Design and Implementation of an Advanced Home Automation System using WiFi Technology

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Abstract: Design and Implementation of an Advanced Home Automation System using Wi-Fi Technology. A system of remote monitoring and self auto controlling are very much necessary. Smart home appliances are one the beneficiary of system equipped with home appliances which we wish to control smartly from anywhere. Machine-to-Machine and Man-to-Machine are the basic communication platforms that enable home appliances to communicate with each other to be more efficiently operated. According to the experimental results, the impact of wireless interference on the proposed smart home control network is substantially mitigated. Additionally, a smart control algorithm for lighting systems and an analysis of the illumination of lighting is present. The energy saving of lighting systems relative to those without smart control is evaluating. Numerical results indicate that the electricity consumption on a sunny or cloudy day can be reduced by at least 40% under the smart control. This paper presents a comprehensive review of the smart home automation network communication protocols that are used to enable bidirectional communication between the home owners, utilities and smart home appliances. Moreover, a prototype for the proposed smart home control network with the smart control algorithm is implemented.

Keywords: *Appliance control, energy saving, smart homes, smart lighting control, Smart Grid, Temperature Sensor, Ambient Light Sensor, Humidity Sensor, ARM, Wi-Fi.*

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I. INTRODUCTION

Numerous studies have that smart homes or intelligent buildings can use energy more efficiently than traditional buildings. Thus, several researchers have promoted building smart homes for reducing energy consumption. Almost all recommended smart home architectures in the literature adopt the wireless design as the dominant technology. The Wi-Fi, has been popularly employed for remote control and monitoring applications because it has a low cost and consumes little power [1]-[3].

Local networking of electronic devices in houses and buildings offer gains in a number of areas, ranging from safety and protection to energy efficiency and home performance features. Home area systems can be performed via both wired and wireless presentations, using multiple different standards, and can be remotely controlled and monitored by a gateway to neighbor, wide area or smart grid networks. While smart grid deployments offer fabulous possibilities for utilities to manage and control energy delivery to their customers, it also gives homeowners the chance to better manage their energy usage through smart energy management.

A home area network is a dedicated network connecting devices in the home such as displays, load control devices and ultimately "smart appliances" seamlessly into the overall smart metering system. It also includes turnkey source designs of systems to monitor and control these networks. Most of our high energy use today comes from heating/cooling, cooking, lighting, washing, and drying. These home appliances are beginning to become smart with connectivity features that allow them to be computerized in order to reap benefits that smart metering and variable tariffs bring. The utility companies are beginning to be able to better maintain the energy demand and perform load balancing more efficiently.

This paper proposes a design using advanced modern technology to make traditional home automation control smarter. Wi-Fi is a wireless technology that uses radio frequency to transmit data through the air. Wi-Fi has initial speeds 1mbps to 2mbps.Wi-Fi transmits data in the frequency band of 2.4GHz. It implements the concept of frequency division multiplexing technology. Range of Wi-Fi technology is 40-300 feet. The controlling device for the automation in this model is a microcontroller. The data sent from PC over Wi-Fi will be received by Wi-Fi module connected to microcontroller. Microcontroller reads the data and decides the switching action of electrical devices connected. The microcontroller is program used embedded 'C' language.

II. RELATED WORK

In-Ho Choi et al. proposed the hardware architecture and software of the smart controller for use as the platform in smart grid system to reduce energy consumption. The smart controller can be installed on the electric plug of the electric appliance. The smart controller grasps the energy amount used in the electric appliance and delivers to the AMI / EMS (Energy Management Server) [4].

Mingfu Li et al. proposed a smart the controller algorithm for lighting systems and an analysis of the brilliance of a fluorescent lamp were presented. The energy saving of lighting systems relative to those without smart control was evaluated. Numerical results indicate that the electricity consumption on a sunny or cloudy day can be reduced by at least 40% under the smart control [5].

Amjad Anvari et al. a multi objective mixed integer nonlinear programming model is developed for optimal energy use in a smart home, considering a meaningful balance between energy saving and a comfortable lifestyle. Thorough incorporation of a mixed objective function under different system constraints and user preferences, the proposed algorithm could not only reduce the domestic energy usage and utility bills [6].

Ayesha Hafeez et al. has presented a comprehensive review of the home area network (HAN) communication protocols that are used to enable bidirectional communication between the home owners, utilities and smart home appliances. The paper presents the most utilized HANs wired and wireless communication protocols and discusses their characteristics, advantages and disadvantages [7].

Jianwen Shao et al. has presented 3 technological advancements addressing key trends in Smart Appliance control, in the context of semiconductors. Around the world, performance and cost efficiency have always been the challenges facing home appliance manufacturers [8].

Hamid Gharavi et al. has represented a major part of the Smart Grid vision, which aims at increasing energy efficiency. To achieve this goal, home appliances need to communicate with entities and players in other Smart Grid domains via home area networks [9]

III. SYSTEM DESIGN

The below system design based on Atmel SAM low-power microcontrollers using the 32-bit ARM Cortex-M0+ processor is used for implementation for Smart Home Automation controlling and monitoring. various sensor used in this system such as Humidity sensor, temperature sensor, Ambient light sensor, and Led seven segment display for output to show the temperature and humidity. By gathering all the information from sensors and running algorithm to make the home appliances loads auto turn on and off And all the output of this sensor showed in PC through RS232 serial communication in visual basic software. The Wi-Fi module is interfaced to controller by using RS232 interface. Wi-Fi module is used for transmit and receive message as per level by set a specific threshold via Wi-Fi router connected. Designed system required +5V power supply by using voltage regulator NCP603 is converted to +5V is regulated voltage. +3.3V power is required for operating the ARM controller. SHT20 sensor IC used to measure the humidity and temperature. TSL2771 light-to-digital converter used to measure the Ambient Light Sensing (ALS). CAT9532 16-bit Programmable LED Dimmer interfaced over I2C protocol to control the home lighting loads. Wi-Fi module publishes the temperature, humidity and Ambient light sensor values for monitoring and controlling. When the temperature exceeds given threshold value, corresponding Ac and Fan auto on-off and transmit the information via RS232 and Wi-Fi. The output message includes also send the information about the change in temperature, humidity and Light values with set threshold by using UART & Wi-Fi.

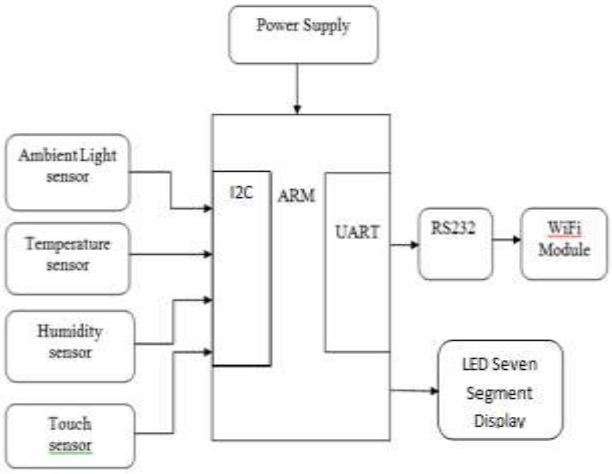

Figure 1. Block Diagram of the System

IV. METHODOLOGY

A. Microcontroller

Atmel SAMD20 microcontroller used to design Smart Home Automation controlling and monitoring. SAMD20 contains GPIO, ADC, PWM, UART, I2C ext. pins which can be used as digital input, output and other peripherals.

B. Sensor Modules

SHT20 Humidity and Temperature Sensor IC used to measure the ambient humidity and temperature. TSL2771 light-to-digital converter IC used to measure the Ambient Light Sensing (ALS). CAT9532 16-bit Programmable LED Dimmer interfaced over I2C protocol to control the lighting loads using PWM. Touch sensor for user interface touch control, temperature and humidity threshold set for controlling.

C. Hardware Interconnections

The Atmel SAMD20 microcontroller and Sensors are connected via Inter integrated communication (I2C) protocol. Sensor UART is use to connect control boards, Wi-Fi module and PC to transmit and receive the data. The Connection Between sensor and microcontroller is a I2C serial communication. So data communication should be two way i.e. Transmitter to Receiver. Led lighting loads are connected with CAT9532 Led driver IC which is controlled with PWM and CAT9532 connected over I2C protocol with SAMD20 microcontroller. Sensor control board is connected with all the sensors, and all receiving data should be transmitted to Wi-Fi module via UART. Here the function of control board is nothing but the monitor and controller. Which observe the working of all sensors and parameters of home appliances, measure and control the working of each parameter and send notification to Wi-Fi module over UART and stored a data in a computer as a server. Also Led seven segment display used to display current temperature and humidity values.

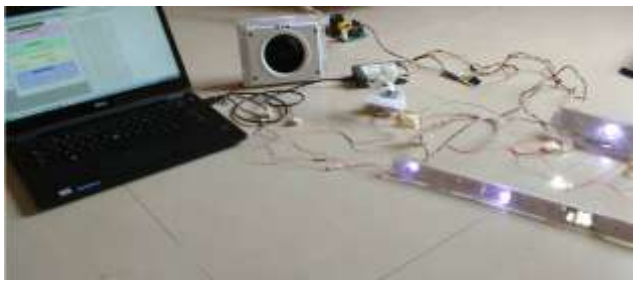

Figure 2. Project System Setup

D. Software

The microcontroller control boards measure the real time temperature, humidity and light values from the sensor. The threshold value is set for all senor inputs using user interface touch key buttons and PC UART interface. Microcontroller control boards checked the connection between all the peripherals and receiving sensor values of each and every parameter and the data to PC via UART protocol which should be stored in a server. In a software part there are different protocol used, like I2C protocol used for reading the temperature, humidity and light sensor values. PWM peripheral used to control the loads like fan, lighting etc. With the help of UART and collect all obtained data information to the PC application take the input values from control board and display as a temperature, humidity and light sensor values. It gives

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instructions based on set threshold values to control fans and lights and can be tracked via internet system.

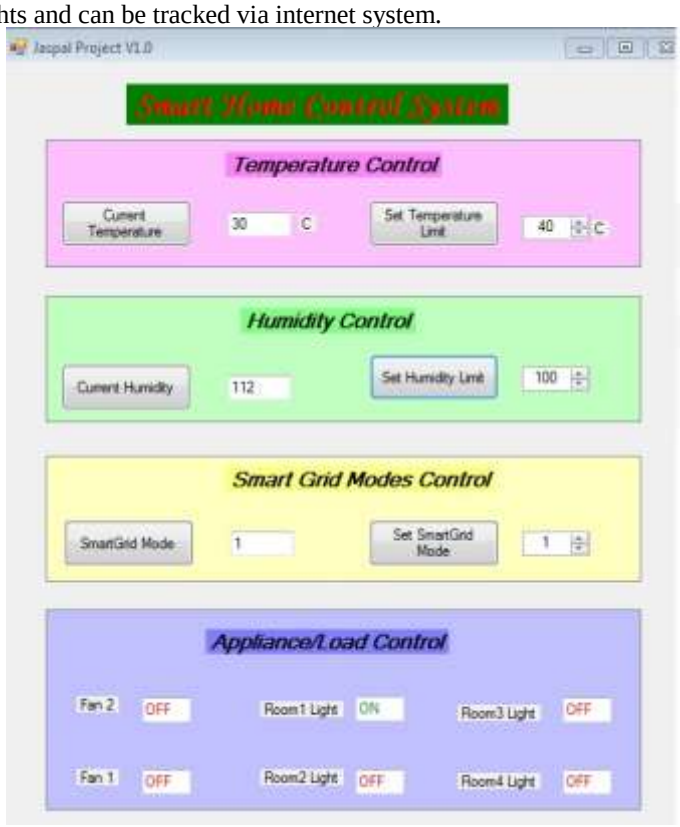

Figure 3. GUI Interface

E. Flow-Graph for Programming

The flow chart explains the functionality of the working model. The system monitors and read all environmental parameters in home by microcontroller control boards. After reading all data by microcontroller control boards, insert data into database. If, input crossed the threshold value then send high output to the port. If, value is below the threshold level then it will again start reading environmental parameters. The three different parameters temperature, humidity and luminescence are monitored by the system. For humidity when the value of humidity goes beyond threshold then FAN OUT will be ON to control the humidity. If no then it will again start reading environmental data. When temperature crosses the threshold value then FAN IN will be on if not then it will again go to the second step and start reading environmental parameters. If Luminescence change is high then light will be ON, if no it will go back to step number two. All the notifications and results will be alert on PC. The system will generate alert notification if any value out three will get changed. The microcontroller control board's uses led based seven segment application to display values of temperature, humidity and light sensitivity. The real time values are stored into PC database and these values are further used for predictive analysis.

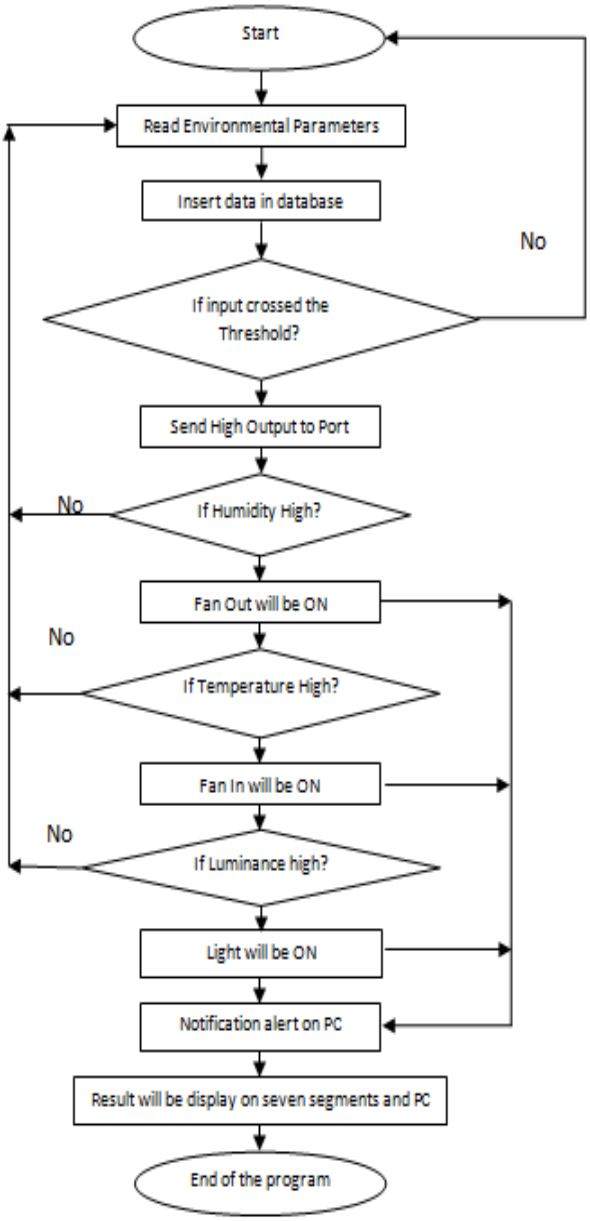

Figure 4. Flow chart of the System

V. RESULT

The prototype of Smart Home Control system there are various sensor used in this system like Temperature, Humidity and Light sensor. This all sensor interfaced with Atmel SAMD20 micro-controller and collect the current values of all sensors and display on Led Seven Segment as well as in PC via UART to serial cable on GUI interface. Various environmental parameters threshold values set and action taken against change in state of environmental parameters. e.g. The threshold value of temperature is in between 24°C to 32°C. If the temperature is below 24°C then the fan will be ON. If the temperature is more than 32°C, then cooling fan will be ON to maintain the internal temperature of room. Similarly for, when intensity of light is more than 45% then according to the climate condition of temperature the light switch will be ON/OFF.

Parameters	Threshold value	Action perform
Max Temp	Th. Max <=40	Cooling Fan ON Send UART message to PC
Humidity	Above 40%	Fan ON Send UART message to PC
Light Luminance	Above 45 %	Light ON Window OPEN Send UART message to PC

Table 1. Performance evaluation

VI. ADVANTAGES

Smart homes obviously have the ability to make life easier and more convenient. Home networking can also provide peace of mind. Whether you're at work or on vacation, the smart home will alert you to what's going on, and security systems can be built to provide an immense amount of help in an emergency. For example, not only would a resident be woken with notification of a fire alarm, the smart home would also unlock doors, dial the fire department and light the path to safety.

Reduce the energy consumption to prolong the network, speed up and extend the communication coverage to increase the freedom for enhance the quality of smart home automation life.

- Easy to monitor remotely
- Easy to control and save energy efficiently
- Man power means human efforts get reduced

VII. CONCLUSION

People including who are elderly or disabled benefit the most from a home automation system that employs artificial intelligence. These systems offer to all including those who are less mobile, or in delicate health, the opportunity to be independent, rather than staying in an assisted living facility. Designing a Smart Home is also very crucial. This can be tough; putting together a home design that reflects your taste, yet also fits your needs and budget is a balancing act that takes planning.

VIII. ACKNOWLEDGMENT

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