VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

MGT1022 Lean Start-up Management

Winter Semester 2023-24

J – Component Final Report

Under the guidance of

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21MID0181

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1. Title of the J-component project:
   Custom Climate Heating, ventilation, and air conditioning System.

2. Student name:
   Samay Raj Adhikari

3. Register number:
   21MID0181

4. Pain point of my project:
   Speaking from what I have noticed in and around my hostel blocks, students have lodged complaints regarding the AC being turned on the whole night and temperature getting extremely cold or the ac not at all being used throughout the day or that the roommates have fought amongst each ither regarding what speeds to keep the A/C fan at. These students who have lodged such complaints have a common pain point i.e., the A/C speed and temperature, either being too cold or too hot.

   Now this is a very valid pain point among hostellers as the hostel blocks here in VIT use the centralized HVAC systems and what are the reasons that make it so are:

   - A/C in VIT hostels are Centralized to each floor.
   - Each HVAC system in the room has a preset temperature.
   - The only controls that they are given are 3 fans speeds and a main ON/OFF switch.

- Hostellers may experience frustration due to a lack of real-time control over their environment.
- HVAC is placed on the ceiling so the preset temperature cannot be changed.
- HVAC systems often provide limited customization options, leading to discomfort for individuals with specific temperature preferences.
- Centralized HVAC systems might not evenly distribute temperature throughout a building, leading to inconsistent comfort levels in different rooms.

If one of the roommates doesn't want the A/C to be turned on, he will have to talk with the remaining of his roommates and if his roommates don't comply with his request, then he will have to go to bed under the unfavourable conditions that might affect him. If this continues then he might be forced to look for another room.

5. Target Customers and beneficiaries:

Identifying my target customers for a customizable HVAC system requires understanding the needs, preferences, and pain points of potential users.

Here is the list of a few targeted customers who are mostly likely to invest in my product:

- Owners or managers of office buildings, retail spaces, or other commercial properties who want to optimize energy usage and provide a comfortable environment for occupants.
- Owners of theatres, which use the modern centralized HVAC system for each screening halls to provide enhanced customer comfort and help Implementing zoned heating and cooling can enable different sections of the theatre to have independent climate control.
- Hotels and resorts aiming to offer a premium experience to guests by providing customizable climate control in individual rooms with the help of a centralized HVAC this in turn cuts the energy costs of the hotel and resorts.
- Renowned big universities that accommodate thousands of students in hostels can really use this customized climate control HVAC to provide a comfortable study and stay environment for the students.
- Businesses that prioritize employee comfort and productivity by providing a customizable climate control system in workspaces using the modern centralized HVAC.

My main beneficiaries would be the students in hostels all over the world. From what we have seen in point 4, i.e., the pain points, college students who have gone for studying face unfavourable temperatures in their hostel rooms during the time of day or while sleeping at night. At times hostel students feel really cold or hot and aren't very comfortable in getting up all the time to regulate the temperature.

- At times this also stir up lot of commotion amongst the roommates and they end up fighting either to keep the AC on or off. These commotions might even lead to something much bigger than fighting.
- Adverse climatic conditions within the room for a prolonged period causes students to fall very sick quickly and the conditions worsen and taken lot of time to come back to stable.

- So, with my product being installed into the centralized HVAC's, the main beneficiaries will be the hostel living students.

6. Limitations of the existing available technology /product / service and description of the gap identified:

The existing products in the market are very costly and according to me take a lot of installation and maintenance cost and time. My product on the other hand is a compact sensor that works on the concept of sensor on and off making it affordable and very easy to install. Market products right now are made for huge rooms and large spaces and office workrooms where the centralized HVAC is spread over a large area on the roof and is individually controlled by remote controlled devices.

The existing products do not offer the flexibility and power saving options such as the one which my device can offer. With minimal to no other extra usage of power my device can work very efficiently as it will be connected to the main switch of the Centralized A/c and will switch ON and OFF simultaneously with the A/c.

This feature is not provided with the other systems that have been designed to be put somewhere outside or away from the people. But my system will not be bothered if humans are there or not as this will be directly connected to the Centralized A/c main outlet without taking up much space or hamper the wiring of existing system.

My product doesn't use the excessive technology that has been used in other heavy and complex systems that take up lot of space and power keeping it very simple to use and install, providing a very easy and user-friendly approach to my product.

7. The problem for which solution was researched / customer feedback collected (Give literature search details such as related patent databases, publications in journals etc.):

The topic: Energy efficient climate controlling air conditioning system.

Research approach: Conducted a literature search in patent databases such as Google Patents and academic journals focusing on HVAC technology, energy efficiency, and climate control systems. Finding out similar products that have been made or have the similar working style and similarly making my changes in the device based on what I had learned and implementing a simpler and better device.

Customer feedback:

Person 1:

- Feels that the current room temperature is directly affecting their health and well-being.
- Desires a solution that not only addresses their personal comfort but also resolves ongoing conflicts with their roommate.
- Emphasizes the importance of having control over the room temperature to ensure a good night's sleep and overall well-being.

Person 2:

- Values a peaceful living environment and believes that resolving temperature-related conflicts would contribute to better roommate relationships.
- Expresses openness to technological solutions like a custom HVAC system if it can promote harmony and reduce tensions among roommates.
- Recognizes the potential of such a system to enhance overall comfort and convenience within the shared living space.

Person 3:

- Appreciates the current balance in room temperature and lack of disputes among roommates.
- Expresses curiosity about the concept of a custom HVAC system and its potential benefits, even though the immediate need may not be as pressing.

- Considers past experiences with roommates' temperature preferences as a basis for interest in customizable climate control solutions.

Person 4:

- Describes significant emotional distress and strain caused by ongoing room temperature conflicts and strained relationships with roommates.
- Expresses a strong desire for a permanent solution to prevent future disputes and improve the overall living environment.
- Views a custom HVAC system as a crucial step towards creating a more harmonious and comfortable living space.

Person 5:

- Notes that room temperature is generally not a major concern among roommates.
- Sees the potential advantages of a custom HVAC system in maintaining consistent and comfortable temperatures based on individual preferences.
- Values the idea of using technology to enhance the overall comfort and convenience of shared living spaces.

8. Description of the J-Component Project include suitable wherever necessary (1000 words):

In modern workplaces and sprawling educational campuses, the adoption of centralized HVAC (Heating, Ventilation, and Air Conditioning) systems has become a standard practice. These systems offer comprehensive heating or cooling solutions to entire floors or halls, effectively replacing the need for individual room air conditioners. Attempting to outfit every corner of a hall or each hostel room with boxed air conditioners would be logistically challenging due to spatial limitations, substantial capital investment requirements, and the logistical complexity of maintenance and management.

However, despite their widespread use, contemporary HVAC systems often operate with fixed, preset temperature settings and limited user control options. Typically, users are provided with a basic regulator offering a few fan speed settings, resulting in suboptimal comfort levels due to frequent temperature fluctuations. The continuous operation of these systems, with little consideration for real-time environmental conditions, can exacerbate discomfort and even lead to health issues such as colds, coughs, throat irritation, skin dryness, and other discomforts.

To address these challenges and deliver a more tailored and responsive HVAC solution, a custom system is proposed. The primary objective is to ensure a consistent and comfortable temperature within the room or workplace by dynamically adjusting the HVAC system's operation based on real-time temperature readings.

The innovative approach of this custom HVAC system involves integrating a temperature sensor directly into the system architecture, thereby bypassing the limitations imposed by preset temperature settings. Instead of relying on predefined temperature thresholds, the system continuously monitors the ambient temperature of the room and autonomously adjusts the HVAC operation to maintain it within a predefined comfort range, such as 18°C to 23°C.

The implementation of this dynamic temperature control functionality requires a sophisticated yet cost-effective combination of microcontrollers and processors. These components enable the system to efficiently process real-time temperature data and autonomously modulate HVAC operation accordingly. The microcontroller serves as the central processing unit, receiving input regarding the desired temperature range and orchestrating the control signals sent to the HVAC unit through a network of processors.

When the temperature sensor detects deviations from the desired temperature range, indicating discomfort, the system springs into action. In such instances, the HVAC system is temporarily deactivated, allowing the room's temperature to stabilize naturally within the predefined comfort range. Once the ambient temperature returns to the desired range, the system seamlessly reactivates the HVAC unit, ensuring uninterrupted comfort for occupants.

At the heart of this innovative solution lies the Arduino Mega 2560 board, a versatile microcontroller platform capable of orchestrating complex control tasks with precision and efficiency. Complementing this core component is a relay module, which facilitates the seamless coordination of various system functions, including the activation of auxiliary components such as lights and fans. Furthermore, a high-resolution 20x4 LCD display unit provides users with comprehensive visual feedback, presenting real-time temperature data and system status information in a clear and user-friendly manner.

The cornerstone of the system's intelligence is the DHT22 Temperature and Humidity sensor, which serves as the primary sensory interface for capturing real-time environmental data. By continuously monitoring temperature fluctuations and humidity levels, this sensor enables the system to adapt its operation dynamically, ensuring optimal comfort conditions are always maintained.

In conclusion, the deployment of this custom HVAC solution represents a significant leap forward in the quest for enhanced comfort and energy efficiency in indoor environments. By leveraging advanced sensing

technologies, intelligent control algorithms, and cost-effective hardware components, the system delivers unparalleled levels of comfort and convenience while minimizing energy consumption and environmental impact. Whether deployed in commercial office spaces, educational institutions, or residential buildings, this innovative HVAC solution stands poised to revolutionize the way we experience indoor comfort, setting new standards for efficiency, sustainability, and user-centric design in the process.

9. USP- Unique features about the work done with respect to available Competitors:

To identify the unique and "wow" factors of your custom HVAC system, you need to highlight features or characteristics that set it apart from standard systems in the market. I have listed down form of them here as follows:

- By incorporating advanced energy-efficient technologies or design principles like novel heat recovery systems, smart controls, or sustainable materials, you'll attract customers who prioritize eco-friendly and energy-saving solutions.

- Leveraging the latest technological advancements such as AI-driven optimization, predictive maintenance algorithms, or IoT connectivity will appeal to those looking for cutting-edge and future-proof HVAC solutions.

- Designing your HVAC system to take up minimal space while maintaining high efficiency highlights its compactness, which can be especially beneficial for customers with limited installation space.

- Ensuring exceptionally quiet operation can be a significant wow factor, as many customers appreciate HVAC systems that provide comfort without disruptive noise, enhancing their overall experience.

- Offering quick and easy installation, reducing downtime for customers, is a strong selling point, as time-saving features are often highly valued in busy schedules.

- Incorporating eco-friendly materials, boasting a low carbon footprint, or contributing to a reduction in greenhouse gas emissions emphasizes its environmental sustainability, appealing to

environmentally conscious consumers. Additional personalized points:

- Your commitment to providing quick and easy installation, reducing downtime for customers, is a strong selling point, as time-saving features are often highly valued in busy schedules.

- Incorporating eco-friendly materials, boasting a low carbon footprint, or contributing to a reduction in greenhouse gas emissions emphasizes its environmental sustainability, appealing to environmentally conscious consumers like yourself.

10. Sales & Marketing aspect for your work:

Research and Development (R&D):

- Costs associated with designing and developing new HVAC technologies, improving existing products, and conducting market research to identify customer needs and preferences.
- Expenses for hiring skilled engineers, technicians, and researchers, as well as investing in R&D facilities and equipment.

Manufacturing:

- Expenses related to procuring raw materials, components, and equipment needed for production.
- Labor costs for manufacturing personnel, including wages, benefits, and training expenses.
- Overhead costs such as factory rent, utilities, maintenance, and depreciation of manufacturing machinery and infrastructure.

Marketing and Advertising:

- Costs for creating marketing materials, including brochures, catalogs, and advertisements, to promote the HVAC products.
- Expenses for online marketing campaigns, social media advertising, and search engine optimization (SEO) to reach potential customers.
- Fees for participating in trade shows, exhibitions, and industry events to showcase products and generate leads.

Sales Commissions:

- Commission payments to sales representatives, dealers, distributors, and third-party agents for selling HVAC products and services.
- Incentives and bonuses based on sales performance to motivate the sales team and achieve targets.

Operational Costs:

- General administrative expenses such as office rent, utilities, insurance, and office supplies.
- IT infrastructure costs for maintaining business systems, software licenses, and cybersecurity measures.
- Legal and compliance costs, including licensing fees, permits, and regulatory compliance expenses.

Customer Support and Maintenance Costs:

- Expenses for providing technical support, warranty services, and troubleshooting assistance to customers.
- Costs associated with maintaining service centers, repair facilities, and spare parts inventory.
- Training and development expenses for customer support staff to ensure they have the necessary skills and knowledge to assist customers effectively.

Supply Chain Costs:

- Costs related to sourcing components and materials from suppliers, including procurement, transportation, and inventory management expenses.
- Supplier relationship management costs, such as supplier qualification, negotiation, and contract management.
- Risk management costs to mitigate supply chain disruptions, including contingency planning and alternative sourcing strategies.

By carefully managing and optimizing these cost components, the business can enhance its competitiveness, improve operational efficiency, and ultimately, drive profitability.

11. Initial Investment / Costing model:

For my model the initial investment of each individual part would be very under budget for how efficiently my product is working and functioning.

When I had first made my MVP of the product and then decided on the parts that I needed to buy, I saw that there might be a big investment into it and I was about to back off from the project.

Upon further research I found that these boards are even found for cheaper and then I found a place near my campus itself that was giving out IOT components for a very student affordable rate.

The same Arduino Mega board that I saw on amazon for around 11 thousand rupees (for the board only), I was getting all my components and some extra components for my project for less than 3.5 thousand rupees.

So, the initial valuation of my project is very cheap and it functions similar to the costly and huge HVAC systems. I would value it more as it provides for a in built temperature modulating systems and doesn't need for you to constantly fiddle with it to set the desired temperature in the rooms or halls.

12. Have you submitted the same work elsewhere or is it an extension someone else work?

No, I have not submitted this work anywhere else, in fact this is my first time working on a IOT project as I am from CSE background, I had no prior knowledge to working with Arduino and IOT modules.

No, it is not a extension of some ones work, it is my own project that I have thought about.

13. Give names of any two companies who are in the market similar to of your work:

My custom climate HVAC system incorporates several innovative features such as real-time temperature monitoring, dynamic adjustment of HVAC operation, and intelligent control algorithms. Companies that offer similar solutions or share some aspects of your system's functionality include:

- Nest (by Google):
  . Nest offers smart thermostats that utilize sensors to monitor and adjust the temperature in real-time.
  . These thermostats learn user preferences over time and can automatically adjust settings for optimal comfort and energy efficiency.

- Ecobee:
  . Ecobee produces smart thermostats equipped with occupancy sensors and remote temperature sensors. These thermostats can detect when rooms are occupied and adjust temperature settings, accordingly, offering personalized comfort and energy savings.

14. What is the feedback you have obtained from target customer/friends/relatives on your final prototype?

I have actually obtained very positive feedback from my friends and especially from my family members as they were shocked. For the first time instead of demolishing the electronic items at home he has built something that works and in all of this my dad was really proud of the concept what I have incorporated to build my project.
My mom and dad asked me if this was only a time pass project or is there something coming out of it? Here I sat a explained them what my course is and told them about how our professor is giving us ideas and approaches to build our project and they were really happy hearing it and reviewing my project.

On the other hand, my friends were amazed by how my system functions and they were insisting me on patenting it and making nice modifications to make it an sellable product, as they felt it would be a very useful product especially in rooms with constant conflicts and that this product would be the only way they can maintain the decorum of the room and also keep the temperature comfort at the maximum level. They also showed interest in knowing how I made this product a possibility and were keen to hear about the modules and parts in incorporated to make my product.

In conclusion, my project has not only received admiration and support but has also ignited discussions about innovation, problem-solving, and the transformative potential of education. It stands as a testament to my ingenuity, perseverance, and the collaborative spirit of those who have encouraged and supported me along the way.

As I embark on further exploration and refinement of my ideas, my journey serves as an inspiration for others to pursue their passions and translate their aspirations into tangible achievements.

15. Two positive aspects you have learnt in this Course?

In this course, I've gained valuable insights and skills that have positively impacted my personal and professional growth. Two positive aspects that stand out to me are:

- Innovative Thinking:
  . One of the most valuable aspects I've learned in this course is the importance of innovative thinking. Through various projects, assignments, and discussions, I've been encouraged to explore creative solutions to complex problems.
  . This has not only expanded my problem-solving abilities but has also instilled in me a mindset of curiosity and experimentation. Learning to approach challenges with an open mind and a willingness to explore unconventional ideas has been incredibly empowering and has equipped me with the confidence to tackle diverse challenges in the future.

- In this course, while my project was primarily an individual effort, I still found collaborative learning to be a positive aspect. Despite not engaging in direct discussions or exchanging ideas with classmates, I benefited from observing and learning from the collaborative efforts of others. Through course materials, presentations, and examples shared by the instructor, I gained insights into various approaches and perspectives, contributing to a more comprehensive understanding of the subject matter. Additionally, while my project focused on independent work, the course structure and assignments fostered a sense of community and shared learning experience among students. This indirect exposure to collaborative learning still played a role in enriching my educational journey and enhancing my skills.

Lean Start-up Management

Final J-Component project Review

Project code:

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Arduino code to power my Arduino Mega 2560:

```
#include <LiquidCrystal.h>
#include <DHT.h>
#include <Arduino.h>

LiquidCrystal lcd(12, 13, 5, 4, 3, 2);
#define DHTPIN 7
#define DHTTYPE DHT22

DHT dht(DHTPIN, DHTTYPE);

const int relayPin = 6;
const int fanPin = 8;
const int redLedPin = 9; // Define the pin for the red LED
const int greenLedPin = 10; // Define the pin for the green LED
const int additionalLedPin = 11; // Define the pin for the additional LED

class HVACSystem {
private:
  float temperature;

  float target_temperature;
  String hvac_mode;
  int fan_speed;
  int iterations;

public:
  HVACSystem() {
    temperature = 0.0;
    target_temperature = 0.0;
    hvac_mode = "off";
    fan_speed = 0;
    iterations = 0;
```

```
    lcd.begin(20, 4);
    pinMode(relayPin, OUTPUT);
    pinMode(fanPin, OUTPUT); // Set fan pin as output
    pinMode(redLedPin, OUTPUT); // Set red LED pin as output
    pinMode(greenLedPin, OUTPUT); // Set green LED pin as output
    pinMode(additionalLedPin, OUTPUT); // Set additional LED pin as output
    dht.begin();
  }

  void set_hvac_mode(String mode) {
    hvac_mode = mode;
    if (mode == "off") {
      digitalWrite(relayPin, LOW); // Turn off HVAC system
      fan_speed = 0; // Turn off fan
      digitalWrite(greenLedPin, HIGH); // Turn off the green LED
      digitalWrite(redLedPin, LOW); // Turn on the red LED
      digitalWrite(additionalLedPin, LOW); // Turn off additional LED
    } else {
      digitalWrite(relayPin, HIGH); // Turn on HVAC system
      digitalWrite(greenLedPin, LOW); // Turn on the green LED
      digitalWrite(redLedPin, HIGH); // Turn off the red LED
      digitalWrite(additionalLedPin, HIGH); // Turn on additional LED
      if (mode == "cooling") {
        fan_speed = 99; // Set fan speed to 90% for cooling
      } else if (mode == "heating") {
        fan_speed = 65; // Set fan speed to 65% for heating
      } else {
        fan_speed = 0; // Default to 0% fan speed
      }
    }
    analogWrite(fanPin, fan_speed * 255 / 100); // Modulate fan speed using
PWM
}

  void read_temperature() {
    temperature = dht.readTemperature();
  }

  void update_target_temperature() {
    if (temperature >= 24) {
      target_temperature = random(max(18, temperature - 5), min(23,
temperature - 1));
    } else if (temperature <= 18) {
      target_temperature = random(max(18, temperature + 1), min(23,
temperature + 1));
    } else {
      target_temperature = temperature;
    }
```

```
  }

  void run() {
    iterations = 0;
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Custom HVAC ON");

    delay(2000);

    int sleep_time = 5; // Set sleep time to 8 seconds

    while (iterations < 20) {
      read_temperature();
      update_target_temperature();

      // Ensure target temperature stays within the range of 18 to 23 degrees
Celsius
      if (target_temperature > 23) {
        target_temperature = 23;
      } else if (target_temperature < 18) {
        target_temperature = 18;
      }

      if (temperature >= 24) {
        set_hvac_mode("cooling");
      } else if (temperature <= 18) {
        set_hvac_mode("heating");
      } else {
        set_hvac_mode("off");
      }

      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("Current Temp: ");
      lcd.print((int)temperature);
      lcd.print("*C");

      lcd.setCursor(0, 1);
      lcd.print("Target Temp: ");
      lcd.print((int)target_temperature);
      lcd.print("*C");

      lcd.setCursor(0, 2);
      lcd.print("HVAC Mode: ");
      lcd.print(hvac_mode);

      lcd.setCursor(0, 3);
```

```
      lcd.print("Fan Speed: ");
      lcd.print(fan_speed);
      lcd.print("%");

      delay(1000 * sleep_time);

      iterations++;
    }

    Serial.println("This is a demo of the Custom Climate Controlled HVAC
System.");
    // Turn off both HVAC system and fan after all iterations
    set_hvac_mode("off");

    // Display "Custom HVAC ON" again after completion
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Custom HVAC ON");
    delay(2000);

    // Stop further execution
    while (true) {
      // Do nothing, infinite loop to halt execution
    }
  }
};

HVACSystem hvac;

void setup() {
  Serial.begin(9600);
  Serial.println("Welcome to the Serial Monitor!");
  Serial.println("---------------------------------");
}

void loop() {
  hvac.run();
}
```