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A USER ACTIVITY BASED INTELLIGENT BUILDING DESIGN FOR FULL AUTOMATION OF A ONE BEDROOM APARTMENT BUILDING

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ABSTRACT: The research paper discusses a user activity based building automation system for real time monitoring and control for a standard one-bedroom unit. Standard buildings designed and built in Nigeria are without any form of automation and with emerging technologies that support automation of certain sections/processes in buildings the intelligent building paradigm can be a realizable objective. This paper thus proposes a microcontroller based design interfaced with appropriate sensors, actuators and voice recognition abilities to develop a building automation system (BAS) whose control action is based on human activity analysis/ human presence detection. The developed system when implemented would offer the advantage of real-time occupancy information for control of lighting and other electronic circuitry so as to save a significant amount of the electrical energy.

KEYWORDS: BAS, Microcontroller, Sensors, Actuators.

1 INTRODUCTION

An intelligent building according to the European Intelligent building group (EIBG) is one "that incorporates the best available concepts, materials, systems and technologies integrating these to achieve a building which meets or exceeds the performance requirements of building stakeholders which includes the owners, managers and users as well as the local and global community" or the definition by the intelligent building institute (IBI) as one that provides a productive and cost effective environment through optimization of its four basic components – structure, systems, services and management as well as the interrelationships between them.

Buildings since the 1980's have slowly been integrated with technologies and processes that have created a safer, comfortable and more productive facility for its occupants. Intelligent building technology thus refers to the integration of four systems namely a Building Automation System (BAS), a Telecommunication System (TS), an Office Automation System (OAS) and a Computer Aided Facility Management System (CAFMS) where a sophisticated BAS is actually the basis of every intelligent building [15]. The desire to improve comfort inside new, large building after the World War resulted in more complex mechanical systems, better heating and control systems, Pneumatic controls and mounted electrical switches. The period through the 50's, 60's, 80's and the current time saw the emergence of different technologies such a Pneumatic sensor transmission that permitted local indication and remote signaling, electrochemical multiplexing systems which resulted in the reduction of installation cost and maintenance, Automatic control, emergence of user friendly systems, man-machine interface, smart multiplexers, field interface devices (FID's), Microprocessor based distributed direct digital control (DDDC), interoperability and expandability that allowed the linking together of monitoring and control systems and more

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compatible communication protocols that were suitable for implementation of diverse technology towards achieving the "Intelligent Building" is very wide and almost never ending as changing human wants/needs would require bigger complex building designs that need to be automated to meet future standards.

Recent research(s) are focused on developing energy intelligent buildings by integrating occupant activity and behavior as a key element with which the buildings can automatically turn off unused lights, computers, etc. This key element has long been used for control of various devices like artificial light, HVAC devices, etc. As an example, past research has shown that the use of real-time occupancy information for control of lighting can save a significant amount of the electrical energy used for lighting. User activity and behavior taken into account in the automation of a building to realize the "intelligent building" paradigm provides answers to questions such as what are the most valuable activities or behaviors and their impact on energy saving potential? Etc. The field of intelligent buildings, intelligent homes, building automation systems (BMS) encompasses an enormous variety of technologies, across commercial, industrial, institutional and domestic buildings, including energy management systems and building controls. The function of building management systems is to control, monitor and optimize building services such as lighting, heating, security, closed-circuit television (CCTV) and alarm systems, access control, audio-visual and entertainment systems, ventilation, filtration and climate control, etc., even time and attendance control and reporting (notably, staff movement and availability).

2 RELATED WORK

Reference [8] proposed a research methodology that describes an integrated approach to using results of literature search and inputs from expert survey in the field of building automation and thus presented a framework for identifying and classifying key parameters thus, a building automation performance index (API) model.

Reference [9] developed a system that can be utilized in assessing a building's energy or operating cost performance where in such case, the building automation system was simply treated as a set of options chosen from a list where automation would be assumed to be at optimum levels whenever an option from the list is selected.

Reference [11] provided a novel survey of prominent international intelligent buildings research efforts with the theme of energy saving and user activity recognition and thus devised new metrics for comparative study, determination of most valuable activities and behaviours with focus on their impact on energy saving potentials for each of the main subsystems that we used as a case studies such as HVAC, light and plug loads. A conclusion with principles and perspectives for energy intelligent buildings based on user activity with clear reference to the most promising and appropriate activity recognition technologies and approaches were discussed.

The CASAS Smart home project is a multi-disciplinary research project at the Washington State University focused on the creation of an intelligent home environment. The approach attempts to view the smart home as an intelligent agent that perceives the environment through the use of sensors, and can act upon the environment through the use of actuators [3].

Reference [6] presented SPOT-LIGHT which was a prototype system that can monitor energy consumption by individuals using a proximity sensor. The basic idea is that an occupant carries active RFID tag which is used for detecting proximity between user and each appliance. This proximity information is then used for energy apportionment, reporting the energy consumption profiles in terms of useful/wasteful power of each user with each appliance.

Reference [12] proposed a microcontroller based design for a building automation system for real time sensing and control of the sitting room, entrance and adjourning doors as well as lightings and window control. The research effort centered on user presence detection control and achieved intelligent control of some basic household appliances.

Reference [7] aimed to provide an overview addressing the state-of-the-art in the area of activity recognition, in particular, in the area of object-based activity recognition. A novel approach to activity recognition based on the use of ontological modeling, representation and reasoning, aiming to consolidate and improve existing approaches in terms of scalability, applicability and easy-of-use initial reviews of existing approaches and algorithms which have been used for activity recognition in a number of related areas were also reviewed from which each of these their strengths and weaknesses were discussed with particular emphasis placed on the application domain of sensor enabled intelligent pervasive environments. Based on an analysis of existing solutions, the researchers then proposed an integrated ontology-based approach to activity recognition where the proposed approach adopted ontologies for modeling sensors, objects and activities, and exploiting logical semantic reasoning for the purposes of activity recognition thus enabling incremental progressive activity recognition at both coarse-grained and fine-grained levels.

Reference [10] considered two requirement models, namely binary satisfaction and continuous satisfaction models, and proposed two decision algorithms to determine the proper illuminations of devices and to achieve the desired optimization goals. A closed-loop device control algorithm was applied to adjust the illumination levels of the lighting devices. A WSN-based intelligent light control system for indoor environments was thus proposed. Wireless sensors are responsible for measuring current illuminations. Two kinds of lighting devices, namely whole lighting and local lighting devices, are used to provide background and concentrated illuminations, respectively in the research effort.

Reference [1] described a system to detect user behavior patterns in an intelligent workplace. The system is designed for a workplace equipped in the context of Sensor9k, a project carried out at the Department of Computer Science at the University of Palermo (Italy). The proposed approach consists essentially of three different phases of analysis of the data gathered by the deployed wireless sensor network, regarding the environment state and the user presence. The pre-processing stage analyzes data in order to detect anomalies, remove outliers and replace missing data, the action, detection and modeling phase analyzes sensor data trends to infer changes which can be ascribed to human actions; appropriate models allow for a better understanding of the extracted information. Finally the Extraction of behavior Patterns phase is accomplished to find relationships of interest and to detect similar clusters in the AMI data.

Reference [13] present a security system for collecting data from detectors for carbon monoxide, flammable gas, smoke, radon and from an access control system based on fingerprint recognition, which sends warnings through a GPRS link. The warnings are sent over the Internet as the concentration of toxic gases or smoke increases over a certain level or an unauthorized access is repeated several times. The transmitted data contains information about the type of danger situation and the location of the system determined by a GPS receiver.

3 METHODS

A structured approach to system analysis as summarized below was used in developing the system.

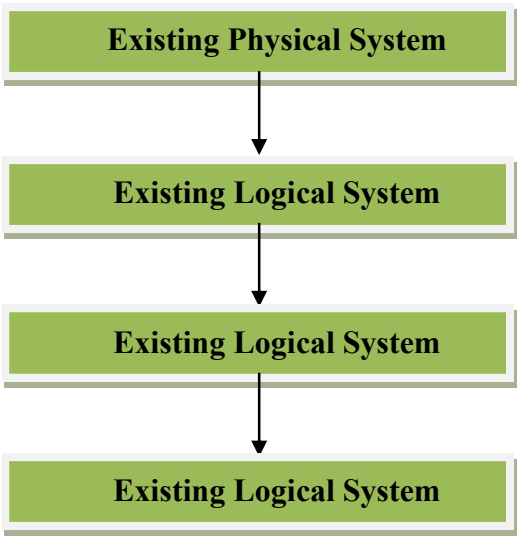

Fig. 1. A Structured approach to System Analysis

Source: Reference [14]

To provide answers to the following questions relating to the problem statement such as:

- What programmable control device can be used to implement the automation required for the One (1) bedroom apartment?
- What sensors and actuators would be required to execute the control action?
- What level of automation is currently being employed and is developed/deployed system flexible for the future?

A top-down design approach was used where the overall system was broken down into smaller modules to handle different areas of the study. AutoCAD was used to draw the design of a standard one bedroom apartment. Microcontrollers, sliding motors (Actuator) and associated circuitry, Infrared/motion sensors, temperature sensor, light illumination sensor, clock alarm circuit and voice recognition device with appropriate electronic circuitry was used to develop the building automation system (BAS) whose control action is based on human activity. The infrared/motion sensor is used to detect human presence at the sitting room and bedroom respectively. The microcontroller triggers the sliding motor enabling the door/window/window blind to open and close. The microcontroller on detecting the presence of an individual in the sitting room/ bedroom would switch on the main bulb(s) in the room, measure the temperature of the room with respect to programmed control with regards time of day/season and thus trigger the appropriate actuators to open the windows/blinds, switch-on heaters/fan/air conditioners, trun on music player etc. The system remains in this state till a preprogrammed voice signal tells it to open door "C" then the microcontroller triggers door "C" to open.

- **Module One:** AutoCAD is used to draw the design of the three bedroom apartment.
- **Module Two:** A microcontroller based design that can automate the apartment as required was developed.
- **Module Three:** The developed system is interfaced with the original building design to effect the control action.

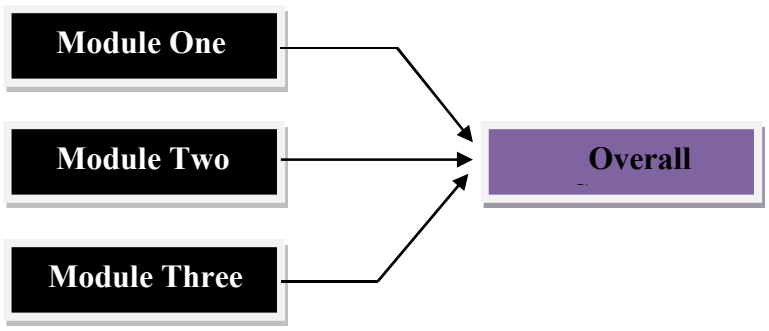

Fig. 2. Modular Framework of System

Source: Reference [4].

4 RESULTS AND DISCUSSIONS

The system operates by the microcontroller sensing a disruption at the receiver end of the infrared/motion sensor which indicates the presence of a human, thus prompting the system to trigger the appropriate actuators concerned to perform activities such as opening doors and windows/ window blinds, switching ON light bulbs, fan, air conditioners, heaters by using a timer circuit to turn ON the water heater in the bathroom whenever it is 6:00am in the morning.

A voice recognition device is also interfaced with the microcontroller so in the event, whenever the keyword which has been stored in memory is observed by the controller it triggers the appropriate actuator to open the associated door.

The microcontroller can be coded using assembly language or suitable high level programming language like C, in order to provide 24-hour service especially in a country like Nigeria which experiences incessant power outages an appropriate inverter could be employed to provide a back-up power solution.

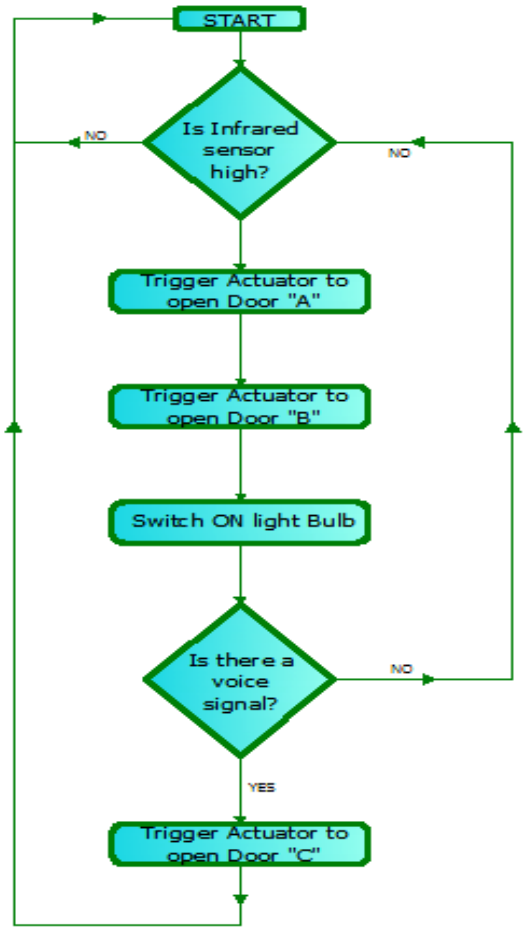

Fig. 3. Flow diagram showing the operation of the microcontroller

Source: Authors' research design

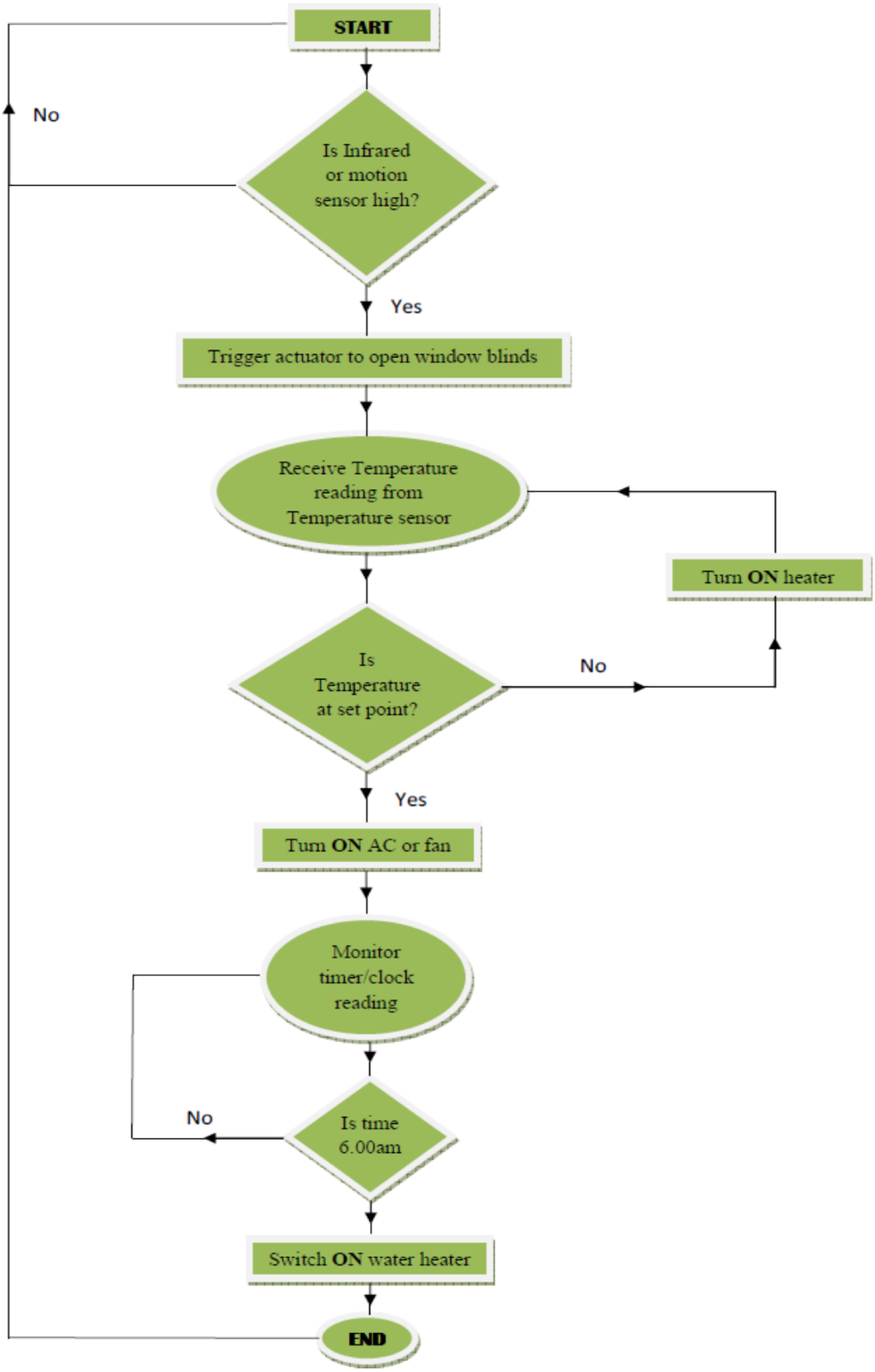

Fig. 4. Flow diagram showing the operation of the microcontroller

Source: Authors' research design

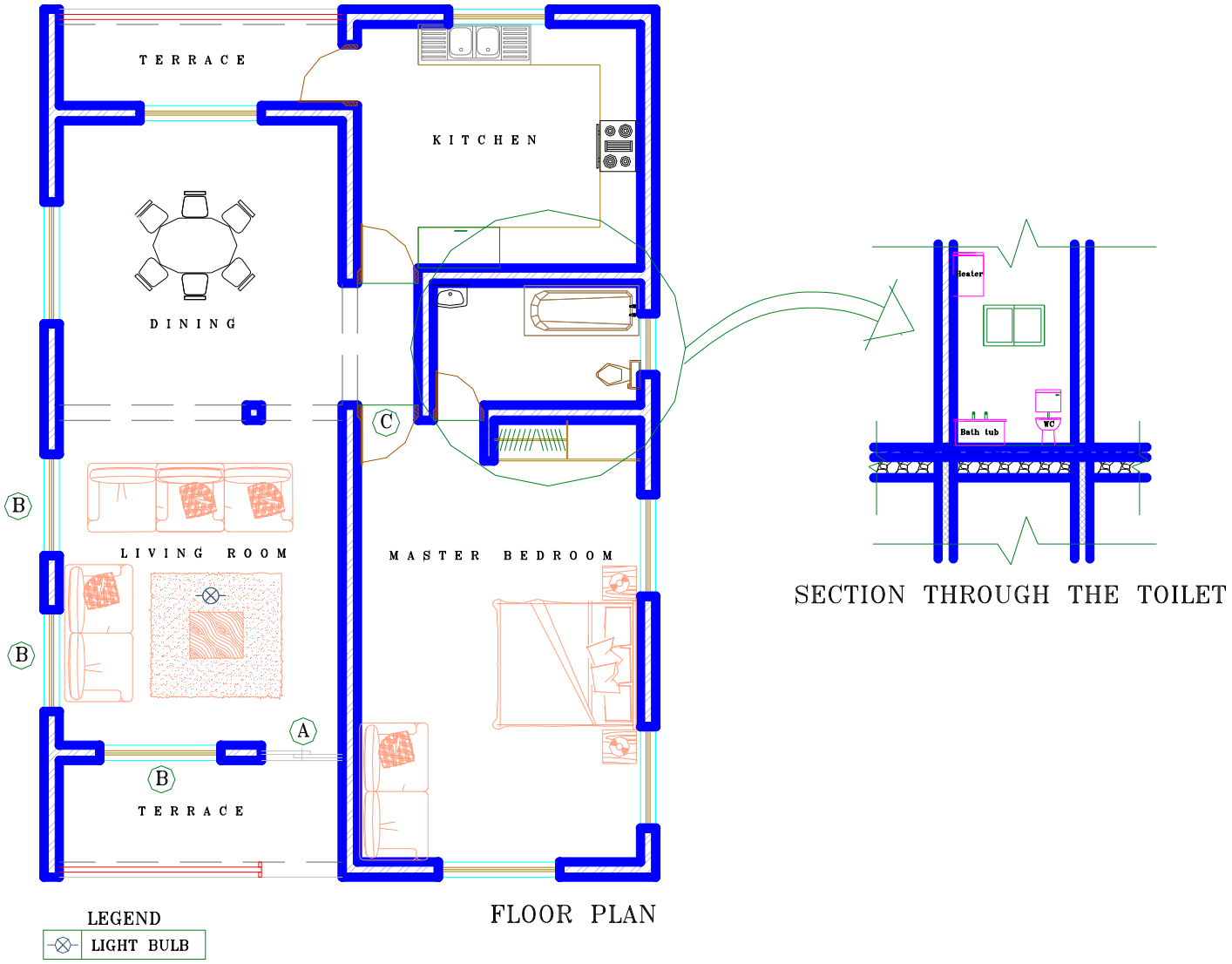

Fig. 5. Floor plan of the proposed building

Source: Authors' research design

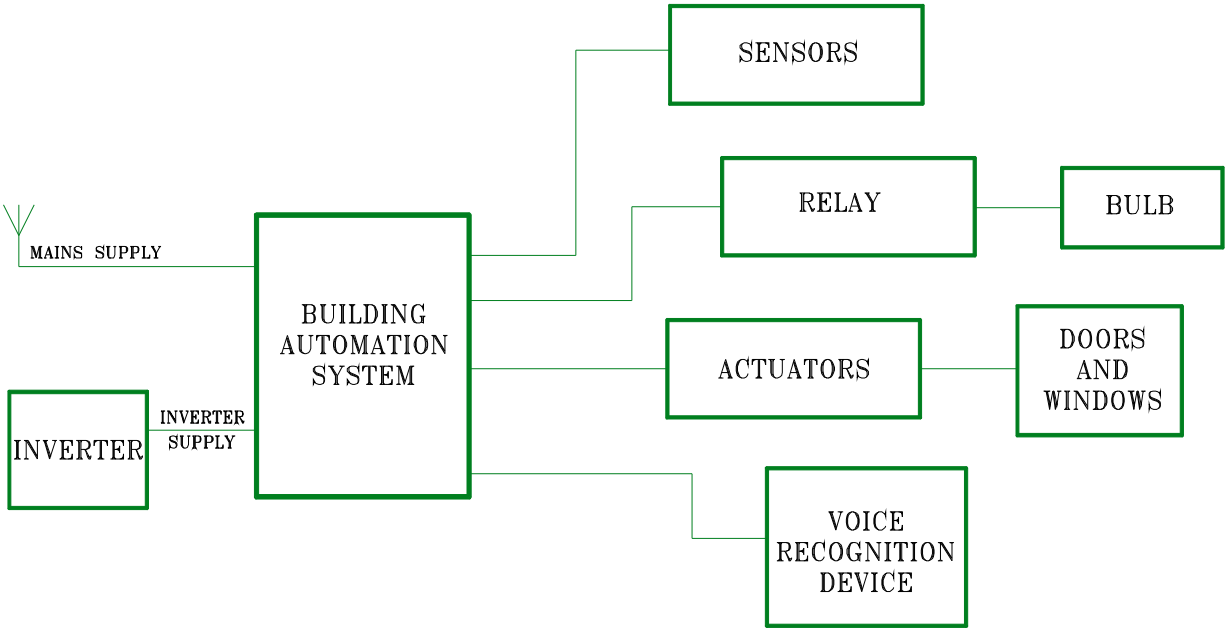

Fig. 6. Total system overview

Source: Authors' research design

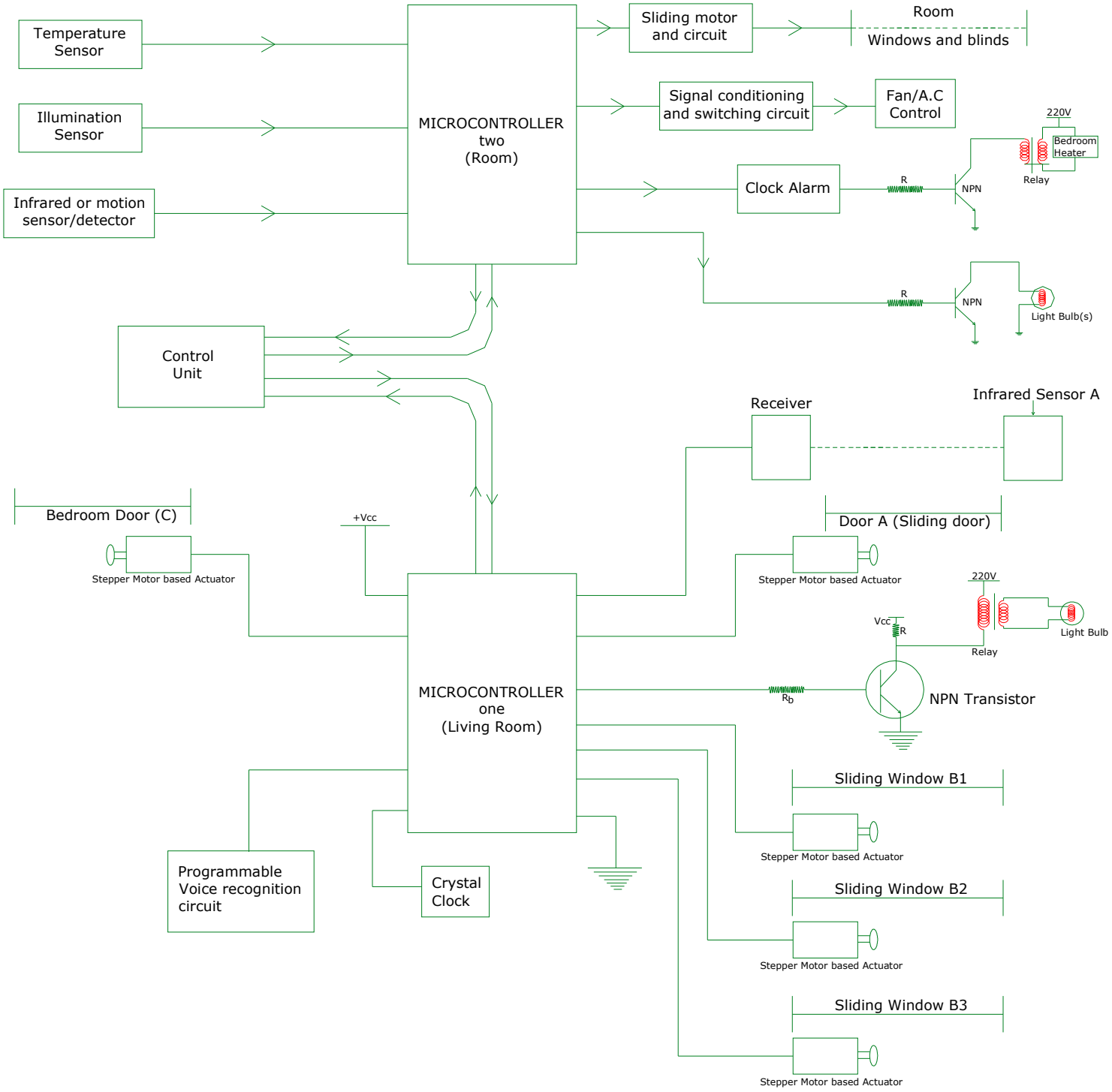

Fig. 7. A Microcontroller base BAS design

Source: Authors' research design

5 CONCLUSION

The research paper proposed a user activity based intelligent building design for full automation of a one bedroom apartment where an attempt was made to control doors, windows, lighting bulb, room temperature, alarm setting for water heater control.

The research endeavor attempts to develop an intelligent building based on user activity and as current situation has shown that building control is mainly done manually from switching lights and appliances to controlling heating systems. We have clearly shown that using appropriate technology the "Intelligent Building" concept can be applied using cheap off the shelf components applied to small residential homes.

6 FUTURE WORK

The researchers intend to carry out further research on the subject topic by incorporating security features that ensure authorized entry, complete automation of the building that incorporates remote monitoring and control functions using smart objects and internet-of-things as well as entire coverage of the entire building plan to achieve the "Intelligent Building".

REFERENCES

[1] Augello, A., Ortolani, M., Lo Re, G., Gaglio, S.(2011): Sensor mining for user behavior profiling in intelligent environments. Advances in Distributed Agent-Based Retrieval Tools. Pp. 143–158

[2] Bellas-Vellidis I, Argiriou A, Balaras C.A, Kontoyannidis S. (1998), "Predicting Energy Demand of Single Solar Houses Using Artificial Neural Networks". Proceedings of the 6th European Congress on Intelligent Techniques and Soft Computing, Aachen Germany, Pp. 873-877.

[3] CASAS Project (2011), Website http://ailab.wsu.edu/casas/

[4] Hawsyszkiewyez, I.T. (1989), "Introduction to system analysis and design". New Delhi: Prentice hall of India.

[5] Intelligent Buildings Project (2011), Website: http://www.bth.se/com/disl.nsf/pages/intelligent-buildings

[6] Kim, Y., Charbiwala, Z., Singhania, A., Schmid, T., & Srivastava, M.B. (2008), SPORTLIGHT: Personal Natural Resource Consumption Profiler, HotEmNets 2008.

[7] Liming, C., Nugent, C., (2010) "Ontology-based Activity Recognition in Intelligent Pervasive Environments" School of Computing and Mathematics, University of Ulster Shore Road, Newtownabbey, BT37 0QB, Northern Ireland

[8] Makarechi, S. & Kangari, R. (2011), "Research methodology for building automation performance index". International Journal of facility management, Vol. 2, No 1.

[9] Markus, T.A. (1967). The Role of Building Performance, Measurement and Appraisal In Design Method, Architects Journal, 146, 1567 – 1573.

[10] Meng-Shiuan, P., Lun-Wu, Y., Yen-Ann, C., Yu-Hsuan, L., & Yu-Chee, T.(2003) "A WSN-based Intelligent Light Control System Considering User Activities and Profiles" In Proc. of ACM Int'l Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc), Maryland, USA,

[11] Nguyen, T. A. & Marco A. (2013) "Energy Intelligent Buildings Based on User Activity: A Survey". Energy and Buildings, 56 (2013) Pp. 244-257. www.elsevier.com/locate/enbuild

[12] Ofoegbu, E.O & Ogunmakinde O.E (2014) "A Microcontroller Based Building Automation System for Real Time Sensing and Control". International Journal of Innovation and Scientific Research. ISSN 2351-8014. 2 (2), Pp. 275-280

[13] Ogrutan, P., Romanca, M., Kertesz, C. (2007) "A multi-sensory GPRS-Based Security System for Intelligent Building" ACTA TECHNICA NAPONSENSIS, Electronics and Telecommunications, 48 (3).

[14] Rajaraman, V. (1991). "Analysis and Design of Information System. New Delhi: Prentice hall of India.

[15] Stavrakakis, G., Kolokotsa, D., & Nikolau, T. (2002), "Introduction to Intelligent Buildings". (35)