Survey on Environmental Energy Harvesting Techniques used for Optimizing Energy in WSN

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***Abstract:*-WSNs are commonly exploited with the motivation of its attribute of Energy Efficiency. However this attribute sometimes could pose as a limitation to the WSN technique, like when its Battery at each Node is utilized completely it can no longer be used or can be used with overhead of Time and cost. So the research focus has directed in identifying better technique with which power can be controlled or a technique with which components of WSN can be utilized limitedly based on the usage thus enhancing the lifetime of battery. In order to progress with the WSNs by overriding the limitations associated with power, EHWSNs are identified which aims at providing long lasting power enabled WSN and also rechargeable batteries thus eliminating the overheads and trade-off associated with usual WSNs. EHWSNs utilizes other forms of natural and available energies such as solar power, wind, mechanical vibrations, temperature variations magnetic fields.**

Keywords: WSN, EHWSN, Energy efficiency, Battery, Natural energy.

I. INTRODUCTION

Wireless sensor networks (WSNs) consist of many inexpensive tiny devices capable of computing, communicating and sensing the information from various nodes to understand physical Environment. WSNs active research area includes wide applications ranging from Environmental/Earth sensingand structural monitoring to border security and human health control. Recent Research areas in the field of WSN has covered the topics like Unmanned Autonomous Aerial VehicleTechnologies, Infrastructures for energy data collection and analysis in networked manufacturing plants,3D visualization of Sensor Networks and Applications, WSN Simulator ,Satellite-WSN routing Technology, Sensors to Control Crystallization of Pharmaceuticals and Fine Chemicals, Crowd as a Sensor, Review of Energy Optimization in Heterogeneous Networks [2]

Some of the potential issues and Challenges of the System includes

1. *Routing*: Sensor Network consists of many nodes .The data sensed from those is to be routed to sink via most suitable path by taking into account of resource constrains of WSN. Hence routing is a challenging concern.

2. *Time Synchronization*: The Data collected from different nodes need to be fused effectively. To do this various level of data integration should be done in the synchronized manner.

3. *Security and privacy*: sensor nodes are often deployed in accessible areas, presenting a risk of physical attacks which are most malicious and harmful attacks on WSNs. Hence providing the Privacy and security to the network poses the major challenge. [3]

4. *Scalability*: There are hundreds and thousands of nodes deployed based on the requirements of the application and deployed region should be monitored. With such large number of wireless connected sensor nodes, there is requirement of techniques and their computations to be scalable enough to respond and operate in real time.

5. *Energy Efficiency*: Nodes of a WSN are typically powered by batteries .Once their energy is depleted, the node is dead. “Only in very particular applications batteries can be replaced or recharged. The recharging operation is slow and expensive, and decreases network performance. Hence Energy optimization poses a major challenge in the field of WSN.[1]

In order to overcome the power optimization problem the natural source of energy like thermal, mechanical, solar energy etc. techniques are used to recharge batteries. such techniques are referred as EHWSN.

II. ENERGY HARVESTING WIRELESS SENSOR NETWORK.

Energy Harvesting-based WSNs (EHWSNs) are proving permanent sources of energy to WSN nodes with the capability of extracting energy from the surrounding environment. Energy harvesting can make use of different sources of energy, such as solar power, wind, mechanical vibrations, temperature variations, magnetic fields, etc. which provides Uninterrupted form of energy and storing it for future use, energy harvesting subsystems enable WSN nodes to last potentially forever.

III. ENERGY HARVESTING TECHNIQUES

EHWSNs are designed in a way such that they are capable of consuming external energy sources and convert them to electrical energy in addition to the sensory and memory function.

Energy source	**Nature of source**	**Transducer**
Thermal	Fully controllable	Thermoelectric element
Mechanical	Uncontrollable and unpredictable	Piezoelectric transducer
Solar energy	Uncontrolled but predictable	Photovoltaic cell
RF energy	partially controllable	Antenna

Table 1: Energy sources with corresponding harvesting devices.[1]

1) Mechanical energy harvesting

Energy Harvester component in EHWSN plays a vital role in converting energy of displacement and oscillations of a spring mounted mass component inside it into electrical energy. Further Mechanical energy harvesting can be drilled down to other techniques such as Piezoelectric, electrostatic and electro-magnetic.[1]

Piezoelectric: Conversion of pressure, force or vibrations into electrical energy forms piezoelectric energy harvesting technique. The *pros* of this technique are that it does not require any explicit source for voltage since the electrical energy conversion here would generate required voltage implicitly. However the *cons* of this technique refer to the breakability of piezoelectric materials and the Charge leakage. [1]

Electrostatic: Conversion of mechanical energy Induced by the capacitance change forms electrostatic energy harvesting. The components involved in this technique are 2 plates with one fixed & one moving both of which are used to create variable capacitor by vibrations. Since the capacitors need to be charged, this requires explicit voltage source in the beginning. The domain of applications mostly apt for this technique is microelectronic-devices.

Electromagnetic: Conversion of mechanical energy induced by magnetic field created based on Faraday's Law of electromagnetic inductions forms the crucial of this technique .This technique forms the RELIABLE technique as it does not require mechanical dependency between parts and the voltage source. However the cons of this technique are size of electromagnetic material.

2) Photovoltaic energy harvesting

This is one of the commercial and mature form of energy harvesting technique which is apt for larger-scale energy harvesting systems as it releases higher power output level. This technique converts the [hotons generated from sources that release photons such as natural solar or artificial light. The conservation involves the dependency on the light source with which the conversion process is performed. Also the level of power and efficiency has implications based on materials used for cell. [4]

3) Thermal energy harvesting

As the name implies, this technique involves conversion of thermal energy created by the thermal gradients into electrical energy. Availability of energy is dependent on the availability of thermal difference induced.[4] Thermal energy harvesting is implemented by thermoelectric energy harvesting and pyroelectric energy harvesting.

Thermoelectric energy harvesting: Thermoelectric energy harvesting is the process of creating electric energy from temperature difference using thermoelectric power generators (TEGs). The TEGs consists of thermopile formed by arrays of two dissimilar conductors-type and n-type semiconductors. It works on the principle of Seebeck effect, which states that electrical voltage is produced when two dissimilar metals joined attwo junctions are kept at different temperatures. This is because the metals respond differently to the temperature difference, creating heat flow through the thermoelectric generator. Hence by this way energy is generated. Energy is harvested as long as the temperature difference is maintained. [4]

Pyroelectric energy harvesting: Pyroelectric energy harvesting is the process of generating voltage by heating or cooling pyroelectric materials. The pyroelectric materials do not need a temperature gradient similar to the thermocouple but they need time-varying temperature changes. Changes in temperature modify the location of atoms in the crystal structure of the pyroelectric material. The *pros* of this technique are that it provides greater efficiency. The *cons* of this technique is that to keep generating the power the whole crystal should be continuously subjected to temperature changes if it is not subjected to temperature changes pyroelectric voltage gradually disappears due to leakage of current.[5]

4) Wireless energy harvesting

Wireless Energy harvesting techniques can be classified as RF energy harvesting and resonant energy harvesting.

RF energy harvesting: **RF** energy harvesting is the process of converting electromagnetic wave into electricity by a rectifying antenna. Energy can be harvested from ambient RF power from the sources such as radio and television broadcasting, mobile phones, Wi-Fi communications and microwaves or from EM signals generated at a specific wavelength. RF energy harvesting is able to efficiently deliver powers from micro-watts to few mill watts, depending on the distance between the RF transmitter and the harvester. [6]

Resonant energy harvesting: It is also referred as resonant inductive coupling, is the process of transferring and harvesting electrical energy between two coils which are highly resonant at the same frequency. The coils can be primary coil and secondary coil. Primary coil produces a time-varying magnetic flux that crosses the secondary coil. The resonant inductive coupling can be implemented as weak inductive coupling and strong inductive coupling. The distance between the coils must be very small in weak inductive coupling and distance between the coils and powering is possible over longer distance. [7] [8]

5) Wind energy harvesting

Wind energy harvesting is a process of converting air flow or wind energy into electric energy. Wind turbine is used to exploit the energy coming from wind into electrical energy. Small scale wind energy harvesting has a low flow rates, fluctuations in wind strength, unpredictability of flow sources etc. the performance of large-scale wind turbines is highly efficient.

6) Biochemical energy harvesting

Biochemical energy harvesting is the process of converting Oxygen and endogenous substances into electricity via electrochemical reaction [8]. Biofuel cells acts as active enzymes and catalyst can be used to harvest the biochemical energy in bio-fluid into electrical energy. Human body contains different kinds of substance which has the capacity to harvest energy. The pros of the technique are that it is considered to be superior of other harvesting in terms of continuous power output and biocompatibility [9].

7) Acoustic energy harvesting

AEH is the process of converting high and acoustic waveform into electrical energy by using acoustic transducer or resonator. The *pros* of this technique is acoustic energy harvesting is used where local long term power is not available. The*cons* of this technique are that in the case of remote orisolated locations, or where cabling and electrical commutations are difficult touse such as inside sealed or rotating systems.

8) Dynamic fluid energy harvesting

Dynamic Fluid Energy consists of wind and flowing water power. The kinetic energy of the fluid can be harvested by two methods. The first method generate electricity by mechanical parts and second method uses non-mechanical parts that works as mechanical energy harvesting for the flowing water which induces mechanical vibration where that can be converted to electricity by piezoelectric [11],electrostatic[12] or electromagnetic principles[13][14].

IV. CONCLUSION

This paper covers different type of energy harvesting techniques which helps in overcoming the challenge of energy efficiency problem in WSN. The techniques described are given by keeping in mind about general network .The future work focuses on implementing energy harvesting techniques to single network and measuring its performance and behavior.

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