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UBIQUITOUS SMART HOME SYSTEM USING ANDROID APPLICATION

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ABSTRACT

This paper presents a flexible standalone, low cost smart home system, which is based on the Android app communicating with the micro-web server providing a method for remotely controlling the appliances in the home. The Arduino Uno microcontroller is used to eliminate the use of a personal computer (PC) keeping the cost of the overall system to a minimum. Devices such as light switches, fans have been integrated in the system to demonstrate the feasibility and effectiveness of the proposed smart home system. The smart home app is tested and it is able successfully perform the smart home operations of switching functionalities. The app has been made user friendly and a password protection feature has been added to improve the security.

KEYWORDS: Android smart phone, Smart home, Home Automation, Internet of Things (IoTs), Remote Control.

I. INTRODUCTION

With the continuous growth of mobile devices in its popularity and functionality the demand for advanced ubiquitous mobile applications in people's daily lives is continuously increasing. Utilizing web services is the most open and interoperable way of providing remote service access or enabling applications to communicate with each other. An attractive market for home automation and networking is represented by busy families and individuals with physical limitations.

IoTs can be described as connecting everyday objects like smart phones, Internet televisions, sensors and actuators to the internet where the devices are intelligently linked together to enable new forms of communication amongst people and themselves [1]. The significant advancement of IoTs over the last couple of years has created a new dimension to the world of information and communication technologies. The advancement is leading to anyone, anytime, anywhere (AAA) connectivity for things with the expectation being that this extend and create an entirely advanced dynamic network of IoTs. The IoTs technology can be used for creating new concepts and wide development space for smart homes in order to provide intelligence, comfort and improved quality of life.

Smart home is a very promising area, which has various benefits such as providing increased comfort, greater safety and security, a more rational use of energy and other resources thus contributing to a significant savings. This research application domain is very important and will increase in future as it also offers powerful means for helping and supporting special needs of the elderly and people with disabilities [2], for monitoring the environment [3] and for control. There are a number of factors that needs to be considered when designing a smart home system. The system should be affordable, scalable so that new devices can be easily integrated into the system, and it should be user friendly [4].

With the dramatic increase in smart phone users, smart phones have gradually turned into an all-purpose portable device and provided people for their daily use. In this paper, a low cost wireless controlled smart home system for controlling and monitoring the home environment is presented. An embedded micro-web server with real IP connectivity is used for accessing and controlling appliances and other devices remotely from an Android based app, which can be used from any Android supported device. The Arduino Wi-Fi module is used for the micro web-server thus eliminating the use of PC and the system requires user authentication in order to access the smart home system.

The remainder of the paper is organized as follows. In Section 2, a brief discussion of the related work is provided. The overall system architecture, implementation and the features of the proposed smart home system are presented in Section 3. Finally the conclusion with some further prospective works is presented.

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II. RELATED LITERATURE

Smart home is not a new term for science society however, it is still far more away from people's vision and audition. As electronic technologies are converging, the field of home automation is expanding. Various smart systems have been proposed where the control is via Bluetooth [5-8], Internet [9-10], short message service (SMS) based [11], etc. Bluetooth capabilities are good and most of current laptop/notebook, tablets and cell phones have built-in adaptor that will indirectly reduce the cost of the system. However it limits the control to within the Bluetooth range of the environment while most other systems are not too feasible to be implemented as low cost solution.

In [11], Wi-Fi based home automation system is presented. It uses a PC (with built in Wi-Fi card) based web server that manages the connected home devices. The users can manage and control the system locally (LAN) or remotely (internet). The system supports a wide range of home automation devices like power management components and security components. A similar architecture is proposed in [12] where the actions are coordinated by the home agent running on a PC. Other papers such as [13-14] also presented internet controlled systems consisting of a dedicated web server, database and a web page for interconnecting and managing the devices. These systems utilize a PC which leads to a direct increase in cost and power consumption. On the other hand, the development and hosting of the web page will also result in additional costs.

The design and implementation of a microcontroller based voice activated wireless automation system is presented in [15]. The user speaks the voice commands through a microphone, which is processed and sent wirelessly via radio frequency (RF) link to the main control receiver unit.

Voice recognition module is used to extract the features of the voice command. This extracted signal is than processed by the microcontroller to perform the desired action. The drawback is that the system can only be controlled from within the RF range. Reference [16] also presents a voice activated smart home automation system. This system provides graphical user interface (GUI) using Microsoft Visual Basic software hosted by a PC, and uses Microsoft Speech Recognition engine. The signal is than transmitted via RF link to the microcontroller to which the home appliances are interfaced. Again a PC is used that account for an increased cost and power consumption

A significant contribution to smart home system has been made by the above mentioned systems. However, a PC is used as a server that increases the cost and power consumption while others require web page hosting that adds up the extra cost.

III. SYSTEM DESIGN

SYSTEM ARCHITECTURE

In the proposed design, a low cost smart home system for remotely controlling and monitoring the smart home environment is presented. An overview of the proposed system architecture is shown in Figure 1. The system consists of an app developed using the Android platform and an Arduino based micro web-server. The Arduino microcontroller is the main controller that hosts the micro web-server and performs the necessary actions that needs to be carried out. The sensors actuators/relays are directly interfaced to the main controller via breadboard. The smart home environment can be controlled and monitored from a remote location using the smart home app, which will communicate with the micro web-server via the internet. Any internet connection via Wi-Fi or 3G/4G network can be used on the user device.

The features that the proposed design offers are the control of energy management systems such as lightings, power plugs , controlling the speed of rotation of fan and the option of seeing the current state of the device (ie...whether it is currently on or off) and then act according to the current state of each device.

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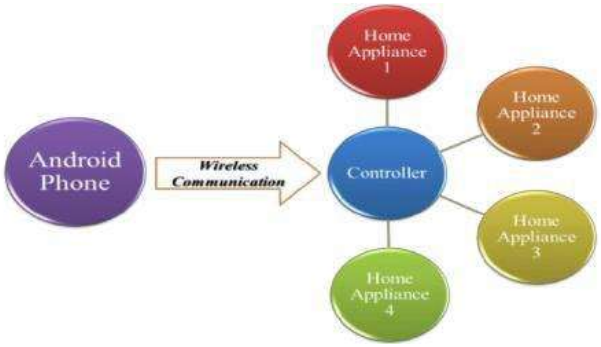
Figure: 1



SOFTWARE DEVELOPMENT OF ANDROID PLATFORM APP

There are several platforms for developing smart phone applications such as Windows Mobile, Symbian, iOS and Android. In the proposed system, the Android platform app is developed as most of the phones and handy devices support Android OS. Java programming language using the Android Software Development Kit (SDK) has been used for the development and implementation of the smart home app. The SDK includes a complete set of development tools such as debugger, libraries, and a handset emulator with documentation, sample code and tutorials.

Eclipse (running on Windows 7 development platform), which is the officially supported integrated development environment (IDE) has been used on in conjunction with the Android Development Tools (ADT) Plug-in to develop the smart home app. The screenshots of the smart home app developed is shown in Figure 2 and Figure 3.

Figure: **2**

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Figure: **3**

The designed app for the smart home system provides the following functionalities to the user:

- Remote connection (via internet) to the smart home micro web-server; require server real IP and user authentication.
- Device control and monitoring.
- Scheduling tasks and setting automatic control of the smart home environment.
- Developer's profile and contact option.
- Exit Button to exit from the app.

In order to successfully connect and access the smart home micro web-server, the user has to enter the correct real IP address and password (see Figure 2). If the micro web-server grants access to the smart home app, response packet containing response code 200 will be received.

The app processes the response packet to determine the micro web-server's response. Response code 200 indicates the password is correct, and the app will switch to the main control page and synchronize using the data from the response packet to reflect the real time statuses of the smart home devices (see Figure 3). If the password is incorrect, "Server address or password Incorrect" message will be received. The general response packet layout is shown in Figure 4. The response message and devices with their statuses are separated by a space in the app design.

For example when the action requested by the user from the app to turn on Light 1 is successful, the response packet will be "200 Light_1:1". A zero indicates off state while a one indicates on state for the status for switching functions.

The user can perform the desired action from the GUI one's access is granted. The user once logged into the system with correct server address and password will be directed to the main page where each of the device connected to the app is listed along with its current status and the device type. The user can then see and change the deice status by clicking on the button provided on the right side of device name.

On pressing the button (which is a toggle button) the button will change its color in accordance with the state of the device. Red color indicated that the device is off and green color indicates that the device is on.

When the user performs an action on the smart home app, command packet is sent to the micro web-server via the internet. The general layout of the command packet is shown in Figure 4. The command packet if formatted in such a way that micro web-server is easily able to read and extract the information from the packet. For example for turning on the fan with the password, the command packet sent will be "1234Fan_On" and for setting the fan speed to 2 the command packet will be "1234FanSpeed_2.

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Figure: **4**

SOFTWARE DEVELOPMENT OF MICRO WEB SERVER

The main controller hosting the micro web-server acts as the heart of the smart home system consisting of the server application software and the Arduino microcontroller firmware. The server application software is the library implementation of the micro web-server running on the Arduino Uno using the Arduino Wi-Fi shield connected to the internet over TCP/IP, which can act as both the server and client. The Ethernet library"<esp.h>" is used to send and receive data in conjunction with the microcontroller. The output messages sent to the smart home app is in JavaScript Object Notation (JSON) format.

The Arduino IDE is the platform used to develop the (code in c language) for the Arduino web server which communicates with both ends .i.e. with the Arduino Uno microcontroller and the android app.

The Wi-Fi shield (esp8266) and Arduino create a simple web server. With the help of included Wi-Fi library, the device is able to answer http request which is generated when the app sends a command to the Arduino Wi-Fi web server. The HTTP request is sent on port 80 on the web server after the correct IP address of Wi-Fi shield and the correct password is inputted into the app and after a secure connection is established between the two entities. Simple GET and POST request operations have been utilized for communication.

Once the web server is connected to app and the microcontroller, it checks the status of the devices connected at different pins at the microcontroller and then communicates those status to the app where they are shown as the color of toggle button associated with each device (red or green). The user can change the status of device by pressing the toggle button which changes the state. The HTTP request is sent by app to webserver via Wi-Fi. The server then sends command to the microcontroller which performs the action on a specific pin and returns the status to the app.

PROPOSED SMART HOME DEVICES

The Arduino Uno and the Arduino Wi-Fi shield have been used to implement the smart home micro web-server. Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Wi-Fi shield is interfaced to the Arduino via the Arduino SPI pins. Low voltage switching relays are used to integrate the devices with the Arduino for demonstrating the switching functionality. A 5v LED has been used to demonstrate the ability of Arduino switch the lights.

IV. CONCLUSION

In this paper, an internet based smart home system that can be controlled remotely upon user authentication is proposed and implemented. The Android based smart home app communicates with the micro web-server via internet using the REST full based web service. Any android supported device can be used to install the smart home app, and control and monitor the smart home environment. A low cost smart home system has been developed which does not require a PC as all processing is handled by the microcontroller. Prospective future works include incorporating SMS and call alerts, incorporating voice search module in the app and reducing the wiring changes for installing the proposed system in pre-existing houses by creating a wireless network within the home environment for controlling and monitoring the smart home environment.

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