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Web of Things Based Smart Grid Architecture to Monitor and Control Energy Sources

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Abstract: The quest for sustainable energy models is the main factor driving research on smart grid technology. Smart Grids represent the bridging paradigm to enable highly efficient energy production, transport, and consumption along the whole chain, from the source to the user. This paper describes a Smart Grid architecture implemented with the help of Web of Things. The goal of the Smart Grid architecture using Web of Things (WoT) is to provide the reliable power supplies to the consumers by making maximum use of solar energy source. The Web of Things comprise of a set of Web services provide on top of a number of Internet enabled Embedded devices. The Web browser on any computer can act as an interface to the services provided by this Web of Things. The Embedded devices are PIC16F877A, Raspberry Pi with Internet capabilities. REST API, Raspbian Operating System are used for process control on each of these embedded devices. The Web interfaces provide us information on each of the energy meters that are installed on site and communicate to the Embedded Internet devices using ZigBee. The real time energy source scheduling, energy source selection, power connection and disconnection are some of the surfaces that are provided to an online authenticated user.

Keywords: Web of Things (WoT), Smart Grid (SG), Solar Energy Source, Smart Home (SH)

I. INTRODUCTION

Increasing energy demands, depletion of natural resources and rising costs make energy conservation a universal problem with tremendous environmental, political and social implications [2]. The future of energy in the world today is focusing more and more on alternative energy sources to remove the stain of fossil fuels which are becoming more and more costly and ageing distribution infrastructure is seriously endangering security of supply. A naturally replenished energy known as renewable energy is promising to become the future energy source around the world and National renewable energy markets are projected to continue to grow strongly in the coming decade. Also, they do not produce any adverse forms of pollution that affect the ecosystem. But these resources are climate and location dependant. Use of renewable energy sources in household electrification has always been the most effective method to reduce the amount of carbon emissions that we contribute towards the cumulative carbon emissions of this planet Earth. The use of alternatives like solar water heaters help to reduce individual carbon emission foot print upon the environment.

Nowadays, researchers propose several different solutions with the purpose of helping the control of energy in all possible ways, such as where the energy is produced, where and how energy is transported, or finally, where the energy is consumed. Most solutions are addressing the problem at the end i.e. where energy is consumed because it is easier to control the consumption, than it is to alter all of the parts that compose an energy system. Thus the solution described in this paper refers to the development of a platform capable of providing energy prediction on buildings, whether the building is residential commercial, or industrial. The main objective of this platform is to use previously recorded records of the building energy consumption, along with a number of other parameters, to accurately predict the energy consumption, so that future, and pondered actions can be taken in order to provide a suitable response.

Technically, the platform itself based on standard online remote communication protocols, and this platform is to be integrated with, among other equipment, energy meters.

This paper presents our work on creating web based smart grid architecture for smart things to facilitate the integration and interaction with such devices for human users. The interface provided by the internet enabled embedded devices and the web gives different services to the users. The authenticated user can access all these through a web browser of any computer with an Internet connection.

This paper is organised as follows. Section II is a brief description of the Web of Things (WoT) solutions. It also introduces the concept of WoT. In section III we describe how WoT based Architecture is used to monitor and control renewable energy sources. Section IV presents results of proposed design. Finally, we conclude our outcome in section V.

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II. RELATED WORK

As more and more devices are working together with the Internet, the next logical step is to use the World Wide Web and its associated technologies as a platform for smart things [6]. In this type of architecture using infrared interfaces or bar codes on objects, users could regain the URI of the associated page simply by interacting with the object. Another way to use the Web for real world object is to incorporate smart things into a standardized Web service architecture.

In practice, this would often be too complex and heavy for simple objects. In the Web of Things concepts, smart things and their services are fully integrated in the Web by reusing adapting technologies and patterns commonly used for traditional Web content. More precisely, very small Web servers are embedded into smart things and the REST architectural style is applied to resources in the physical world.

The smart grid (SG) are expected to spread the intelligence of the energy distribution and control system from central core to many peripheral nodes, thus enabling more accurate monitoring of energy losses as well as more precise control and adaptation. The concept and objectives of such intelligent nodes are also used in a smart home in Melbourne, Victoria, Australia [4] that has solar panels installed on the roof for local electricity generation and batteries for energy storage.

The architecture for the cyber-physical system considered in the context of a smart grid consists of three layers. Physical appliances and their sensing and control using Low Pan smart plugs are included in Layer 1. The smart plugs communicate with a dual router which acts as the Gateway Layer. Application Layer enables householders to acquire relevant information from the web and visualize their power consumption in various formats on desktop or mobile devices. The smart home network is linked to a smart meter and smart grid.

A wide range of industrial actors have been forming association in order to boost the development of flexible standards, suitable to address the novel SG communication paradigm. In particular, the ZigBee, Bluetooth, RFID and Home plug appliances are working on the definition of wireless and wired interoperable profiles suitable for the SG. The academic interest toward SG is spinning up as well: IEEE recently introduced conferences and journals specifically addressing SG-related topics [7].

III.PROPOSED WORK

The proposed design will maintain energy consumption of different Renewable energy sources of different houses and also control the appliances. Generally Renewable energy sources are using effectively for household purpose the units of load consumption is transmitted through ETHERNET protocol. So that consumer can maintain data base in the web services. Hence consumer can know the indoor environment consumption units on web services and also we can control the home appliances from web services.

A. Methodology of Proposed System

The Smart Grid architecture implemented has two kinds of energy sources. The first kind of energy sources used is non-renewable energy source i.e. 230 VAC that leaves a significant carbon emission footprint on the environment. The second kind of energy source is renewable energy source i.e. solar energy source which is environment friendly.

The choice of energy sources in smart grid architecture should be based on the particular demands of the application and also availability of energy sources. The renewable energy sources used in the smart grid are location and climate dependant. The deciding factor in choosing energy sources can be based on ease of availability of renewable energy source.

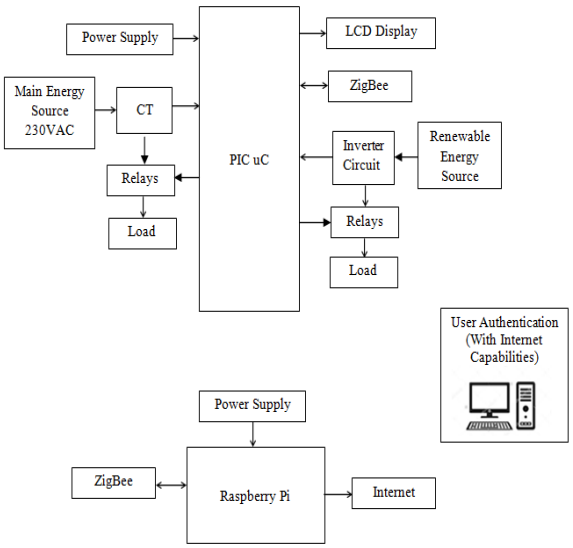

Fig. 1 Block diagram of Proposed Smart Grid

The goal of this project is to provide a reliable power supplies to the consumers by making maximum use of renewable energy sources. Fig. 1 shows the block diagram of Smart Grid. The first choice of architecture is always a renewable energy source, if it not available then architecture switch towards main energy source 230 VAC. Relays connected to PIC microcontroller helps to switch energy sources.

Role of CT is used to measure the energy consumption of loads. These readings can be captured by controlling embedded device by means of a series commands. Raspberry Pi plays role of server, continuously fetches the information from PIC microcontroller through ZigBee, so that when authenticated user login to his account it helps to give appropriate information to the authenticated user.

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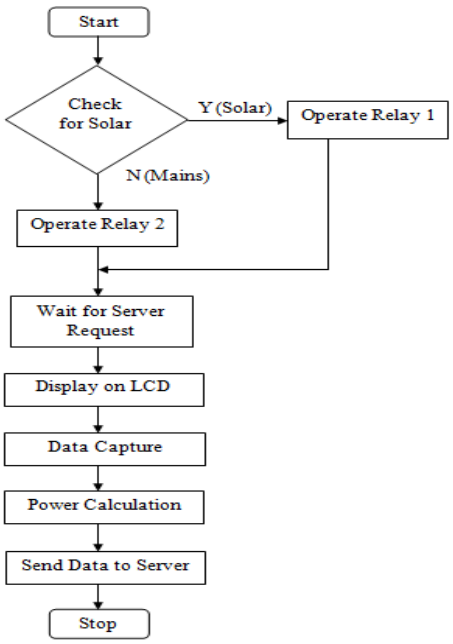

Fig. 2 Flowchart for proposed System

Above Fig. 2 is of flowchart for proposed system explains how data can be processed and analysed in our system. Proposed system divided into two parts one is system board whose main component is PIC Microcontroller and other is server with Raspberry Pi and through any computer with internet capabilities any authenticated user can access services of this system.

B. User Account Management and Services Provided

A GUI (Graphical User Interface) is provided to the user through any web browser on any computer connected to the Internet. The user is authenticated as a bona fide user after he registers himself for a connection. This can be done by applying for a new connection on the Login screen shown in Fig. 3.

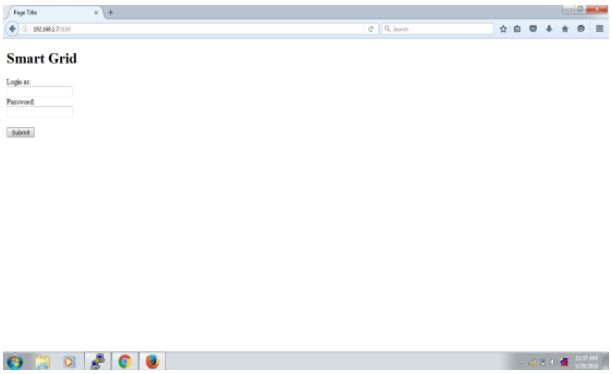

Fig. 3 User Login Page

The user after logging in enters an Index page which gives him a couple of options shown in Fig. 4. One of these options is to check for the average power consumption of a home. This helps the user to accordingly plan the scheduling of his power sources and to track his energy needs shown in Fig. 5. The graphical representation of average power consumption is shown in Fig. 6. Also power sharing of solar energy source is possible if excess power of solar energy source is available. By simply clicking "Share" button available on Index Page user can share extra power of solar source with other consumers.

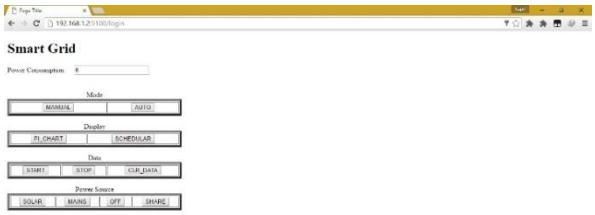

Fig. 4 Index Page

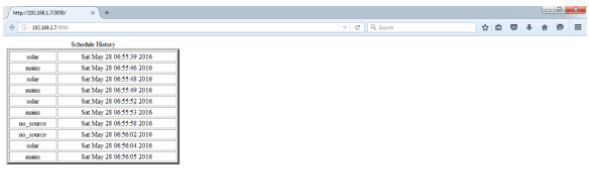

Fig. 5 Power Scheduling Page

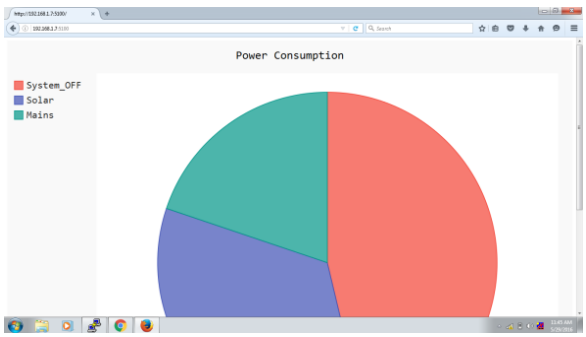

Fig. 6 Pi Chart for Average Power Consumption

Based on the power consumption data, the user plans ahead how and when to use its energy sources using the web of things. The web services allow the user to configure the switching of energy sources according to a planned schedule. The user can remotely configure this scheduling from any location at his ease.

IV. RESULTS

The proposed smart grid architecture constitutes different web services like authentication of subscriber, monitoring of power consumption from different power sources, power connection and disconnection, power scheduling and representation of data. Also, sharing of excess power of renewable energy source is possible.

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V. CONCLUSION

The smart grid architecture is a good way to improve energy saving techniques by using the renewable energy sources which would otherwise have been underutilized. The integration of Web of Things power grid architecture will provide us various opportunities for improvement in our energy saving techniques. As most of the services are provided through the Web of Things, the procedure of operation can be remotely reconfigured depending on user feedbacks and needs. The Web of Services can be reconfigured from time to time when we need arise, which is the promising direction for further development. The smart grid also adds bidirectional and intelligence communication and energy flows to today's power grid in order to address the efficiency, flexibility and stability issues that plague the grid.

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