube Retro reflectors). BS has complete information of location coordinates of all main nodes. A Thin film Corner Cube Retro reflector (TCCR) is also proposed as a variant to the standard CCR.

D. *Node Activation Policy* [5]

The author has considered the problem of optimal node activation in a network of sensors, where the individual sensors get recharged continuously, according to a random process. The sensors activate (i.e., participate in sensing and transmission) themselves according to an activation policy employed in the network, and get discharged during the activation period, again according to another random process. The rate of discharge is typically higher than the rate of recharge for a sensor node. In addition, the discharge and/or recharge processes across the different sensor nodes could be correlated. The decision question that we address is when and which sensors should be activated (or "switched on") so that the time-average system utility is maximized.

VI. CONCLUSION

Due to the large number of nodes and the possibly hazardous environment in which these nodes are deployed, their batteries cannot be replaced. The failure of a single node in the network could possibly cause network partition and cut a part of the WSN off from the rest of the network. In this paper, we have presented several existing techniques for recharging a sensor node in wireless sensor networks. One of the possible future directions of research is in exploring the possibilities of recharging the mobile wireless sensor network.

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