Chapter 15
An Application of IoT to Develop Concept of Smart Remote Monitoring System

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15.1 Introduction

One of the main contributors of clean energy all over the world, currently, is the solar photovoltaic system. A PV system's power generation potential is the main factor to be determined [1]. This potential may vary depending upon various constraints such as the technology employed as well as the location considered. The expense of every kWh pay backs the return on investment on the electricity potential [2]. Hence, before the installation of PV systems, certain measures need to be taken, so as to have larger energy potentials. There may be chances of collapse and maintenance issues at the time of operation of the system despite the efforts made during or before the installation of the PV systems. Such problems are occurring more often where the installations are in remote locations. Therefore, to mitigate such problems, a suitable approach is desired. The most accurate way to avoid such issues is the frequent check that is almost impossible for a person to carry out. Even problems involving concentration, giving full attention, and identification of solution cannot be encountered [3].

The best way to cater such a problem is to adopt the most emergent method known as the "Internet of Things" (IoT) for remote evaluation of models. IoT helps us to interact with objects used in our daily life in a much quicker and easy way with the usage of communication devices following network protocols [4, 5].

IoT has a vast range of applications including infrastructure, industrial automation, healthcare support, home power management and the renewable energy framework, traffic maintenance, automotive enterprise, micro-grids, and intelligent drive

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A. Haldorai et al. (eds.), *Business Intelligence for Enterprise Internet of Things*,
EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-44407-5_15

systems, among others [5, 6]. Based on the advent of the IoT, solar PV systems are the latest targets being focused upon. This is because of their increasing usage in the current energy sector trends especially in energy distribution. Solar PV system's popularity would be a major breakthrough for the implementation of IoT systems in combination with it, thereby giving an edge for the IoT service suppliers as well as the consumers.

15.2 Photovoltaic Systems

A PV system consists of the arrangement of a PV module, power converters, and storage devices. In essence it is the power harvester, which changes sunlight into electricity [7]. This technique is quite different from the traditional process which involves fossil fuels for power generation. Although power transmission and distribution embraces similar traditional methods, PV arrays are formed by grouping PV modules; such PV arrays are known as PV generators when arranged in series and parallel configurations [8–10]. They are then installed in a manner such that they are exposed to direct sunlight. The DC electricity generated from the PV generator is changed into AC with the assistance of the inverters. This power can be self-consumed or distributed to the energy grid through the transmission network [11]. Nonetheless, the energy can be stored using the batteries instead of being transferred. The PV models are grouped into two forms, i.e., the off-grid and the on-grid PV models, centered on various forms of functional components. An illustration in Fig. 15.1 provides a layout of the operation of the photovoltaic system.

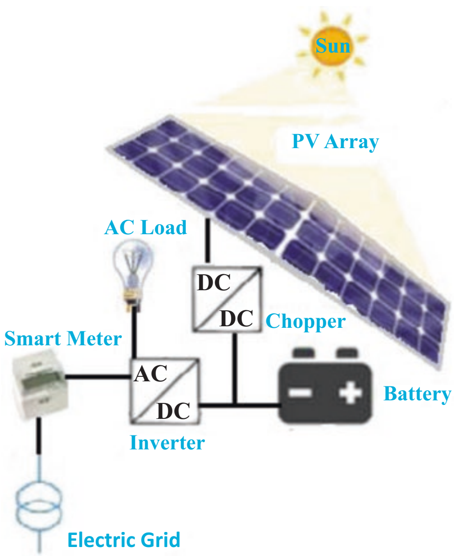

Fig. 15.1 Layout of a typical photovoltaic system [12]

15.2.1 IoT and Its Requirement in Photovoltaic Systems

Internet of Things, abbreviated as IoT, is a technology that is developed by grouping together "wireless technologies, micro-electromechanical systems, and the Internet" [3–6]. The mechanical/digital machines, computing devices and objects, solitary identifiers, and other such analogous things coordinating together constitute IoT. Because of this synchronization, which transmits the data across the network, the distance between the operational systems and information technology is closed without the aid of human-to-human and human-to-machine interaction.

The contemporary science and engineering systems cannot solve the most intricate issues which IoT can solve. The operational behavior of various components of the PV systems, which are used for generating power, varies. In short, a constant generation of power is not achievable throughout because of the solar intensity being weather dependent and time varying [12]. This has an indirect effect on the working of other components of the device such as voltage levels of power converters, status of battery charging, and load energy demands. Some environmental conditions, such as accumulation of dust, are also sometimes responsible for the poor performance of the PV system. Nevertheless, these problems can lead to the collapse of the whole system in longer terms. In order to maintain the operating data log, humans face difficulties to monitoring since it requires visits to the plant site time and time again. Henceforth, humans consume a lot of time in addressing these failures because of system breakdown or bad performance [3]. To check the parameters of the system and store them in cloud, a continuous monitoring system together with the PV system is to be equipped. This stored data will provide the performance parameters and the causes of poor performance and will make troubleshooting and maintenance operation much easier and faster. Therefore, the need for IoT is necessary to optimize the device parameters with the option of remote control.

15.2.2 IoT-Based Photovoltaic System Architecture

The IoT architecture of a photovoltaic system consists of three distinct layers. Figure 15.2 clearly displays the IoT photovoltaic system architecture. The initial layer incorporates the PV model design ambience and is connected for user satisfaction according to the required configurations. In this particular case, the Arduino server is interlinked with the components of the PV device, creating the second layer of the IoT architecture. Along with an Internet firewall option, using a router, the web server can be inter-connected with the hardware projects of the PV scheme, hence forming the gateway linkage in this second layer. The Arduino server is majorly responsible for this integration. It carries out the main functions of controlling, monitoring, and managing the PV scheme hardware constituents. The server collects the data from the third and last layer known as the remote monitoring and control layer. This information is transmitted to the storage devices that

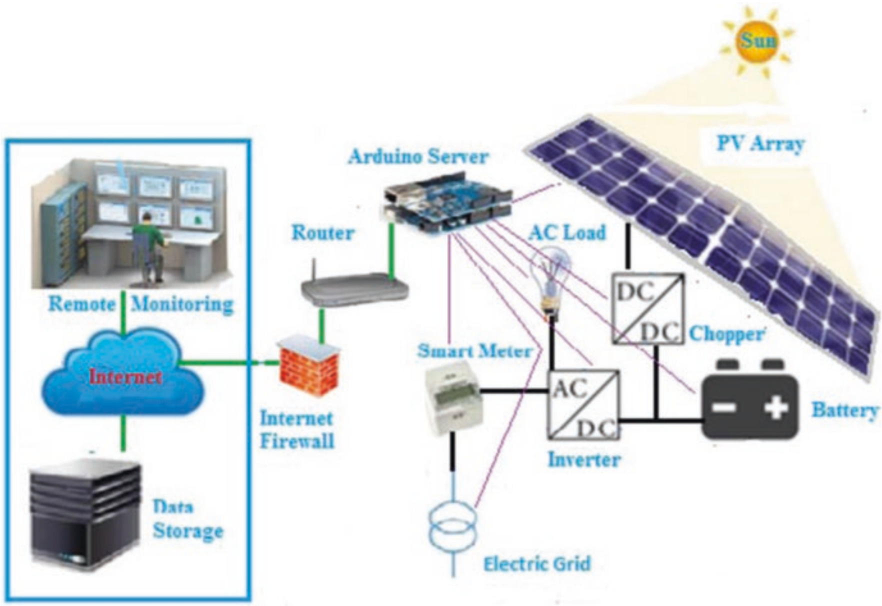

Fig. 15.2 IoT-aided layout for photovoltaic system [12]

help generate periodic reports. Using an Android interface with cloud data storage via a Wi-Fi network, these data can be drawn up in the form of visual graphs and reports, and then the users can access it accordingly.

15.2.3 Proposed Concept for IoT-Aided System for Photovoltaic Monitoring

This research proposes a device that evaluates the condition of the PV framework based on the IoT-centered network with the purpose of remotely controlling it. For the transmission of sensor information, a mobile radio network is used. The remote server data is sent through a GPRS module [13]. Figure 15.3 displays IoT technology schematics for a solar power plant.

A three-layered schematic diagram having the bottom layer as the sensing layer consists of current and voltage sensors, irradiance-measuring device (pyranometer), and other sensors. The sensing layer also consists of a microcontroller-based data processing which is acquired by the sensors. A wireless module is utilized to communicate with the microcontroller in order to initialize and start transmitting data to the server.

The second layer, known as the system layer, is where information logging is done from the plant for real-time transmission and includes database storage as

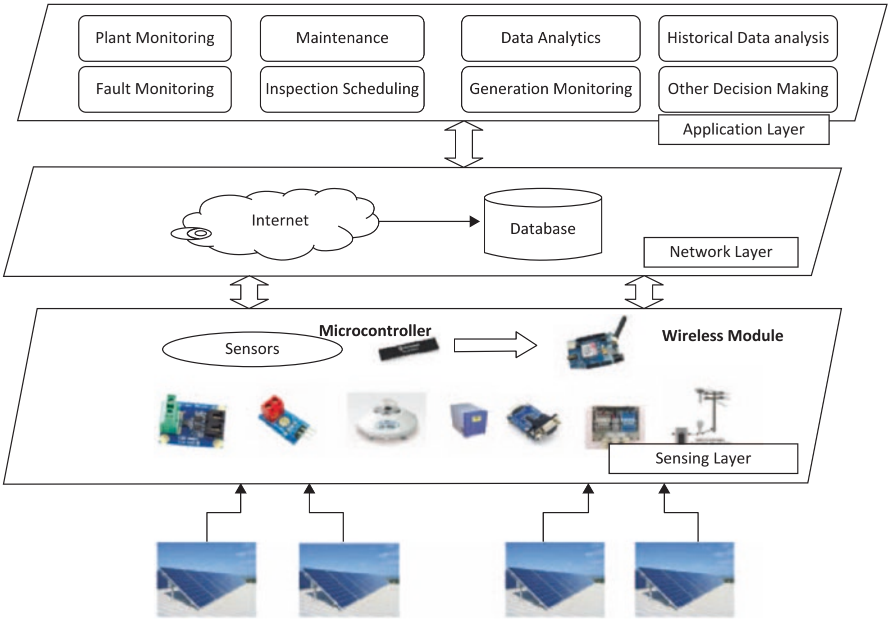

Fig. 15.3 IoT-based solar power plant [7]

well [14]. The application layer further uses this stored and processed data from the network layer. Based on the collected data's processing and storage, the web-based services are hence designed smartly. In order to help in monitoring the plant's performance, graphical user interfaces are employed. With the console, the decision-making time is shortened, indicating the administrator with historical data-based decision.

A remote monitoring system based on IoT makes it much easier to supervise the solar power plant's performance as a whole using a web-based technique as shown in Fig. 15.4.

15.3 Summary

The main advantage of using IoT photovoltaic technology is that we can accurately view the status of our property from the central control panel. Through connecting the computer to the cloud network, we can even pinpoint where the problem lies and allow technicians to repair it long before the entire system breaks down. The network is less vulnerable to the production issues (due to power outages) and potential security threats through the use of the Internet of Things. Through installing an IoT solution directly and linking solar devices, we can monitor our solar

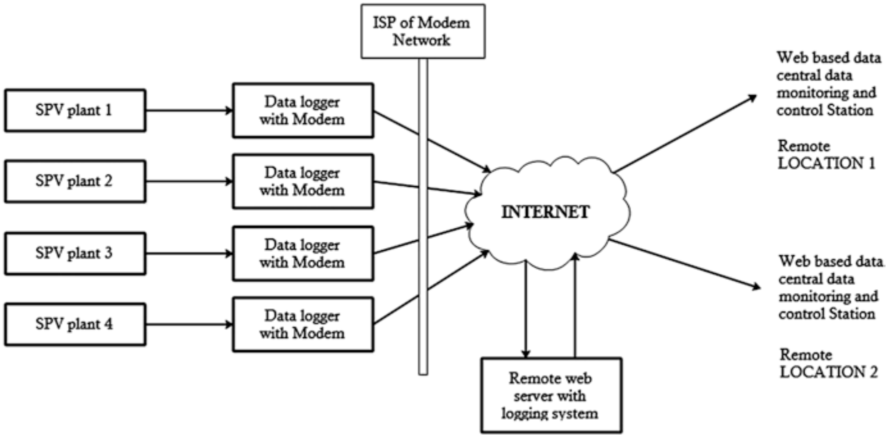

Fig. 15.4 Complete schematic of the smart remote monitoring system [7]

power system's broadband even when there are thousands of devices connected to the network. In addition to real-time business notifications, the solar industry's Internet of Things increases energy efficiency and profitability by gathering historical modeling data. This makes energy generation more efficient in terms of both costs and logistics.

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