Designing Smart University using RFID and WSN

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ABSTRACT
Attendance is one of the important factors that determine the students rendering. There is a necessity to build a smart system that decrease load in managing the attendance and improves the performance of colleges, universities and any educational institute. The most common actions in educational organizations involve identification of student, maintenance of student attendance, security of attendance and electrical power conservation at the place where the attendance is taken. In this paper, the mentioned topics are considered and present how evolving technologies of radio frequency identification (RFID) and wireless sensor network (WSN) can be used for building a smart university. Prototype is developed considering main cases concerned in a smart university. The system is interesting of smart student attendance, smart automation of electrical items and taking attendance in authenticated manner. Results show that consumption of energy is decreased while authentication and truthfulness of attendance record are increased.

Keywords
RFID, Smart University, WSN, ZigBee, Arduino

1. INTRODUCTION
Designing smart home [1] [2] is an evolving issue that enclose ubiquitous/pervasive computing concept of Mark Weiser [3] that favors the seamless integration of technologies in human lives. The stimulus of this paper is to concentrate the advantages of using RFID and WSN technology in development of smart university. The developed prototype shows how evolving technologies of RFID and WSN can add in improving student's attendance method and power conservation .RFID technology provides the means of persons identification and forms the basis of:

- Student attendance record.
- Employee attendance record.
- Authentication of attendance.
- Automation of electrical appliances.

The rest of this paper is organized as follows: Section 2 provides the main technologies required for building, better understanding about the technologies used. Section 3 discusses about the concept of smart university. To support

The concept, cases of study for building smart university are also described. In Section 4 hardware prototype implementation of smart classroom is described. Section 5 is presenting the result and section 6 discusses conclusion and future work.

2. THE KEY TECHNOLOGIES OF THE SYSTEM

2.1 Identification Technologies
RFID, barcode and smart card are some of the technologies that are commonly used for identification. Following, Table 1 will present various features to provide the basis of selecting RFID for this research project [4].

Table 1: Comparison of identification technologies

	RFID	Barcode	Smart card
Line of Sight	Not required (in most cases)	Required	Required (exposed to reader)
Memory	Small ≥ 2 KB	No memory	Large
Cost	Medium	Low	High
Range	Inches to 100's of feet	Inches to feet	Inches
Reusability	Yes	No	Yes
Read Rate	Multiple (simultaneously)	One at a time	One at a time
Security	Medium	Very Low	High (Encryption)

2.1.1 RFID Technology
The method that uses radio waves to automatically identify objects within certain vicinity is called Radio frequency Identification. RFID includes tagging objects with a transmitter which will send information including, but not limited to the identification of the tag. There are three main categories of tags: Active, Semi-active and Passive [5]. RFID system is consisted of tags (transponders) and tags reader. The most commonly used RFID transponders are Active tags (that does contain an internal battery power source that powers the tags chip) and Passive tags (that do not have an internal power source, but are externally powered typical from the reader). The most important attributes of RFID systems is the

operating frequency and the resulting range of the system. The transmission frequencies are classified into the three main ranges, LF (low frequency, 30–300 kHz), HF (high frequency, 3–30MHz),UHF(ultra-high frequency,300MHz–3 GHz) and microwave (>3 GHz). In general, the LF RFID systems have short reading ranges and lower system costs. In case longer reading range is required, HF RFID systems can be used, however, their cost is higher [6].

2.2 Communication Technologies

Zigbee, Bluetooth, Wibree and WiFi are part of many different IEEE Wireless communication standards. These technologies have different features and properties on which they are accomplished. A concise comparison is given in Table 2 [7]. Zigbee is selected for this paper according to its low cost, long communication range and low power consumption

Table 2: Comparison of wireless communication technologies

	ZigBee	Bluetooth	Wibree	WiFi
Frequency	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz
Range	30m - 1.6km	30 - 300ft	Up to 10 ft	100 – 150 ft
Data Rate	250kbps	1 Mbps	1 Mbps	11 - 54 Mbps
Power Consumption	Low	Medium	Low	High
Cost	Low	Low	Low	High
Modulation Protocol	DSSS, CSMA/CA	FHSS	FHSS	DSSS/CCK ,OFDM

2.2.1 Zigbee Communication Standard

Zigbee is a wireless communication technology for Wireless Personal Area Network (WPAN). It is depended on IEEE 802.15.4 standard which was presented in May 2003. The ZigBee protocol enhances the IEEE 802.15.4 standard by adding network and security layers and an application framework. It operates on Industrial, Scientific and Medical (ISM) band such as 2.4 GHz. In the 2.4 GHz band there are 16 ZigBee channels, each channel requiring 5 MHz of bandwidth. It provides full wireless mesh networking able of supporting more than 64,000 nodes on a single network. There are three types of nodes in a ZigBee system .They are Coordinator (Forms the root of the network tree and might bridge to other networks), Router (operates as intermediate nodes, relaying data from other devices) and End devices (can be low-power /battery-powered devices. They can collect different information from sensors and switches). Depend on data processing capabilities, ZigBee physical devices consist of two types are: Full Function Devices (FFD) and Reduced Function Devices (RFD). Full Function Devices can perform all available operations within the standard, including routing mechanism, coordination tasks and sensing task. The FFD plays role of coordinator or router or end devices. The reduced function device (RFD) carries limited (as specified by the standard) functionality to lower cost and complexity. It's generally found in network-end devices. It's considered to connect the widest range of devices, in any industry, into a single control network. Its low cost and low power consumption property makes it applicable for many applications like industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation, home automation, etc... [8].

2.3 Processing Technologies

In physical computing, there are many types of microcontrollers and microcontroller platforms, all of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package.

2.3.1 Arduino Microcontroller

An Arduino is a uni-board microcontroller and software ready for programming it. It consists of a simple open hardware design for the controller with an Atmel AVR processor and on-board I/O support. Arduino software consists of a standard programming language and the boot loader that runs on the board [9].

The Arduino is considered as a Physical or Embedded Computing platform, in another word, it can interact with its environment through the use of hardware and software. Arduino can be used to develop interactive objects, taking inputs from different switches or sensors, and controlling a variety of lights, motors, and other physical outputs. The Arduino programming language is an application of Wiring, a similar physical computing platform, which is depend on the Processing multimedia programming environment [10].

3. TOWARD BUILDING SMART UNIVERSITY

This section explains the description of RFID-enabled space, i.e. "Smart University". To start with, several actors should be tagged:

• Every employee will be tagged using RFID tag.

• Every student will also be tagged having their unique tag.

Also, RFID reader units are placed at strategic places as follows:

• RFID reader unit will be placed beside the door of each room.

• Reader unit will also be placed at the University entrance and exit.

• University cafeteria and common rooms will be equipped with reader node.

• Labs and other facilities will also be having at-least one reader at the entrance of each room.

Cases of study

There are many cases for smart university to identify the benefits of RFID like identification, smart attendance, tracking, smart lecture room, class automation, smart lab, room security. Following, some of the important cases are conferred:

3.1 Employee and Student Identification

This is the most important task that the system would do in order to carry out the other use cases of the system. When a user enters a room, his unique ID is sent to the control circuit and the central attendance server. The person is identified and a log is made according to the time and location. If the person identified has a valid ID, the control circuit performs the room automation function as described in its profile.

3.2 Smart Attendance Record

Logging attendance for employees and students is always a oppressive job. Their check-in and check-out time, duration of their presence, if managed manually is a huge task. Also, if done using traditional methods like bare code, smart card and short range RFID lead to waste of time and persons queue. The proposed system would simplify this problem in the following case. When an employee enters the university, the reader node detects its tag, so that it's check-in time is marked and log is maintained at the central database server. This operation repeated when he sits in an office, a class room, etc. An employee has the liberty of wandering in the university premises. Many hours duration of presence should be required in a day to confirm his or her attendance at the end of the day.

3.3 Room Automation

This is a very useful feature resulting in ubiquitous use of electrical equipments and also helps in power conservation. Against each authenticated user of a room, a profile is saved in the control circuit (Figure 5) that can handle four electrical equipments involving lights, data show, fans and air conditioners. When an authenticated person enters the room, his ID is matched against its profile and the preset electrical appliances turn on and vice-versa happens when the person leaves the room. To track the entry and exit in a room, each entry of a person in room is marked and its exit is properly managed in depending on tags and motion sensors to control the automation of electrical equipments. This feature automatically enables power conservation which is a big advantage as described later in the paper.

4. IMPLEMENTATION OF THE PROPOSED SYSTEM

System is providing multi node environment (ZigBee module can reach to more than 64,000 nodes) and it is capable of dealing with an unlimited number of rooms by increasing the number of reading nodes. Every room can store up to 45,000 card IDs. It is easily scalable by extending the tag ID single byte to multiple bytes similarly by increasing memory size of Arduino board, so that each room can handle up to 65000 card IDs .The network block diagram as shown in Figure 1.

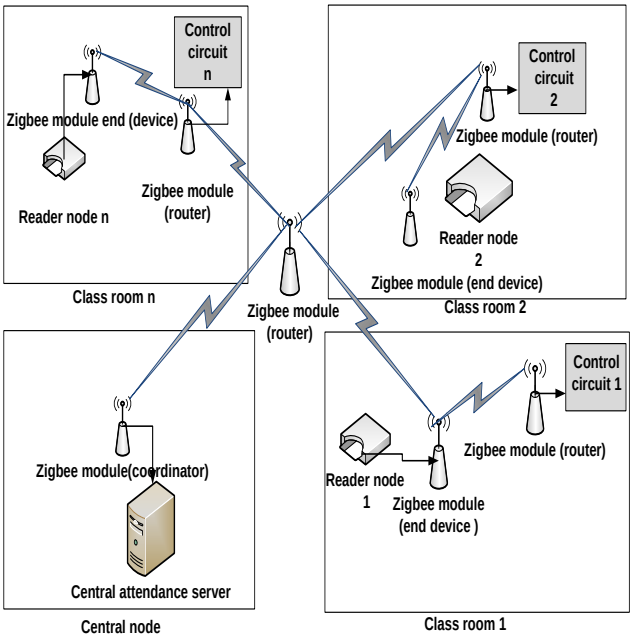

Fig. 1: Network block diagram

Generally, System is working as follows:

First Reader detects RFID card and forward that ID to Arduino microcontroller. Microcontroller authenticates the ID and generates a specific number (1byte code) against that ID. This specific number is then forwarded to the Zigbee transceiver (via serial link) from where it is sent to the receiving nodes. One of the receiving nodes is the central attendance server where attendance record is managed. At the same time control circuit node receives the broadcast and automates the office equipments based on the number of users that enter.

4.1 Hardware working methodology

The design cycle consists of following stages as shown in Figure 2.

4.1.1 RFID Reader Node

Reader node consisting of long range RFID reader and Zigbee node (series 2 pro) configured as end device connected to Arduino mega microcontroller board. Once the person carrying the tag is in the vicinity of the reader, Tag is detected. Arduino then verifies valid tag number by comparing it with predefined tag numbers already saved in the microcontroller ROM. In case tag is valid, it is stored on the microcontroller's RAM for further processing (10 bytes tag mapped to 1 byte) and byte are then broadcasted to central and control circuit nodes. The block diagram and flowchart of reader node as shown in Figure 3 (designed by fritzing [11]) and 4 respectively.

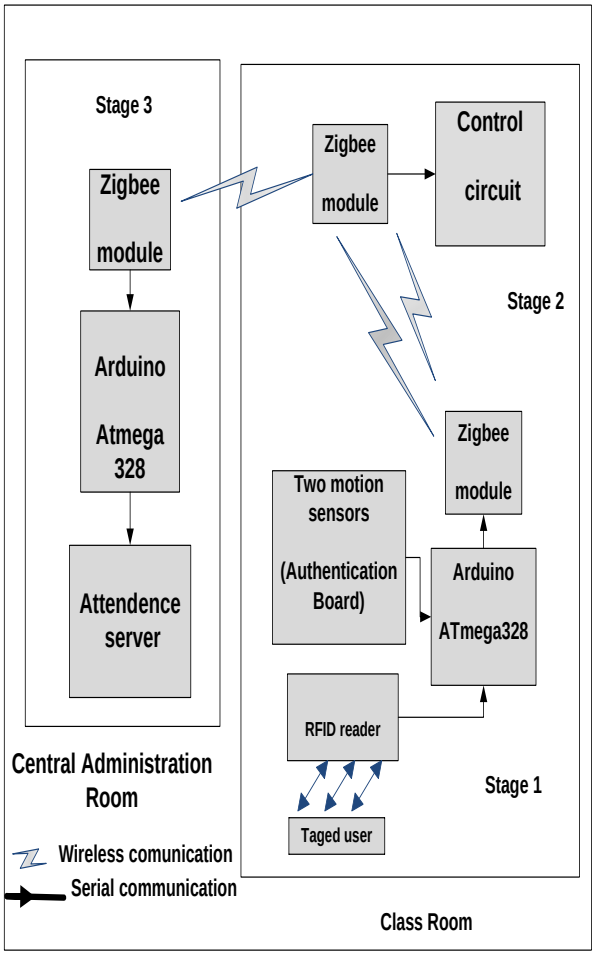

Fig .2: System block diagram

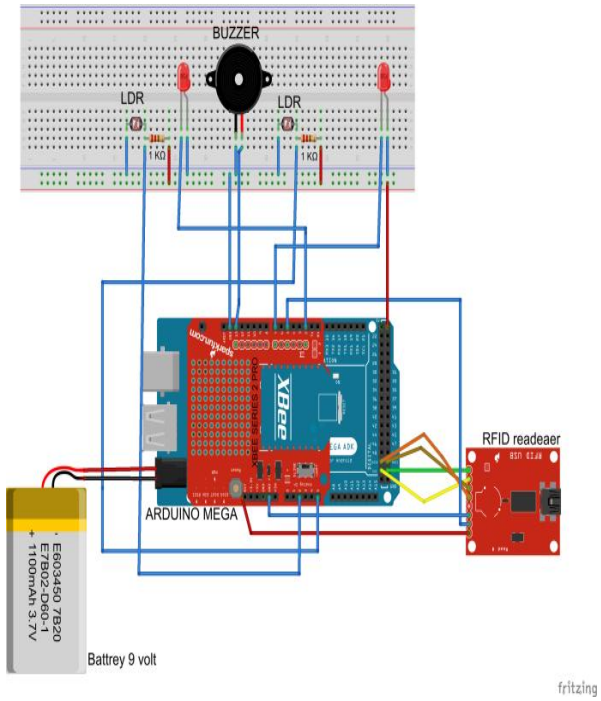

Fig. 3: Block diagram of reader node

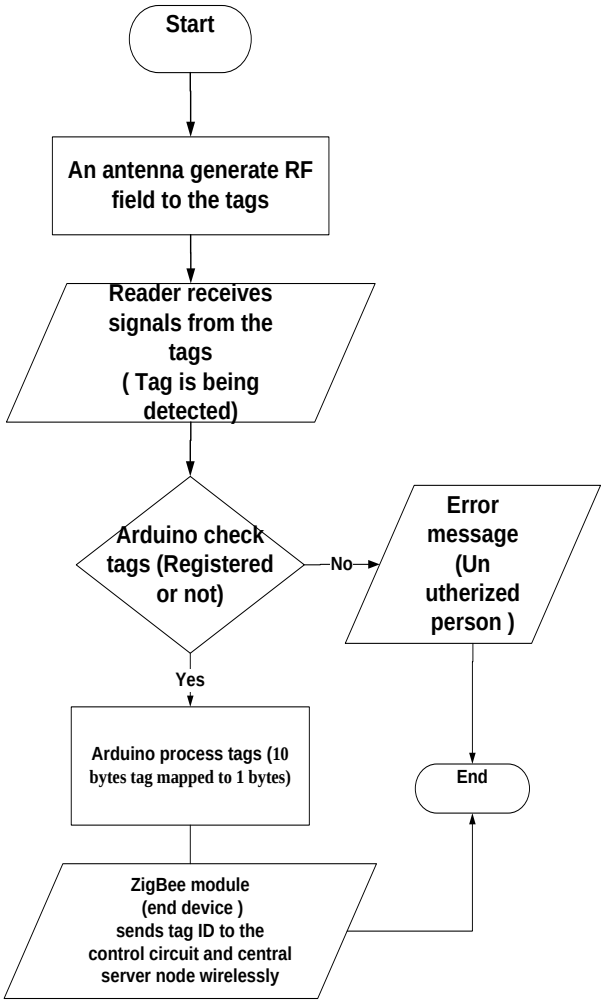

Fig .4: Flow chart of reader node

4.1.2 Authentication circuit

In order to avoid student's deception, authentication circuit should be placed beside reader node at the entrance of each class room. It consists of two motion sensors one for entrance and other for exit. When the student enters the class, he cuts entrance sensor first then exit sensor and vice versa at departure. The system compares the number of students with the number of tags in each class. When it detects number of tags more than number of students turns buzzer on. Other benefits of this circuit, it is used with the reader node to automate control circuit wirelessly. The flowchart of authentication circuit as shown in Figure 5.

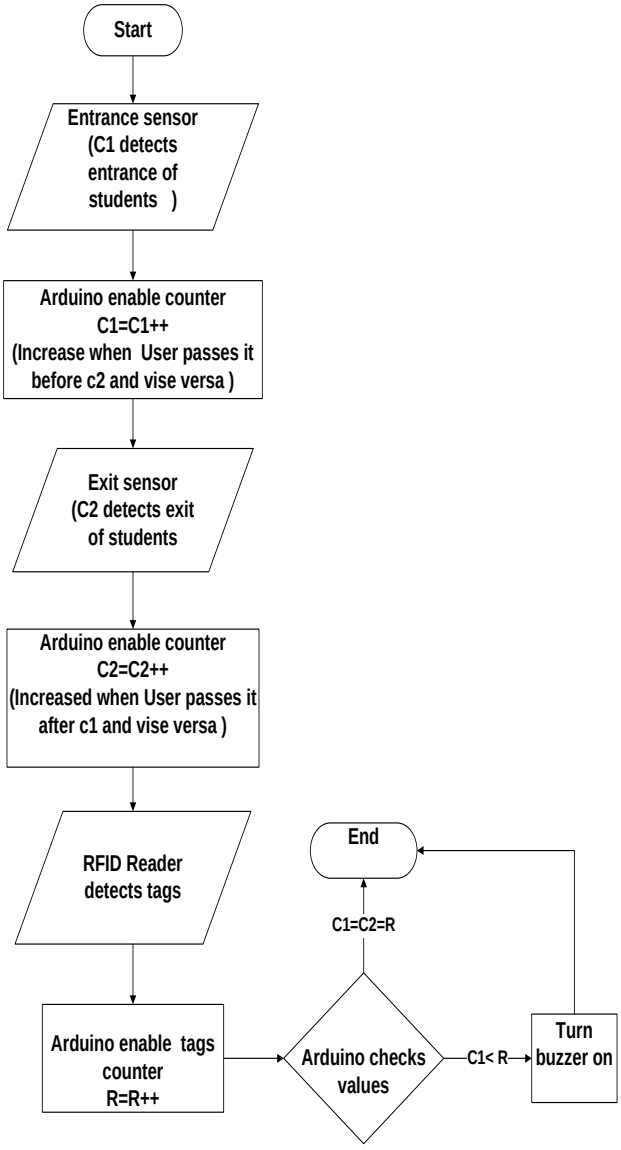

Fig. 5: Flow chart of authentication circuit

4.1.3 Control circuit

In parallel with the central attendance server, mapped tag is also received by the control circuit node. Control circuit consists of 4 channel smart relay, receiving Zigbee node set as router and both of them connected to Arduino board. Control circuit automates office/classroom equipments (data show, lights, fan, air conditioner etc.) according to the amount of current tags and predefined profile of each tag holder. Block

diagram and flowchart of control circuit as shown in Figures 6 and 7.

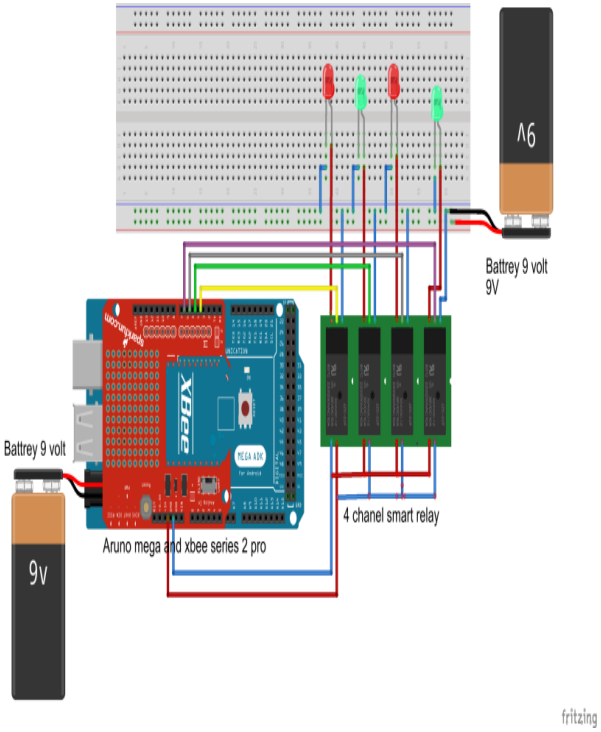

Fig. 6: Control circuit block diagram.

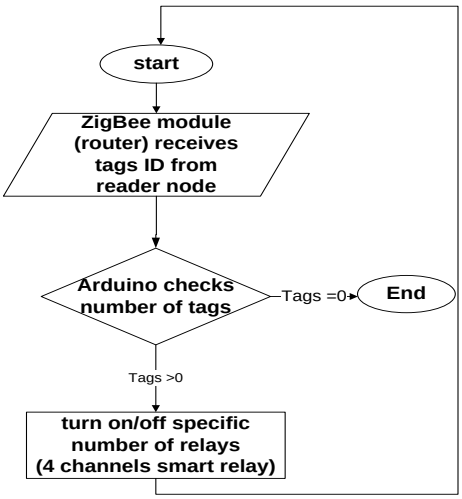

Fig. 7: Flow chart of control circuit

4.1.4 Central node

It consists of Zigbee receiving node (series 2 Pro) set as coordinator connected to Arduino microcontroller board. This node must be one at each network so that it must connect to the central attendance server. The function of this node is receiving tags ID, other information and forwards it to the central server where the attendance is managed. The flowchart of central node as shown in Figure 8.

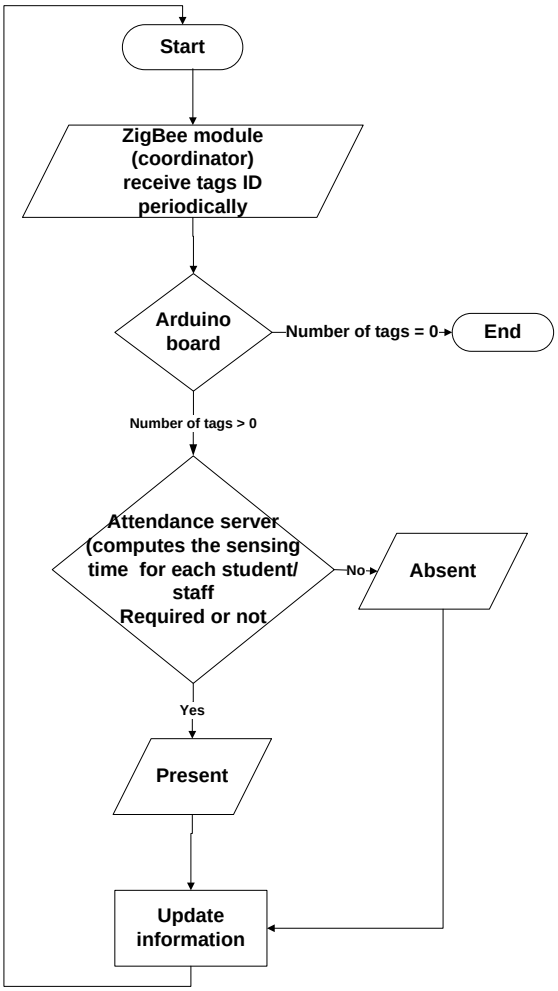

Fig. 8: Flow chart of central node

4.1.5 Transmission

The Transmission of information between nodes is wireless (using Zigbee protocol). For serial communication UART standard is used.

4.2 Software system

The monitoring software involves of a central database server and a front end application known as "Smart University Attendance System (SUAS)".This system is built using visual studio 2010 professional.

SUAS maintains the attendance in database keeps profiles against unique IDs and provides facility to add/edit tags in case of need. System add features for searching profiles, viewing the attendance record according to calendar, building graph and check-in / check-out time for each card holder. This application has also many checks and balances which makes it more secure. For example, it prevents a card holder to check in at two places simultaneously, detects deception when someone carries more than one tag and it marks attendance if and only if a card holder spends a minimum time required for attendance that will be provided by the university administration. The GUI of the smart attendance monitoring system as shown in Figure 9.

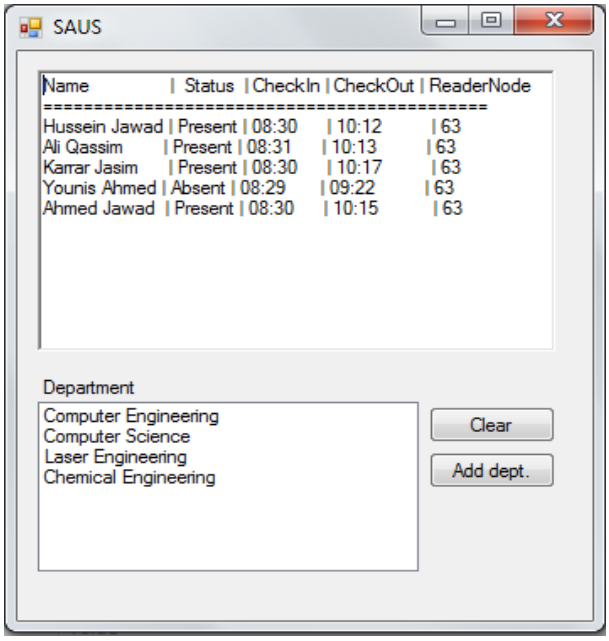

Fig. 9: GUI of smart attendance monitoring system

5. HARDWARE IMPLEMENTATION RESULTS

The main task of the applied system is the person identification at any instant and location. This system provided with the actuation mechanism gives benefits of power conservation and smart record keeping. In addition to that, one of the important features provided by the system is an authentication approach of attendance. However, the prototype system had been placed to a variety of rooms at the university to measure the duration for which a room has been occupied and number of times entry/exits are made into the room. The electrical power consumption had been estimated in a room when it is occupied and observe the utilization and loss of power pattern. Smart University Attendance system (depicted in Table 3and Figure 10) recommends the need to use the identification based smart automation of equipment usage to cut down the power wastage, as it reach to an average of 25 to75% depending on the current number of students/employees are existent. The security of the attendance has been increased as an authorized person may not enter the room with more than his own tag and avoids taking attendance for others. A case of taking attendance was done with the old manual and traditional methods and using new proposed system; the results show decreasing the cost and time spent of taking attendance with the lowest possible number of wireless transmission nodes. Different components of the system are designed in such a way that is easily scalable with minimum cost and efforts.

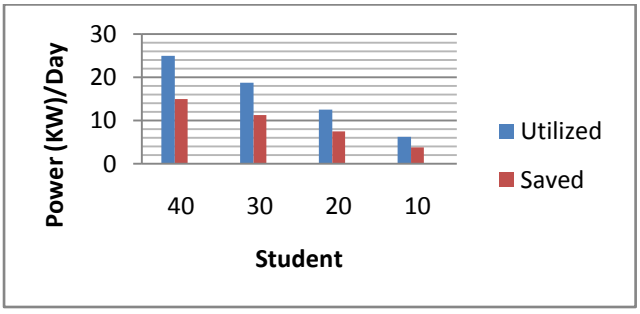

Fig.10: Class room power utilization

Table 3.Power consumption and utilization

Number of students	An average equipment Load (K w)	Duration Occupied (hrs)	Duration Not Occupied (hrs)	Power Utilized/ Day (K w)	Power Saved /Day (K w)
40	5	5	3	25	15
30	3.75	5	3	18.75	11.25
20	2.5	5	3	12.5	7.5
10	1.25	5	3	6.25	3.75

6. CONCLUSIONS AND FUTURE WORK

A smart university prototype developed using long range RFID technology, ZigBee communication standard protocol, motion sensors and Arduino microcontroller .These technologies integrated to gather to improve creditability, authenticity of attendance and electrical power conservation in a smart manner. The beauty of the system is providing these features inexpensively. The using of Arduino board opens the way to integrate the system with wireless ZigBee camera to enforce the authentication approach. In addition to that, electrical power sensor (current/voltage) should be applied over the control circuit to send the sensing values to the central server wirelessly, in order to observe the power consumption over the campus and how can it be automated smartly.

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