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Design and Development of Internet of things based Smart Grid System

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Abstract---*This paper describes a Smart Grid architecture implemented with the help of Web of Things .Web of Things comprise of a set of Web services provided 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 these Web of Things. The Embedded devices are ARM Cortex M3 Processor based devices with Ethernet capabilities. CMSIS Real Time Operating System is used for process control on each of these embedded devices. LwIP Protocol Stack is implemented on top of each of these devices so that IP connectivity can be established. The Web interfaces provide us real time information on each of the energy meters that are installed on site and communicate to the Embedded Internet devices using MODBUS communication protocol. Real Time energy source scheduling, energy source selection, power connection and disconnection are some of the services that are provided to an on-line authenticated user. The Embedded Systems lab Infrastructure at the TIFAC CORE for 3G/4G Communication at National Institute of Science and Technology was used for the hardware testing of the embedded modules. We were greatly helped by the Software developers at NIST Technology Consultancy Services in designing the web applications and interfaces for our Web of Thingsarchitecture.*

Keywords-*IoT, ARM Processor, Display, E Meter, USB load*

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 theenvironment. But the use of these alternatives is location and climatedependent.

The power grid supply to our homes still remains the primary source of energy for most of the Appliances in ourhomes. Also the reconfiguration of the electrical circuitry of the entire home is a cumbersome process for the enduser.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] [2] 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.

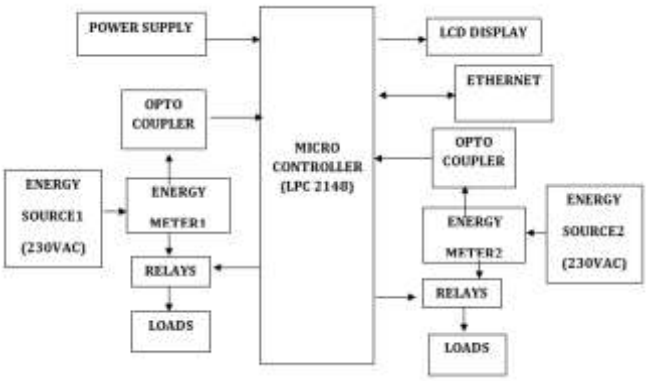

Figure.1.System Block Diagram of WoT and energy management

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 energysources [3] [4].

II. LITERATURE SURVEY

Web of Things consist of a set of Web services provided on top of a numeral of Internet aided embedded devices .The Web browser on any computer can work as an interface to the services provided by these Web of Things. (Saswat Mohanty, Bikash Narayan Panda, 2014). The literature states that The Web interfaces offer us real time information on every energy meters that are mounted on location and communicate to the Embedded Internet devices using MODBUS communication protocol. Real Time energy source arrangement, energy source selection, power connection and disconnection are some of the amenities that are provided to an on -line identified user. The Embedded Systems lab Substructure at the TIFAC CORE for 3G/4G Communication at National Institute of Science and Technology was applied for the hardware testing of the embedded components. We were greatly helped by the Software developers at NIST Technology Consultancy Services in designing the web applications and interfaces for our Web of Things architecture. Mahesh Hiremth, Prof: Manoranjan Kumar(2012)[2] The target of the Energy management using Internet of Things (IoT) is to provide the reliable powe r supplies to the consumers by making supreme use of renewable energy to the smart metering data from current sensors and stores it in cloud and device will select any of the two power sources automatically according to power consumption of load, later Embedded device by communicating with Internet real time information about power consumption and controlling authority can be given to the legal person applications, wherein people communicate with data and vice versa, including remote control to objects by humans, and objects. According to Liu Hua1, Zhang Junguo, Lin Fantao[3],implementation in the construction of smart grid which is depend on Internet of things are made, and the design and implementation in typical application links, including wind power estimation, condition monitoring of overhead transmission lines, power analysis, smart home and asset management are evaluated insistently

III. EXISTING SYSTEM

The smart grid [4] [6]is an intelligent power generation, distribution, and control system. The proposed system is helpful in collection and analysis of real time data along with the control of electrical loads for energy reduction. emphasizing the importance of the communication infrastructures required to support device control and data exchange between the various domains which comprises the smart grid. Our proposed scheme is implemented with a ETHERNET protocol.

Avoid the possibility of hacking the system, and basically, taking free electricity. To prevent meter tempering.

Real-time Models and design methods describing reliable interworking of heterogeneous systems (e.g. technical/economical/ social/environmental systems). To reduce the human efforts, and to cut the power automatically if the bill is not paid.

IV. PROPOSED SYSTEM

In proposed system we extend our data transmission to IOT [7] [8] so that the relevant parameters are monitored through ETHERNET. This is very useful in the case when the user is moving in industrial area. Along with the data monitoring devices is also controlled based on the values.

The Smart Grid [3] [5] 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 485connections

Energy generation companies supply electricity to all the households via intermediate controlled power transmission hubs known as Electricity Grid. Sometimes problems arise due to failure of the electricity grid leading to black out of an entire area which was getting supply from that particular grid. This project aims to solve this problem using IOT as the means of communication and also tackling various other issues which a smart system can deal with to avoid unnecessary losses to the Energy producers

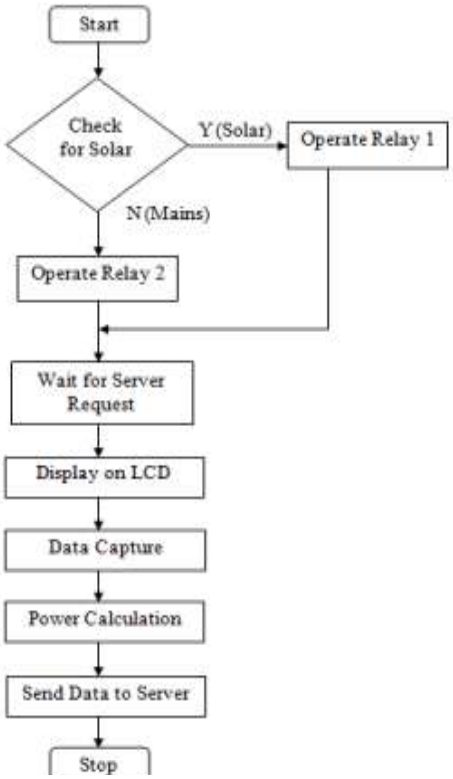

Figure.2. Flow chart for Proposed System

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 systemdevices.

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 applications [6] WoT [7] [8] 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 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 [9] [10] [11]. The Web services comprise of authentication of subscriber, monitoring of power consumption from different power sources, power scheduling and graphical representation of data.

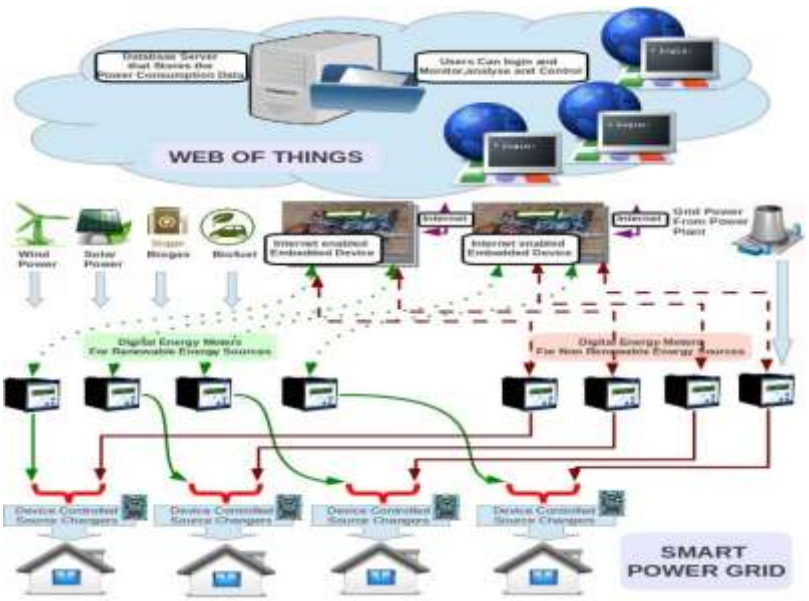

Figure.2.1. Web of Things to control a smart grid

V. IMPLEMENTATION

A. *Internet of things Enabled EmbeddedDevice*

In this setup an ARM cortex M3 processor is used to design an embedded system device. The LPC1768 processor from NXP [5] [13] 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.

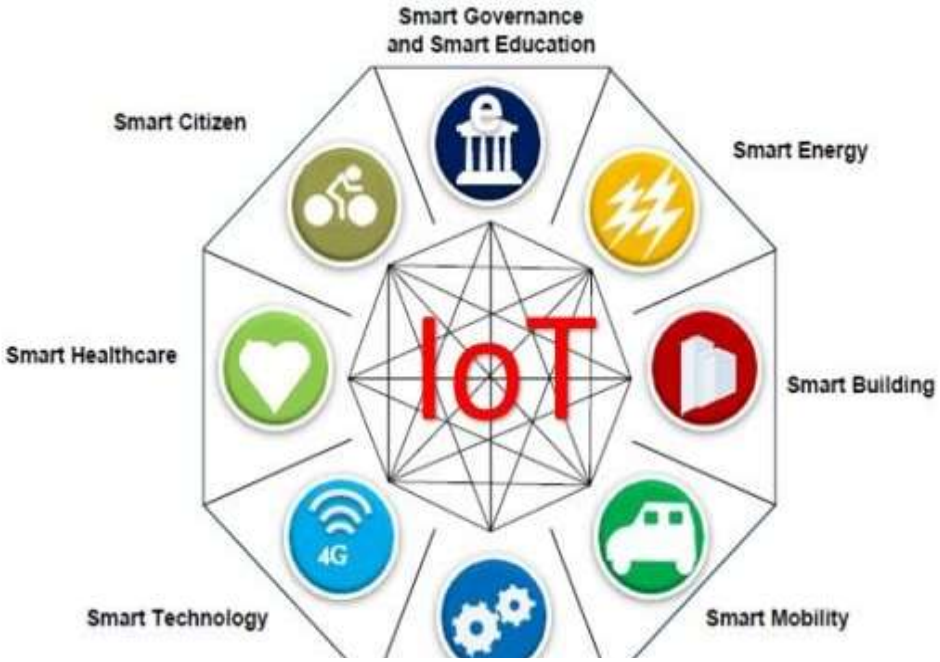

Figure.2.2 IoT with various Activities

IOT Smart Energy Grid is based on ARM controller which controls the various activities of the system. The system communicates over internet by using Wi-Fi technology. A bulb is used in this project to demonstrate as a valid consumer and a bulb to demonstrate an invalid consumer. The foremost thing that this project facilitates is re-connection of transmission line to active grid. If an Energy Grid becomes faulty and there is an another Energy Grid, the system switches the Transmission Lines towards this Grid thus facilitating uninterrupted electricity supply to that particular region whose Energy Grid went OFF. And this information of which Grid is active is updated over IOTGecko webpage where the authorities can login and can view the updates. Apart from monitoring the Grid this project has advances capabilities of monitoring energy consumption and even detects theft of electricity. The amount of electricity consumed and the estimated cost of the usage gets updated on the IOTGecko webpage along with the Energy Grid information. Theft conditions are simulated in the system using two switches. Switching one each time will simulate a theft condition and also will notify the authorities over the IOT interface.

B. *Serial communication with EnergyMeters*

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.

C. *Ethernet Port on EmbeddedDevice*

The Ethernet port (RJ 45) needs to be interfaced to the LPC1768 processor in order to establish an Internet connection .The LwIP protocol suite 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.

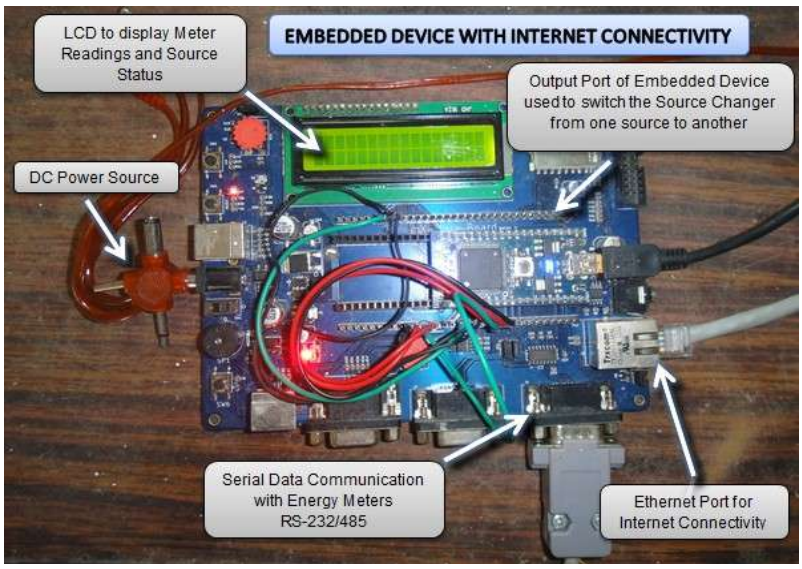

Figure.3. ARM Processor based Internet Enabled Embedded Device

D. Interfacing to electrical sourcechangers

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

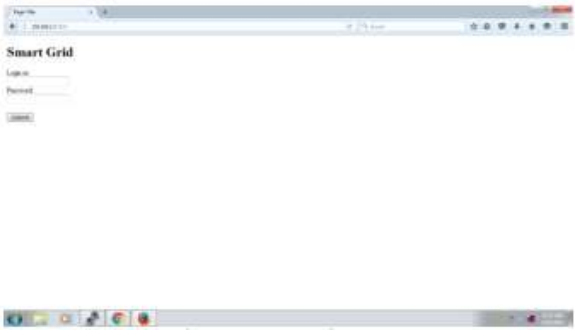

Figure.4. User Login Page

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. below

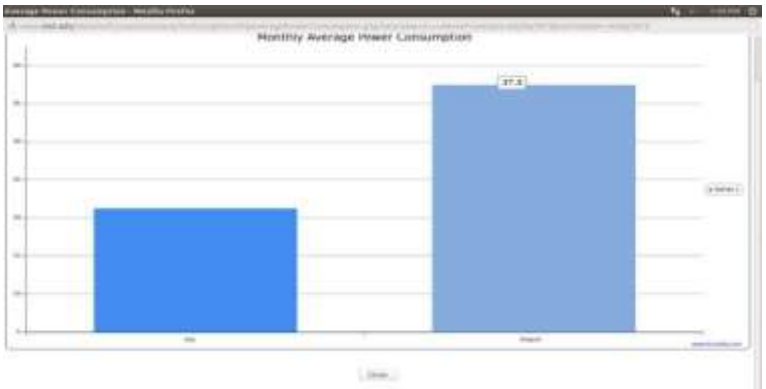

Figure.5. Comparison of average power consumption data graphically represented

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.

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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