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Energy Harvesting Techniques for Wireless Sensor Networks

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Abstract:
Wireless Sensor Networking is crucial in supporting continuous environmental monitoring. Energy harvesting provides solution to energy problems by harvesting energy that already exists in surrounding environment. By harvesting energy from the surrounding environment, the sensors can have a continuous lifetime without any need for battery recharge or replacement. Energy harvesting refers to harnessing energy from the environment and converting it to electrical energy. If the harvested energy source is large and continuously available, a sensor node can be powered constantly. Since massive data is captured by the WSN and the data transmission that happens in the process, there is a continuous operation of the WSN device as WSN is battery-powered and often deployed in a remote location that is hard to access for a battery replacement. This paper focuses on the method of harvesting the power using RF and solar source and network was established to observe the performance of WSN. In this work, are view of RF and Solar energy harvesting techniques have been analyzed to address the feasibility of their integration with WSN.1.

Keywords: Wireless; node; harvesting; RF; solar; battery.

I. INTRODUCTION

There are different sources of energy harvesting, such as solar power, wind, mechanical vibrations, temperature variations, magnetic fields, etc. For deployment of different loads in remote areas, energy harvesting is the only source for powering devices [1].The primary reasons for its use are:

• **Convenience–** Consumers wouldn't have to worry about changing or recharging batteries for devices such as laptops or cell phones or other electronic devices.

• **Backup Energy Sources–** Such devices can serve as backups to primary power sources. This would increase their reliability, as a backup energy harvesting source would prevent power interruptions.

• **Mobility–**Wireless sensor networks can have secure mobile nodes, which are a useful feature for fire fighters, the military, and law enforcement. At the same time equipment that takes advantage of the sensor networks would also be secure and mobile.

Energy harvesting subsystems enable WSN nodes to last potentially forever for continuously providing energy, and storing it for future use. WSN is battery operated device. It is a distributed wireless network for monitoring and recording physical conditions of environment like temperature, sound, pollution level, humidity, wind, pressure and organizing the collected data at central location. There are three types of nodes that includes coordinator, sensor and router. The coordinator (base station) acts as a gateway between the devices in a network. Complete information from the network can be retrieved from the base station.WSN comprises of larger number of sensor nodes that sense, process and communicate information with other nodes in a network. Router nodes receive and route the data[2]. Energy is harvested from the environmental sources. Then this energy is stored in a small storage device like battery. This stored energy powers the sensors that are deployed in locations for sensing.

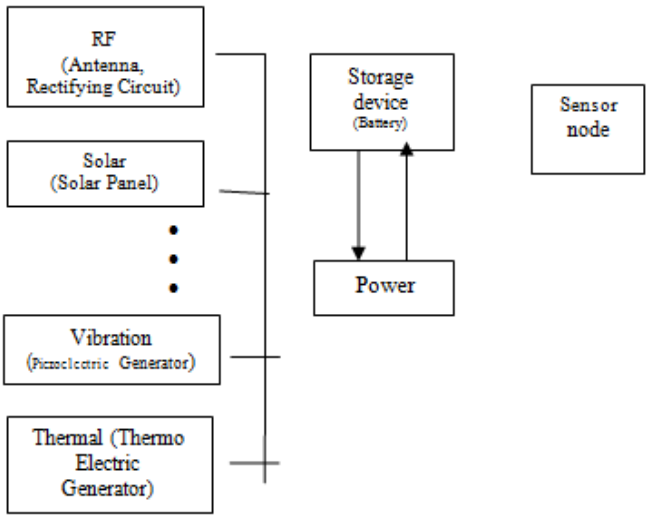

Figure.1.General .block diagram of Energy harvesting technique

II. ENERGY HARVESTING METHODS

1. RF ENERGY

RF energy harvesting technique is used for indoor applications. A dedicated RF source is used [3]. The Lifetime Power Energy Harvesting Development Kit for Wireless Sensors is a complete demonstration and development platform for creating battery-free wireless sensor applications powered by RF energy (radio waves).The kit includes an RF transmitter, RF energy harvesting receiver boards and directional antenna, wireless sensor boards [4]. The wireless sensor boards are powered by the Power Harvester Receiver, which converts RF energy into DC power. The transmitter is the source of RF energy at 915MHz. The included wireless sensors measure temperature, humidity and light, and have an interface for an external sensor. A small network was established using RF energy harvesting kit including transmitter, receiver and access point (base station). The network was established to study the performance of RF

energy harvesting kit in indoor environment. The amount of energy harvested by varying the receiver position was also studied. Here transmitter acts as a power source which in turn powered by AC supply. The transmitter provides power and data to receiver. To the receiver unit directional antenna was interfaced and sensor conditioned module with temperature, light, humidity and external sensor was interfaced as add on board. The base station was connected to PC usinga USB cable. The transmitter was mounted on the wall that includes a status LED. When the transmitter was powered ON, there was a LED flash which indicate that the transmission is ready to send data. Whenever there was sufficient power, LED on the receiver board flashes. The receiver receives the data and sensor board mounted on receiver convert data from analog to digital form which is transmitted to access point connected to PC. The received data packet was displayed and logged on XCTU software .The receiver has been positioned at various distances (30cm, 60cm….5m) from the transmitter which is shown in fig.2.and the experiment was repeated for 4 different intervals(11:00-12:30pm, 1:30-3:00pm, 3:00-4:30pm and 5:00-6:30pm) to observe the performance of RF energy transmission from transmitter to receiver.

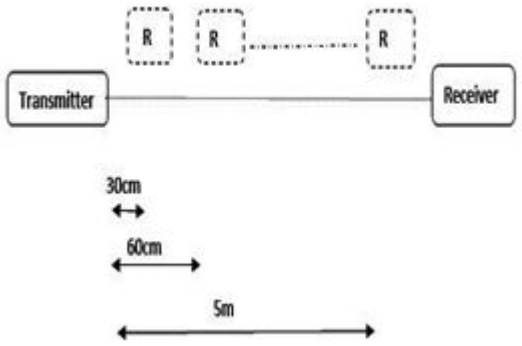

Figure.2. Position of receivers at various location

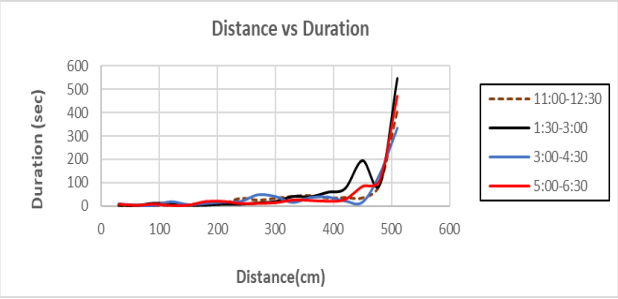

Figure.3.Distance Vs Duration

From these observations, the graph has been plotted between the distance and data transmission interval which is shown in fig.2. For smaller distances the increase in the transmission rate is normal. At a particular distance say 4.5-5m there is a sudden increase in the transmission rate. The experiment was done with dedicated RF source. RF energy harvesting is suitable for indoor deployment. The efficiency is high when the transmitter and receiver are at smaller distances.

2. SOLAR ENERGY

Solar energy harvesting technique is usually used for outdoor applications [5]. For harvesting the solar energy, solar panel is used. The panel absorbs sun rays and convert into electricity. The system is comprised of a solar panel, a lithium ionbatteryandaWSNnode.Solarenergyisusedwheneversunshinei ssufficient and the lithium ion battery is a complementary power supply during rain and night. Solar panel charges the node and the battery. It works on the principle of photovoltaic effect. When certain materials are exposed to light, they absorb photons and release free electrons. This phenomenon is called as the photovoltaic effect. Based on the principle of photovoltaic effect, solar cells or photovoltaic cells are made. They convert sunlight into direct current (DC) electricity. During night time, since the solar energy is not available the circuit gets switch over to battery and load will be powered. This leads to discharge of battery. Once when the solar energy is available the circuit gets switch over to the panel and powers the load as well as charges the battery. Sensor nodes and router nodes were powered with solar source to check how much time has been taken to charge the discharged battery. Nodes were deployed in outdoor and interfaced with solar panel. The time taken for charging the battery of WSN sensor and router nodes were observed with the experiment performed during sunny days from 11:30am to 4:30pm.Based on the observation, graph has been plotted shown in fig.3. and fig.4.

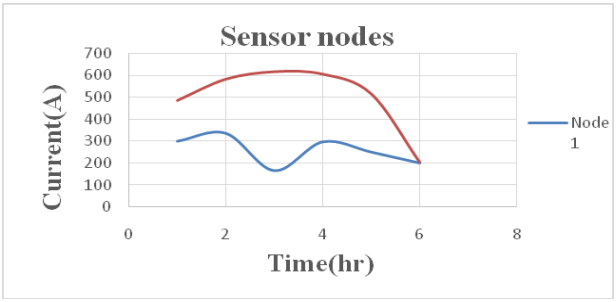

Figure.4.Battery charging profile of Sensor nodes

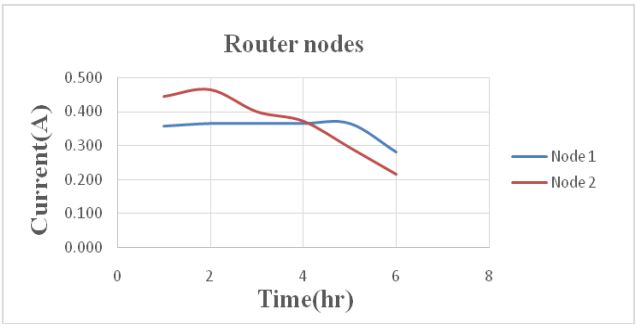

Figure.5.Battery charging profile of Router nodes

From fig.4 and fig.5, it is inferred that initially the current consumed by battery was high. After 6 hours it was observed that the current consumed was reduced since the battery was fully charged.

2.1 NETWORK ESTABLISHMENT

WSN network was established on the rooftop of the building using three noded network. The deployment was made outdoor to observe router node performance with solar power. Three router nodes were configured to transmit temp and voltage sensor values. These nodes were placed in such a way that the data reaches the base station ina routing manner. All the three nodes were not directly connected with the base station. They were configured to work in 2.42 GHz frequency to transmit data in 2s once interval .Nodes were distributed at a range of 10m.Base station was connected to laptop. R1 was interfaced with antenna and the network was established. The data received by base station was monitored using XCTU graphically user interface (GUI) software [6] and received data was logged in database for future reference. From the data logged in the database, the graph was plotted between battery voltage and time taken to charge the battery which is shown in

fig.6.From the fig.6. it is inferred that the nodes took approximately6hourstoreachtheupperthreshold limit of battery of WSN nodes.

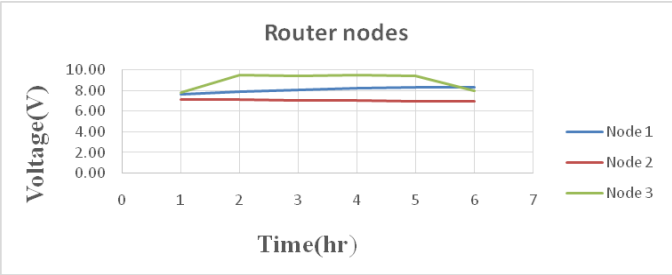

Figure.6.Variation of battery voltage with respect to time

III. APPLICATION

Wireless sensor networks comprise of different types of sensors like low sampling rate, seismic, magnetic, thermal, visual, infrared, radar, and acoustic, which are clever to monitor a wide range of ambient situations. Sensor nodes are used for constant sensing, event ID, event detection & local control of actuators. The applications of wireless sensor network mainly include health, military, area monitoring, air pollution monitoring, forest fire detection, landslide detection, water quality monitoring, industrial monitoring, home & other commercial areas[7].

IV. CONCLUSION

Energy harvesting is the only option for powering the devices with battery backup in remote areas. Among all the available energy harvesting techniques an overview of RF and Solar energy harvesting techniques have been done. Experiments have been carried out to observe the energy that can be harvested from both the energy harvesting techniques when it was interfaced with WSN nodes. From the study and experiments performed it was inferred that the energy harvesting options are application specific. As the energy that can be harvested from RF energy harvesting technique varies with distance it is suitable for indoor applications. With dedicated RF source the amount of energy harvested is offen mW, it can be mainly used for fixed time monitoring applications. Solar energy is available forever naturally and the energy harvested from solar energy harvesting is more when compared to other techniques. It is a suitable technique for outdoor application. The energy harvested depends upon the illumination of solar radiation on solar panel. This energy harvesting technique is suitable for continuous monitoring applications.

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