INTERNET OF THINGS COMMUNICATING WITH ELECTRICAL SMART GRID

[1]DR. V LAKSHMI DEVI, [2]DEVISRI SNIGDHA KADULURI

[1]Associate Professor, EEE SVCE, Tirupati
[2]Associate Professor, ECE SVCE, Tirupati

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. Web of Things is a new information processing and acquisition method, that is been widely used in intelligent transportation, environmental monitoring and other fields. The WOT is an important technical mean to the development of smart grid and security smart grid. WOT technology can effectively combine the infrastructure resources in increase the level of power system information, and improve the utilization efficiency of infrastructures in the existing power system

I. INTRODUCTION

Use of Renewable Energy Sources in Household electrification has always been the most effective method to minimize the amount of carbon emissions that we contribute towards the cumulative carbon emissions of this planet earth. These carbon emissions have given rise to global warming due to depletion of the ozone layer. Use of alternatives like solar water heaters helps to reduce individual carbon emission footprint upon the environment. But the use of these alternatives is location and climate dependent. The power grid supply to our homes still remains the primary source of energy for most of the Appliances in our homes. Also the reconfiguration of the electrical circuitry of the entire home is a cumbersome process for theend user. If the users are provided with an inexpensive process to configure the power supply of their homes as per requirement, the use of generated renewable energy can be maximized. This would eventually put an impact on the total carbon emissions due to the generation process of power from non-renewable energy sources. The Web of Things [1] comprise of a number of Internet enabled Embedded devices which provide such an interface to the user by means of Web services. The end user can access this through a web browser of any computer with an Internet connection. This paper is organized as follows. Section II is a brief description of Web of Things (WoT) solutions. It also introduces the concept of WoT. In Section III, we describe how WoT applications can be implemented using hardware components. The different hardware components providing Internet connectivity, support for data acquisition from energy meters and communication within modules are described .Section IV presents an analysis of the Web services provided. The Web services comprise of authentication of subscriber, monitoring of power consumption from different power sources, power scheduling and graphical representation of data. Section V discusses the problems faced and Section VI discusses the scalability and sustainability of the whole project. Finally we conclude our outcome in section VII.

II. IMPLEMENTED WEB OF THINGS

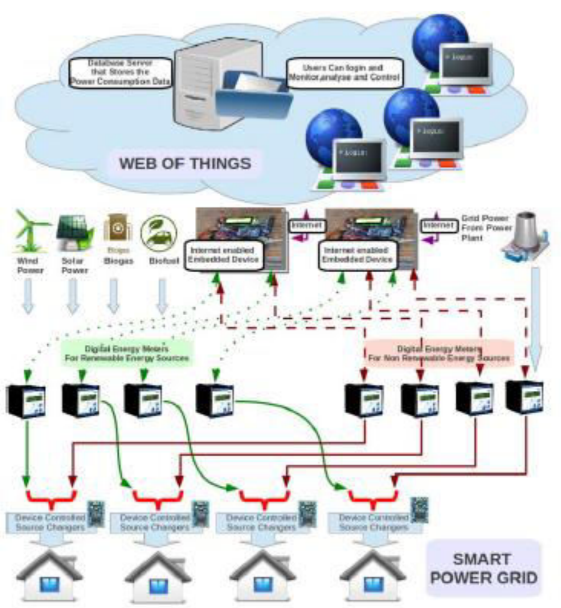

Fig1. *Web of Things to control a smart grid*

The Smart Grid [3] architecture implemented has two kinds of energy sources. The first kind of energy sources used is non – renewable Energy Sources that leave a significant carbon emission footprint on the environment. The second kind of energy sources that we used comprised of a number of Renewable energy sources that were environment friendly .Our goal was to maximize the utilization of the latter .But the final choice of the Energy Source that is used is taken by the end user of the services that are provided by the implemented Web of Things architecture. This is depicted in Fig 1. The Non-Renewable energy sources consist of Nuclear Power plants, Thermal Power plants etc. The Renewable energy sources consist of wind turbines ,Solar panels, Biogas plant and energy derived from Biofuel .The Energy sources are connected to individual digital energy meters of industrial standard. Different parameters like current, voltage, power, frequency etc. are derived from each of these energy meters by means of RS 485 connections. The collection of meter readings is controlled by Internet enabled embedded devices which are in constant communication with the meters. The data that is collected from the meters is periodically updated into a server. This server provides the web services that make up the web of thing on top of these embedded system devices. The services provided by the server include display of meter information, location of the homes connected through smart grid, scheduling of the power sources for each individual home and remote control over the energy sources by switching the source controllers by means of the embedded devices [2]. A user only needs a username and password to gain access to these services from any computer connected to the Internet. The controlling of the energy sources for each home is done by the help of source changers. These source changers are controlled by embedded devices. The embedded devices wait for the instruction from the server which is furthermore instructed by the authenticated user to switch the energy sources.

III. HARDWARE COMPONENTS

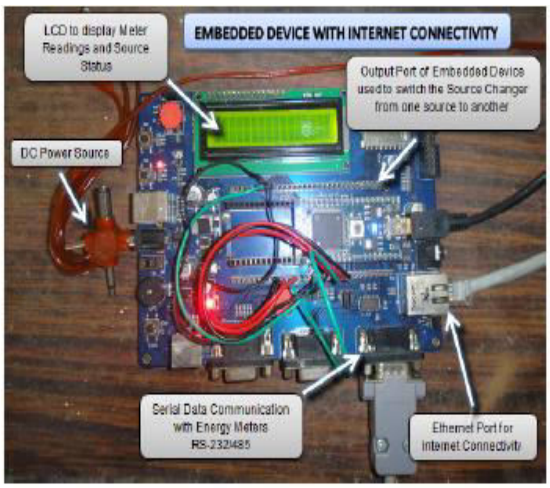

Fig2. *ARM Processor based Internet Enabled Embedded Device*

A. Internet Enabled Embedded Device

In this setup an ARM cortex M3 processor is used to design an embedded system device. The LPC1768 processor from NXP [5] is used as our version of ARM processor. The processor is interfaced with a RS 232 port, LCD and Ethernet port. A Real time operating system called CMSIS [4] is used for task optimization .On top of that a small protocol stack called LwIP is used to support TCP/IP capabilities on the board. The device is shown in Fig 2.

B. Serial communication with Energy Meters

The ARM processor board communicates with the RS 232 port by interfacing its UART (Universal Asynchronous Serial Transmission) Port with MAX232 IC .But the data from the commercial digital meters is obtained in form of RS485 Port out. So we convert the output from RS232 to RS485.The RS485 MODBUS protocol allows the serial data to be transmitted over a distance of 1200 meters. So, several energy meters within 1 km (theoretically 1km, tested about 200m) can be accommodated with a single processor board. The meters are connected to the various Non-Renewable and Renewable energy Sources directly to record the voltage and current readings. If voltage is more than 450V, Voltage Transformer is required and for current, Current Transformer is required for current more than 5A.The Transformers also help to isolate the meters from the high current and voltage of the input supply. These readings can be captured by the controlling embedded device by means of a series of commands. The choice of current transformers depends on the maximum current that is expected to be measured.

C. Ethernet Port on Embedded Device

The Ethernet port (RJ 45) needs to be interfaced to the LPC1768 processor in order to establish an Internet connection .The LwIP protocol suite [6] helps to establish the Internet connection on the port. There are 3 steps for this

(1) Initializing the Internet connection(mapping MAC address to a particular IP address which has access to the world wide web)

(2) Connecting to the Internet when the need arises

(3)Terminating the Internet connection when there is no longer required to transfer or receive data over a connection.

D. Interfacing to electrical source changers

Electrical source changers which are DC Voltage controlled are interfaced to the embedded controller boards by means of relay controllers like H-bridge drivers.

IV. SOFTWARE DEVELOPMENT MODEL

A. User Account Management

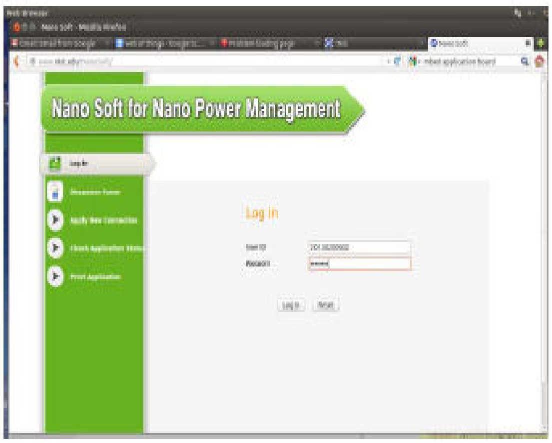

Fig 3 Login Page for the user to access the web services

A GUI (Graphical User Interface) is provided to the user of the services 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. The necessary documents a verified and after proper verification an installation is carried out by professional to include the home in the smart grid. The status of his application processing can be tracked by the user on the login screen. After the application has been processed, the user can print the application details on this page. The user after logging in enters an index page which gives him a couple of options. The Login page is shown in Fig 3.

B. User Power Consumption

Fig 4 Web page to check average power consumption data for a particular time span

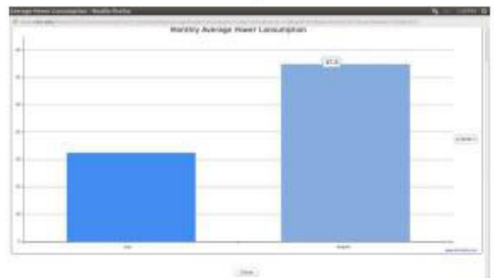

Fig 5 Comparison of average power consumption data graphically represented

One of these options is to check for the average power Consumption of a particular home. This helps the user to track his energy needs and accordingly plan the scheduling of his power sources. The user can track his consumption day-wise, month-wise or year-wise. The consumption data can be compared to consumption data of other times by means of graphical representation of comparison of average consumption data. The GUI for the user to enter options is shown in Fig 4.The consequent output in the browser window is shown in Fig 5.

C. Power Scheduling

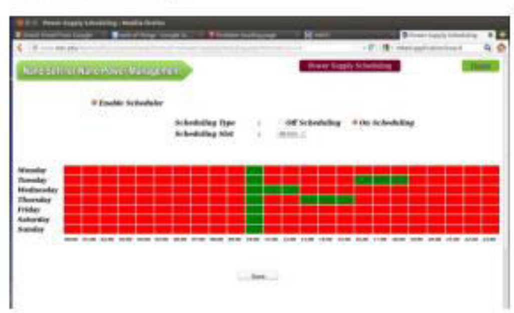

Fig 6 Power Scheduling

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 allows the user to configure the switching of energy sources according to a preplanned schedule. The user can remotely configure this scheduling from any location at his ease. The power schedule can be adjusted in the GUI provided by the browser depicted in Fig 6.

C. Power Source Changing

Fig 7 Changing of Power Sources

But in case of emergency the user has the privilege of reconfiguring the current energy source. Only one user is allowed to access at a time. This configuration has direct connection to the embedded boards through Internet. The control embedded boards change the source by controlling the source changers which are connected to the grid power supplies of individual homes. While remote configuring the sources the user can view all the parameters of each power source alongside which aids decision making. The Changing of power source through the browser is depicted in Fig 7.This scenario fits when a community of people is driving their own grid. As each are consumer as well as in maintenance.

V. PROBLEMS &CONSTRAINTS

The use of a relay controllers is restricted because it needs a constant DC Voltage supply to keep operating .This problem is solved by extracting constant DC Voltage from a DC Voltage regulator IC taking input from a battery source. Also the proper functioning of power source changers depends on uninterrupted and smooth DC power supply. This makes the whole setup dependent on an uninterrupted DC Power supply. Also a high DC Voltage supply is needed as alternate power supply for the energy meters connected to the power sources. So we have presently attached a 220 V DC Voltage supply and a SMPS (Switched Mode Power Supply) to it to cater to the different DC Voltage requirements to keep the setup alive at all times.

VI. SCALABILITY AND SELF SUSTAINABILITY

The proposed model is easy to set up on existing homes with meters installed .The setup can be configured with the electrical components being chosen according to the scale of the project. It can be a low cost installation on a rural home and can be extended to a high security setup for bigger projects. As most of the services are provided through the web of things, the procedure of operation can be remotely reconfigured depending on needs and user feedback. The web services can be reconfigured from time to time when the need arises.

VII. CONCLUSION

The designed system is easy to implement and very customizable according to needs. It provides very effective techniques of using our renewable energy resources which would otherwise have been underutilized.

Finally it gives a very effective method for implementing green energy concept on a larger scale .The integration of Web of Things with existing power grid architecture will provide us numerous opportunities for improvements in our energy saving techniques.

REFERENCES

[1] Dominique Guinard, Vlad Trifa and Erik Wilde ,"A Resource Oriented Architecture for the Web of Things". Proc. of IoT 2010 (IEEE International Conference on the Internet of Things). Tokyo, JapanNov. 29 2010-Dec. 1 2010 ,ISBN:978- 1-4244-7413-4

[2] Dominique Guinard and Vlad Trifa,"Towards the Web of Things: Web Mashups for Embedded Devices". Proceedings of the International World Wide Web Conferences. Madrid, Spain.

[3] N Bui, A.P Castellani,P Casari and M Zorzi, "The internet of energy: a web-enabled smart grid system," Network, IEEE ,vol.26,no.4,pp.39,45,July-August2012

[4]ARM."CMSISOS,"arm.com.[Online].Available:http