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Design and Development of RFID based Software Framework Prototype for Smart Home

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***Abstract*—** The concept of home automation for realizing the remote access cum control of electrical appliances has been migrating to the concept of smart environment by the rapid incorporation of the information and communications technologies. In this regard, several research works are currently going on all around the globe by different researchers of different technical fields at different levels. This work is to design an efficient software framework for smart home environment through the use of RFID communication technology for identifying the presence of inhabitants individually and also for providing the required services accordingly from the environment based on previous behaviors of the individuals. One algorithm/ method has been introduced in this work to identify the user on his/ her presence in the environment and also to access the required information from the system database about the services, as per his/ her previous settings of the appliances. Again another one data mining based algorithm is also introduced in this work in order to learn the association of the appliances available in the environment so that proactive services from the environment can be initiated. The work is mainly to focus over the sensing and processing part of the proposed smart home environment, rather than giving stress over the deployment of real actuators and hence the status of the appliances has been shown in GUI based platform. This work concludes with challenges related to the smart home environment in order to make the entire technology more efficient and robust.

***Keywords*—**RFID, Smart Home, Data Mining, RS 232 Serial Communication, Qt, MySQL databse

I. INTRODUCTION

In this time, the world is witnessing the rapid migration/ up-gradation of all the technologies individually, as well as merging of more than one technology into one platform to find out new facilities/ tools/ services for the mankind. As technologies grow the need of the new facilities/ tools/ services for the mankind are also to be innovated. One of such innovation may be to use the RFID for automatic identification of user/ inhabitant in an environment and controlling the various appliances/ devices of that environment in a convenient way, as it would remove the manual aspects of controlling the same by ensuring the presence of the inhabitant. The example scenario may look like that whenever a person enters the room, the appliances inside room will be activated automatically according to the specified settings, which will exclude the manual commands through a switch, keyboard or remote control gadgets. Again, as the appliances would be activated automatically according to the specified settings, specifications of the users/ inhabitants for various appliances attached to the automated home system needs to be pre-programmed according to some condition based fixed criteria. As a result, one needs to access the automated home system and also need to interact with the micro-controllers attached with the system to program the same. Hence, it seems that there is a need to have a convenient software framework to interact with the system with multiple appliances from a single interface. Again, implementing data mining techniques in home automation software will make it intelligent enough to learn various aspects of inhabitants' daily life activities through experiences gained by monitoring and observing their regular activities. The system can keep the track of every inhabitant's regular activities and gradually learn to identify their changing pattern of behaviour as well as requirements and according to that it will keep on updating the user/ inhabitant specific specification in the database.

The rest of the paper is organized as follows- Section II contain the objectives of the work, Section III contain the related work in smart home and its technology, Section IV contain the proposed mechanism with algorithms, Section V contain the implementation details, Section VI contain outcomes of the work and Section VII concludes research work with future directions.

II. OBJECTIVES

In this work, some specific goals/ objectives towards the development of the proposed system have been placed in the following and also addressed accordingly.

- Designing an efficient RFID based home automation software framework, which can automatically generate activation commands to turn on a set of LIGHTs corresponding to the incoming user and to activate a set of FANs or ACs at user specific speed.
- Making the software framework a user-friendly one so that interaction with the automated home system becomes more convenient by providing a control panel for configuring various appliances settings according to each user's specification in an efficient manner.
- Proposing a decision making mechanism by implementing Association Rule Mining Techniques in order to identify the frequency of use of various devices/ appliances and finally establishing some strong associations among each user's pattern of devices/ appliances usage.
- Periodically updating the user specific device settings based upon previous behaviour of each user according to the strong association rules and reflecting the same accordingly into actions.

III. RELATED WORK

S. Kumar and et al. [1] explored the different types of smart home systems available and analysed the possible ways of utilizing artificial intelligence techniques in such smart homes in order to increase their effectiveness. S. Palniappan and et al. [2] also discussed about the possibilities of hardware and network technologies for designing home automation system. In their paper, they mentioned about GSM based home automation system, Bluetooth based home automation system, phone based home automation system, ZigBee based home automation system etc. followed by a mixed interface to work simultaneously. M. S. Soliman and et al. [3] proposed a system to describe two scenarios based on wired and wireless tools. In the wireless platform, they used cellular phone and Wi-Fi in order to control and access the home appliances and for the wired FPGA kit is used. E. O. Heierman and D. J. Cook [5] also proposed a noble data mining technique for mining the data stream captured by various sensors which record the regular interactions between the inhabitants and devices inside the home environment and finally discover significant patterns to automate these device interactions. The proposed technique also addresses various challenges such as excessive noise in data collected. D. J. Cook and et al. [6] introduced a MAVHome (Managing An Intelligent Versatile Home) architecture along with two learning algorithms in order to create an intelligent smart home environment. The first algorithm predicts actions of the inhabitants inside the home by perceiving the state of the home through sensors, while the second algorithm learns a policy to control the home and acting through device controllers. L. Xuemei and et al. [7] pursued their research in making a context aware and situation aware home automation system based ubiquitous computing. They developed framework called Smart Home safety Management (U-SHM) by integrating RFID technology for providing automatic control service and context based light and temperature management using sensor. They also considered the required security aspects in their work. H. Hsu and et al. [8] also worked to develop a reminder system for smart home that uses the RFID technology to detect the objects that a user brings along. The system then provide a reminder object list to the user based on the history data collected from the same user and the events in the user's calendar on that day.

IV. PROPOSED WORK

A design of smart home has been proposed in this work which can provide a flexible and user friendly interface for allowing the users/ inhabitants to specify the device setting for particular time periods in specific days of a week. The proposed system in this work is dynamic enough to automatically adjust the various device configurations at a particular time and day of the event, depending on the presence of different users/ inhabitants inside the room. The system will also maintain record of each user who has entered or left the room with the time duration of their presence and also the devices/ appliances that they have used, which will help to keep track of each user's regular activities inside the home. The RFID tag in conjunction with the RFID reader has been used for user identification and authentication mechanism. The signal from RFID tag, which contains an identification code unique for each user, will be read by the RFID reader whenever the tag is within the detectable range from the reader. The system is also composed of a software module which acts as the brain of the system for taking all decisions. The software provides a user friendly interface through which different users can set their preferred device specifications. The records of each user along with their IDs are stored in a database. Data from the RFID reader are transported to the computer via serial port interface. The software running on the computer will detect the signals from the RFID reader and reads the corresponding tag ID. The software then determines which user has entered by interpreting the tag ID through comparison with the IDs stored in the database. The detail records of each user's specifications for various device settings are stored in the database available in the computer. Whenever the software identifies a particular user entering the room, it will access the corresponding device settings for that user and generate a device activation command.

A data mining based feature has been incorporated in the smart home system so that the software can keep track of every user's regular activities and gradually able to learn to identify the changing pattern of the behaviour of each user as well as requirements and accordingly it will keep on updating the user specific device settings in the database. Two algorithms are proposed in this work to incorporate learning capabilities into the smart home system and both algorithms are finally implemented in the software framework developed in this work to enhance the overall smart home framework. The first algorithm is going to introduce more flexibility into the software interface and the second algorithm makes the entire smart home system intelligent by enabling it to take automatic decisions based on reasoning deduced by observing regular behaviours of users and learning their activity patterns.

A. Algorithm-1

Using this algorithm, the system provides a user-friendly interface of a control panel where the user can specify the settings of all the required devices. The software is flexible enough to allow the user to select one or more of the 7 days of the week (Monday - Sunday) as well as the starting time and ending time of activation period for a particular device setting. For each day selected by the user, the record is going to be stored in the database in a 7-bit format, such that the selected days will be stored as 1 while those not selected will be stored as 0. E.g. if a User-A selects Mon, Wed & Fri for a particular device settings then it will be stored as 1010100 in the database. The user can also specify the starting and ending time for the device settings in the format "HH:MM:SS", i.e. if the same User-A selects 09:00:00 AM as starting time and 04:30:00 PM as ending time then the specified devices will be activated on Mon, Wed & Fri within a period from 9 o'clock morning to 4:30 evening, provided the User-A is inside the room. Finally the User-ID along with his/her device specifications as well as 7-bit format for selected days and starting and ending activation time period will be stored as a record in the database. So, whenever a user enters the room the software will immediately identify his User-ID and access his device specification records from the database. The steps of the algorithm is as follows-

1) *Identify the user entering the room and determine his User-ID*
2) *Generate current day from the system and store it as 'DAY' such that DAY = 1 for Mon, DAY = 2 for Tue…, DAY = 7 for Sun.*
3) *Generate current time from the system and store it as 'TIME' in the format "HH:MM:SS".*
4) *Access the first device specification record for that particular user in the database.*
5) *Read the 7-bit format of selected days of activation and store it in an array 'A'. If A [DAY-1] is '1' then GOTO Step 6, otherwise GOTO Step 8.*
6) *Read corresponding starting time and ending time of activation period as 'S_TIME' and 'E_TIME'. Compare whether TIME >= S_TIME and TIME <= E_TIME. If conditions are satisfied, then GOTO Step 7; otherwise GOTO Step 8.*
7) *Read the corresponding device specifications from the database and generate activation commands for those devices according to their settings.*
8) *For each of the device specification records for that user in the database, access them one by one and repeat Step 5.*

B. Algorithm-2

The second algorithm is implemented in this work by deriving Apriori algorithm [9], which is widely used association rule mining algorithm. Apriori algorithm is slightly modified/ configured to get the flavour of suitability for mining frequent sets of devices (i.e. set of devices which are used together more frequently) from the database. The following steps of the algorithm will generate strong association rules among the frequently used devices for a particular user only. The steps of the algorithm-2 is as follows-

1) *Determine the Candidate Set by calculating the support count of all the devices specified by the user from the database. (*Candidate set comprises of the device names and their settings along with their support counts*).*
2) *Generate Frequent Set from the Candidate Set. (*Sets of devices which occurs at least as frequently as a predetermined minimum support threshold value are considered frequent sets*).*
3) *Generate Candidate Set from the Frequent Set by performing Join operation. (*Candidate sets are obtained by performing join operation of the previous frequent set with itself*).*
4) *Iteratively find the new Frequent Sets from the Candidate Sets. (*Repeat Step 2 and Step 3 until frequent sets having a maximum of four devices are obtained*).*
5) *Generate strong association rules among devices from final set of Frequent Sets. (*Association rules are strong if they satisfy both minimum support threshold and minimum confidence threshold*).*

V. IMPLEMENTATION

In this work, the RFID reader uses EM4102 protocol to detect passive RFID tags of 125 KHz from a range of about 1 foot. The RFID reader reads the data from the tag and sends it to a computer via RS-232 Serial Interface Connection. Again, the RFID tags are a passive Transponder made of EM4102 chip having a CMOS integrated Circuit with frequency of 125 KHz. The tag is a proximity card with 48 bit ROM to store a unique 48 bit binary identification number integrated in it. Within the detectible range, the RFID reader can read this 48 bit binary number from the tag

and transmit it to the computer in a 12 bit hexadecimal format via serial cable.

The software framework implemented in this work reads the Tag ID in 12 bit HEX code format which has been transmitted by the RFID reader to the computer via RS-232 serial port interface and stored it in the database created during the design of the system using proper E-R diagram to relational schema transformation rules. The relational schemas used in the database loaded in the designed system are LOGIN, DESIGNATION, DEVICE, FAN, AC, LIGHT, ENTRY, USER_ORDER, TRANSACTION, CANDIDATE and FREQUENT; in order to work with both the algorithms mentioned above. The following flowchart shown in the Figure 1 describes how the software framework reads the RFID tag and store it in the database created during the design of the system.

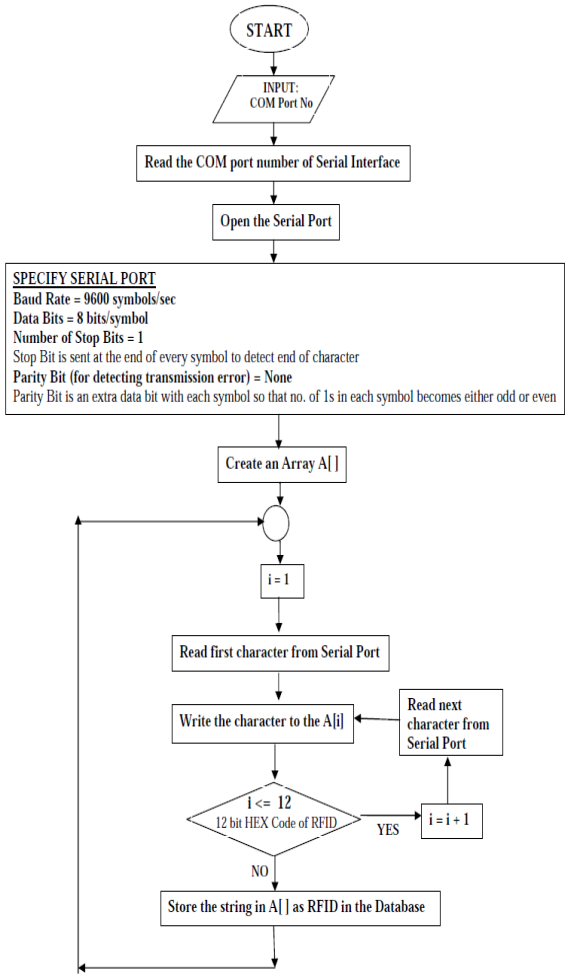

Figure 1. Flowchart showing RFID tag reading and storing at database

One of the key components of the designed smart home system is a friendly and comprehensible user-interface which can be easily accessed by any non-technical individuals. The work to design the system is developed in C++ using Qt platform and the user interface is created using Qt Creator IDE to have a flexible, user-friendly that allows the inhabitants to control the multiple devices and appliances throughout the home from a single computer without manually interacting with each device/ appliances.

VI. RESULTS AND DISCUSSION

In the result section, some outputs are illustrated below in a step by step manner by using some pictures of hardware implementation and snapshots of the software execution as follows-

The first step is to connect the RFID reader to the serial port of the Computer using a RS-232 Serial Interface Cable as shown in Figure 2. In this work, Laptop is used and hence a USB-to-Serial Converter has been used to connect the reader to the USB port.

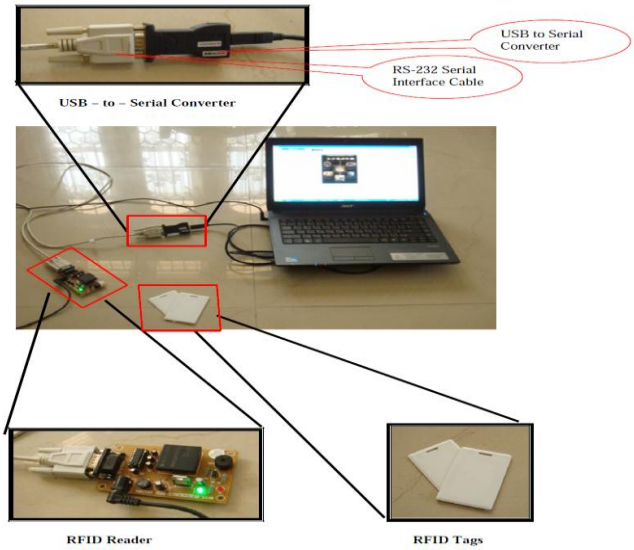

Figure 2. The propotype system

After connecting the RFID reader to the computer, the system is ready to identify any tag in the vicinity. When a tag is within the range of the reader, a red LED attached with the reader will blink showing the detection of the tag by the reader, which is shown in Figure 3.

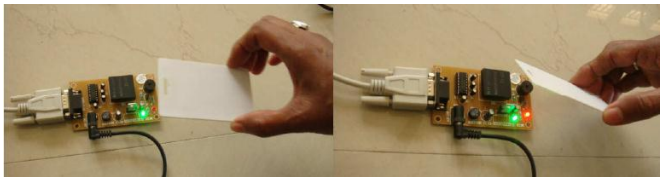

Figure 3. Detection of RFID tag by the RFID reader

The tag used in this work has a 12 bit HEX code ID (48 bit binary number) such as 400064064F6D. To read the ID from

any tag, the software first displays a user interface where one needs to select the appropriate COM port as shown in Figure 4. Once the serial interface cable is connected, click the "Start Reading" button to begin the reading process. As long as the software is running and the RFID reader is powered on, any tag within range will be detected and the corresponding ID will be read by the software.

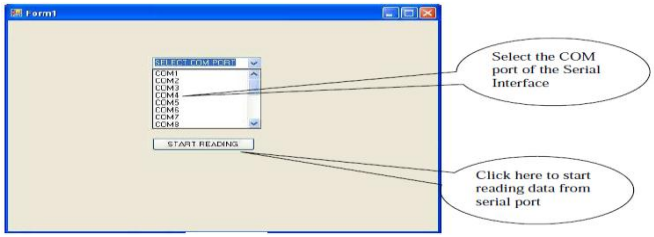

Figure 4. COM port selection to read the RFID reader

The software can be accessed only by an authorized user. For authorization one must register to the software by providing valid information such as Name, contact number, designation and Tag ID. After registration the authorized user must submit correct Username and Password as shown in Figure 5, for authentication purpose to successfully signing in to the software.

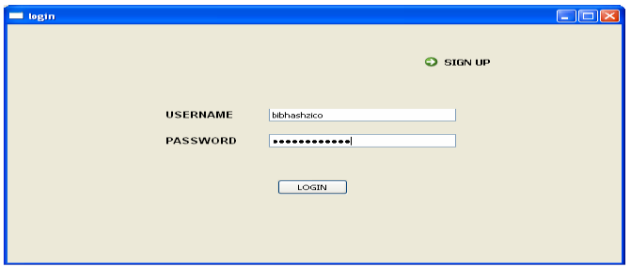

Figure 5. System access authentication

The homepage of the software framework provides various information as well as options to the user as shown in Figure 6 below-

Figure 6. Home page of the system

In the homepage, the user can view his/ her profile as shown in the Figure 7.

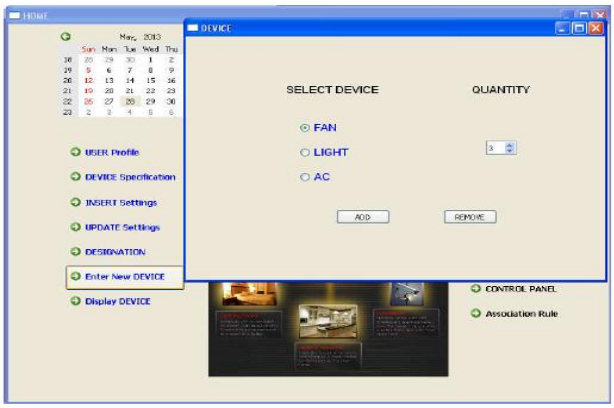

Figure 7. Viewing user profile in the system

The software is flexible enough to allow the user for selecting the device specifications for a particular time periods in a day and is shown in the Figure 8.

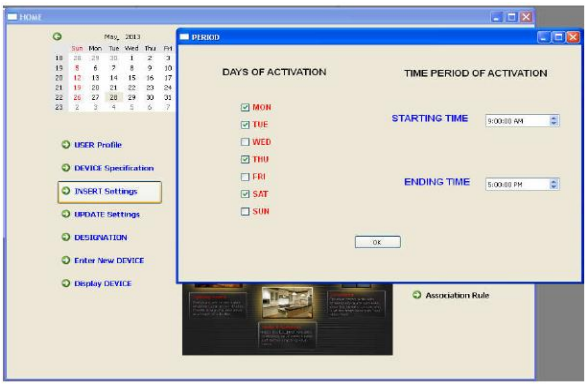

Figure 8. Platform for Device specification selection

To perform modifications to the device specifications, the user can even update the device setting as shown in Figure 9.

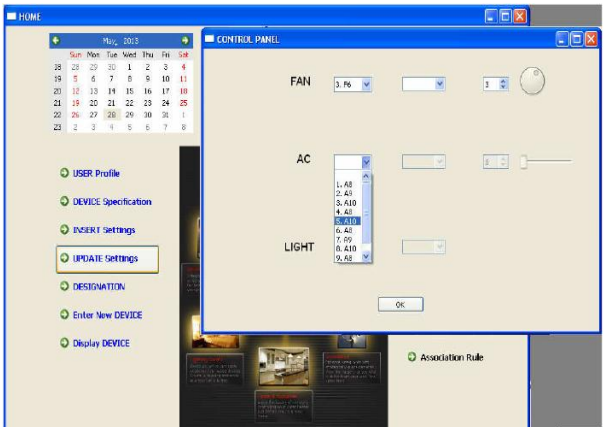

Figure 9. Updation of device specification

VII. CONCLUSION and Future Scope

This work has presented RFID based smart home system architecture. It is tries to make the software interface flexible enough to provide more convenient services to the users. A data mining approach is also taken to impart learning capabilities into the designed software to make the entire smart home system intelligent. It is believed that this work has laid the foundation for providing necessary guidance for future research in creating a more flexible, efficient and cost-effective smart home system. The software is designed such that it can automatically generate an activation command for the user specific devices whenever the corresponding user is detected at the entrance of the room for the first time. If the system detects the user for the second time again, it assumes that the user is leaving and hence system will generate deactivation commands for the said devices. Now again, if there are other users in the room who want those devices to remain active then the system will fail to comply with their commands. So, a mechanism should be developed so that whenever a user leaves the room, the devices used by him will not be deactivated by the system, but rather will be restored to their previous settings as preferred by other users present inside the room. Moreover, two or more users might specify different settings for the same device. For example, one of them might want a fan to run at full speed while another one may prefer a slow speed and again another might not want any fan at all. Now, if they all are present in the room at the same time, then their activation commands for that particular device will result in a conflict. Although this problem could be solved by assigning each user some priorities based on their designation or social status, this problem will still arise in case of equal priority users. Therefore, a systematic research needs to be done in this regard by considering more criterions for assigning user priority and to come up with a more effective solution for this problem.

REFERENCES

[1] S. Kumar, M. A. Qadeer, "*Application of AI in Home Automation*", International Journal of Engineering and Technology, Vol.4, No.6, pp.803 -807, 2012.

[2] S. Palaniappan, N. Hariharan, N. T. Kesh, S. Vidhyalakshimi, A. S. Deborah , "*Home Automation Systems - A Study*", International Journal of Computer Applications, Vol.116, No.11, pp.11-18, 2015.

[3] M. S. Soliman, M. O. Dwairi, I. I. M. A. Sulayman, S. H. A. Almalki, "*Towards the Design and Implementation a Smart Home Automation System Based on Internet of Things Approach*", International Journal of Applied Engineering Research, Vol. 12, No.11, pp. 2731-2737, 2017.

[4] D. J. Cook, S. K. Das, "*Smart Environments: Technology, Protocols and Applications*", Wiley-Interscience, 2005.

[5] E. O. Heierman, D. J. Cook, "*Improving home automation by discovering regularly occurring device usage patterns*", In the Proceedings of the 3rd IEEE International Conference on Data Mining (ICDM), FL, USA, 2003.

[6] D. J. Cook, M. Huber, K. Gopalratnam, M. Youngblood, "*Learning to Control a Smart Home Environment*", American Association for Artificial Intelligence, 2003.

[7] L. Xuemei, X. Gang, L. Li, "*RFID Based Smart Home Architecture for improving lives*", In the Proceedings of the ASID 2nd International Conference, Guiyang, CHINA, pp.440-443, 2008

[8] H. Hsu, C. Lee, Y. Chen, "*An RFID-based reminder system for smart home*", In the Proceedings of the IEEE International Conference on Advanced Information Networking and Applications (AINA), Singapore, pp. 264-269, 2011.

[9] L. Dongre, G. L. Prajapati, "*The Role of Apriori Algorithm for Finding the Association Rules in Data Mining*", In the Proceedings of International Conference on Issues and Challenges in Intelligent Computing Techniques (ICICT), Ghaziabad, INDIA, pp. 657-660, 2014.

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