Implementation of Wi-Ap; An IEEE 802.11b/g Based Electrical Switch Module With Web Enabled Interface for Electrical Appliances Control

E. Adetiba, J.O. Onaolapo, O.E. Oyewole, M. Yusuf, T.A. Tanimomo and A. Shodipo
Covenant University, College of Science and Technology, School of Engineering and
Technology, Department of Electrical and Information Engineering, Ota, Nigeria

Abstract: The aim of this research study is to design and implement a Wi-Fi-based control panel for remote control of lights and electrical appliances with a web functionality that allows for wide area control via the intranet or Internet. This eliminates the inconvenience of moving from one switch to another for analog operation of light fixtures and appliance in home, office and campus environment. The wireless technology we adopted is IEEE 802.11 (2008) b/g, also called Wi-Fi (Wireless Fidelity) which operates in free band and is easily accessible. Wi-Ap (Wi-Fi Automated Appliance) control system contains a web portal which allows for management and control purposes via the intranet or Internet. We built a standalone Wi-Ap console that allows the wireless switching on and off of any appliance(s) that is(are)) plugged into it. The prototype we built was tested within the Electrical and Information Engineering department, Covenant University, Nigeria intranet and the test achieved our aim of remote appliances control from a web portal vial the intranet.

Key words: Appliances, internet, Wi-Ap, Wi-Fi, wireless

INTRODUCTION

Appliance control can be considered to have acquired a new face, especially with advancement in technology and the prolific presence of handheld devices and computer networks. As a result, it is now possible to control appliances in a specific building without being physically present in the building. This level of remote control offers a lot of flexibility and a degree of security.

Various forms of remote control have been explored in times past, but most of them require some degree of proximity to the appliances being controlled. Examples of such systems include Bluetooth (offering line-of-sight control) and X10 technologies (control over power lines). However, they have their limitations especially in the areas of flexibility and distance.

Previous study on appliance control include Web-based Home Appliance Automation by Isong (2009) which aimed at improving available home automation systems by making it web-based. Appliances can thus be monitored from a remote location over the Internet. Communication was via a parallel port on the server to control the required appliances at home. The limitations encountered in the project include lack of backup power (in case of power failure), limitation of network coverage imposed by the wireless router, delays in signal transmission, distance limitation on connection between

computer and switching unit as imposed by physical parallel port connection.

A Home Appliance Control System over Bluetooth with a Cellular Phone was reported in (Kanma *et al.*, 2003). As the name implies, this is a system that incorporates remote control, fault diagnosis and software update for home appliances on a cellular phone based on the Java2 platform. The major limitation encountered in this project is the problem of coverage. Bluetooth, being a short range wireless technology, covers only about 100 m. This automatically means that a user can only control appliances when he is within 100m from those appliances.

Brad (2004) designed a sytem which uses handhelds for wireless remote control of PCs and appliances. Its aim was to provide a framework for the application of wireless handheld devices such as mobile phones and PDAs in control of appliances (in the context of 'remote control').

A Web-based Automation System over power lines using X10 Technology was reported in (Ajisafe, 2007). This project aimed at improving existing technology for home automation and it was web-based, It allows constant remote monitoring and control of devices when the user is away from home. Hardware used include X10 lamp modules, X10 appliance modules, X10 CM11A controller interface, a wireless router and a web server.

In Fahdil, 2010, mobile phone SMS was used for home appliance control through PC parallel port

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Corresponding Author: E. Adetiba, Covenant University, College of Science and Technology, School of Engineering and
Technology, Department of Electrical and Information Engineering, Ota, Nigeria
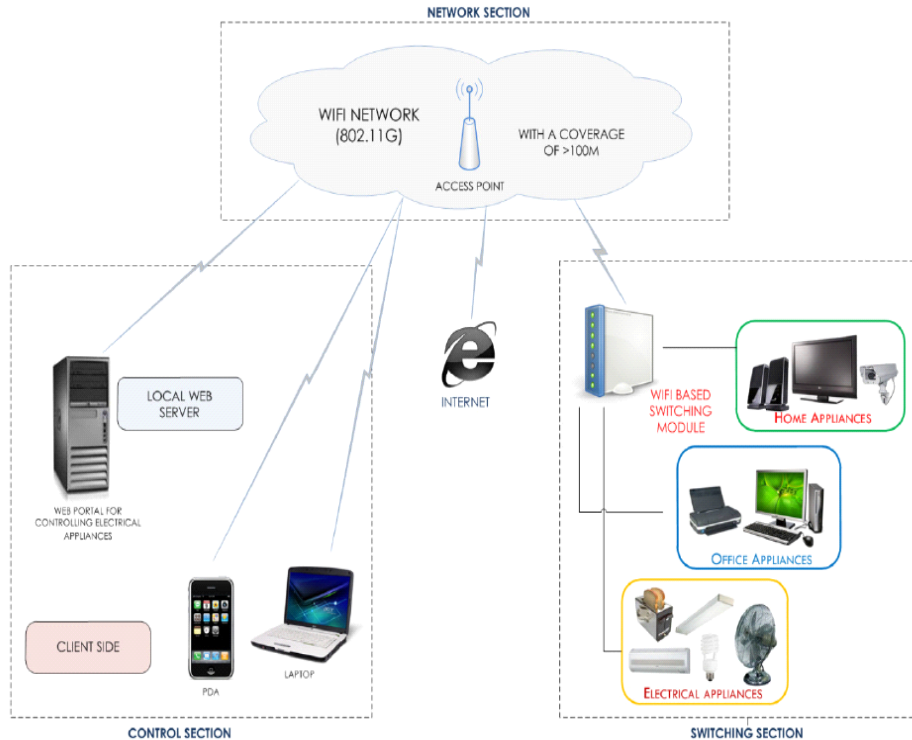
Fig. 1: System layout of the Wi-Fi automated appliance (Wi-Ap) control system

interfacing. The project involved developing a system of PC remote control with mobile phones. Communication was implemented through serial and parallel ports. The serial port was used for transferring data from mobile phone to PC and the parallel port was used for interfacing the PC with real time control hardware. The system was implemented based on the Short Message Service (SMS).

Wi-Fi is the fastest growing wireless connectivity technology in the world. It is fast, cheap and convenient to use. As consumers increase demand for better technology to suit their mobile lifestyles, Wi-Fi is multiplying and it is everywhere.

According to (Jiwire.com, 2010), more than 20% of the U.S. online populations currently use public Wi-Fi and in 2009, all laptops and smartphones were shipped with embedded Wi-Fi capabilities.

In this research study, we implemented an appliance control system that operates over a wireless intranet and the Internet. We designed and implemented a Wi-Fi based control panel and a web portal for turning on and off of lights and appliances from laptops, PDA and cellphones that are Wi-Fi compliant. This allows for mobility and remote monitoring of electrical installations. Also, we prototyped a home or an office building with model electrical installations to test the switching control panel and the web portal.

MATERIALS AND METHODS

The research study was carried out between January and May 2010, at the department of Electrical and Information Engineering, College of Science and Technology, Covenant University, Ota, Ogun State, Nigeria. The system is divided into 3 main parts which are the control section (web server, PDAs, laptops with Wi-Fi), the network section (wireless network based on IEEE 802.11, 2008 b/g) and the switching section (Wi-Fi module, microcontroller, switching IC, relays and some other components). The network section serves as the connecting medium between the control and switching sections. The block diagram of the entire system is as shown in Fig. 1.

The following sections describe the basic sub-units (control, network and switching sections) of the system in further details:

- **The control section:** The control section is subdivided into two parts: Client side and Web server side. The web server side hosts the web application developed using Hypertext Markup Language (HTML), Hypertext Preprocesssor (PHP) and MySQL. The web application provides a friendly user interface through which a user can control and
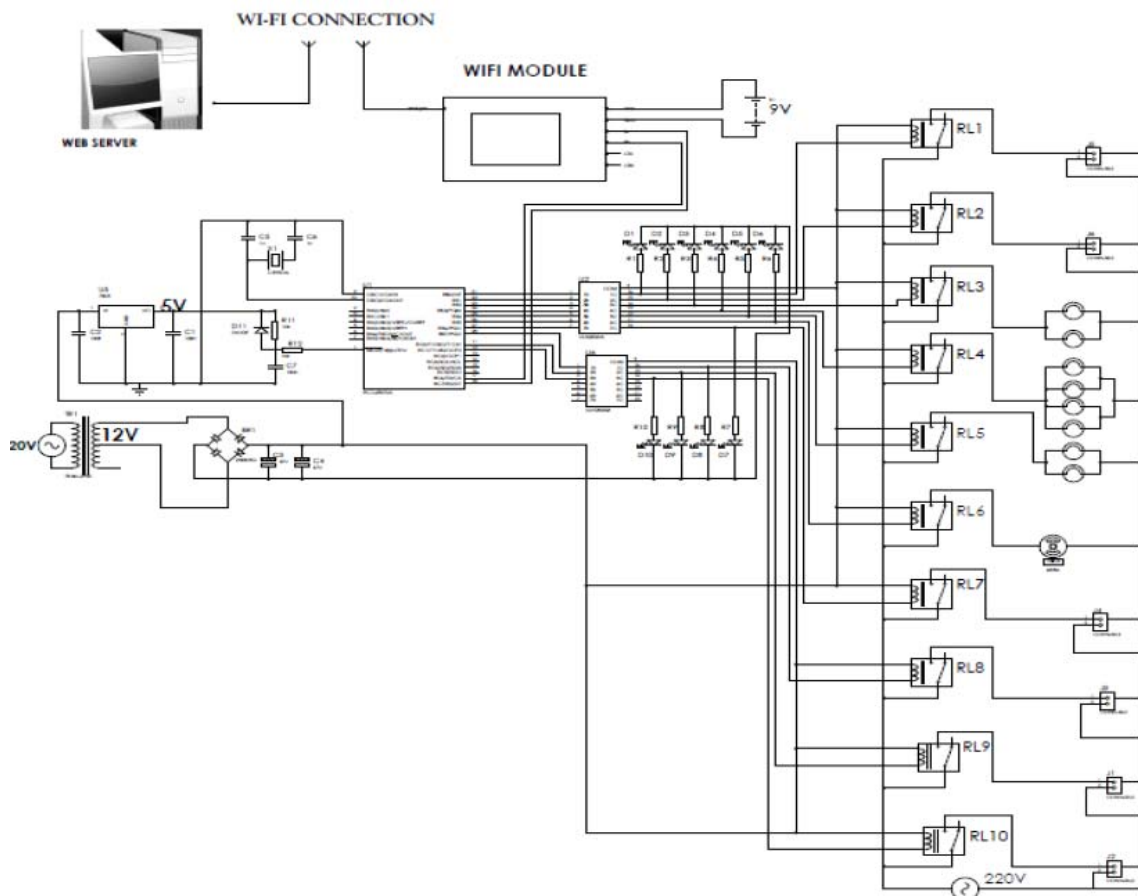
Fig. 2: Wi-Ap hardware circuit diagram

monitor the status of electrical network connected to the switching section. The client side however, consists of the user's mobile control devices such as laptops and Portable Digital Assistants (PDAs) with Wi-Fi functionality and other devices that are Wi-Fi compliant. The client accesses the application on the web server via a device by connecting it to the network and entering (www.wiap.com) in a web browser. This prompts a login page for authorization. If login is successful, the user can begin controlling the electrical appliances.

• **The network section:** This is a wireless network using the IEEE 802.11 (2008) b/g wireless LAN standard. This wireless network provides a transmission medium for the control section to send signals to the switching section. The wireless network can either be in infrastructure mode or ad-hoc mode. Infrastructure mode is created with the use of an access point for multiuser connections, while the adhoc mode allows for pee-to-peer connections only (Lai, 2009; Stallings, 2002). A wireless control scheme was used for this project rather than wired scheme because of reduced costs and distance limitation with other existing technologies.

• **The switching section:** This comprises of a Wi-Fi module, microcontroller, switching IC, relays and other components. The Wi-Fi module connects to the wireless network and it keeps listening to the connection for packets. Once a packet is received, it is forwarded to the Universal Asynchronous Receiver and Transmitter (UART) interface of the Wi-Fi module which in turn forwards it to the UART interface of the microcontroller. The microcontroller handles the processing of data received from the Wi-Fi module. The data is in the form of a concatenated string. The string is parsed and extracted control information is acted upon to control the relevant pins. The switching IC and relays act as amplifier and switch for output signals from the microcontroller. The circuit diagram for Wi-Ap hardware is shown in Fig. 2 and the software layout is shown in Fig. 3.
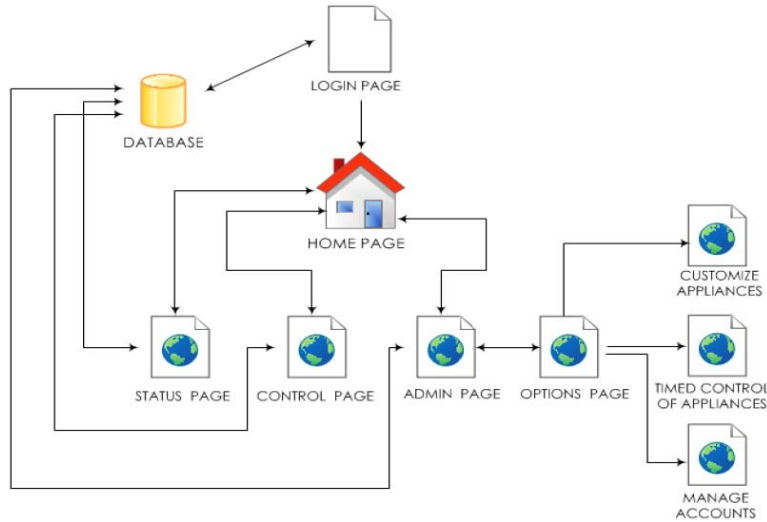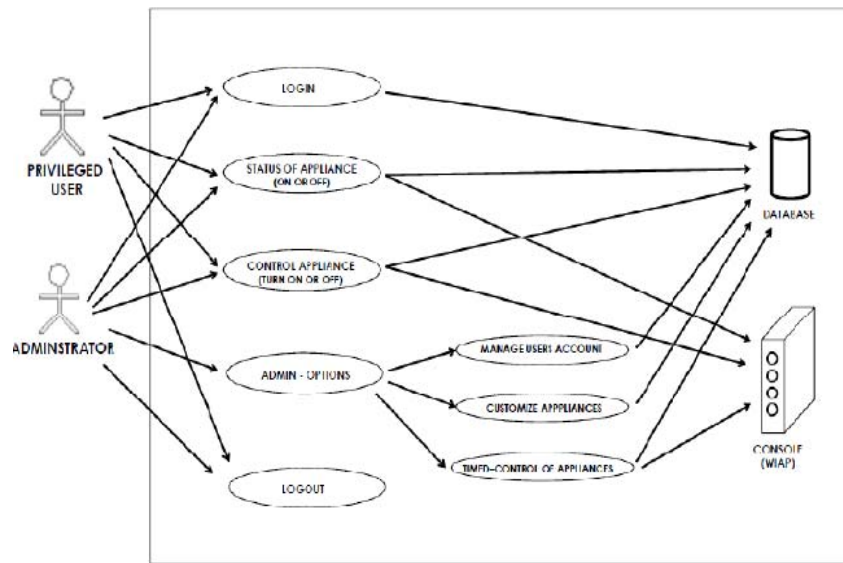
Fig. 3: Wi-Ap software design layout

Fig. 4: Use case diagram for Wi-Ap portal

RESULTS AND DISCUSSION

The login page is the first page encountered by the user/administrator on accessing the web application. The user or administrator logs on by entering a username and password combination which is then compared to the one previously saved in the database. If the combination is correct, the user or administrator is redirected to the home page. The use case diagram for the Wi-Ap portal is shown in Fig. 4.

The home page contains hyperlinks for navigating to the status control pages among others. The control page provides the user with a means of controlling the status of appliances (Fig. 5). The status page indicates the current state of the appliances.

The manage users page is available only to the administrator and it allows him to create users, delete users and change passwords. The timed control page allows the user to configure an appliance to come on/off after a specific amount of time. The about page
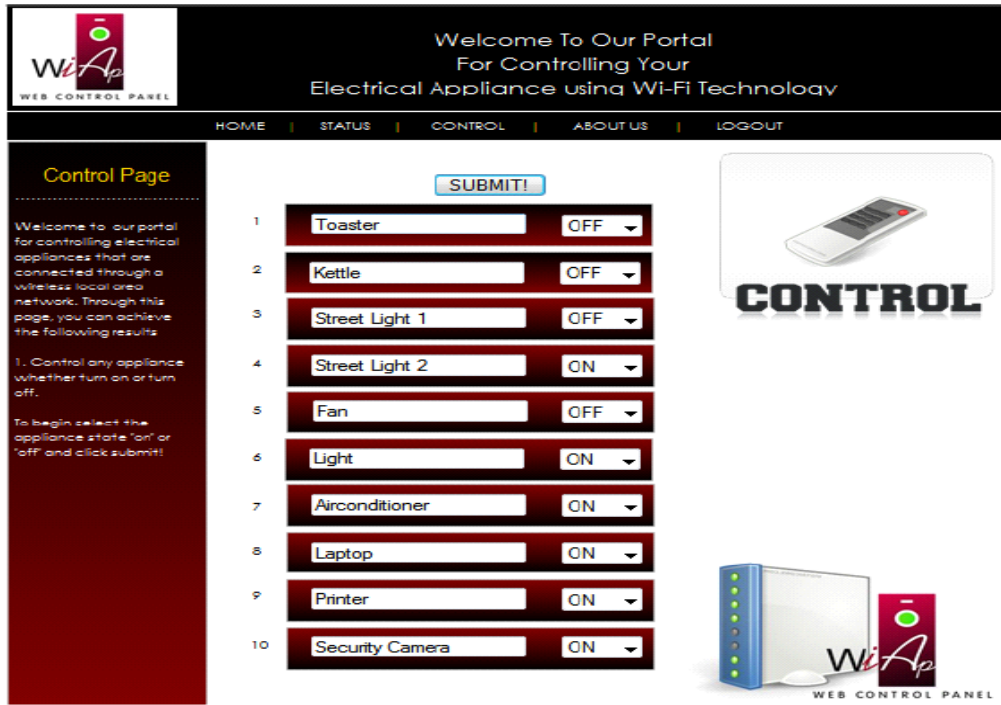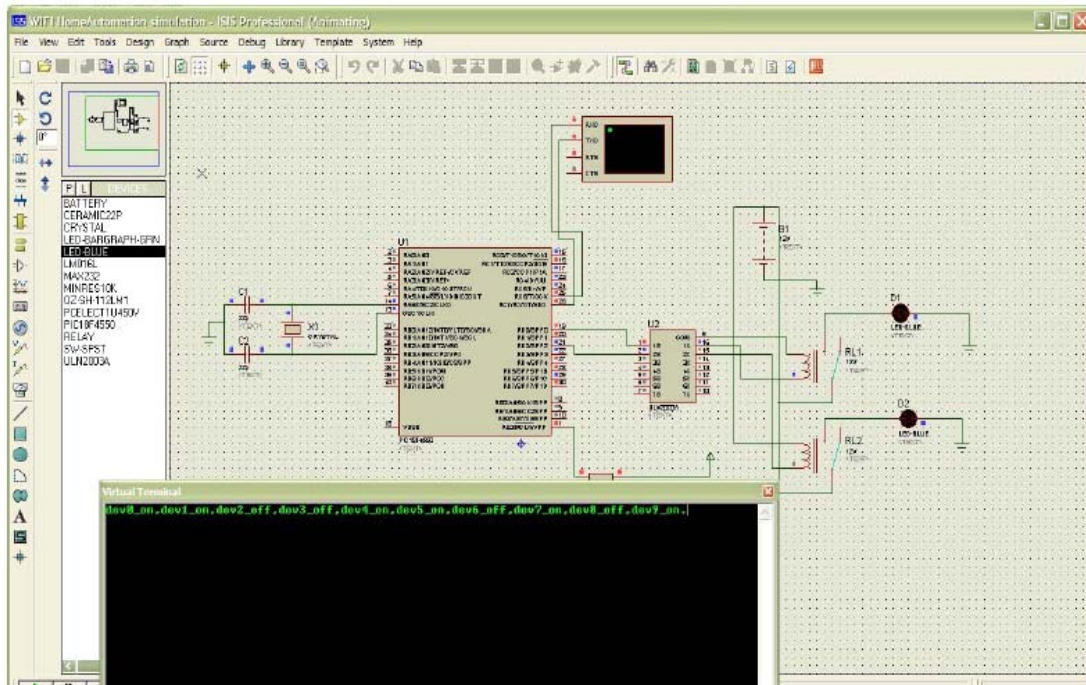
Fig. 5: Screenshot of the control page

Fig. 6: System simulation and testing

(a) Wi-Ap switching circuit

(b) Wi-Ap console

(c) Wi-Ap deployment prototype

Fig. 7: (a) Wi-Ap switching circuit, (b) console and (c) deployment prototype

gives a brief overview and description of the entire web application.

Proteus was used to carry out simulation tests on the entire design during and after design. Proteus has no provision for Wi-Fi modules so, a modem was used instead. The simulation took place in real time.

The simulation diagram for the switching section is as shown in Fig. 6 and 7 shows.

- The completed Wi-Ap switching circuit
- The Wi-Ap console
- Wi-Ap deployment prototype

CONCLUSION AND FUTURE WORK

The prototype of our Wi-Fi Automated Appliance (Wi-Ap) control system is fully ready and functional. Implementation and deployment of the system has a huge potential of providing increased flexibility in remote electrical appliances control. However, for future prototypes and improvements, areas to improve upon include wireless network, work-around for the web server, and improvement in control mechanism.

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