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Implementation of a Secure and Smart Lab with Wireless Sensor Network

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Abstract: ***Application of wireless technologies in smart home automation has gained high emphasis due to its ease of operation and maintenance. The smart home automation extended to college laboratories to form a smart lab is the main idea of this paper. The description of real-time implementation of smart lab is presented in this paper. The implementation of smart lab is based on combination of two modules: 1) Ambient lighting module and 2) Security module. The modules are implemented by the use of Passive infrared sensor (PIR) and environment sensor (ES). The prototype was tested based on actual data sensed by sensors and actuators are made to perform respective actions.***

Keywords: Wireless sensor network, Smart lab, Passive infrared sensor, Environment sensor, Actuators**.**

1. Introduction

Networking technology plays a vital role in human life by virtually penetrating through different technologies. One of the popular domains of networking technology is Wireless Sensor Networks (WSN). Huge numbers of applications are supported by WSN. Applications of WSN include habitat monitoring, wildfire monitoring, navigation and many more. In this paper we concentrate on home automation based on WSN. The home technology is moving rapidly from the programmable thermostat to an era where all home systems are integrated into a centralized control one which can be accessible from multiple entry points like touch pads, telephones, smart phones and tablets. The result is highly personalized home environments which interpret and react to human needs. We extend the technology of home automation to college campus laboratories leading to smart labs. Smart labs are implemented with two important aspects:

1) Smart power management for energy cost reduction.
2) Providing security for intrusion from unauthorized people. Smart lab thus creates wire free systems which cause minimal cost and disruption. The routing mechanism which is implemented in routing the data collected by sensor nodes to the sink is through Labeled Based Multipath Routing (LMR) protocol.

In today's world, people rapidly use internet for most of the activities in daily life. The control of smart labs can also be extended to PDA's equipped with internet. This leads to Internet of Things (IOT) where it is all about physical items talking to each other, machine-to-machine communications and person-to-computer communications will be extended to things. This paper illustrates a cost effective and flexible solution for energy management and security related aspects by the use of sensor networks.

2. Related Work

J.Byun[1] proposed a situation based self adjusting scheme to the existing sensor systems which were not robust and scalable due to fixed architecture. The self adjusting scheme was ZiSAS (ZigBee based Intelligent Self Adjusting Sensor). J.Byun et al., have tested the architecture on test bed. The disadvantage is, this scheme is not applied to context aware services and lack of real time result. Federico [2] described the wireless sensor technology adopted in smart homes. His main concern was to assist elderly people and smart metering to gauge the power consumption**.** User monitoring and localization methodologies are integrated in proposed system. The proposed system is still to be applied to real world to get real time results. K. Gill[3] outlines a novel , stand-alone, low cost and flexible ZigBee based home automation system. K. Gill et al. reviewed the existing state of home and identified five important areas that hinder consumer adoption. The areas are complexity and expense of existing architectures, lack of interoperability between systems, lack of interoperability between different networks, difficulties in system installations and interface inflexibility. The use of ZigBee technology helps to lower costs and installations difficulties. The problem of network interoperability is overcome by the inclusion of home gateway. The gateway provides interoperability between different networks. M.Raisul[4] presents the survey made on existing smart home technologies and there importance. The author's main concern is to make use of proper middleware required to coagulate devices of different vendors. Real time implementation of middleware is yet to be done. J.Kim[5] proposed a prototype of home gateway for smart home. The home gateway implementation is based on OSGi (Open System Gateway Interface). The disadvantage of proposed system is lack of resolving conflicts that occur when more than one person try to access the same device at same time. Furthermore protection mechanisms should be implemented to the devices involved. A.A.Nippun Kumar [6] proposed an intelligent lighting system using wireless sensor networks. The proposed system consist array of light sensor nodes which can communicate with the master node providing information about the light conditions at each sensor node. M.Shiuan[7] proposed the system of light controlling system considering user activities and profiles. In the proposed system it is to be assumed that the location of each user is known and each user carries a wireless sensor which can detect the local light intensity.

3. System Architecture

In this section we present the system architecture of the proposed system. The general three tier architecture is depicted in the figure 1. The first tier comprises the data collection part. The sensors collect data from surrounding environment and transfer the collected data to sink or base station. The routing of the data from sensors to base station is done by the use of LMR (Label-Based Multipath Routing) routing protocol. The second tier comprises processing systems that process the collected data. The collected data is then transferred to the processing system through serial communication. The third tier comprises the working of actuators. The parameters collected are processed and commands are sent to actuators via power line.

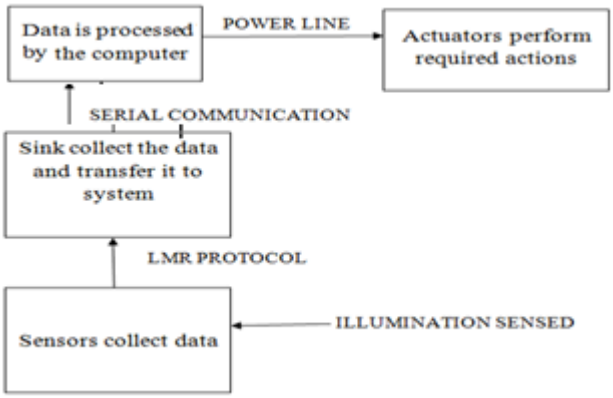

Figure 1: System Architecture

The complete system architecture is divided into two modules:

1) Security for smart lab.
2) Ambient lighting for smart lab.

The security to the smart lab is implemented by the use of Passive Infrared Sensor (PIR). The PIR senses the human generated heat when passed across the PIR sensor. The architecture for security module is as shown in figure 2.

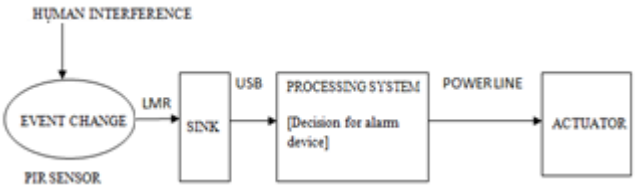

Figure 2: Security Module Architecture

Any change in event is sensed by the PIR sensor and sensed data is transferred to the sink through routing protocol. The parameters sensed is sent to the processing system where decision is taken depending upon the criteria. The actuation is done by the actuators where respective actuation is done through power line.

The ambient lighting to the smart lab is provided by the use of Photo Sensor (PS) which is a part of Environment Sensor. The PS senses the luminance of sunlight. The sensed data is sent to the sink or base station through routing protocol. The sensed parameters are processed by the processing system and respective decision is taken based upon exceeding threshold values. The architecture for ambient lighting module is as shown in figure 3.

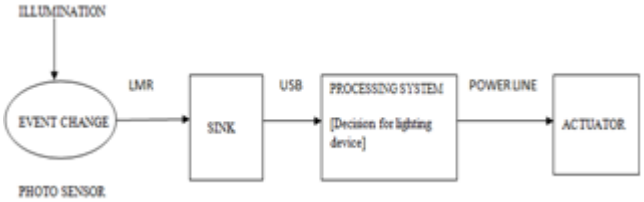

Figure 3: Ambient Lighting Module

3.1 Flowchart

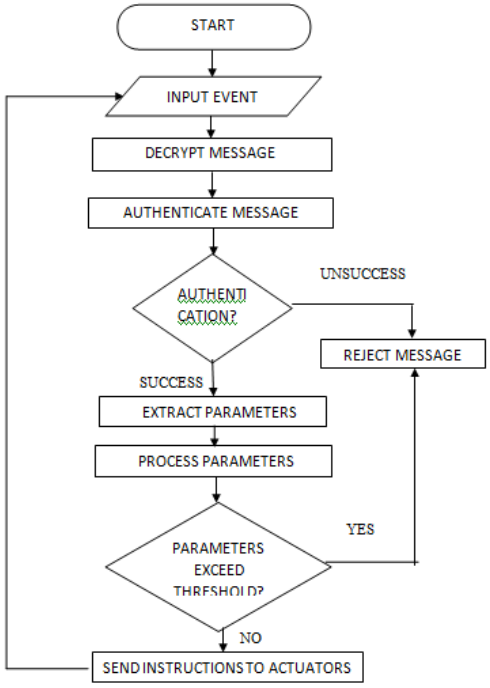

Figure 4: Flowchart

Figure 4 represents the overall flow of implementation. Change in the event is sensed by the sensor nodes and the data collected by the sensors are encrypted one (AES). The message is decrypted and authenticated. On successful authentication the parameters are extracted from the message and processed. Failure of authentication leads to rejection of the message. The parameters processed are compared with threshold level which is set in prior. If threshold level is exceeded, the actuators are sent instructions to perform respective actions such as lighting up danger light or raising a burglar alarm.

4. Proposed System and Implementation

The proposed system comprises the real time implementation of smart lab. The objectives of smart lab are reviewed with the actual implementation using respective sensor nodes which are apt to the objectives specified. The objectives are:

1) Smart power management (Ambient Lighting).
2) Providing security for intrusion of unauthorized people (Security).

The implementation details of above mentioned objectives are described below.

4.1 Security Module Implementation

The security module implementation is achieved by the use of PIR sensor. The PIR sensor image (Figure 5)[9] and description is as shown in figure 5.

Figure 5: PIR Sensor and Base station

The PIR sensor is used to detect the moving object which is achieved by the change in temperature within the distance of 10mts. The sensor offers a wide range of 110 degree for comprehensive monitoring. The sensor is switched on by driving low the D1O9/TIM_0_CAP/PIR_ON pin of X1/X2 [9], the PIR sensor generates interrupts on the DIO8/TM0GT/S1_INT pin of X1/X2 upon object detection. The sensor needs stabilization time up to 4 seconds on average. During this time the interrupt generated are disabled. Hence the sensor is dysfunctional for 4seconds at the start. The security module consists of 3-axes accelerometer that is configured to accelerations. The sensor generates interrupts on movement or free fall. Even camera can be attached to the sensor module to capture the images of moving object.

4.2 Ambient lighting intelligence module implementation

The ambient lighting intelligence module is implemented by making use of Environment Sensor (ES) [9].

Figure 6: Environmental Sensor

The ES is attached inside the lab at a particular place where the amount of sunlight is better measured inside the lab. The ES consists of both thermometer and light sensor (Photo Sensor). Both sensors are accessed via the I2C serial interface, but can also generate interrupts. The Environmental Module is switched on by driving low the DIO11/TIM1GT/EM_ON pin of X1/X2 [9]. The light sensor provides two light values, one delivered by a sensor sensitive to all kinds of light and the other one from infrared light sensor. The difference between these values yields the luminance which is human visible only. Light sensor also provides threshold operation. Threshold operation is a proportional change to the pre-defined values. On exceeding the threshold, respective interrupts are generated by the sensor. The light sensor generates interrupts on DIO8/TM0GT/S1_INT pin of X1/X2 [9].

5. Experiment and Results

In the experiment, we measured the luminance value in real-time and the measured data was displayed on the interface (IShell) [9]. A special message is printed during the exceeding of threshold value of luminance. The message was an indicator to turn on the actuators. On receiving the interrupts, the actuators were actuated and respective action was performed. The snapshot of interface where the measured values are displayed is as shown in figure 7[10].

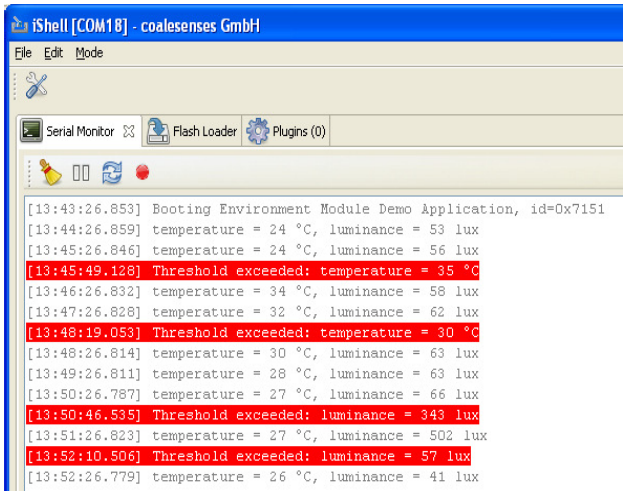

Figure 7: Temperature and Luminance values

The experiment was also conducted on PIR sensor to detect the human intervention in unauthorized way. The sensor detects the infrared rays generated and interrupts are raised. A special message "ACC" is printed if there is any unauthorized access, or else "PIR" message is printed on the interface (IShell). The actuators are actuated to perform respective actions such as raising an alarm or glow the danger light. The snapshot of the interface is as shown in figure 8[11].

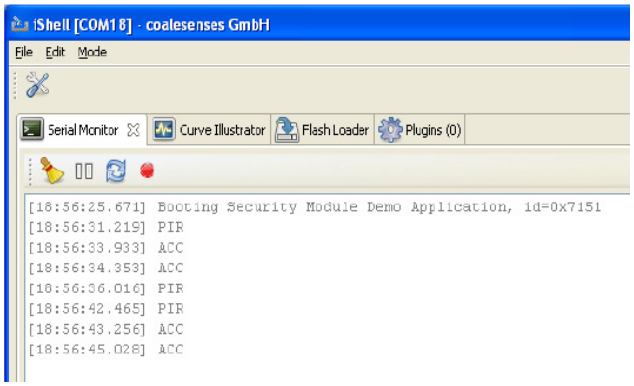

Figure 8: PIR sensor sensed values

The interface is designed to plot graph on the data received. These graphs are plotted in the form of curves. The curve illustrator tab of interface (IShell) exhibits the curves generated based on the data acquired. The snapshot of curve illustrator is as shown below. The curves are spread widely on detection of any human intervention (Figure 9)[11].

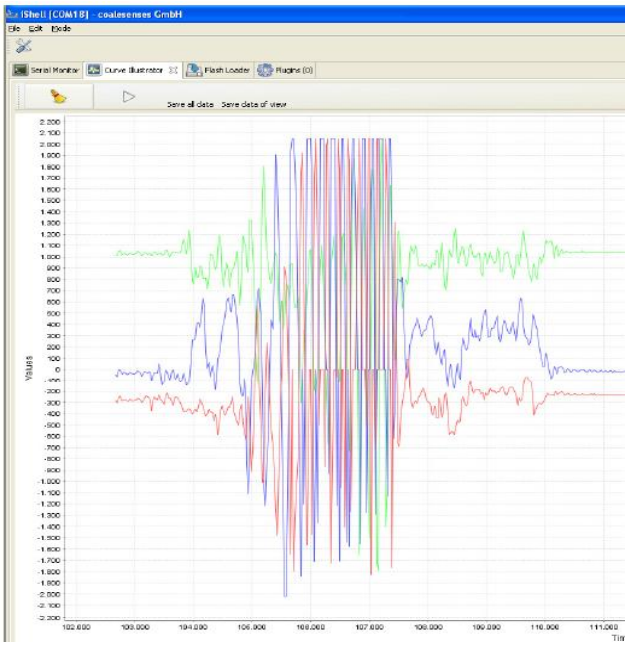

Figure 9: PIR sensor sensed data graph

6. Conclusion and Future Work

There has been much research made on WSN's. Recently, the WSN technology has been applied to home automation system to provide safety and secure ease of operation to human beings. This paper extends the home automation technology to the college laboratories, and hence to create a smart lab. This paper comprises the methods to implement the smart lab by the use of actual sensors. The experimental results give strong hope for enhancing the present methodologies. The smart lab idea can be extended to offices and other important areas. As a part of future works, we are doing research to count number of people entered into the lab in some particular interval of time.

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Author Profile

Mary Cherian has 29 years of experience in professional field spread over Education, Research and Industry. She holds B.E degree in electronics and communication from Kerala University, India (1983) and M.Tech.in computer science and engineering from Visvesvaraya technological university Belgaum, India (2005). She started her career in 1984 as research engineer in O/E/N India and has worked in the field of engineering and software in industries like Kerala state electronics Development Corporation, Keltron controls, Electronics Research and Development Centre, ABB and Chemtrols Software private limited in capacities of System Engineer, System Manager and Director. Later, she concentrated on education and contributed in academic field for the last 10 years in India and abroad educating pupil in the field of science and technology especially in Computer Science and Engineering. Currently she is working as Associate Professor in the department of Computer Science in Dr. Ambedkar Institute of Technology, Bangalore, India. She has publications in national and international conferences. Her areas of interests include Computer networks, Sensor Networks, Real time routing protocols, and Cognitive routing. Prof Cherian has life membership of professional bodies like CSI, ISTE, IE and IETE.

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