International Journal of Reconfigurable and Embedded Systems (IJRES)
Vol. 11, No. 1, March 2022, pp. 34~48
ISSN: 2089-4864, DOI: 10.11591/ijres.v11.i1.pp34-48

Design and implementation of an automated office environment system using embedded sensors

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Article Info

Article history:

Received Nov 11, 2021
Revised Jan 10, 2022
Accepted Feb 2, 2022

Keywords:

Application programming interface
Exypnos office system
Local area network
Radio frequency identification
Short message service

ABSTRACT

Office automation is the process using machines with the help of embedded computing perform the office activities and its tools and applications. The office automated using computer-aided processing stored, visual and audio data to simplify, improve, and automate the power saving and time management of the organization. A very important component of office automation concerns the automation of employee centred activities such as authentication, automatic alerting of appointments and automatic powering on/off personal computer. The employee image is captured using Java media framework, attendance records for all employees is gathered and processed automatically, and they can be accessed from the database on a monthly or weekly basis. The various software and hardware components of the system were developed and integrated to form the Exypnos Office System and validated on real life scenarios. Java proved to be a versatile platform for implementing a project of this nature with diverse requirements. Web camera interfacing and image capturing are implemented in the Java environment with the help of Java media framework (JMF). Java short message service (SMS) application programming interface (API) and Bluetooth technology is used for sending schedules through SMS. Radio frequency identification (RFID) systems use many different frequencies, but the most common and widely used and supported by our reader is 125 kHz. Office automation systems have more benefits to an organization. The project is implemented on MS Windows platform and in future can be implemented in Linux platform.

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1. INTRODUCTION

Office Automation is the use of computer systems to execute a variety of operations such as word processing, accounting, and electronic mail. Office automation usually implies a network of computers with a variety of available programs. Broadly, office automation is a general term, which includes a wide range of applications of computer, communication, and information technologies in the office environment. Office automation products are used in the office to make all official work happen at a faster speed without any problem. These products include computer, calculator, printer, copier machine, fax machine (facsimile), laminating machine, note binding machine, typewriter, voice messaging, telemarketing, teleconferencing, and e-commerce.

The term office automation refers to all tools and methods that are applied to office activities which make it possible to process written, visual, and sound data in a computer-aided manner. Office automation is intended to provide elements which make it possible to simplify, improve, and automate the organization. The different types of functions integrated by office automation systems include: i) Electronic publishing; ii) Electronic communication; iii) Electronic collaboration; iv) Image processing; and v) Office management. At the heart of these systems, is often a local area network (LAN). The LAN allows users to transmit data, voice, mail, and images across the network to any destination, whether that destination is in the local office on the LAN, or in another country or continent, through a connecting network. An office automation system (OAS) makes office work more efficient and increases productivity.

Several research are being carried out in the domain of office automation. A survey of office automation was carried for the office management automation. Radio frequency (RF) based attendance was begun to develop to track the timing of the swapping by the employee which was low cost and effective with the help of microcontrollers such as AT89C52 [1]–[3]. As research progress mobile generation improved and hence with application over mobile the office automations able to moinitor using the mobile such as scheduling a meeting and tracking the people attending the meeting [4]. Such automation using mobile technologies and using other board made of low-cost microcontroller for home and office management played a major role with GPRS and internet [5]. The automations need a proper security to control the data for the proper maintenance of the system [6].Todays the prime concers is to energy management of the office environment where the employe working on computing systems, lightning of the day time to support the necessary and maintained illuminance. To control the energy and manage it need microcontrollers and electrical components and electrical appliances which need a control algorithm [7]–[11]. The electrical appliances such as air-conditioner, fans, and other ventillation systems to be monitored for the proper functioning and its usage [11]–[16]. The design demand to involve and design system more of event driven user centric middleware and give solution mre distributions approach for system design to confilict in the events that occurring in the office management automation [10]–[18]. Such automation leads to smart systems due to software. With the help of the software the working environment providing attendees with high information acquisition and exchange of space and providing a better efficiency of office organisation [19]–[21]. Office automation provides outcomes better human interactions and mobility patterns in indoor spaces office environments [22], [23]. The software applications are developed using Java to make interactive office automation system [24].

2. OFFICE MANAGEMENT AND THEIR TECHNOLOGIES

Figure 1 represents the system architecture of an automated office environment system using infrared (IR) and RF Sensors that has been implemented for this project. The system mainly constitutes of a Server, a LAN, a radio frequency identification (RFID) reader and a Mobile.

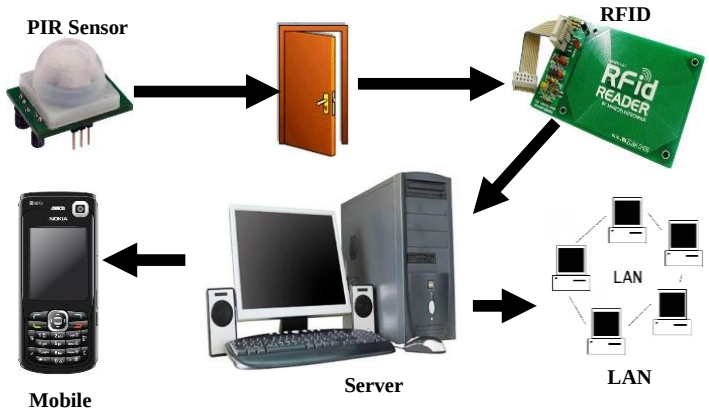

Figure 1. System architecture of Exypnos office system

As shown in Figure 2, Office management systems include electronic office accessories, electronic scheduling, and task management. These systems provide an electronic means of organizing people, projects, and data. Business dates, appointments, notes, and client contact information can be created, edited, stored, and retrieved. Additionally, automatic reminders about crucial dates and appointments can be programmed.

Projects and tasks can be allocated, subdivided, and planned. All these actions can either be done individually or for an entire group. Computerized systems that automate these office functions can dramatically increase productivity and improve communication within an organization.

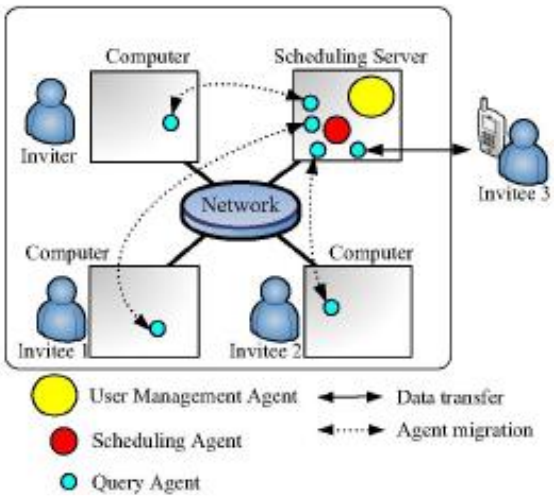

Figure 2. Overview of the meeting scheduling system

3. DESIGN AND IMPLEMENTATION

The Figures 3, 4, and 5 show the block diagram of Exypnos office system that has been designed and implemented.

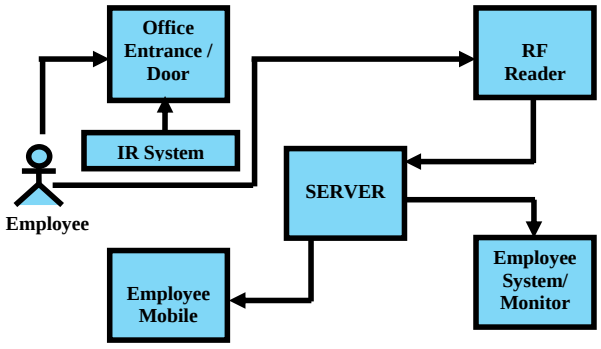

Figure 3. Block diagram of Exypnos office system

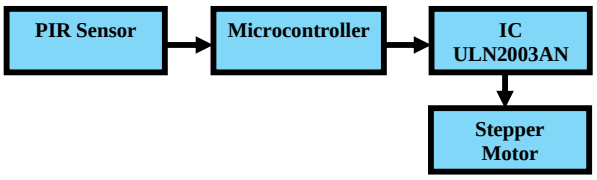

Figure 4. Block diagram of door entrance system

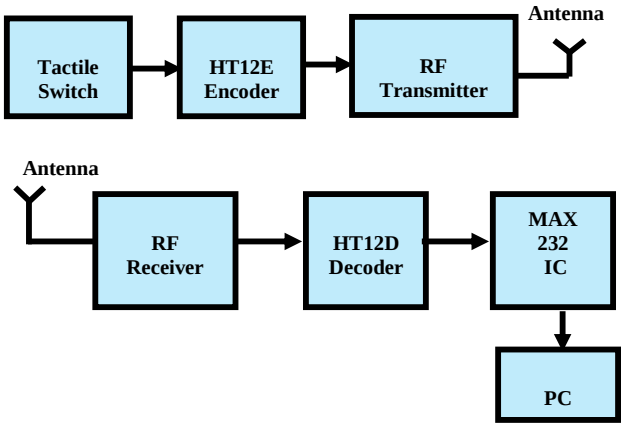

Figure 5. Block diagram of employee system/monitor

3.1. Office automation systems

Office automation refers to the varied computer machinery and software used to digitally create, collect, store, manipulate, and relay office information needed for accomplishing basic tasks and goals. Raw data storage, electronic transfer, and the management of electronic business information comprise the basic activities of an office automation system. In its basic form, information exists as letters, memos, graphs, records, messages, and so on. When that information is electronically transferred, raw data is exchanged between two or more office employees, either at the same or different locations. Generally, there are three basic activities of an office automation system which are listed:

- Data storage and manipulation
- Data exchange
- Data management

3.2. Data storage and manipulation

Data storage usually includes office records and other primary office forms and documents. Data applications include the capture and editing of a file, image, or spreadsheet. Word processing and desktop presentation packages accommodate raw textual and graphical data, while spreadsheet applications enable the easy manipulation and output of numbers. Image applications allow the capture and editing of visual images. Text-handling software and systems cover the whole field of word processing and desktop publishing. Word processing is the input (usually via keyboard) and manipulation of text on a computer. Word processing is frequently the most basic and common office automation activity.

3.3. Data exchange

The exchange of stored and manipulated information is an equally important component of an office automation system. Electronic transfer is a general application area that highlights the exchange of information between more than one user or participant. Electronic mail, voice mail, and facsimile are examples of electronic transfer applications. Systems that allow instantaneous or "real time" transfer of information (i.e., online conversations via computer or audio exchange with video capture) are considered electronic sharing systems. Electronic sharing software illustrates the collaborative nature of many office automation systems. The distinction between electronic transfer and electronic sharing is subtle but recognizable. Protocols to deal with mobility may be unnecessary and overweight.

3.4. Data management

The last major component of an office automation system, which can be seen in Figure 6, offers planning and strategic advantages by simplifying the management of stored information. Task management, tickler systems or reminder systems, and scheduling programs monitor and control various projects and activities within the office. Electronic management systems monitor and control office activities and tasks through timelines, resource equations, and electronic scheduling. As in data exchange, groupware is gaining in popularity for data management. Each member of the work group or larger group may share access to necessary information via the automated office system and groupware.

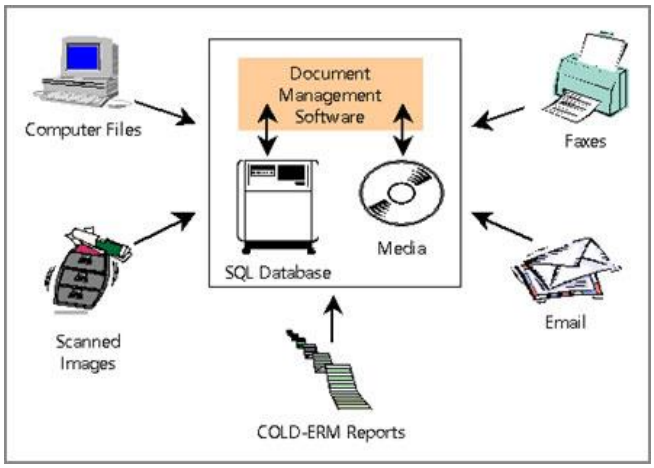

Figure 6. Typical data management system

3.5. Choosing office automation software

Office automation software was designed to take even the most disorganized office and help it to run smoothly. Even offices that seem to run smoothly can reap organizational rewards from utilizing a software package to manage their day-to-day concerns. As more and more types of business are turning to computer automation, many specialized options have emerged onto the market.

A software package should make running our office less of a chore, not more. The net goal of automating an office is to be able to spend less time doing paperwork and administrative tasks, and more time doing business. A proper office management software should make mundane tasks such as invoicing clients and scheduling appointments a breeze. If our office management software makes it more of a hassle for office staff to do their jobs, then they are not going to be very likely to utilize it.

3.6. Exypnos office system

Figure 3 shows the functional block diagram of Exypnos office system, in which the main block of the system is the server that maintains all the information related to the employee. The information which will be stored in the server will be utilized by all other resources such as the RF reader which is used to read the RFID tag information of the employee and that information is stored in the server. The information related to the employee system such as internet protocol (IP) address and media access control (MAC) address is also maintained in the server and the employee mobile number is also stored in the server. The other sections in the block diagram such as the IR system and employee system, will be explained in the coming sections along with the working principle of the block diagram.

Figure 4 shows the block diagram of the door entrance system which is the first block of the Exypnos office system in which a passive infrared (PIR) sensor, microcontroller, and stepper motor are used. The PIR sensor is a pyroelectric device that detects motion by measuring changes in the infrared levels emitted by surrounding objects. This motion can be detected by checking for a high signal on a single I/O pin. The PIR sensor requires a ‘warm-up’ time to function properly. This is due to the settling time involved in ‘learning’ its environment. This could be anywhere from 10-60 seconds. During this time there should be as little motion as possible in the sensors field of view. The PIR sensor has a range of approximately 20 feet. This can vary with environmental conditions. The sensor is designed to adjust to slowly changing conditions that would happen normally as the day progresses and as the environmental conditions change. It responds by toggling its output when sudden changes occur, such as when there is motion. The output of PIR sensor is given as input to the microcontroller i.e., PIC16f873A. Figure 4 shows the pin diagram of PIC16f873A which is a 28 pin IC and the features of this 16f series of PIC microcontrollers are, it has a high-performance reduced instruction set computer (RISC) central processing unit (CPU) and only 35 single word instructions to learn whereas compared to other series of programmable interface controllers (PIC) microcontrollers such as 18f series which has 75 instructions.

Figure 5 shows the block diagram of the employee system in which the main components are the encoders, decoders, RF transmitter, receiver, and a tactile switch, which will work as the input to the system. The decoders and encoders used in the implementation were HT12 encoder and HT12 decoder. The name is denoted as HT12 because they can encode and decode 12 N bit data at one time. But in the project, only 1 bit is used. The other blocks of the system are the RF transmitter and receiver, which operate at 433 MHz. The

other block is the tactile switch, used to trigger the encoder. The output of the decoder will be connected to the employee PC via MAX232 IC. The solution procedure consists of the design and implementation of hardware and software. In the paper, the project had utilized Java for application development and C for embedded software and embedded application development.

3.7. Software implementation

Analysing the user requirements, software development and implementation of an automated office environment system had been performed. Java was the main software language used for the completion of the project. Java is an object-oriented programming language developed by Sun Microsystems; a company best known for its high-end UNIX workstations. Modelled after C++, the Java language was designed to be small, simple, and portable across platforms and operating systems, both at the source and at the binary level. It provides a set of services and different application programming interfaces (APIs).

- Java's higher level of abstraction allows for increased programmer productivity (although recognizing that the tradeoff is runtime efficiency)
- Java is relatively easier to master than C++
- Java is relatively secure, keeping software components (including the JVM itself) protected from one another
- Java supports dynamic loading of new classes
- Java is highly dynamic, supporting object and thread creation at runtime
- Java is designed to support component integration and reuse
- The Java technologies have been developed with careful consideration, depending on the conservative side using concepts and techniques that have been scrutinized by the community
- The Java programming language and Java platforms support application portability
- The Java technologies support distributed applications
- Java provides well-defined execution semantics

3.7.1. Exypnos welcome screen

Figure 7 shows the welcome screen of the project, which is developed using Java development kit, the initial step of the project. The main graphical user interface (GUI) will be developed using software named Netbeans and after the GUI is developed. The Exypnos loader class will load the Exypnos welcome screen class. Before loading, the loader will check for the image in the current directory and if the image is present in the directory, then the loader will load the image along with settings such as height and width of the GUI and it will set the screen size.

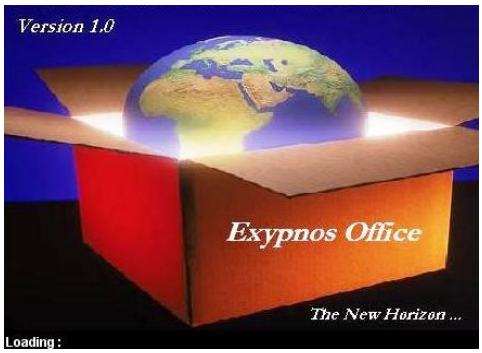

Figure 7. Welcome screen of Exypnos office system

3.7.2. Data handling of Exypnos office system

Figure 8 shows the data handling of Exypnos office system, which is the most important section of the system. This is used to enter the employee details by the administrator in the blank fields as shown in Figure 8. After the Exypnos office is loaded into the system tray, the Exypnos loader class will load the data handling section to enter the employee details, such as employee RFID that will be entered through serial com ports. The employee's first name and last name will be entered, and this is used to greet the user as soon as he logs in or logs out using the Java speech API. The employee mobile number will be entered to send a short message service (SMS) of the schedules to the employee mobile number. The SMS will be sent using Java SMS application programming interface (API). The system IP and MAC addresses are entered to

automatically boot up and shutdown the system. The employee image will be captured using a simple webcam, which will be associated by Java media framework. After the administrator has entered all the data, the information can be saved, updated, or deleted. The employee information will be stored in the Microsoft Access database, which is created with Java data base creation (JDBC). The administrator must ensure that no fields in the data handler should be left blank and in case if it is left blank. There will be an error message stating that the fields cannot be left blank. If the mobile number entered is less than 10 numbers, then one more error message will be displayed as mobile number should not less than 10 numbers.

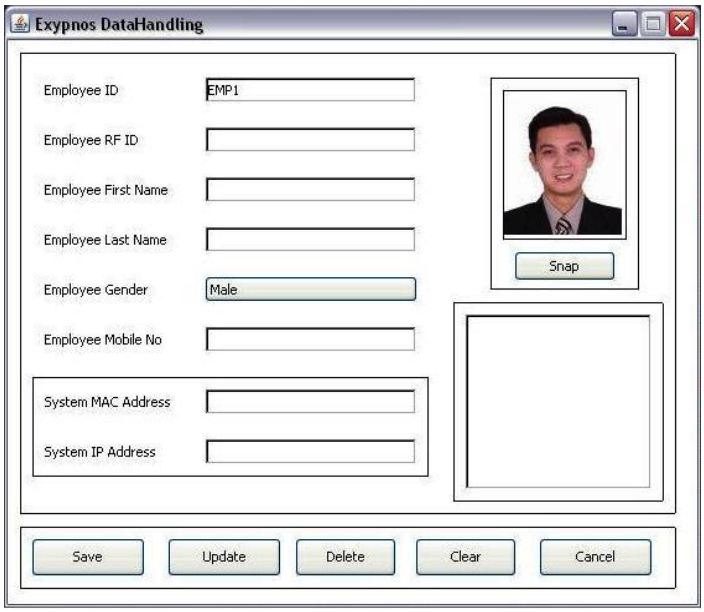

Figure 8. Data handling of Exypnos office system

3.7.3. Setting of com ports

Figure 9 shows the setting of the com ports for the RF reader and for mobile communication, after registering the com ports the com port settings must be made to receive the data from the RF reader and send the data to the employee mobile. This is important because, if the com ports which are registered earlier as can be used by other applications. The com port registered for mobile communication is COM2 and the mobile communication is done through COM5, then there will be no information transferred thorough that com port. After the registering of the ports is established, the Exypnos office GUI will be loaded into the system tray. After the GUI is loaded in the system tray, the Exypnos loader class will load the Exypnos settings class for the setting of suitable com ports, the Exypnos office system will have to be restarted once the settings have been modified.

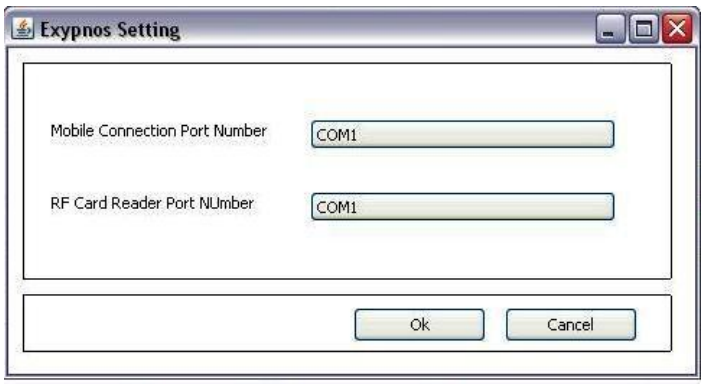

Figure 9. Setting of com ports

3.7.4. Overall viewer of Exypnos office system

Figure 10 shows the overall viewer of Exypnos office system. After the GUI is loaded into the system tray, the Exypnos loader class will load the Exypnos viewer class. This will be used to view the overall information of the employee, such as name, ID number, RFID number, IP, and MAC address of the system. Along with this information, the employee login, logout time, employee schedules and the status of the employee i.e., if the employee has logged in, then it will be shown as active. If the employee has logged out, then it will be shown as inactive. The main advantage of this viewer is that all the employee related information can be viewed in one GUI including the employee image.

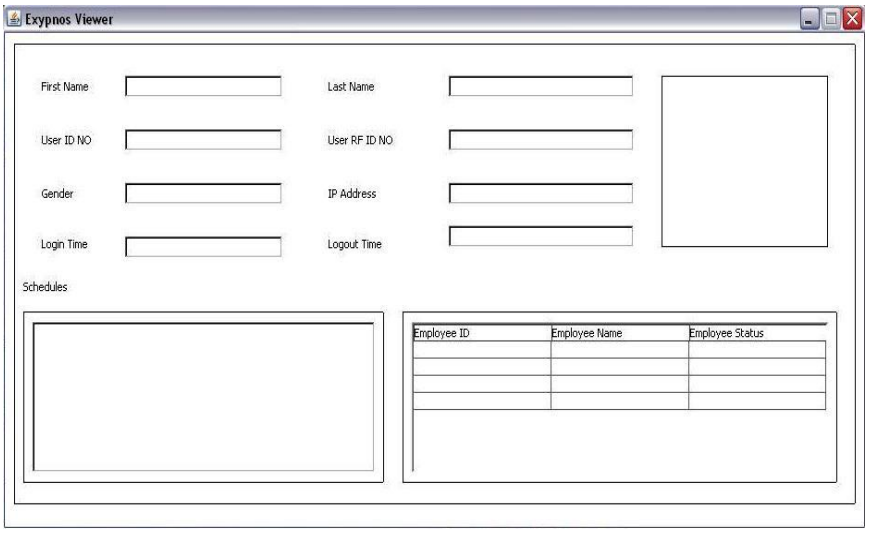

Figure 10. Overall viewer of Exypnos office system

3.8. Hardware implementation

In this section, the hardware implementation of Exypnos office system is discussed. Along with the hardware, software's MPLAB has been used to program the PIC microcontroller and Java has been used.

3.8.1. Hardware setup for door entrance system

Figure 11 shows the prototype of the hardware connections for the door entrance system, also called as IR system in this project. The main components of this system are PIR sensor, 16f873A PIC microcontroller, IC ULN2003AN, and stepper motor. The PIR sensor is a pyroelectric device that detects motion by measuring changes in the infrared levels emitted by surrounding objects. The PIR Sensor is a 3-pin header in which, the minus (-) pin is connected to ground or Vss, the plus (+) pin is connected to +5 volts or Vdd and the out pin connects to the input pin of the PIC Microcontroller (16f873A) i.e., to A0.

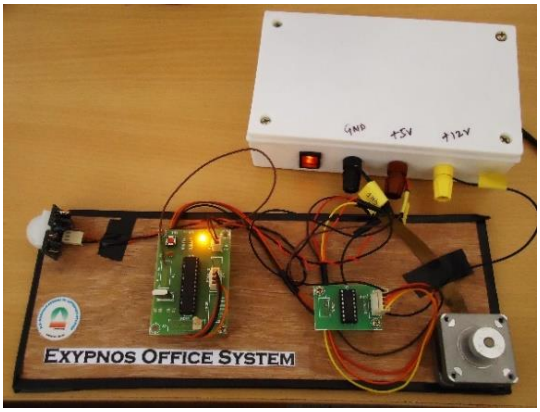

Figure 11. Hardware setup for door entrance system

The output pins of 16f873A i.e., B0 to B3 are connected to the input pins of ICULN2003AN and the IC's output pins are connected to the stepper motor. The PIC 16f873A is also connected to a switch, which is used for master clearing and resetting the microcontroller.

3.8.2. Hardware setup for employee monitor (transmitter)

Figure 12 shows the hardware setup for the employee monitor, which is the transmitter section. The main components of this setup are tactile switch, HT12encoder, and RF transmitter. In this setup, the tactile switch is used to trigger the input for the encoder which is connected to the input pin of the encoder i.e., A0. The input is received by the encoder and is given to the output pin i.e., D0. The output of this encoder is given to the input pin of the RF transmitter. The RF transmitter is a 4-pin compact size module which can be used directly in a PCB. This transmitter can also be interfaced directly to encoders and microcontrollers with ease. The RF transmitter transmits the data with an operating frequency of 433 MHz. The input for this transmitter is pin 2 and the data out pin is pin 1. The other two pins are Vcc and Gnd respectively.

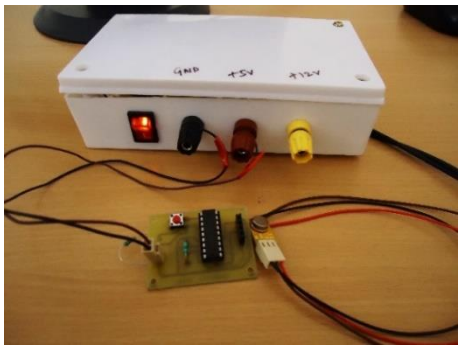

Figure 12. Hardware setup for employee monitor (transmitter)

3.8.3. Hardware setup for employee monitor (receiver)

Figure 13 shows the hardware setup for the employee monitor, which is the receiver section. The main components of this receiver section are the RF receiver, HT12 decoder, PIC microcontroller, and IC RS232. The RF transmitter transmits the signal bit and then in the receiver part. The RF receiver receives the signal, which also operates at the same frequency i.e., 433 MHz. This RF receiver does not include the decoder IC.

Figure 13. Hardware setup for employee monitor (receiver)

Therefore, HT12 Decoder is used, and this receiver is sensitive to RF noise in the pass band because the desired transmitter signals are at very low power levels. Therefore, the microcontroller, which has the lowest rise time and lowest fall time, must be chosen and thus microcontroller PIC16f873A has been preferred for this project. After the signal is received, it is given to the input pin of the decoder i.e., pin 14 to decode the signal bit received. The output of the decoder is given to the input of the microcontroller through pin 17 of the decoder. After receiving the input signal, the output of the microcontroller is given to IC RS232, which in turn is connected to the employee system via RS232 cable for transmission of signal.

3.8.4. Hardware setup for image capturing and sending SMS

Figure 14 shows the hardware setup for image capturing and sending SMS, which will be used to capture the employee image and sending SMS to the employe mobile. The employee image will be captured using a simple webcam and the drivers must be configured for this camera in order to capture the image. After the camera has been detected, it must be registered to the Java media framework (JMF), only then the camera starts capturing the image when the Exypnos office system project is executed. The Bluetooth dongle is used to send the SMS to the employee mobile. The software for Bluetooth dongle will be installed into the system named widicom and after the software has been installed, an icon will be shown in the system tray. The implementation of sending SMS will be done by searching the Bluetooth enabled mobile and pairing that mobile with the dongle. After pairing the mobile, the mobile services will be verified and the mobile offers different types of services namely dial up networking and image transferring. The dial up networking service will be used to send the SMS to the employee mobile.

Figure 14. Hardware setup for image capturing and sending SMS

3.8.5. Hardware setup for RFID reader module

As shown in Figure 15, the RFID reader module consists of an antenna and reader:

- Antenna: seen as black colored box, this helps in collecting the message transmitted by the RFID tag.
- RFID reader: is used to generate radio waves to activate the passive RFID tags which in turn sends unique EPC by backscattering the carrier waves of the reader. When a valid transponder tag is placed in the range of an RFID reader a unique code is transmitted serially at, the given baud rate to the RFID decoder. It also has a LED indication for indicating when the reader is active.
- RFID tag: Passive tags are used here, since the range to be determined is not long and in addition, it is cheaper in cost. Low frequency RFID tags of carrier range 125KHz are fabricated from copper or aluminum.
- Between RFID tag and RFID reader: A 10-byte code is transmitted on a carrier of 125 kHz. Data is transmitted in an asynchronous manner.
- Communication protocol: Anti collision algorithm is used for multi card reading. Each tag has been coded in a standard format and carries tag ID in a coded format and has a reading range up to 10 cm.

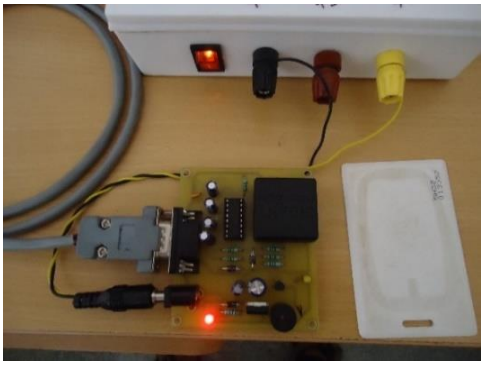

Figure 15. Hardware setup for RFID reader

4. RESULTS AND DISCUSSION

In this paper, a project with a prototype of an office automation product was implemented. The aspects of the design were implementing both i.e., hardware and software give an advantage to the user.

4.1. Data entering for the employee

Figure 16 shows the snapshot for entering the employee related information. The information includes employee first and last name, employee gender, employee mobile number and at last the employee system MAC address and IP address. After all the information is entered, the information can be saved or deleted, or information can also be updated.

Figure 16. Data entering of Exypnos office system (EOS)

4.2. Image capturing for employee

Figure 17 shows the snapshot for capturing the employee image using webcam. This webcam must be previously stored in JMF and after the camera has been stored, it starts capturing the image. After the image has been captured, a conformation message will be displayed.

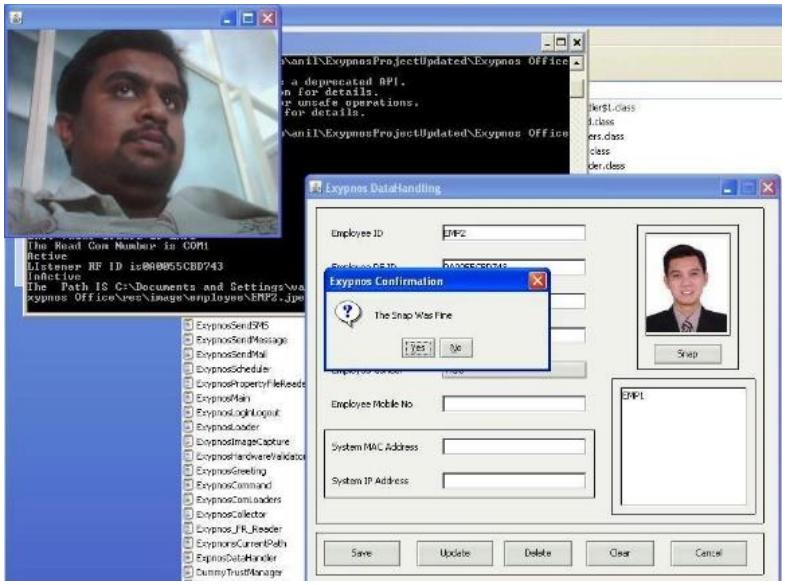

Figure 17. Image capturing of EOS

4.3. Database creation

Figure 18 shows the snapshot of the database created based on the information entered. The other information that will be in the database is the employee's login, logout time and employee schedules which will be later sent as an SMS. The database will be created by using Java database creation (JDBC) drivers, which will be loaded as soon the project is executed.

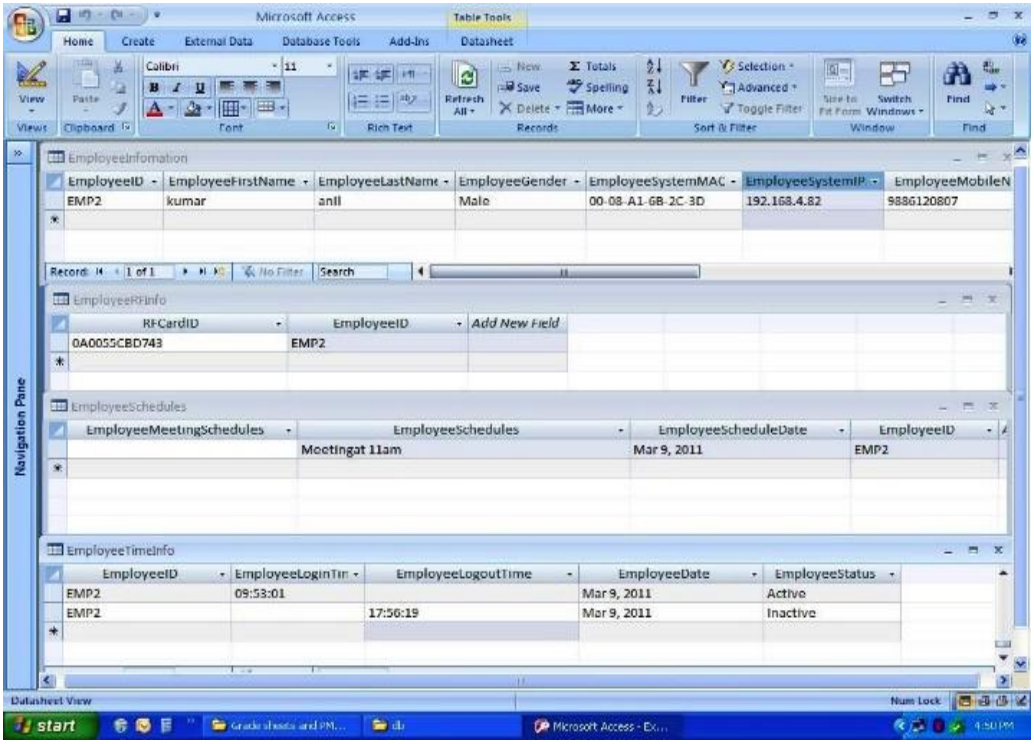

Figure 18. Database creation for EOS

4.4. Employee system booting up and shutdown

Figures 19 and 20 show the snapshots for employee system booting up and shutdown respectively. The employee system will be booted up by sending wake on LAN packets to the IP address, which would have been stored earlier in the database as soon as the employee logs in as shown in Figure 19. The employee system will be automatically shutdown by sending a shutdown command to the employee system as soon as the employee logs out as shown in Figure 20.

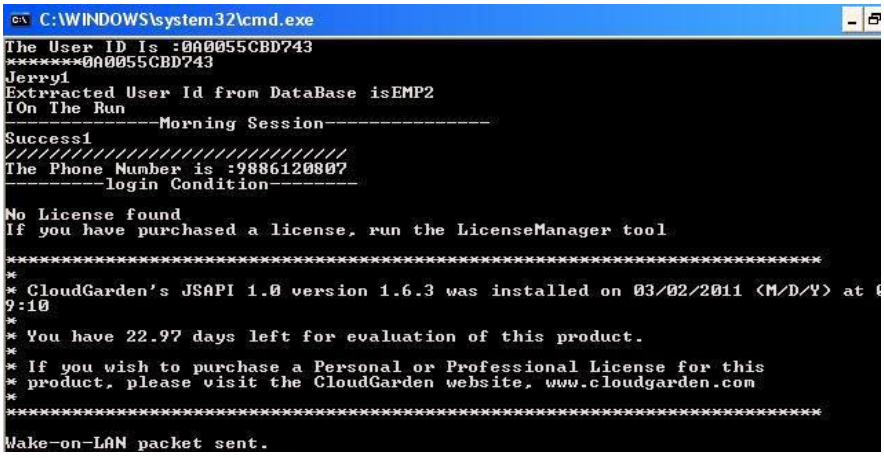

Figure 19. Employee system booting-up

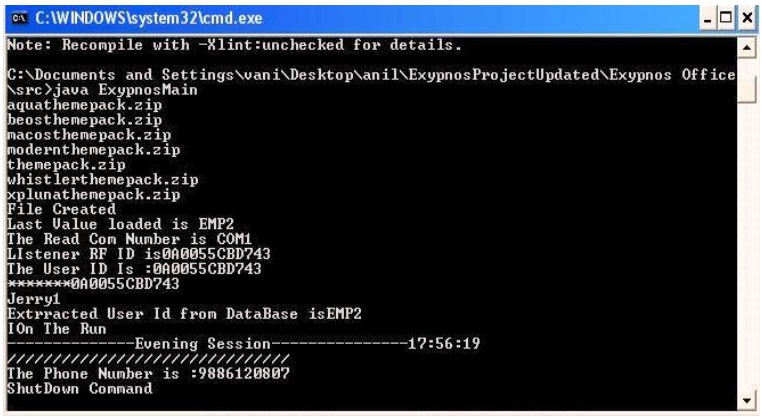

Figure 20. Employee system shutdown

4.5. Employee monitor turning off and on

Figures 21 and 22 show the snapshot of the employee monitor, which will be turned off and turned on in the presence of the employee. As seen in Figure 21, which shows the message “Employee present in seat”, this means that the employee is present in his seat and the monitor will be on. As seen in Figure 22, which shows the message “Employee not present in seat”. This message indicates that the employee is not present in his seat and the monitor will be turned off. This will be established with the help of RF transceivers. As soon as the RF receiver, receives the signal from the transmitter, a program named nircmd.exe stored in the bin file will be executed to turn off the monitor.

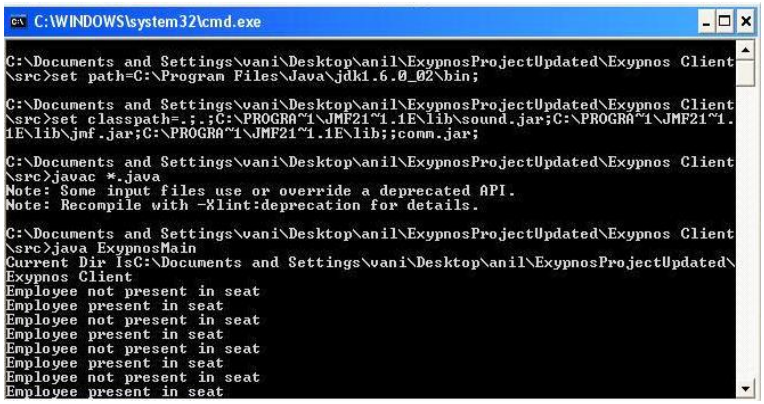

Figure 21. Employee monitor on

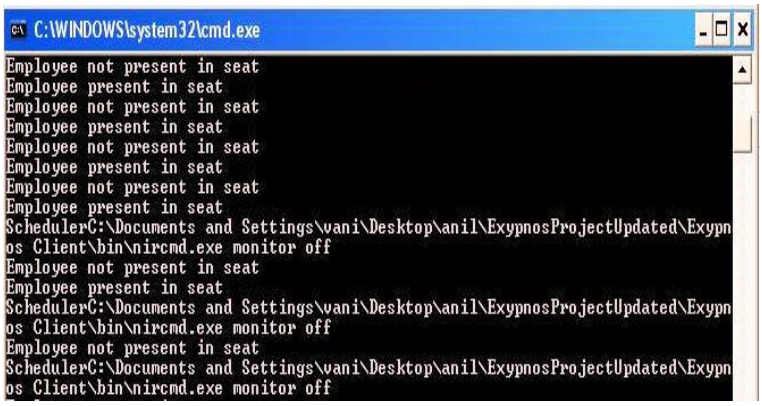

Figure 22. Employee monitor off

5. CONCLUSIONS AND FUTURE WORK

The backbone of office automation is the LAN, which allows users to transmit data. Office automation system mainly depends on three factors i.e., the people, the tools used and the organization. The people will be the end user of the system developed, the tools will be the different software's used by the user and at last the developed system will depend on the organization whether it is a big organization or small.

Java is used in this project, and it has proven to be a language and platform of choice in desktop, web, and mobile applications, widely displacing C and C++ in those application areas, resulting in substantial improvements in quality and productivity. Database handling in Java is easier compared to other programming languages as only drivers for the database should be loaded.

Web camera interfacing and image capturing are implemented in the Java environment with the help of JMF. Java SMS API and Bluetooth technology are used for sending schedules through SMS. RFID systems use many different frequencies, but the most common and widely used and supported by our reader is 125 kHz. Office automation systems have more benefits to an organization.

The proposed Exypnos office system has been implemented and has met all the requirements, but still further improvements can be made to the existing project as: i) As soon as the user gets the SMS of his schedules with 4G technology, and once the employee enters the office and sit on his seat then automatically his/her mobile to put in the silent mode; ii) Once the employee reaches office, an SMS can also be sent to his boss, home by storing more numbers in the database; iii) The employee login and logout time can be retrieved at the end of the day from the database and a mail can be sent to the administrator using Java Mail API; iv) RF technology was used to provide an identification number to the employee, but Zigbee would be a better choice as it is very accurate, and the data losses are very less than compared to the RF technology; and v) Tactile switch was used to sense the employee presence in the seat, but PIR sensor can be implemented which is very simple and easy to handle.

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