# Combining Two Ambient Energy protocols for IoT devices

1st Hassan Farooq
Department of Computer Science, Bahria University Karachi, 75260, Pakistan
hassanfarooq.bukc@bahria.edu.pk

2nd Adnan Ahmed
Department of Computer Science, Bahria University Karachi, 75260, Pakistan

3rd Dr. Sadique Ahmad
Department of Computer Science, Prince Sultan University, Riyadh, 11586, KSA

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***Abstract*:** IoT devices, known as the internet of things, are becoming more popular daily for connecting the WSNs, which are wireless sensor nodes. This is due to their quality that these devices can easily connect to the internet, making them more popular. Their applications range from the automation of industries to the automation of healthcare systems. But the critical issue was that batteries are the primary power source for IoT devices with a limited charge. New technology was required to make them lifetime usable without any replacement until the hardware failure. The ambient energy solved this problem by providing lifetime power to the sensor nodes. Ambient energy works to generate energy from the environment using the technique known as energy harvesting. Some protocols are followed to harvest the point, including RF radio frequency, thermal, electromagnetic, and thermoelectric energy.

**Index Terms:** WSNs, RT, Harvesting, ENO, sensor nodes, ERI-MAC

## 1. INTRODUCTION

For several decades, computational technology has been widely regarded as dynamic, adaptable, and highly connected. In the year 1999, Kevin Ashton was the first person to use the term "internet of things" (IoT) [16,17]. The term "Internet of Things" (IoT) refers to a relatively new paradigm in the field of information and communication technology (ICT) that is used for distributed embedded computing and communication systems. The Internet of Things (IoT) is an intelligent network infrastructure in which a large number of things or objects that can be identified individually (for example, sensors, actuators, and wireless devices) are connected to collaborate on the completion of complex tasks [19, 20]. An increase in the demand for low-powered embedded devices and sensors was found in past years. In multiple domains and fields, there is the usage of these WSNs. In these domains, many sectors are included, such as automobile industries, healthcare organizations, the monitoring of the environment, etc. For instance, in healthcare systems, these wireless sensor nodes are used to monitor the condition of patients far from a physical medical facility and where doctors, nurses, and medical staff are not available, these sensors help to work remotely there. But on the other hand, the primary and core issue with these devices is that they have low powered nature. So, we must rely on something different than the batteries that give the required power to these devices. To make them scalable, many researchers proposed some solutions to increase the lifetime of these IoT sensors. The answer was that instead of relying on batteries, we must improve the efficiency of the energy and its reliability. An algorithm called MWCDCT, an algorithm about sleep mode scheduling, was proposed to add a surge in the life of these WSNs. This algorithm used a subset of nodes to monitor the targeted area.

## 2. LITERATURE REVIEW

When the task was assigned to combine two or more energy harvesting protocols for the IoT devices, though we found much done on radiofrequency energy, we needed help finding work in the thermal energy harvesting protocols domain. So, to improve the lifetime of the WSNs, we decided to give our contribution by combining thermal energy and radio frequency. Our research paper is the combination of two energies thermal and RF. To conclude our results, we tried to find a simulation tool that could help us in the simulation process, and we found a device known as Green Castalia. As this simulator is a paid version and we did not have the resources to buy it, we decided to take the results of this simulator from different research papers. The evolution showed in infographic form of Internet of Things in Figure 1. ARPANET, the Advanced Research Projects Agency Network, was the first technical foundation of the internet, developed in 1969. ARPANET was also the pioneering organization behind existing internet-controlled devices. In 1982, Carnegie Mellon University created a "vending machine" that was one of the earliest examples of a device connected to the internet. The toaster was the first device that could be controlled via the internet and was invented by John Romkey in 1990. The term "Internet of Things" was initially conceived and first used by Kevin Ashton, a British innovator who currently serves as the executive director of the Auto-ID centre at the Massachusetts Institute of Technology (MIT). In 2000, LG Electronics Inc. introduced the world's first smart refrigerator to the commercial market. 2009 saw the introduction of Google's self-driving car, while 2013 saw the introduction of Google glass. The company developed and introduced the intelligent home device Google Nest in 2010. From the time when 2017, the devices of Internet of Things, big data and artificial intelligence (AI) that integrate blockchain and seen widespread adoption around the worldwide world city of closed systems, including smart speakers, video cameras, sensors, metres, and so on, have been connected to the internet and are there, ore very simple to operate. Nevertheless, a lot of these devices are wireless terminals built on sensor technology, making them quite small and challenging to access. Because of this limitation, only relatively little batteries can be used to power Internet of Things nodes. Due to the high cost, amount of complexity, and need for human labour required in installing a battery in tiny sets, this is not a practical solution. The development of EH technologies from ambient sources is a useful strategy that can aid in resolving the issues with powering IoT-controlled devices in these circumstances.

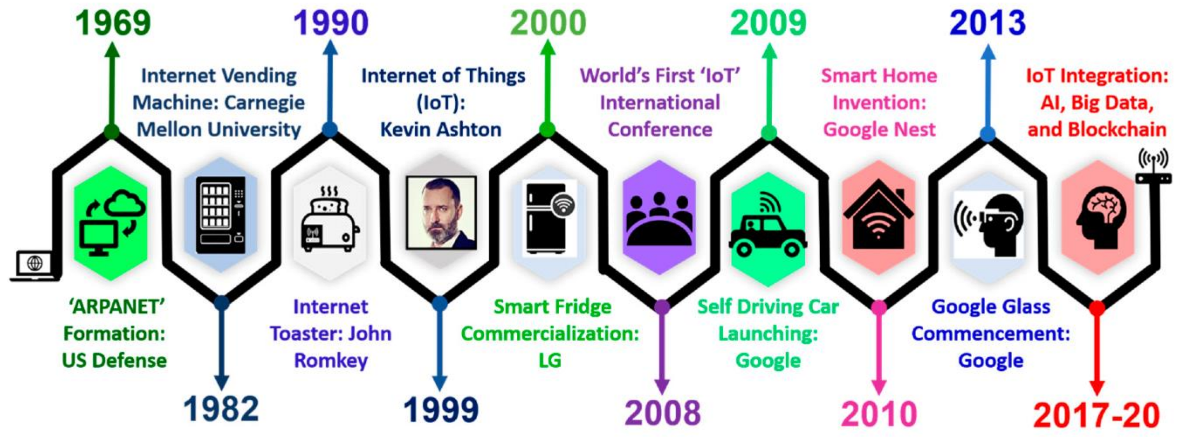


*Figure-1: Timeline in infographics Internet of things (IoT) [15]*

We have used some acronyms in this paper, and the following are the definition of these acronyms.

### 2.1. Energy Harvesting Techniques

This part of our research paper includes the significant differences between the two techniques we will combine.

### 2.2. Energy Harvesting

A technique with the help of which we can provide energy to the sensors without any usage of the batteries is called Energy harvesting. Energy harvesting techniques depend on protocols like wind, thermal, etc. Energy harvesting techniques have been evolving for many years. The harvesting of energy will help us reduce the usage of batteries in the future. Compared to batteries, the maintenance of the harvesting power is much more feasible.

## 2.3. Energy Harvesting Sources

The energy harvesting sources are included in the following table, which will give a complete understanding of the difference between energy harvesting sources.

## 2.4. RF Energy Harvesting

Nowadays, RF energy is everywhere around us in the form of radio waves that could be emitted from a cellular phone, mobile base station, and broadcasting or television. The main advantage of RF energy is that it can be easily collected from the surrounding, which the environment can easily manage. The energy collected from the environment can replace batteries in wireless devices and increase the devices' efficiency. However, harvesting energy with the help of the RF is quite complicated since the receiver harvests energy without support from the source. With the use of flat power transmitters functioning at close range, RF energy could be utilized to charge different devices, along with wearable medical sensors, a global positing system (GPS) module, and end-user electronics, an example of which is a wireless headset or an e-book reader. In a densely populated urban area, over a broad spectrum of frequencies, electromagnetic waves are functional. Radio waves can provide a critical source of energy that is universally available if they can be easily harvested. As the consumption power of components is going down continuously, we could see an increase in the efficiency of RF. This is the reason why the demand for WSNs charging IoT is increasing.

## 2.5. Thermal Energy Harvesting

The potential thermoelectric harvester is used for energy harvesting, which utilizes input heat as a source for the conversion of electrical energy. The leading causes of thermal energy production include walking, breathing or any body movement which can be used to produce and harvest thermal energy. This thermal energy can easily be converted, by the TEG, into Direct Current, also known as DC voltage. The efficiency is directly dependent upon the temperature drop in the material and the thermoelectric exhibition conversion across the TEG. The main drawback of this energy harvesting technology is that the amount of energy harvested could be much higher when we compare it to other types of energy harvesting techniques.

## 2.6. Design Proposal for the harvesting of Energy for IoT devices

For instance, IoT sensor networks have increasingly raised their demand in healthcare applications. These sensors are responsible for receiving the patient data and processing it for doctors, nurses or concerned people so they can take the appropriate actions accordingly. The working of these sensors relies on the movement of the body organs. The gateways could be localized to communicate with the patients and the doctors. At all times, these devices are directly connected to the Internet. The medical staff can efficiently perform the collection and the usage of the data of the patients. These devices have many tiny sensors that monitor the patient's condition by passing the signals to the doctors. Star topology is used in this to make it an IoT network. The sensor node present with a doctor is called the server node, which is connected to different patients, making it a star topology. Here is the block diagram for the design.

## 2.7. Modes and Associated Components

Following are some modules and the associated components.

## 2.8. Basic Structure of RF Energy Harvesting

Once compared to other energy harvesting sources, RF energy harvesting often offers a more adaptable installation. For instance, An RF antenna typically performs interceptions and converts, into voltages, the electromagnetic waves. These RF harvesters could be created for the voltage series in sync with the corresponding resistances.

## 2.9. Power Management

Power management depends upon the structure of RF harvesting and thermal energy harvesting. Both designs consist of a unit which is called a storage unit. Capacitors are responsible for supplying loads to the sensors that directly store the power that the antenna and the TEG harvest.

### 2.10. Fall detection

This key technology worked with the help of accelerometers that can differentiate between the standing and fallen posture, with some predefined internal functions and the output signals responsible for the representation of different poses. It's a simulated natural environment where users can test and implement their software and ideas as if they were in the real world. Current virtual environments can be displayed on screens so that operators can interact with them. All of the system's software is executed by it.

### 2.11. Control Unit

As we all know, the control unit is the manager of all the systems, responsible for managing the energy harvesting source’s power generation. Until a tolerable level is attained to provide the ability to the loads, all DC power is collected in the supercapacitors. Both switches are turned open when the capacitor is charging to remove, from the load, all sources of the harvested energy. To control this process, a control unit is required, which discharges the stored energy from the capacitor to bring down the input voltages.

## 3. IoT Sensor and Device Power Requirements

Classification of everyday electronic gadgets according to the energy they draw from is shown in Figure 2. Figure 2 illustrates that the Internet of Things (IoT) or low-powered electronic devices require power from 10 nW to 100 W, also called small-scale energy. These devices' typical power densities can be categorized according to one of four primary and already-existent energy sources: ambient light, vibrational/motion, thermal, or radio frequency (RF). In most cases, the disparity between the power densities and the available energy sources can be easily bridged by effectively harvesting the energy that comes from natural sources.

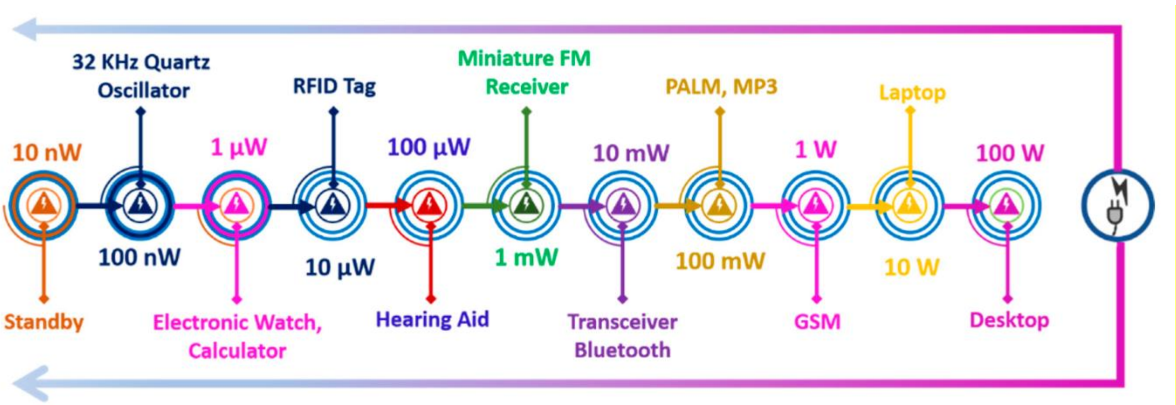


*Figure 2 Power requirements of different IoT sensors and devices (10 nW–100 W) [18]*

## 4. Results and Discussion

While gathering results, we found that many authors used the same simulator and their results after the simulation was almost identical. Packets sent by each node are reflected in the following figure. The number of sensor nodes is presented on the X-axis, and the Y-axis depicts the number of packages shipped by each node. This graph shows that the number of packets sent by each node differs from the receiving node, so the containers can easily be converted into a division of two categories: data packets and synchronization packets.

Because of the significant usage of collision avoidance protocols, the number of packets is received with and without the reference. The following two images demonstrate that the number of packets received without references is relatively high.

A contrast is being drawn between thermal energy and RF energy harvesting. The reason for the comparison is to find the feasibility of the network that relies on the effective functioning of IoT devices.

The investigation of the effect on the lifetime maximization of the protocols of the energy harvesting mechanism. The bards indicate the lifecycle of the network in the figure, which is increased in a hybrid energy harvesting network.

## 5. CONCLUSION

In effectually providing healthcare services, the critical role of on-body IoT networks must be considered. A hybrid energy harvester model is presented in this research to improve IoT healthcare devices in terms of their network lifetime. To increase the device's lifetime, and this model utilizes a thermal energy harvester and the RF energy harvester. Generally, it was observed that the energy harvest is around 0.740 J and PCE at 2.4 GHz is around 80 percent, whereas 0.530 J at a heat gradient of 15 degrees Celsius is the value of the thermal energy harvest. Since the energy harvested in this context can be further improved, this energy can be stored at an adequate level using a supercapacitor to power IoT devices. On average, against a network without energy harvesting, a 24 percent increase in network lifetime is noted in favour of hybrid energy harvesting. Future studies can extend the current research in this area by integrating more varied energy harvesting sources.

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## Authors' Profiles

**First Author**

**Mr. Hassan Farooq** is a researcher who completed his Master of Science (MS) in Computer Science from one of the leading institutes, Bahria University, Karachi, Pakistan. He obtained a Bachelor of Engineering (BE) from IQRA University, Main campus Karachi Pakistan. He was also a member of the BUKC CS Department. His research Interest includes Machine Learning, Deep Learning, Artificial Intelligence, Heterogeneous Networks & Satellite Object Recognition.

**Hassan Farooq**
Department of Computer Science, Bahria University, Karachi, 75260, Pakistan
E-mail: hassanfarooq.bukc@bahria.edu.pk
**Corresponding author: First Author (e-mail:**hassan99663@mail.com)

**Second Author**

**Mr. Adnan Ahmed** completed his Masters in Computer Science from the University of Karachi and MS in Computer Science from SMI University Karachi, pursuing his Ph.D. in Machine Learning under NED University Karachi. Presently he is working as a Senior Lecturer in the Computer Science Department of Bahria University Karachi. His research Interest includes Machine Learning, Deep Learning, Artificial Intelligence, Brain signals & Quantitative EEG.

**Adnan Ahmed**
Department of Computer Science, Bahria University, Karachi, 75260, Pakistan
E-mail: adnan.bukc@bahria.edu.pk

**Third Author**

**Dr. Sadique Ahmad** is a Postdoc (Data Science) at Prince Sultan University & Senior A. Prof at Bahria University. His research interests include Deep Learning Satellite Image Analysis, Cognitive Computing, and Machine Learning Artificial Intelligence.

**Dr. Sadique Ahmad**
Department of Computer Science, Bahria University, Karachi, 75260, Pakistan
E-mail: sadiqueahmed.bukc@bahria.edu.pk