ABSTRACT

As a rapid change in technology always aims to serve mankind, the expectation for living a simple yet advanced life keeps on increasing. This very fact is the main reason behind 'Automating'. In order to bring advancement to this, the concept of A.L.I.E. has been introduced, which are the entities (Artificially Linked Intelligent Entity) that will work for the amelioration by replacing old systems into the smart ones that would be able to predict as well as work upon human commands with minimum intervention.

The sole motivation behind creating this project is to make use of the extreme potential of IoT together with the streams of Data Science and Machine Learning in order to achieve extreme boundaries beyond human capabalities. Thus leading towards the development of secure, reliable, effecient, and, highly customizable automated entities that could bring revolution in almost any aspect of real scenarios such as in security surveillance, agricultural, construction, healthcare industries, and even for personal usage like home automation.

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1. Introduction

1.1 Introduction

As rapid change in technology always aims to serve the mankind, the expectation for living a simple yet advance life keeps on increasing. This vary fact is the main reason behind 'Automating'. An internet connection is a wonderful thing, it give us all sorts of benefits that just weren't possible before. Let's think of a cellphone before it was a smartphone. We could call and surely text too, but now we can read any book, watch any movie, or listen to any song all in the palm of our hand. And that's just to name a few of the incredible things a smartphone can do. The point is that connecting things to the internet yields many amazing benefits. We've all seen these benefits with our smartphones, laptops, and tablets, but this is true for everything else too.

The Internet of Things as a concept wasn't officially named until 1999, however devices following this idea already existed. One of the first examples is from the early '80s: a Coca-Cola machine located in Carnegie Melon University. Programmers would connect via the Internet to the machine, and check if their preferred drink was available and cold, before heading to the machine. The idea of adding sensors and a connection to the Internet was discussed already a few decades ago, but progress was slow; the technology just didn't exist yet. As you can tell by the graph, the growth has been exponential for the past ~10 years and more internet-connected devices are being created, very fast.

The Internet of Things (IoT) describes the network of physical objects or things that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools.

Since decades we have been using a traditional approach to manually operate or manage any appliance that can efficiently send and receive data. This internet-connected devices are probably a lot more than we realize in our physical routine. It is desirable to improve daily processes and save time on menial or time-consuming tasks in addition to reducing the physical workload on the routine activities through automation and mass customization thereby removing all barriers. In early 2000, the popularity of smart home automation began to increase due to different of technology started to arise. Smart home automation turns into a more affordable choice and therefore a viable or available technology for consumers. With the uprising of the prestige of smart home, home networking, domestic technologies and other gadgets began to emerge on store shelves Today's smart home automation are more emphasize about smart living, living greener and security. Thus now, there needs more and more advancement into what is currently in existance rather than simply turning on and off

any device. This could be done by building stacks of features with user side customizability and also developing and integrating it with more fast and efficient algorithms alongwith with new technologies.

A smart home incorpates sensors,actuators,middleware,and a network and has two major interacting components which is a smart network and a smart load. The Smart home known as House automation, with the use of new technology, to make the domestic activities more convenient, comfortable, secure and economical.

Nowadays, people with the hectic daily life routine sometimes makes them forgetful to switch off the devices at home.As a human being we can't run from the clumsiness attitude plus with our packed daily routine life that sometimes makes ourself such in hurry situation that sometimes makes us forgot to switch off the lamps.It will causes the electricity bill rose sharply.Besides,it is one of the electricity wastage that will lead the earth to became an unhealthy ones.Besides, the elderly and the handicapped user faced problem to manually access control of light and fan instead of automation process.

The home automation system is implemented for decades but due to the costing and budgeting of the project, it remains a niche product for high-end consumers. The Intelligent Home Automation System, security is one of the major factors that does not implement the home automation system. The hectic daily life routine sometimes makes them forgetful to switch off the devices at home. The clumsiness attitude plus with our packed daily routine life that sometimes makes ourselves such in hurry situation that sometimes makes us forgot to switch off the lamps. It will cause the electricity bill rose sharply.

1.2 Scope

1.2.1 Current Scope

The system is capable of controlling various commercial/household items such as lights, fans, charging ports, alarms, televisions, air conditioners, curtains, and many such entities. These digital or physical entities could either be controlled using a web app or simply by using a mobile application. It supports many advanced functionalities such as scheduling, weather forecasting, air quality measure, air quality analysis, accurate temperature and humidity measure of room, smart security intelligence system, power-saving modes, smart recovery, etc. The scope of this product furthermore even tends to reach new heights when it consolidates with new technologies, and techniques to achieve it using standard tools and further improvements.

1.2.2 Future Scope

Providing scalability of the project to be made possible as notable gains can be made by the full deployment of this IoT project, in the longer term it is data-driven techniques and models based on AI and its subsets (machine learning, deep learning, and computer vision) along with data analysis that will deliver lasting value in disaster management, urban management, smart healthcare, construction industries, security surveillance, networking and communication, and many other applications which would ultimately provide seamless communication between people, processes, and things with minimal or without human intervention.

1.3 Project Summary and purpose

1.3.1 Project Summary

This project leads to the design and development of an IOT based secure, reliable, effecient, and, highly customizable automation project named Artificially Linked Intelligent Entity (ALIE) with wide range of functionalities such as scheduling, weather forecasting, air quality measure, air quality analysis, accurate temperature and humidity measure of room, smart security intelligence system, power-saving modes, and smart recovery, to name a few as seamless posibilities could be made by stacking up features on top in this hyperconnected world.

1.3.2 Purpose

The main intention behind the creation of ALIE is to provide high-end connectivity of any real-world entities across the world to the customers to operate those entities with great ease or by fully automating it to increase the living standard by minimizing the efforts. Its purpose equally scales well for not only the basic needs but also for the day-to-day industrial requirements to automate the process thus reducing the labor costs and achieving high-end results.

1.4 Objectives

Objective(s) of the proposed work:

- Automate daily work routine and improvise digital transformation to Industrial Internet of Things (IIoT) and for business scalability.

- Enabling the interconnection and integration of the physical world and the cyber space.
- Async Web server to be used for feeding real time updates
- Using Amazon web services for security, scalability and reliability (AWS)
- Ensuring compability with the most commonly used virtual assistant such as Google Home, or Alexa, or Siri.
- Create efficient power utilization method enabled application model.
- Provide superior functionalities.
- Empowering user to customize the both interface and functionality according to their requirenment.
- Provide an elegant UI with realiable backend service that meets almost any system requirenments.
- Selecting the right hardware that meets all requirenments with the overall project cost in mind thereby creating a low-cost, low-powered, convenient, fast, effective, scalable, and feature loaded application model.
- Safety needs to be kept in consideration such that no other connected objects gets affected or becomes unresponsive, or malfunctioned incase one is affected.
- Creating a compact 3d model for hadware to be fitted inside.

2. System Requirement Study

2.1 User Characteristics

The user of the system could broadly be divided into following 3 categories who must satisfy their respective characteristics and needs to be proficient in the those areas:

Administrator (Top Management):

- This user is the Level-1 (root level) user, the head of entire system.
- Has all the access and privileges to control the whole application.
- This level user can modify all the information of the user to the level below it.
- These updation could be done to achieve and maintain the integrity of the system as a whole by providing necessary services or for security in case of critical circumstances by the agreement upon all the high-level authorities.

Registered User (Customers):

- These are the Level-2 users who might be owning an entity and form a basis for controlling it.
- Has access to all the entities linked with his/her registered account in order to adjust, modify, and tune the necessary parameters to attain its functionalities.

- This level user can add or remove multiple guest users under their ownership and can modify or control their pieces of information along with providing controlled access to their entities.
- No minimum qualification of a is user needed in order to operate over the application but must have basic ideas of working of some of the services in use.

Guest User

- They are the subsistent (Level-3) users who come under the ownership of one Level-2 user.
- Has low-level access for controlling the entities but they cannot make high-level changes.
- This level user can only perform authorized operations and tends to be surrounded by boundaries of limited usage.

2.2 Software and Hardware Requirements

2.2.1 Software Requirements

User Interface Requirements:

- Menu options must contain quick access links such as home page, server configuration settings, profile settings, dropdown linked device access, pricing & show cart, add or renew a subscription, and logout option.
- Low-level entity parameter tuning functionalities (such as alarms, weather forecasting, air quality measure, warnings or alerts, and operational messages) must be embedded inside the control interface of the respective entity.

Capability Requirements:

- The overall performance of the system under low load conditions must be negligible and for high load conditions, the operation must be executed within 3 seconds after processing.
- Operations over the microcontroller must be executed considering memory size limit in mind, and necessary measures must be introduced to rectify buffer overflow condition and the system must be made ready of recovering from it.

Software Inputs and Outputs and Data Requirements:

- The software must only accept alpha-numeric data for naming the linked entity within the range of 32 characters.

- Event logging over WAN must be reflected through a server running on a local network using XHR requests. However, this must be directly introduced for software over LAN.

Software System Interface Requirements:

- Connections over an external interface must be made possible using a server running on a local network connected to an active internet connection.
- Software shall support the serial HTTP protocol per specification.
- The system requires 3rd party cookie access for logging into the application using other auth services such as Google, Facebook, Github, etc.

Security Requirements:

- Password encryption technique to be made in use while logging the user.
- Two-factor authentication service option to be provided to the end-user.
- Software must use audit trails to verify and track subscription and product purchase transactions.
- Authorization check to be made while controlling the entity to authorize the validity of the incoming request to be made from an authorized user and provide security against various Ddos or MITM attacks.

Risk Control Requirements:

- Data protection techniques must be employed using RTC memory in case of power failure or when kept in power-saving mode.
- The speed of recovery of the software after a crash must be minimal of about less than 5 seconds.
- The system must be able to handle at least 100,000 simultaneous requests and load them parallelly with minimal cost of delay.

Installation and Maintenance Requirements:

- At least 3 Mbps speed or bandwidth of WiFi is required to load that content, and surf smoothly over the application.
- Windows 7 version (with latest Windows updates) or higher
- Browser minimum version requirement for IOS users is IOS 12.1+ with Safari 12+ or Chrome 77+. And for Android users Android 7+ with Chrome 77+.
- A browser must support CGI, HTML & Javascript.

2.2.2 Hardware Requirements

- 1 GHz or fast processor. Quad-core or better recommended
- GB of RAM required for controlling machine; 8 GB of RAM recommended (2.5 GB minimum if running on a virtual machine)
- A minimum of 300KB of RAM is required for the microcontroller (controlled machine) to operate without the risk of buffer overflow.
- It is recommended for a microcontroller to have at least 4 data pins.
- 5-12 Volt AC to DC converter to be made in use with less than 0.5 Volt fluctuation. (Recommended 5 volt DC supply)
- At least 1 Ampere of input supply is required (2A recommended)
- An entity must contain necessary sensors, LEDs, and other peripherals attached to use their features. (comes in accordance to their versions)
- The hardware must be enclosed with proper casing to avoid shocks due to leakage of current. A compact 3D prototype is made to be designed and printed to this end.

2.2.3 Funtional Requirements

- The administrator must be able of tracking the audit of each registered user.
- The design interface of the software application must be neomorphic
- Advanced encryption techniques must be employed while logging the users into their accounts.
- The first page that a user gets to when entering his/her account is the entity access area with a vertical menu bar to the left of the screen.
- Users must only be able to add or remove an entity after entering a valid EID.
- A menu bar should be collapsible and must contain quick access links such as home page, server configuration settings, profile settings, dropdown linked device access, pricing & show cart, add or renew a subscription, and logout option.
- Account verification is mandatory while performing payments transactions for either purchasing an entity or for renewing a subscription.
- Software must be capable of performing additional functionalities such as weather forecasting, air quality measures, active location tracking, smart recovery, etc.

- Software must be flexible enough to provide parameter tuning functionalities for other peripheral devices and other services irrespective of the alie-version being used by the entity.

2.2.4 Non Functional Requirements

- The site should load in 3 seconds when the number of simultaneous users are greater than 10000
- The system must recover itself incase of power failure.
- User must be able to control entities over WAN connections.
- The logging request must be completed within a latency of no greater than 5 seconds.
- XMLHttpRequest must be sent and the outcome must be reflected with a latency of no greater than 2 seconds.
- The guest users must be prevented from altering externsive information other than the functionalities assigned by an entity owner.
- The application should provide users with easy-to-use and intuitive navigation both in their profile and in between other system elements.

2.3 Constraints

2.3.1 Parallel Operations

The software is designed such that multi-processing could be done simultaneously so that a user could perform multiple tasks at a time within a system within the same network by sending XHR requests to the microcontroller. This is done by using HTTP protocol for sending data packets to the controller or by requesting a service. Thus parallel operations could be performed seamlessly with minimal latency in delay.

2.3.2 Reliability Requirements

Reliability is one of the most important factors to be worked upon, especially when the communication links are made over WAN. To this end, there lies a need for the use of a fast, efficient, easily manageable, scalable, and trusted database keeping security in mind. Thus this project uses the ‘Cloud Firestore’ database which is the successor of ‘Firebase Realtime Database‘ so that the reliability over the operations can be achieved.

This reliability could further be enhanced by adopting various tools and techniques such as using of RTC memory to recover system from power failures or data loss.

2.3.3 Criticality of the application

A.L.I.E. is the collection of intelligent entities with which criticality becomes one of the important factors in which various parameters come under consideration such as the typically deployed environment and the value of data used by the application. Thus there rises a need to take care of some specialized measures such as maintaining the temperature along with performing high end tasks, input voltage load-bearing capacity, etc.

2.3.4 Safety and security considerations

Safety and security are the key parameters which makes ALIE much more advanced than any other traditional system. Here, security is kept as one of the most important factor in mind by adopting standard tools and optimized techniques to achive high end results. Thus safety of the user against both physical and cyber threat comes pre integrated with any of the alie's product and its services.

2.3.5 Hardware limitations

Accessing the service and extracting all sorts of functionalities of an application could be the main goal of any end-user. But with these benefits, there come some limitations and their fixes to overcome those limitations. Some of those limitations are hereby mentioned below:

- Hardware cannot be used over a WAN connection without an active local serve setup in the LAN network.
- The controller in use must contain enough data pins to connect over all the peripheral devices.
- Hardware requires enough data signals to process the data request by maintaining an active internet connection.
- The hardware may or may not be waterproof based on the alie version in use. So there lies a need for extra precaution to be taken care of while using devices like WALL-E in bathrooms to avoid shocks or damaging the product.
- Hardware installation might be difficult in some rare cases such as when used in foreign countries where input voltage does'nt meet spec.

2.3.6 Regulatory Policies

Regulatory support is a dedicated function as a part of ALIE services, not an additional responsibility. It takes a holistic approach for managing any specific regulatory obligations, rather than placing experts in silos by sector or jurisdiction.

In addition to data, reporting and filing services, these regulatory policies focus on delivering the information that users need to stay on top of regulatory change. Through workshops, seminars, newsletters and commentary, it provides users with insights on both the challenges and opportunities in current and upcoming regulation.

2.3.7 General Constraint

The general contraints imposed on the product are:

- There must be enough RAM size of about 300KB for functioning of the system with high reliability.
- The disk storage size must meet the minimum requirement of about 2.5MB in size.
- The source code must be written in C/C++
- The OS must be DOS 3.3 or later

2.4 Assumptions and Dependencies

2.4.1 Assumptions

ALIE will grow as a leading tool for emerging multiple real-world entities and providing a smarter way of controlling those entities that could serve mankind and for the betterment of the world thus improving living standards as a base level. However notable gains could equally be made possible for the industrial revolution in the field of business, healthcare, agriculture, constructions, etc for developing an accurate monitoring system spanning the boundaries above what humans could do within a short time span and minimal error rates. Thus Using such standard tools and advanced techniques will help accompany the critical goals with minimum error rates, with less labor, cost of time, and efforts resulting in the scaling of profit margin.

2.4.2 Dependencies

A part of ALIE uses various dependencies a mentioned below:

- EspAlexa library is used to connect the entities with the Amazon Alexa assistant (Echo Dot, Echo Show, etc) for performing operations using voice commands.
- IFTTT is used as a 3rd party service to connect the entities with Google Assistant for performing operations by giving voice commands.
- Firestore database is used as a database for storing the state and necessary information of the data of each system-level user and entity.
- AccuWeather API is used for weather forecasting purposes, temperature monitoring, air quality measure, and gives necessary alerts and updates about a thunderstorm or any other natural calamities.

3. System Analysis

3.1 Study of current system

The current system could broadly be categorized into 2 parts; Hardware-level and Software level.

In order to communicate between this two-level system, we make use of XMLHttpRequest (XHR) which is a browser-level API that enables the client to script data transfers via JavaScript. Despite the name, XHR can be used with protocols other than HTTP (the system uses HTTP protocol) and data can be in the form of not only XML but also JSON, HTML, or plain text. These communication requests are invoked when a user wants to perform operations over an entity either by voice or mobile commands using any device connected to an active internet connection. Currently, the system is capable of handling these requests over LAN without the use of a server, but when it comes to WAN connection, the system requires an actively running server within the local network area to send these requests. These systems can also be imposed to work upon other expensive servers provided by the server hosting companies like AWS, but it takes a lot of processing power and is not feasible for simple applications.

The hardware-level system varies based on different standard tools being used for controlling different entities and based on different versions. Thus, the current system uses a more dynamic and synchronized approach to provide services to the Software level system. Some of the most commonly used hardware being used at this level are sensors, actuators, motors, n-channel Relay, middleware, LEDs, jumper wires, a 220-

240 V input current-carrying wire, and AC to DC converter or a +5 – 12 V battery, a microcontroller, etc. These devices could be chosen so as to accomplish the desired task of controlling an entity by extracting all benefits while using its functionalities and by minimizing the cost of operation and equipment needed. Interaction occurs amongst these devices through a microcontroller for flow control which could be considered as a central hub consisting of various sets of instructions implemented in the C++ programming language.

Software level system could be considered as an interface either lying within a day-to-day mobile device such as laptops or mobile phones or within the devices such as Google Home or Echo Dot that could be used for controlling those hardware-level devices by giving (digital or voice) commands to the microcontroller. It could be composed in the form of any web or mobile application. In order to link the hardware level system (entity) with a software level system, a user is supposed to scan or enter a valid 16-bit codeword of that entity to get controlled access over that entity as an owner.

3.2 Modules and Functionality of proposed system

The main functional modules of each level of users of the system are as follows:
A "module" in A.L.I.E. gives a high-level description of a functional area, consisting of a group of processes describing the functionality of the module and a group of packages implementing the functionality are listed here:

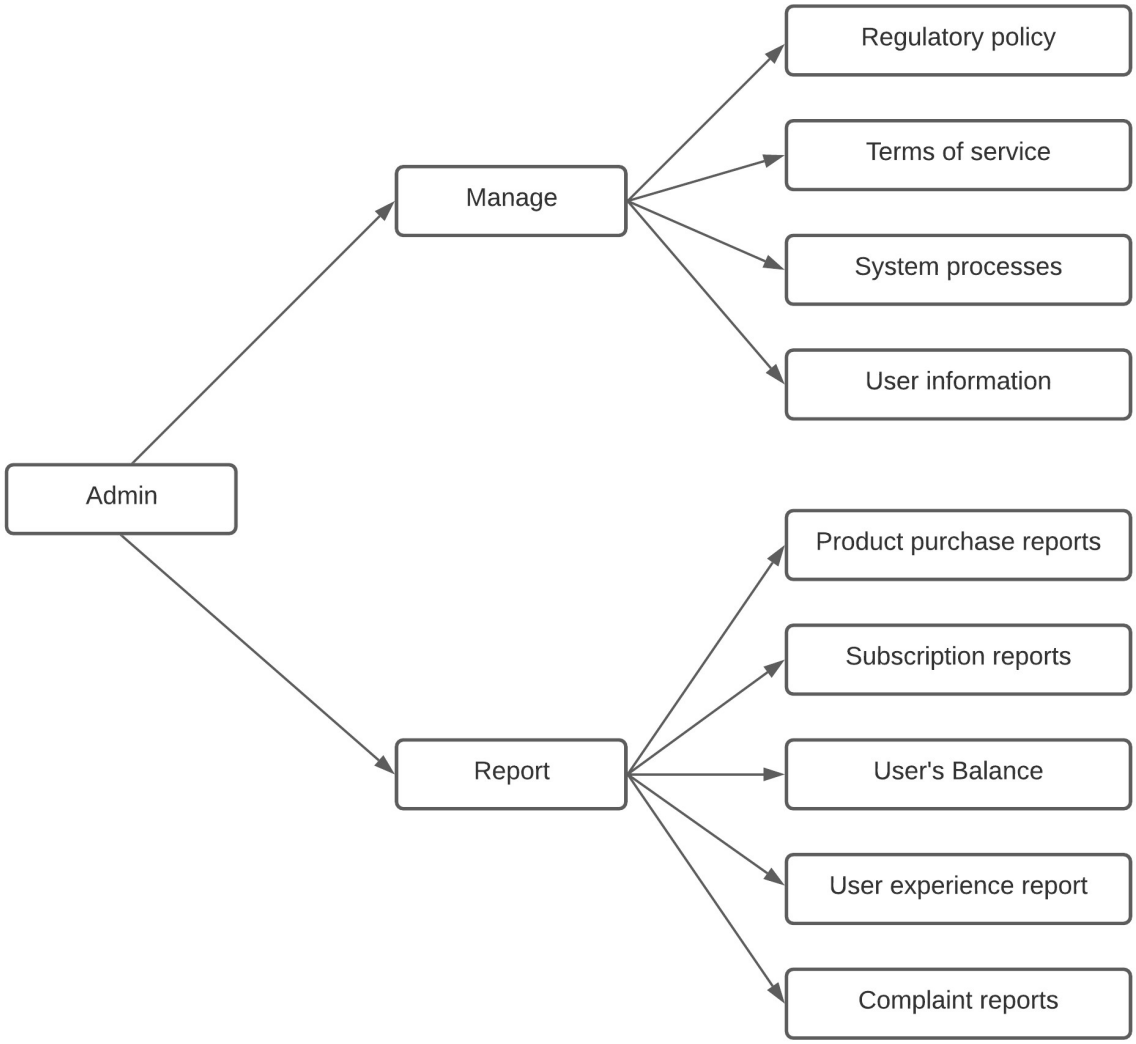
- Business Intelligence & Reporting
- Collaboration & Knowledge Management Module
- Customer Relations Management
- Service Management
- Product Development
- Project Management
- Software Development
- IT Services Management
- Finance
- Translation
- Reporting
- Helpdesk & support

However, below are some functional modules that are caregorized on the basis of each level user of the system:

Administrator
Admin of the root system mainly aims to perform the following functions:

- Provide regulatory services to the user
- Manage users and their critical information
- Views all reports:
    - Product Purchace reports.
    - Subscription reports
    - Balance reports.
    - User experience reports.
    - Feedback reports.
    - Complaints reports.
- Implies and maintains terms and policies on regulatory basis.

Functional Diagram of Administrator

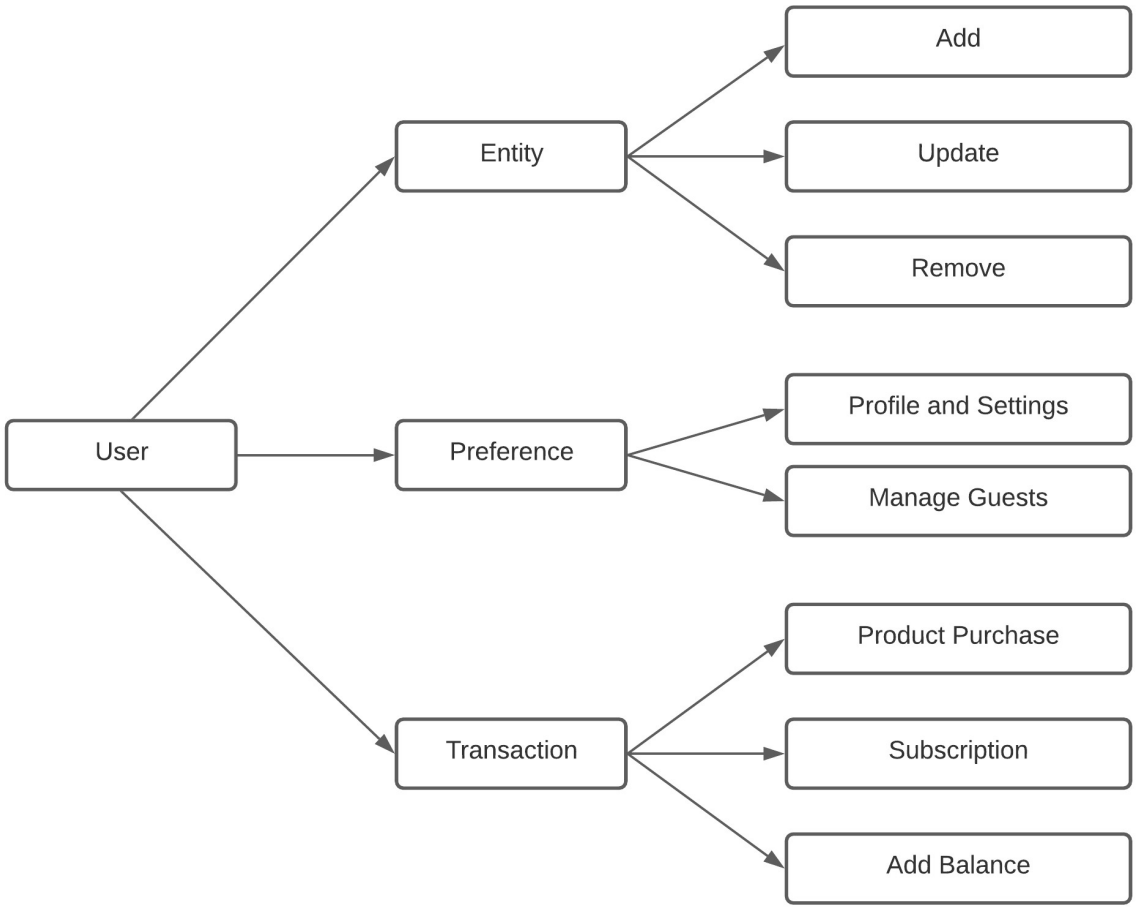


Users

Users or simply an entity owner can perfom specific tasks

- Add, remove or update entities
- Manage user level preferences
- Manage their profile and settings
- Manage guests preferences
- Perfom transactions for:
    - Purchasing an entity
    - Add or renew the subscription
    - Add balance to AliePay

Functional Diagram of User

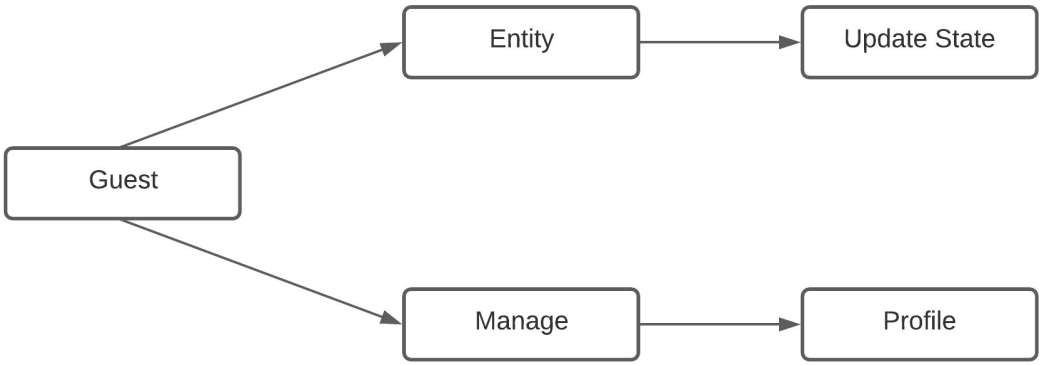


Guests

Guests are authorized to perfom specific tasks those are granted by the entity owners.

- Access the service granted by an alie owner.

Functional Diagram of Guest



3.3 Feasibility Study

3.3.1 Technical feasibility

Each entity is designed to operate by accomplishing the factors such as reliability, maintainability, scalability, portability and usability. Corrective measures are also taken while making use of multiple recource and technology used during the production of each alie version and providing a standard way of communication of all devices apart from the variation in hardware and updates in software.

3.3.2 Operational feasibility

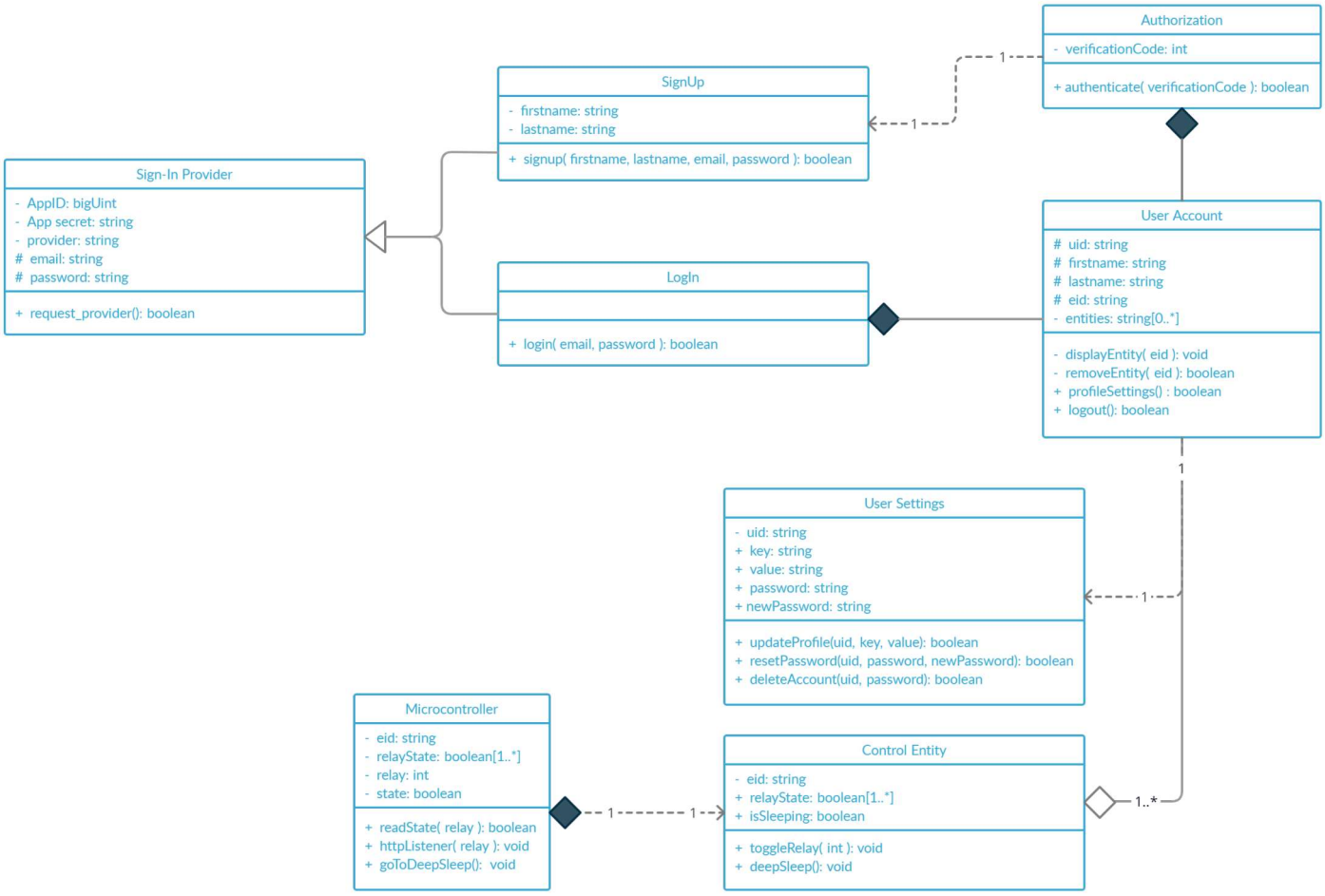
The system uses a highly reliable Firestore database and standard protocols to act upon changes in order to achieve high degree of operational feasibility in terms of service.

3.3.3 Economic feasibility

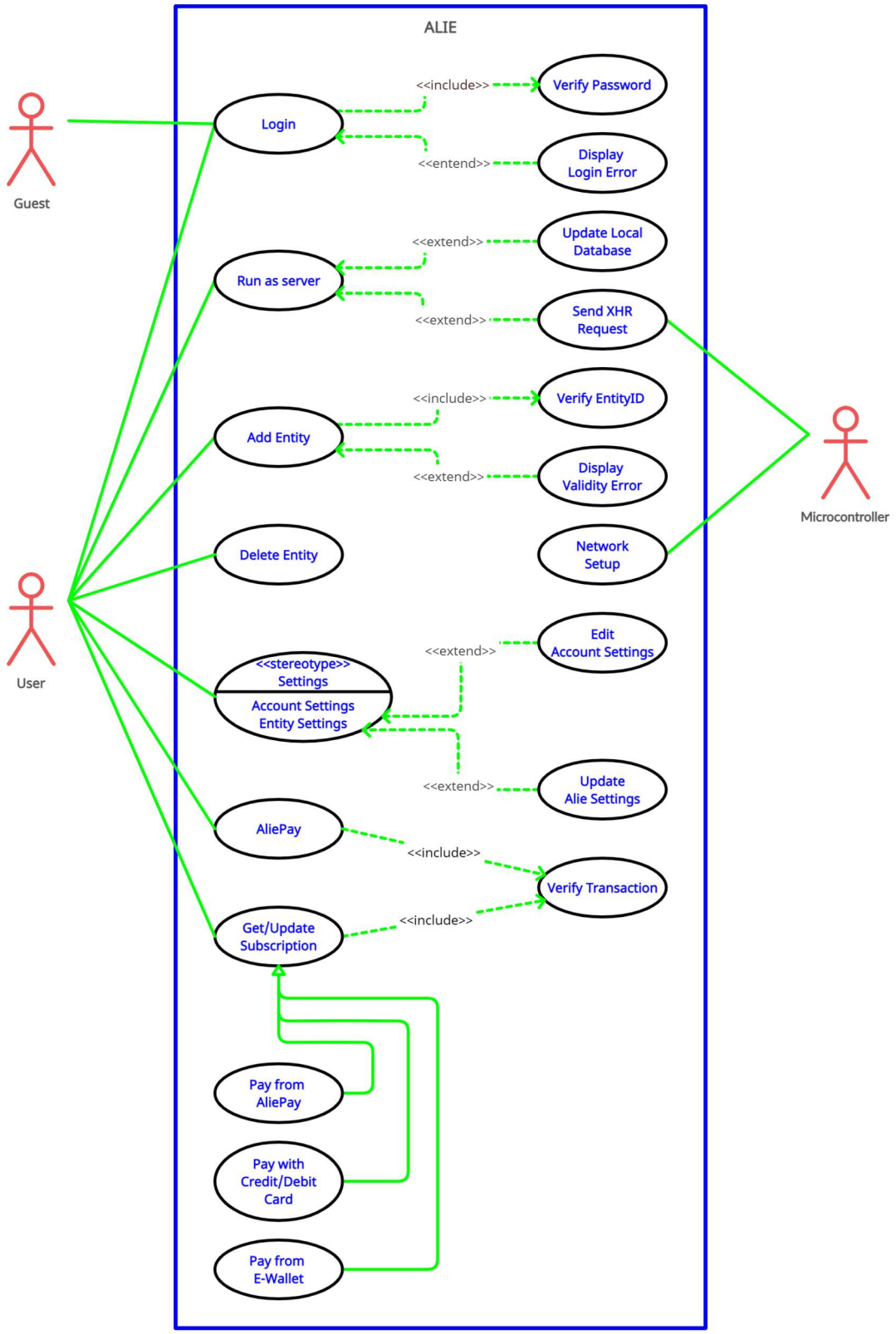
Based on research by perfoming study, analysis and tests over the system, each entity is designed and developed by minimizing the cost of operation and budget of the equipments in use by adopting advance techniques and idea to overcome the boundaries and achieving high-end results.

3.4 Class Diagram

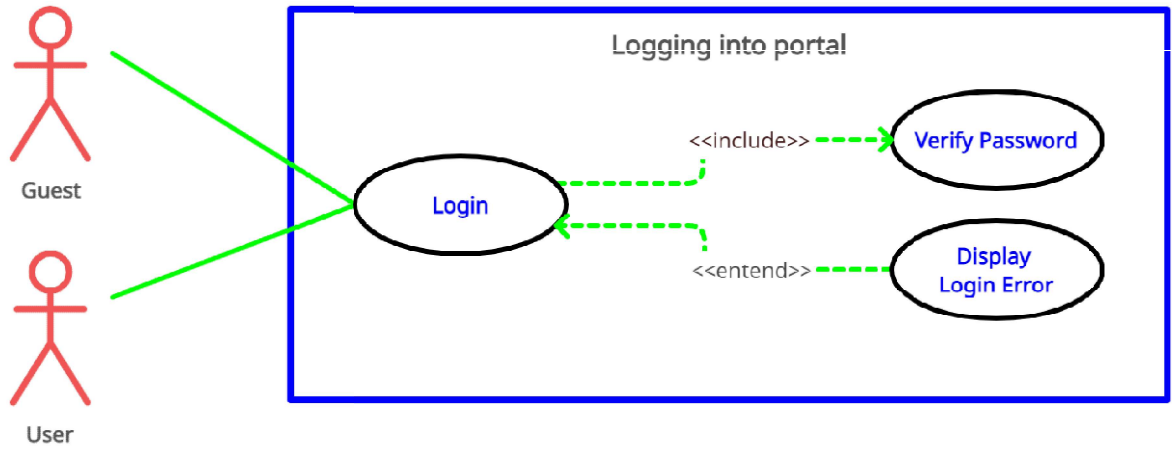
UML Class Diagram



3.5.1 Use Case Diagram of ALIE



3.5.2 Use Case Senarios and Diagram for Logging into Portal



Scenario for Logging into Portal:

1. Logging into Portal

1.1 Introduction: This usecase describes on how a user or guest could log into their account through alie home page portal.

1.2 Actor: User, Guest

1.3 Precondition: User have valid credentials.
Guest must have valid Guest-ID and Password

1.4 Postcondition: None.

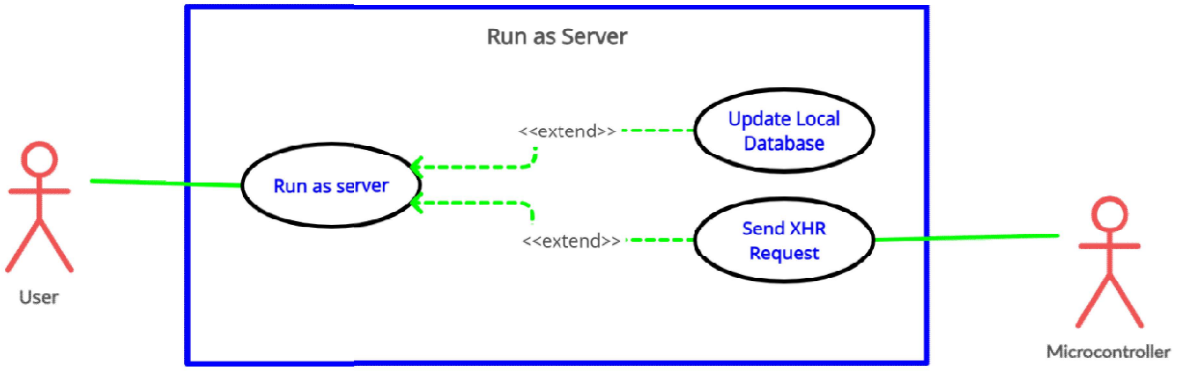
1.5 Basicflow: This usecase starts when a user or guest opts for signing request on webpage.

-User enters credentials.

-Authentication process starts.

-User logs into his/her account incase authentication process was successful

3.5.3 Use Case Senarios and Diagram of Run as Server



Scenario for Running Server:

2. Run as Server

2.1 Introduction: This usecase describes to run local machine as server so that each entity could communicate over WAN remotely.

2.2 Actor: User, Microcontroller

2.3 Precondition: User must provide local storage access (incase blocked by browser)
User must have atleast one entity registered into his/her account
User must be loggedIn into his/her alie accout
There must be no other server running
User must agree to terms of service

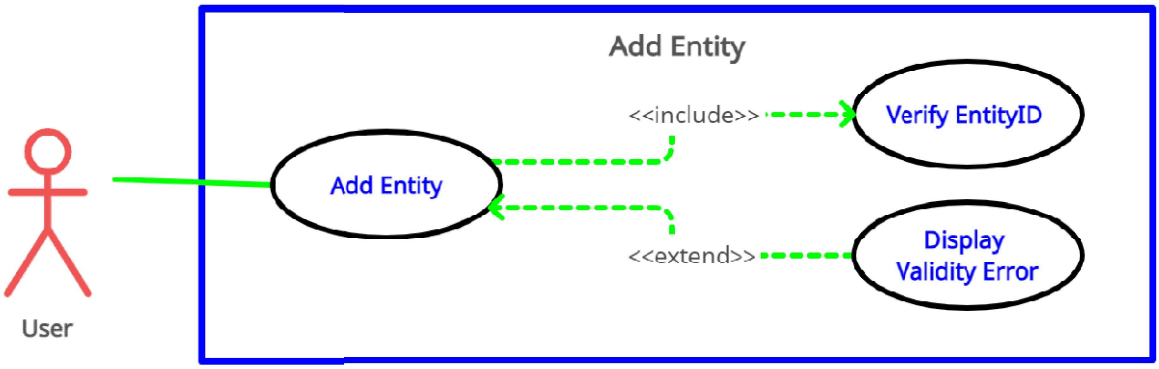
2.4 Postcondition: Running machine must maintain active internet connection in order make communication with entities via XHR/MQTT protocols.

2.5 Basicflow: This usecase starts when a loggedIn user choose to run his/her local machine as server

-User click 'Run this device as server' button

-User agrees to the terms of services (ToS).

3.5.4 Use Case Senarios and Diagram of Add Entity



Scenario for Adding a new Entity:

3. Add Entity

3.1 Introduction: This usecase is used when a user choose to add/register a new entity into his/her account.

3.2 Actor: User

3.3 Precondition: User must be loggedIn into his/her alie accout
User must have valid Entity ID (Alie-ID)

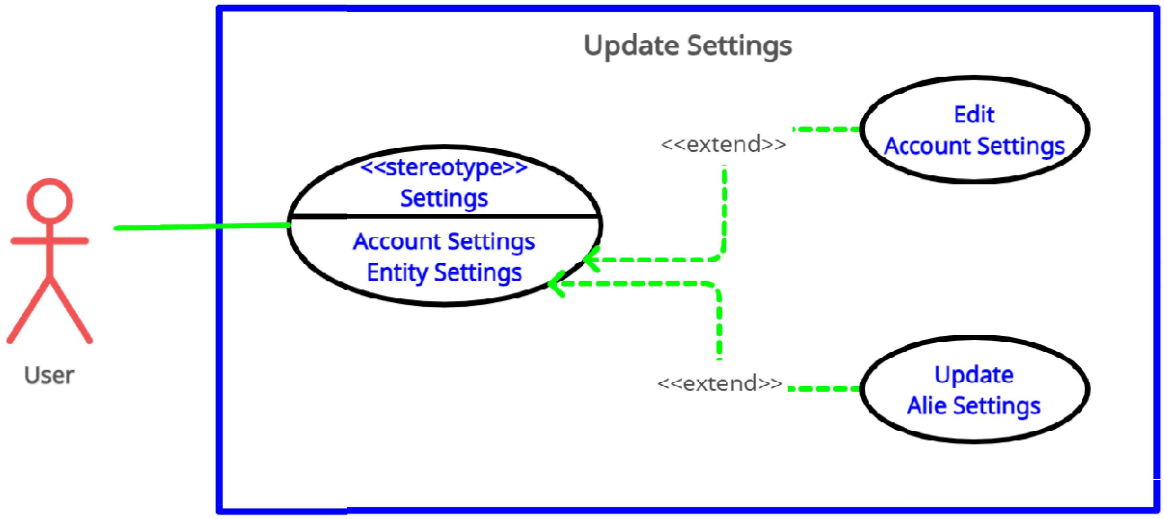
3.4 Postcondition: None.

3.5 Basicflow: This usecase starts when a user clicks on 'Add Entity' button.

-User enters/scan correct Alie-ID

-Entity gets linked with user's account if he/she enters a valid Alie-ID

3.5.5 Use Case Senarios and Diagram of Update Settings



Scenario for Updating the settings:

4. Update Settings

4.1 Introduction: This usecase starts when a user wants to change his/her profile settings or what to either add/tune/update some features of the registered entity

4.2 Actor: User

4.3 Precondition: User must be loggedIn into his/her alie account

4.4 Postcondition: None.

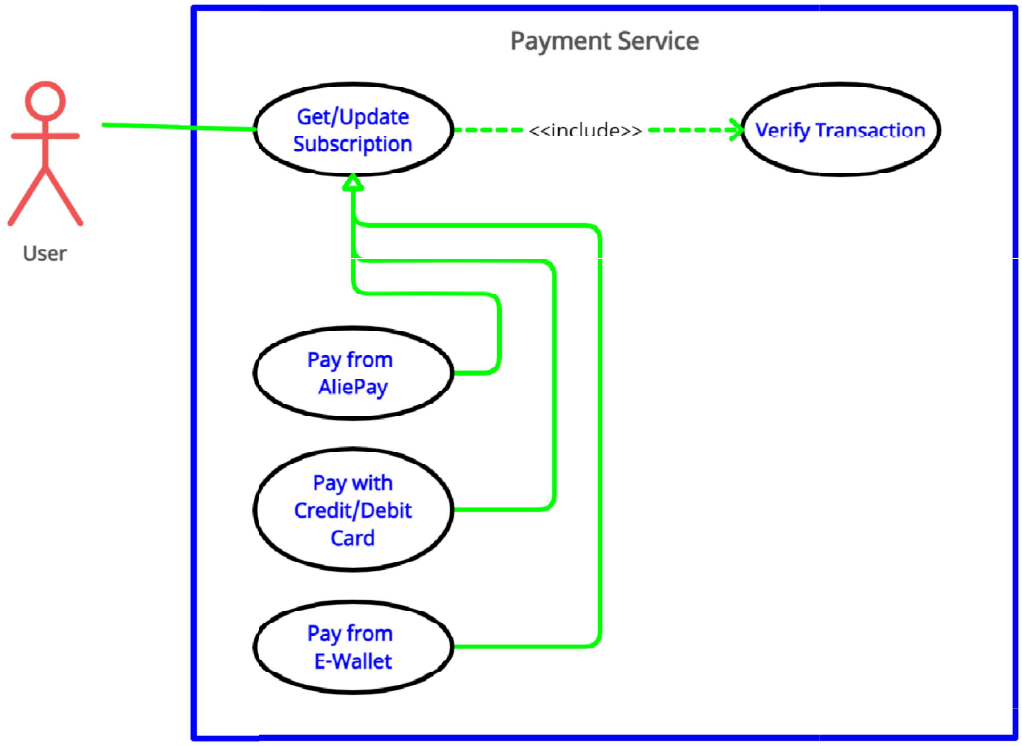
4.5 Basicflow: This usecase starts when a user clicks on 'Settings' button

-User choose a between account or entity settings

-User updates the existing state or value

-Changes gets verified and saved

3.5.6 Use Case Senarios and Diagram of Payment Service



Scenario for Payment Service:

5. Payment Service

5.1 Introduction: This usecase is used when a user wants to get or renew his/her alie account subscription based on numbers of entities registered.

5.2 Actor: User

5.3 Precondition: User must have a valid credit/debit card or must have enough balance on their e-wallet account or AliePay

User must be loggedIn into his/her alie accout

5.4 Postcondition: The transaction must be successful before updating subscription status.

5.5 Basicflow: This usecase is starts when a user goes to the payment portal of the webpage

-User selects payment option

-User enter payment credentials

-Payment transaction fails or get verified

4. Project Planning - Estimation and scheduling

4.1 Estimation

4.1.1 FP based Effort and Cost Estimation

Function Points of the system could be brodaly categorized into 2 categories consisting of total 5 functional units:

1. Transactional functional type:
   - External Input (EI): Touch Pin, Mobile commands, Voice commands, Activated/Deactivated, Payment, User Info, Guest Info, Entity Info, Entity Operations, Server request.
   - External Output (EO): Messages, Sensor readings, Sensor status, Entity status, Server response.
   - External Enquiry (EQ): Zone inquiry, Sensor inquiry, entity state inquiry, server inquiry, database inquiry, API services inquiry, timing inquiry.

2. Data functional type:
   - ILF: System configuration file, Dependencies files
   - EIF: Sensor readings, zone settings, Alarm alert, Activated/Deactivated, 3rd party service

Computing FP of the ALIE system using the following relationship:

F.P. = U.F.P × C.A.F.

Computing UFP (Unadjusted Functional Point)

Measurement Parameter	Counts	Weighted Factor			Complexity
		Low	Average	High	
External Input (EI)	10	3	4	6	30
External Output (EO)	5	4	5	7	20
External Enquiry (EQ)	7	3	4	6	21
Internal Logical File (ILF)	2	7	10	15	14
External Interface File (EIF)	5	5	7	10	25
UFP with simple weight factor is equal to					110

Complexity Adjustment Factor is calculated using below 14 aspects of processing complexity on a scale of 0 – 5

0 – No Influences or no important or no applicable
1 – Incidental
2 – Moderate
3 – Average
4 – Significant
5 – Essential

Sr. No.	Measuring aspect	Scale
1.	Data Communication	5
2.	Distributed Data Processing	5
3.	Performance	4
4.	Heavily Used Configuration	3
5.	Transaction Role	3
6.	Online Data Entry	2
7.	End-User Efficiency	3
8.	Online Update	2
9.	Complex Processing	4
10.	Reusability	1
11.	Installation Ease	2
12.	Operational Ease	5
13.	Multiple Sites	0
14.	Facilitate Change	3

Σ Fi = 5 + 5 + 4 + 3 + 3 + 2 + 3 + 2 + 4 + 1 + 2 + 5 + 0 + 3
= 42

CAF = 0.65 + (0.01 x Σ Fi)
= 0.65 + (0.01 x 42)
= 1.07

Thus the Function Point based effort and cost estimation of the project results:

F.P. = U.F.P × C.A.F.
= 110 × 1.07
= 117.7

4.1.2 COCOMO based Effort and Cost Estimation

Computing the estimates of size, effort, cost, time and quality of the software being develoed using the COCOMO model (Constructive Cost Model) which is a regression model based on LOC, i.e number of Lines of Code.

Software Product	a	b	c	d	Selected
Organic	2.4	1.05	2.5	0.38	
Semi detached	3.0	1.12	2.5	0.35	✓
Embedded	3.6	1.20	2.5	0.32	

ALIE system follows Semi detached mode of development by using 60,000 LOC (Lines of code). Thus the system consists of 60 KLOC.

$$\text{Efforts} = a \times (\text{KLOC})^{b}$$
$$= 3 \times (60)^{1.12}$$
$$= 294.20 \text{ Person} - \text{Month}$$
$$\approx 294 \text{ Person} - \text{Month}$$

$$\text{Development Time} = c \times (\text{Efforts})^{d}$$
$$= 2.5 \times (294.20)^{0.35}$$
$$= 18.27 \text{ Month}$$

$$\text{Average Staff Size} = \text{Effort} / \text{Development Time}$$
$$= 3 \times (60)^{1.12}$$
$$= 16.09 \text{ Person}$$
$$\approx 16 \text{ Person}$$

$$\text{Productivity} = \text{KLOC} / \text{Efforts}$$
$$= 60 / 294.20$$
$$= 0.2039 \text{ KLOC / Person} - \text{Month}$$

The key parameters which define the quality of any software product, which are also an outcome of the Cocomo are primarily Effort & Schedule (development time) using which we can easily compute the cost esteems of the A.L.I.E. system that is to be developed.

- Each person working under this project gets 20,000 Rupees per month.
- Average Staff Size required for the development of the project is 16.
- And the estimated development time of the project is 19 months (consider the upper bound).

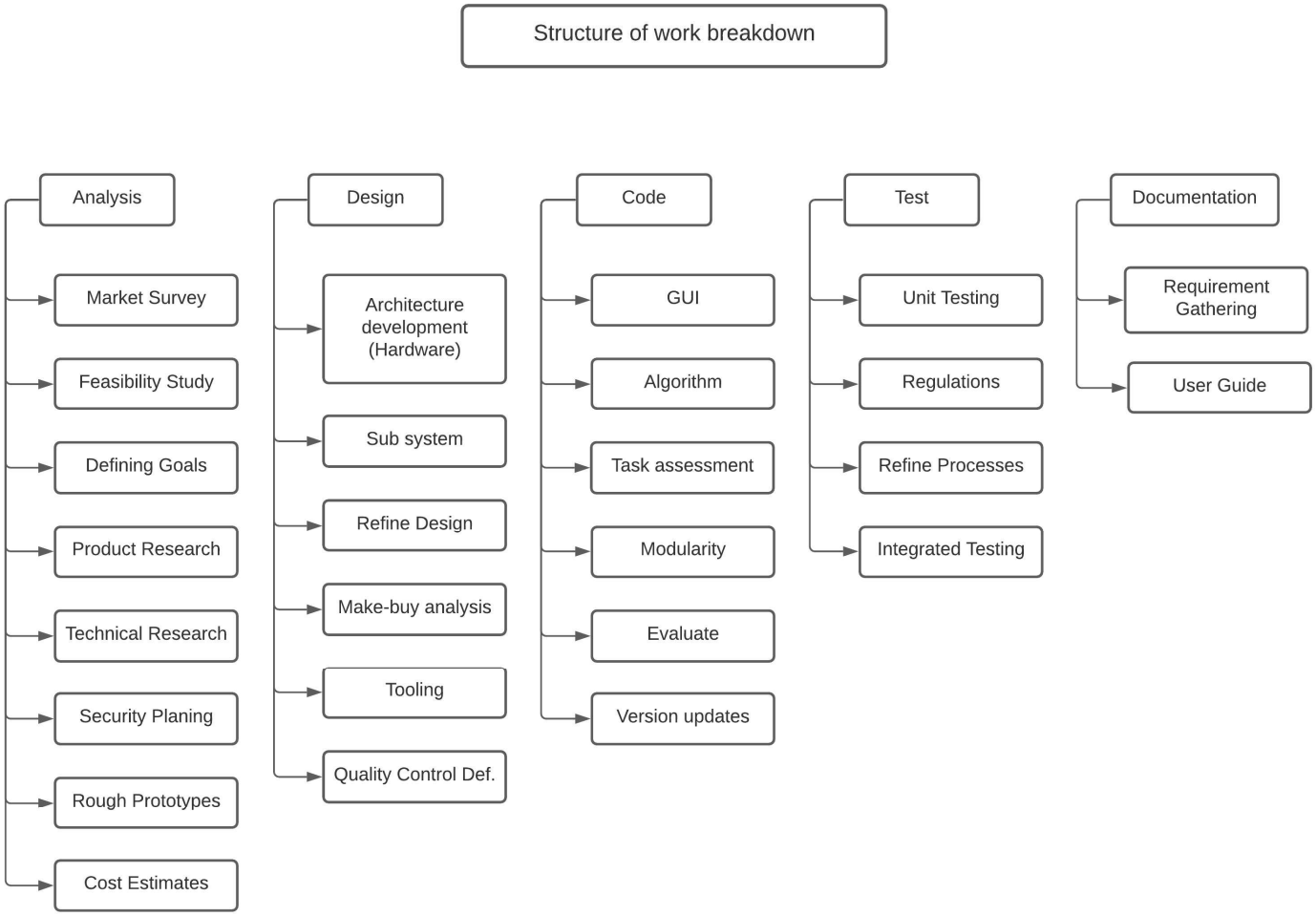
Thus the estimated average development cost of the software is:
= 20,000 × 16 × 19
= 6,080,000 ₹

Over and above to this cost, the cost of hardware equipments, application tools, transportation, etc are remaining to be added to this.

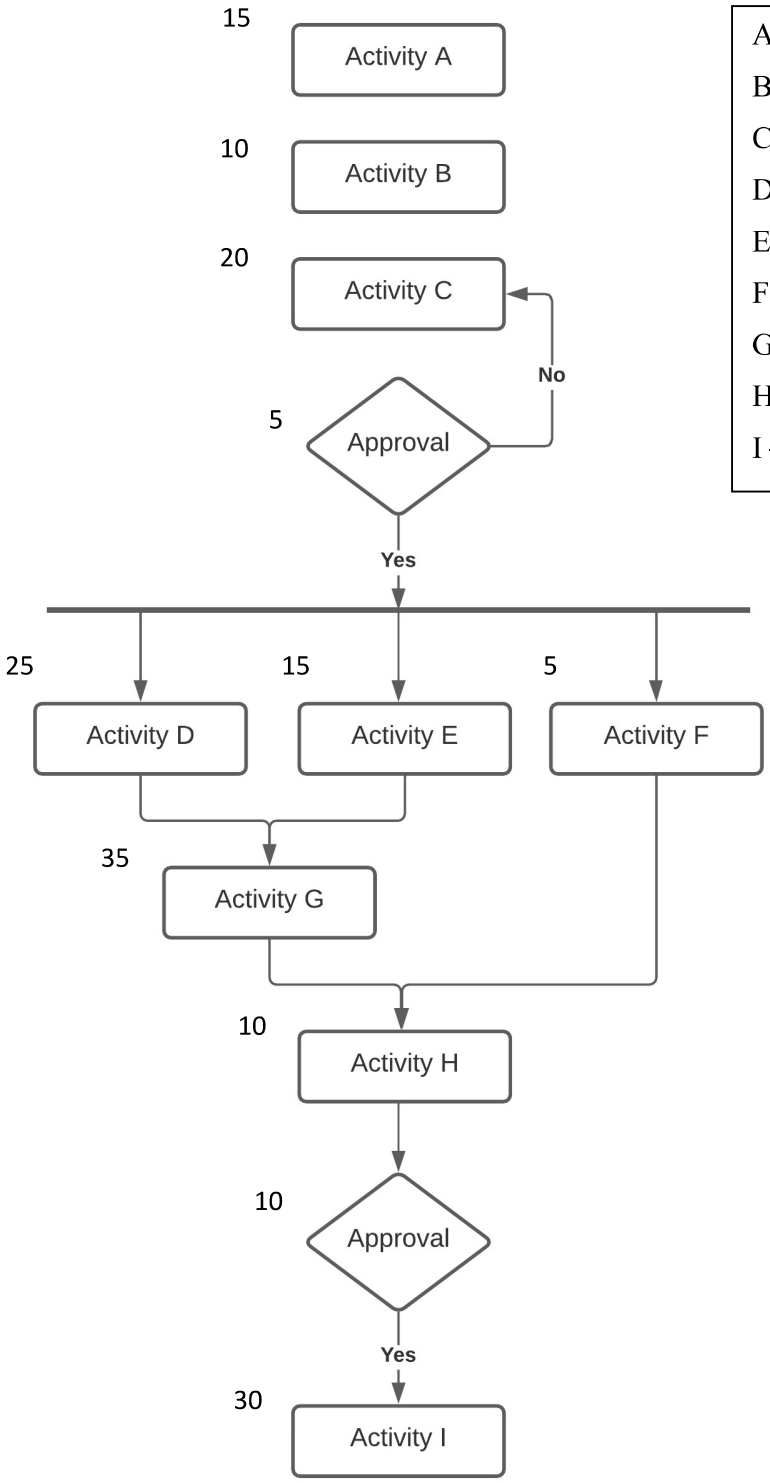
4.2 Project Scheduling and Time Line Chart

Multiple parallel and series of activities are carried out in developing the A.L.I.E system by accomplishing both the hardware and software level need. This process is carried out to break up this larger project management timeline into more manageable phases and conquering each phase by staying in timeline.

Work Breakdown Structure is used to decompose a given task set recursively into small activity

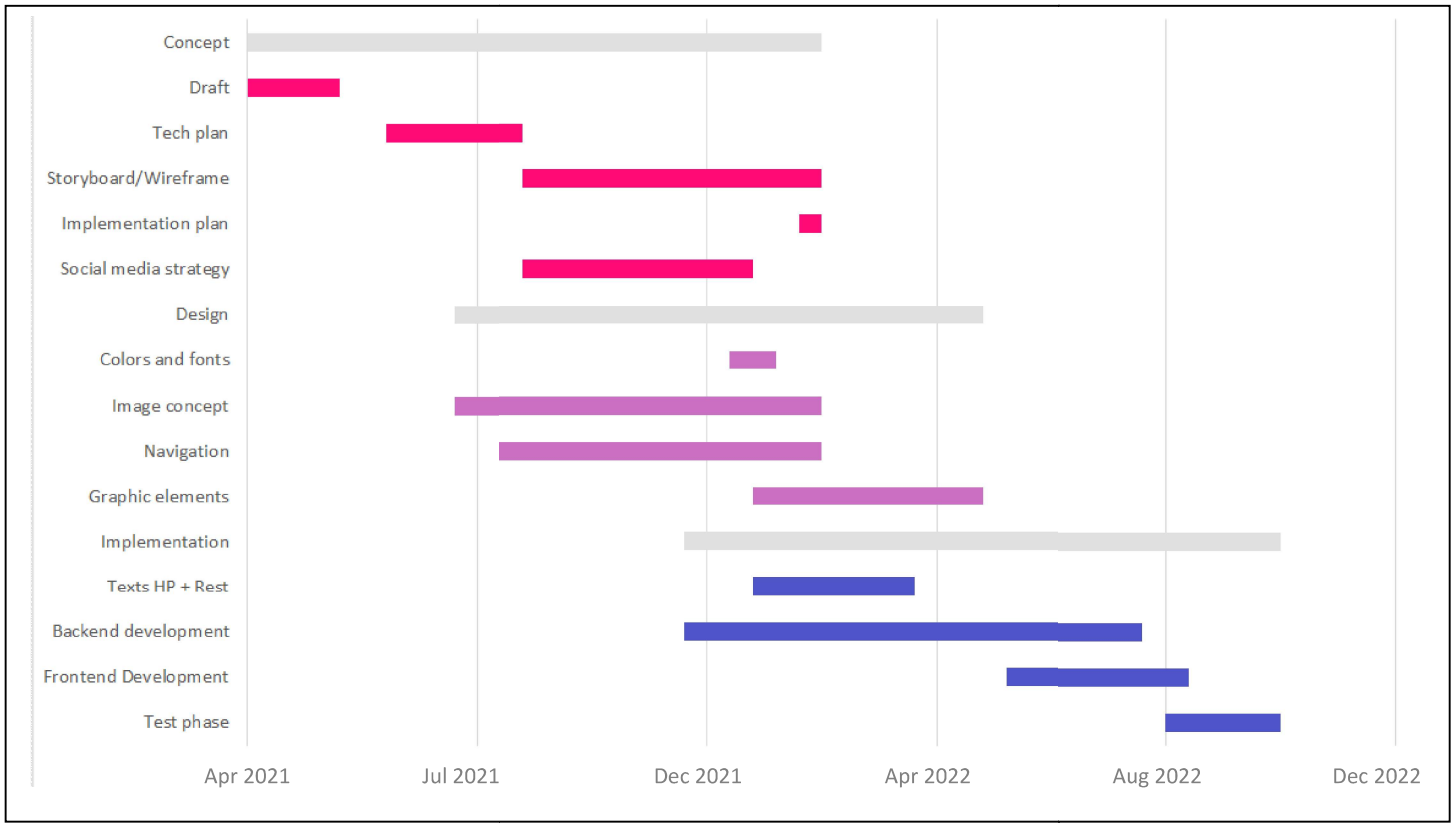


Activity Network Requirements



A – Requirements Gathering
B – Requirements Analysis
C – Conceptual design
D – System design
E – User interface design
F – Documentation
G – System Development
H – System Testing
I – Implementation

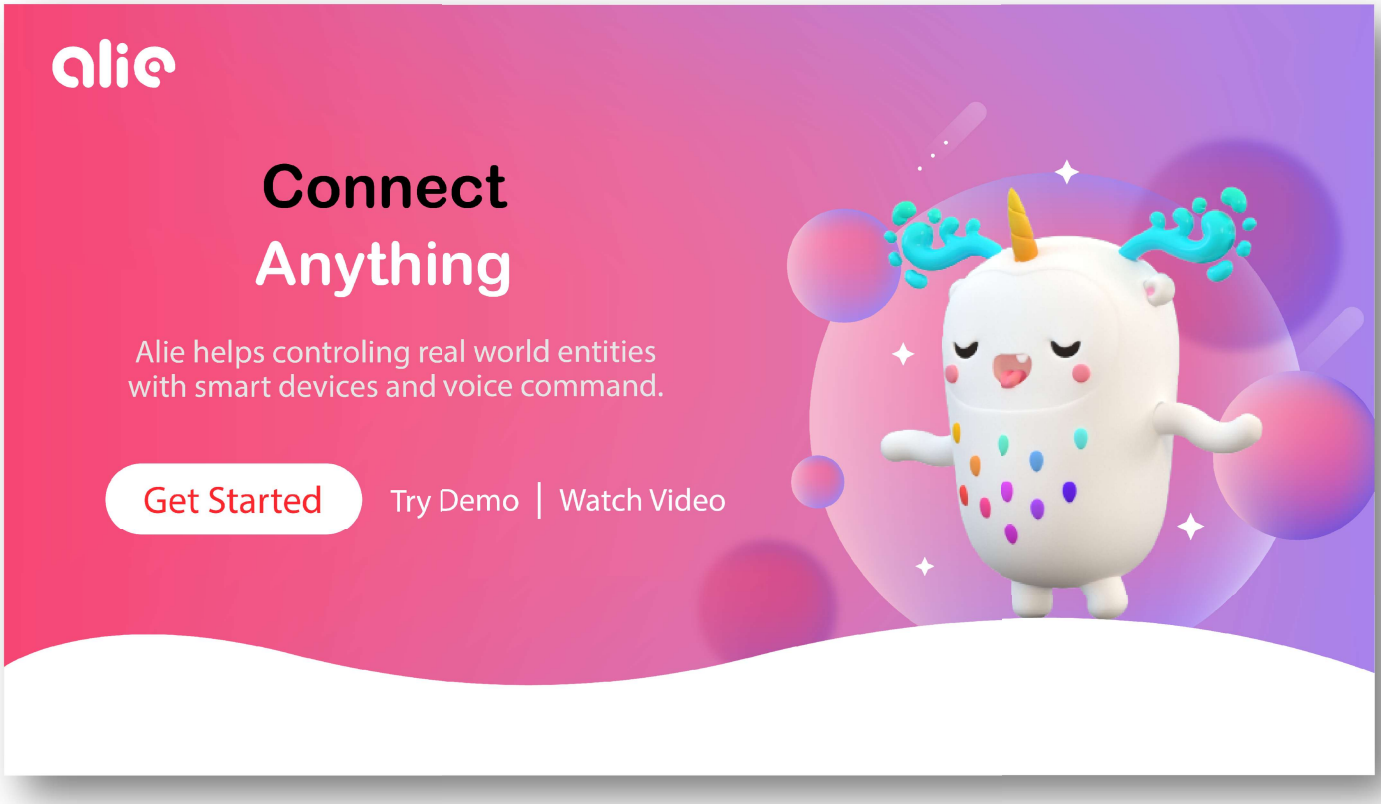
Gann Chart


Concept
Draft
Tech plan
Storyboard/Wireframe
Implementation plan
Social media strategy
Design
Colors and fonts
Image concept
Navigation
Graphic elements
Implementation
Texts HP + Rest
Backend development
Frontend Development
Test phase
Apr 2021
Jul 2021
Dec 2021
Apr 2022
Aug 2022
Dec 2022

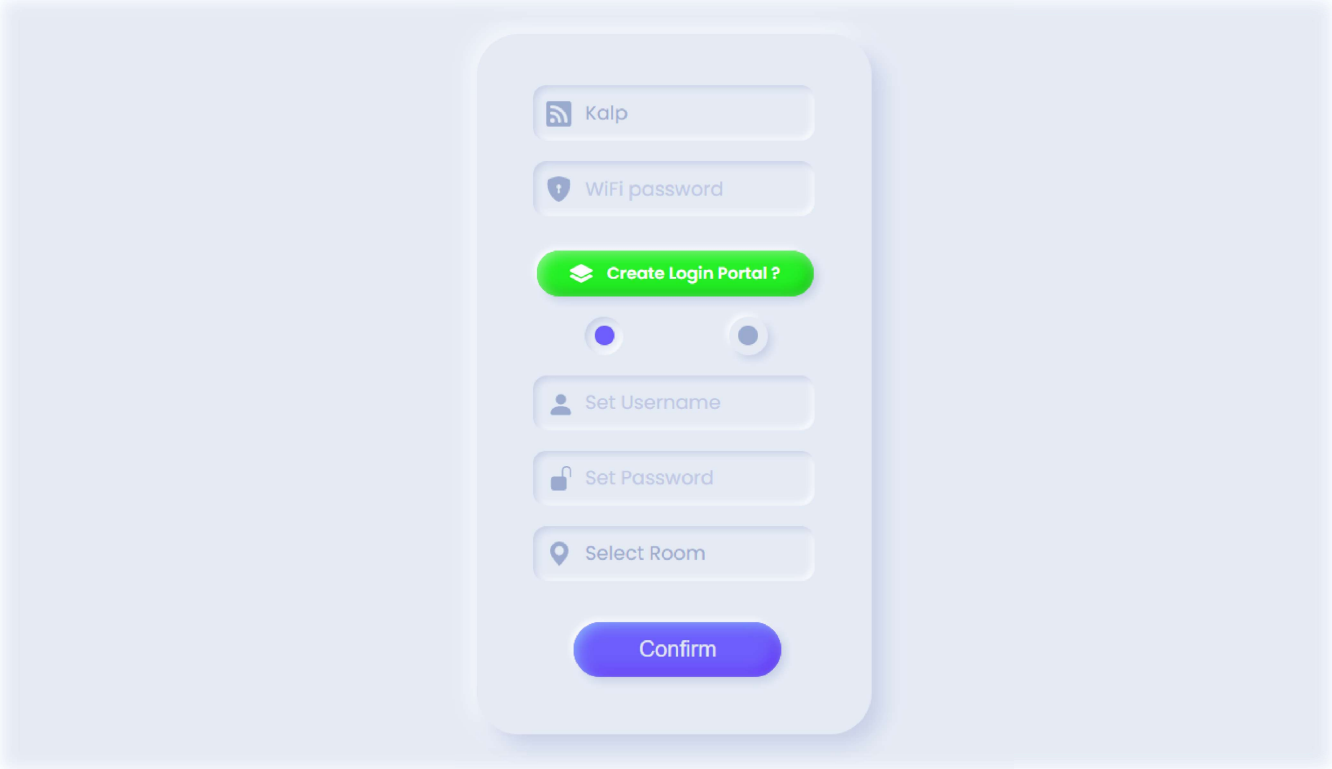
5. System Desing

The designing aspect of the A.L.I.E. system cover various aspect of front-end and back-end designing to optimise the system level operations with great efficienty and reliability of each tasks and the scalability of the entire system to perfom further enhancement over both Hardware and Software level upgrades thus building, enhancing and maintaining the entire ALIE system and its processes providing a great user experience (UX) in an eligant environment, using a neumorphic design theme (UI) as shown in the wireframe below;

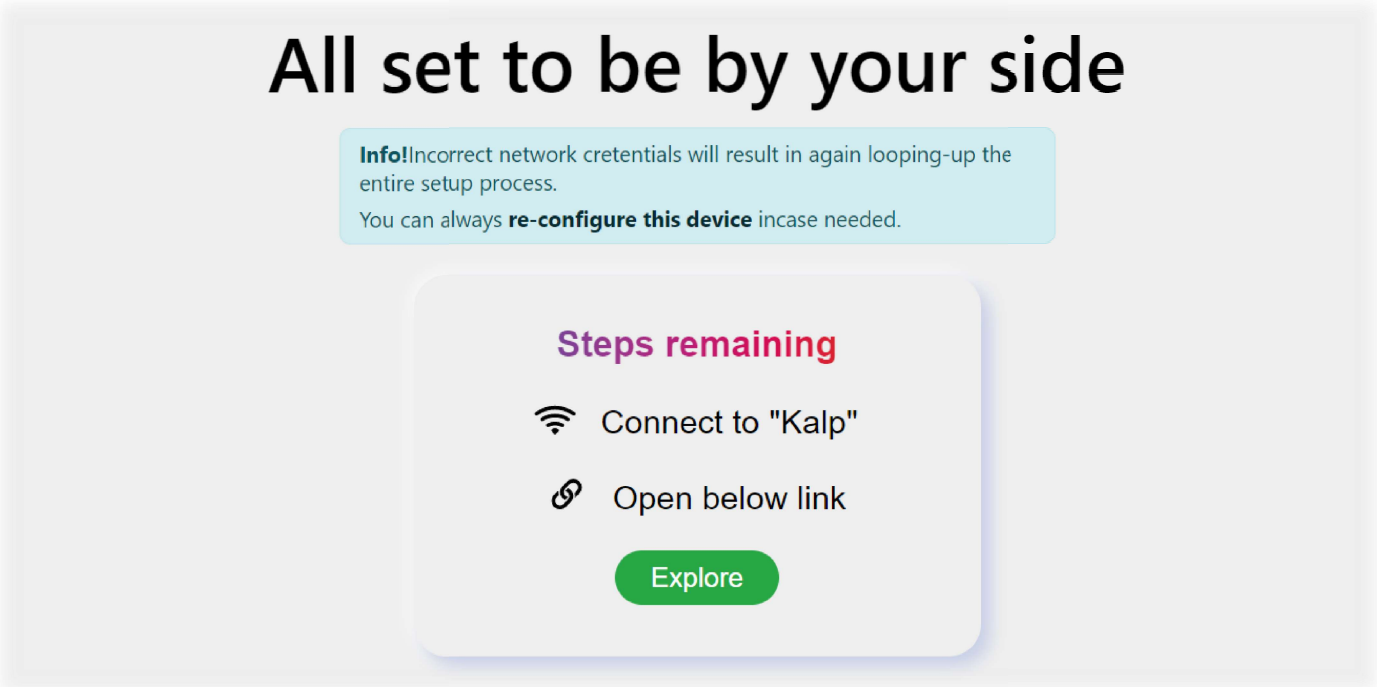
Landing Page Wireframe:



WiFi Setup Wireframe for WALL-E:

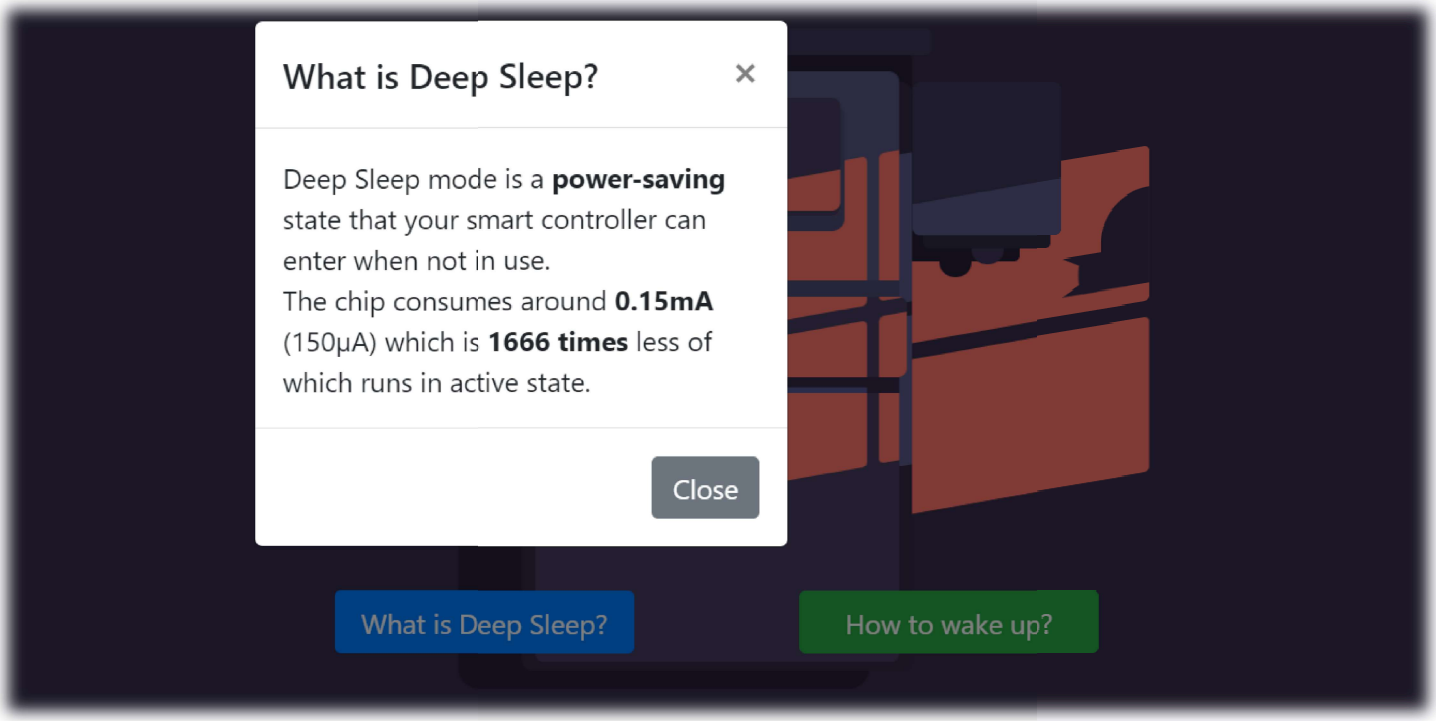


Successful Setup message Wireframe:

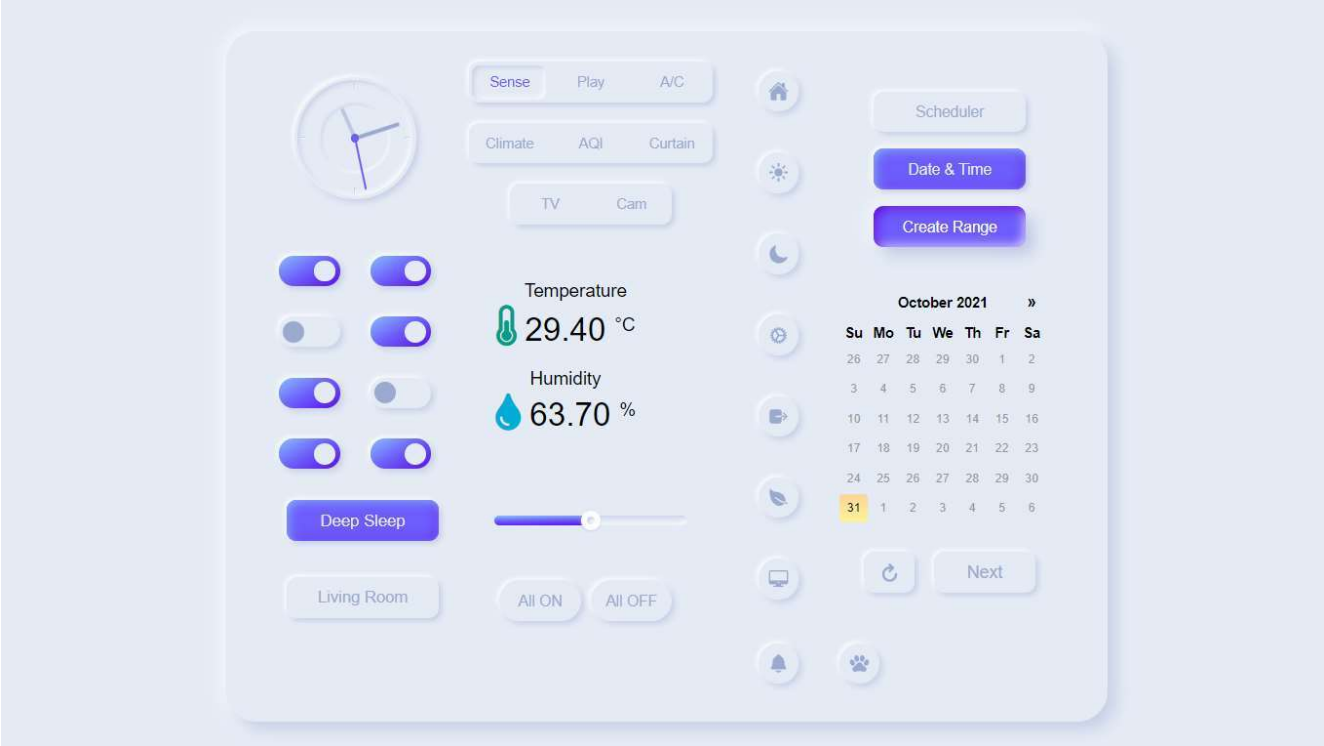


Deep sleep (power-saving) mode wireframe:

Info & Instructions about power-saving mode wireframe:

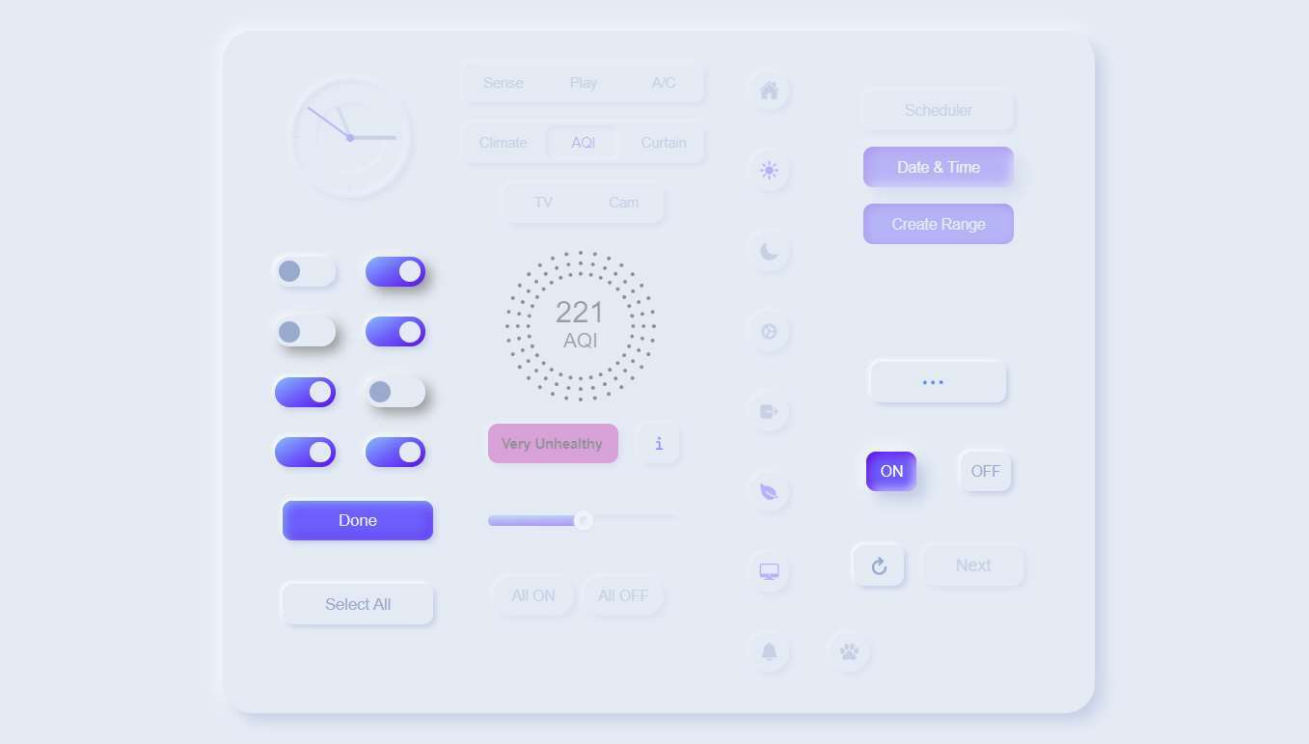


WALL-E Control Panel wireframe:

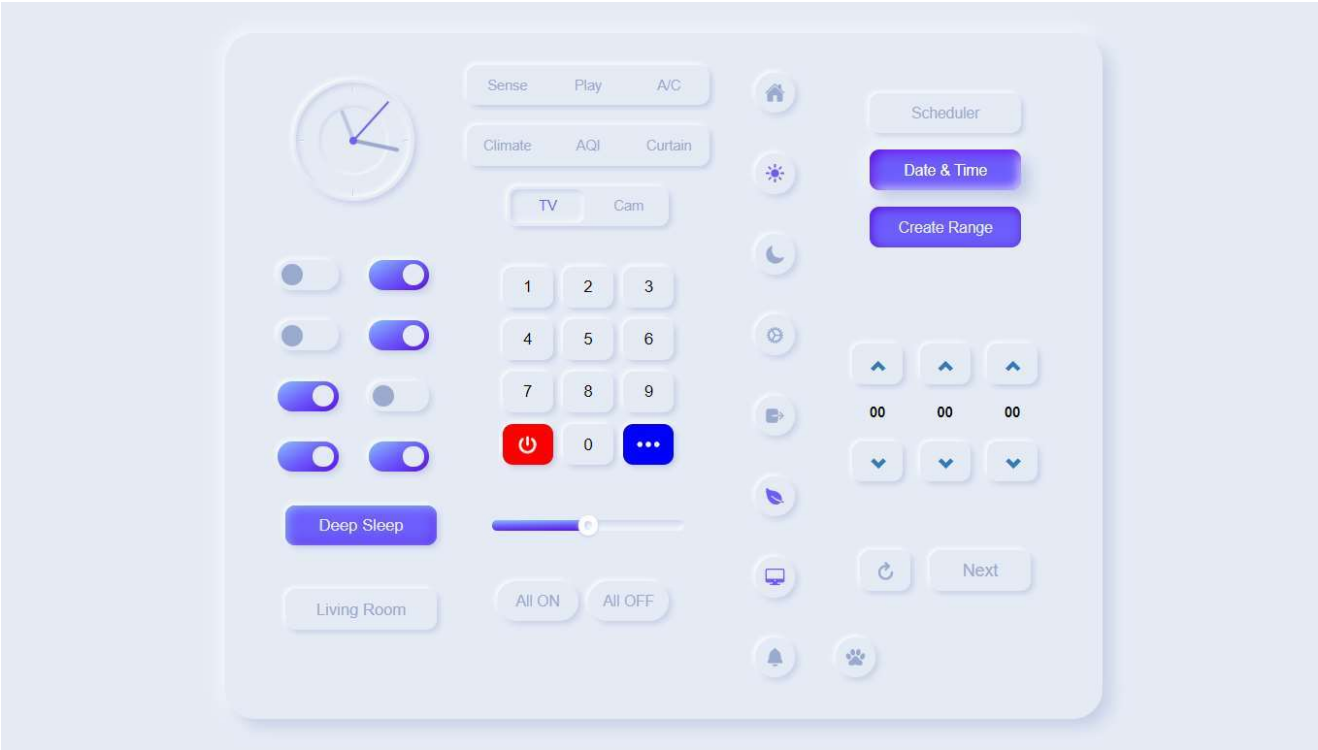


Control Panel Weather Forcasting using AccuWeather API wireframe:

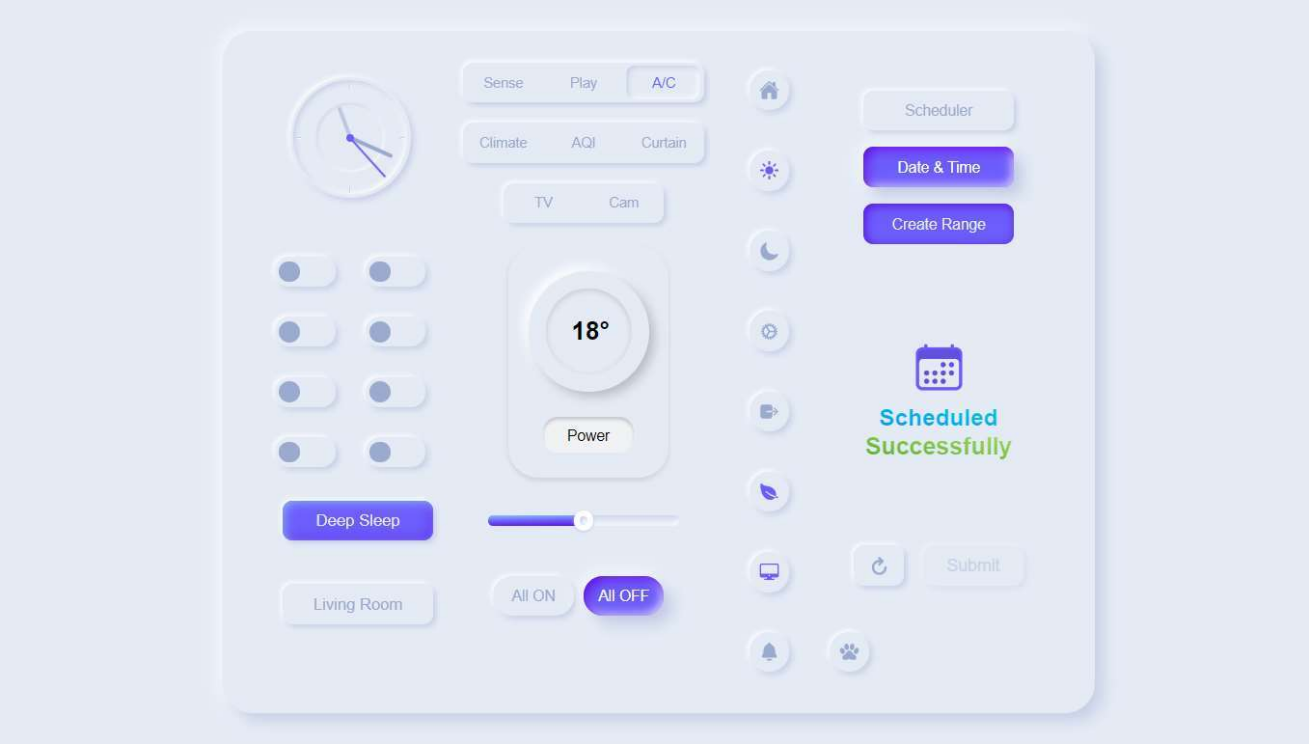
Switch Scheduling wireframe:



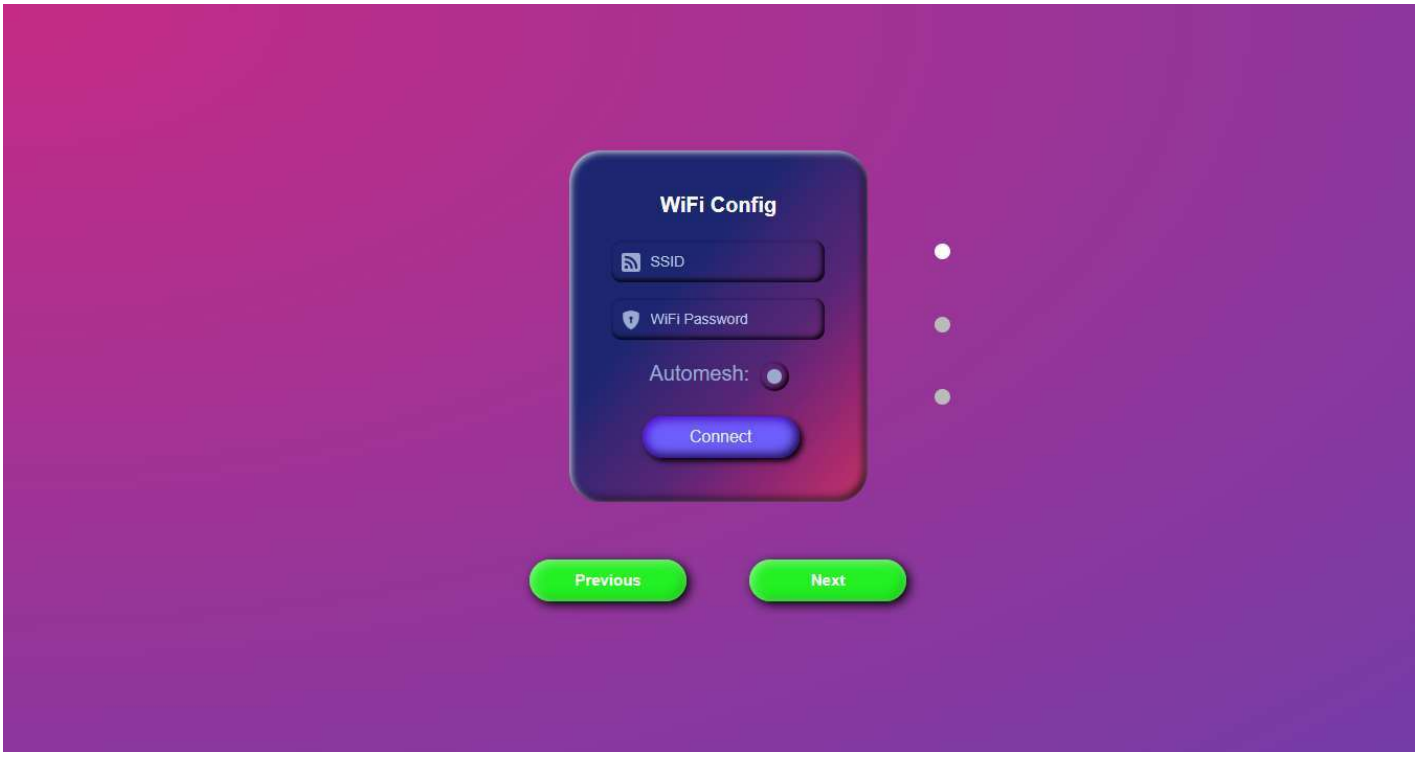
TV operate segment wireframe:



A/C operate segment wireframe:



Repeater Entity setup (night-mode) wireframe:



5.1 Database Dictionary

Table Name: AuthCredentials

Primary Key: UID (UserID)
Description: This table stores chief credentials for logging users into their account alongwith necessary measures like hash conversion for passwords and keeping track of user sessions for security reasons. Each credential must be equally valid for any of the auth provider like Google, Facebook, or Github.

SrNo.	Column Name	Data Type	Size	Constraints	Description
1	UID	varchar2	30	Primary Key	Uniquely identifies each user
2	Provider	varchar2		Not Null	To identify the auth provider
3	Email	varchar2	320	Primary Key	Unique identity of user in public
4	Password	varchar2	64	Not Null	Secrete key for logging into acc.
5	CreatedAt	int	11	Not Null	Account init EPOCH timestamp
6	LastLoginAt	int	11	Not Null	Last session EPOCH timestamp
7	EmailVerified	boolean	1	Not Null	To identify user's authenticity
8	Subscription	tinyint	1	Not Null	Selected plan

Table Name: AccountDetails

Primary Key: Null
Description: This table keep track of user's information which he could frequently update or gets reflected to the front-end on daily basis.

SrNo.	Column Name	Data Type	Size	Constraints	Description
1	UID	varchar2	30	Foreign Key	Uniquely identifies each user
2	GID	varchar2	30	Foreign Key	Uniquely identifies each guest
3	UserName	varchar2	64	Not Null	Used for display user's name
4	PhotoUrl	varchar2	100	-	Used for display user's image
5	EID	varchar2	100	Foreign Key	Uniquely identifies each ALIE
6	Address	varchar2	100	-	Used for product delivery
7	Zip	Int	11	-	Used for product delivery
8	ServerID	varchar2	30	Not Null	To associate EID with the server

Table Name: SubscriptionPlans

Primary Key: SID (SubscriptionID)
Description: This table includes the detailed information of all plans with prices, associated features and other subscription specific details

SrNo.	Column Name	Data Type	Size	Constraints	Description
1	SID	tinyint	1	Primary Key	Users subscription plan
2	PlanName	varchar2	10	Not Null	Name of the plan
3	Price	varchar2	64	Not Null	Price of the plan
4	AvailableCoupen	varchar2	100	-	Available coupen code
5	Timeline	timestamp	10	Not Null	Subscription period validity
6	NumberOfGuest	smallint	5	Not Null	Max guest a user could keep
7	NumberOfEntity	Smallint	5	Not Null	Max entities a user could keep
8	Features	varchar2	50	Not Null	Features which user could avail

Table Name: UserSubscription

Primary Key: Null
Description: This table keeps track of each user associated with any of the subscription plans listed in SubscriptionPlans and gets features and services in accordance.

SrNo.	Column Name	Data Type	Size	Constraints	Description
1	UID	varchar2	30	Foreign Key	To identifies user's account
2	SID	tinyint	1	Foreign Key	Connected subscription plan
3	AppliedCoupen	varchar2	10	-	Discount availed by user

Table Name: Entity

Primary Key: EID (EntityID), UID (UserID)
Description: This table provides a generalised information of all ALIE products or entities with which a user would be connecting/connected.

SrNo.	Column Name	Data Type	Size	Constraints	Description
1	EID	varchar2	30	Composite Key	Uniquely identifies each entity
2	UID	varchar2	30	Composite Key	To identify connected user
3	ProductID	tinyint	1	Foreign Key	Entity association with product

Table Name: WALL-E

Primary Key: EID (EntityID)
Description: This table handles as well as keeps track of the entity specific information and settings based on its sub-components, services, integrated features & functionalities.

SrNo.	Column Name	Data Type	Size	Constraints	Description
1	EID	varchar2	30	Primary Key	To uniquely identify entity
2	AlieVersion	tinyint	1	Not Null	Defines the version of product
3	EntityState	boolean	1	Not Null	Describes state/mode of entity
4	SwitchState	varchar2	50	Not Null	Toggles switch state
5	FeatureID	smallint	5	Foreign Key	Integrates associated features

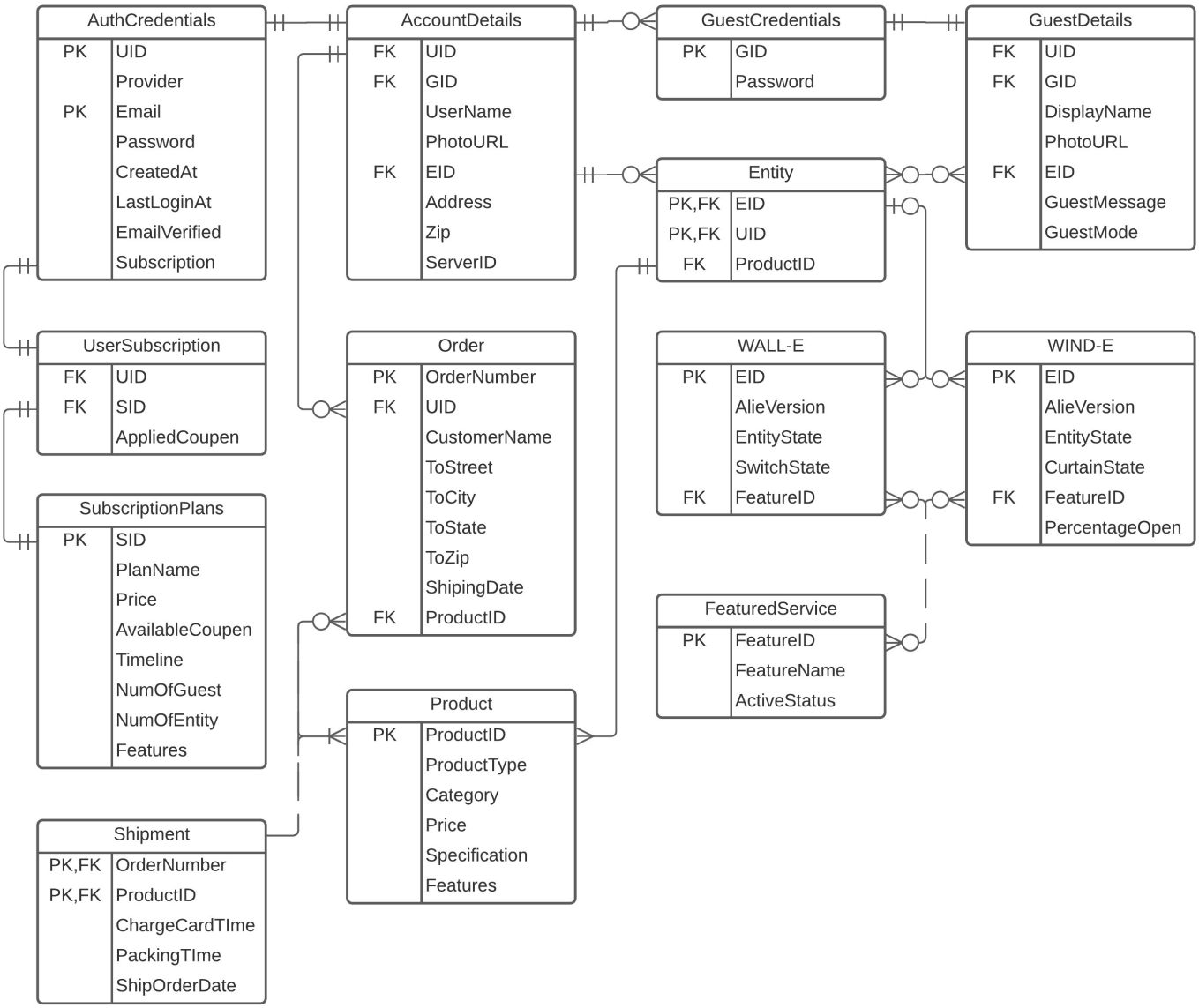
Table Name: WIND-E

Primary Key: EID (EntityID)

Description: This table handles as well as keeps track of the entity specific information and settings based on its sub-components, services, integrated features & functionalities.

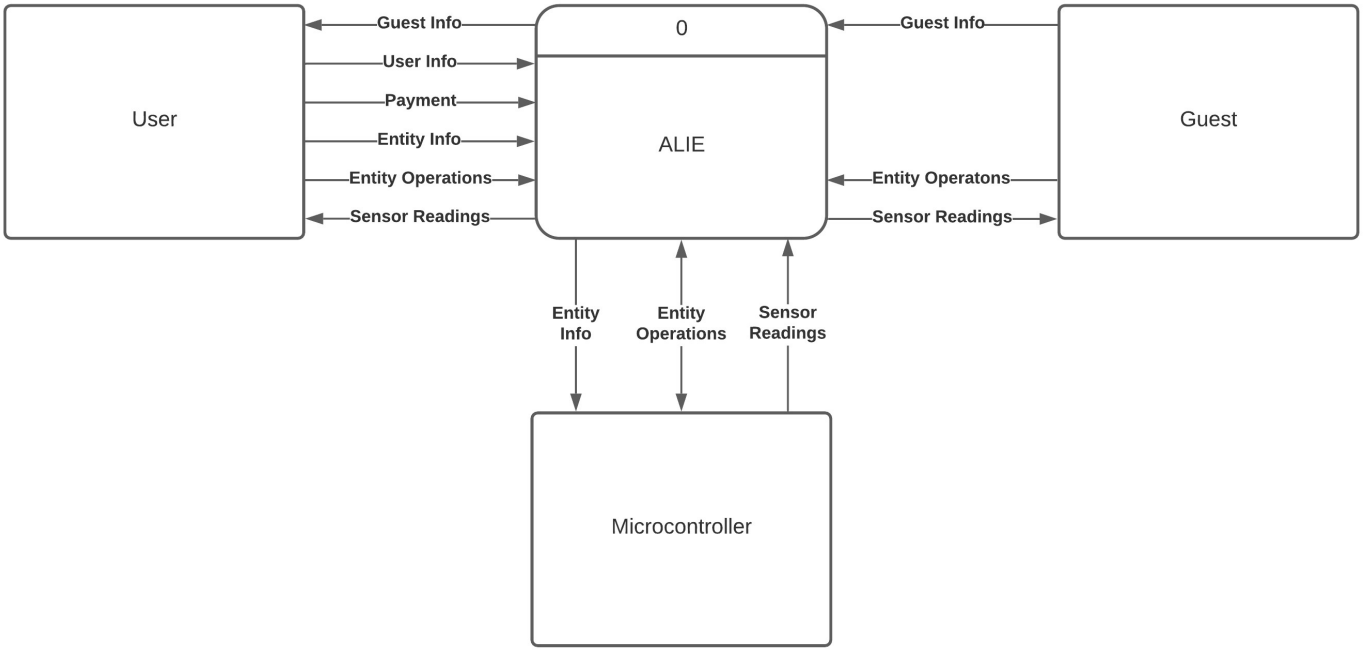
SrNo.	Column Name	Data Type	Size	Constraints	Description
1	EID	varchar2	30	Primary Key	To uniquely identify entity
2	AlieVersion	tinyint	1	Not Null	Defines the version of product
3	EntityState	boolean	1	Not Null	Describes state/mode of entity
4	CurtainState	boolean	1	Not Null	Defines curtain state (open/close)
5	FeatureID	smallint	5	Foreign Key	Integrates associated features
6	PercentageOpen	tinyint	1	NotNull	Keeps track of window visibility

5.2 Entity Relationship Diagram

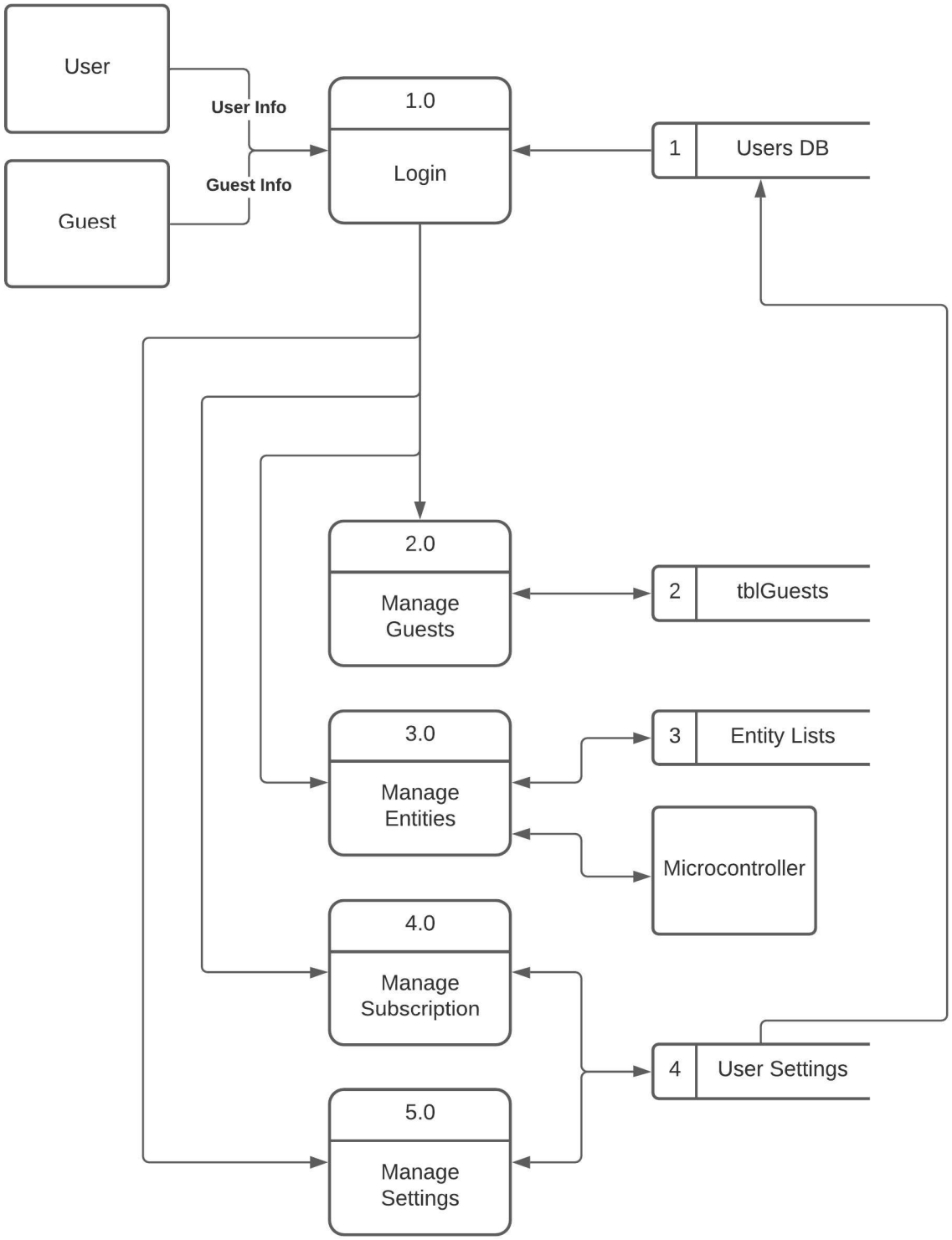


5.3 Data Flow Diagram

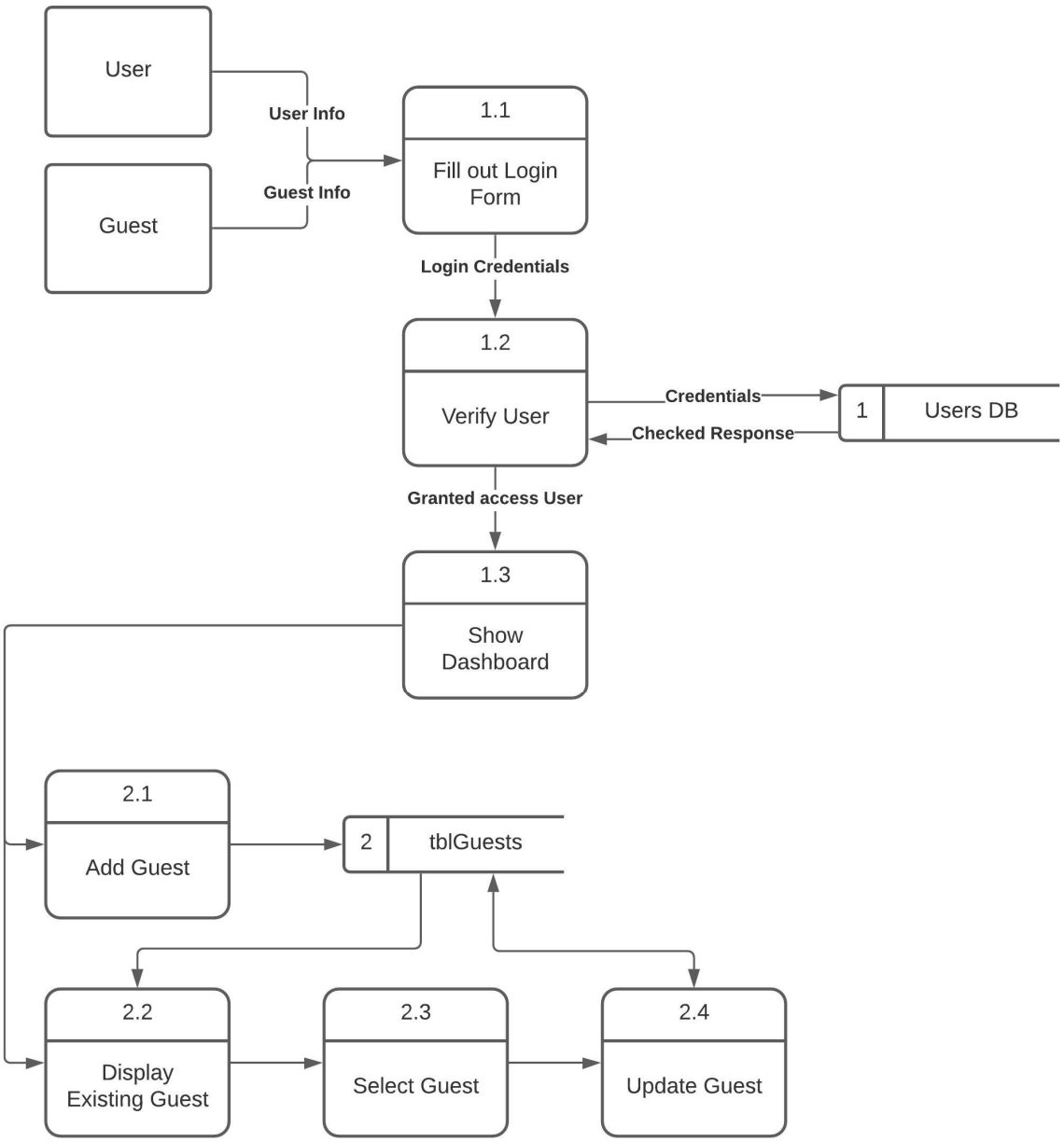
5.3.1 Context level



5.3.2 First level Data Flow Diagram

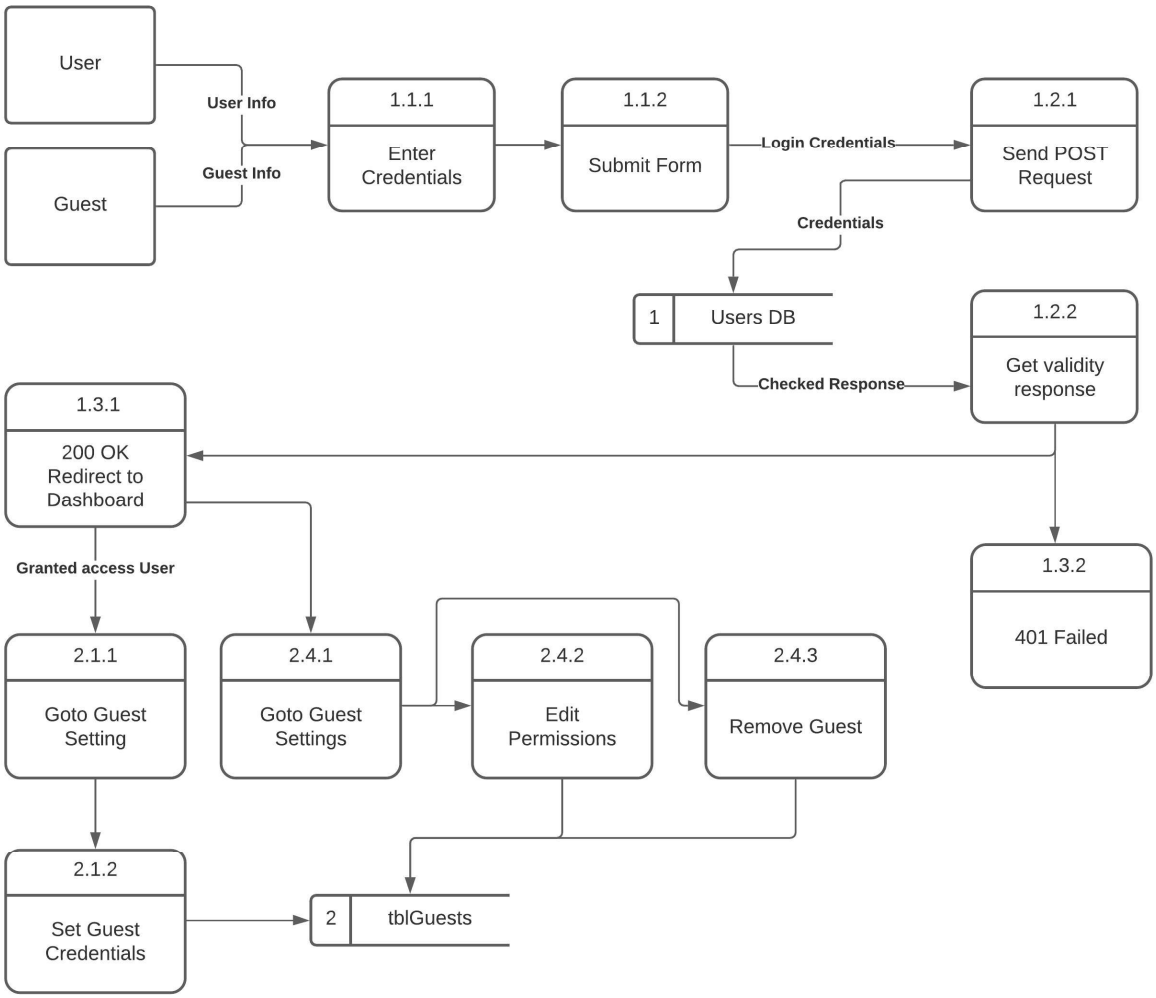


5.3.3 Second level Data Flow Diagram



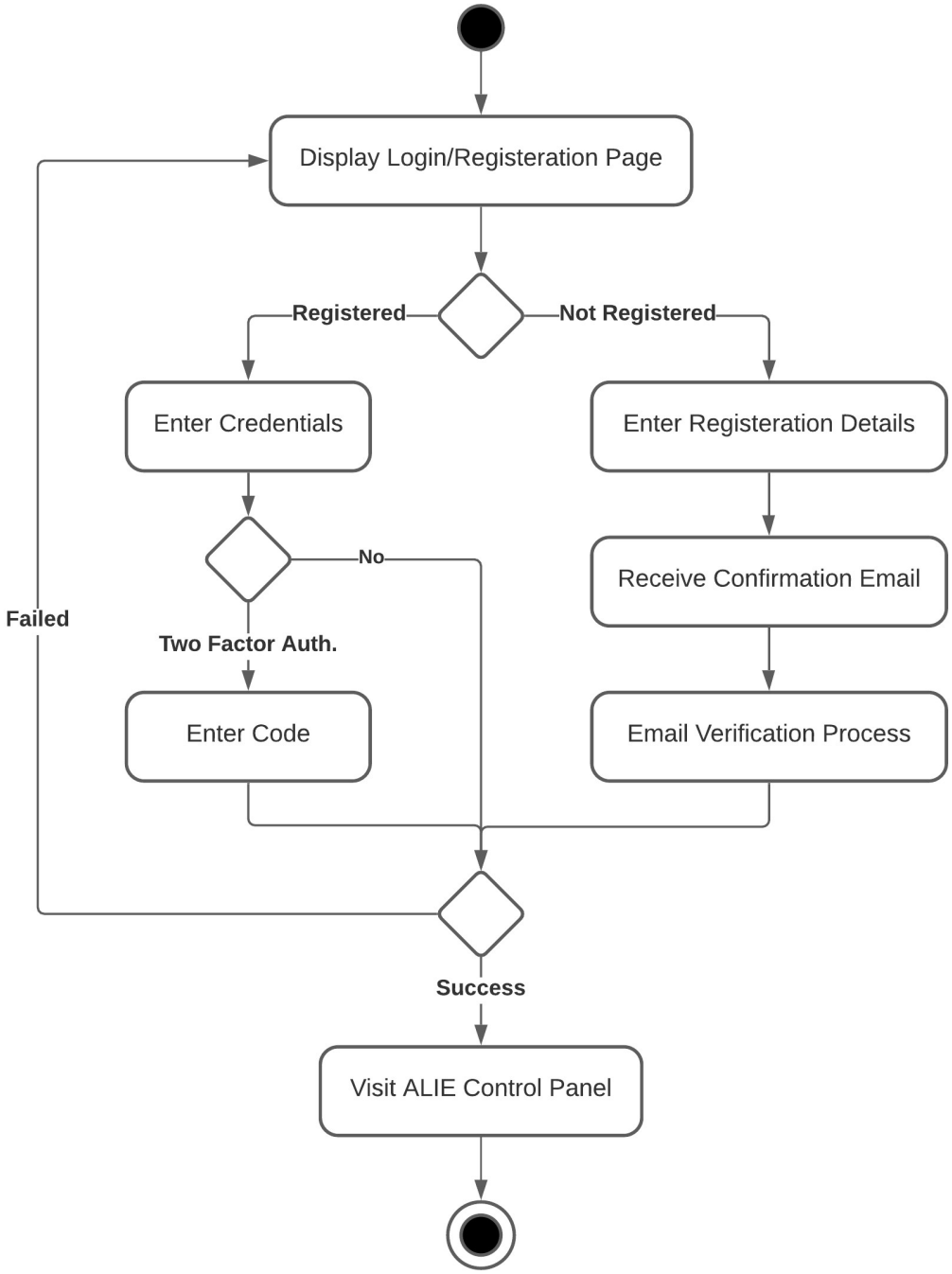
Note: In Level 2, exapansion of the hierarchy is only implemented for 1.0 & 2.0 processes from Level 1

5.3.4 Third level Data Flow Diagram

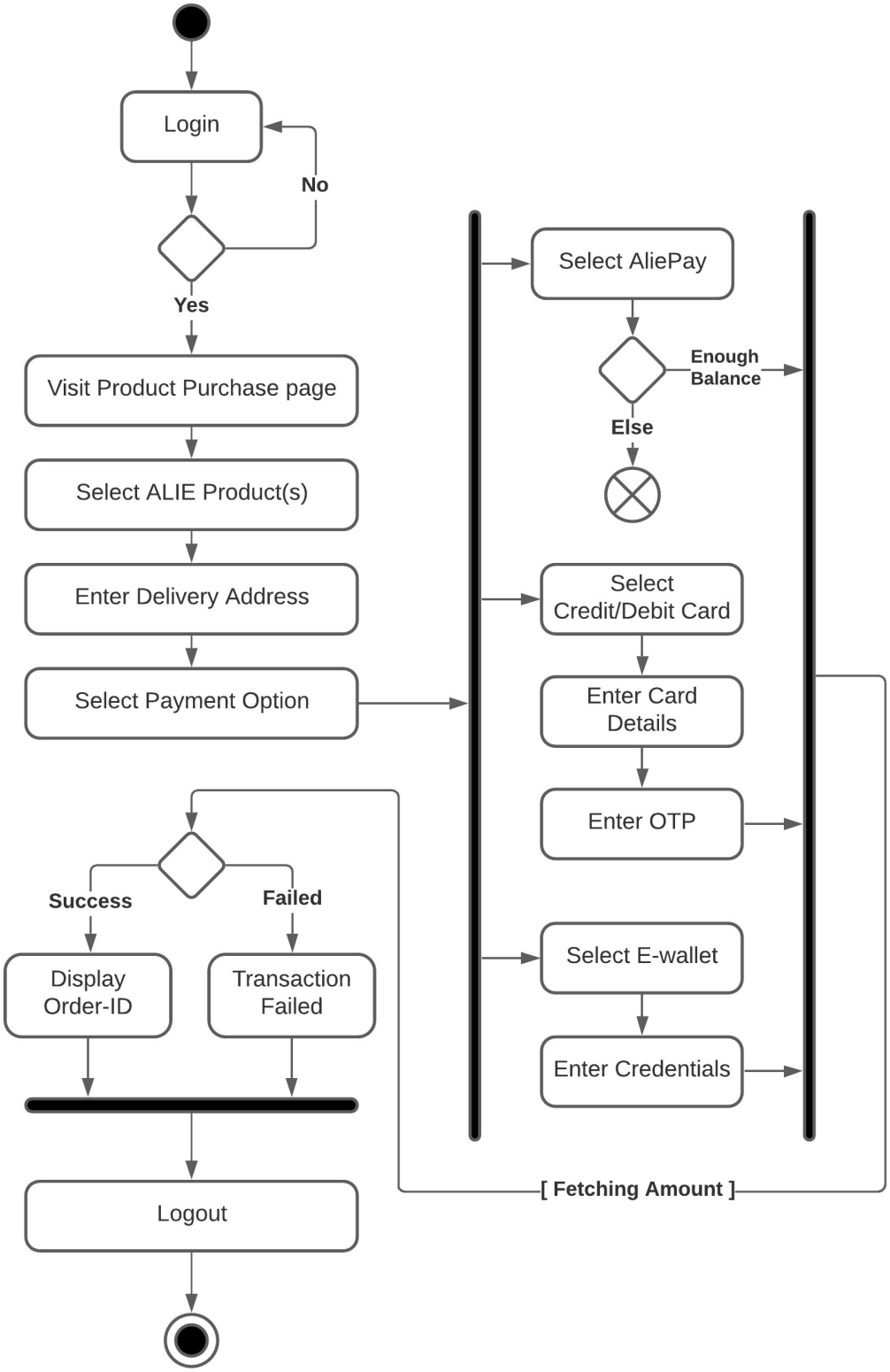


5.4 Activity Diagram

5.4.1 Activity diagram of admin/user's logging process



5.4.2 Activity diagram of purchasing ALIE product



6. Testing

- Test Case for Inconsistant Database

TEST CASE ID: TC001	MODULE NAME: Database Inconsistency
TEST PRIORITY	Medium
PURPOSE	Checking out the consistency of Cloud firestore database
INPUT	Inserting new data (email, username, password) into registeration form.
EXPECTED OUTPUT	Reflection/addition of data in database.
STEPS:	
1. Open user registeration form. 2. Enter details/credentials. 3. Click on submit button. This changes must be reflected in the database	

- Test Case for Foreign Key Constraint Violation

TEST CASE ID: TC002	MODULE NAME: Foreign Key Violation
TEST PRIORITY	High
PURPOSE	To preserve entity settings when the user of the entity removes or delete his/her account.
INPUT	User delete his/her ALIE account
EXPECTED OUTPUT	Entity information and settings must be preserved inside the database.
STEPS:	
1. Go to settings and click on delete option. 2. Enter password and surpass CAPTCHA code verification process.	

- Test Case for identifying redundancy of data.

TEST CASE ID: TC003	MODULE NAME: Redundancy Checks
TEST PRIORITY	Low
PURPOSE	Avoid the inclusion of extra components which are not strictly necessary to functioning, in case of failure in other components.
INPUT	User perfoming standard operations over the system
EXPECTED OUTPUT	Change in system must be reflected when the operation is perfomed over that redundant data (or to the data inherited from it) to be checked.
STEPS:	
1. Perfom operations over the data/function whose reundancy needs to be checked. 2. Look for changes over the system and the components affected by it.	

- Test Case for perfoming entity operations over LAN

TEST CASE ID: TC004	MODULE NAME: Entity Operation over LAN
TEST PRIORITY	Medium
PURPOSE	To check the reliability of the operations perfomed over an entity in local area network connection.
INPUT	User perfroms any standard entity operation over LAN
EXPECTED OUTPUT	Changes of the operation perfomed must be reflected in real-world.
STEPS:	
1. Connect the device over the same network to which the entity is connected. 2. Go to control panel of that entity. 3. Perfom any standard operations over that entity.	

- Test Case for perfoming entity operations over WAN

TEST CASE ID: TC005	MODULE NAME: Entity Operation over WAN
TEST PRIORITY	High
PURPOSE	To check the reliability of the operations perfomed over an entity while staying in wide area network connection.
INPUT	User perfroms any standard entity operation over WAN by keeping the serve ON and connected to an active internet connection.
EXPECTED OUTPUT	Changes of the operation perfomed must be reflected in real-world.
STEPS:	
1. Turn on the server and make sure that it is connected to internet. 2. Connect the device to the internet. 3. Go to control panel of that entity. 4. Perfom any standard operations over that entity.	

- Test Case for verifying login functionality

TEST CASE ID: TC006	MODULE NAME: User Login Functionality
TEST PRIORITY	High
PURPOSE	To validate the user login functionality by decrypting the password and perfoming necessary checks and prevent system from brute force attack.
INPUT	User enters his/her login details
EXPECTED OUTPUT	User must be logged in incase when server response with the success message when correct credentials are entered and the number of total attempts within 5 min timeframe are less than 3.
STEPS:	
1. User must be albe to successfully load the login page using any device. 2. The input fields must be from from XSS (Cross sde scripting) vulnerabilities. 3. The input fields must not be prone to SQL injection attacks. 4. The input field must not accept data when it detects multiple simultaneous requests being made over an account to avoid brute forcing. 5. User must be entering his/her correct credentials and must be pre-registered in order to login after clicking the submit button. 6. After successfully logging int the account, a session must start over the device where loging took place and user must be able to pre login without entering the credentials until he/she logout or the session expires. 7. After successfully logging into the account, user must be redirected to ALIE control panel.	

- Test Case for search box

TEST CASE ID: TC007	MODULE NAME: Search Box
TEST PRIORITY	Low
PURPOSE	To perfom live search when provided with the valid or somewhat valid product name inside search box.
INPUT	User search for the desired product name inside search box.
EXPECTED OUTPUT	User must be getting live searched results by filtering the matching data from the database.
STEPS:	
1. User opens the product buying page. 2. User enters the name of the desired product in need. 3. The product visibility section area must be filtered based the searching input. 4. Listed products must be no other than the matched results of the text being searched. 5. The listed products must also be filters when the text or data is pasted inside the search box. 6. All the products must be listed when the search box is empty. 7. A valid message must be displayed when there is no product matching the value inside the search field.	

- Test Case for scheduling entity operations

TEST CASE ID: TC008	MODULE NAME: Scheduler
TEST PRIORITY	Medium
PURPOSE	To perfom scheduling operations with high reliability.
INPUT	Assigning a scheduled task to an entity using all 5 types of different possible scheduling operations provided by an entity.
EXPECTED OUTPUT	The scheduled task must be completed in time.
STEPS:	
1. The scheduler must not accept the past time. 2. The scheduler must be capable of handling the limit of scheduling that could be assigned by any registered user based on his/her subscription plan. 3. The scheduler must not accept the duplicate timestamps when assigned for perfoming the conflicting operations. 4. After deleting the schedued task, the entity must not perfom that scheduled operation. 5. Scheduler must auto detect the change in timezone based on the location where the evice is installed and perfom operations using standard EPOCH time format. 6. Incase of power failure, the operation must immidiately be executed after the entity has recovered and it detects the loss in scheduled time for any assigned task. 7. After a user perfoms one-time scheduling operation over an entity, the operation must be completed only once and with the delay of no greater than 5 seconds from that scheduled time. 8. After a user sets a countdown scheduler, the operation must be completed only once and with the latency of no greater than 5 seconds from that scheduled time. 9. After a user perfomes a range based scheduling operation, the operation must be completed as assigned with the latency of no greater than 5 seconds from that scheduled time. 10. When a user sets any one-time scheduler, only one new entry must be reflected into the database. 11. When a user sets any range based scheduler, two independent entries must be reflected into the database.	

7. Experience, Limitations And Future Enhancement

7.1 Experience during project development

During the tenure of my 5th sem in bachelors of computer engineering, I got a pretty good experience about creating a project report (without creating a project) and learning various aspects of software development (in theoritical sense only). And it was also a good experience in listinging to the folktale stories about software engineering and its process from my respected Prof. Ashish Patel. It was not possible (impossible) to complete this project report without creating a project. But it came true only after the valuable guidance of Prof. Ashish Patel and I learnt a lot.

7.2 Limitations

- To operate an entity over the WAN connection requires an active server running in a local network with an active internet connection.
- The system demands a server running over local network with active internet connection to take actions over air quality measures incase of that feature turned on.
- There exist a latency of 1-3 seconds while perfoming operations over wide area network connection because it require multiple interface to be passed such as updation into the database, server detecting that update, sending update request signal to the addressed entity, and then entity perfoming that operation.
- To perfom weather forecasting and AQI measure readings, there occurs 5-8 second delay to fetch data using API.
- Weather forecasting could only be done within the range of 90 days.
- After entity goes into the deep sleep (power-saving) mode, it can't be remotly turned on as the entire microcontroller becomes inactive after that stage.
- The system takes 1-2 second more time when the entity operation are perfomed using voice based commands.

7.3 Future Enhancement

Further, more enhancement could be implied by the full deployment of this IoT project, in the longer term it is data-driven techniques and models based on AI and its subsets (machine learning, deep learning, and computer vision) along with data analysis that will deliver lasting value in disaster management, urban management, smart healthcare, construction industries, security surveillance, networking and communication, and many other applications which would ultimately provide seamless communication between people, processes, and things with minimal or without human intervention.

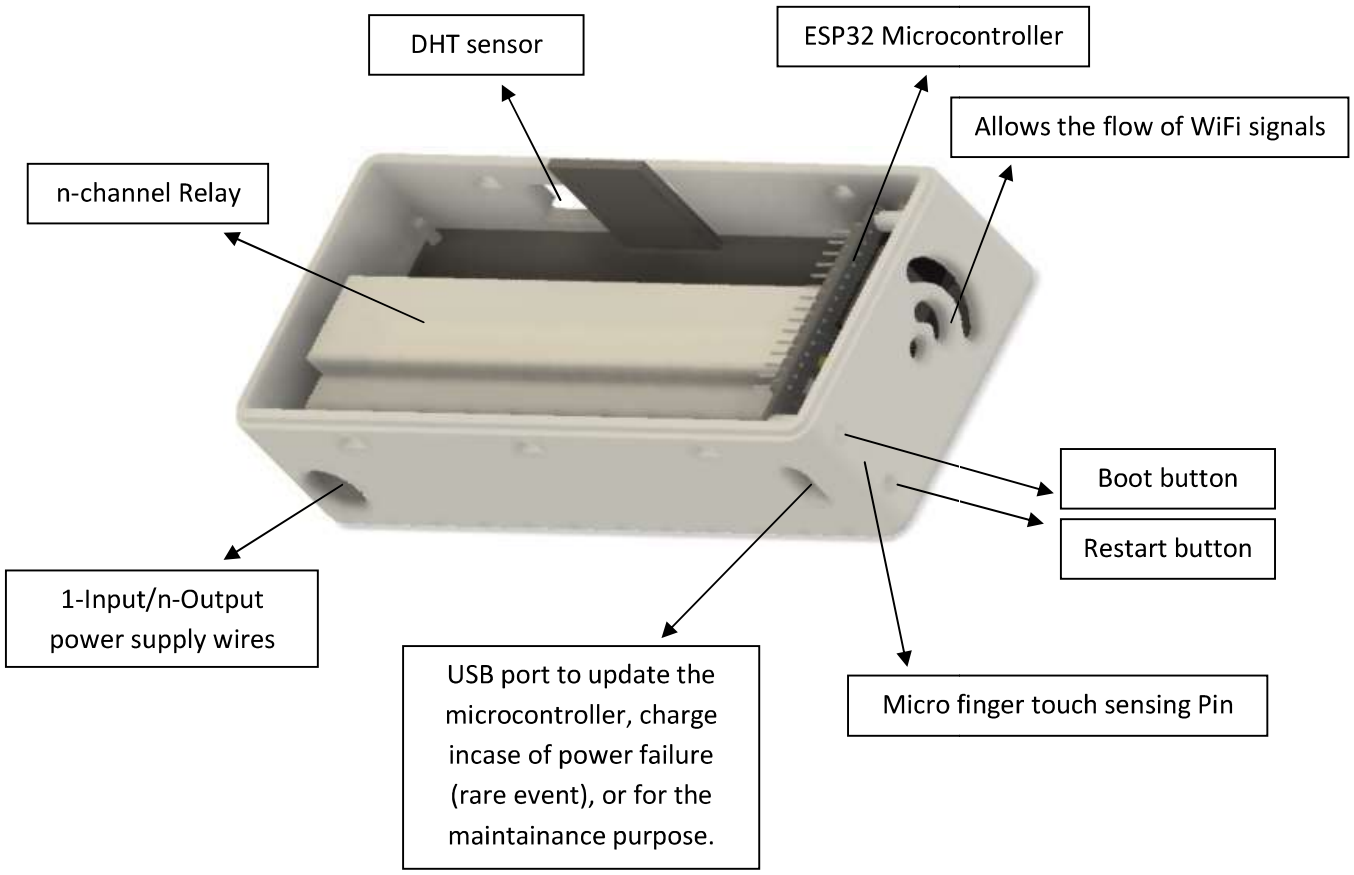
8. Bibliography

8.1 Conclusion

ALIE (Artificially Linked Intillegent Entity) is is/are the group or collection of one or more entities over a network that forms a basis for controlling one or multiple, similar or different real world objects or perfom measurements in order to achieve high end results with minimal or without human interventation. As the entire system provides seamless communication between people, processes, and things, the possibilities of it in collaboration with various aspects of IOT, or AI, ML and DS makes the scope of the current system even tends to grow further more by using standard tools and adopting advance techniques. Thus it is a never ending race for the betterment of mankind.

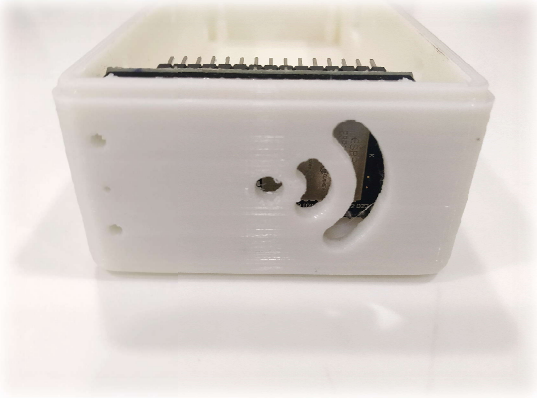
Below are the glimps of incremental stages of hardware build of WALL-E:

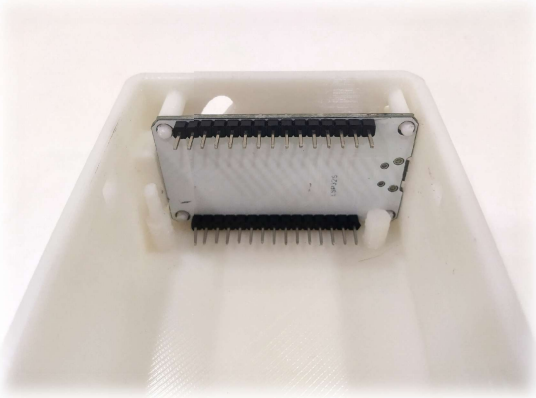
Stage 1: Designing a casing in Autdesk Fusion 360 (AutoCAD software)



Stage 2: Printing the prototype using a 3-D printer and get it read.

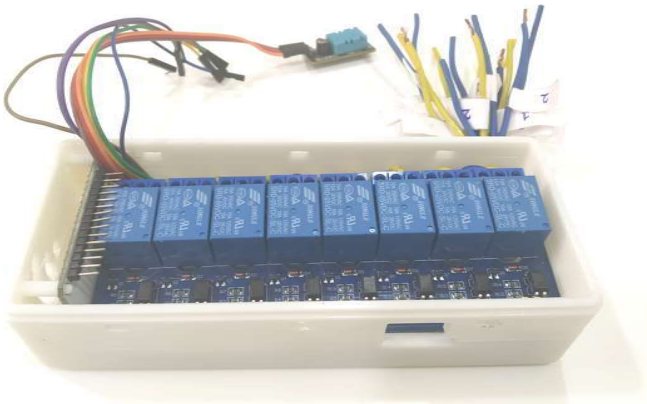
Stage 3: Inserting the microcontroller



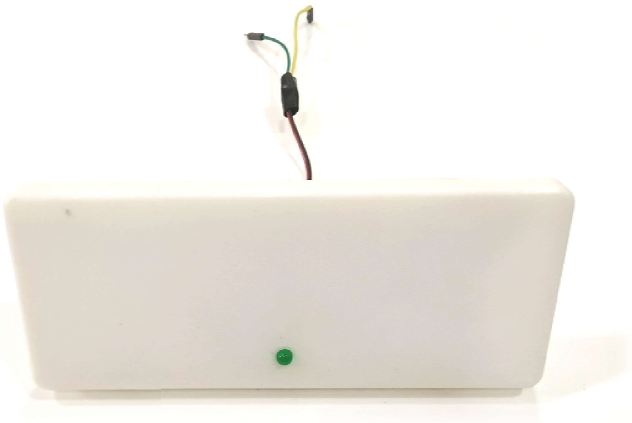


Stage 4: Getting the relay ready:

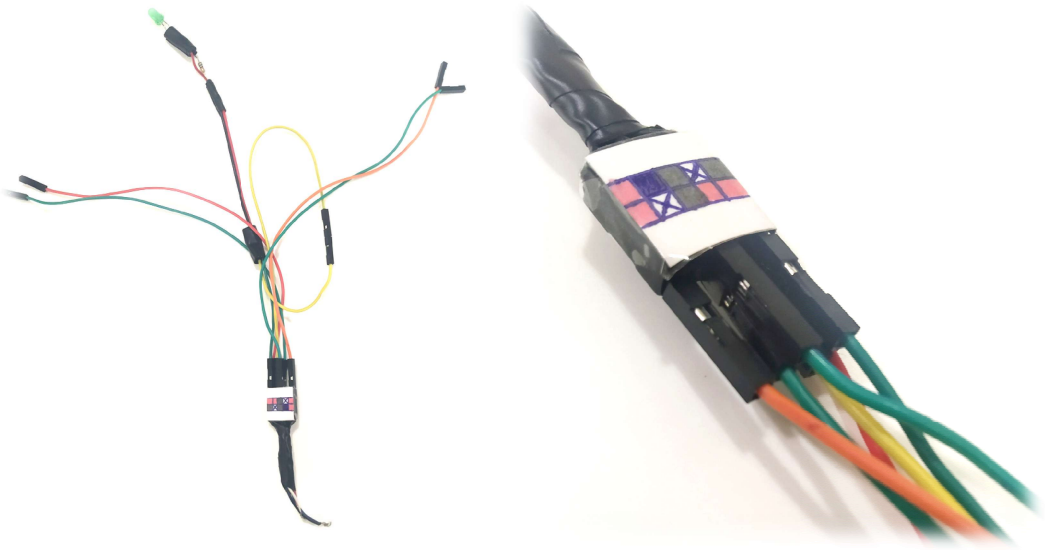
Stage 5: Integrating Relay and DHT sensor with ESP32:



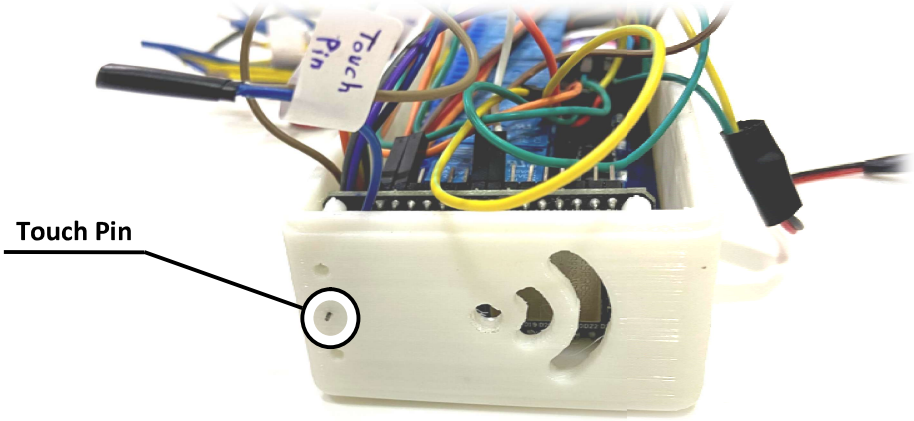
Stage 6: LED indicator to front cover:



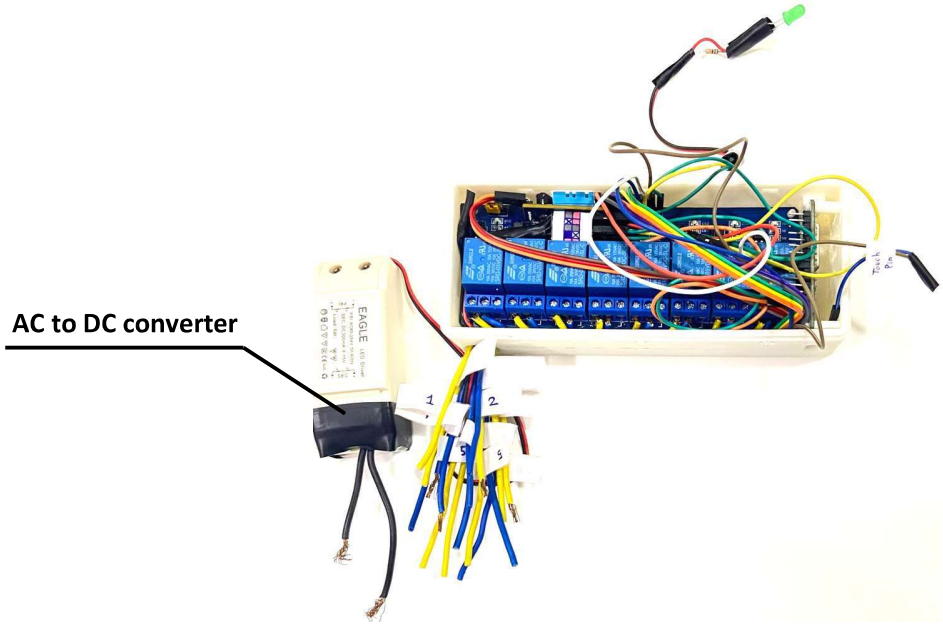
Stage 7: Designing power connection circuit amongst Microcontroller, Relay, LED, DHT sensor, and AC-DC adapter circuit using mini breadboad.



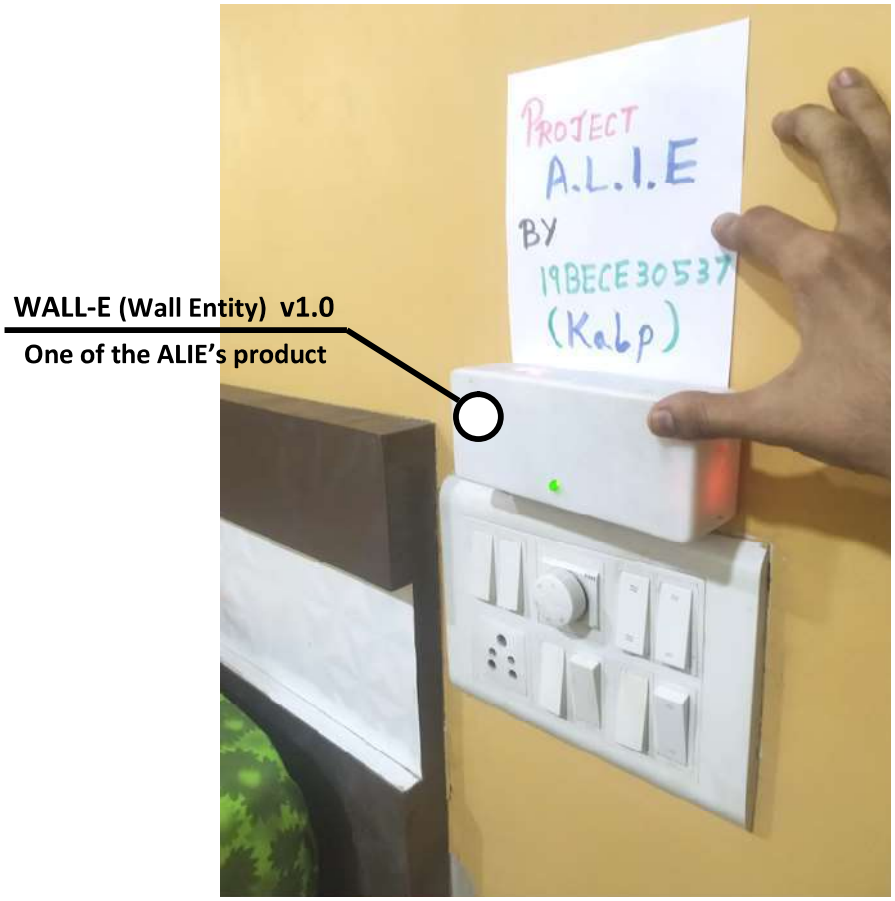
Stage 8: Adding a micro finger touch sencing pin for enabling, disabling, reseting, restarting the entire module and regulate power-saving (deep sleep) mode.



Stage 9: Connecting internal/external AC to DC voltage converter circuit



Stage 10: Successfully installed and deployed WALL-E (a product of A.L.I.E.)



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