Solar power for Wireless Sensor Networks in Environment Monitoring Applications-A Review

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Abstract- Routing in Wireless Sensor Networks has to take into account the limited battery resources of the nodes. Sensor nodes can also be powered by other energy sources like solar energy. This paper provides a review of Environment monitoring using Wireless Sensor Networks. The issues related to environment sensor networks is highlighted. The real time applications in environment monitoring is presented with emphasis on energy conservation. Furthermore in this paper we address the problem of scavenging energy using solar powered devices.

Index Terms- Environment monitoring, Wireless Sensor Networks, routing, energy conservation, solar power

I. INTRODUCTION

Wireless Sensor Networks (WSNs) are deployed in adverse areas in random infrastructure. Environmental monitoring is achieved by a large number of sensors with precision that can measure temperature, light, pressure, humidity and motion. WSNs comprise of thousands of sensor nodes working together to accomplish a common task [1].

The Key contributions of this paper are as follows: Section 2 highlights the issues in Environmental Sensor Networks. In Section 3 we present a few applications for environment monitoring. In Section we discuss the use of solar powered sensor nodes in routing for environmental monitoring and Section 5 concludes the paper.

II. ISSUES IN ENVIRONMENTAL SENSOR NETWORKS

Environmental Monitoring applications are based on the development from data to information to knowledge. Hence, the more meaningful data is obtained, the more knowledge is derived [ ]. Because data is gathered through measurement and observation, the measurement system capabilities of WSNs offer several advantages to the field of Environment Monitoring. An ideal WSN observes the environment at multiple locations and automatically transmits the data to a gathering point via the networked infrastructure. Because the sensing networks are usually directly connected to the Base Station that can be connected to the Internet, data is gathered in real-time.

The vast number of solutions that have driven the research community over the years made WSN phenomenon a reality. However their proliferation has so far been limited with just a number of commercial applications. The major challenge for the proiferation of WSN is energy. Extemely energy-efficient solutions are required for each aspect of WSN design to deliver the potential advantages of the WSN phenomenon. Therefore, energy efficiency is the major challenge in both existing and future solutions of WSNs. Sensors and Actuators will be mandatory to accomplish the term Internet of Things where networks and embedded devices are omnipresent in our lives and provide relevant content and information whatever the user location [6]. Although efforts have been done to achieve the Internet of Things vision, there still some challenges that need to be addressed. The most relevant are presented below.

- **Power management.** This is essential for long-term operation, especially when it is needed to monitoring remote and hostile environments. Energy Harvesting schemes like solar power and new power storage devices are possible solutions to increase the sensors lifetime.
- **Remote management.** Systems installed on isolated locations cannot be visited regularly, so a remote access standard protocol is necessary to operate , manage to configure the WSN, regardless of manufacturer.
- **Scalability.** A WSN comprises of thousands nodes. Current real WSN for environment proposes the use of tens to hundreds nodes. So it is necessary to prove that the available theoretical solutions are suited to large real WSN.
- **Usability.** The WSNs are to be deployed by users who buy them off the shelf. It is necessary to propose new plug and play mechanisms and to develop more software modules with more user-friendly interface.
- **Standardization.** The IEEE 802.15.4 represents a milestone in standardization efforts It is important to specify standard interfaces to allow interoperability between different modules vendors in order to reduce the costs and to increase the available options.
- **Size.** Reducing the size of sensor nodes is essential for many applications. Battery size and radio power requirements play an important role in size reduction. The production of boards compatible with the smart dust can be established in WSN environmental monitoring.
- **Support other transducers types.** Environmental monitoring usually uses limited type of transducers, such as temperature, light, humidity and atmospheric pressure. New environmental monitoring applications will be developed and new

transducers will be necessary to measure new physical phenomena, for example image and video. To transmit images and video on resources and power constrained networks are a challenge .

III. ENVIRONMENT MONITORING APPLICATIONS

(i)Great Duck Island [3]: The Intel Research Laboratory at Berkeley in collaboration with the Col-lege of the Atlantic in Bar Harbor and the University of California at Berkeley have developed habitat monitoring wireless sensor network that enables re-searchers worldwide to engage in the *non-intrusive* and *non-disruptive* monitoring of sensitive wildlife and habitats. The network was first deployed on Great Duck Island, Maine in Spring of 2002. This network consisted of 32 motes and monitors the microclimate in and around nesting burrows.

Each mote had sensors for temperature, humidity, barometric pressure, and mid-range infrared. Motes periodically sample and relay their sensor readings to computer base stations on the island which then make them available to researchers world-wide over the internet. In June 2003, a second generation network with 56 nodes was deployed which was then augmented with 49 additional nodes in July 2003 and with 60 more burrow nodes and 25 new weather station nodes in August 2003. Among the main requirements is that there should be no human presence on the island for the approximately 9 month breeding season, thus each node should conserve its energy to last until the end of the monitoring period.

(ii)Syracuse Project [4]:

Syracuse University researchers have installed a dozen robotic sensors (RUSS system – Remote Underwater Sampling Stations) to form an underwater monitoring system to safeguard drinking water. The 12 robots will cover (in almost real-time) part of the Seneca River and five connected lakes that provide drinking water for more than 500,000 people in central New York. Such a robot network can automate the process of water testing making it significantly easier and faster. Similar underwater environmental monitoring programs are under way in Minnesota, Washington, Nevada and North Carolina. In this system, each robot is equipped with temperature, oxygen, turbidity, light and salt content sensors. As the robots move in the lake, they record measurements every 10 minutes and send them to a central location using mobile phone technologies.

iii)North Temperate Lakes: The North Temperate Lakes project [2] is another example of sensor net-works for environmental monitoring. The main goal of the project is to “develop an intelligent environmental sensing network for detecting ‘episodic environmental events and understanding their consequences to lake dynamics”. The network is collecting measurements of the overnight Dissolve Oxygen (DO) level from the sensors and its aim is to understand the interactions among the processes (physical, chemical, and biological) that along with external drivers result in the long-term dynamics within the lake. The proposed embedded sensor network needs to have an intelligent command control system to implement adaptive sampling and query the sensors for more information in case of an event.

iv) Home Applications: Home control applications provide control, convenience, and safety using WSNs. Sensing applications facilitate flexible management of lighting, heating and cooling systems from anywhere in the home. WSNs applications capture highly detailed electric, water and gas utility usage data. Home security systems are widely used to prevent thefts.

IV. UTILIZING SOLAR POWER IN WSN FOR ENVIRONMENT MONITORING

Environmental energy harvesting has emerged as viable technique to supplement battery supplies. However , designing an efficient harvesting requires an in-depth understanding of several factors. For example , solar energy supply is highly time varying and may not always be sufficient to power the sensor network. Harvesting components, such as solar panels, and energy storage elements, such as batteries or ultracapacitors , have different voltage-current characteristics, which must be matched to each other.

Designing most of the research in routing in WSN assumes that all nodes are battery driven. Some of these nodes can be powered by solar or gravitational power. Nodes powered by these sources can transmit and receive packets without consuming battery energy as in Figure 1.

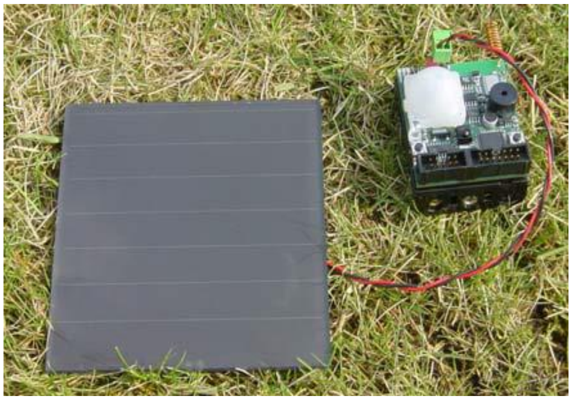

Figure 1. Solar panel connected to Sensor Board

Therefore routing packets through these solar powered nodes is made use of in a simplified version of directed diffusion[4].The results of routing through the above strategy proved that it is worthwhile to make routing protocols solar-aware ;that is the fact that one could route via solar-powered nodes should be incorporated into the routing decision.The simulations of the study conducted as in [6] showed that significant energy savings occurred in routing traffic via nodes powered by solar energy.

In sLEACH[5] , besides the remaining energy and the position of the nodes, it can also transmit their solar status to the Base Station. This protocol assumes the solar driven nodes that have a high remaining energy level have a high chance of becoming Cluster Head.

V. CONCLUSION

Environmental monitoring using sensor networks shares some common issues and important challenges that researchers are faced with today. In our view, the most important challenges include

1) Taking the vast amount of data produced by the thousands of sensor nodes deployed and turning them into something useful that the final user can benefit from. This process implies that spatial and temporal infield data must be compressed to remove redundancy and exploit correlations, e.g., use situation-aware adaptive sampling. Furthermore, the data processing may be done in a *decentralized* fashion by employing data-centric communication.
2) Detection of driving events by observing readings of many different sensors and using in-field power-aware decision fusion. This also raises the issue of area coverage such that the "miss" and "false alarm" probabilities are minimized.

To address these challenges (within the sensor power and processing constraints) one needs to find ways for information management (sensor data collection, storage, quality control, applications for querying and analyzing data) in an energy efficient way. Use of solar energy could come to aid in energy supplies to batteries of the sensor nodes.

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