RESEARCH ARTICLE OPEN ACCESS

Smarter Grid Embedded in an Internet of Things

Jamuna H G[1], Shobha Hugar[2]

[1] PG Student [2]Assistant Professor
Dept. of E&C, Sapthagiri College of Engineering

Abstract:
Building the smart grid means integration of advanced information, communication and networking technologies in the traditional electric grid to make it smarter and faster in making decisions. IoT platform provides very high redundancy, virtually unlimited data storage and worldwide data access. Through the IoT, consumers, manufacturers and utility providers will uncover new ways to manage devices and ultimately conserve resources and save money by using smart meters, home gateways and connected appliances. In this paper, we propose an architecture for monitoring power in smart grid applications using wireless sensor network (WSN) technology embedded in an Internet of Things platform (IoT). The advantages of the proposed architecture are: 1) it ensures privacy and provides secure access to data; 2) it enables users, service providers and application developers to interact with the platform through user interfaces.

Keywords — **Raspberry pi, Smart Grid, Smart Energy Meter, Internet of Things (IoT).**

I. INTRODUCTION

In today's modern world, Internet has become a basic need of everyone. Apart from the basic features of the Internet, i.e., surfing and web browsing, we need additional features such as entertainment, online video streaming and socializing etc. To utilize different features of the Internet, different devices are available that varies in terms of cost, computing power, display and energy consumption. The Internet of Things (IoT) will deliver a smarter grid to enable more information and connectivity throughout the infrastructure and to homes. Through the IoT, consumers, manufacturers and utility providers will uncover new ways to manage devices and ultimately conserve resources and save money by using smart meters, home gateways, smart plugs and connected appliances. The Internet of Things (IoT) is expected to grow to 50 billion connected devices by 2020 providing valuable information to consumers, manufacturers and utility providers.

A. Smart Grid

The smart grid means adding computer and communications technology to the existing electricity grid. With an overlay of digital technology, the grid promises to operate more efficiently and reliably. Much like computers and routers manage the flow of bits on the Internet, smart-grid technologies use information to optimize the flow of electricity. The digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines is called smart grid. Like the Internet, the smart grid will consist of controls, computers, automation, and new technologies and equipment working together.

The Smart Grid represents an unprecedented opportunity to move the energy industry into a new era of reliability, availability, and efficiency that will contribute to our economic and environmental health. During the transition period, it will be critical to carry out testing, technology improvements, consumer education, development of standards and regulations, and information sharing between projects to ensure that the benefits we envision from the smart grid become a reality. More efficient transmission of electricity, quicker restoration of electricity after power disturbances, reduced operations and management costs for utilities, and ultimately lower power costs for consumers, reduced peak demand, which will also help lower electricity rates, increased integration of large-scale renewable energy systems, better integration of customer-owner power generation systems, including renewable energy systems and improved security are the benefits associated with the smart grid.

B. Smart Energy Meter

The energy data collection system is a very important step and part in the research of energy visualization and analysis. Through this system, consumer can easily know their electricity usage at any instance and their behaviour to reduce their energy consumption and costs. In this paper, an automatic remote meter-reading system based on Wi-Fi can be used as a part of home automation. Wi-Fi based smart energy meter system is designed in terms of reduction of errors, absence of consumer while taking reading etc. There are many possibilities to collection of energy data.

The present billing systems have many problems like problem of payment collection, energy thefts, quality of photographs that is printed on bill etc. due to which the traditional billing system is slow, costly and unreliable. The proposed smart metering system has an advantage over the existing meter system. The present billing system has chances of error and it is also time consuming. Also, in the existing meter system, consumers are presented with usage information only once a month with their bill.

The main aim of this paper is to develop remote energy measurement system using Raspberry pi board consisting ARM11 processor and use sensors. Sensors data are stored in Raspberry pi and sends related data over Wi-Fi through the home's wireless router to the cloud as shown in the Fig. 1

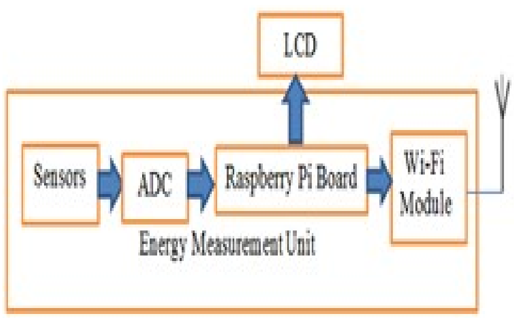

Fig.1. Proposed smart metering system

Furthermore, displays all the data such as energy consumption (Power), unit or other sensor details on GUI. The cloud collects the energy data in real time, stores it in database and uses it for energy visualization, calculation and analysis at any instance using GUI application. The design of GUI for embedded systems is different from that of traditional data computing, which often handles mouse or keyboard events to complete a specific calculation, while for embedded systems the events are caused by external devices [6].

II. RELATED WORK

Rajesh *et al.* [4] proposed a power distribution system that provides an overview of wireless sensor network by managing the equal power distribution by using ZigBee network sensor.

Han *et al.* [8] proposed a Home Energy Management System (HEMS) using the ZigBee technology to reduce the standby power. The suggested system consists of an automatic standby power cut off outlet, a ZigBee hub and a server. The power outlet with a ZigBee module cuts off the ac power when the energy consumption of the device connected to the power outlet is below a fixed value. The central hub collects information from the power channels and controls these power channels through the ZigBee module. The central hub sends the present state information to a server and then a user can monitor or control the present energy usage using the HEMS user interface. This facility may create some uneasiness for the users. For example, if the users may want low intensity of light, for some situation but the system will cut the power off leading to darkness.

Huiyong *et al*. [9] examined the integration of WSN with service robot for smart home monitoring system. Most of the proposed implementations connect the home sensor or automation network to the wide area network or to a central server by means of a complex gateway, with large computational power. Many transport options are typically proposed, such as the use of dedicated lines, to POTS/modem, PLC, wireless links [10]. Compared to these related papers, this paper presents an architecture of the smart grid, based on a platform for the IoT that can host a broad range of smart home applications

III. INTERNET OF THINGS PLATFORM

The architecture for the smart grid that is embedded in a platform for the internet of things (IoT) is presented. A platform for the IoT is a scalable distributed system that can seamlessly support an in-home smart grid and different concurrent applications for remote monitoring and control.

The system has been designed for measurement of electrical parameters of household appliances. Important functions of the system are the ease of modelling, setup, and use. From the consumer point of view, electrical power consumption of various appliances in a house along with supply voltage and current is the key parameter. Fig. 2 shows the functional description of the developed system to monitor electrical parameters and control appliances based on the consumer requirements architecture is illustrated in Fig.2.

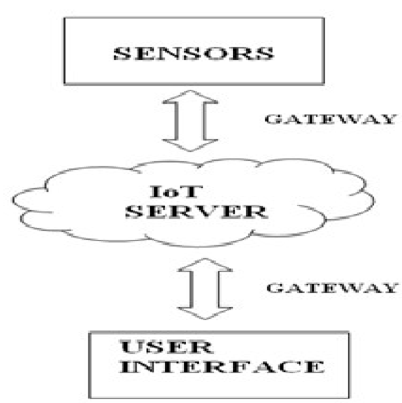

Fig.2. Block diagram of the Internet of Things platform

It consists of three main parts: the sensor, the IoT server and the user interfaces for visualization and management.

Sensor nodes communicate in a reliable bidirectional way with the IoT server. The communication between the nodes and the IoT server follows the TCP/IP client-server model. Sensors send messages in their native format to the IoT server (through a gateway, if needed), over an encrypted link.

The IoT server converts the raw payload, containing information from heterogeneous nodes, into a standard format, containing object identifier, object type, measurement unit, data field, geographical position, and timestamp. In this way, data can be easily represented, manipulated and aggregated without considering the communication protocol of the originating source.

The gateway is the element connecting a sensor network—if it has no direct IP capability—to the IoT server via an IP link. The gateway is bidirectional: for uplink communication it collects data received from the network nodes, performs reformatting/encapsulation if required, and sends them over a secure TCP/IP link to the message dispatcher. For downlink communication, it forwards to the receiver node(s) the commands received from the IoT server.

Users, service providers and application developers can interact with the platform through user interfaces. A web-based graphical interface allows users to access real time and historical sensor data. The same interface allows users with administration privileges to manage networks and single nodes. Third-party software can access the platform using a representational State Transfer application programming interface. Due to the possibility of using the system to collect sensitive and confidential data, the platform ensures an adequate security level both to end-to-end communications and to data access [1].

III. HARDWARE DESIGN

The smart meter collects the load information from the attached electrical equipment. Information includes: single phase active, reactive, and apparent power; power factor; sampled waveforms; root mean square (RMS) current and voltage; on/off status.

The sensor module contains various sensors such as current sensor, voltage sensor and temperature sensor. These sensors are automatically measure the current, voltage and temperature. These sensors are connected to raspberry pi via ADC. The ADC is connected to the Raspberry Pi at the SPI pin. The sensors data will be sent to the SPI pin that will be taken as an input of the raspberry pi and is sent to the base station. The raspberry pi collects these sensor's data for the energy calculation, visualization and analysis.

A. RASPBERRY PI

The raspberry pi is a credit sized, low cost and single board computer as shown in the Fig. 3. It is advanced by Raspberry pi foundation in the UK. Raspbian Linux OS optimized for the ARM architecture controls it. It has five models model A, model A+, model B, model B+ and latest model Generation 2 model B. The Model B+ has 512 MB RAM, Broadcom BCM2385 ARM11, 700 MHz low power System on chip CPU. Dual core Video core IV GPU and 4 USB 2.0 ports with up to 1.2A Output.

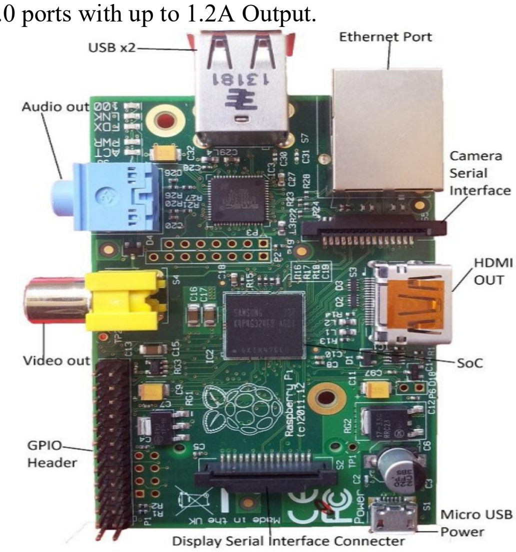

Fig.3. Raspberry Pi Model B

B. CURRENT SENSOR

A current sensor is a device that detects and converts current to an easily measured output voltage, which is proportional to the current through the measured path. A current sensor, ACS712 is as shown in the Fig. 4. When current flows through a wire or in a circuit, voltage drop occurs. Also, a magnetic field is generated surrounding the current carrying conductor. Both of these phenomena are made use of in the design of current sensors. Thus, there are two types of current sensing: direct and indirect. Direct sensing is based on Ohm's law, while indirect sensing is based on Faraday's and Ampere's law.

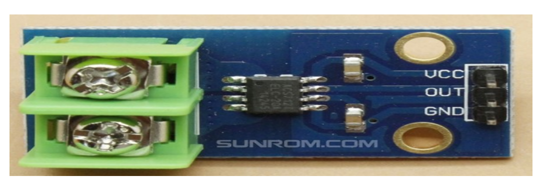

Fig.4. Current Sensor-ACS712

A. VOLTAGE TRANSFORMER

The voltage transformer can be thought of as an electrical component rather than an electronic component. A typical voltage transformer is as shown in the Fig. 4. A transformer basically is very simple static electro-magnetic passive electrical device that works on the principle of Faraday's law of induction by converting electrical energy from one value to another.

Fig.5. A Typical Voltage Transformer

The various sensors are connected to the ADC and it is connected to the raspberry pi. The raspberry pi does not has built in analog input and sensors will have an analog output, so it can be converted into digital using analog to digital converter (ADC). The ADC uses the SPI bus protocol, which is, configure by the raspberry Pi's GPIO header. It is a 10bit 8-channel Analogue-to-digital converter. It is cheap, easy to connect and does not require any additional hardware.
The Wi-Fi module is responsible to send energy data to the IoT server. These data is then accessed using GUI application.

The Voltage and Current are measured using Hall Effect current transformer and voltage transformer. These sensors continuously measure the current and voltage and the result is saved at regular time interval.

IV. EXPERIMENTAL RESULT

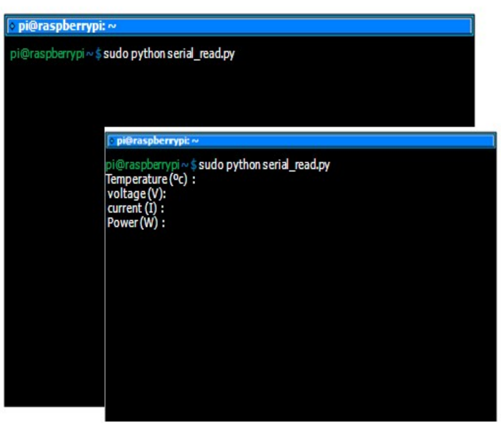

Fig.6: Output terminal

The software side of this system is divided into program running on Raspberry pi (Raspbian OS), GUI and SQLite database. The output terminal is as shown in the Fig.6. UI framework is used for writing web-enabled applications for mobile, desktop and embedded operating systems. The data from the sensors are taken from energy meter and then these data is accessed from GUI application.

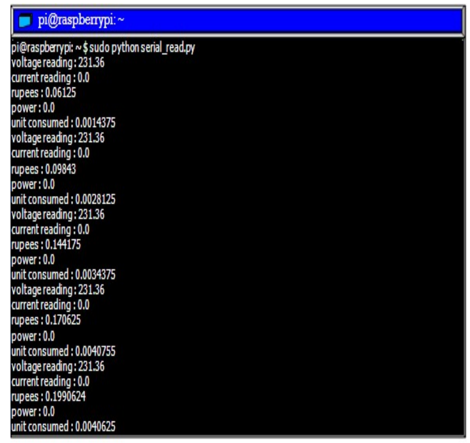

Fig.7: Output terminal showing voltage and current readings

V. CONCLUSION

The Internet of Things and Smart grid are of great importance in the development of advanced secure information, communication and networking technologies. Wi-Fi based Wireless Sensor Network (WSN) on an IoT platform has the features of high bandwidth and rate, non-line transmission ability, large-scale data collection and high cost-effective, and it has the capability of video monitoring, which cannot be realized with ZigBee. The research on Wi-Fi based WSN and its application has high practical significance to the development of smart grid embedded on internet of things. The advantage of this approach is that, it ensures privacy and data protection. It provides access to stored information and network configuration only to authorized users. In addition, the visualization interface allows authorized users to send commands to actuators. Users can create custom data views and visualization pages, send commands, set rules and alarm notifications.

ACKNOWLEDGMENT

The authors would like to thank the Management and Principal of Sapthagiri College of Engineering, Bengaluru for providing excellent computer and library facilities.

REFERENCES

[1] Nagender Kumar Suryadevara, Subhas Chandra Mukhopadhyay, Sean Dieter Tebje Kelly, and Satinder Pal Singh Gill, "WSN-Based Smart Sensors and Actuator for Power Management in Intelligent Buildings," *IEEE Transactions on Mechatronics*, vol. 20, no. 2, April 2015

[2] Hermes José Loschi**,** Julio Leon, Yuzo Iano, "Energy Efficiency in Smart Grid: A Prospective Study on Energy Management Systems Smart Grid and Renewable Energy," *Smart Grid and Renewable Energy,* no.6, pp. 250-259, 2015

[3] R. Ma. H. H. Chen, Y. Huang, and W. Meng, "Smart Grid Communication: Its Challenges and Opportunities," *IEEE Trans. Smart Grid*, vol. 4, no. 1, pp. 36-46, Mar. 2013

[4] Rajesh V. Sakhare, B. T. Deshmukh, "Electric Power Management Using ZigBee Wireless Sensor Network*," IJAET*, July 2012

[5] Lingfeng Wang, Soma Shekara Sreenadh Reddy Depuru,"Smart Meters for Power Grid – Challenges, Issues, Advantages and Status,“ *IEEE*,2011

[6] Waqas Anwaar, Munam Ali Shah, "Energy Efficient Computing: A Comparison of Raspberry PI with Modern Devices," *International Journal of Computer and Information Technology*, Vol 04, Issue 02, March 2015

[7] Dinesh Thanth, Amol Borole, "Wi-Fi Based Smart Energy Meter," *International Journal of Research in Computer and Communication Technology*, vol 4, issue 4 , April 2015

[8] J. Han, C. S. Choi, and I. Lee, "More Efficient Home Energy Management System Based on ZigBee Communication And Infrared Remote Controls," IEEE Trans. Consumer Electron., vol. 57, no. 1, pp. 85–89, Feb. 2011.

[9] W. Huiyong, W. Jingyang, and H. Min, "Building A Smart Home System With WSN And Service Robot," in *Proc. 5th Int. Conf. Measuring Technol. Mechatronics Autom.* Hong Kong, China, 2013, pp. 353–356.

[10] V. N. Kamat, "Enabling an electrical revolution using smart apparent energy meters & tariffs," in *Proc. Annu. IEEE India Conf.*, 2011, pp. 1–4.

www.raspberrypi.org/help [March 01, 2016]
www.allegromicro.com [March 05, 2016]
www.electronics-tutorials.ws/transformer.html [March 05, 2016]