



**NUST COLLEGE OF
ELECTRICAL AND MECHANICAL ENGINEERING**



Cloud Based Home Automation

A PROJECT REPORT

DE-40 (DC&SE)

Submitted by

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BACHELORS

IN

COMPUTER ENGINEERING

YEAR

2022

PROJECT SUPERVISOR

DR. RIZWAN MASOOD

COLLEGE OF

ELECTRICAL AND MECHANICAL ENGINEERING

PESHAWAR ROAD, RAWALPINDI

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DECLARATION

We hereby declare that the project work entitled “Cloud Based Home Automation” submitted to the Nust College of E&ME, is a record of an original work done by our group members under the supervision of **Dr.Rizwan Masood**. Final year project is required for the award of degree in bachelor’s in computer engineering. This report is submitted to the department of computer engineering of Nust College of E&ME.

All the results, data, figures,tables and the research included in this report is not submitted to any other institution or any other organization.

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We express hearty regard to **Dr.Rizwan Masood** for providing us guidance throughout this project. With dedication, motivation and inspiration we finally became able to pave our way towards the completion of final year project. At first it was quite challenging for us to gather all the data, road map required for this project. Later on after consultancy with **Dr.Rizwan Masood** we became able to identify the resources including both hardware and software part required for our project.

Dr.Rizwan Masood partitioned project in to three phases and every phase has to be completed in the specific time slot. This divide and conquer technique made the working of this project more interesting.

Apart from doing his daily work, our supervisor has shown personal interest in this project, at every step he appreciated our work which bloomed the spirit of motivation in us. His friendly attitude and guidance resulted in achievement of all the phases that we planned in planning phase of this project.

ABSTRACT

Cloud based home automation project is automation of home, using cloud computing. Cloud computing is on demand services including storage, virtual images of the operating system and the other resources required for the computation having ubiquitous access.

The major benefit of using cloud computing is to provide centralized storage with “security, real time complex computation” which normally requires some latency in personal computers. Keeping these points in view, for the sake of making the home appliances accessible round the globe 24/7 by utilizing **Microsoft Azure** cloud.

Previously there has always been a hassle of controlling the home appliances manually either by manually operating them or seeking help of some other person to do this job. But now the scenario has changed.

In the new era of technology all worries are faded away after the introduction of automation.

In order to achieve the goal of remotely controlling the appliances (smart and non-smart devices), This project is partitioned into three parts

- **Front-end user interface**
 - Website programmed in React Node Js. Responsible for the connection between the front end and azure services.
- **Azure cloud**
 - For the assistance of using the services required for this project including
 - **Azure Active Directory:** - Providing the identity services to our project
 - **Cosmos Database:** - Real time data base for storing the appliances data, states in real time
 - **Azure Web Service:** - For deploying the web application and making it available to users
 - **Azure Iot-Hub:** -For interfacing the “smart home hub” to Azure
- **Smart home Hub**
 - Hardware based solution for controlling the appliances including
 - Non-smart home appliances
 - Smart home appliances
 - Wireless Non-Smart appliances

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Chapter 1: Introduction

1.1 Introduction

Lately, the worldwide utilization of PCs and cell phones has inclined. It has increased the worldwide competition and need for organizations to venture into various geological regions to be supportable. To meet this demand, there is a requirement for the efficient use of assets in the pursuit of functional excellence. Distributed computing, an arising development looks to address these necessities. Despite of the fact that distributed computing is n't absolutely new, its commercialization begun around year 2000. Distributed computing just the arrangement of data innovation (IT) arrangements as a help instead of as an item through the Web. As such there may be fierce competition amongst predominant cloud carrier carriers consisting of Amazon, Microsoft, Salesforce, and Google for a proportion in this Revenue.

Cloud computing may be defined as "the ability to access records, databases, files, information, programs and services from an Internet through the Web browser", and "paying for the utilized services and resources". Erroneously it is often used for software as a service (SaaS), and grid computing, which are just two forms of services, cloud computing can give. During the past three decades, today the figuring field can imagine changing in to the cloud computing period on account of the amazing advances in Information Technology. The advances incorporate the development of the Web spine, the far-reaching reception of broad band admittance to the Web, the strong organization of servers and capacity in server farms, the advances in elite execution and adaptable programming frame work for the server farms and the Internet, and soon. The engineering of a cloud incorporates a few key modules: client communication interface, structure resource executive's panel with a cloud inventory, and asset connectivity circuit. The machine useful resource control module deals with a gigantic server working parallel. It likewise utilizes virtualization strategies to progressively allot and de-allot registering assets and services.

To help the greatest number of client and flexible service, with a smaller number of resources, cloud computing was invented. In couple of years, the emerging cloud computing has turned into the most sweltering innovation. Starting from Google paper publication to the commercialization of Amazon, and to the assistance giving Synaptic Facilitation, cloud computing has been advanced from interior IT framework to public help, from cost saver to income producer.

Like web-based business, cloud computing is one of the most dubious strategy phrasings ever. This is because cloud computing can be utilized in numerous applications, and it is also used by many individuals, companies and organizations for business advancement through the utilization of its global accessible services.

The PC utility turn in to the premise of a new and significant industry, which suggested the hidden ideas of cloud computing. Presently there are loads of definitions and similitudes of cloud computing. Cloud Computing is a sort of processing procedure where IT administrations are given by gigantic minimal expense figuring units associated by IP.

some of the core attributes of Cloud computing are:

- Universally useful.
- Dynamic Scheduling of resources
- Virtualized and Actual asset
- High versatility and flexible
- Huge scope figuring assets

A tight stress is positioned to the prevailing storage and Computing. The Internet carrier carriers begin to use the reasonably-priced PCs for the underlying hardware platform. Different varieties of software program technology introduce to these elastic PCs, leading to three essential cloud computing patterns primarily based totally at the underlying useful resource abstraction technology: and Microsoft style(Hypervisor), Google Style (precise sandbox approach) and Amazon style (virtualization of server).Deciding the best out of them is not an easy job, however reputedly virtualization of server is extra bendy and well suited with current software program and applications; even as the sandboxes positioned extra regulations ,however much less over headed abstraction. Currently, virtualization of Server is the maximum famous useful resource abstraction approach in cloud computing. Cloud computing is important method for IT vendors, carrier carriers of ISP and telecom.

1.2 Cloud Computing for Home Automation

With the advancement in the field of sciences and technology, the prices of the devices operated on the principles of technology has been reduced as compared to the previous era. This led to the idea of utilizing more and more devices and making a common pool of these devices to perform a unified dedicated functionality.

One of the notable advancements is in the development of the Embedded systems which is basically the cluster of different devices arranged in such order to meet the specific requirements and to make the life of human comfortable.

The main target is to automate the living place of human which is for most important to innovate it. Innovation includes automating the appliances of the house without the human intervention and thus avoiding the hassle of physically going to operate manually appliances. For the sake of making the ordinary home automated, home has taken hold in conjunction with such automated households.

As mentioned in the introduction section, using the services and the concepts provided by the cloud computing, home automation can be taken to the next level. Previously when the data was taking long time to process, now with the integration of the cloud computing on the back-end side, large data can be processed with the minimal execution time thus reducing the latency of data processing and transmission opening the gateway to the secure home automation system accessible around the globe any way and time.

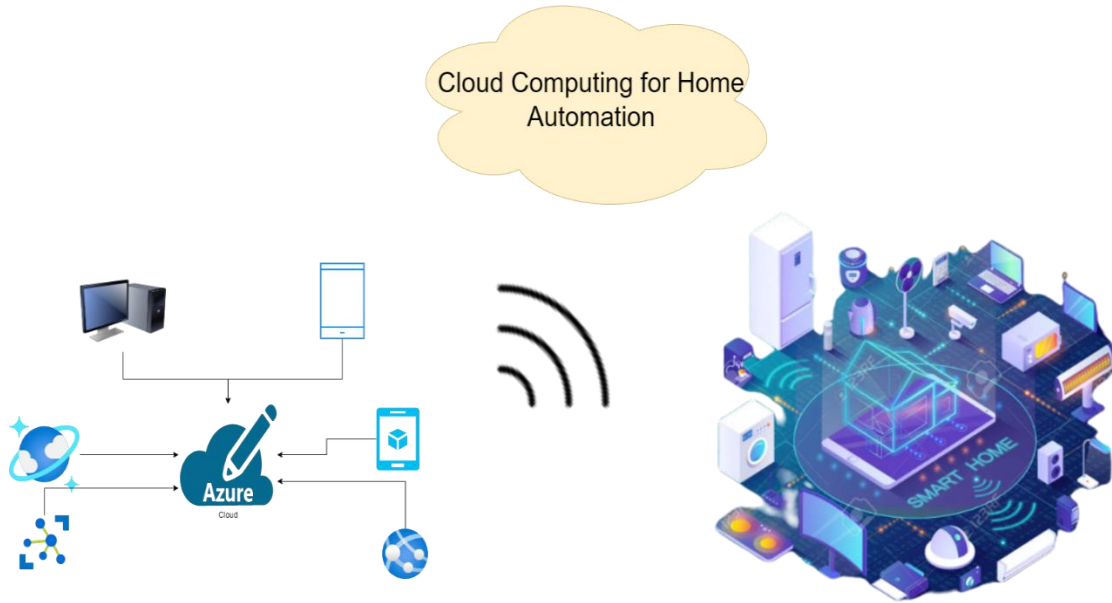


Figure 1. Cloud Computing for Home Automation

1.3 Motivation

Home Automation is in ascent from couple of years. Presently most of the things are constrained by Cloud (IOT), a consistently developing innovation. There have been intelligent and developed arrangements in the space of home automation. All the appliances should be entirely autonomous with no client mediation in any structure at all for improve the way of life. Empowering the end client bother free collaboration with the appliances as it seeks and respond on the client's desire without him actually tapping the on/off button. Sensor wired frameworks are more challenging to deal with and furthermore require a lot of measure of wiring the sensors at various areas. Subsequently, the significance of remote sensor hub has been on the ascent and is a basic variable for proficient execution of home automation. Energy saving is one of the critical benefits of mechanizing home apparatuses. Consequently, the client should be kept mindful of the energy utilization of the mechanized apparatuses. In an emerging nation like ours, where individuals have occupied life plans, giving productive energy saving and solace at low costs and higher proficiency is of most extreme significance. The Security and privacy of home is compulsory due to the intervention in many homes, on the off chance that we have different kind of safety highlights, a mind peaceful life of home.

Home Automation is the basic requirement of today's lifestyle and is of great importance. Everybody running a futile daily existence, booking our regular errands helps us by and large. Innovation of different technologies are the boon by Automation:

- Dealing with each of your home gadgets from one spot.
- Adaptability for new gadgets and apparatuses.
- Increasing the security of home.

- Controller of home capacities.
- Expanded energy proficiency.
- Further developed apparatus usefulness.
- Innovations in housing control

1.4 Scope

This project aims to make the home automation using cloud computing. Home automation is a system that consists of a combination of smart appliances integrated with the mobile app and website. Home automation improves the resident's degree of satisfaction. Home automation allows homeowners to have complete power over own houses from whatever location. Smart home efficiently connects with one another, and the industry is expected to develop quickly over time.

Home automation innovations have the power to enable houses significantly smarter in the coming days. Automating the home appliance such as lights, fans and other category of appliances that can be embedded into buildings to facilitate autonomous appliance controlling depending on circumstances. So much power could be saved by confirming that the building is occupied prior switching on gadgets, monitoring the lighting, as well as turning lights off when not in use.

Thus, by having such benefits over non-smart homes where power saving is always been a challenge to the customers. The scope of the project can be extended from a normal small-scale home to the large-scale industries depending upon the demands and needs of the customers.

For this project, the need of the customer is categorized in to front-end interface which includes mobile application and for the making the common pool of devices such as laptops and personal desktop solution and for other kinds of the system, website solution is purposed. For the backend hardware installation, the smart home hub hardware is fabricated in order to communicate with the front-end solution.

Customers of the smart home has always a query regarding the interfacing and controlling all home appliances thus to make the unified interface for the smart home, to meet such requirements it is an essential job to integrate the smart devices including smart bulbs of different vendors with the non-smart devices already connected to the “smart home hub”. With the integration of smart home devices, the scope of the project is to be taken to the next level and is extended from installation in ordinary traditional appliance holder to the industries and the houses with the technological advancements.

The surveys conducted regarding the demand and needs of the smart home automation also defines the scope of the project that how the society is looking towards the innovation of the houses with the technological improvements.

”The global home automation market size was **USD 64.58 billion** in **2020**.The market is projected to grow from **USD 72.30 billion** in 2021 to **USD 163.24 billion** in 2028 at a

CAGR of 12.3% during the 2021-2028 period..Based on analysis,the global market exhibited a significant growth of 11.9% in 2020 compared to the average year-on-year growth during 2017-2019.The rise in CAGR is attributable to this market's demand and growth,returning to pre-pandemic levels once the pandemic is over” [1]

Thus, the recent survey clearly defines that how the world is now moving towards the modernization and obviously the very first step toward innovation is to automate the living space. By looking in this evidence it can clearly be figured out that how far the scope of this project extends.

1.5 Structure

Following is the structure of the report ahead:

- **Chapter 2**, it mainly contains the in-depth view of services that are used in this project. Azure services are discussed which are essential for integration
- **Chapter 3**, it focuses on the methodology of how the website is interacting with the back-end azure services and how the hardware integration is involved
- **Chapter 4**, Hardware portion is discussed with technical specification and with connection diagrams
- **Chapter 5**, In depth discussion related to scheduling the project
- **Chapter 6**, it deals with the market analysis of this project
- **Chapter 7**, it covers the future innovation related to this project that how in future improvements can be made related to this project

Chapter 2: Cloud Computing Services

Cloud computing is access to where needed, via the Internet, access to computer resources applications, servers(portable servers and virtual servers), datastorage, development tools,communication capabilities,etc.Cloud computing is hosted on a remote data center managed by cloud services provider(or CSP).CSP makes these services available for a monthly subscription or billing depending on usage.

Compared to conventional IT,and depending on the cloud services which is needed,cloud computing helps to do the following:

- The cloud allows us to spend some or all of the cost and effort to purchase, install, repair, and manage our local infrastructure.
- With the cloud, organization can start using business applications in minutes, of waiting for weeks or months for IT to respond to requests,purchase and configure supporting computer systems,and install software.Cloud also allows to empower certain users especially engineers anddata scientists to help themselves with software and support infrastructure.
- The cloud offers flexibility of buying overtime that can be depleted overtime,organization can the volume up to respond to spikes and traffic immersion.Also taking advantage of cloud network provider to spread applications around users around the world.

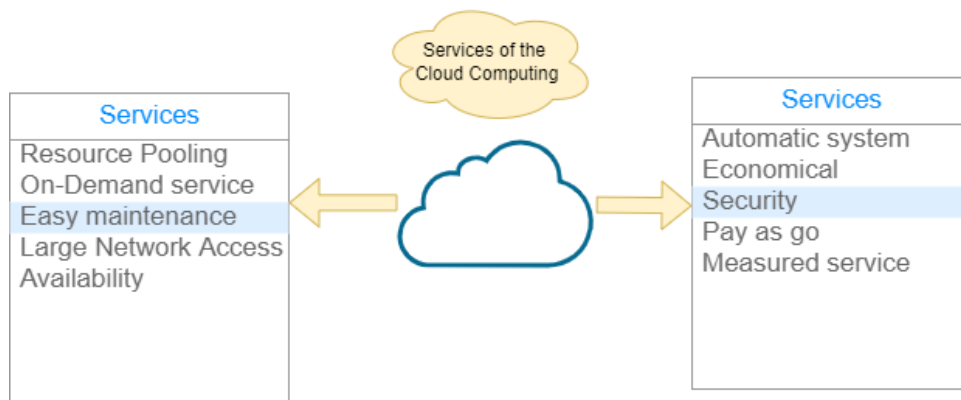


Figure 2. Cloud Computing Services

Cloud infrastructure offers the same capabilities as virtual infrastructure but can offer additional benefits such as lower ownership costs,greater flexibility,and durability.

Cloud computing is available privately and publicly. Delivers as Saas , Paas and Iaas. Depending upon the need and requirements, also user can use the Iaas model of some other cloud provider to host the Paas or Saas model. This feature makes the user friendly with worry hassle of cloud dependency.

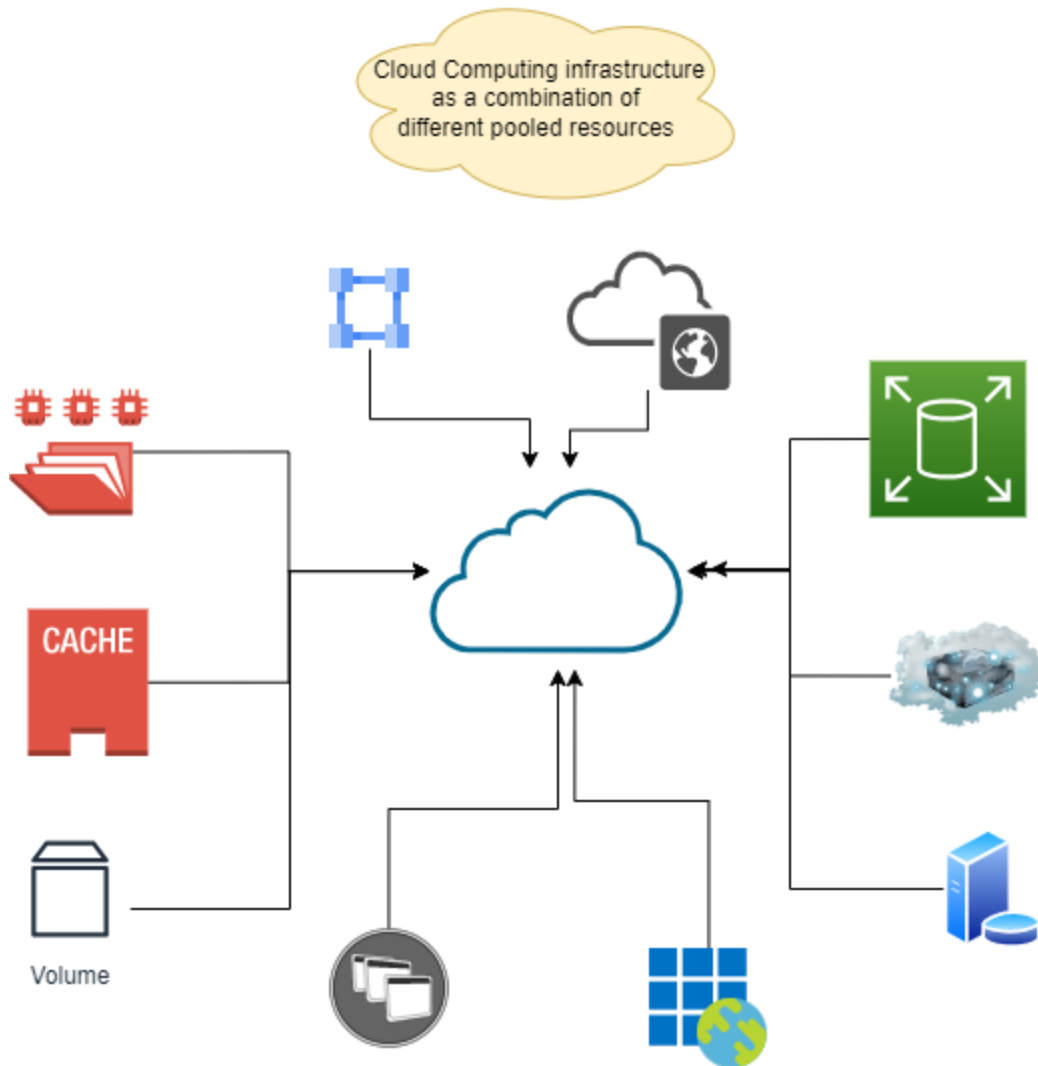


Figure 3. Cloud Computing infrastructure

2.1 Microsoft Azure Cloud

Azure is a Microsoft cloud platform, just as Google has Google Cloud and Amazon has Amazon Web Service or AWS. In general, the forum may be used to use Microsoft services. For example, to setup a large server, we will need a large investment, effort, virtual space and more. In such cases, Microsoft Azure is helpful. It will provide us with virtual equipment, fast data processing, analysis and monitoring tools and more to make our job easier. Azure prices are also simple and expensive. Most popularly known as "Pay As You Go", meaning how much you spend, just pay for that.

Though there are other cloud providers such as

- Amazon Web Service(AWS)
- Microsoft Azure
- Google Cloud Platform
- IBM Cloud Services

- Adobe Creative Cloud
- VM ware
- Rack space
- Red Hat
- Drop box
- Sales force
- Oracle Cloud
- SAP
- Verizon Cloud
- Navisite

In a 2017 study, Microsoft Azure was identified as the most widely used public cloud, and the most likely to be purchased or renewed, according to 28% of respondents in the survey the highest percentage of any public cloud provider. With results like these, it is not surprising that the number of businesses interested in Azure continues to rise.

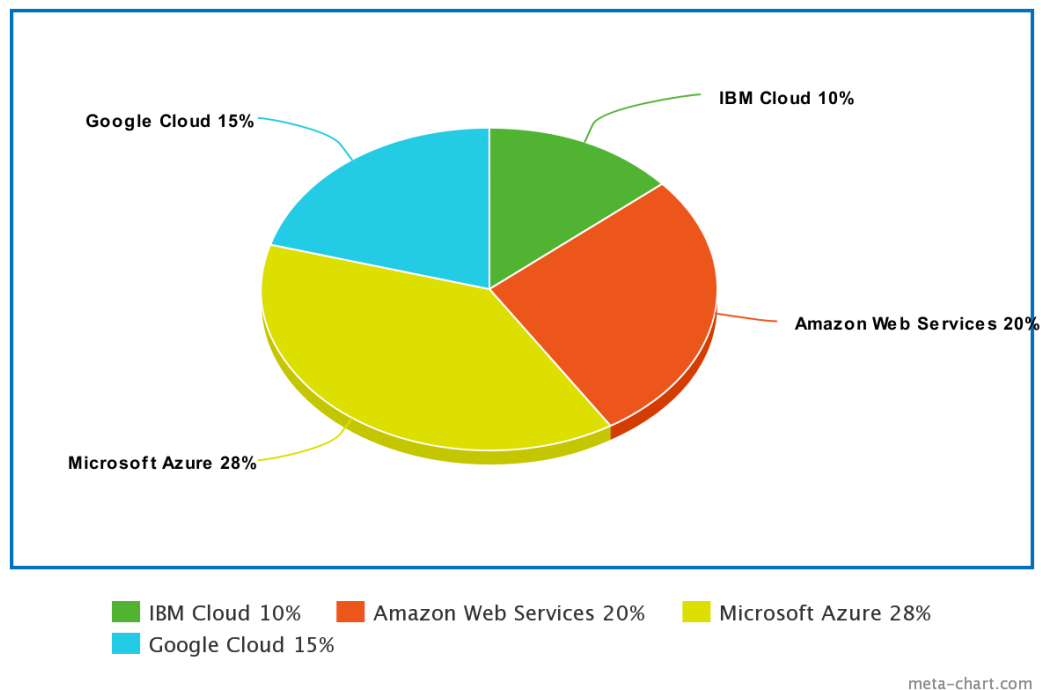


Figure 4. Microsoft Azure Comparison Chart

2.2 Azure assistance to business

The foremost important question arises why to choose the azure over other clouds. Azure apart from being the highest popular candidate amongst the other cloud provider providing several notable key assisting factors to the new venture to use it as a backend service. Some of the notable key assisting points are

- **Capital less** We should not worry about the capital as Azure reduces high hardware costs. Just pay as we go and enjoy a kind subscription-based model on our cash flow. Also, setting up an Azure account is very easy. Just subscribe to Azure Portal and select our required subscription and go.
- **Cost Effectiveness** When we setup the server ourselves, we need to hire a technical support to ensure that things are working properly. Sometimes the technical person may take very long time, but Azure built-in service of maintain and backup assists to get the recovery fast which makes it user friendly.
- **Easy Back Up and Recovery options** Azure backs up all our data. In the event of a disaster, we can restore all our data with a single click without our business being affected. Cloud-based backup solutions save time, avoid major overhead investments and upgrade third-party technology as part of the agreement.
- **Better Security** Azure provides more security than local servers. Ignoring our data and business requests. As it remains secure on Azure Cloud, which means, in natural disasters, where resources can be damaged, Azure is a shield. The cloud is always open.
- **Easy to implement** It is very easy to use Azure business models. With a few clicks, we are ready to go. There are even a few lessons to make learning and applying quickly.
- **Working from anywhere** Azure gives the freedom to work anywhere and any time. It just needs a network connection and details. And with the most sophisticated Azure Cloud services that provide apps, thus we are not limited to which device to carry.
- **Increased collaboration** Azure holds collaboration with other cloud providers such as AWS. Thus, increasing the collaboration makes the common pool of resources.
- Thus, by having such services provided, Azure becomes the best match for the integration in backend.

2.3 Requirement modeling with azure services

In order to integrate the Microsoft Azure as a backend service, the very first step is to model the requirement related to the home automation with the services provided by the Microsoft Azure. The requirements related to the home automation using cloud are

- Segregation of the Users so that every user is having separate access to the cloud and the activities should be hidden and must be uninterruptable with the other users of the home automation system.

- Every User of the smart home automation using cloud must have an account on the cloud such as every authorized personal is given access to the services to the cloud depending upon need and the license agreement given to him by using the front-end interface.
- User should be able to add and remove his/her devices that are created on the front-end interface such that the real appliance connected to the smart home hub can be triggered from the interface.
- There should be the database in order to store the data of registered user, so that the secure process of the authentication is made possible.
- Website and the application for making the solution interactive should be integrated with backend azure cloud for security purposes.
- The database should be made for the sake of sole purpose of storing the states of the devices and the data.
- Common pool of the devices should be made to make the unified interface.

Thus, all of these requirements must be modelled to the backend azure services in order to meet the dedicated functionality from the cloud-based home automation.

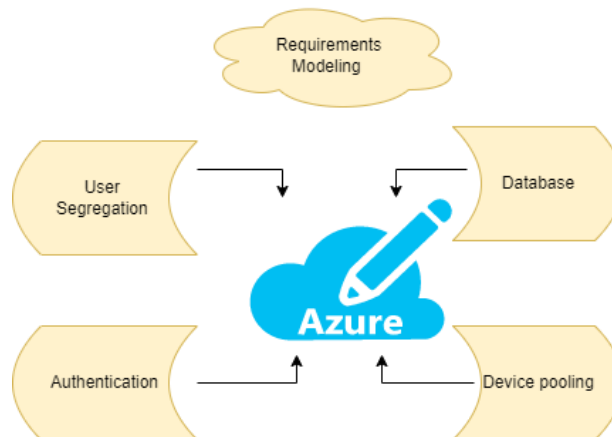


Figure 5. Requirements modeling to Azure Services

2.4 Azure Services

Azure as mentioned in the above sections offers the numbers of the services to customers depending upon the demands need analysis. In order to the meet such requirement for the home automation fortunately azure provides enough resources to perform such functionalities.

In order to make the user authentication, Azure provides the “Azure active directory”. This service is responsible for handling all the secure authentication process to the Azure, the

user is given access from the front-end web or mobile application to the cloud after all the credentials requirements.

Azure cosmos Db is the perfect choice for the real time data base operation, Obviously the user must maintain the state of the appliances in the real time with the minimal of zero percent latency Such latency is minimized and thus making the real time database possible by the azure cosmos data base.

Another notable requirement that had to be modelled is to make the common pool of the data and by seeking the assistance of Azure to handle the devices registered to the cloud, Azure IOT Hub apart from the registering the devices called as “IOT” devices allows the users to perform some additional functionality thus assisting the user to the grass root level.

One of the most crucial things is to host the website and the application which provides the front-end assistance or can be said as a gateway to the cloud, to the Azure. For this functionality Azure web services is responsible.

The later section will explore briefly about in depth working of these services.



Figure 6. (a)Azure Iot Hub (b) Azur Cosmos DB (c) Azure Active Directory (d) Azure Web Services

2.5 Azure Active Directory

Active Directory(AD) is a website and set of services that connect users to the network resources they need to get their job done.A website(or a directory)contains about location, which users and computers are and which one is allowed to do what.

For example, a website can list 100 user accounts with details such as an individual's job title,phone number and password.It will also record their permissions.

Azure Active Directory (Azure AD) is a cloud-based proprietary and access control service.This service enables our employees to access external resources,such as Microsoft 365,Azure Website,and thousands of other SaaS applications.Azure Active Directory also enables them to access internal resources such as applications on our business intranet network,as well as any cloud applications designed for our organization.

Services that manage a lot of on going work in IT environment. In particular, they make sure that every one is who they claim to be (verify), usually by checking the user ID and password they enter, and allowing them to access only the data they are allowed to use (authorization).

Who can use AD?

Azure AD is intended for:

IT Managers

- An IT engineer may access its application based upon need and requirements. AD provides the user-friendly way to host the application on the azure and accessed from anywhere around the globe. Azure active directory as it provides the secure authentication to the customers thus it can very useful where hundreds of authentications are required such as in banking sectors etc. Automating the windows application with the server can be done very easily with the assistance of azure AD.

Microsoft 365, Office 365, Azure

- Microsoft offers the pool of the services and integrate all of them in such a way that buying the subscription for a service offers the other service to the customers. Such that buying office 365 offers other services. Each Microsoft 365, Office 365, Azure, and Dynamics CRM Online tenant automatically becomes an Azure AD tenant. We can quickly start managing access to our integrated cloud applications.

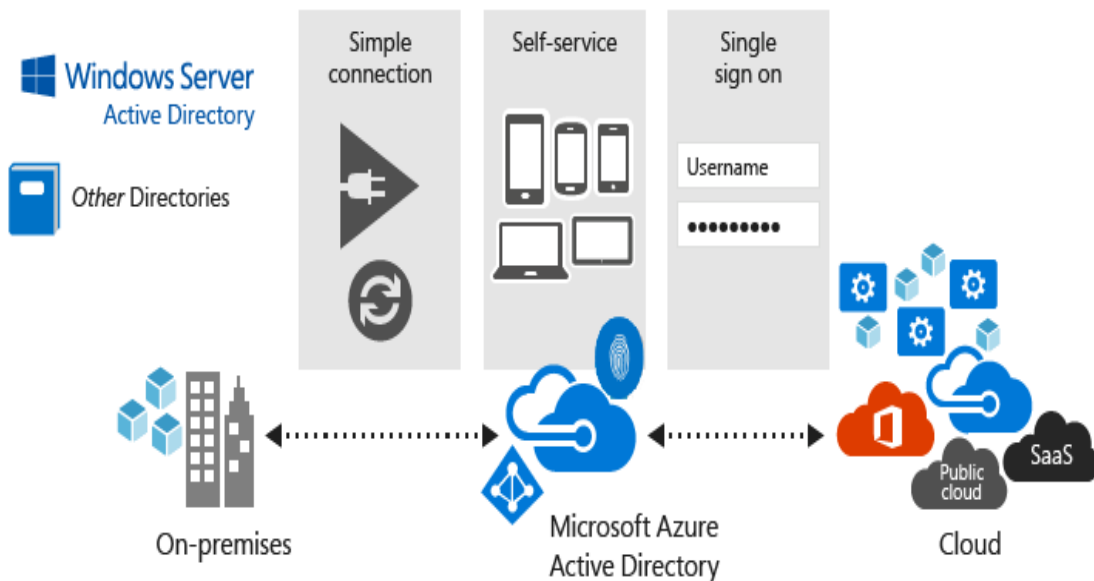


Figure 7. Azure Active Directory

2.5.1 AD features used in our application

Azure AD B2C

- Azure Active Directory B2C Business to customer offers the ownership of the business to the customer as a service. By doing this the consumer of the AD can use their business to get access to the APIs and other applications which is a very unique feature.
- Azure AD B2C is a customer identity access management(CIAM)solution that can support millions of users and billions of verifications per day.Provides platform security and security for authentication,monitoring,and automatic management of threats such as denial of service,passwords pray,or violent attack.
- Azure AD B2C follows the different principle as compared to the AzureAD.Though both follow the same technology, but the purposes are different. Thus, allowing businesses to create their own customer applications and other and allowing everyone to sign into these applications without having the issue of user account.

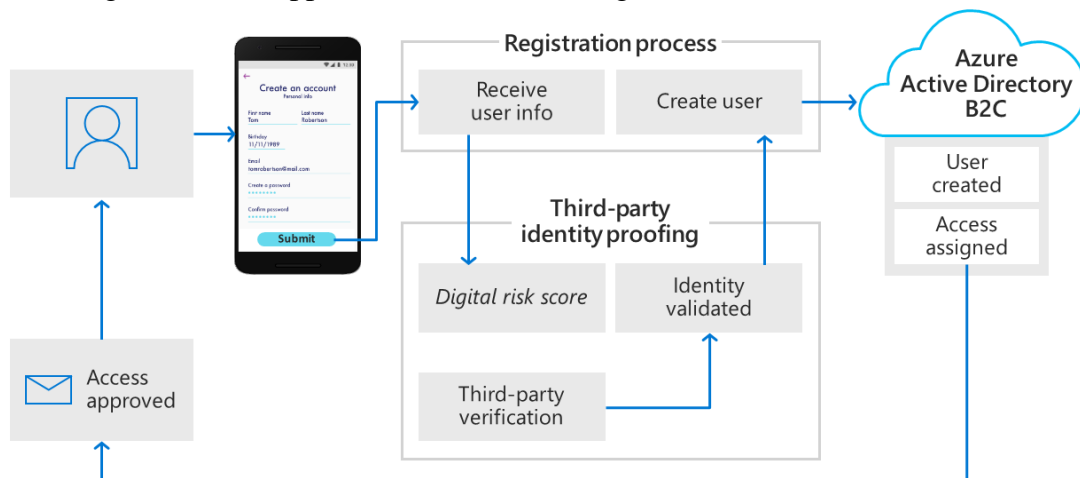


Figure 8. Azure Active Directory Structure

Azure AD Authentication

One of the key features of a proprietary platform is to verify, or authenticate, credentials when a user logs into a device, application, or service. In Azure Active Directory (AzureAD), authentication involves more than just username and password verification. In order to maintain the security and quality of service, Azure Active D provides these features

- Helping the customers to reset their password without staff interaction
- Multi-Factor Verification in AD
- Hybrid integration for resetting the password
- Protecting the local password based upon some policies

- Verification of password without any cost

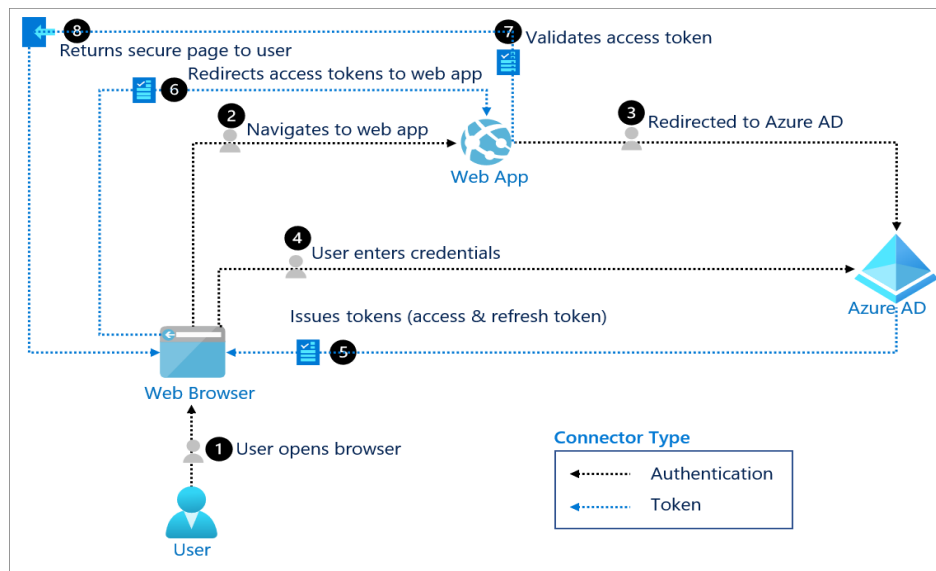


Figure 9. Authentication

2.5.2 Self-service password reset

Self-reset password reset gives users the ability to change or reset their password, without the controller or help desk involvement. If a user's account is locked or he or she forgets his or her password, he or she may follow instructions to free himself/her and return to work. This ability reduces help desk calls and product loss where a user cannot log into his device or app.

Self-reset password reset applies in the following cases:

- **Password change** if the user knows his password but wants to change it to something new.
- **Password reset** if the user is unable to login, such as if he forgot the password, and wants to reset his password.
- **Open account** -if the user is unable to sign in because his / her account has been closed and you want to open his / her account.

If a user updates or resets their password using a self-reset password reset, the password can be rewritten back to the active directory location. Password encryption ensures that the user can quickly use his or her updated credentials with local devices and applications.

2.5.3 Azure AD Multi-Factor Verification

Multiple authentications are a process in which a user is instructed during login to obtain an additional type of identification, such as entering a code on his or her cell phone or providing a fingerprint scanner.

A conceptual picture of the various forms of authenticity of many things.

Azure AD Multi-Factor Authentication operates by requiring two or more authentication methods:

- Something we know, usually a password.
- Something we have, such as a trusted device that can be easily repeated, such as a phone key or hardware.

2.5.4 Azure AD Multi-Factor Verification

The ultimate goal of multiple sites is to eliminate the use of passwords as part of login events. Features such as Azure password protection or Azure AD Multi-Factor Authentication help improve security, but user names and passwords are always a weak authentication method that can be exposed or aggressively attacked.

verification process that leads to password expiration

When we sign in without a password, the information is provided using methods such as biometrics with Windows Hello for Business, or the FIDO2 ID authentication key. These verification methods cannot be easily repeated by the attacker.

Azure AD provides traditional authentication methods using password-free methods to simplify login information for users and reduce the risk of attack.

2.6 Azure Cosmos Db

Azure Cosmos DB is a world wide distributed platform, based on **JSON** presented as 'Platform as a Service' (PaaS) at Microsoft Azure. Allows users to build and deploy their applications on the Azure database automatically without the need for pre-configuration. Because it is part of Azure, it is available in all regions where Azure is located, and duplicates its data across all the various data centers on the network. It uses several different, very SQL-based connections.

Since our app needs to be more responsive and stay online. In order to achieve low delays and high availability, the features of our application need to be installed in the data centers closest to their users. App needs to respond in real time to major changes in high-speed usage, keeping ever-increasing volumes of data and making this data available to users in milliseconds. Since we want no delays in our app. For example, when user want to turn off a light, he can do so without any delay.

Azure Cosmos DB is a fully-fledged No SQL site for modern application development. One-digit milli second response times, with automatic and fast measurements, ensures speed on any scale. Business continuity is guaranteed by SLA-based acquisition and business-level security. Application development is fast and highly productive due to the distribution of data for many turn key regions anywhere in the world, open-source APIs, and SDKs for popular languages.

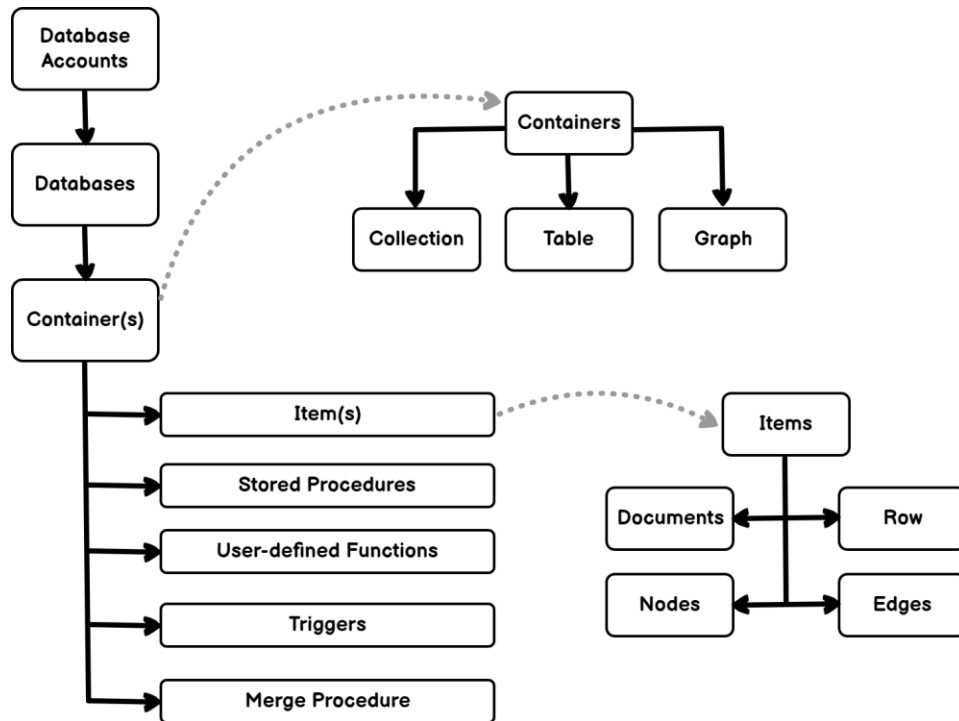


Figure 10. Azure Cosmos Data Pictorial

2.6.1 Key Benefits of Cosmos DB

Speed at any scale

- Real-time access to fast global latency delays, as well as excellence and consistency all supported by SLAs
- Many regions write and distribute data to any Azure region at the click of a button.
- The maintenance of an independent and flexible scale and operation throughout the Azure area - even during an unexpected traffic explosion - at an unlimited level worldwide

Simplified application development.

- Choose from a wide range of web APIs including Core (SQL) native API, MongoDB API, Cassandra API, Gremlin API, and Table API.
- Change feeds make it easy to track and manage changes to website vessels and create activated events with Azure Functions.

- The Azure-less schema-less service of Azure Cosmos DB automatically identifies all your data, regardless of the data model, in order to deliver quick query.

Cost effective and managed completely

- Fully managed database service. Automatic, no touch, maintenance, repairs, and updates, saves time and money for developers.
- Inexpensive options for unexpected or occasional workloads of any size or scale, allowing engineers to get started easily without planning or managing capacity.
- The server-free model offers loads of awesome automated and responsive functions to control the explosion of traffic where needed.
- The Auto scale provided for out-of-service performance automatically and instantly assesses the volume of unpredictable workloads, while maintaining SLAs.

Always ready at critical times

- Enjoy business-level encryption-at-rest with the keys they control.
- Azure-based access controls keep your data secure and provide well-configured controls.

2.7 Azure Iot Hub

Azure IoT Hub is user for the communication on internet of things devices to the azure cloud. It provides and secure connection with the high standards of reliability which ensures the communication possible in the user effective manner. Furthermore, it offers different mode of communication

- **From device to cloud**-e.g.,the temperature values given to the sensor connected to the IoT device,sent for analysis,too
- **From cloud to device**-e.g.,a message for software updates.

IoT Hub supports multiple messaging patterns,such as device telemetry go-to-cloud,file download from devices and monitor the health of connected devices.

2.8 Azure Web Services

Some of the features of web services are

- It provides a website hosting service so that the developers can get the assistance and features for use to improve mobile or web applications.
- Developers can also use these services to build API applications or Logic applications,
- Provide the integration with Software as a Software.
- It replaces a few different Azure services,
 - Azure Website
 - Azure Mobile Services
 - Azure BizTalk Services
- Offers us a single product called Azure App Services.

2.9 Services Free Tier

- **Azure Cosmos DB**
 - Provisioned throughput of 400 request units per second with 25 GB storage
 - Use a fast NoSQL database with open APIs to build contemporary apps at any size.
- **Azure App Service**
 - 1 GB of storage for 10 web, mobile, or API apps
 - Use a variety of technologies, such as Node.js and PHP, to quickly construct sophisticated apps for any platform or device.
- **Azure IoT Hub**
 - Free edition has 8,000 messages per day and a message meter size of .5 KB.
 - Use a scalable platform to connect, monitor, and manage IoT assets.
- **Azure Active Directory (Azure AD)**
 - 50,000 items saved using a single sign-on (SSO) for all cloud apps
 - Enable cloud-based identity and access management. [2]

Chapter 3: Methodology

3.1 Website interface

As discussed in the previous for the front-end website and mobile application solution is developed.

Overall, the architecture of the application is as follows:

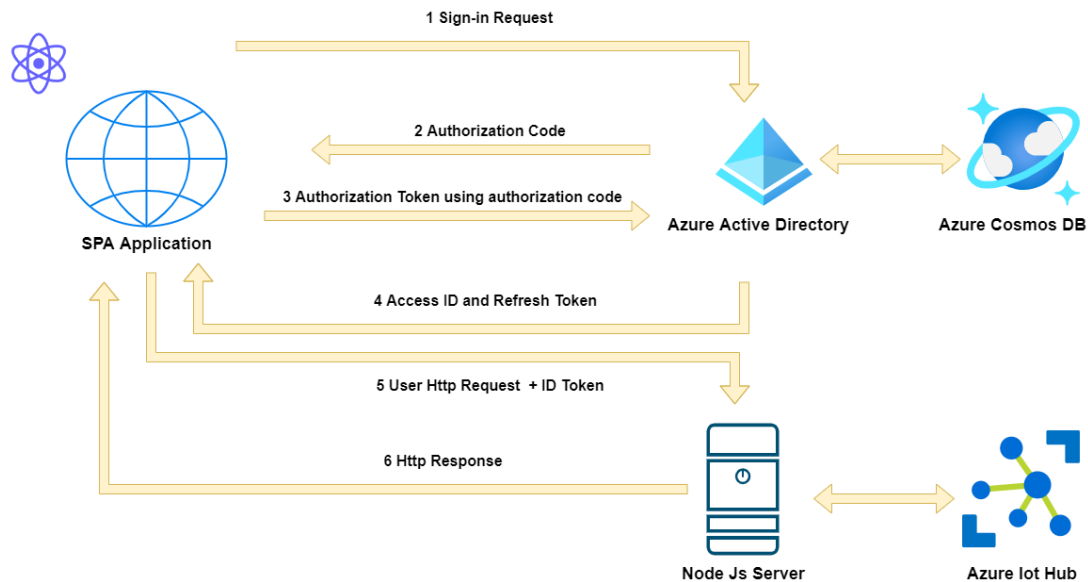


Figure 11. Website logical representation

First user sends a sign-in request to Azure Active Directory that is being used as an Identity Service.

It sends back an Authorization code. That Authorization code is then exchanged by the Identity service to get Access, ID and Refresh tokens and which are then used to authorize a service.

When a user authenticates with Azure AD B2C the authentication is passed to the SPA React application via JWT (JSON Web Token). The redirect URI is provided where AD B2C will pass the

JWT. Now after the authentication is completed request for any action the user would like to perform will pass through the Express.js server. Here the ID token will be used as a 'Bearer' token That will authorize the user to use the desired services.

Express.js server uses Passport.js as a middleware to check whether the ID token is valid or if the user is authorized to use the service. The Express server can then connect to the Azure Cosmos DB for any requests related to data.

In the SPA MSAL REACT (Microsoft Authentication Library for React) is used and leverages MSAL.js which is a library for JavaScript that enables client-side applications to authenticate users using Azure AD and React Router is used to control client-end routing.

In the Azure Active Directory B2C, two applications are registered one for the Node API and one for the SPA application. API exposed in B2C exposes the Express.js backend application as an API for which the client application (SPA in this case) can obtain an access token. For this unique URI is declared that clients will be using to obtain access tokens for the API and has the following format:

<https://{tenantName}.onmicrosoft.com/{clientID}>

Then scopes are published for the client's application to obtain access tokens successfully.

In applications created in B2C to link SPA app registration is configured to enable it to return JWT web tokens to our front-end application. With that token SPA application will be able to identify the user accessing the application. Here the image below shows after successful authentication JSON Web Token is returned to the SPA application and is stored in Session Storage of the browser.

```

▼ {credentialType: "IdToken",...}
  clientId: "799bf85d-b260-49cb-aa26-8d354e0d48a6"
  credentialType: "IdToken"
  environment: "smarthomesolutionsmain.b2clogin.com"
  homeAccountId: "1b2c3414-6888-417f-a5a9-068b6e6dc0c1-b2c_1_sign_signup.72f8aa52-15e8-431d-92e1-d57df3139f07"
  realm: ""
  secret: "eyJ0eXAiOiJKV1QiLCJhbGciOiJSUzI1NiIsImtpZCI6IiZVhrNHh5b2p0RnVtMwtsM110djhkbE5QNC1jNTdkTzZRRlRlQndhTmsifQ.eyJleHAiOjE"

```

Figure 12. Azure Access Token

Next 'User Flows' are created that allow users to Sign in/Signup in the application. All other features like password reset and control of what data to be collected from the user during registration can be handled using User Flows created in the app registration.

SQL API is leveraged to communicate with Azure Cosmos DB which contains a container to store data related to the devices registered by the users. Each user a unique id that is used to identify the devices related to a particular user.

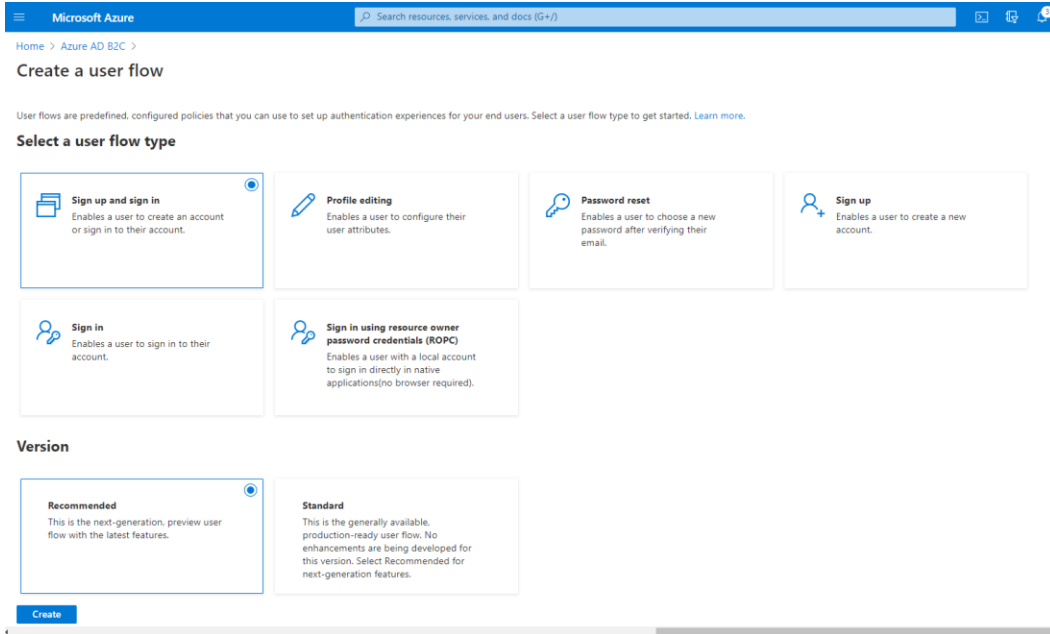


Figure 13. User Flows

The image below depicts the Sign up and sign in user flow in the SPA application.

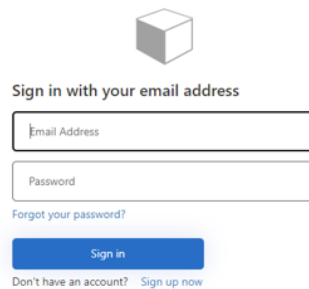


Figure 14. Azure Sign In

When a user flow is created in app registration, we choose what information to collect from the user while they register in the application. The information collected during user registration process is called as 'Attributes' and when a particular user will sign-in after completing the registration process Azure Active Directory B2C will return the Attributes as ID Token Claims as shown below. Below in the signup User Flow we see some additional information like Country, Given Name and Surname.

The screenshot shows a web browser window with the URL `smarthomesolutionsmain.b2clogin.com/smarthomesolutionsmain.on...`. The page contains a registration form with the following fields:

- New Password
- Confirm New Password
- City
- Country/Region (dropdown menu)
- Given Name
- Surname

At the bottom of the form is a blue button labeled "Create".

Figure 15. B2C Login

ID token claims returned by the Azure AD B2C after successful sign in.

```

▼ idTokenClaims: {exp: 1654429705, nbf: 1654426105, ver: "1.0", ...}
  aud: "799bf85d-b260-49cb-aa26-8d354e0d48a6"
  auth_time: 1654426104
  city: "Gujranwala"
  country: "Pakistan"
  exp: 1654429705
  family_name: "Butt"
  given_name: "Shuja"
  iat: 1654426105
  iss: "https://smarthomesolutionsmain.b2clogin.com/72f8aa52-15e8-431d-92e1-d57df3139f07/v2.0/"
  nbf: 1654426105
  nonce: "2e659d72-ea5e-4bce-bca3-2bbfe03880d9"
  sub: "1b2c3414-6888-417f-a5a9-068b6e6dc0c1"
  tfp: "B2C_1_signin_signup"
  ver: "1.0"
  localAccountId: "1b2c3414-6888-417f-a5a9-068b6e6dc0c1"
  realm: ""
  username: ""

```

Figure 16. Successful Sign in Using B2C Response

After successful authentication the user then allowed to proceed to the ‘Device Categories’ where devices can register, configured, accessed and removed the user based on the categories of the devices.

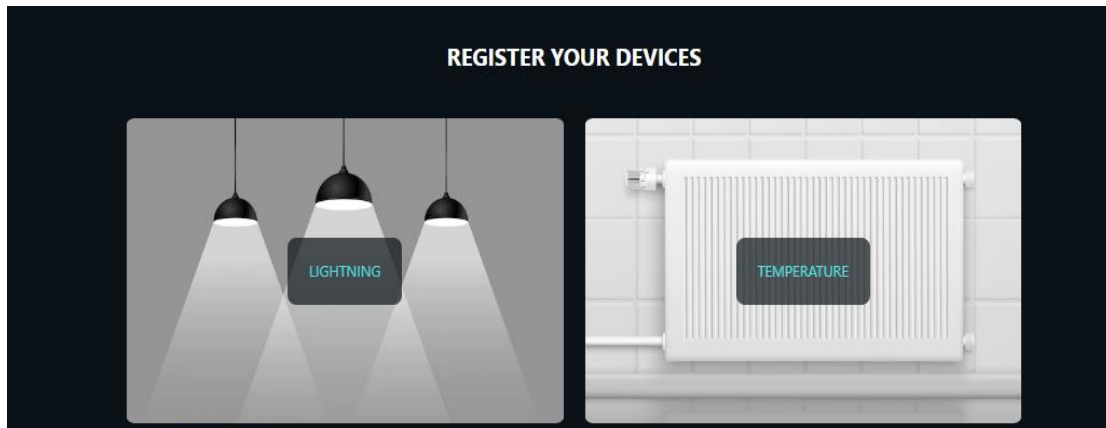


Figure 17. Device Registration Menu

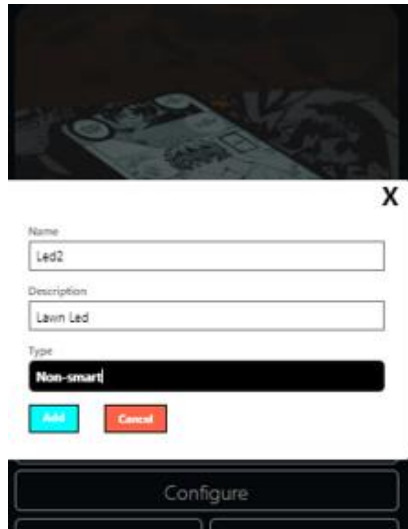
Now when the user selects particular category a request is send to the Express.js server along with the ID token that serves as ‘Bearer Token’. Passport.js then authenticates the user and request is send to Azure Cosmos DB to fetch information regarding devices registered by the user in a particular category.

If the process is successful, the user can then see the devices registered as shown below:



Figure 18. Light Control Panel

More devices may be registered by the user by clicking on Add a new device option. This will open a Model where information regarding a new device can be added by the user as depicted by the following images:



A screenshot of a mobile application interface for creating a new device. At the top, there is a dark image of a smartphone. Below it is a white form with a close button 'X' in the top right corner. The form contains the following fields: 'Name' with the value 'Led2', 'Description' with the value 'Lawn Led', and 'Type' with a dropdown menu showing 'Non-smart'. At the bottom of the form are two buttons: 'Add' (green) and 'Cancel' (red). Below the form is a dark button labeled 'Configure'.

Figure 19. Customization Device Creation

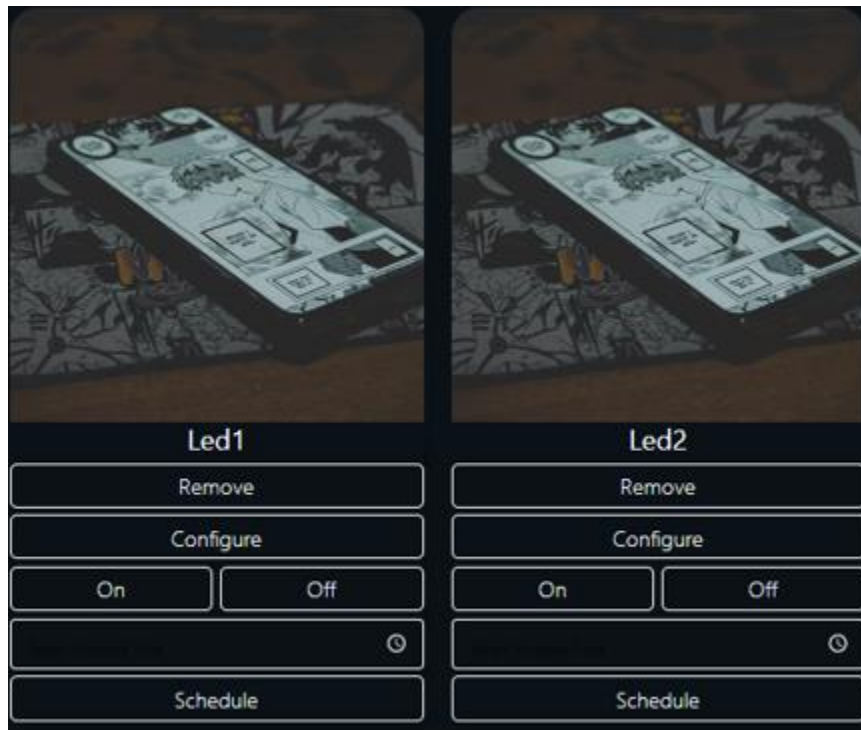


Figure 20. Dashboard with multiple Devices

In the same way, the user may configure or remove a device.

The Schedule option leverages ‘node-cron’ which is a task scheduler in JavaScript for Node.js based on GNU crontab which allows to schedule tasks in Node.

3.2 Hardware integration with Azure

In order to integrate the hardware resources which is commonly named as the “Smart home hub” there has to be a triggering mechanism based upon the signal generated by the azure.

As discussed in the Chapter 2, Azure Iot Hub service allows the user to create the common pool of the data, and all the operations and functionalities required to access and control the device can be performed in very friendly manner.

Azure is accessed via internet; therefore, hardware device must be based upon the Iot principal.

Raspberry pi is chosen to as the core of the smart home hub (benefits of choosing it over another available microcontroller will be discussed in the chapter 4). Raspberry pi is connected to the internet so that it can receive the signal anywhere, in any corner of the world to make the smart home accessible from any part of the world.

3.2.1 Communication exchange of Azure Iot Hub

Azure Iot Hub provides different mechanism to communicate with the devices. One of the notable and key functionalities is involving the “**Direct Method**”. The state of the registered connected Iot device is changes and triggered based upon the calls made by the direct method.

“IoT Hub gives the ability to request direct access to cloud-based devices. Specific methods represent application and response communication via a device such as an HTTP call because they are successful or fail immediately (after closing the time specified by the user). This method is useful in situations where the immediate action is different depending on whether the device was able to respond.” [3]

Each device path directs one device. The multi-device schedule of tasks shows how to provide a direct route request for multiple devices, as well as a schedule of calling for disconnected devices

Specific methods follow the application response pattern and are designed for communication that requires immediate verification of their out come. For example, interactive device control, such as fan opening.

3.2.2 Method life cycle

Specific methods are used on the device and may require zero or more inputs to the payment method to be properly validated. When we are requesting a direct route with the URI facing the service (`{iot hub} / twins / {device id} / methods /`). Device finds specific methods

with MQTT-specific device (`$ iotHub / methods / POST / {method name} /`) or with AMQP links (IoThub-methodname and IoThub status application features). [3]

3.2.3 Invoking a direct method from a website

Approach to device routes HTTPS calls made with the following components:

<https://fully-qualified-iotHubname.azure-devices.net/twins/{deviceId}/methods?api-version=2021-04-12> [4]

POST method

- Topics containing authorization, application ID, content type, and content encoding.
- JSON body displays in the following format:

JSON

```
{
"methodName": "device1",
"responseTimeoutInSeconds": 200,
"payload": {
"input1": "on",
"input2": "off"
}
} [5]
```

3.4 Raspberry Pi Integration to Azure Iot Hub via Direct Method

At the raspberry end, python program is running to receive the direct method invoke calls from the Azure Iot Hub. After the installation of the packages necessary to install **Azure Iot Hub Python Client**, raspberry pi is fully ready to receive such call and then trigger the respective appliance.

The basic body of the python code running at the raspberry pi end is

```
async def main():
```

```
    # The connection string for your device.
```

Azure Iot Hub provides the unique connection string to every device in order to segregate the devices, therefore the reference of that connection string is required

```
conn_str = "";
```

```
# The client object is used to interact with your Azure IoT hub.
```

```
device_client = IoTHubDeviceClient.create_from_connection_string(conn_str)
```

```
# connect the client.
await device_client.connect()
```

The method is being defined so that the execution of the program flow directly to that method

```
# define behavior for handling methods
async def method1_listener(device_client):
    while True:
        method_request = await device_client.receive_method_request(
            "method1"
        ) # Wait for method1 calls
```

The response to check either the execution is made successfully

```
payload = {"result": True, "data": "execute successfully"} # set response payload
status = 200 # set return status code
print("executed method1")
method_response = MethodResponse.create_from_method_request(
    method_request, status, payload
)
await device_client.send_method_response(method_response) # send response
```

Use the concept of threading to run the methods parallel

```
# Schedule tasks for Method Listener
listeners = asyncio.gather(
    method1_listener(device_client),
)
loop = asyncio.get_running_loop()
user_finished = loop.run_in_executor(None, stdin_listener)

await user_finished
listeners.cancel()
```

```

await device_client.disconnect()

if __name__ == "__main__":
    asyncio.run(main())
    
```

3.5 System Level Diagram

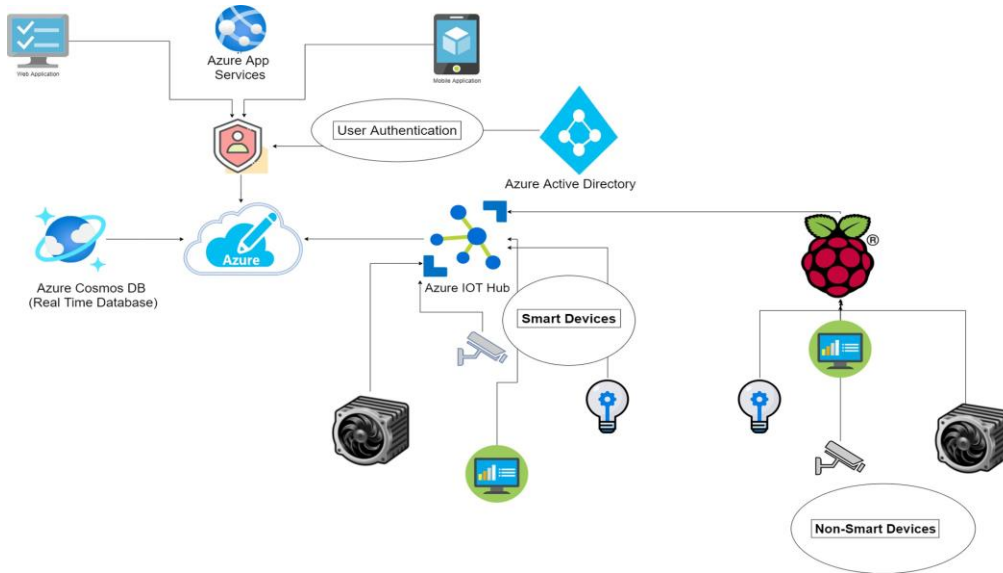


Figure 21. System Level Diagram

3.6 Website Communication

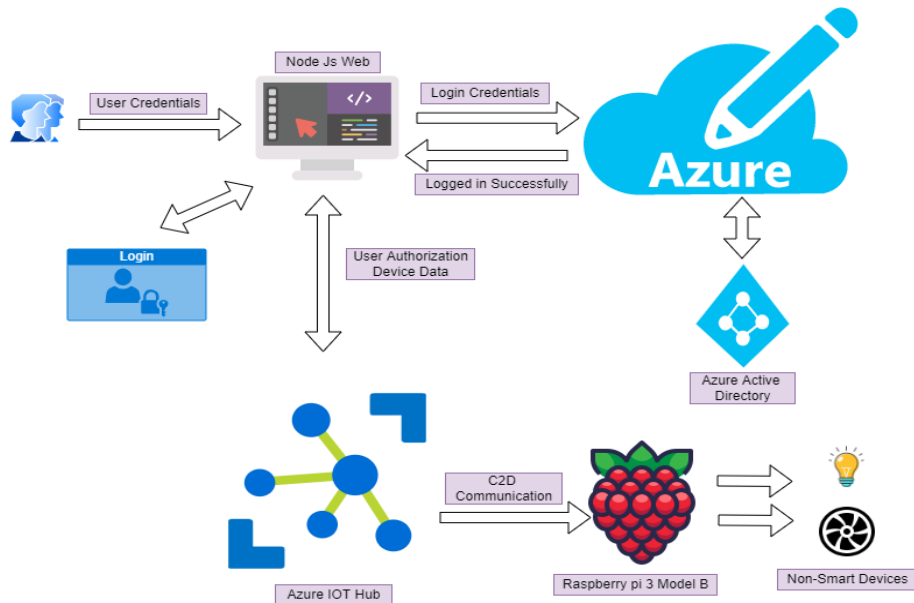


Figure 22. Website Communication

Chapter 4: Hardware

4.1 Smart Home Hub

In order to access the home appliance using front-end user interface there has to be a device responsible for the communication required for the turning on/off and scheduling the appliances. Smart home hub is composed of following different components

- Raspberry pi
- Relay board
- Wireless Relay Board
- Lcd



Figure 23. Smart Home Hub Technical Diagram

4.2 Raspberry pi

The major backbone of smart home hub is Raspberry pi microprocessor as shown in figure 23. Raspberry Pi as a world's most inexpensive microprocessor as compared to others available microprocessor. After the launch of Raspberry Pi from 2012, there are different versions available in the market. For this project Raspberry pi 3B model is used. The major decision for choosing this is based upon specifications and features available in this version.

4.2.1 Raspberry Pi 3 Model B Features

Several notable features found as best match for the cloud-based home automation such as

- **CPU:** Raspberry Pi 3B model uses “Broadcom BCM2837 SOC 64-bit quad-core ARM Cortex A53 (ARMv8 CPU) with 512KB shared L2 cache”.
- As the scope of this project can be made broader depending upon the customer’s requirement and can include complex computation of the image processing for the security surveillance system and voice recognition processing for the “voice assistance”
- **Memory:** This model is having 1 GB RAM which provides the quite handsome amount of storage for holding data in memory required for the computation
- **Wi-Fi Support:** 802.11n Wireless LAN. Having built in WIFI support by excluding the additional hardware required for the wireless connection. Furthermore, providing the Maximum data rate 600 (Mbps) with the RF Band of 2.4 or 5 (GHz) with Modulation “CCK, DSSS, or OFDM
- **Bluetooth:** Bluetooth 4.1 with the support of Bluetooth Low Energy (BLE)
- **GPIO Pins:** Supporting 40 GPIO Pins General Purpose Input Output. Which is useful for driving the relay board up to 30 + channel which provides the user accessibility of controlling/scheduling 30+ appliance around the globe, thus providing the unified interface which is both best match and economically efficient for industries.
- **Micro SD card slot:** Allowing easy and hassle-free installation of firmware in the product
- **Audio/Video:** Combined 3.5mm audio jack and composite video
- **Camera interface (CSI):** Enabling the interface of camera installation thus enabling the collaboration of security surveillance system

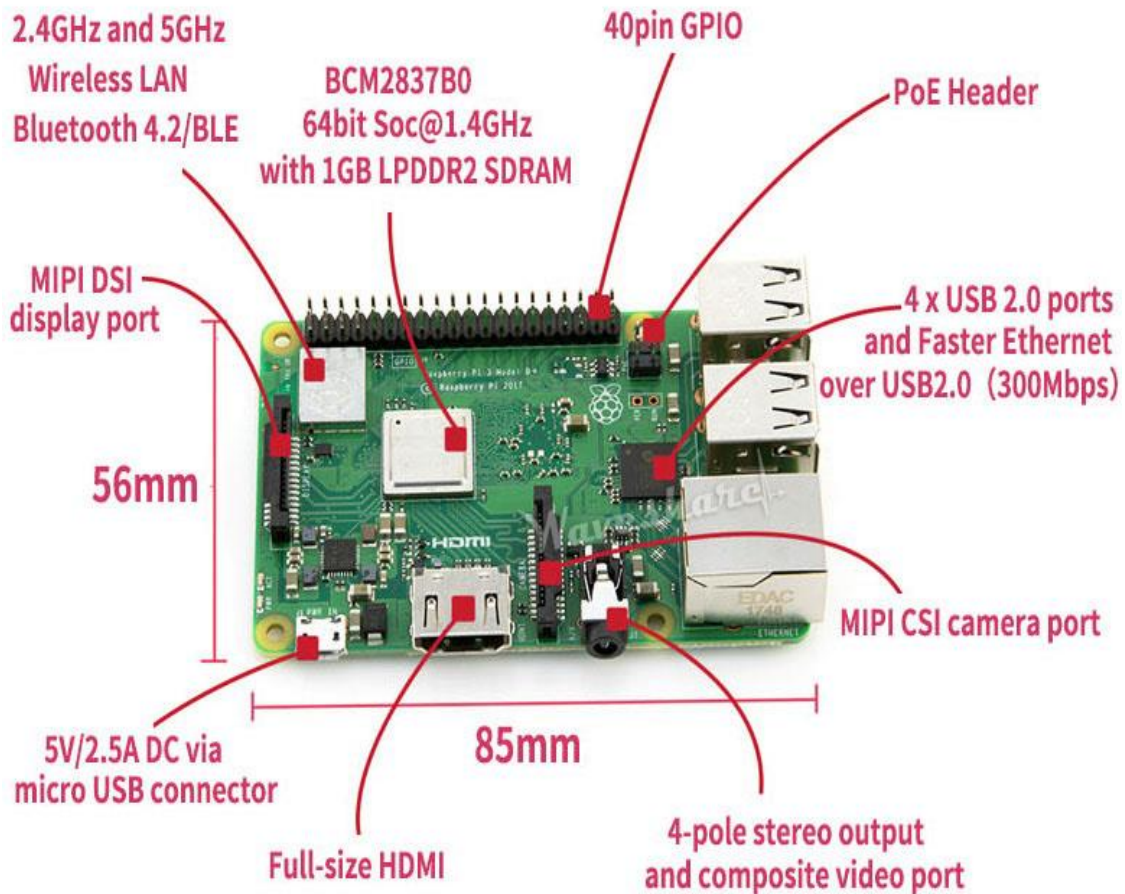


Figure 24. Raspberry pi 3B [6]

4.2.2 Why to choose Raspberry Pi

Apart from features providing the core features essential for the home automation system, there are other various benefits which is provided by Raspberry Pi:

- Low cost (~\$35) which is economically efficient for large scale production of many units of smart home hub
- Complex processing power in a single compact board thus no longer requiring additional hardware which can increase the cost as well as complex hardware solution
- Many interfaces (multiple USB (Interfaces of camera and additional hardware having the USB port can easily be configured and installed), Ethernet, onboard Wi-Fi and Bluetooth, many GPIOs, USB powered, etc.)
- Providing the supports of Linux and other operating system, choices to be made depending upon the computation requirement. Apart from that several other platform support such as “Python “, “Java Script”, “C++” and other languages and tools such as “Visual Studio Code”, “Thonny Python Editor”, “Geanny Compiler” thus providing user ease and platform independency for programming the firmware for smart home hub
- Developing such an embedded board is going to cost a lot of money and effort

4.3 Relay Board

In order to interface the non-smart devices which, include conventionally used house appliance including old age fans, light bulbs, water pumps, old generation refrigerator and other devices which are not smart and can't be automated until and unless some other mechanism is to be driven, for this there has to be device which should interface raspberry pi and these devices. In order to cataphor this complexity, in this project for the demonstration purpose of 4 wired devices, "4 channel relay" board is used. The contacts on each relay are specified for 250VAC and 30VDC and 10A in each case, which means that this relay board can drive the load based upon the capability and endurance of the relay board as marked on the body of the relays.

4.3.1 Relay board pinout

Table 1. Relay Board

Pin Number	Pin Name	Description
1	GND	Ground reference for the module
2	IN1	Input to activate relay 1
3	IN2	Input to activate relay 2
4	IN3	Input to activate relay 3
5	IN4	Input to activate relay 4
6	V _{CC}	Power supply to relay module
7	V _{CC}	Power supply selection jumper
8	JD-VCC	Alternate power pin for the relay module

[7]

4.3.2 Relay module specification

The technical specification of this board is as follows

- Supply voltage range–3.75V to 6V
- Triggering current–5mA
- Current flow in relay activation mode- ~70mA (single),~ 300mA (all four)
- Relay maximum voltage range–250 VAC,30 VDC
- Relay maximum current endurance– 10A

[8]

4.3.3 Relay Module Technical Diagram

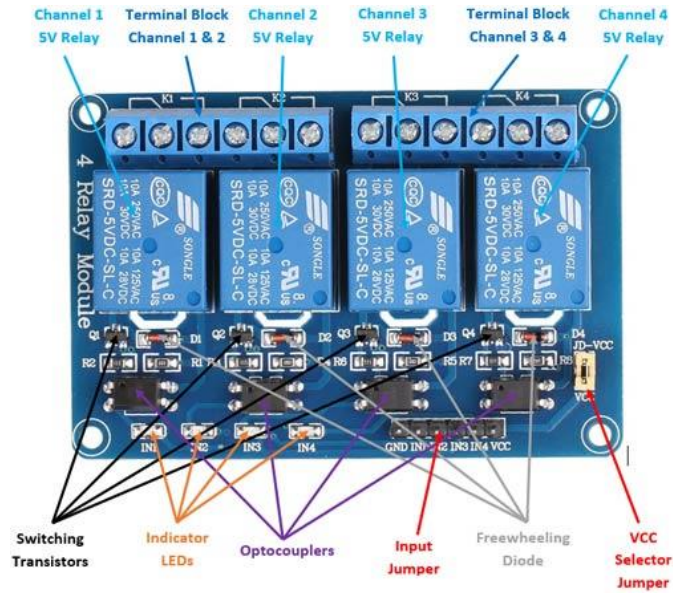


Figure 25. 4channel Relay Module Diagram [9]

4.3.4 Logical Connection Relay Module with Raspberry Pi

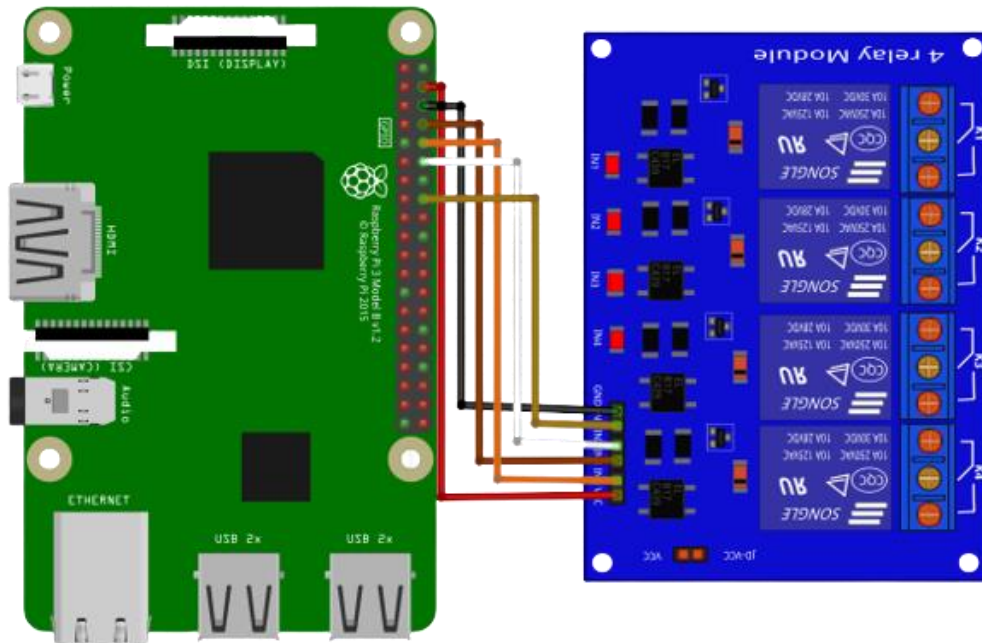


Figure 26. Relay Board Logical Connection

4.3.5 Raspberry pi communication to Wired Relay Board

As discussed in the figure 24, raspberry pi contains 40 GPIO for communication. So, the communication with the relay board is make possible only by using these GPIO pins and configuring them as output because the output signal is required

On raspberry pi, python code is running to receive the calls whenever “direct method” as discussed in chapter3, based upon the calls, the payload is checked so that to trigger on and off the specific GPIO pin.

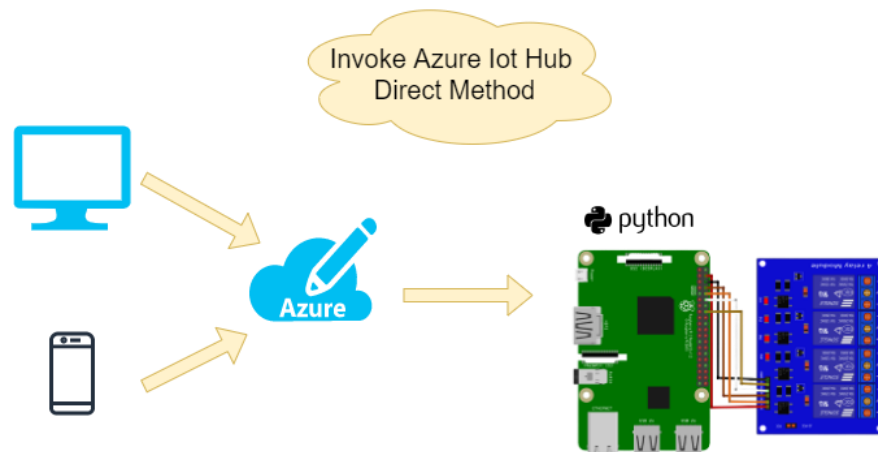


Figure 27. GPIO Pins Triggering Logic

4.4 Display Module

In order to meet the requirement, the prime objective is to provide the hardware-based solution that must have the lcd display for the end user interface. Though there are several lcd modules available in the market depending upon the features and specifications having different pricing range. In order to make the “smart home hub” economically efficient, the hardware parts should be cheap, but the dedicated functionality must synchronize with the quality as well as the user ease.

As this project contains the mobile application and the website-based solution therefore the end user smart home hub does not need such high-class features required for the lcd. The prime functionality required for the display point of view is that the display module should display

- Device status including on/off status
- Raspberry pi “IP Address” for assisting the third part application for providing the remote connection with “VNC Viewer” for changing the WIFI internet connection
- Displaying the connection with the wireless devices connected to the wireless relay module using the Bluetooth connection (will be discussed in next section)
- Internet connection indication so that the user become able to know either the device is connected to the internet or not

So, the best match within the economic range is “16x4 LCD Module”.



Figure 28. 16x4 Lcd [10]

4.4.1 16 x 4 Lcd Display Module

This 16x4 display which has built in ST7066 controller IC; its default interface is 6800/4/8-bit parallel, 5V power supply. These LCD display 16x4 modules are also available in SPI and I2C interface by using RW1063 controller IC. The 16x4 display LCD series is available in several different backlight colors blue, green, white, yellow-green, amber, red, white LEDs.

In order to make the connection with raspberry pi, first **I2C** module is interfaced with the Lcd, the major benefit of using this module is not to engage to many GPIO pins of raspberry pi which can be connected to the relay board thus providing the connection for more appliances. I2C module has 4 input pins and 16 outputs pins which are connected to the 16x4 Lcd module. Out of four pins, two pins provide the connection with the raspberry pi, thus saving the GPIO pins

4.4.2 Logical Connection 16 x4 Connection with Raspberry Pi

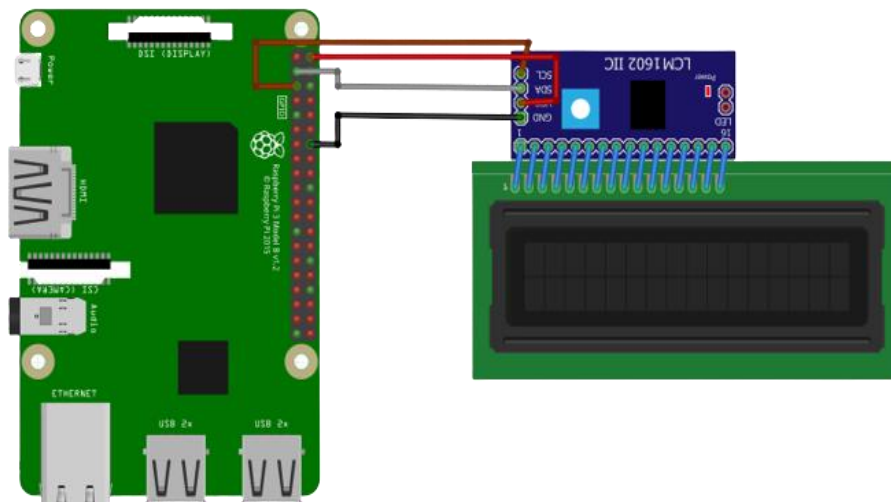


Figure 29. Lcd interface with Raspberry pi using i2c

4.5 Wireless Relay Board

As discussed in section “4.3” there has to be a certain mechanism to receive the signal from the raspberry pi and based upon that signal the house appliance should be triggered. The triggering mechanism is solely based upon the signal delivered from the raspberry pi which is basically propagated from the back-end user end.

There are some house appliances which are installed far apart from the “smart home hub” installation. Obviously, it will cost more by making wired connection from the “smart home hub” to these appliances.

Consider the scenario of the house garage. Obviously, there are certain devices installed for the assistance purpose and the main “smart home hub” is installed in the drawing room. It will cost more for manually installation of the wire from the home hub to the garage which apart from becoming the costly solution, will sure be adding the wire to this product.

The best solution to aforementioned solution is to add the mechanism of wireless transmission from the “smart home hub” to the relay board. In order to meet such requirement, the built-in Bluetooth support of the raspberry pi 3B is utilized (WIFI transmission support could be utilized, but this is required for the connection to the wireless internet connection).

Furthermore, in order to enable the Bluetooth in the relay module 2 essential component is required

- Chip to process the Bluetooth signal and triggering the respective relay
- Bluetooth module “Hc-05 Bluetooth module”

The preferred chip for the fabrication of this relay board module is “ATmega 328P”

4.5.1 Wireless Relay Board Chip

Some basic specification of ATmega 328p which makes it perfect match to use in this project are

- AT mega 328 is an 8-bit, 28-Pin AVR Microcontroller, product of Microchip.
- RISC Architecture and has a flash-type program memory of 32KB.
- It has an EEPROM memory of 1KB and its SRAM memory is 2KB.
- It operates ranging from 3.3V to 5.5V but normally we use 5V as a standard.
- Its excellent features cost-efficiency, low power dissipation, programming lock for security purposes, real timer counter with separate oscillator.
- It’s normally used in **Embedded Systems applications**. [11]

Thus, this purposed solution eliminated the hassle of going toward the costly solution.

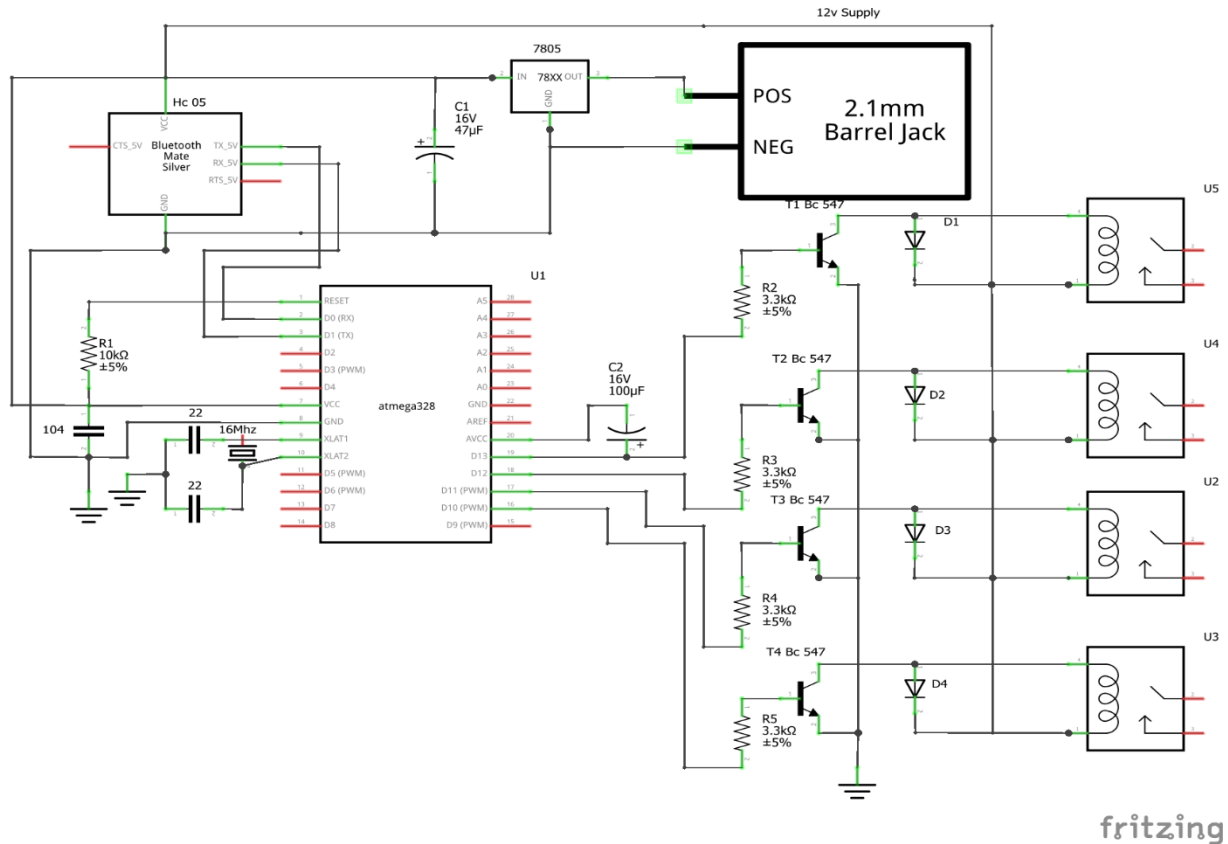


Figure 30. Wireless Bluetooth Module Schematics

4.5.2 Relay module specification

Same nature of relays is used as in the case wired relay board.

- Voltage Rating
 - 3.75V to 6V as 5v relays are used
- Current
 - Triggering current rating “5mA”
- Current flow
 - Relay activation mode (70mA “single”, ~300mA “when 4 are in use”)
- Output maximum voltage rating
 - 250VAC, 30VDC
- Maximum output current endurance
 - 10A

Most of the specification is kept as same as the relay board connected to the raspberry via wire. Thus, the intended functionality is same, but the major difference is avoiding the hassle of manipulating with the wire.



Figure 31. Relay with Appliances

4.6 Integration of Smart Bulb

For the sake of integrating the smart devices with the smart home hub, in this project we have integrated the “yeeligh bulb”. The basic motivation to integrate this bulb is the numbers of the features that it provides

- Yeelight bulb has pre-built -in Wi-Fi support
- Output light can be dimmable depending upon the input signal
- It has support of more than 16 million colors
- Color can be automaticaaly set to the desired picture color
- Timer adjustable
- Offering many features of customizations
- So many colors support
- Cheap price range with many features
- Energy-efficient [12]



Figure 32. Yeelight Bulb [13]

4.6.1 Yeelight bulb Interface with Raspberry pi

In order to interface the yeelight bulb with the raspberry pi, series of tests are conducted. As yeelight bulb operated on wireless network therefore it has to connected to same wireless network as raspberry pi.

So, for this test connecting the yeelight bulb and raspberry pi over same network and trying to fetch the Ip address of the yeelight bulb using the sets of commands on python on raspberry

First thing to do is to install the library of yeelight bulb on raspberry using

```
pip install yeelight [14]
```

After installing the yeelight library, what we needed is to discover the Ip address of Ip using command

```
discover_bulbs() [14]
```

function returned the ip address along with another perimeter. Using the set of functions provided with the documentation we were good to interface the smart bulb with raspberry pi

After discovering the IP address of the yeelight bulb, certain functions such that changing the brightness, HSV, changing the temperature of the bulb is set by using the python API running on raspberry pi.



Figure 33. (a) Yeelight Bulb with changes RGB (b)Yeelight Bulb with changed Temperature

4.7 Software Tools

The software tools used are mainly for web application development and hardware editing and azure cloud background.

4.7.1 Visual Studio Code

VS Code is the most popular compiler offering an open-source editor and development tool product of Microsoft. It has rich functionality and can be customized to create an evolving environment for all types of applications and coding. It has debug support and contains built-in Git support as well as syntax highlighting and Intellisense.



Figure 34. Visual Studio Code logo

4.7.2 Node.Js

Node.js is an open source language that has the support of cross platform with the template of javascript.

Node.js uses the V8 Java Script engine, This allows Node.js to run more efficiently.

Node.js provides a set of asynchronous I/O primitives in its standard library that prevents Java Script code from being blocked and, in most cases, libraries in Node.js are written using non-blocking paradigms, making block behavior different from normal.

If Node.js performs I/O function, such as network reading, website access or file system, of blocking cable and wasting CPU cycles pending, Node.js will restart when feedback returns.

This allows Node.js to host thousands of simultaneous connections on a single server without sending any load management function, which can be a significant source of disruption.

Node.js has a unique advantage because millions of advanced developers who wrote Java Script in the browser are now able to write server side code in addition to the client side code without the need to learn a completely different language.



Figure 35. Node Js Logo

4.7.3 Python

Python is typed and collected by garbage. It supports multiple program paradigms, structured (especially, systematic), object-oriented, and functional program. Python is often described as a "battery-powered" language because of its typical library.

Since 2003, Python has been ranked in the top ten most popular programming languages in the TIOBE Programming Community Index which, since February 2021, is the third most popular language (after Java, no C).



Figure 36. Python Logo

Chapter 5: Project Scheduling

The very first and foremost part of any project after the planning phase is how to schedule the project? Project management planning is a list of tasks, deliveries, and recordings within a project. The schedule also usually a scheduled start and end date, duration, and resources assigned to each task. Effective project planning is an part of effective time management. Therefore by having such importance, it became essential for us to adopt the approach of project scheduling.

Scheduling in project includes many things, such as first analyzing the important tasks that has to be covered for the completion of the project, analyzing the dependencies among the tasks, which task is dependent on which sub task that has to be covered before going toward the other one.

The tasks are called as the activities in the project scheduling. As every project is composed of some of tasks, therefore by breaking down the project into smaller chunks of tasks led towards the completion of tasks.

5.1 Analyzing the activities

Cloud based smart home automation project is divided into the numbers of the task, each task is responsible for delivering the output which is essential for some of the other tasks before going to start.

Again, referring to what is required in the project in broader in the generic term?

- Front end website and mobile application interface to assist the user to perform the dedicated functionality
- Middle layer of the Azure cloud
- Hardware required at the user end to get signal from the cloud controlled from the front-end website and mobile application

So, in order to complete the project, these tasks must be done

Table 2. Activities

Activity	Description	Immediate Predecessor
A	User Authentication	---
B	Azure Cosmos Data for storing the data	---
C	Azure Active directory	B
D	User Data Base	C

E	User Authorization	A, D
F	Database	A, D
G	Device Registration	E, F
H	Front End	G
I	Back End	G
J	Phase 2	I, H
K	Relay Based Module	J
L	Non-Smart Device Interface	J
M	Device Registration	K
N	Device Connection to Raspberry pi	L

Below is the work breakdown model structure of dividing the project

5.2 Work Break Down Structure

Project is divided in to three phases, such as

- **Phase #01**
 - User Authentication on Azure
 - Authenticating the user on the Azure using Azure Active Directory
 - User Authorization using the Azure Active Directory
 - Devices Registration
 - Devices Registration on Azure Iot Hub
 - Devices Data Bases to be stored on Azure using real time database “Cosmos Database”
 - Website
 - Using the Azure Web Services for the front-end website
- **Phase #02**
 - Front end interface for user using the website solution
 - Programming website using React Node.js and front-end using CSS
- **Phase #03**
 - Hardware
 - Using Raspberry pi 3B model to interface with cloud
 - Using relay board for controlling the appliances
 - Using Bluetooth Relay Board for wireless control of appliances
 - Using yeelight bulb as a smart bulb

5.3 Gantt Chart

Chapter 6: Market Analysis

Commercialization of any project requires a complete market analysis on the basis of which a business plan is created. The market analysis helps in figuring out not only the need but also the demand of the device. The key objective is establishing that there is in fact a market in which this is a sellable device, and that demand will be enough to generate suitable profits to sustain a business that can in the long run grow and invest in further research and development.

6.1 Analysis of the Home Automation Market

The expanding potential and popularity of the Internet of Things(IoT)along with a greater demand for technology that relies on arange of linked products such as televisions, refrigerators, and other appliances are driving the worldwide home automation industry forward. In emerging countries, increased disposable income and a growing taste for beautiful and luxury lifestyles will propel the industry to greater heights. Moreover, throughout the projection, strategic adoption partnerships and increased marketing budgets will drive the global home automation market to new heights. Furthermore, the rising use of cloud-based solutions in smart home appliances will provide the global home automation market with new revenue potential.

As per a Facts andFactors report,the Internationally Home Automation Growing demand & share is anticipated to boost fromWorth us \$48.7billion in 2020 to USD89.6 billion in 2026,at an 11.5 percent annual CAGR growth rate from 2021 to 2026,\$163.24 billion in 2028 at a CAGR of 12.3 percent in the fore cast period of 2021-2028 ,and \$239,897.8 million by 2030,registering a CAGR of 17.6.Crest on Electronics,Inc.,AMXLLC,Control 4 Corporation,Honey well International,Inc.,Johnson Control,Inc.,Siemens AG,Savant Systems LLC,ABB Ltd,and others are among the leading market companies profiled in the study, along with their sales, revenues, and strategies. [15]

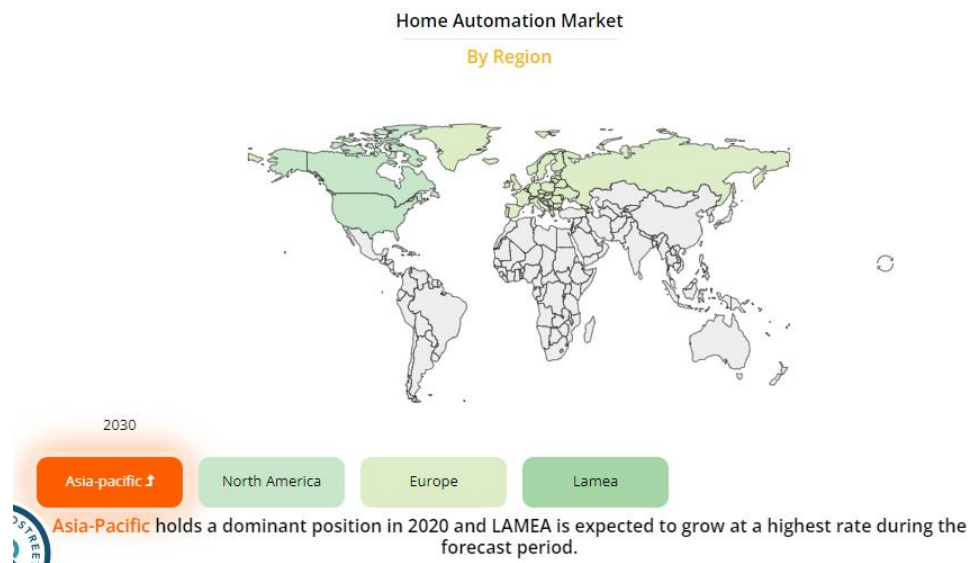


Figure 37. Home Automation Market [15]

Lighting control, security and access control, HVAC control, entertainment, and other goods are the most common types of property automation equipment. Control systems are a form of smart lighting system that will allow users to regulate the amount, quality, and characteristics of light in a given space. These smart gadgets reduce electricity waste while simultaneously increasing energy efficiency. The numerous technologies include wired and wireless home automation systems, which are used in a variety of settings including residential, commercial, and others.



Figure 38. Smart Home Market [16]

In the projected future, the growing usage of (IoT) devices in home automation systems is likely to drive market expansion. To control many of the smart home's devices, IoT based home automation system use network protocols or cloud-based services. Flexibility, simplicity of setup, prevention of the difficulty of running through cables or faulty electrical wiring, quick problem detection and triggering, and, most importantly, are all advantages of an IoT-based home automation system over a wired system. Modern devices accounted for 63 percent of all installed IoT equipment in 2020, according to Ericsson data, and the number of IoT connections is expected to reach 3.5 billion by 2023, according to Ericsson statistics on IoT in modern houses. As a result, the growing usage of IoT systems in smart appliances is propelling the market forward.

The home automation industry is being shaped by technology breakthroughs. To enhance their stance, major players in the home automation industry are focusing on creating technology solutions for home automation. For example, Crestron Electronics, a producer and

distributor of audio-visual automation and integrated equipment located in the United States, announced Horizon EX Dimmers and Keypads related to wireless mesh technology in December 2019. As part of a comprehensive Crestron smart home, the new line of wall-box controllers, which includes matching dimmers and keypads, provides a unique bespoke control option.

Zero1 was purchased for an unknown sum by Jersey Telecom (JT) Ltd., a UK-based telecommunications business, in June 2020. Jersey Telecom's intelligent engineering and home automation service offerings have now been enhanced as a result of this purchase. In the Channel Islands, Zero1 is a designer and seller of home and commercial environment and entertainment automation systems.

ABB, Crestron Electronics Inc., Schneider Electric, Honeywell International Inc., Johnson Controls Inc., Siemens AG, Legrand, Control4, Home Brain, Savant Systems Inc., Lutron Electronics Company, Sauter AG, United Technologies Corporation, Bosch Security and Safety Systems, Silvan Innovation Labs, Elan Home Systems LLC, Fueb, and Harman International are some of the major players in the home automation market. In 2021, the largest region in the home automation industry was North America. Asia-Pacific, Western Europe, Eastern Europe, North America, South America, the Middle East, and Africa are the areas included in the home automation market study.

“Australia, Brazil, China, France, Germany, India, Indonesia, Japan, Russia, South Korea, the United Kingdom, and the United States are among the nations included in the home automation market study.”

6.2 SWOT Analysis

6.2.1 STRENGTHS

Cloud based home automation monitor, triggers and control home wall switches and plugs, LED light bulbs, motion sensors and lighting devices, all the other appliances from browser or smartphone app. Apart from that referring back to chapter 4, after the integration of wireless relay board, remotely many appliances can be triggered and interfaced same as wired appliances connected to the wired based connected relay board connected to the central “smart home hub” which in turn add the market value to the project. One of the best features is to integrate the smart devices. With such revolution, now appliances are sharing common pool, which assists the customer to control all types of appliances.

Some company offers the smart home automation products having high cost as compared to the project made by our group, for example by making the comparison between the cost which is spent on this project. As this project is composed of different components. Each component is contributing cost to the product. The overall cost spent on this project is

Table 3. Cost

Raspberry pi 3B	Rs 8000 [16]
4 Channel Relay Board	Rs 500 [17]
Bluetooth Relay Board	Rs 800

16x4 Lcd Display	Rs750 [18]
------------------	------------

Companies that are doing business in home automation sells their product a high cost. Such as while researching, it was found that the wall socket switch which can support only 2 appliances costs Rs 3450 [19] . As compared to the solution proposed by our team providing the interface of 4+4 appliances depending upon the number of supportable channels on the relay board, is cheap solution. Notable point is that raspberry pi has 40 GPIO pins, which means that wired relay can be expanded to more than 32 channel which can automate the whole industry also Bluetooth relay is adding its contribution.

Another key feature is accessing the appliance around the globe anywhere at any time.



Figure 39. Pricing Comparison

Table 4. Azure Iot Hub Free Services Comparison

Edition Type	Price per IoT Hub unit (per month)	Total numbers of messages/day per IoT Hub unit	Message meter size
Free	Free	8,000	0.5 KB

6.2.2 WEAKNESSES

As the home automation becomes new to the market, weaknesses could be opportunities for adequate IT support. Other weaknesses are inconsistent, slow, or weak wireless connections. This may be due to distance problems, physical barriers, wireless interruptions, outdated firmware on the route, and/or power outages.

- Adequate IT support
- Wireless connectivity: May be inconsistent, slow, or weak.



Figure 40. SWOT Analysis [21]

6.2.3 OPPORTUNITIES

As the cloud-based home automation is new venture in the market of Pakistan which means that this product can be distributed in worldwide before most competitors. The business of home automation is growing in the market too.

- Opening new opportunities to the cloud-based home automation
- Growth of a home / business transformation industry

6.2.4 THREATS

As the system operates on the internet, such as cloud-based solution thus there can possibly be threats of intruder, security breach attempts that can lead to compromise the integrity of the data stored on the cloud. Though azure cloud has very strong security algorithm but there can always be the room of security breaching attempt.

- Security: Security threats may affect the safety and privacy of our home.
- Merchant cooperation: May affect market expansion.

Chapter 7: Conclusion and Future Prospects

7.1 Conclusion

Cloud based home automation project aims to automate the home appliances using the front-end application and backend azure cloud integration. As discussed in the previous chapters integrating with the azure makes the smart home secure, ubiquitous and add some extra features over other already available products.

Different services of azure cloud are used such as

- Azure Active Directory
- Azure Cosmos Database
- Azure Iot Hub
- Azure Web services

In order to achieve the objectives, two things are important

- User friendly interface to assists the personals with zero knowledge of technology
- Making the hardware easily to install and manageable

Making front-end user interface falls into developing the website-based solution to this project. Website is programmed in java node.js while the hardware side requires

- Raspberry pi 3B
- Wired Relay board
- Wireless Relay board
- Lcd interface

Now the world is shifting towards the cloud computing concepts because of having several notables features such as resources pooling, minimal data transmission latency.

7.2 Future Prospects

We aimed to make home automation over cloud by pooling the non-smart and smart devices in to a unifies interface called as smart home hub. The project can be extended to the next level by integrating the security surveillance cameras. As azure is providing several services in the backend, azure Machine Learning service can be used in future to assist the security surveillance system such as

Another integration is of adding the voice recognition system in the project. Voice control takes comfort and convenience at home to the next level and integrates seamlessly with smart home technology. Yes, there are benefits to asking voice control assistant to turn on lights or lower shadow through the engine window in the evening, but there is much we can do with our voice control system.

As voice control assistant can be connected to the internet, which means we can search for things online without having to hold our phone or turn on our laptop.

Appendix A

Hardware Evolution

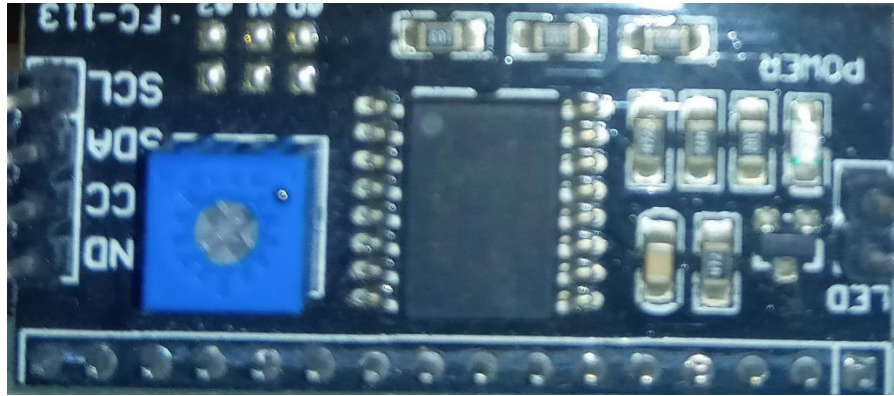


Figure 41. I2C Module



Figure 42. 16x 4 Lcd



Figure 43.. Raspberry Pi 3B

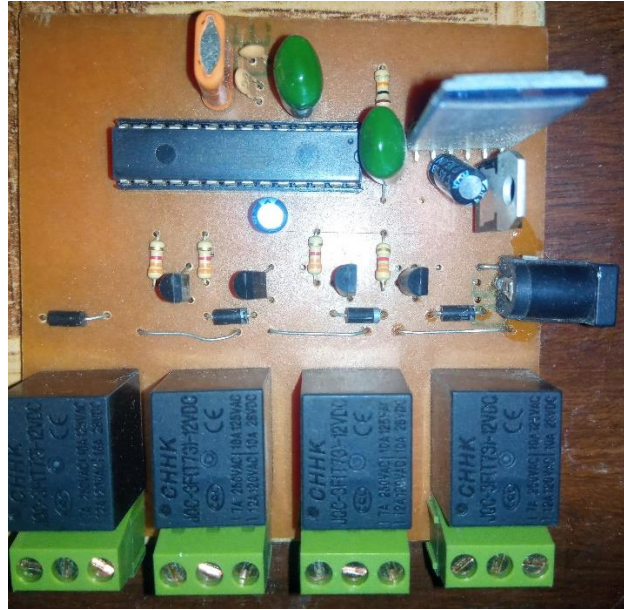


Figure 44. Bluetooth Relay Board

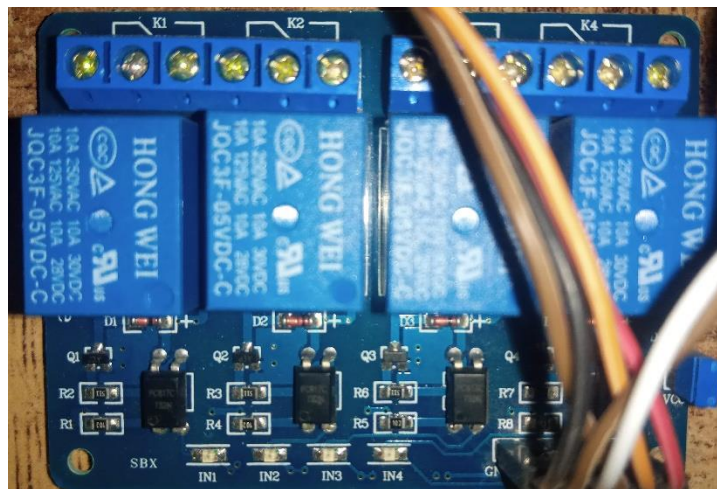


Figure 45. Wire Relay Board



Figure 46. Overall, Installation of Hardware

Website Interface

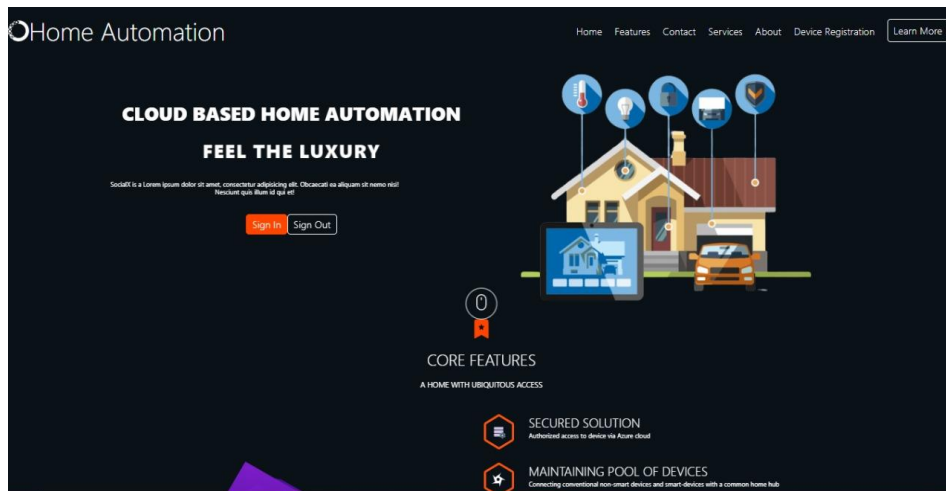


Figure 47. Website Main Page



Figure 48. Website Feature Page



Figure 49. Website Footer Section

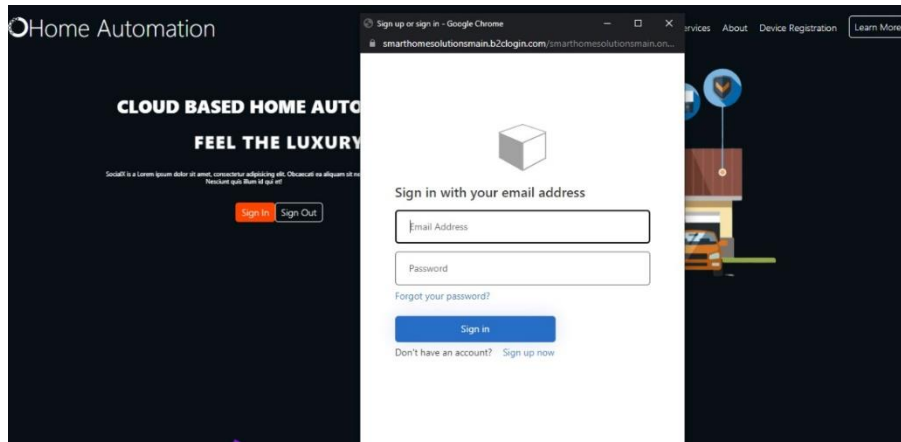


Figure 50. Website Sign In

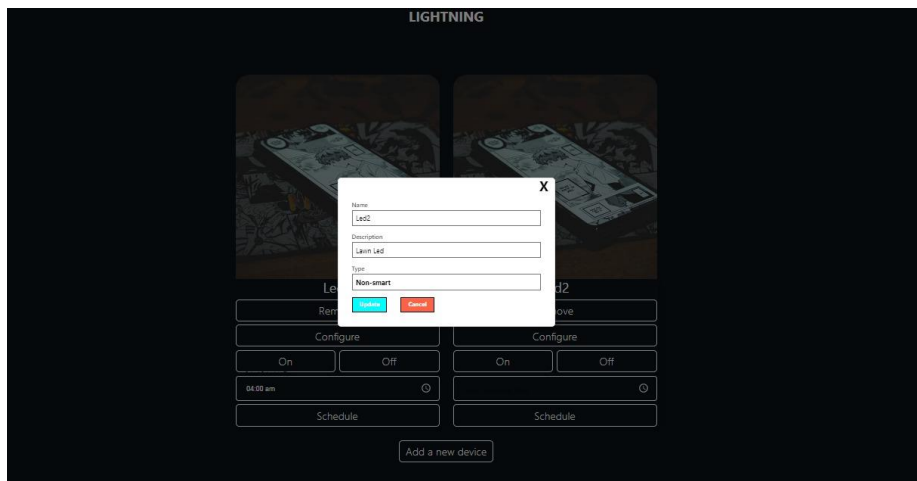


Figure 51. Devices

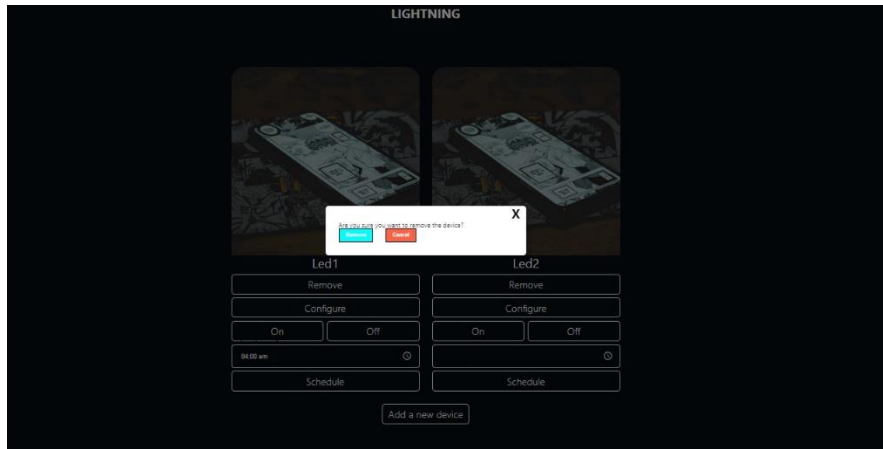


Figure 52. Devices

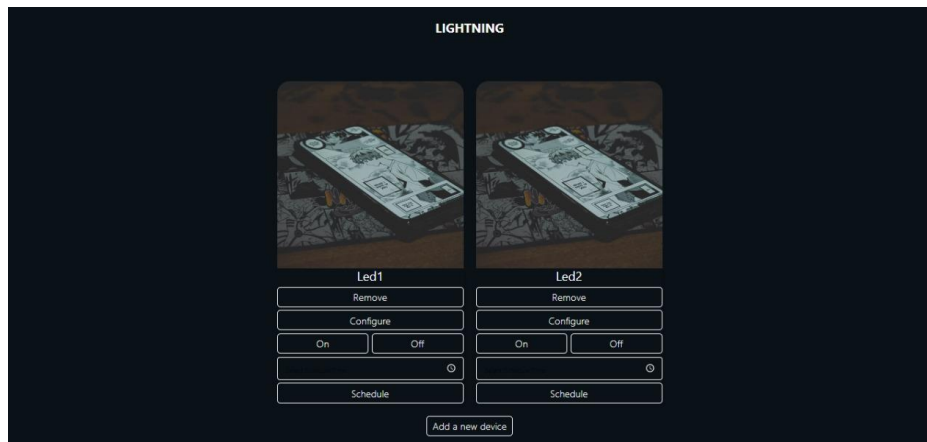


Figure 53. Two Appliance

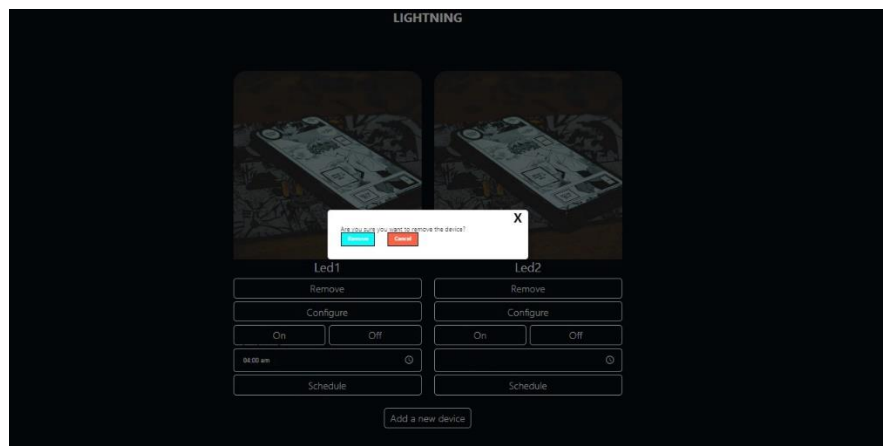


Figure 54. Devices

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