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Performance Analysis of Various Techniques Used in Wireless Home Automation

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Abstract: In the recent years all the implemented techniques have not realized the Intelligent Home design in all quality aspects since every technique has its own pros and cons whether we talk in terms of technology adapted, efficiency or cost. This work presents a brief comparative analysis on implemented techniques. The performance parameters of various communication techniques used to implement a home automation system has been analyzed. There are various techniques available to be implemented in home automation systems as discussed in this dissertation work. These communication techniques includes Radio frequency, Infrared, Bluetooth, Wi-Fi, GSM, DTMF, etc. These techniques have been integrated with various sensors and modules like PIR sensors, ultrasonic sensors, speech recognition modules, temperature sensors, pressure sensors, accelerometers, gyros, smoke detectors, gas sensors etc and implemented on the hardware using a widely used eight-bit microcontroller platform i.e. AT89S52 to verify and validate the work. It is found that each of these communication protocols possesses some unique characteristics of its own. A study of these protocols have proved that each system possess certain trade-offs.

Keywords: Home Automation, Microcontroller, Wireless, GSM, PIR, IR, RF, DTMF, Ultrasonic, Bluetooth.

INTRODUCTION

The home automation system is mainly implemented by sensors, controlling devices and actuators. The sensors detects light, motion, temperature and other sensing elements, and then send that data to the main controlling device. These sensors can be thermocouples or thermostats, photo detectors, level sensors, pressure sensors, current transformers, IR sensors, etc., which need an additional signal conditioning equipment to communicate with the main controller. Controllers may be personal computers/laptops, touch pads, smart phones, etc., attached to the controlling devices like programmable-logic controllers or microcontrollers that receive the information from the sensors, and based on the program, control the actuators like relays. The system can be modified based on the load operations. The programmable controller allows to connect various sensors and actuators through various input and output modules whether they are analog or digital. Actuators are the final controlling devices like limit switches, relays, motors and other controlling mechanisms which finally control the home equipments. Communication plays an important role in this home automation system for the remote access of these operations. There are various communication protocols available for home automation systems like RF, IR, DTMF, Wi-Fi, Bluetooth, GSM, Zigbee, Ethernet, IOT and PC Serial Communication.

IMPLEMENTED WORK

As technology is advancing so houses are also getting smarter. Modern houses are gradually shifting from conventional switches to centralized control system, involving RF controlled switches. Presently, conventional wall switches located in different parts of the house makes it difficult for the user to go near them to operate. Even more it becomes more difficult for the elderly or physically handicapped people to do so. Remote controlled home automation system provides a simpler solution with wireless technologies.

RF Based Wireless Home Automation System

The main objective of this system is to provide wireless control of various electrical appliances with a RF controlled remote. The project RF based home automation system is developed to automate the use of conventional lighting mechanism (wall switches) in house by using RF controlled remote. The project requires a RF remote that is interfaced to microcontroller (of 8051 family) on transmitter side which sends ON/OFF signals to the receiver. Receivers are connected with loads that can be turned ON/OFF by operating remote switches on transmitter wirelessly. Here the loads are interfaced to microcontroller by utilizing opto-isolators and relays. Thus the system serves a convenient way of lighting up the house without any physical movements. ASK RF Transmitter and Receiver pair is a low cost ideal solution for remote control applications. It is able to transmit data over 100 meters range. It is available in two frequencies, 315MHz and 434MHz. Transmitter is able to operate in a wide voltage range, 3 – 12V making it ideal for battery powered applications. Receiver operates in 5V making it ideal to interface

with microcontrollers. The RX – ASK is an ASK Hybrid receiver module. It is an effective low cost solution for using 433MHz. The TX-ASK is an ASK hybrid transmitter module. TX-ASK are designed by the saw resonator, with an effective low cost, small size and simple to use for designing. Please note that this device will not support direct UART communication when connected to PC or microcontrollers as there is a lot of noise always available on these frequencies. For remote control applications please use Encoder and Decoder ICs.

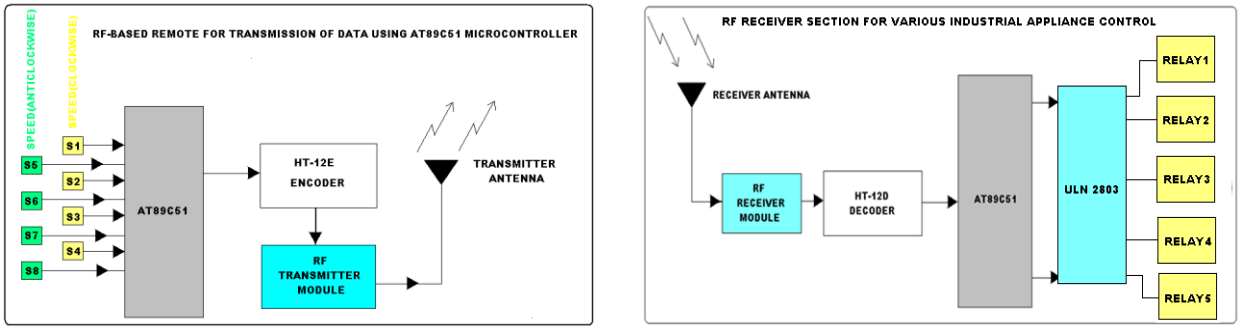

Figure-1 Basic Architecture of RF Transmitter & Receiver

IR Based Wireless Home Automation System

Home automation system with an IR Remote control is a combination of Infrared Transmitter and Receiver which contains 4 Relays and 1 TRIAC output which can be controlled wirelessly. This makes the unit very easy to operate and integrate with existing systems. The remote control operates the corresponding relay on the receiver board, i.e. (Light 1 operates relay 1), (Light 2 operates relay 2), etc. Relay contact can control any equipment. Each relay has indicator LED showing the ON/OFF status. The Transmitter uses a Modulated 38 KHz carrier to transmit data about which button is pressed. This method is used in all IR remote controls as it offers a high degree of noise immunity against interfering light sources. At the Receiver end, the IR receiver module extracts the data signal from the carrier. This active HIGH output is used to operate a relay via opto-coupler. A memory backup EEPROM saves the last condition of relays so that when power fails and resumes all the settings will be retained.

Bluetooth Based Wireless Home Automation System

The Bluetooth wireless technology is set to revolutionize the way people perceive digital devices in our homes and office environment. Now they are no longer just the individual devices; instead, with the embedded Bluetooth technology, they form a network in which appliances can communicate with each other. This wireless technology is especially useful in home environment, where there exists hardly any infrastructure to interconnect intelligent appliances. It could be suitably used for home automation in a cost-effective manner. Operating over unlicensed, universally available frequency of 2.4 GHz, it can link digital devices within a range of 10 m (expandable to 100 m, by increasing the transmitted power) at the speed of 1 Mbps.

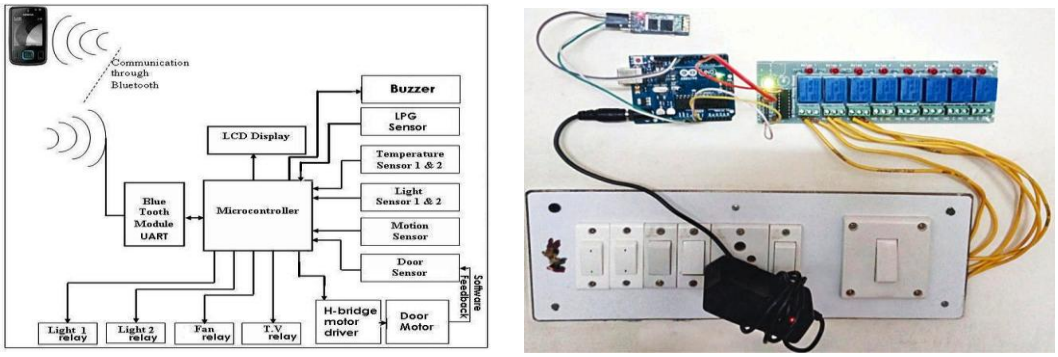

Figure-2 Basic Architecture of a Bluetooth Based System

METHODOLOGY

ATMega328 Microcontroller

The ATmega328 is a single-chip microcontroller created by Atmel in the megaAVR family. ATmega328P in a 28-pin dual inline package (DIP) is shown. The Atmel 8-bit AVR RISC-based microcontroller combines 32 kB ISP flash memory with read-while-write capabilities, 1 kB EEPROM, 2 kB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. The device achieves throughput approaching 1 MIPS per MHz.

RESULTS

HomeRF and Bluetooth Wireless Communication Compared

HomeRF is a wireless radio communications technology developed to provide a solution for wireless in-home networks.

- Both were developed at roughly the same time, and both operate in the unlicensed 2.4GHz ISM band for RF communications.
- Each one enables both voice and data traffic; and each one is designed for relatively short-range, low-power operation.
- Their packet structure and protocol layers are different.
- HomeRF was designed from the outset for home networking environments, whereas Bluetooth technology is optimized for use with WPANs and mobile.
- HomeRF communication range is about 50 meters (designed to cover a typical home), which is greater than the 10-meter range of the typical Bluetooth radio.
- Initially, the data rates of the two technologies were similar at about 1Mbps; recently, HomeRF version 2.0 has specified data rates up to 10Mbps.
- With all other factors being equal, higher data rates and greater range require more power consumption, so HomeRF often could require more power, although both technologies include power-saving schemes in their respective specifications.
- Like any technologies that operate in the same frequency spectrum, HomeRF and Bluetooth wireless communications can interfere with each other.
- Radio frequency interference is to be expected in the unlicensed 2.4GHz ISM band. One means to mitigate RF interference is the use of frequency-hopping spread-spectrum (FHSS), and both of these technologies use FHSS as a way to deal with undesired interference.

IrDA and Bluetooth Wireless Communication Compared

IrDA is an infrared wireless communication technology developed by the Infrared Data Association.

- IrDA is a specific use of infrared light as a communications medium; Bluetooth technology is a specific use of radio waves as a communications medium.
- Although both technologies are wireless, they use different parts of the electromagnetic spectrum with quite different signal propagation characteristics.
- Infrared uses the non-visible infrared light spectrum so IrDA communication is blocked by obstacles that block light (such as walls, doors, briefcases, and people). The signal wavelength used with Bluetooth communication (about 12.5 cm, at its associated frequency of 2.4GHz) is three orders of magnitude greater than that of IrDA. At this wavelength, radio frequency (RF) communications can penetrate many of these sorts of obstacles.
- Much of the IrDA equipment in use today uses a relatively narrowly focused beam, which usually requires that the two devices engaged in IrDA communication be aligned with (pointed at) each other. RF transmission patterns radiate in some pattern (ideally, spherical) around the radio antenna, so any two devices within range can communicate with each other, whether or not they are "pointed at" each other.
- IrDA can achieve data rates of up to 4Mbps, with even higher rates ready to be implemented. Bluetooth wireless communication occurs at a raw data rate of 1Mbps, with higher speeds being investigated.

- The effective range for Bluetooth wireless communication is about 10 meters using the standard 0 dBm radio. With optional power amplification of up to 20 dBm, range on the order of 100 meters can be achieved. IrDA range is about 1 meter and, as noted already, generally requires a line of sight to establish a connection.
- Both Bluetooth wireless technology and IrDA communication are optimized for low power consumption and low cost.
- IrDA consumes significantly less power than Bluetooth technology, because far less power is required for infrared transceivers than for RF transceivers.
- IrDA hardware also already is less expensive than Bluetooth radio modules, owing largely to the maturity and wide deployment of IrDA.

This brief discussion indicates that IrDA technology compares favorably to Bluetooth technology in the areas of cost, power, and data rate. However, Bluetooth technology can add convenience and user mobility by relaxing the device alignment and line of sight requirements of IrDA communications.

Wi-Fi and Bluetooth Wireless Communication Compared

- Bluetooth was initially defined under IEEE 802.15.1 standard but is now taken care by a Special Interest Group (SIG). Wi-Fi, on the other hand, is defined under 802.11.x (x=a, b, c, and so on) series of protocols and is currently maintained under the same. A Wi-Fi alliance founded by various companies tests and authorizes gadgets to be Wi-Fi compatible.
- Since its inception, Bluetooth has seen several versions of it such as Bluetooth 2.0, Bluetooth 2.1, Bluetooth 3.0 and the latest, Bluetooth 4.0. Added technologies such as Enhanced Data Rate (EDR), Alternate MAC/PHY, low energy protocols etc have been implemented in these updates. Various versions and upgrades are there in Wi-Fi too which are quite different than those in Bluetooth. Since, it is an IEEE 802.11 standard, Wi-Fi versions are termed as 802.11.a, 802.11b and so on. These versions vary in terms of security protocols, radio frequency used for data exchange, maximum speed for data exchange, bandwidth occupied etc.
- Bluetooth works at 2.4GHz frequency while Wi-Fi based networks work at 2.4, 3.6 and 5 GHz.
- The latest additions to Bluetooth (Bluetooth 4.0) promises data transfer rates to be upto 25mbps while latest Wi-Fi version of Wi-Fi direct can reach upto 250mbps of data transferring rate. Earlier versions of Bluetooth were able to deliver data at 800 hops per second while Wi-Fi clocked up at speeds like 54mbps.
- Maximum range for Bluetooth based wireless connections is 30m while for Wi-Fi, it can extend well upto 100m. In Wi-Fi, range depends on the version of Wi-Fi protocol applied and addition of antennas in the communication system while no such concerns of range or extra antenna are much known in Bluetooth.
- In Bluetooth, upto 7 devices can be connected to each other (piconet) while in Wi-Fi, the maximum connections depend on Wi-Fi router which can accommodate 1 to several communicating devices at a time.
- Connecting two devices over Bluetooth is fairly simple as there is just a simple key matching process. On the other hand, connections concerning Wi-Fi need an expertise in configuration and security pass code matching process. This makes Wi-Fi connection process more complex than the Bluetooth ones.
- Earlier versions of Bluetooth were encryption and even now Bluetooth security is limited to key matching. Whereas in Wi-Fi, the security standards have been raised with inclusion of new versions. Wireless Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA) are two most used security accesses used in Wi-Fi with the former being less secure than the latter.
- Able to works at longer distances and loaded with high quality security protocols makes Wi-Fi a more power consuming protocol than Bluetooth.
- Wi-Fi technology is more used in connecting computers to routers or internet gateways. Moreover, a number of electronic gadgets such as camera, gaming consoles, PDA's etc. also make use of Wi-Fi to connect to each other or internet.

IR and RF Wireless Communication Compared

RF stands for Radio Frequency waves which range from 3 KHz to 300 GHz in the frequency scale. IR stands for Infrared waves which range from 300 GHz to 400 THz in the scale. Wavelength of infrared ranges from 700 nm to 1 mm. Typically, the remote control device operates on IR (Infrared) or RF frequency range. Both remotes are used for the same applications to control the remote device mostly television (TV). Let us understand difference between IR and RF remote controls. Due to advantages of RF over IR as well as easy replacement of IR LEDs with RF Transmitter and IR receiver with RF receiver many IR remote controls are now replaced by RF remote controls. But

RF hardware is considered complex compare to IR hardware. Hence choice between IR remote or RF remote lies with the applications of use.

CONCLUSION & FUTURE SCOPE

Home automation systems must comply with the household standards and convenience of usage. This paper details the overall design of a wireless home automation system (WHAS) which has been built and implemented. The system has been tested and verified. More sophisticated home automation systems can be developed using the new technologies like Internet-of-Things.

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