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# IoT Based Secure and Energy Efficient Home Automation

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**Abstract:**

The concept of Internet of Things experiences a rapid growth with the ongoing technologies and plays an important role to collect and exchange data in the real time using embedded sensors. The main purpose of Internet-connected devices is to enable people to communicate with each other, as well as allow the devices to communicate and access the online data. IoT has a variety of applications including security and safety, automation, ease of work, time and energy conservation, etc. Few of the most important applications of IoT include agriculture, health, traffic monitoring, etc. Smart Home being one of the most common and best applications of it, can be implemented on a small as well as a large scale. Our paper is designed and modelled to implement energy conservation and security features – user authentication for a small home. In this paper, the main door is authenticated using RFID tags, followed by automated lighting using the PIR and LDR sensors to detect the motion and switch the lights on and off accordingly. The mobile application displays temperature, humidity values and access details from the ThingSpeak Cloud which collects data from the DHT sensors and RFID Reader through the NodeMCU Microcontroller. The idea of the paper is to have a feasible automated home at small scale level, with the main idea to provide security and conserve energy. The prototype can be extended with other features such as smart bins and overhead tank monitoring systems..

**Keywords:** IoT, RFID, Micro Controller, Automation

## 1. Introduction

Internet of Things (IoT) connects a large number of embedded devices to the Internet. It is a networking of physical objects that contain electronics embedded within their architecture. They communicate and sense interactions between each other with respect to the external environment. These devices along with people need to communicate with each other. The devices could be tracked, controlled or monitored using remote computers connected through Internet. The sensor data needs to be provided to cloud storage to go for further processing and analysis [15].

With the increase in the criminal activities, burglaries, break-ins, etc. the need for security increases and demand for safe homes rises. There are many families where both parents are working. This leads to the need of basic secure home, where the parents can go to work without worrying about the house or the kids, if left alone. Here comes the idea of bringing in smart homes that is now possible with the emergence of the Internet of Things. Smart homes are an effective way of integrating multiple devices to achieve an automated, smart and a secure home. Most of such families, who have both adults working, come from a middle-class background, making the purchase and set up of the security systems unaffordable [12].

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With the aim to build and make a prototype that is affordable and feasible by providing basic security and conserving light energy, we propose a model that works on Arduino and Node MCU. The Ultrasonic sensors sense the entry of the car at the main gate, and switch on the path lights. When the car is parked in the garage, the garage lights are also turned on, sensing the distance with the ultrasonic sensor. This is built to save and conserve the electricity. Next, the door is authenticated using the RFID tag and reader to grant access only to the authenticated users. Once inside, the lights are turned on after sensing the motion and the intensity of the light present in the room. Along with this, the humidity and temperature is also checked and regularly uploaded to the cloud. There are three ways to check the execution [14]:

1. On the Web Application (ThingSpeak Cloud)
2. Through the model/prototype
3. On the Mobile Application

In today's world, security is a highly demanded need, rather than a luxury. The need for secure homes has increased, along with the need to save and conserve energy. Hence,it is very important to address the ways to reduce power consumption. The aim of this implementation is to demonstrate the automated control of lights to save energy, facilitated by ultrasonic sensors that turn the lights ON and OFF by calculating the distance of the car, as well as by the PIR motion sensor, by sensing the motion, or presence of a human body.

Having a secured home with high level security systems is highly expensive and unaffordable for many families. The aim is to design a model that is affordable and feasible, providing basic security at a minimal cost. This is done by using RFID tag and an RFID reader that gives access only to the authenticated users. This system is designed to reduce the cost, but at the same time provide the basic security features. [13].

## 2. Relevant Work

John A. Stankovic in the paper "Research Directions for the Internet of Things" highlights things that many communities, be it Internet of Things, Mobile Computing, Cyber Physical System( CPS) etc are trying to achieve smart devices/ homes/ cities, by relying on underlying technologies such as Machine Learning, Big data, Security etc. This paper puts forward different research areas to be addressed for better and advanced offering of services like architecture and dependencies, security, privacy, openness, massive scaling, human in pool etc [1].

Ahmed Khalid in his paper "Internet of Thing Architecture and Research Agenda" presents the 3-layered architecture of IoT. These are named as Perception, Network and Application. He focuses the need for research on various domains like Identity Management, Communication and Network technologies, Software, Services and Algorithms, etc. Research in this field is very necessary as these issues will remain hot topics in future as there will be an increase in number of devices to be connected to the Internet. Estimates suggest that the number of devices that will be connected to the Internet will be 50 billion by the year 2020 [2].

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Amine Rghioui et al. in the paper "Internet of Things: Visions, Technologies and Areas of Application" highlights the technologies being employed in implementing IoT. RFID-Radio Frequency Identification is a key technology in identifying objects using radio signals by sticking an adhesive tag on objects. WSN-Wireless Sensor Network is another technology which is a network of sensors connected wirelessly used in detection of physical conditions such as temperature, pollution levels, humidity, etc. Other technologies being discussed are Middleware, Cloud Computing. Further Challenges being faced by IoT and its applications in various fields are also discussed. A faint idea of future of IoT is also depicted [3].

Pallavi Sethi et al. in their paper "Internet of Things: Architectures, Protocols, and Applications" discusses various Architectures being presented for IoT with most of the Architectures having Perception Layer focusing on sensing, preprocessing, A Communication/Network Layer for devices to communicate with each other and Application Layer as common ones. The IoT Network Protocol Stack is also discussed and comprises of Physical and MAC, Adaptation, Network, Transport and Application Layers [4].

Sandip Sonawane in the paper "Survey on Technologies, uses and Challenges of IoT" discusses different technologies like the use of RFID to transmit the identity of an object, Cloud for data pre-processing, post-processing and analysis, Machine to Machine (M2M) as a Communication Technology, Sensors and Actuators to gather data from the environment and to perform necessary action and Wireless network connectivity. Challenges of IoT include privacy issues, security concerns, availability, energy management, inter-operability standard issues [5].

Muhammad Bilal in the paper "A Review on Internet of Things Architecture, Technologies and Analysis" expressed an IoT through a simple formula IoT=Services + Data + Networks + Sensors. The Key Technology Enablers include tagging things with RFID, sensor technology, making things smart, use of nanotechnology [6].

Samson Otieno Ooko in the paper "A Comparison of Arduino, Raspberry Pi and ESP8266 Boards" compares the GPIO pins, Processing Speeds, type, memory, storage, power consumption and operating voltages of the three boards, Raspberry Pi having the highest storage and fast processing speed making it a mini computer. ESP8266 NodeMCU being able to connect to the Wi-Fi. Arduino is an open-source board having its own open-source IDE [7].

Moyeed Abrar in his research article "Interfacing a Servomotor with Arduino Uno Microcontroller" discusses the principle, features and operation of servomotor consisting of three components Controlled device, output sensor and feedback system. Hardware design, experimental setup, system specifications are mentioned in detail [8].

Yogendra Singh Parihar in his paper "Internet of things and Nodemcu A review of use of Nodemcu ESP8266 in IOT" gives a brief description about Arduino which is an Open Source platform, its hardware design is open to edit/modify/build. NodeMCU Dev Kit/board consist of ESP8266 wifi enabled chip. The ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. NodeMCU uses an on-module flash-based SPIFFS (Serial Peripheral Interface Flash File System) file system. Development Platforms: Espruino,

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Mongoose OS, Software development kit (SDK) provided by Espressif, ESP8266 add-on for Arduino [9].

## 3. Proposed Architecture

There is no single consensus on architecture for IoT, which is agreed universally. Different architectures have been proposed by different researchers.

Different components in IoT Architecture:

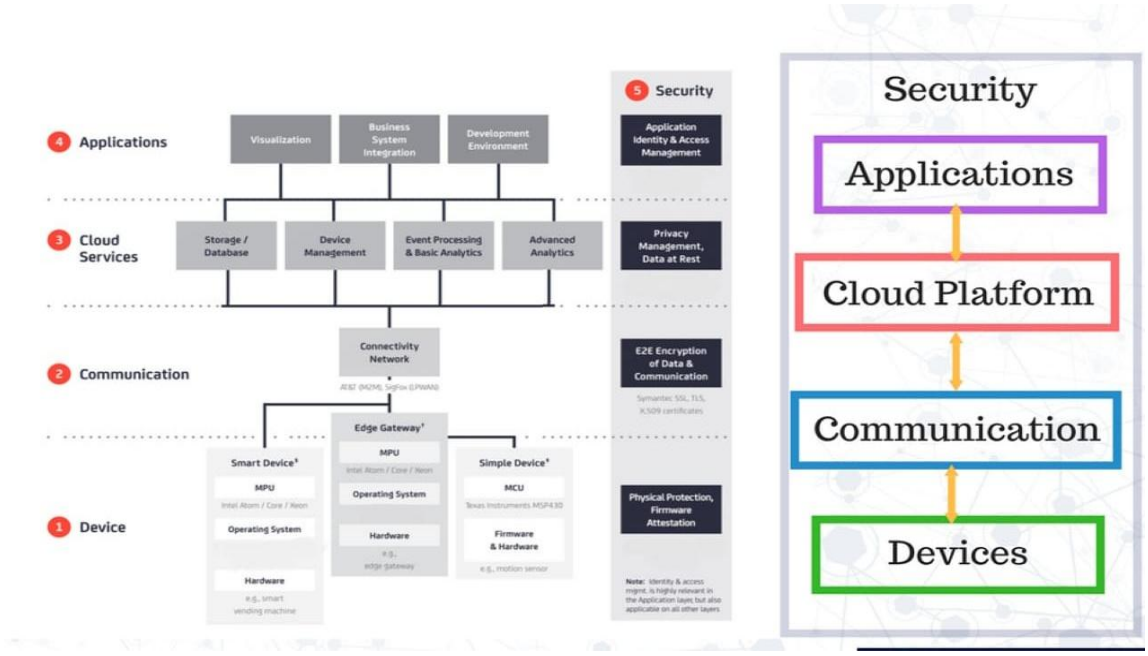


Fig. 1 Generalised IoT Architecture of any IoT System [10-11]

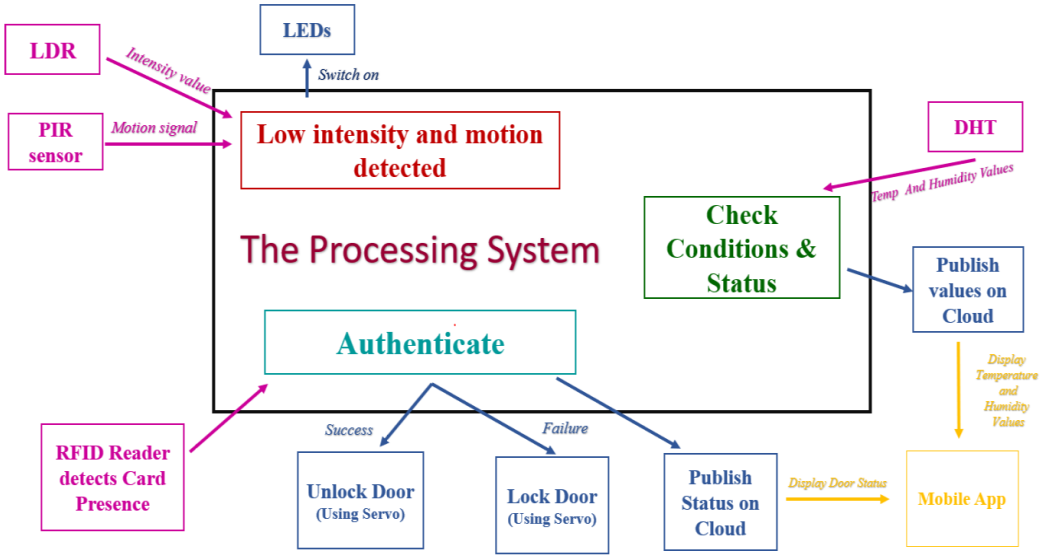


Fig 2 Block Diagram of the Proposed System

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The prototype of the home for demonstrating the paper is described in detail as follows:
The prototype Home consists of an entrance/exit gate, a front yard that leads user/car to garage (for the car to be parked) and the main door of the house building. The house consists of two rooms. The diagram below shows how the different devices are placed in the prototype.

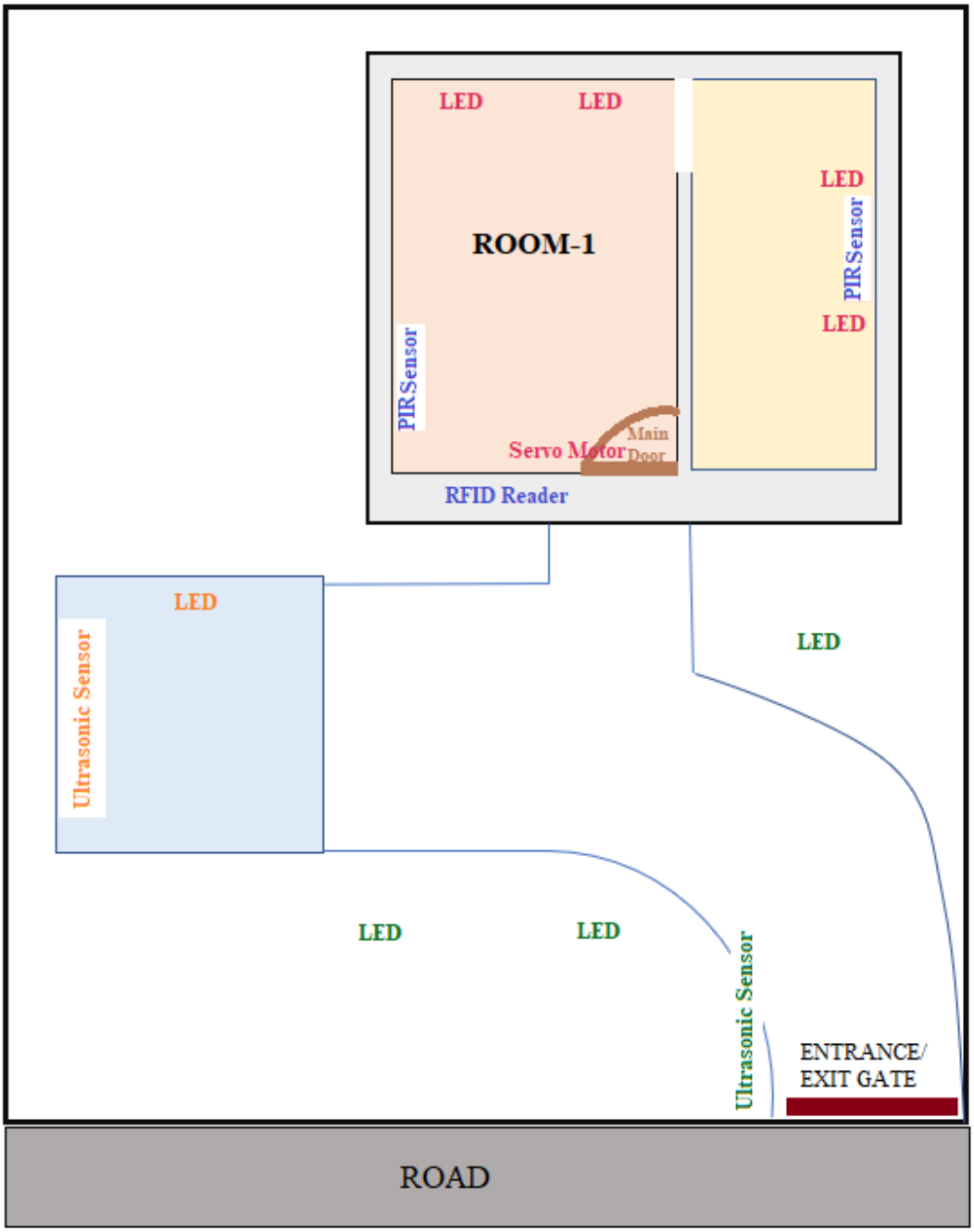


Fig 3. House Plan of the Prototype with Sensors and Actuator Locations

**Devices**: A "Device" is an object equipped with **sensors** that gather data which will be transferred over a network and **actuators** that allow things to act (for example, to switch on or off the light, to open or close a door, to increase or decrease engine rotation speed and more).

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Devices used in this layer for our paper includes different sensors, actuators and processing boards.

Sensors used are Ultrasonic Sensors, RFID Reader and Tags, PIR Sensors, LDR Sensors.

- LDR: Suitable LDR values for the different conditions is presented in the table below:

| **Lighting Condition** | **Mean Value of Light Level (in lux)** |
|---|---|
| Dark Indoors | 125 |
| Dim Indoors | 300 |
| Normal Indoors | 700 |
| Dim Outdoors | 7500 |
| Very Dark | 30 |

  Therefore, to demonstrate on the prototype we have taken the threshold to be 300 lux.
- PIR Sensor: PIR sensors are used indoors in the prototype to demonstrate effectively. On detecting presence of infrared bodies, the sensor sends a high pulse to the Arduino Uno on the pin to which it is connected to.
- Ultrasonic Sensor: It uses SONAR (SOund Navigation And Ranging). It has a transmitter and receiver within it. A square pulse is transmitted in the surrounding. When the pulse encounters an object, it gets reverted, which is received by receiver in sensor and is acknowledged at echo pin.
  Distance = Speed of sound (0.034)*(time/2). Here time calculated, is the time to travel from the sensor to obstacle and back to sensor (hence it is divided by 2). We use two Ultrasonic Sensors, one placed near the entrance/exit gate and the other in the garage. The distance measured from the sensor to the object is sent to Arduino Uno.
- RFID Reader and Tags: Whenever and RFID reader detects the presence of an RFID tag, it reads the unique ID associated with the card and sends it to the NodeMCU for further processing. Hence RFID tags act as keys here.
- DHT11 Sensor: It measures the temperature and humidity levels inside the prototyped house and sends the values to the NodeMCU for further processing.

Processing boards include Arduino Uno, NodeMCU ESP8266

- Arduino Uno: This microcontroller runs the code for Automated Lighting system which is a component that does not require sending any data to the cloud. It is responsible to check if any presence is detected in any area/room (through the distances received by Ultrasonic sensors are less than the values of the threshold, or when PIR sensor sends a HIGH pulse) and when this is the case it then

switches on the LEDS for the particular area/room where the presence was detected.

- NodeMCU ESP8266: This device runs the code for the modules:
  "RFID Card Authentication" and "Temperature and Humidity Measurement".
  It is responsible to connect to the Wi-Fi network and send necessary data to the ThingSpeak cloud. The data includes the status of the door, the temperature and humidity values of the house. It is also responsible to authenticate the door access by comparing the ID of the tag read by the RFID reader to the ID of the tag that has access allowed to the house. On successful authentication, the servo motor is turned to an angle to allow the door to be opened.

Actuators used are LEDs, Servo Motor

- LEDs: These are switched on when presence is detected and light intensity is low. They remain off whenever there is no presence detected or when the light intensity is high.
- Servo Motor: Is responsible to allow the main door of the house to be locked or unlocked depending in the authentication.

**Communication**:As the Internet of Things is growing very rapidly, there are a large number of heterogeneous smart devices connecting to the Internet. IoT devices are battery powered, with minimal compute and storage resources.
In our paper we are making use of the HTTP, IP and the Wi-Fi IEEE Std:802.11 communication protocols and technologies.

**Cloud Platform**: IoT cloud platforms bring together capabilities of IoT devices and Cloud Computing delivered as a service over an end-to-end to platform. They are also referred by other terms such as Cloud Service IoT Platform. In this age, where billions of devices are connected to the Internet, we see increasing potential of tapping big data acquired from these devices and processing them efficiently through various applications.

We are making use of the ThingSpeak IoT Platform. It uses API Keys to give access to device to read/write data from/to the cloud channel. It gives a URL to read the channel feed, which gives us the JSON object of the data it is storing. This URL is then used in the MIT App Inventor, so that the app periodically reads the data from this URL and displays it to the user.

**Applications**: This layer where we can say its presentation layer or decision was taken layer. Based on the requirement we can display reports or applying machine learning or some custom logic and takes a smart decision and send a signal back to the sensors.

The mobile app is implemented using the MIT App Inventor. The App reads the data fields from the cloud periodically, processes the data and displays it to the user. The displayed data includes:
The temperature and humidity values
The current status of the door (Locked or Unlocked), the date and time when the last time door was successfully unlocked and when the access was denied to an unauthenticated user

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## 4. Discussion & Results

With the aim to make a prototype that is affordable and feasible, we successfully designed a model that is secure and cost-effective by providing basic security and conserving light energy at low cost. As the demand for smart home increases, so does its value. Execution of the paper is successfully shown in three ways:

The Model- prototype made, that shows the working of the paper.

On the ThingSpeak cloud to store the value of the data recorded by the sensors.

On the Mobile Application to show the humidity and temperature values, and the door access status.

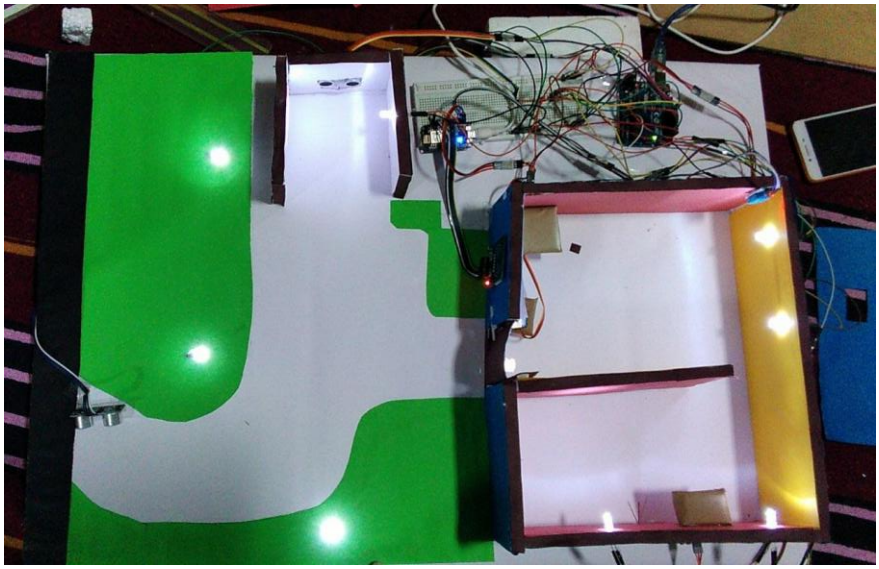

Fig 4. The Prototype

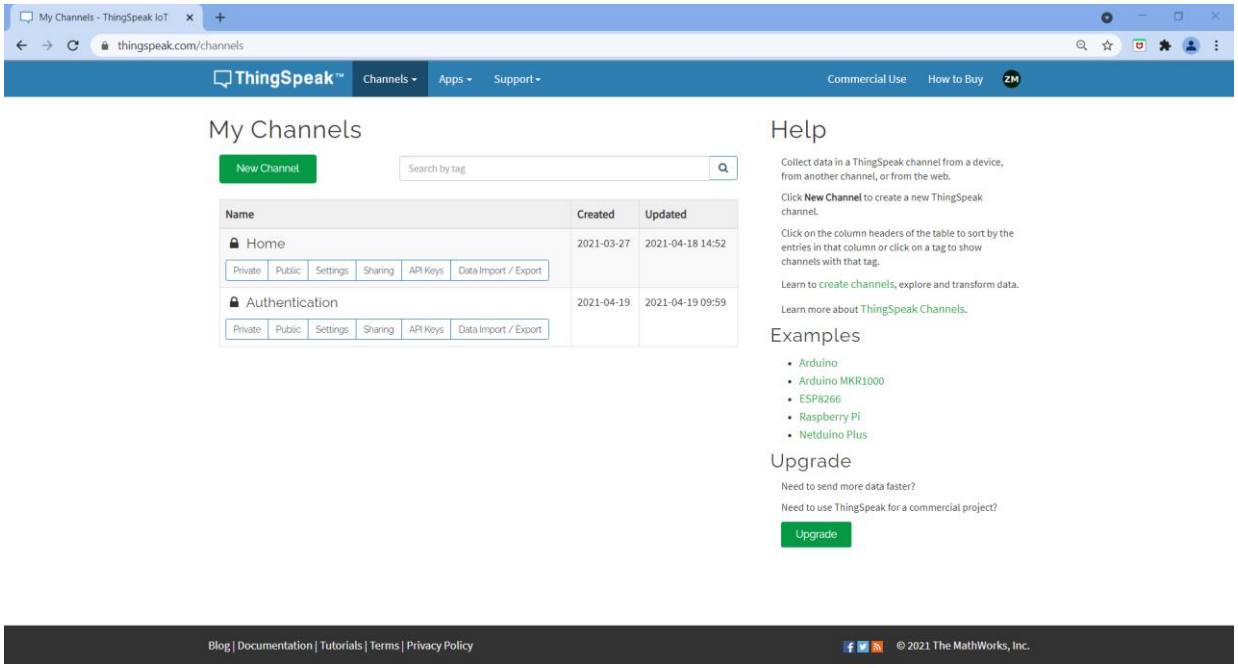


Fig 5.The ThingSpeak Cloud

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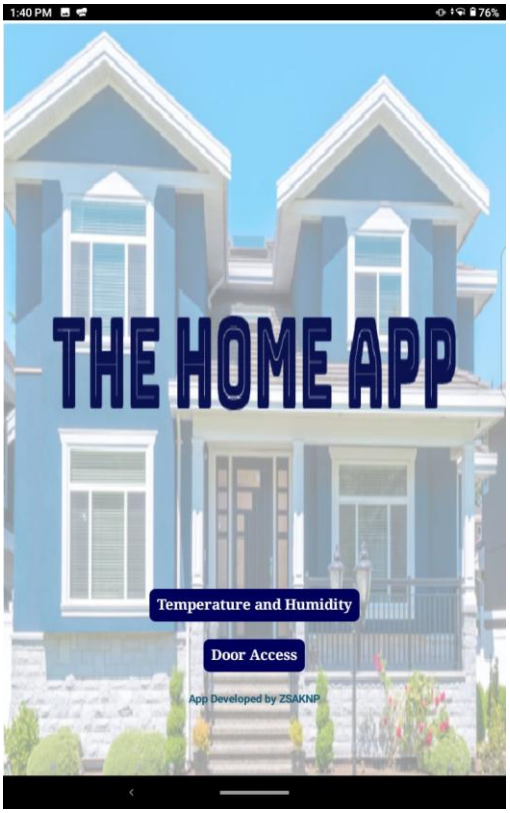


Fig 6 The Mobile App

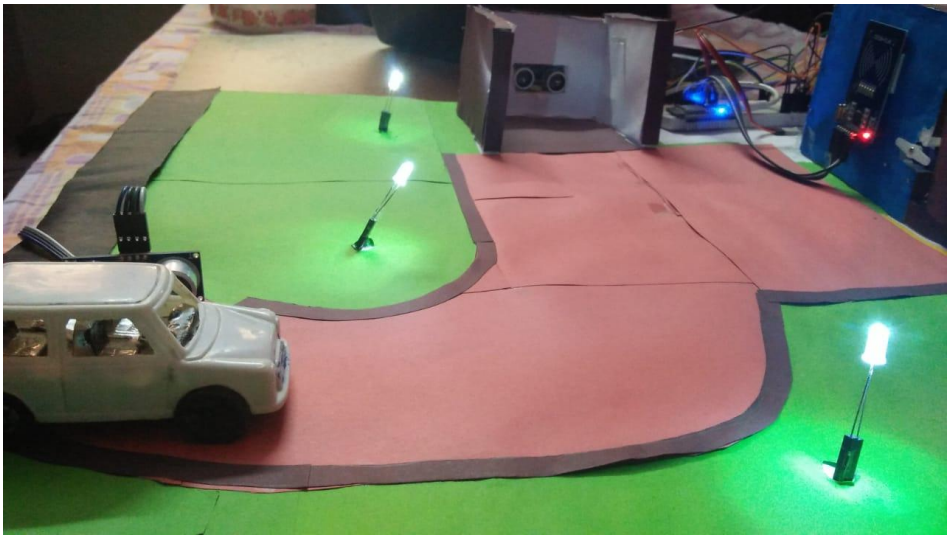

Fig 7. Light Automation when presence is detected near Gate

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Fig 8. Light Automation when presence is detected in the Garage

## 5. Conclusions

As the demand for smart home increases, so does its value. We intend to make a prototype such that it can be affordable and bought by every family so that they feel safe and secured, in minimal expense. Safety is the need, and this prototype demonstrates a safe home for all families, irrespective of the high price. This is done by using minimal hardware and achieving the security by having the authentication done at the door.

The prototype is basic, but can be enhanced to a better version, by adding a few features to it. The app can be advanced to handling the light control manually, to switch them on or off. There can be an addition of controlling the windows, fans, ACs etc. from the app depending on the temperature and humidity given by the DHT sensor. The authentication can be separately put up on the main gate for more security, and alarms can be installed to alert the neighborhood if there is an unauthenticated entry. Furthermore, the app can also be extended to send notifications when a user is given or denied the access to entry as a precautious step

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