RFID Technology: Design of a smart tool to allow interaction with everyday life objects.

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Abstract
Taking care of children (1-6 years) consumes a lot of time (like playing lullabies, reading Tale book, etc) and a person should be dedicated to play with children and look after children in all their precious daytime. This RFID project is aimed to develop the prototype for human activities and reduce the time spent by any person or parents to play with baby. To realize this feature, we identify the wish of child using RFID reader & tags and also register in our local file system. Reader sends the unique id of wish to an Arduino microcontroller board which triggers a unique infrared action associated with different wishes of child accordingly through controlled TV, Hi-fi system, etc. This prototype is associated with feature of pre-configuration, customization according to the child's interest or parents' idea of their children's learning.

Keywords: Internet of Things, RFID Technology, Arduino, RC522, reader, tags, infrared, remote control.

INTRODUCTION

Now a days, RFID Technology has evolved as the medium of communication for Internet of Things apart from its classical identity to be as only for inventory management. Many research and case studies has been published to find the usage and importance of the RFID technology over the human driven market. Now in new evolving technology of IoT where machine to machine communication takes place often, the RFID technology with the help of Arduino and Raspberry low level based computing unit has significantly recorded its presence.

Arduino is an open source electronics platform based on easy-to-use hardware and software. It is intended for making interactive projects. Arduino can be programmed using Arduino software by writing code in the Arduino programming language and using the Arduino development environment. These days many people try to use arduino because it makes things easier and due to the simplified version of C++ and the already made arduino microcontroller (atmega328 microcontroller [1]) that you can program, erase and reprogram at any given time. In this project we propose a system, using Arduino to get information from a RFID reader which is detected by a RFID tag and control the home's appliance with a universal infrared control that we build thanks to infrared emitter and receiver.

I- RESEARCH PROBLEM CONTEXT.

Children are one of the best creature while they are playing or engaged in some activities otherwise controlling children is a nightmare for anyone. Once they are free from activities they need special attentions of parents out of their busy work time. Also for understanding the need of children is also a challenge for parents. In this era, People have busy schedules, multiple location working style, both (mother and father) works outside and it is very difficult for them to manage children maintaining proper care. In this scenario, one or both of the parents take leave from their work for long time to take care of child so that they can take care of their child. The busy life, competitive work environment doesn't allow people to get engaged with children's activity by spending most of their time. It is not mere work, it is also not feasible for any human being to dedicate most of the time towards baby and playing with baby every day. In the beginning, looking after of child may look exciting and enjoyable but soon it turns to be a boring activities and at last as a burden. Some parents hire some nanny, some parents subscribe to day care centers and use their applications to get child's notifications

at daycare center but none of these methods are very much accurate and convincing methods to trust for their loved ones. The main problem associated with these system is that Children has to go out of the house and also Parents do not have control of the learning process of the children. After problem analysis, We have outlined some activities from the list of interested activities of children like listening lullabies, playing with doll or teddy, reading/ listening fairytales, etc. which are group of in-door activities.

Now a days, RFID device has become domestic item in household and are frequently used for door lock system, inventory control, Student Id card/ Employee Id card, Restaurant card and many more. On the same time, Infrared technology has grown old being employed in different TVs, remote controlled cars, Hi-fi systems, Air conditions, etc. We have understood the requirements of parents to engage the child in activities which children generally like. So main idea is to engage children using their interested activities and engaging children in their activities are performed using different technologies like RFID, Infrared, Arduino, etc. Our prototype known uses the RFID technology and infrared technology to develop a smart tool to control different TVs, Hi-fi systems, etc… according to the wish list of the child [1]. The understanding of the children's interest adds multiple options in the smart tool to look after the children and guarantees for complete engagement of children.

II- RESEARCH PROBLEM STATEMENT

1. RFID Technology

RFID technology uses radio frequencies to read information on devices known as tags that can be fixed to or embedded into virtually any object, and these tags either reflect or retransmit the radio-frequency signal, this signal can be received by a reader and transmitted to a controller. In order to realize an autonomous system for the child, we use the rfid technology to uniquely identify the action to trigger by the system, in function of the desired of the child and the requirement of parents.

We have associated different RFID tags with different objects like fairy tale book, doll/ teddy, DVD, lullaby. Once the tag comes in contact with the contactless RFID reader RC522, it detects and records the unique tag id associated with tag and stores in file system. Once the unique Id is stored, then it finds a corresponding match in the lookup table to find the infrared action for the associated tag id and sends the unique id for this action to a PC via Arduino board.

2. Infrared Technology

The infrared remote control has the performance of the high signal to noise ratio, strong anti-interference, reliable transmission of information, and untouchable, low power and cost, therefore it is widely used in home appliances more or less, even as the highlight on sale. In addition to utilizing in home appliances, it has been brought into the industrial control, the aerospace, the security and so on. But the formats of infrared remote control protocol used are different between the different companies' production, the consequence from this is that an infrared remote control device must be fit for the home appliances. Because of that, this project presents also a system for IRCP to coding and decoding based on the infrared coding format in now infrared remote control devices [2], in order to control the different home appliance like TV, Hifi thanks to our system.

RELATED WORK

1. Children engagement tools

As a first step, the various Children engagement tools were observed and some of the interesting work were found:

a- Integrated Parent information system to increase parental involvement in children's learning process in Malaysian primary school [3]

This research focuses on framework which outlines an integrated parent information system (SMIB) to mediate the parents and their children's academic achievement plus school activities information. According to the framework, the components include the parents, teachers and school administrator module. Teachers provide information about their students and knowledge resources while parents gain information and initiate communication with teachers. At the meantime, school administrator control access to parents and teachers, create new users and manage the content of the system. Functionally, SMIB's

main focus is to provide comprehensive tutorial and notes which is generated based on children's academic achievement level. These knowledge resources aid the parents in guiding their children throughout the learning process effectively specially in homework. This research utilizes questionnaire approach on a random sample of parents to acquire the information regarding the parent's involvement level and to gather parent's requirement in order to increase their involvement in the children's learning process. The questionnaire study reveals that parents desires for knowledge resources support to assists them in children's learning process. Thus, this research is helpful to facilitate the parents to be actively involved in their children's learning process and relieve the schools in portraying close relationship with parents parallel with their effort to ensure high academic achievement in the children's overall performance.

b- **Field trial of asynchronous communication using network-based interactive child watch system for the participation of parents in day care activities** [4]:

Team of authors developed the network-based interactive child-watch system called "Meru-robo digital log system". It is composed of the "action switch platform (AcSP)" (developed by NTT Laboratories) for exchanging dialog with a "personal robot" (called "PaPeRo") (developed by NEC Corporation) by using cellular phone text messaging. A field trial showed that parents could send their intentions and receive information in a schedule-flexible manner via cellular phone text messaging. Since the robot in the nursery linked the parents to the teacher, their information exchanges did not interfere with the activities of the children. We report results of information exchanges using this system in two situations: parents are the same building (but not the same room as the children) and parents are in other locations going about their daily life. In the limited situation of children playing in a nursery, we found that parents in remote locations could get detailed information about their children's activities and expressions when desired via asynchronous communication.

c- A study of Parent-child play in a multiplayer competitive educational game [5]:

This study conducted an empirical study of parent-child play in a multiplayer competitive English vocabulary learning game to investigate parents' and children's attitudes towards educational games and whether there were differences between parents' and children's attitudes after parent-child play. Twenty groups of parent-child volunteers were recruited. The children were fifth or sixth grade elementary students. The results show that the educational game can effectively enhance children's recognition of English vocabulary. Both children and parents had positive attitudes towards the game in terms of pedagogy, game, society, and system. The results also reveal that children had significant higher ratings on pedagogy, game, and system than parents had and there was no significant difference on society. Interview responses show that parent-child play in multiplayer competitive educational games provides a solution for parents to help low academic performance children learn. Many parents gave their children advice to spell words and almost children were willing to accept advice even though they were opponents in the game. Children may feel a sense of accomplishment when they win their parents so that get motivated to learn through parent-child play. Children enjoyed parent-child play in that they can have more time to interact with their parents. This study provides evidences that parent-child play in educational games can be a possible way to not only let parents help children learn but also enhance parent-child relationships

d- Solving family communication problems between children and parents by Mobile Serious Games [6]:

This paper adopts an innovative approach by using Mobile Serious Game (MGS) to produce edutainment mobile games which allow children to learn the meaning of filial piety to parents during the process of playing. The objective of this kind of game is to let children understand the meaning and connotation of 24 filial piety stories in ancient China, realize the importance of filial piety and know how to give their parents something in return. The finding of this research has shown the acceptance rate is high among those target groups and the relationship between children and parents can be enhanced while they are playing the games together. More importantly, the approach in this paper significantly offers an effective communication channel to the children and parents.

2. RFID Technology

a- Main architecture

RFID is an acronym for radio frequency identification, which is a wireless communication technology that is used to uniquely identify tagged objects or people. It has many applications. An RFID system is composed of three basic components: a tag, a reader, and a host computer.[7]

- The tag: (sometimes called a transponder), which is composed of a semiconductor chip, an antenna, and sometimes a battery.

- The reader: (sometimes called an interogator or a read/write device), which is composed of an antenna, an RF electronics module, and a control electronics module

- A controller: (sometimes called a host), which most often takes the form of a PC or a workstation running database and control (often called middleware) software

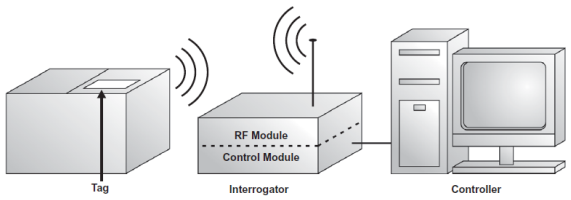

Fig1: The Basic building blocks of an RFID system. Source: LARAN RFID

The tag and the interrogator communicate information between one another via radio waves. When a tagged object enters the reading zone of an interrogator, the interrogator signals the tag to transmit its stored data. Tags can hold many kinds of information about the objects they are attached to, including serial numbers, time stamps, confi guration instructions, and much more. Once the interrogator has received the tag's data, that information is relayed back to the controller via a standard network interface, such as an ethernet LAN or even the internet [7]. The controller can then use that information for a variety of purposes. For instance, the controller could use the data to play "some music on the HiFi, or read some history on the TV".

b- Presentation of the different components of a RFID system.

- **The tag**

The basic function of an RFID tag is to store data and transmit data to the interrogator. At its most basic, a tag consists of an electronics chip and an antenna (see Figure 2) encapsulated in a package to form a usable tag, such as a packing label that might be attached to a box. Generally, the chip contains memory where data may be stored and read from and sometimes written to, in addition to other important circuitry. Some tags also contain batteries, and this is what differentiates active tags from passive tags.

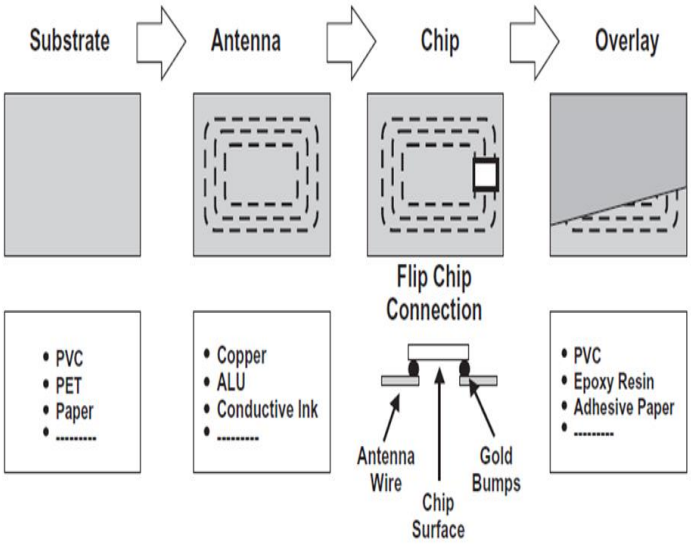

Fig2: RFID Tag Component

The RFID tag can be grouped in different categories: active and passive tag, in term of frequency, or read only/smart tags.

RFID tags are said to be **active** if they contain an on-board power source, such as a battery. When the tag needs to transmit data to the interrogator, it uses this source to derive the power for the transmission. Active tags can communicate with less powerful interrogators and can transmit information over much longer ranges, up to hundreds of feet. Furthermore, these types of tags typically have larger memories, up to 128 Kbytes [8].However, they are much larger and more complex than their

passive counterparts too, making them more expensive to produce.

Passive RFID tags have no on-board power source. Instead, they derive power to transmit data from the signal sent by the interrogator, though much less than if a battery-were on-board. As a result of this, passive tags are typically smaller and less expensive to produce than active tags. However, the effective range of passive tags is much shorter than that of active tags, sometimes under two feet. Furthermore, they require more powerful interrogators and have less memory capacity, on the order of a few kilobytes. The majority of RFID tags produced today are passive RFID tags, comprised basically of a micro-circuit and an antenna.

Frequency refers to the size of the radio waves used to communicate between RFID system components. RFID systems throughout the world operate in **low frequency (LF)**, **high frequency (HF)** and **ultra-high frequency (UHF)** bands. But more recent research have introduced the **Microwave frequency** RFID. Radio waves behave differently at each of these frequencies with advantages and disadvantages associated with using each frequency band

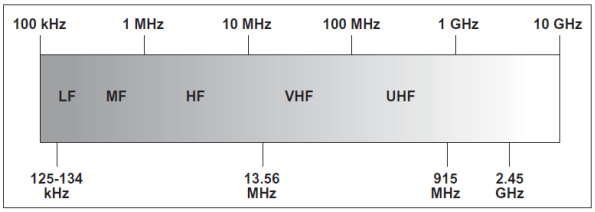

Fig3: Radio Frequency Spectrum. Source: Texas Instruments.

- **LF RFID**

The LF band covers frequencies from 30 KHz to 300 KHz. Typically LF RFID systems operate at 125 KHz, although there are some that operate at 134 KHz. This frequency band provides a short read range of 10 cm, and has slower read speed than the higher frequencies, but is not very sensitive to radio wave interference.

- **HF RFID**

The HF band ranges from 3 to 30 MHz. Most HF RFID systems operate at 13.56 MHz with read ranges between 10 cm and 1 m. HF systems experience moderate sensitivity to interference.

HF RFID is commonly used for ticketing, payment, and data transfer applications.

There are several HF RFID standards in place, such as the ISO 15693 standard for tracking items, and the ECMA-340 and ISO/IEC 18092 standards for Near Field Communication (NFC), a short range technology that is commonly used for data exchange between devices. Other HF standards include the ISO/IEC 14443 A and ISO/IEC 14443 standards for MIFARE technology, which used in smart cards and proximity cards, and the JIS X 6319-4 for FeliCa, which is a smart card system commonly used in electronic money cards [7].

- **UHF RFID**

The UHF frequency band covers the range from 300 MHz to 3 GHz. Systems complying with the UHF Gen2 standard for RFID use the 860 to 960 MHz band. While there is some variance in frequency from region to region, UHF Gen2 RFID systems in most countries operate between 900 and 915 MHz.

The read range of passive UHF systems can be as long as 12 m, and UHF RFID has a faster data transfer rate than LF or HF. UHF RFID is the most sensitive to interference, but many UHF product manufacturers have found ways of designing tags, antennas, and readers to keep performance high even in difficult environments. Passive UHF tags are easier and cheaper to manufacture than LF and HF tags. However, because the high frequency bands pose some health concerns to humans, most regulating bodies, such as the FCC, have posed power limits on UHF and microwave systems and this has reduced the read range of these high frequency systems to 10 to 30 feet on average in the case of passive tags.

- **RFID Interrogator**

An RFID interrogator acts as a bridge between the RFID tag and the controller and has just a few basic functions.Read the data contents of an RFID tag, write data to the tag (in the case of smart tags), relay data to and from the controller, power the tag (in the case of passive tags).

RFID interrogators are essentially small computers. They are also composed of roughly three parts: an antenna, an RF electronics module, which is responsible for communicating with the RFID tag, and a controller electronics module, which is responsible for communicating with the

controller. In addition to performing the four basic functions above, more complex
RFID interrogators are able to perform three more critical functions:

- implementing anti-collision measures to ensure simultaneous RW communication with many tags,
- authenticating tags to prevent fraud or unauthorized access to the system,
- data encryption to protect the integrity of data.

3. Arduino Technology

The Arduino platform [9] has become well acquainted with people into electronics. Unlike most previous programmable circuit boards [10], the Arduino does not have a separate piece of hardware in order to load new code onto the board, you can simply use a USB cable to upload, and the software of the Arduino uses a simplified version of C++, making it easier to learn to program, and it provides you with an easier environment that bypass the functions of the micro-controller [11] into a more accessible package. An Arduino Board can be classified into two parts [14]:

- **Hardware**

The Arduino board hardware consist of many components that combine to make it work, but we are going to discuss the main component on the board such as follows:

- USB Plug: This is the first part of the Arduino because it is used to upload a programm to the microcontroller [10] and has a regulated power of 5volts which also power the Arduino board.

- External Power Supply: This is only used to power the board and has a regulated voltage of 9 to 12 volts, mostly if the USB plug does not provide sufficient power for whatever you have programmed it to do.

- Reset button: This button resets the Arduino when it when it is pressed in case you have uploaded another command and want the Arduino to do it.

- Microcontroller: This is the device that receive and send information or command to the respective circuit.

- Analog Pins (O-5): This are analog input pins from AO to A5.

- Digital I/O Pins: This are the digital input, output Pins 2 tol3.

- In-Circuit Programmer: This is another source to upload or program, It can also be done using "TX-l,I" output and "RX-l,O" input.

- Digital and analog Ground pins.

- Power Pins: we have 3.3 and 5 volts power pins etc...

- **Software**

The software is a set of instructions that informs the hardware of what to do and how to do it. The Arduino IDE (Integrated Development Environment) is divided into three main parts:

a) Text Area: This is where you write your code which uses a simplified version of C++ programming language that makes it easier to write your programme, which is also called a sketch. When writing your code there are mainly two important parts :

b) The setup function: Before the setup you need to intialize the variables you intend to use and assign them. Then the setup routine begins, This is where you set the intial condition of your variables and run preliminary code only once. Here is an example of how it should be written [10].

c) Message Window Area: This shows message from the IDE in the black area, mostly on verification on your code.

4. Infrared technology

Infrared (IR) is a wireless mobile technology used for device communication over short ranges. This technology is very used in the control of home appliance like TV, Hifi, DVD, etc…The main problem of the using of this technology is the diversity of protocol implemented in the device. The common IRCP (Infrared Remote Control Protocol) are NEC, Phillips RC-5 and so one [2].

a- The NEC protocol

The NEC protocol is developed by NEC, the protocol uses the carrier frequency of 38 kHz, and has no extreme requirement to the duty cycle, which is always 30%. NEC manufactures the remote control IC, which includes the μPD6121, μPD6122 and others. The NEC protocol is made up of three segments, they are leader code, 16-bits custom code and 16-bits data.

b- The Philips RC-5 protocol

The Philips RC-5 protocol is developed by Philips, although the much better protocol RC-6 is also drawn up, the RC-5 protocol has been widely used in the electronic production. The RC-5 protocol takes the carrier frequency of 36 KHz, the coding chips include the SAA3010, PT2210 and others. Four sections build up the RC-5 protocol, all have 14 bits which are start bits, toggle bit, address and command [2].

PROPOSED APPROACH

To make sure to trigger the correct action for the children, we have to get the order. So we need to do a system which read the tag of the object present by the child to a reader, and transfer it to the PC via the Arduino board, the PC will look up the tag id and sent the sequence of action to trigger to the Arduino, which will control the corresponding home appliance thanks to infrared emitter.

1. Architectural conception of the system

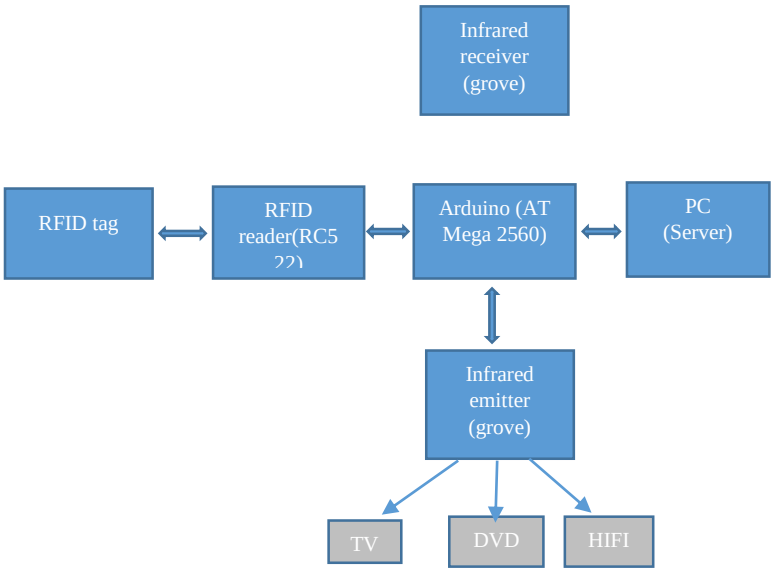

Fig4: Framework from the design.

The contactless reader, get the information about the tag, when this one is near of reader, and send these information to the Arduino board. In the Arduino one program is implemented to get from all the information sent by reader, the id of the tag. Then this tag's id is send to the PC. The PC search the set of action record for the corresponding id tag, and send it to Arduino. These action are a set of decimal coding value of the Infrared remote control protocol of home appliance (TV, HIFI…) that we have launch. The Arduino send these data to infrared emitter, which code them in infrared signal and control the desired home appliance.

2. RFID reading design

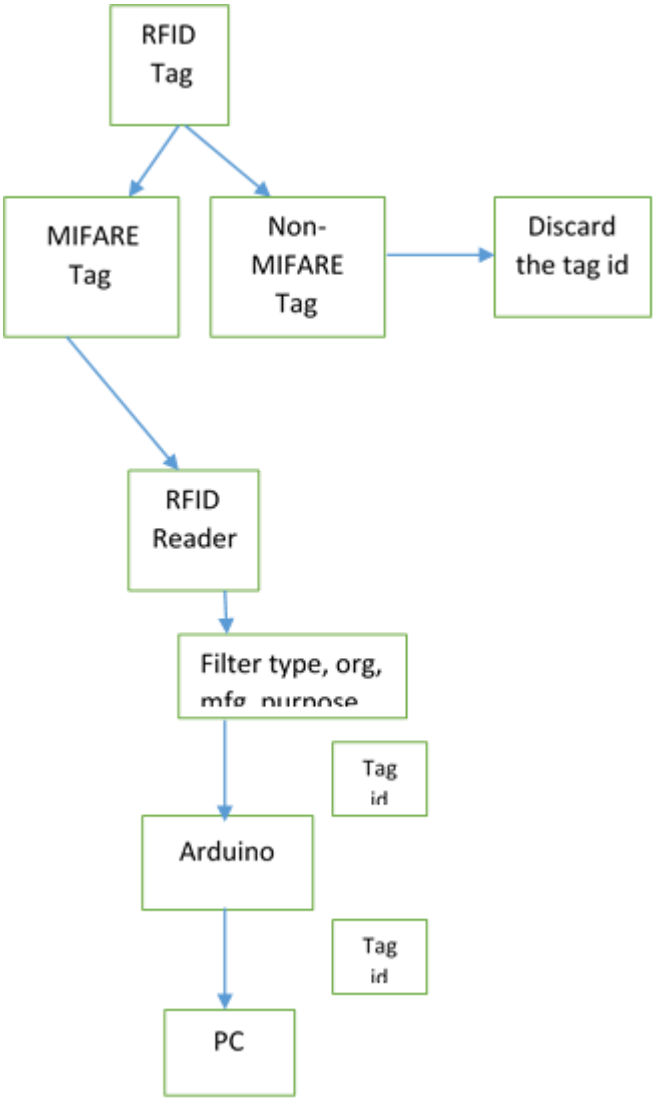

Fig 5: RFID Reading design

Figure 5 shows the RFID reading design performs the reading responsibility of RFID tag and on the basis of genuine tag, it sends the tag id to the RFID Reader. It discards the other card which don't follow MIFARE standard. Once the tag is detected, it checks the various information included the type of tag, manufactured date, purpose of tag, other information. Once the tag is genuine MIFARE tag, it filters the tag id and sends to Arduino which is connected with reader sequentially on SPI. Once the tag id reaches to Arduino, it forwards the hexadecimal id to PC which contains the application which lookup the corresponding Infrared id and sends the corresponding match to TV, HI-FI systems using emitter.

3. Infrared design

a- Infrared receiver

Due to large number of IRCP implemented in the device, in other to realize and autonomous system, we have design a circuit to decode the infrared signal from any remote, thanks to infrared receiver and Arduino. Then we can save this protocol in our database and control like an universal remote control any home appliance that we have save the protocol.

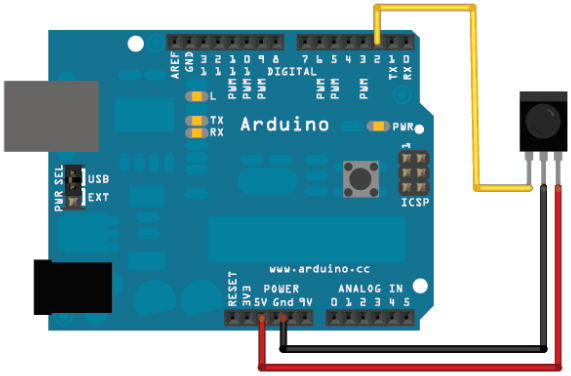

Figure 6: circuit of decoding infrared signal

The infrared remote control uses the frequency band 36 kHz – 38 kHz. In this project we use the infrared receiver grove, which include in his circuit, an infrared led, and a filtering circuit. As the infrared led absorbed any infrared signal, to achieve our goal (get only the signal from the remote control) we use a filtering circuit which leave pass only the frequency between 36kHz and 38Khz corresponding to the IRCP frequency.

Fig7: infrared receiver grove

ArduinoATMega 2560	Infrared receiver grove
Ground	ground
Vcc- 5v	Vcc
Pin11	Rx

Tab1: connection of receiver to Arduino

To program the Arduino, we use the IR remote Lib which is a github project, containing some library to manage the infrared signal and get from them different type of information, like the corresponding protocol, and decode the infrared signal to get the hexadecimal or decimal value of any control command.

b- Infrared emitter.

Once the command of IRCP are save, we can use the emitter to coding different action that we want to trigger, like switch on a tv, or start the DVD. We use for this case an infrared emitter circuit, made up of an Arduino board and an infrared emitter.

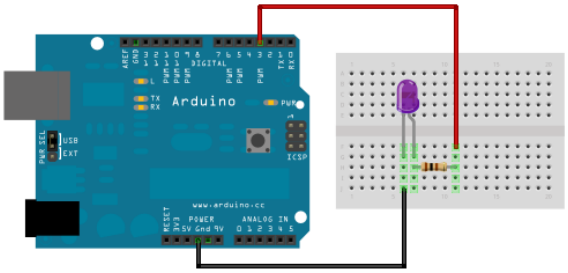

Fig8: circuit of coding of infrared signal

In this project, we use a grove infrared emitter, which included directly in the same circuit the infrared emitter led and the protection resistance, so this emitter can be directly connected to the Arduino.

Fig9 : Infrared emitter grove

Arduino ATMega 2560	Infrared emitter grove
ground	ground
Pin 9	Tx

Tab2: connection of emitter to Arduino.

We use again the IR remote Library to coding the value to send in the correct protocol, and the emitter convert the bits received in the infrared signal sent to the home appliance to control.

4. Design of Pc software

The purpose of PC purpose is to save the correspondence between the id tag and the set of instruction to trigger for this tag, and sent these actions to the Arduino board when it received the tag id. So the software have to save in the light format the id tag and the desired action related to this tag. We use in this project the Xml format to save all of data in the file. The different IRCP are hardcoding in the java program, but this is one of lacking of the project, because the IRCP are too many, and we should anytime modify one part of the code to add the new protocol registered.

The communication between the PC and the Arduino is the serial communication, through the USB port. The algorithm below show the functioning of the PC software.

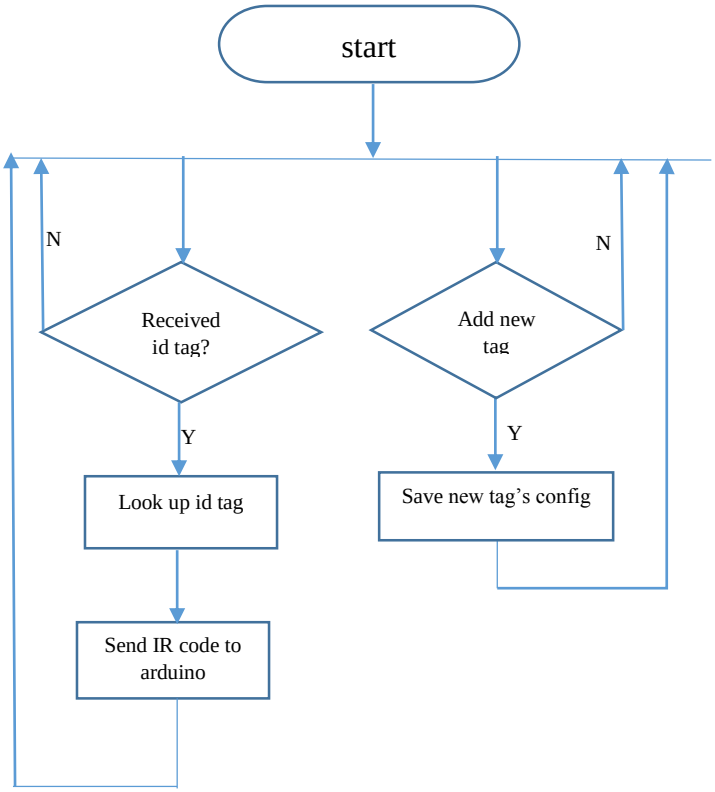

Fig10: PC sofware's work flow chart.

CASE OF APPLICATION

To validate our system, we got the command of a LG remote control (AKB72915207) with our infrared receiver, and we have used it to realize an scenario, where we have an tag representing an object of child, the reader (MFRC522 Reader), an arduino board (ATMega 2560), a Sony's PC acting as a server and a grove infrared emitter.

When we approach the tag to reader, we read the id of this tag in the console of the PC, thanks to the Arduino which is connected to PC via a serial communication. Then the PC look up the id tag in the database file, and send the command captured with infrared receiver, in order to switch on the TV.

1. Image of our realization

The image below show the circuit of the infrared receiver and the global system circuit.

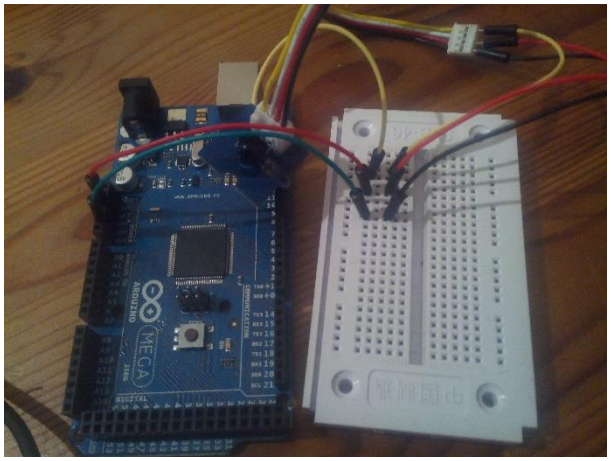

Fig11: circuit of infrared receiver

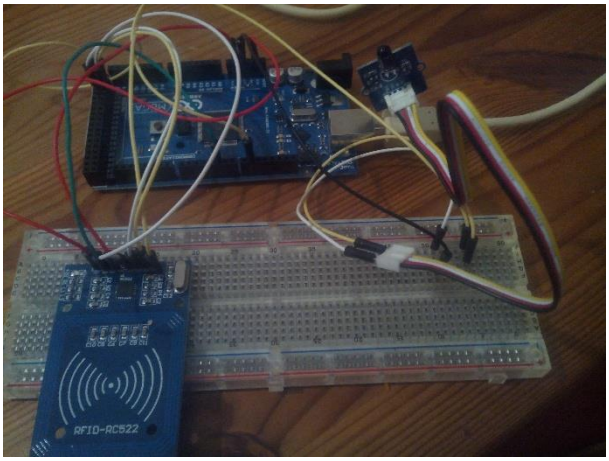

Fig 12: circuit of whole system.

2. Decoding the infrared signal of LG remote

command	Hexadecimal value
power	20DF10EF
Vol+	20DF40BF
Vol-	20DFC03F
Page up	20DF00FF
Page down	20DF807F
menu	20DFC23D
OK	20DF22DD

Fig13: Some command of LG remote.

The figure below show the serial console of the Arduino board. We can also see that when we apply directly the same command two time, the second time the corresponding hexa decimal code obtain is

FFFFFFFF. So we can conclude that this command correspond to “again” for the previous command.

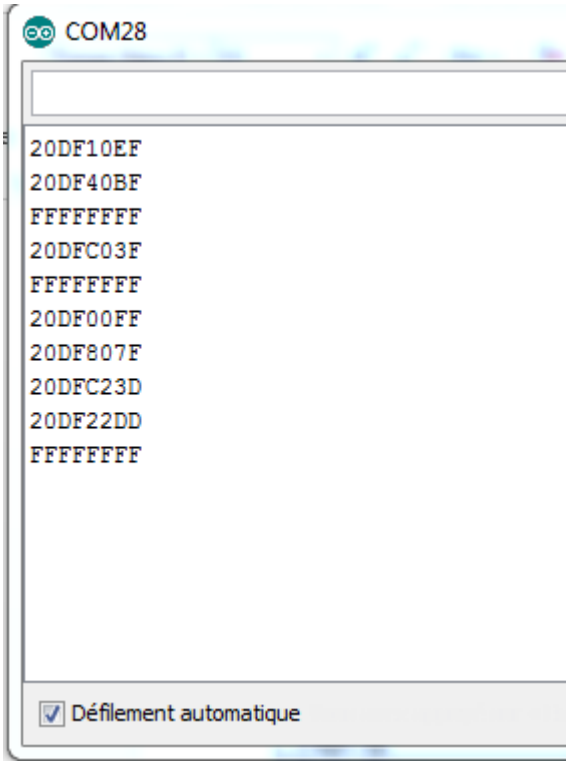

Fig12: console of Arduino in the infrared received circuit

3. Interpretation of the result of the testing of our scenario.

The result of the testing scenario proves the fact of correct detection and transmission from one entity to other entity of the tool. It provides some decoding to find out the anticipated actions to be triggered. The result also shows that hexadecimal code are being transferred from one end to other which guarantees to be good data sent and at the same time, Data sent and action triggered are also corresponding to each other which ensures functional operation in TVs and HIFI system. The tool uses HF frequency which also take care of the children’s health inside the house. With all points taken into account, the smart tool is observed as good prototype for engaging children.

The Reader and tag communication is based on Near field communication in which the maximum distance between the reader and tag can be 20 cms but we realized that the RFC522 IC was able to detect the MIFARE tags up to distance of 5cms only. The smart tool provides the better list of interests and identifies the different tag ids associated with different activities.

PERPESPECTIVES

Our work in this project consists to provide one autonomous system which can supply the parent to take care of the child, using RFID technology and the infrared remote control to manage automatically the home appliance for the child. We remark some lacking in our project which constitute the perspective of this.

First the possibility to add new protocol in our system, due to large number of existing IRCP and the possibility to new one, it will be good to find the way to add automatically the new IRCP in our software.

Second, the sensor on the home appliance will be a good thing, because our system at this state doesn’t know if one command has been correctly get by the device or not. For example, to switch on the tv, if when the signal is sent, someone pass in front of the system, the signal will not reach the tv, and we don’t have a way to detect it.

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