TEST Engineering & Management

January-February 2020
ISSN: 0193-4120 Page No. 15315 - 15319

A Study of Various Simulator for an Energy-Neutral Operation of Internet of Things Nodes

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Article Info
Volume 82
Page Number: 15315 - 15319
Publication Issue:
January-February 2020

Article History
Article Received*: 18 May 2019*
Revised*: 14 July 2019*
Accepted*: 22 December 2019*
Publication*: 28 February*

Abstract:
The eventual deployment of Internet of Things nodes infrastructure are likely to be equipped with energy harvester to extensively increase the lifetime and autonomy of the nodes. However, network lifetime is one of the captious concern in sensor nodes, as the availability of natural energy source is completely reliant on the geographical locations, especially when the sensors are deployed in remote and isolated areas such as arctic stations, where supplying the required energy is critical. The objective of this paper is to study the various extensive energy simulator using which the energy neutrality for the IoT nodes can be attained and to estimate the energy consumption and lifetime of the Internet of Things nodes.

Keywords: *Internet of Things(IoT), Energy Harvester, Energy Simulator*.

I. INTRODUCTION

Internet of Things is one of the efficient claimant to realize accurate management and observation for environment concept. This requires a huge amount of Internet of Things nodes to be deployed in the environment. However, it is estimated that by 2020, there will be larger number of Internet of Things devices greater than 20 billion devices which will be interconnected to Machine to Machine and IoT server applications. With such a drastic increase in the Internet of Things devices indicates the necessity of energy for IoT devices to carry out the required operations efficiently. Therefore, the study of the lifecycle of Internet of Things networks with a various simulator is very important to anticipate the level of operations that the Internet of Things nodes can sustain. Advancement in Machine to Machine and Internet of Things technology has an explicit impact on lifestyle, business and society, there are various probable alternation to extract energy from the natural sources, but the availability of the energy depends on the various factor based on ambient parameters, environmental variables, and other eminent random external features. For examples, using internet of Things technology and healthcare sensors, a vital signs of a patient can be monitored eventually and quick automated response can be exchanged with other devices during emergency conditions. Hence using necessary data, internet of things provides a client way of analyzing a data and in turn could be transformed into business. Energy is one of the critical and crucial factors that prompt the reliability of the internet of things nodes. The internet of things nodes in order to avoid excess consumption of energy and packet retransmission on a link, aIoT device must only activate the specific nodes to transmit the data considering the availability of energy. Analyzing these in consistency with the different experiments is a reliable approach for energy management system whose aim is to increase the lifetime of the devices. Therefore, it is always advantages to make use of an reliable simulator to experiment the device efficiency and to estimate the lifetime of the internet of things nodes.

II. RELATED WORK

The demand in IoT devices in order to adopt it to our environment for societal, environmental benefits is rapidly growing every year and this motivates for the investigating the simulating the functionality of them

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before they could be applied to the real world. And it is noticed that there are only few number of simulators which could support storage modules, power consumption units and energy harvesters.Software Network simulator affords an invaluable methodology for the existing network with more intricated topologies and design architecture. The programmer can deploy the nodes and analyze up to the minute proposal and projects to evaluate the accuracy related to the experiment causing the freedom from the load of "trial and error" hardware execution. A conservative network simulator can lavish the originator with the interthread communication and manifold thread of control. The functions and protocols of these simulator are depicted by native programming code or finite-state machine or a combination of both. A software network simulator and the conservative simulator both consist of a set of predefined user-friendly graphical user interface modules. For instance, some of the popular simulator which are primarily designed for research purpose is as follows,SolarCastalia SimulatorMost of the simulators which exist make use of battery power for the Internet of Things nodes to communicate. [3] proposes a simulator called solarcastalia for the wireless sensor networks which makes use of solar energy to harvest energy as its energy source. Solar energy harvesting is one of the most efficient natural energy harvester when compared with the other environmental energy harvesting sources. [3] deigned an solar energy harvester considering high periodicity, high conversion efficiency, energy density and rechargeable batteries as main characteristics.The energy scavenging module in the solarcastalia simulator makes use of the equation given below, which reflects the characteristics of both the rechargeable batteries and photovoltaic cells in which the harvested energy is stored.

$$H_{t_1}^{t^2} = \int_{t_1}^{t_2} P_{size}^{ratio} * P_{efficiency}^{ratio} * B_{efficiency}^{ratio} * D_t \; dt$$

$H_{t_1}^{t^2}$specifies the amount of energy scavenged during the time t1 and t2 and P_{size}^{ratio} specifies the size ratio of the photovoltaic cells and $B_{efficiency}^{ratio}$ which specifies the characteristics of the rechargeable battery and on the other hand, the solarcastalia simulator also shows the energy consumption module [3]

$$C_{t1}^{t2} = \left(C_{RX} + C_{TX} + C_{system} + C_{battery}^{t1}\right) * (t_1 - t_2)$$

C_{t1}^{t2}specifies the total amount of energy consumed during the time period t1 and t2, which includes both transmitting and receiving and C_{RX} specifies the energy consumed during transmitting of data and C_{TX} specifies the energy consumed during receiving the data [3].[3] concludes that the author has designed energy harvesting model and energy consumption model in wireless network solarcastalia simulator that can simulate different solar energy scavenging systems. This simulator also provides scalability through the implementation of object-oriented programming and better user-friendly GUI.WirelessEnergySim Simulator

The author in [4] proposes a discrete event simulator called wirelessEnergySim, where its main objective is to develop an autonomous system which should be able to manipulate its duty-cycle and devices accurately in order to adjust itself to the available energy sources.WirelessEnergySim simulator is also specially designed to evaluate the energy usage of various devices of the Internet of Things nodes, it makes use of various energy harvesting modules in order to harvest energy from the natural sources such as RF, vibrations, solar, temperature and etc., for the internet of Things nodes. In the fig.1 shows the flowchart of working principles of the WirelessEnergySim simulator.

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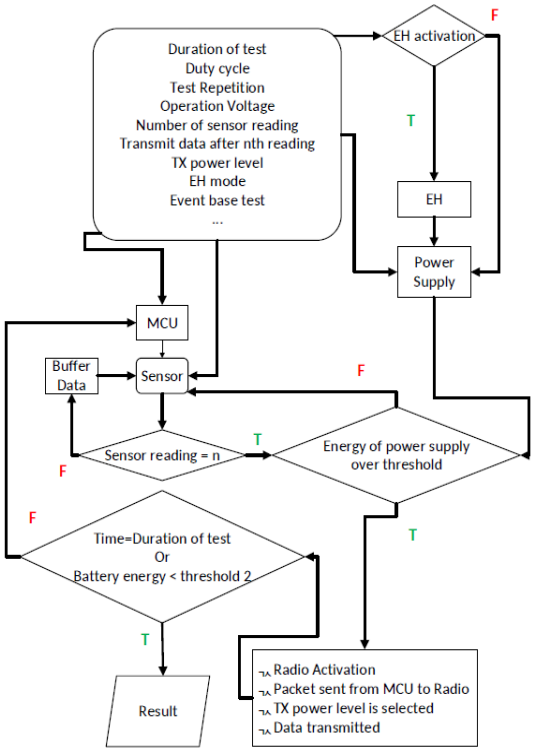

Fig.1 Flowchart of the WirelessEnergySim simulator [4]

WirelessEnergySim consist of two major blocks i.e., energy consumption block and energy harvester block for the energy consumption block in simulator which makes use of the equation

$$E_{con,i}(T) = \int_0^T V_{powSup}\ (t) I_{con,i}(t) dt$$

Where $I_{con,i}(t)$ is the energy consumed by the i^{th} node, V_{powSup} is energy supply voltage and t represents the active duration of the i^{th} node [4].By considering the various case studies of the modules designed by [4] in WirelessEnergySim simulator, where it is able to operate as autonomous system which is capable of manipulating the nodes duty-cycle and components accurately in order to adjust itself to the available energy source. MATESChina Kimberly et al., has developed a MATES which is an energy harvesting wireless sensor network simulator using MATLAB. [5] has developed an analytical model based energy scavenging simulator. The Distributed Transport for sensor Network (DTSN) protocol, for the energy scavenging variant namely the naïve (DTSN-EN) has been developed to demonstrate the efficiency of the simulator. During the transmission of data, inorder to avoid packet loss, the author has developed an packet loss mechanism which might occur during network congestion and multipath fading. When the receiver node receives a data, the probability of the data being cached is calculated using cache –probability logic, where when the cache is full, the receiver nodes removes the first data packet from its cache list and the capacity of the buffer is calculated using the equation

$$E = 1/2CV^2$$

and the transmission and reception of the sensor nodes are calculated using the equation given below.

$$E_{tx} = \frac{bits_{packet}}{bitrate} V_{tx} I_{tx}$$

$$E_{rx} = \frac{bits\_packet}{bitrate} V_{rx} I_{tx}$$

The author has made use of two different kind of simulator called HarvWSNet and SensEH simulator with some modification based on requirement. The HarvWSNet simulator extends the wireless sensor network by developing modules for the energy scavenging low energy consumption in MATLAB.

SensEH simulator allows the client to deploy code and simulate reliably using software framework using cooja emulator. The objective of both the simulator is to provide the client with virtual interface and results for an energy scavenging, since they are able to simulate using HarvWSNet simulator and emulate using SensEH which provides more accuracy [5].

NETWORK SIMULATOR 3

Network Simulator is a discrete event simulator for wireless sensor networks, which mainly focuses on educational use and research aspects. NS-3 provides a lot of various features to solve many different types of network related issues, constitutionally energy harvesting system of embedded modules are simple, and a lot of simulator are unsuccessful to take into account a lot of aspects of the scavenging

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process. Giovanni Benigno et al ., aims at extension of NS-3 model with the implementation of solar energy harvesting system, this system makes use of photovoltaic panel which accurately model the scavenging capabilities of the nodes. The solar energy harvesting system works based on latitude where the nodes are deployed, the photovoltaic cells rotate about 360 degree using tilt sensor based on the sun direction in order to extract the energy to maximum [6].The amount of energy radiated on a given surface specifies the intensity of incoming solar radiation is called Isolation. This isolation varies depending on earth sun distance, time of year, solar declination, atmosphere, time of day. Therefore, the isolation $I_M(t)$, is calculated using the equation given below.

$$I_M(t) = I_{direct}(t) + I_{diffused}(t)$$

I_{direct} (t)specifies the sunrays passes directly to the photovoltaic cells without any deviation. $I_{diffused}$ (t)specifies the sunrays are deviated by some atmospheric molecules and are dispersed before they reach the earth.

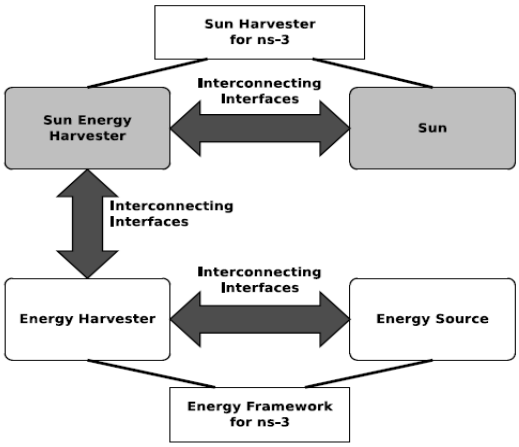

Fig.2 The Sun Energy Harvester Structure [6]

The fig.2 shows the Sun energy Harvester structure which consist of sun energy source and a sun energy scavenger. Most of the solar energy harvester is an implementation of energy scavenger incorporated in an energy framework of Network Simulator 3. The energy harvester system implements all the basic mechanism such as recharge of batteries, evaluation of energy consumed [6].

III. CONCLUSION

In this literature survey research, we have concluded that the forthcoming generation is all about Internet of Things technologies. The energy assortment and sensing assortment are the two main mechanism that aims to match the demand of power supply to that of energy scavenging in IoT technology. This literature survey procedure paves a path for alleviating the constraints of various existing simulators which can be used for energy scavenging. We believe that this survey has broadened the scope of various energy harvesting procedure using various simulators. An Internet of Things nodes should be able to modify its duty cycle and nodes in order to efficiently make use of available energy to energy neutrality. For such an implementation, various simulator can be utilized to design Internet of Things based applications and authenticate the energy efficiency of the application. in this work, we conclude that the surveyed simulators failed to achieve energy neutrality in arctic or remote conditions and hence there is necessary to design Hybrid Energy Scavenging framework for simulator in order to achieve energy neutrality even in arctic or remote conditions where Hybrid energy harvesting is envisioned to play an important key role in attaining energy neutrality in near future.

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