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Energy Harvesting Techniques in Internet of Things-A survey

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Abstract

IoT(Internet of Things) itself is a very broad concept that includes various technologies that help the people to interact with the real life objects. With the growing demand of the electronic gadgets, it is very important for the researchers and scientists to improvise IoT in terms of energy harvesting. This paper contains various layers of IoT in architecture, domains of IoT, various applications etc. It also includes various energy harvesting techniques that uses various sources like solar , wind, vibration and piezoelectric for IoT. In this paper we will mainly discuss about Energy Harvesting Techniques.

Keywords: Internet of Things, wireless sensor networks, energy harvesting techniques, architecture

1. Introduction

Internet of Things (IoT) is no more a rear technology in today's world rather it has become very common now a days . People use this technology to interact with other devices that are connected through the internet like car, wifi , phone and other daily objects. The Internet of things makes possible for us to interact with the real world objects like car, television, wifi etc so that we can grab the information about them by sitting at one place only.[1] IoT is an interconnection of numerous real-world objects , equipped with common intelligence that help in interacting with the humans.[2] IoT is an interconnection of ordinary objects and their respective addressing so that it can provide their intelligence services to the humans.[3]
The IoT is also called as Internet Of Everything or Industrial Internet which resembles with the web connection of machines and devices that can interact with each other.[4] IoT is truly a emerged technology. It is a technology that uses the concept of M2M (machine to machine) communication like the mobile phones that connect with another mobile phone to create connection between two people. With the help of this technology man can gather information about various devices that are connected over the internet.[1] Internet of Things mainly consists of the components like sensors, connectivity, processors, energy efficiency , cost effectiveness, quality and reliability and last but not the least security.The various layers in the IoT architecture are: .[5]

1. **Edge layer** – This consists of the sensor networks and the embedded system
2. **Access gateway layer** - In this layer the handling takes place i.e maintaining the message routing.
3. **Middleware layer** – This layer acts as the interface between the hardware layer(bottom) and the application layer(top) and is responsible for device and information management.
4. **Application layer** – This layer gives various applications to different users of IoT.

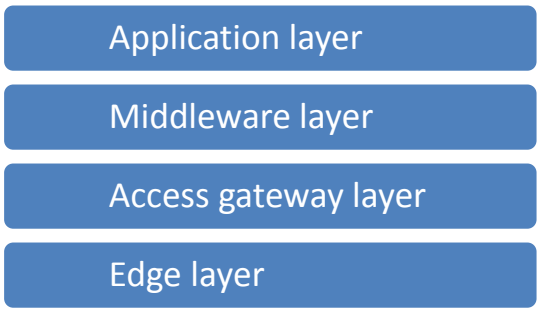

Fig1: Layers of IoT Architecture

The applications of IoT are many. Some of them are concerned with aerospace to provide the safety and security of services and products. In automotive industry by the equipment of sensors in bicycle,car etc to increase the processing power. Telecommunication industry introduces new technologies like NFC, GSM .WLAN etc. Applications related to environment monitoring includes detection of the environment related

activities. Transportation industry for creating the technologies that can screen the bags, luggage, goods etc. of the passengers travel. IoT covers a huge number of connected device. It is a network of many interconnected devices whether big or small. If we talk about practicality it not possible to change the batteries on huge devices specially when they are distributed in different places. In such cases ideas about power convertors and rechargeable batteries comes into our mind. But we cannot deny the fact that such replacement can prove to be heavy and expensive. After this we get a strong idea that self -sustainable techniques are very important in the replacement of batteries. Energy harvesting is a permanent solution to our problem of battery replacement and discharge. It is cost effective too. [4] There are many technologies that are still developing and can surely serve as a part of Internet of Things(IoT).For example, if we talk about solar energy, kinetic energy and thermal energy, they have developed and advanced to such an extent that in near future they will curve the path for the development of wireless sensor devices. These particular devices will serve as the building block of IoTs. [6] The two main sources of energy in IoT are the light and the motion. Many studies were made but still there is no proper clarity in the concept of motion energy availability . Unfortunately there is no commercially available harvestors that can be used for human motion. So the main focus is drawn on how to characterize the kinetic energy that can be harvested by IoT .[6] Many of our everyday activities can be helpful in making innovative energy conservation techniques. Research is going on how to use man's action of walking with shoes to harvest energy, how to develop the mobile phone chargers that are attached either to our bags or the phone itself.[6] However there are many ways by which we can harvest the motion energy. But we will take into account inertial energy harvesting since they fits the IoT applications better than others.

Recently WSNs (wireless sensor network) is equipped with the solar cells so that the problem of discharging and going to sleep can be prevented. Traditionally WSNs use the technique of adopting sleep scheduling so that the nodes can go to sleep and increase the power life. But the WSNS that are coming with solar cells also need duty cycle technique because it can also be greatly affected by the location and weather. However making the sensor nodes to go to sleep can only reduce the power consumption but will give no help in energy harvesting.[7] As shown in figure 2 the concept of energy harvesting can be discussed in three main broad domains: Harvesting techniques, Transmission techniques and the Harvesting applications.

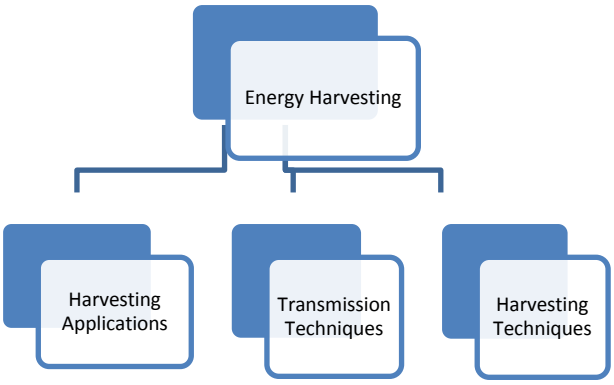

Fig 2: Energy Harvesting Domains in IoT

Energy wastage is major issue nowdays. If appropriate measures are not taken then it can lead to hazards in near future. That's why the researchers are inventing various energy harvesting techniques that can save power in the field associated with IoT. The various techniques involves solar harvesting technique, wind harvesting technique ,vibration energy harvesting and piezoelectric energy harvesting. The energy transmission techniques are becoming popular due to the need for the infrastructure-less environment to support IoT. The concept of IoT will be successful only when there will be complete removal of the need of IoT devices to be plugged in for charging.

2. Energy harvesting techniques

Energy harvesting technique these techniques can also be used in various applications to create a smarter surrounding . These applications can be further divided as wireless sensor network to make a smarter city, smarter metering and to achieve smarter agriculture, body area network that promotes eHealth and wireless electronics/networks for industrial control logistics. These techniques are basically divided in two architecture: Harvest-store-use and Harvest use [8]:

2.1 Harvest-store-use architecture:

As using batteries created the problem of discharging and replacement , so they were replaced by super-capacitors in this technique which shows almost longer lifetime as compared to the batteries. However, the flaw of super-capacitors

is its high cost and the leakage which highly limit its use in IoT. Another disadvantage it the need of two voltage convertors that are bulky and costly.

2.2 Harvest-use-architecture:

The main idea behind this architecture is to remove the voltage convertors and the long term energy storages. The two main operations under this are the **convertor-less operation** according to which the target devices may not face the power supply problem if a tolerable range of voltage is provided from the PMU (phasor measurement unit is a device which measures the electrical waves on an electricity grid using a common time source for synchronization) devices to the target devices and synchronization) devices to the target devices and **storage less operation** which has the main target of properly controlling the operation modes depending on the amount of harvested energy.[4] There are several other energy harvesting techniques as shown in Figure3.

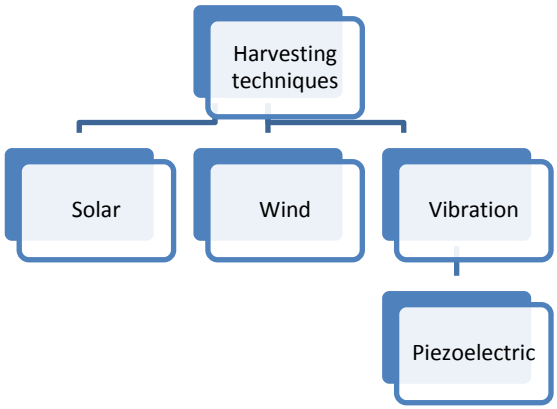

Fig 3. Energy Harvesting Techniques

2.2.1 Solar energy harvesting

Solar energy harvesting is a way to convert solar energy into electricity which can differ in terms of solar panel type, capacity and complexity of the circuit. There are various types of solar energy harvestings namely **Heliomote** : Single storage solar energy harvesting using Mica2 platform that can monitor and track the amount of solar energy extracted. **Prometheus**: Double storage solar energy harvesting using telos B platform.It has both primary and secondary buffers in which primary charges the secondary when access energy is available and sensor nodes extract energy from the primary after which it falls back to secondary buffer when energy at the primary buffer falls below threshold level. **Everlast**: It is an integrated wireless sensor nodes that which does not uses the batteries. **Ambimax**: It is a double storage energy harvesting system using the Econode and used to harvest solar and wind energy. It has both primary and secondary buffers to retain energy but transfers the energy through hardware only.

2.2.2 Wind energy harvesting

It is a way to convert the wind energy into electric energy. Along with other components like turbine blades, rotors and shafts , the main and the basic part is wind turbine. Ambimax working on Econode is one of the mechanism that uses wind energy harvesting technique. Apart from this a linear array of cylinders attaches to the piezoelectric energy transducers is proposed to this work.

2.2.3 Vibration: Piezoelectric energy harvesting:

Electric energy can be converted from kinetic energy using what is called the piezoelectric effect. Piezoelectric energy is a form of vibration energy. If the product or device in which the electronic components are there vibrates, moves with enough force and speed. It can be used to produce enough power to feed most of today's sensors. Even if there is not quite enough movement to provide constant power to a system, there are methods to store the energy in a large capacitor or battery for later use.

Table 1: Comparison of various Energy Harvesting Techniques

S.NO	TECHNIQUE	AUTHOR	TYPE	EFFICIENCY/PERFORMANCE	PARAMETERS
1.	Device with bidirectional resonance frequency tenability	[9]	Piezoelectric	resonance tuning to ±20% of the untuned resonant frequency	Magnetic force
2.	Heliomote	[8]	solar	Track the amount of energy extracted	Energy
3.	Prometheus			primary charges the secondary when access energy is available and sensor nodes extract energy from the primary after which it falls back to secondary buffer when energy at the primary buffer falls below threshold level.	
4.	Everlast			Integrated wireless sensor nodes that does not uses the batteries.	
5.	AmbiMax			Has double storage buffer to harvest solar and wind energy.	
6.	AmbiMax on Econode	[8]	Wind	Uses the biologically-inspired mechanism like the swaying of trees	Energy
7.	Redback Technology	[10]	Solar	uses smart technology to take advantage of the 'solar window' ,draws power from battery during night time , making homes more self-sufficient and less reliant on the grid.	Energy
8.	Alta Devices Solar Cells Integrated into a Wearable Device	[11]	Solar	high efficiency(28.8%), flexibility, thinness , low weight	Weight and flexibility

3.Conclusion

This paper discusses many interesting and important topics in the field of energy harvesting. There are two important architectures in the space of IoT namely Harvest-store-use-architecture and Harvest-use-architecture.Also there are many techniques discussed which uses solar , wind, vibration and piezoelectric energy. In solar there are many types like Heliomote, Prometheus, Ambimax, Everlast etc. which uses various platforms as discussed. Wind energy is used by Ambimax and Econode mechanisms. Piezoelectric energy uses the concept of vibration energy. A number of new harvesting techniques needs to be implemented which can help us to conserve energy.

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