Internet of Things Platform for Advantageous Renewable Energy Generation *

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Abstract. This work describes the details about various types of Internet of Things and their eco-system that is utilizing for increasing the efficiency of the energy system, mainly focusing on renewable energy technology.RE system is highly dependent on surrounding environmental parameters. In the field of IoT, signal processing, Analog to digital conversion is crucial. Here, making better approximation gives better results that are important for increasing the efficiency of any kind of system. It is important to get better resolution from IoT devices to give optimum performance in the energy production industry. Close interaction between PV technology and other renewable sources, like wind, solar thermal with IoT devices is the key to overcome all the drawbacks of uncertainty in renewable power generation and improve communication and monitoring. Getting support from the best IoT with sensors, the renewable energy sources give the best output mainly the Solar panel gives the best-expected output. IoT has different types of significant characteristics, and it is important to choose a particular device depending on the specific application. These significant behaviors are described in this work to identify the better components to make the best solution for the targeted system.

Keywords: Internet of things (IoT) · Sensors · Renewable Energy Generation · Communication Technologies.

1 Introduction

1.1 Notions

Due to the scarcity of energy, people from all over the world is now giving importance to the renewable energy. Sources of renewable energies are all around us and they are plenty in among with tentatively endless of raw material flow. Among the renewable energy, Photovoltaics gets an enormous concentration due to its decreasing low costing and increasing efficiency day by day [1, 2]. Among

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other renewable energy solar concentration, wind energy, hydro etc also getting the market share [3]. In the field of RE power generation, the fact uncertainty is getting concern due to its dependency on unstable environmental parameters. Also due to the importance of keeping constant monitoring on the total energy application field, IoT plays an important role [4]. IoT plays the main brain of the system that keep communication and make the best utilization of the different parties.

Analog and digital signal processing through IoT devices is getting importance to increase the efficiency of Renewable energy power generation technology. Monitoring the system is really important to always see the output and identify the fault instantly and to improve the total performance of any renewable system [5]. For forecasting the generation of renewable energy system, it is needed to get forecasting idea about the weather parameters to forecast the power generation from Solar, wind system [6, 7].

Solar panel or solar concentration system directly depends on the solar radiation. Solar radiation assists solar panel or solar concentration bowl to generate the power from panel. But this system does not only depend on solar radiation,but it also depends on other environmental parameters, like humidity, wind speed etc. Environmental model is a complex model that is very closely related to solar energy production system [8–10].

Solar energy production system also depends on the wind speed. More the wind blow, more the power is generated from wind power plant. Mainly three things the wind plant are dependent on, 1. Wind speed, 2. Air density and 3. Turbine Design. These parameters are dependent on other different parameters also. Total system is a complex model of environmental factors other than mechanical design of turbine design. Wind power generation system is also depends on the environmental fact [10–13]. For forecasting about the wind power generation, needs forecasting about the environmental parameters to give the idea how much the system could generate electricity [14].

1.2 Motivation

During Paris Agreement in 2016, 196 countries all over the world agreed to keep the temperature increase on an average less than 2 degree Celsius [15]. For keeping a healthy environment for this planet Earth, in the meeting policymakers take 17 goals.Among them, to reach the SDG goals, energy has had an important role that has a great impact on building sustainable society [15].

To survive from the starting of human history, people need energy that is in different form. Presently, to live a better life, human beings are looking for electrical energy and its transformation to different energy. People find comfort in electrical components, to feed these devices, need electrical energy.In the last few centuries, electrical energy was generated mainly from fossil fuel [16–18]. At this present time, interestingly it is found that fossil fuel has a great impact on the environment to increase the temperature and have a big impact on carbon footprint.All these issues raise the needs to search for a new source of energy that

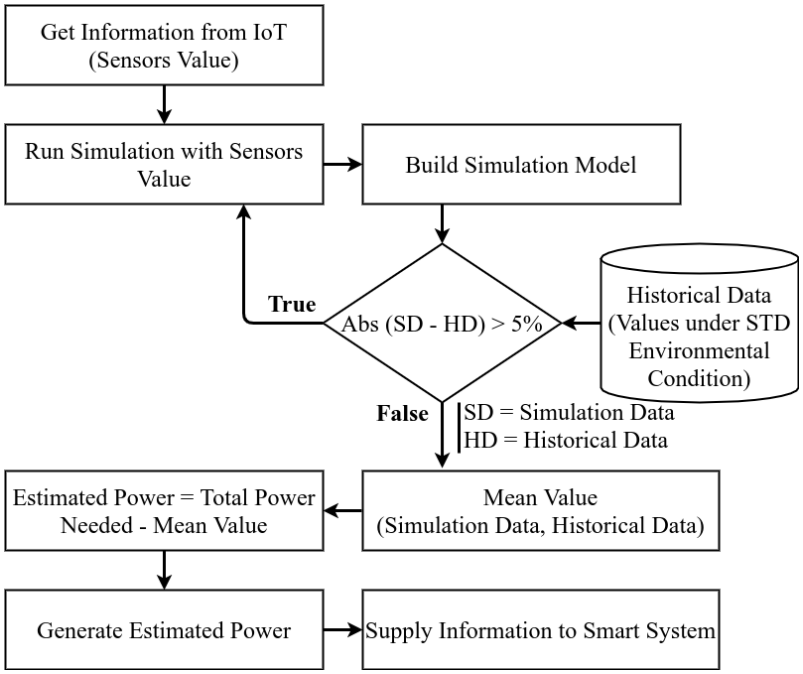

Fig. 1. Flowchart of IoT enable Smart System.

is renewable and not as harmful as fossil fuel. Renewable resources reduce the emission of greenhouse gases and also fulfil the scarcity of energy resources [19].

Fig. 1 shows flowchart of IoT enable smart system. IoT is a tool that can give a good boost to renewable energy systems. IoT is used as a monitoring system and keep communication between peers. This bi-directional communication is important for making the system smarter and efficient. IoT is capable of taking information from the environment and also from the renewable energy system, which can make a unique system to overcome different obstacles [20–23]. This unique system can forecast the future power generation from renewable sources and give this to the transmission and distribution system and also to fossil fuel power generation part. In this way, it is possible to reduce the harmful emission gases and reduction of the use of less fossil fuel generation [21].

IoT creates a total ecosystem for real-time communication between different parts to make the system smart. This smart system has artificial intelligence that takes the decision to make a better efficient platform for the total energy ecosystem.

1.3 Methodology

This work is mainly focusing on existing works related to IoT and the renewable energy sector. Signal processing is always an important part of IoT. It collects

the analog signal and converted them to a digital one and transmit to different part to improve the performance of a system. IoT is the era that is going to make the energy sector more efficient and assist humankind to improve the quality of the environment by using less fossil fuel [24].

For conducting this survey work, a systematical work has done and search over the internet with keywords IoT, renewable energy and signal processing. This work focus on getting the idea about different micro-controller devices and technologies and their bit resolution from analog to digital conversion system, also their processor performance with memory units. These micro-controllers are playing an important role to build low-cost IoT systems with different types of sensors and network connectivity [25, 26].

To enrich the survey work, different articles are collected from SCOPUS, Hindawi, ScienceDirect, IEEE, MDPI and keep the recent works from 2010 to study and get the inner information from those articles that fully describe the IoT idea in the renewable energy sector and also signal processing things to get the clear idea about this eco-system. The work focuses on IoT applications in the renewable energy.

The rest of the article is organized as follow, section 2 discusses about IoT, section 3 discusses about different technologies that enabling IoT, section 4 discusses about the IoT in Renewable energy generation, section 5 gives an overview of the current challenges related to IoT and to enable them in renewable energy generation sector and section 6 is for the conclusion of this work.

2 Internet of Things (IoT)

Internet of things (IoT) is a system that gives the advantage over the internet to connect with devices to devices as things. These devices could be anything like environmental equipment, industrial devices, home components, etc. Using a device platform with different sensors and communication protocols, this system establishes a communication channel between different parts and creates valuable services. These systems can provide different types of data and important establish services [26–30].

IoT platform includes IoT devices, IoT communication protocols, Data storage, Data analytics and different IoT applications. The combination of these components built the IoT eco-system. This eco-system is efficient and powerful to make any system intelligent, flexible, smart, cost-effective and sustainable [29]. Fig. 2 gives an overview of IoT eco-system.

First, need to identify the application where a new IoT system is going to deploy to make it smart. After identifying the application area, then need to identify the valuable parameters that are going to collect the data, have to identify sensors to collect them. These sensors are connected with other platforms to send over the communication protocol [30]. These communication protocols could be Wi-Fi, Bluetooth and then send to a central server with the connectivity of the internet. These communication protocols are important and play a crucial role in connectivity with the central server and data storage. When the data

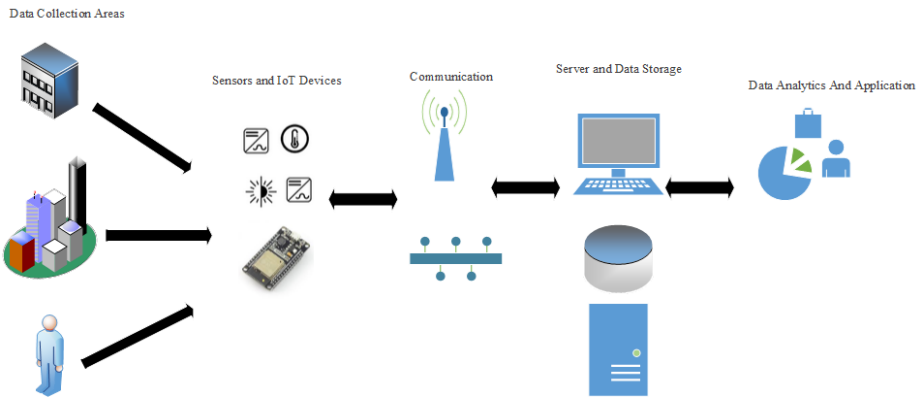

Fig. 2. Internet of Things (IoT) eco-system.

is available on the server-side, the analysis is done for extracting knowledge. The data analysis is done through different techniques and extracts knowledge through analytic. After extracting knowledge from the data the information is used by the application's user and clients [31]. In IoT applications, the data size is very huge and it's a challenge to keep tracking the data and extracting information from data. This system is effective for the renewable energy sector and to get the best output from the system [31, 33–35].

3 Different Technologies for enabling IoT eco-system

IoT ecosystem is the combination of sensors, microcontroller, actuators, communication protocol to communicate with each other. All these work together for making meaningful services.

3.1 Sensors and Actuators

Different kinds of sensors are the key to collect data from different targeted sectors like the agriculture field, industries, environment, human health, renewable energy plant, etc.

The temperature sensor is a basic sensor that is used to sense the temperature from a system. Four types of temperature sensors are available, named; a. thermocouples (MAX31855, MAX31856), thermistors, resistance temperature detector (MAX31865) and semiconductor-based integrated circuits (MAX31875). In the weather sector, energy sector temperature is important to design the predicted model and monitoring system [32].

A humidity sensor is used to sense the amount of air humidity and moisture. This part is important for the weather, agricultural field monitoring system and also renewable energy sector.

The current sensor is an important sensor that senses the current and gives an important output from a renewable system.

The light sensor is used in the room to take a reading and get the value for luminance, the brightness level of light.

Actuators are devices that taking electrical energy as input and convert them into motion. These kinds of devices are important in automated switching techniques to control different systems, connected with IoT platforms.

3.2 IoT and Micro-Controller

For creating IoT eco-system in easy and fast way nowadays different types of micro-controllers are used which give advantages to build own and cheap system. Now in the market, there are different types of micro-controllers are available in the market. These micro-controllers are easy to program and easy to customize as any specific Target work. In the field of renewable energy, these devices are important to build smart monitoring system [31].

It is important to select a type of microcontroller for a specific task. There are different important factors that should be considered to choose, like; 1. Processing Power, 2. Memory capacity, 3. Power consumption, 4. Wake up time, 5. Network connectivity interface, 6. The number of input/output ports, 7. Analog to digital conversion bit resolution 8. Security 9. Cryptographic boot loader, 10. Cryptographic hardware accelerator, 11. extension shield, 12. Memory protection unit 13.Cost. These all factors are very important to identify the best microcontroller among the huge amount of them in the current market for a special IoT task [33, 34].

All of them are important for REpower energy generation and make it feasible.

3.3 Communication Technologies

Communication technologies are important to ensure the end to end communication of data for every party. This communication system has different types of standards, establish connectivity with different types of communication protocol is crucial for deploying IoT. Wireless Ethernet is the main communication scheme. In wireless communication, there are different types of technologies and those are used in different levels of communication in the IoT ecosystem [27–31].

Wireless technologies are improving in the field of low power consumption technology, among them Narrow-Band IoT(NB-IoT), Low power wide area network (LPWAN) as LoRa (long-range), ZigBee. All of them are low power, low cost and long-range wireless technology [23–27].

Wireless fidelity (Wi-Fi) is a short-range wireless communication facility which is getting attention from different audience for IoT application. This technology is working in a medium-range area, it normally uses 802.11n and its works around 50m area [26].

Bluetooth is another wireless technology that works for short-range, at low cost. Its working range from 0 to 30m. Using Bluetooth technology it is possible to make a small private network [16].

Zigbee is another wireless technology that is low in cost, low power consummation solution and possible to make a private network. Using this mesh network it is possible to build to connect a huge amount of devices through this network [16].

There are different LPWAN, among them narrowband IoT (NB-IoT), Long term Evaluation for Machine-type Communication (LTE-M), Weightless. All of them can support the huge amount of IoT devices with low power consummation [14].

Satellite is one of the long-range communication protocol. Its installation cost is very high and power usage is also very high [19].

4 IoT for Renewable Energy Generation

IoT application for renewable energy power generation is an important area. It is now crucial to make an efficient renewable energy power generation system to keep the temperature of this world low. RE plays a crucial role to make the world greener [33].

The renewable energy power plant needs a close monitoring system to always get the information. The output from a RE system is unpredictable and it depends on weather parameters. There are so many techniques to predict the weather parameters but still, the research is going on to make it more perfect. It is really a challenging task to predict weather parameters. Renewable energy systems totally connect with these weather parameters. Forecasting weather parameters' values together with RE power generation information make a smart system that will predict power generation [16–19].

RE generated power is stored as electricity in a battery and they are connected with the central grid. During connecting with the grid system and make the system smarter it is important to deploy IoT devices. The bi-directional connection between RE generation plant, grid system, and consumer with artificial intelligence makes smart grid (SG) [33]. SG is electric grid management that works with information and communication technology with big data analytics. It is the future of energy systems that is the combination of distributed power generation and load. IoT makes this system efficient and secure. Bi-directional communication gives the security of the power supply to each component [25–31].

Fault identification of the RE system is very vital for improving the quality of service of the energy system. Different types of IoT application is build to monitor RE and SG [30].

Battery energy management (BEM) is another field of energy where IoT is playing a vital role. IoT is monitoring all activities while it is charging and discharging the energy. Implementing this technology in BEM make it more flexible, reliable and efficient [29].

The microgrid is getting attention in the rural area which works as an electric grid for the small areas. Deployment of IoT in the microgrid is making it an independent grid without the support of a central grid. This ensuring security of supply, it enables interoperability after connecting with the central grid [33].

5 Challenges

IoT is used for increasing the efficiency of the renewable energy sector and make a better smart system. There are different types of challenges that need to overcome to make the IoT system more efficient and workable. In this section, different types of difficulties and obstacles are discussed [33, 34].

In the renewable energy plant, a huge number of small devices are deployed to collect data from the field to monitor them and make them more workable. Hug amount of energy is needed for this big amount of devices to make them active and workable. Creating low power devices, is a crucial challenge to overcome this challenge. Energy consumption by IoT entities is an important challenge to overcome. Now very low consumption energy devices are built that can work and consume a very low amount of energy to work [1–27, 33].

The architecture design of an IoT ecosystem is important for making the total system more effective. This design combines all the components including communication protocols, it ensures reliable communication between all parties [19].

Another important part is to integrate IoT with the rest of the system to ensure the best output from the total eco-system. Different sensors, microcontroller, and other subsystems have to connect with each other [16].

Implement the privacy of the different entities is crucial for the eco-system. Every entity of the system needs their privacy and also has their common data for the betterment of the eco-system. This communication with each other is vital and makes the system flexible and trustworthy [33].

In the field of IoT eco-system, connectivity of the system with the internet is making the system fall into the threat of cyber-attack. Large among of the coverage of this system introduces threat. Sometimes for some systems, different parties all around the world are connected. This huge connectivity makes the system more vulnerable [33–35].

All these issues become crucial to implement IoT eco-system in the real-life system. Introducing a block-chain in this ecosystem is a solution to make the system more secure. It is a decentralized platform and without third-party intervention, the system can work properly.

6 Conclusion

Renewable energy systems are important for the future green world that is the ultimate solution for the source of energy. Including IoT with this energy system, make it efficient. The smart grid system is getting more motion by utilizing the IoT eco-system. This system needs more improvement to make it more secure

and flexible. introducing block-chain is the key point to improve it more. This work gives a review of the IoT eco-system and its importance in the renewable energy sector. It describes challenges that should be noticed carefully to improve the quality of services and include blockchain as a key game-changer in the field.

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