2016 Symposium on Colossal Data Analysis and Networking (CDAN)

ESP8266 based Implementation of Wireless Sensor Network with Linux Based Web-Server

Tejas Thaker
M.E.-VLSI AND ESD
GTU PG SCHOOL
Gandhinagar, India
Email: tbthaker@gmail.com

***Abstract*—A Wi-Fi wireless platform with embedded Linux web server and its integration into a network of sensor nodes for building automation and industrial automation is implemented here. In this system focus is on developing an ESP8266 based Low cost Wi-Fi based wireless sensor network, the IEEE 802.11n protocol is used for system. In most of the existing wireless sensor network are designed based on ZigBee and RF. The pecking order of the system is such that the lowest level is that of the sensors, the in-between level is the controllers, and the highest level is a supervisory node. The supervisor can be react as an active or passive. The system is shown to permit all achievable controller failure scenarios. The supervisor can handle the entire control load of all controllers, should the need arise. An integrated system platform which can provide Linux web server, database, and PHP run-time environment was built by using ARM Linux development board with Apache+PHP+SQLite3. Various Internet accesses were offered by using Wi-Fi wireless networks communication technology. Raspberry Pi use as a main server in the system and which connects the sensor nodes via Wi-Fi in the wireless sensor network and collects sensors data from different sensors, and supply multi-clients services including data display through an Embedded Linux based Web-Server.**

Keywords: ESP8266, Wireless Sensor Network, Internet of Things, Embedded Linux Web-Server, Wi-Fi

I. INTRODUCTION

The Internet of Things is a popular archetype that potentially offers a wide range of embedded applications. With the advancement of Internet of things, the concept of wireless sensor network has become more and more acceptable. Sensors are affix to the Internet and wing their reach. The Internet of Things is a popular archetype that potentially offers a wide range of embedded applications. With the advancement of Internet of things, the concept of wireless sensor network has become more and more acceptable. Sensors are affix to the Internet and wing their reach. The Embedded Web Server mechanism is most disclose technology for Internet devices. There are number of sensors in Wireless sensor Network field with different usage, such as, pressure meter, flow meter, temperature and Humidity measurement, level transmitters [5]. Wired networks are mainly used to transfer data to base station by connecting from sensor. It brings ascendancy as it provides decent and stable intercommunication for instruments and controls as well as for building automation. However, the cables are very costly. So, recently low cost wireless networks are robustly required. And With evolution of Internet of Things its application areas are increasing day by day. Linux as the open source operating system, powerful embedded Linux web server can developed with low value, low power consumption, high performance, and high reliability [1].Comparison between Wi-Fi and ZigBee is given in Table I.

TABLE I
WI-FI & ZIGBEE COMPARISON

	Wi-Fi	**ZigBee**
Range	50-100 meter	10-100 meter
Data Rate	11 & 54 Mbps	20,40 & 250 Kbps
Topology	point to Point	Ad-hoc,peer to peer,star,mesh
Working Frequency	2.4-5 GHz	2.4 GHz
Complexity	High	Low
Power Consumption	High	Very Low

In this proposed WSN (Wireless Sensor Network) is consists Wi-Fi for node to server communication. Each node mainly consist an ESP8266 Wi-Fi module to communicate with a main server. Raspberry Pi embedded Linux board is used as a network main server. The function of the Raspberry Pi server is to begin the communication with apportioned end device nodes through the Wi-Fi cordless communication protocol, Raspberry Pi periodically collects the data from sensor node to the MySQL database. Raspberry Pi analyzes the received data and take action according to data result. Raspberry Pi server has an Ethernet interface for Network and Internet access to run web-server, Hence Raspberry Pi transferring data from node to server and server to node over Wi-Fi network, and user can observe the sensor data and control the Wireless Sensor Network from web browser remotely anywhere.

978-1-5090-0669-4/16/$31.00 ©2016 IEEE

II. DESIGN AND IMPLEMENTATION

From a literature survey most of the existing Wireless sensor network are developed on RF and ZigBee, Network which was build using Wi-Fi is very costly. RF based Wireless sensor Network has its range indefinite quantity, so RF based Wireless sensor network is suitable for small area. And ZigBee is working on IEEE 802.15.4 protocol and used cluster based Network topology to transmit a data from Wireless Node to base station. In cluster base network topology formation of cluster is depends on the happening of an event. So it will take more time to send data from sensor node to base station. Simple block diagram representation of Wireless Sensor Network is shown in figure 1.

In this wireless Network system protocol used is IEEE 802.11n, which provides multicasting facility.Communication speed is relatively more than IEEE 802.15.4 ZigBee network. The projected system is divided into three stages such that the lowest stage is the wireless sensor node, the mediate level is the main server controller, and the top level is a supervisory node. Proposed system is handle all possible system failure. The supervisor node can handle the entire control of the system if any error occurred during data transmission.

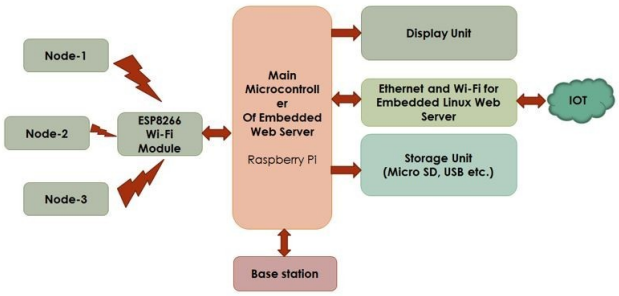

Fig. 1. Block diagram of WSN system

If transmission between any wireless node and Base station having some trouble, that sensed data will be stored on node memory or it will be transferred to other neighbor node and from neighbor node this sensed data will be transferred to base station. So, this types of mechanism avoid all type of tolerance in Wireless sensor Network. All sensors in a network are configured such a way to improve the latency of a Wireless sensor Network.

We are using Raspberry Pi Linux board to develop Embedded Web Server based on Linux operating system. It will provide a muscular networking mechanism over comfortable range of Wireless sensor areas over Internet. Raspberry pi is used as a main system server which control the Wireless sensor control. ESP8266 Wi-Fi module is used to transmit the detected sensor data is transmitted to the base station using the Wi-Fi 802.11b and then transmit that data to the end user by Raspberry Pi Ethernet port or ESP8266 module. It can also send command from end user to node to control the node operation.

III. EMBEDDED WEB-SERVER AND DATA BASE

The Embedded Web Server Technology is most evolving engineering science for Internet of Things. Embedded Web Server is designed the database based on MySQL, which is establish on Raspberry Pi Linux board .our developed web page for monitoring and handling wireless sensor system through network or Internet is shown in figure 2.

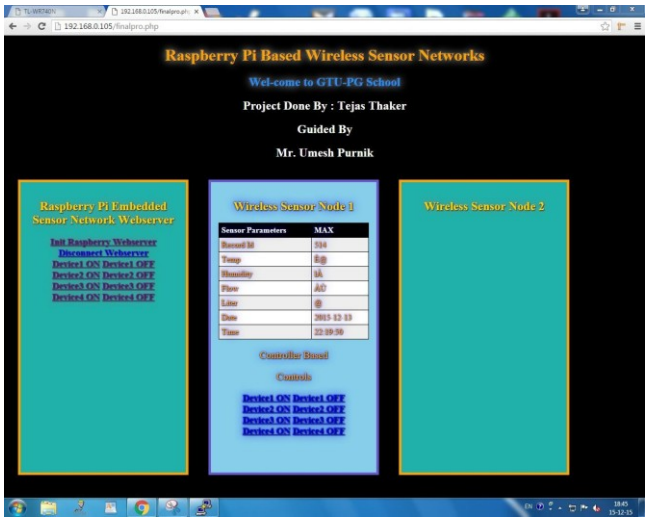

Fig. 2. Linux Webpage

MySQL is the democratic choice of database in a “WWW” directory. It is the relational database management system (RDBMS). Database stores the Sensor’s parameter content send by a sensor node in it for defined time. The interface is implemented and the collected data is displayed through a series of HTML/PHP/MySQL based pages. It provides the user access for information monitoring to the web page remotely. IEEE 802.11 Wireless Local Area Network became the preferred solution for providing Internet access in both indoors and outdoors environments for personal and public usage.

IV. METHODOLOGY

The system should be able to acquire data from remote areas, store and should be in a position to reproduce the data whenever demanded by the client at the other end. DS1820 is the sensor used for acquiring temperature. There is even a provision for controlling an electronic component from the client end which is demonstrated by controlling an LED. The methodology is such that, there are temperature sensors and LED in the remote area, which are connected to the Raspberry pi module which acts as a Mini-computer in this case. This will be continuously monitoring the sensors and storing it in the database using SQL which is a light weight Database

Management System. Since data is stored at a very high frequency, like lot of unnecessary data is stored continuously in the Memory leading to filling up of memory space. To avoid this undesired event Croon Job is used, which is basically a job scheduler in UNIX like operating System. This helps in scheduling and updating of data in database at a fixed time interval that can be decided by the user. So every five minutes (as defined by user) the Croon job automatically executes the program and stores temperature values in the database.

V. RASPBERRY PI WSN LINUX SERVER

Raspberry Pi is a tiny, effectual, affordable computer Board. This credit card-sized computer with many performances and affordable, it is perfect platform for interfacing with many devices. Raspberry pi acts as a base station which connects to sensor nodes by ESP8266 Wi-Fi communication protocol and clients. For wireless connection and multi-hop networking communications protocol, we used 802.11n.

Fig. 3. Raspberry Pi 2

A. Features of Raspberry Pi 2

We use Raspberry pi 2 Model B. Raspberry Pi comes with Mounting Points and 1 GB of RAM and ARM 7, 1GHz powerful processor. Raspberry pi has integrated Video core 4 Graphics GPU with capable of playing Full 1080p HD Videos with HDMI Video Output.it also contains 4 USB Ports with maximum current rating of 1.2A.Raspberry Pi 2 Board operated on 1.8 mA and 5v power supply. Micro SD Flash Memory Card Slot is given for OS porting.

B. Raspbian

We are using Raspbian wheezy Linux operating to establish a Wireless sensor network system using Raspberry Pi. Raspbian is an open source operating system, which is based on debian optimized for the raspberry pi board. It is Linux kernel based operating system. At the first startup of Raspbian OS system configure menu appear which shown in figure 5.

C. Apache

For developing an Embedded Web-Server for WSN system we are installing Apache Web-server on Raspberry Pi board, which is also known as Apache HTTP Server. Apache server provide online distribution facility of website service using HTTP (Hyper Text Transfer Protocol). It is widely popular web server for different operating systems such as Linux, UNIX, Windows, Solaris, Mac OS X, Novell NetWare, etc. Apache2 version was used in this project for creating web server. After installing Apache web server on Raspberry Pi, we can test the Apache server using test HTML file. Browse the default test web page on the Raspberry or using Web Browser, Web page appear as shown in figure 4.

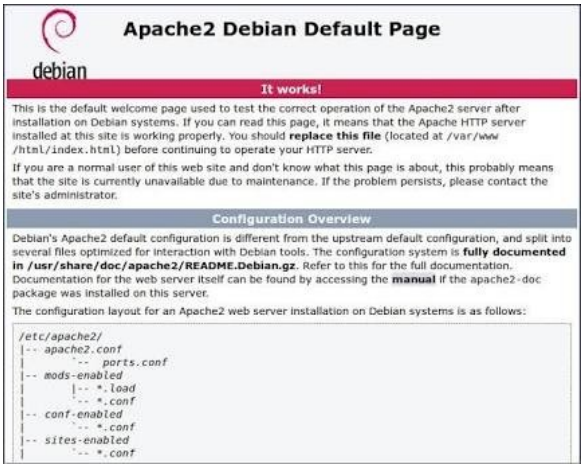

Fig. 4. Apache HTML test web page

D. SSH(Secure shell)

SSH provide a remotely gain access of the command terminal of Raspbian OS from other system on the same network. SSH provide only command line access, not the full Raspbian desktop. Using VNC we can get full remote desktop access of Raspbian OS.SSH server can be enable or disable from raspi-config menu, which is appear by ”sudo raspi- config”. Raspberry configuration menu is shown in figure.

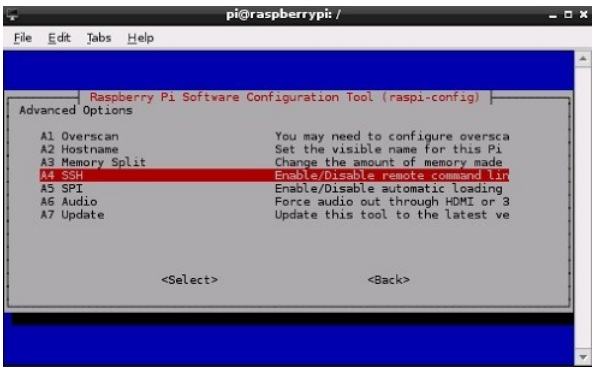

Fig. 5. Apache HTML test web page

E. PHP

The Hypertext preprocessor (PHP) is a scripting language designed for web development. PHP code is integrated by a web server with a PHP processor module which generates the resulting web page. PHP is basically used for developing web based software applications and also to manage database, dynamic

VI. WIFI FRAME STRUCTURE

The presented algorithm for Wi-Fi in the wireless nodes to validate the improvement efficiency. In the actual transmission process, there are two cases of data loss, one is continuous loss and another is discrete loss. The constant data loss undoubted has a bigger effect on the robustness communication than the discrete one. Proposed Wi-Fi algorithm can avoid continuous data loss during transmission. If any node failed to communicate with server than it will send its data to neighbor node and neighbor node will send this data to server. In the implementation of Wi-Fi frame the algorithm, channels data are packed together and sent to the base station. Figure 6 shows the details of a Wi-Fi frame.

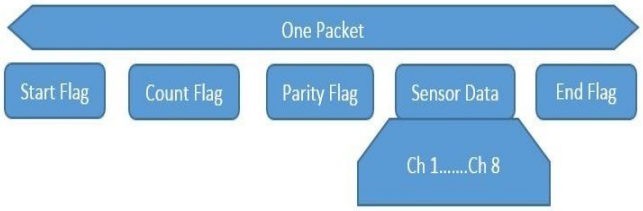

Fig. 6. Wi-Fi Frame Algorithm

VII. WIFI MODULE ESP8266

We are also considered a cost of a designed Wireless network, here we use Low cost and energy efficient ESP8266 Wi-Fi module for developing a Wireless Sensor Network. ESP8266 module configure such a way to provide high performance, high integration performance. Power saving operation algorithm for ESP8266 is shown in figure 7.

Power down logic and advance power management provide an energy efficient Wi-Fi based wireless sensor network. ESP8266 consumes 60uA in deep sleep mode with RTC clock still running and less than 1 mA to stay connected to the access point. Cost and performance parameter comparison of ESP8266 module with Arduino shield and RN-131C is shown in Table II.

The comparison is not exhaustive, but it still appears to show ESP8266 solutions support most features than price competing modules. There are however, case where competing solutions have an edge, for example if you need an Arduino shield, although ESP8622 can be programmed with the Arduino IDE, and some ESP8266 based shields are available, but probably not as well supported as the ones from Sparkfun and Adafruit. Mike also considers Arduino shields and CC3000 to have better software support and documentation, although he acknowledges ESP8266 community has help narrowing the gap.

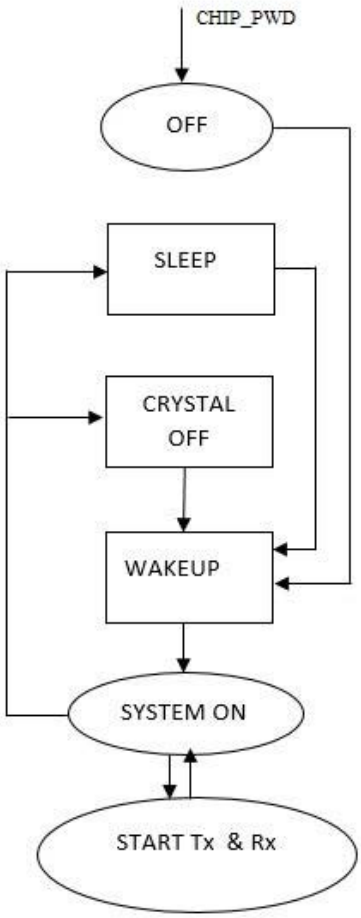

Fig. 7. Wi-Fi Frame algorithm

TABLE II
WI-FI MODULE COMPARISON

	RN-131c	**Arduino shield**	**ESP8266**
Wi-Fi Standard	802.11 b/g	802.11 b/g	802.11 b/g/n
Packet	TCP & UDP	TCP & UDP	TCP & UDP
Mode	Client-Server	Client-Server	Client-Server
Transmit Current	210 mA	210mA	215mA
Programmable Controller	No	Yes	Yes
Cost	$69.95	$84.95	$2.75

VIII. CONCLUSION

In this proposed design, we have introduced the event of a Wi-Fi based Wireless Sensor Network management exploitation using Linux board Raspberry pi and Internet of Things technology using ESP8266 Wi-Fi module. The system is suitable for real time Wireless sensors monitoring and for remotely controlling the Sensor network and improve the latency compare to ZigBee and RF based sensor network. The proposed system may be employed in many fields like home and Building automation and Industrial automation. Now a days Wi-Fi network is easily available in all fields like Office Building and Industrial Building so proposed wireless sensor network easily controlled using any Wi-Fi network.it is not possible to overcome all the current issues in a single system, but proposed system can avoid any type of failure in node to server communication.

ACKNOWLEDGMENT

I would like to express my special gratitude to Mr. Umesh Puranik (Persistent System Ltd-Pune) and thanks to GTU and CDAC for giving me such valuable platform. I would also like thank my Parents, Family and Friends, for their constant support and tender loving care throughout this challenging period.

REFERENCES

[1] “ZigBee vs. Wi-Fi: Understanding Issues and Measuring Performances of their Coexistence”, Zenghua Zhao, Xuanxuan Wu, Xin Zhang, Jing Zhao, Xiang-Yang Li, School of Computer Science and Technology, Tianjin University, China, IEEE - 2014

[2] “Wireless Sensor Network System using Raspberry Pi and ZigBee for Environmental Monitoring Applications”, Sudhir G. Nikhade, Assistant Professor, Walchand College of Engineering, Electronics Department, Sangli, Maharashtra, India, International Conference on Smart Technologies and Management for Computing, Communication 2015

[3] “Wi-Fi-based Hierarchical Wireless Networked Control Systems”, Esraa A. Makled, Hassan H. Halawa, Ramez M. Daoud, Hassanein H. Amer Electronics and Communications Engineering Department American University in Cairo (AUC) Cairo, Egypt, IEEE 2015

[4] “Wi-Fi-Pi Tracking at Mass Events”, P.H.Patil, A.A.Kokil, Professor & HOD E&TC department, Indira College of Engineering & Management, Parandwadi, Pune, International Conference on Pervasive Computing 2015

[5] “Raspberry Pi as a Wireless Sensor Node: Performances and Constraints”, Vladimir Vujovic and Mirjana Maksimovic, Faculty of Electrical Engineering, East Sarajevo, Bosnia and Herzegovina, IEEE 2014