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Design of intelligent home appliance control system using embedded Linux

[1] Bhushan S Thombre, [2] Rajesh Shekokar

[1] Department of Electronics & Telecommunication, R.M.D Sinhgad School of Engineering, Pune, India.
[2] Prof. Department of Electronics & Telecommunication, R.M.D Sinhgad School of Engineering, Pune, India.

Abstract
Intelligent home appliance is a part of ever increasing need to control all the electronic devices through a single device. The appliance control field is mainly focusing on developing the intelligent information appliance. Intelligent appliance network uses small amount of data with low data transmission speed. Nowadays in family there are many appliances which needs more network capacity. This paper introduces the intelligent home appliance control system, the system is developed through BeagleBone Black microprocessor, embedded Linux operating system, Wi-Fi wireless communication technology, Android Phone and network technology. It gives the overall framework of hardware and software design, and describes ways to implement the system. User can control appliances through hand-held mobile terminal.
In this paper the connection between the different electronic devices are done by using a wireless fidelity network. The Wireless Network will be implemented by using Wi-Fi transceiver which is connected to an embedded device running Linux. The interconnection between embedded Linux device (BeagleBone Black), various sensors and wireless devices using Linux Device Drivers will be explored.

Keywords: BeagleBone Black, Linux, Wi-Fi, Android Phone

1. Introduction
Intelligent information appliance is the main direction of development in the appliance control field. Intelligent appliance network has small amount and low speed of data transmission; there are many appliances in family and it needs more network capacity. The rapid increase in number of consumer electronics and home appliances makes it essential to connect them with one another for easy control. To achieve this, different types of home automation systems have emerged to offer networked control [1]. With the swift development of cellular mobile technology comes the development of mobile phone-based home automation systems that integrate mobile technology into home automation [2].
The architecture of the proposed home automation system is described and its mechanism is explained. Section II describes the proposed system architecture based on Wi-Fi network and an information exchange format between the home appliances. Finally, in section V our conclusions are presented.
Sriskanthan proposed an automation system that can control home appliances from a PC using Bluetooth [3]. However, the system cannot be controlled remotely through the Internet. Another approach to home automation using Bluetooth was discussed by Shepered [4] but no implementations were proposed.
The core of the home automation system consists of two hardware components: the home server and the BeagleBone black board.

2. Architecture of automation system
In functional analysis and numerical analysis, home appliances are connected to the digital output of the BeagleBone board via relays to provide sufficiently high currents and voltage compatibility. Fig 1 shows the relay configuration for each device and figure 2 depicts the BeagleBone Black board's communication with the home appliances.

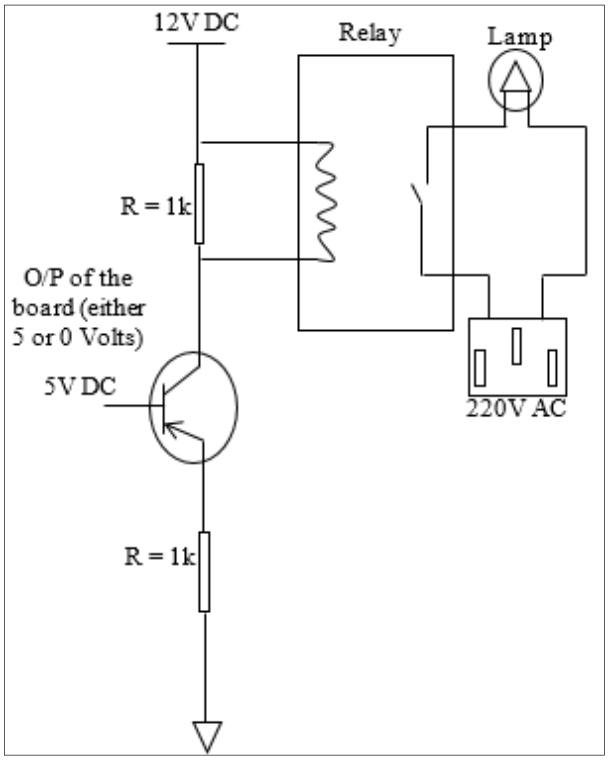

Fig 1: Device relay interface Feedback

Sending a software command to turn a device ON/OFF may not grantee the successful operation of the device as the device may be defect. To overcome this problem, a feedback circuit has been designed and implemented to indicate the device's actual status after it received the software command (ON/OFF). Once a command is sent to turn a device ON, the feedback circuit senses the current and gives an output signal indicating that the device is ON. Otherwise, the device is not

functioning and a message will pop up informing the user that the command was not executed successfully. The main sensing element is a current transformer and signal conditioning circuit that will output a digital signal indicating if the device responded to the command correctly.

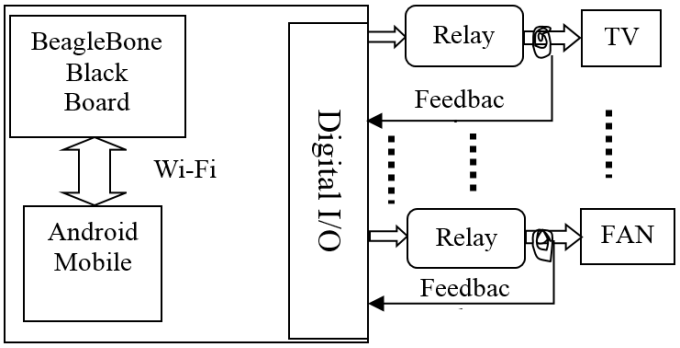

Fig 2: Hardware architecture of home

3. Overview

Linux is an open source operating system which is a POSIX Compliant system. In the implementation the Linux OS that is used is a Linux distribution that has been ported to an Advanced RISC Machines (ARM) Cortex-A series processor (Application processor). The Sensors and the different nodes were all implemented on an embedded Linux platform. The implementation uses a Linux distribution called Angstrom whose binaries are built using Open Embedded. This open Embedded group offers the best cross-compile Environment for any Linux Distribution made for embedded systems. This offers a main advantage that it supports ARM processors and it has multiple releases for a particular kernel version. The Embedded device used here is BeagleBone Black which runs Angstrom.

The Home automation system comprises of different nodes. These nodes are interconnected with each other with the help of the wireless network as shown in Fig 3.

These nodes are interconnected to form a home automation system. The function of this network is:

- Detect the motion.
- Once the motion is detected then it informs the Network Controller, Servo motor controller, and lighting controller.
- Servo motor module on receiving the commands runs and opens the door.
- The lighting Control will switch on the light depending on the time of the day.
- Each of these nodes will send the status information to the network controller.
- The network control module will have all the information of the nodes in the network. The user will be able to control the nodes or read their status.

The above is the sample Wireless Sensor Network implemented in this paper. The nodes of the network are all running embedded Linux on a device called BeagleBone Black. Thus the entire network is made to run from a Linux Environment. The Implementation is made in a way that the system performance is never hindered.

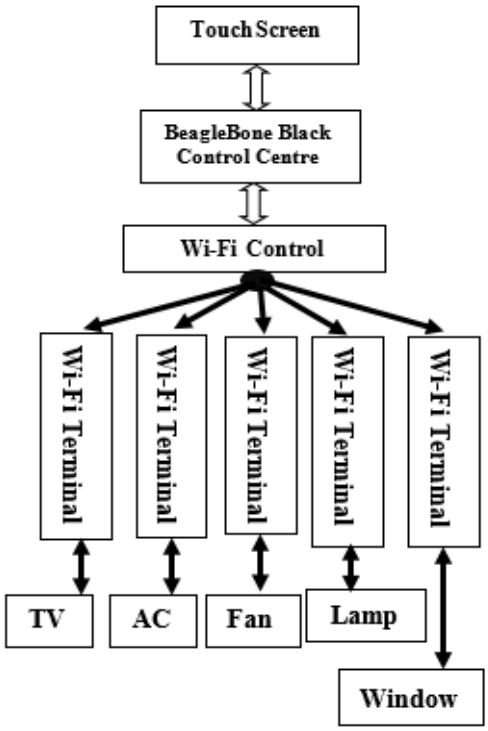

Fig 3: Block Diagram of a system

A. BeagleBone Black

BeagleBone Black is the latest in the series of the BeagleBone family. It is a low cost high expansion focused BeagleBone, the application processor used is Sitara XAM3358AZCZ100 Cortex-A8 ARM processor from Texas Instruments.

Table 1: BeagleBone Specifications

Processor	Sitara AM3358, 1 GHz 2000MIPS	
SDRAM	512MB DDR3L 800MHz	
On-board	2 GB, 8bit Embedded MMC	
Power	Mini USB	5V DC Jack
Ethernet	10/100 RJ45	
SD Connector	Micro SD 3.3V	
Video/Audio	16 bHDMI	

The Linux Distribution used on the On-board Flash is Angstrom. The advantage of BeagleBone over the rest of the Open Source hardware is that BeagleBone supports Linux operating system. BeagleBone beats the rest of the boards in the BeagleBone Family and others that support Linux by giving a max number of pin expansion Headers. Hence more flexibility is achieved by the developer.

4. Software Design of the system

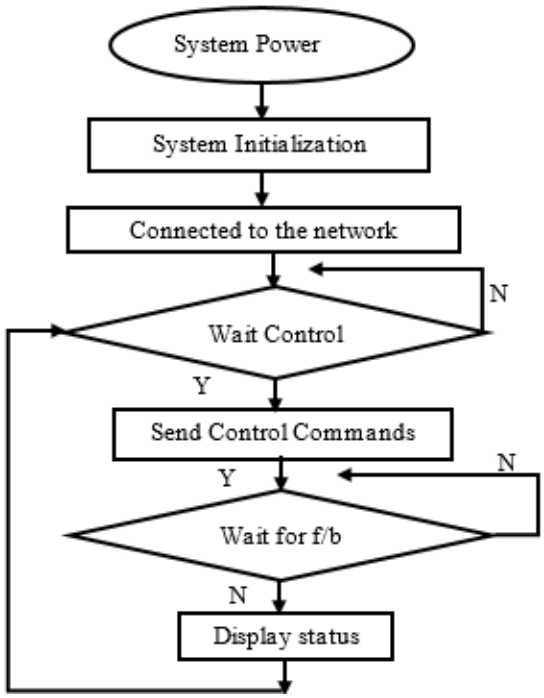

Fig 4: Terminal Device workflow

B. Embedded Operating System

Embedded operating system is the soul of embedded system, it is very important to choose a suitable embedded operating system. The open source code, extensive technical support, good scalability, support of many hardware are all unique advantages of embedded Linux. Linux can be customized and its minimum system kernel is only about 134KB. The core program with Chinese system and graphical user interface can also be less than 1MB. Linux's stability, reliability and operating efficiency has been proven [5]. In addition, it is compatible with most UNIX systems and easy to develop and port applications. Linux has excellent network support. So this article was designed with embedded Linux operating system.

C. Software Process of Wi-Fi communication

Wi-Fi coordinator establishes and maintains the home network, it receives control commands from ARM controller and forwards to other Wi-Fi devices. The system uses the network topology, the set-up of network includes system initialization, network topology update and node communication. Home gateway is the system master, it leads the whole process of network's set-up. It communicates with many nodes and controls and configures them when system is running. In addition, the home gateway must be able to discover the change of network topology and achieve network self-organizing feature. Network formation and communication processes are shown in Fig 4.

5. Conclusion

The design uses ARMS3C6410 as the core device and combines Wi-Fi wireless communication technology and embedded Linux operating system make research on intelligent appliance control system. User can easily control home appliances through the touch screen mobile terminal.

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