iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** IX **Month of publication:** September 2022

DOI: https://doi.org/10.22214/ijraset.2022.46859

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue IX Sep 2022- Available at www.ijraset.com

Design of Smart Home Automation Systems with Advanced Security Configuration

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Abstract: ***With the rise of cloud computing and sensor man- ufacturing technologies, the IoT revolution is almost here. This has been the trend since past 10 years with an estimation of at least 10 billion smart devices in the market/use by 2020. But the truth is, the revolution is not yet here and the main reason for that turns out to be the security. As long as the Cloud interferes in the user's data, these security issues shall prevail.***
Keywords: Internet of Things (IoT), Home Automation, Smart homes, Communication Protocols, Cloud Computation, GSM Module, Wi-Fi Module, Parashu Micro-Processor

I. INTRODUCTION

In layman terms, IoT is a platform where devices connected over the internet will be able to communicate with each other without requiring human-to-computer interaction. The devices having the ability to connect to the internet, known as smart devices are embedded with sensors, softwares and other necessary technology allowing them to connect to a cloud server where data is shared among other devices connected to the network.

Home automation gives you the access to control your devices in the home from any corner of the world. Although home automation is not something new to the world, the IoT revolution has helped in fastening its growth and development. The idea of cloud-powered smart homes sounds good, but they do come with disadvantages. Since home automation involves connecting to a cloud server, all the data from the smart devices can and will go to the cloud. Also a consistent internet connection is required for devices to stay connected to the cloud and an internet outage will simply mean that the smart devices will not work. Another major issue with devices connected over the cloud is that the data is continuously sent to and from the cloud, making it highly vulnerable to cyber-attacks. This puts the user's personal information at risk since it is possible for hackers to hack into home systems. So taking all these issues and concerns into consideration we aim to design a home automation system where security is of utmost priority. In our design we try to eliminate the need of cloud computing and employ a design which ensures that the smart home data is restricted to the home.

Taking a country like India, where smart devices are not really into the essential systems of consumer houses, home automation still looks like a long shot. So, here, we're trying to solve the two main problems of the home automation systems.

1) Creating an automation system that can also be imple- mented with non-smart devices (at least to control the essential systems like the lighting).
2) Eliminating the use of cloud to handle most of the user data collected by various smart devices (if not all).

II. BUILD AND INSTALLATION

The system consists of the controller module at its heart. This is the brain of our system. From figure 1, we can see that it takes inputs from various modules (GSM, Wi-Fi etc) and gives out the necessary control outputs to various devices via wired outlets or Wi-Fi and GSM modules. The "Shakti processor" comes into picture here. This control unit has a separate memory storage to store necessary programs. All these modules together are called main block . Besides GSM and Wi-Fi modules, the controller module also controls a few contactors that are installed in the electrical circuits of the house/building. Now, the main block can be installed anywhere in the house. But a place with good connectivity to Wi-Fi and reach to all the electrical circuits (main) would be a good place to start.

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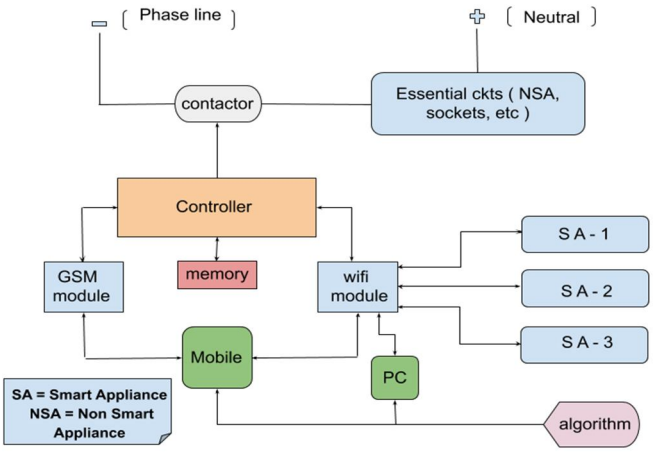

Fig. 1. Basic Block Diagram

III. FUNCTIONALITY

The systems main functions can be divided into three broad classes:

1) Control of the building's electrical circuits
2) Control of smart devices
3) Emergency systems

The control of essential circuits of a house is done by physically modifying the electrical circuits of the clients house i.e, we install contactors in the circuits of these essential appliances (like lighting, sockets, fans etc). These contactors are controlled by the control signals generated by the controller module. The control unit can either take the instantaneous command given by the user interface (a mobile application) through the GSM protocol or the Wi-Fi protocol OR the set of programs already stored inside the memory storage of the Main Block. (these programs stored in the Block's memory can be edited from time to time or even new ones can be added). "This will serve as our primary objective for time being".

The control of smart devices can be obtained by creating a Local Area Network, where the commands to the devices are issued by the processor instead of the cloud (Check the "Smart Home Concept" in the end).

There is one more function to be discussed. Emergency systems can be implemented here since the Controller module makes use of a GSM module. In times of a security breach or a medical emergency or any other accident, the controller module can send SOS signals to nearby medical services, police stations, fire stations and close contacts of the user. This panic mode in the controller module can be triggered in various ways depending on the client's building. A panic button can also be included in the user's interface (handset say).

The system functions in two modes of operation namely proximal mode and non-proximal mode.

a) *The Proximal Mode:* It is basically when the interface that the user has (a mobile phone for example) is in the LAN. All the communication between the interface and the controller module takes place through Wi-Fi. The utility here is huge. The smart devices can be includedin the LAN.
b) *The Non-proximal Mode:* It is when the user interface is not in the LAN (say, far from home). Here the controller module makes use of a GSM module. Thus making a private and secure connection from the user's handset to the home system. The security is definitely an advantage but the trade off is that the utility is rather limited. As a result of low data, complex tasks like live streaming of security cameras cannot be achieved.

A. The Wi-Fi Protocol

Wi-Fi (Wireless Fidelity) is a radio-controlled technology which transmits data through air using radio frequency. The initial speeds of Wi-Fi are 1 mbps to 2 mbps. Wi-Fi sends data in a 2.4Ghz frequency band. The Wi-Fi protocol enables the connection between the Wi-Fi Module and the Wi-Fi Router. This Wi-Fi Module is attached to the microprocessor. As the router can only communicate to a minimum number of devices, we introduce a node in between the smart devices and router. This node helps to establish better communication between the smart devices and the Wi-Fi module.

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And the whole operation takes place from the user mobile. The bridge between the smart devices and the user commands is the router. Here the router plays a major role, it usually collects the commands from the mobile and it sends to the Wi-Fi module. The Wi-Fi module sends the data to the microcontroller, thereby it will process and send back the commands to the router. And the router as the mediator again establishes the connection to communicate with the node. This node receives the command signal and redirects to a proper smart appliance.

B. The GSM Protocol

The GSM module/modem is directly connected to the microprocessor. The processor acts as a bridge between the GSM modem and the sensors of connected devices . This module works in the same way as a normal cellular phone would work. It will be able to make calls, receive SMS and send SMS. This communication over GSM is done using a set of commands known as AT commands. The GSM module consists of a sim slot, power jack, GPIO pins, few status LEDs and also an RS232 connector which helps in physically interfacing the GSM module to our processor. The RS232 connector is used for serial communication and establishes a link between DCE(Data Communication Equipment) and DTE(Data Terminal Equipment). Though parallel communication is faster, it is not used in this setup because of its increased complexity. The rate of data transmission over the RS232 may be comparatively low, but it provides us with a means of secure communication. Now to control our devices using this model, we will first send a message to the registered SIM card, this information is channeled to the processor over the RS232 cable, the microprocessor now decodes the instruction to give device address and command. Then the processor generates a control signal and then sends it to the driver of the power circuit to perform a particular task.

IV. THE SMART HOME CONCEPT

The Smart Home concepts in existence today rely com- pletely on IoT. I.e, the smart devices can collect a wide range of data from the user. (from the blood pressure to the most watched channel on TV). These devices cannot store the data they collect. Thus they upload it to the cloud continuously. This huge amount of data is then processed in the cloud using complex algorithms and the resultant programs (commands) are sent back to these devices. This system is pretty elegant but the tradeoff is the Privacy and Security of the User. Therefore, with such sensitive information collected from the user, any third party cannot be involved.

We are thinking of a different take on Smart Homes. The goal is to restrict all the information collected from the user to a particular

LAN (their own home). The problems to be solved here are:

1) Data storage
2) The processing power required to process the data
3) Software to process data

The data collected from all these smart devices will be stored inside the “Main Block’s” memory. All this information can be transmitted to the Main Block’s memory through the Wi-Fi protocol.

The collection and storage of data is manageable. But processors like Shakti cannot process such amounts of data in the Main Block’s memory. So we can make use of a local PC in the LAN. A software shall be installed in the PC. The Data stored in the Main Block’s memory will be transmitted to the PC periodically via Wi-Fi when the user’s PC is in an ideal state. Therefore the data processing happens inside the PC of the user instead of the Cloud.

All the Algorithms required to process the data can be downloaded from the software present in the PC.

The results of these algorithms (set of commands) can then be transmitted back to the main block through Wi-Fi and stored in it’s memory. Thus the controller module can take these new programs from time to time to control the smart devices. The user’s experience with the home systems will be more and more personalised with each passing day.

Until now, We’ve only been talking about the programs to control the smart devices. But, the controller module can also control the electrical circuits of the house like lighting, sockets, fans etc (via contactors). These circuits can also be automated (instead of just executing the commands from the user’s interface). But it can be said that the programs here will only be primitive when compared to the smart device scenario. Since these programs are pretty simple, they can be downloaded in the user’s handset (application in the handset). Any basic processing required can be done in the mobile application itself. And the resultant command set can be transmitted to the Main block through Wi-Fi (GSM protocol can also be used here).

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V. HARDWARE RESOURCES

1) Controller module with PARASHU E-CLASS SHAKTIPROCESSOR (32-bit E-class SoC on Artix7 100T board)
2) GSM module
3) Wi-Fi module (LAN)
4) Smart sensors (as replica of smart appliances)
5) Contactors
6) Hard drive

The Parashu board is particularly chosen because it is provided with an Ethernet lite port which aids in high speed transfer of data from the hard drive to the local PC.

VI. TECHNICAL ASPECTS

Our entire design can be divided into 3 main blocks, the processor module, GSM module and the Wi-Fi module. The controller module with PARASHU E-CLASS SHAKTI PROCESSOR (32-bit E-class SoC on Artix7 100T board) is chosen to serve our purpose of home automation. Additionally a Wi-Fi router and a hard drive are used in the design for specific purposes which will be discussed. The interfacing or all the modules is discussed in the corresponding section.

A. GSM Module

This GSM module consists of a cellular chip at its heart. The operating voltage of the chip is around 3.4V to 4.4V. So, it can be easily powered by a Li-Po battery. The GSM module uses serial communication. An RS232 connector is used to communicate with the SOC, which supports the serial communication of data. The module also comes with pins which are essential for communicating with a microcontroller over UART (Universal Asynchronous Receiver Transmitter). A baud rate of up to 115200bps is supported by the module in addition to Auto-Baud detection. A 3dBi GSM antenna is used along with the module to connect to the network, which will allow for communication. The maximum on UART in this module is 2.8V, also the module does not contain an in-built voltage regulator. The power consumption of this module is also quite high with a peak current value of 2A. So in such a case it would be perfect to use the Li-Po battery which provides the above specifications and also the same voltage at these 2A peaks. Now our main job is to interface the receiver and transmitter pins of the GSM module with that of the Parashu SOC which will help in serial communication over the RS232 connector. Now to start off, we will first insert the micro sim in the given socket. We then connect our 3dBi GSM antenna to the NET pin which will connect to the network. The UART pins on the Parashu SOC will be at a higher voltage level. So we cannot directly connect the TX pin of the Parashu SOC with the RX pin of the GSM module, since the module will not be able to tolerate voltages above 2.8V, any voltage above the specified value will kill the module. So we need to somehow step down the voltage which is coming from the UART pin of the FPGA board to a low-level voltage. The simplest way to do this would be to use a resistive divider, in the required ratio which will bring down the voltage from the UART pin to a value tolerant by the GSM RX pin. Now after the hardware interfacing of the module is done, we will now move on to the software part which involves the actual communication between the GSM module and our Parashu SOC. Using the Shakti SDK we will be able to send AT commands to the GSM module which will be able to decode the particular AT command and perform the assigned task, which mostly involves sending SMS in our particular application. Communication here is two way, where the processor will also be able to read the incoming messages from the GSM module, again in the form of AT commands. Once the instruction is received by the processor, the processor may instruct to make or break the circuit using contactors. In this manner our SOC will be able to communicate with our GSM module. We will be able to communicate with our GSM module by simply sending an SMS, when we are far from our home. So this module is employed when we are away from the home, when we are in the house a far more efficient Wi-Fi module can be used for communication.

B. Wi-Fi Module

The whole point of having a Wi-Fi module in the setup is to establish a communication with the devices and the processor module, and also the communication should not involve the internet and also not connect to the cloud for storing information. We use this Wi-Fi module for proximal mode of communication when we are in the house.

The Wi-Fi module is interfaced with the processor module for communication with the processor. Now we need to some- how establish a communication link between the processor and all the smart and non-smart devices which we aim to control as a part of home automation. We need to establish a node point which will allow communication between the smart devices and the processor.

In our design a Wi-Fi router is used as the node point which will serve as an intermediate between the processor module and our devices which we aim to control. For communication over the router it is essential that the devices have a Wi-Fi module, so this mode of communication is only possible with smart devices which come with a Wi-Fi module.

In the most primitive case, this proximal mode of com- munication involves an instruction (may be switching ON or switching OFF an appliance) being sent through our smart phone which will be channeled via the router and then to the Wi-Fi module connected to our processor. Now the processor will be able to decode the instruction sent by the user and generate a new instruction or a signal to perform the particular task. This instruction from the processor will be sent to the smart device, again via the router, the Wi-Fi module in the smart device will then be able to decode the instruction received and perform the task assigned. This is the simplest form of communication which can be established over the Wi- Fi module.

Now, in a more practical case we would like our devices to communicate directly with our processor without an input from the user which is the main essence of home automation. We would like to have real time processing which will allow communication between the devices without human intervention. For this we will need an external hard drive which can be connected to the processor for storing the huge amounts of data which will be generated by the smart devices. The memory module of the processor will not be able to store such huge chunks of data, so to accomplish our task we will be needing a hard drive. Now once we have data from all the smart devices, the next step will be to analyse the data and generate programs based on some specified algorithms which will then schedule the smart devices based on its use pattern over a specified period of time.

The Shakti processor does not possess the processing power needed to process the huge amounts of data. To process the data generated by the devices we can use a local PC and run a predefined set of algorithms which will be able to generate useful information from the data which can be used to enhance the user's experience. When the PC is an idle state the data from the processor can be transferred to the local PC for processing it. An Ethernet port will be used for fast transfer of data from the processor module to the local PC. So, for this purpose the Parashu SOC is chosen, which comes with an in-built Ethernet lite port which will allow the fast transfer of data.

VII. BUSINESS MODEL

A. *Novelty*

The Smart Home concepts in existence today rely com- pletely on IoT. I.e., the smart devices can collect a wide range of data from the user and upload it to the cloud continuously. This huge amount of data is processed in the cloud using complex algorithms and the resultant programs are sent back to these devices. This system is pretty elegant but the trade- off is privacy and user-security. Therefore, with such sensitive information collected from the user, any third party cannot be involved. Also, modern IoT based home automation systems require constant internet connection. So here, we're trying to eliminate the use of cloud to handle most of the user data by creating a local field. Also, It's pretty obvious that IoT networks operate only in the smart domain (i.e, only the smart devices can communicate and interact with a IoT network). So here, we're also trying to create an automation system that can also be implemented with non-smart devices which acts like a pseudo IoT network.

B. *Opportunity*

Home automation is not something new to the world, the IoT revolution has helped in fastening its growth and development. IoTs are the obvious future. Even in the home automation industry. It's only a matter of time before smart home technologies become a basic necessity. Introducing centralised home automation systems can also create a better base for the already existing IoT devices in the market.

C. *Market Feasibility*

Customer service and feedback are very essential, our focus shall be on Indian Market initially (This includes IoT Market and Construction market). This will serve as our Addressable market for the time being. Since our focus is mostly on the Indian market, we'll currently be considering only the urban areas. Since our system can be installed in a home at any point of time, even after the construction of a building, we'll be targeting both pre-existing and new residential users and office users.

D. *Commercialisation Road-map*

The whole idea can be recognised and implemented with already existing technologies. So, no research is required.

The main vision of this innovation is to serve as a secure home automation system rather than having connection with cloud based computing

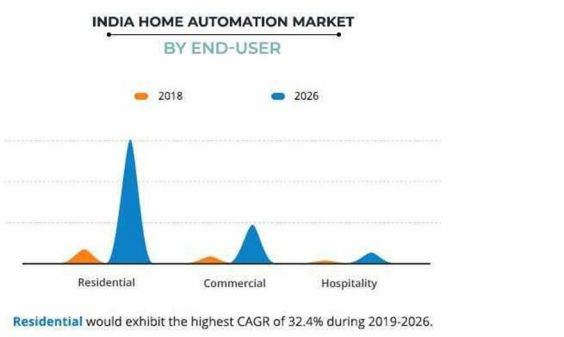


Fig. 2. Home automation growth in terms of end-user

1) First level entry products will have basic control over the electrical circuitry of the house. This includes the operation and monitoring of these circuits. Also, there will be some basic programs pre-installed in the main block's memory to be executed. Since the system has to be tailored specifically to each and every customer's requirements, The instalment shall be done by a company hired technician. Due to the sophistication required in this process, the product shall be launched only in a few selected cities initially.

2) The Forecast Period of 2020 to 2025 predicts that, there would be a CAGR of approximately 25% in the smart home industry globally.

3) The Smart Homes Market was valued at USD 64.60 bil- lion in 2019 and is expected to reach USD 246.42 billion by 2025. Coming to the Indian Market, Home automation market size was valued at USD 1,790.9 million in 2018, and is expected to reach at USD 13,574.1 million by 2026, growing at a CAGR of 29.8% during the forecast period 2019-2026. In 2018, the India home automation share is highest among the Security safety segment, owing to the growth in urbanisation. There has been a rise in smart home startups such as Oakter, Inoho, IFIHomes, and Home Brain in India owing to the government of India programs such as 'Make in India', and 'Digital India'.

Time with respect to launch date	Plan of Action	Why?
First Month	Models will be introduced into the market of a selected city	Initial feedback will be taken in the areas of product performance and customer service (including installment efficiency) and algorithms shall be refined based on real time user feedback
Third Month	Models will be introduced into the market of selected cities	Business expansion
Ninth Month	Increase of software workforce	For increase in development rate of algorithms required for enhanced user experience

Fig. 3. Road-Map

A. Challenges and Risk factors

1) Finding the ripe Time to Launch: IoT revolution has not yet gained its full momentum in India. There were predictions that the IoT industry would be prospering by 2020 in India. But considering a country this large, it's not an exaggeration to say that IoT (hence smart home concept) is still in its infancy here.

2) GSM Module Licensing: The method we proposed uses a GSM module to enable long range communication with the Home automation systems. So, we must either tie up with a third party cellular network provider or special licensing must be taken from the government to use the telecom infrastructure.

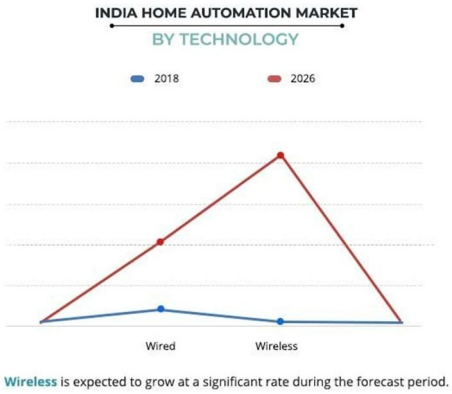


Fig. 4. Home automation growth with technological advancement

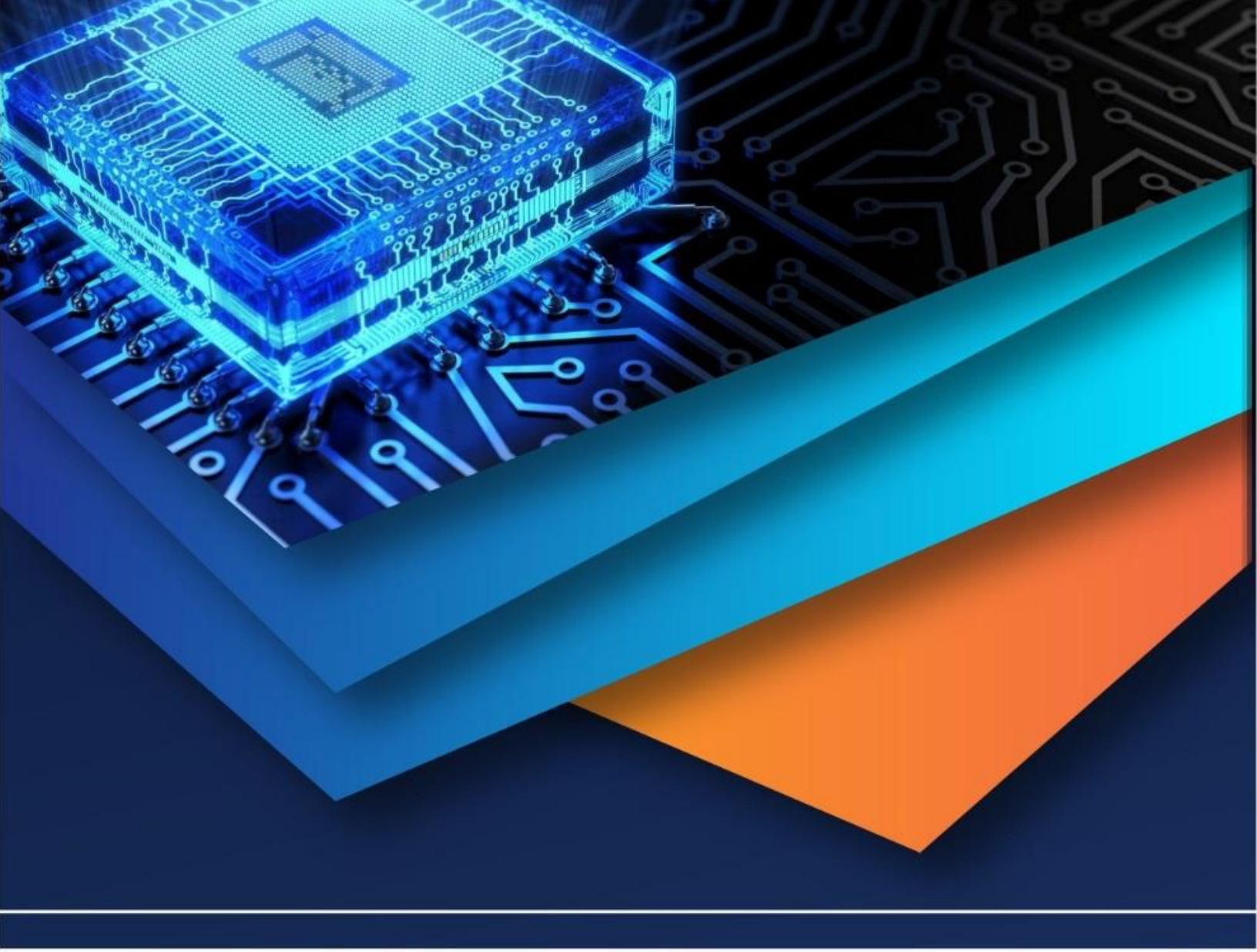
3) *Reliability:* Since most of the electrical circuits and sys- tems that are embedded in a house/building are controlled by a single centralised system, reliability and safety are two biggest technical challenges faced in product development.
4) *Customer's trust Factor:* It's a known fact that the major issue with IoT networks is privacy. Thus it's a tough task to break the stereotype and gain the customer trust even when the product is marketed as something that operates on a completely secured Local Network.

VIII. ACKNOWLEDGMENT

We would like to express our gratitude to Professor Dr. Manoj B.S., Ph.D. who was a source of constant inspiration throughout the development of the project idea. It wouldn't have been possible to do this project without his proper guidance and constant mentoring.

REFERENCES

[1] Amar Chinchane, A., Vivek Bani, B. (2019). India Home Automation Market by Product Type (Lighting, Security And Safety, HVAC, Entertainment, and Oth-ers), Technology (Wired, and Wireless), and End-User (Residential, Commercial, and Hospitality): Opportunity Analysis and Industry Forecast, 2019–2026. Allied Mar-ket Research
[2] Shelley Singh, A. (2020). Home smart home: India's booming home automation market . The Economic Times.
[3] Vaishali Wagh, Prof.Manisha Wasnik, 2014, Different Technologies Used in Home Automation – A Re- view and Comparison, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH TECHNOLOGY (IJERT) Volume 03, Issue 02 (February 2014)
[4] Ilyas Baig, A., Chiktay Muzamil, B., Salahuddin Dalvi, C.(2015). Home Automation Using Arduino WIFI Mod- ule ESP8266. Anjuman-I-Islam's Kalsekar Technical Campus Panvel.



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