Keeping the above scenario in sight, our goal is to identify and solve the most common problems faced in any educational institution, taking our own university as a canvas.

For a long time, attendance has always been taken manually. This has caused multiple discrepancies and has wasted useful class time. In addition to this, classroom equipment like fans etc. have occasionally been left on thereby wasting considerable energy.

Our approach is a fully edge computed, integrated biometric-based solution for attendance which is modular and carried by the teacher to ensure security. An ambient and spatial sensor-based approach to dynamically turn on and off the fans and lights based on the occupants of the room.

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<https://ieeexplore.ieee.org/abstract/document/8030479>

1. https://www.vxchnge.com/blog/iot-statistics

**CHAPTER-2**

**CHAPTER-3**

**CHAPTER-4**

**DATA**

4.1 Overview:

4.2 Dataset:

**CHAPTER-5**

**SOFTWARE REQUIREMENTS SPECIFICATION**

# 5.1. Product Perspective

We have observed that even if the classrooms have been hugely automated in most of the institutions, there are quite a few loopholes in the previously existing solutions which can be optimized to make the systems full proof. One of those problems is attendance systems. For a long time, attendance has always been taken manually. This has caused multiple discrepancies and has wasted useful class time. We have observed that even if it is automated, there are several flaws. In addition to this, classroom equipment like fans etc. have occasionally been left on thereby wasting considerable energy.

# 5.1.1. Product Features

* Automated Attendance System:

A full proof attendance system using a fingerprint scanner attached to a mic system carried by the teacher such that there are minimum loopholes for the students to exploit.

* Electricity Optimization:

Estimating and reducing the average energy footprint of a classroom by using motion sensors to detect if there are students in a certain section of the classroom where the fans/lights are running and using temperature, humidity sensors for optimizing the classroom temperatures thereby aiming at providing a perfect environment to study.

* Cloud-based Dashboard:

Designing a cloud-based dashboard containing a detailed analysis based on the attendance information.

# 5.1.2. User Classes and Characteristics

* Students:

The students take the fingerprint scanner from the teacher for every class, mark their attendance and pass it around as their attendance gets marked automatically for that particular class.

* Teachers:

The teachers carry the fingerprint scanner attached to the mic system they usually take to class. Their attendance is marked once the mic is switched on and then they would pass the fingerprint scanner throughout the class for the students to mark their attendance.

* System Admin:

The system admin monitors the attendance of the students and basically looks after the entire working of the attendance as well as the energy optimization system.

# 5.1.3. Operating Environment

* Hardware available in campus: Relays, Wiring, Fans, Tube lights.
* Hardware required for the project: UART Capacitive Fingerprint Sensor, Digital Temperature Controller Thermostat, Tolako 5v Relay Module, PIR Motion Detector Sensor Module HC-SR501, Microcontroller: Raspberry Pico, Transmitter and Receiver.
* Software Components: Wireless Connectivity (Wi-Fi Module), Server: Agile, Django/ IoT Platform like ThingSpeak.

# 5.1.4. General Constraints, Assumptions and Dependencies

* Availability of Raspberry Pico:

Raspberry Pico is very new to the market and needs to be tested whether it satisfies all the requirements for the project. As per the documentation, it does seem to satisfy them. As a backup, we would still have Raspberry Pi ready, but the cost would be more if we use Raspberry Pi instead of Raspberry Pico.

* Server systems in the Institutions:

Our project also highly depends upon how the server system exists at a particular institution. If there is no existing server, it would be very easy to implement. If there exists a server, then we have to check how exactly we will be able to implement our project on it.

* Existing Wiring in Institutions:

It depends which wiring system exists at the institution because our project would work on almost every existing wiring system unless it’s very old.

# 5.1.5. Risks

* We assume that the server at the institutions is very easily compatible to our project.
* We also assume that existing wiring and relay system in institutions is not very old such that we cannot even implement our project on those systems.

# 5.2 Functional Requirements

*Attendance Management System:*

The singular component of smart attendance management system involves analyzing and taking fingerprint scans of student and validating the same over a cloud database.

* Validity Tests Involved:
  + Every student of every classroom will have their individual fingerprints scanned and registered in the class’s database.
  + Upon commencement of classes, a scan of every student who are present is taken and validated in the database, thereby marking them present.
* Error Handling and Recovery:
  + Upon encountering an error, the student may request the teacher after through identification to manually mark the said student as present.
  + The database will employ its own error identification and correction techniques.
* Sequence of Operations
  + Student scans fingerprint
  + Scanner relays finger-print identification data wirelessly to microcontroller.
  + Microcontroller checks online database and verifies attendance.
  + Database logs in time and date as well.

*Classroom Energy Management:*

* Validity Tests Involved:
  + The power system of the classroom’s compatibility with relays must be ensured for a smooth functioning of power cutoff.
  + Bidirectional switch connections must be accounted for.
  + The temperature of the room is checked, and the speed of the fans is adjusted accordingly.
  + The temperature can be manually overridden.
  + In the event of the classroom being empty, power must be cut off to all equipment.
* Error Handling and Recovery
  + In the event of an error, circuit breakers are to break the circuit to prevent equipment failure.
* Sequence of Operations
  + Temperature is kept in constant check by the microcontroller.
  + As and when the temperature rises/falls, the fan speed is modulated.
  + When the occupants of the classroom leaves, the power to the lights are cut off.

# 5.3. External Interface Requirements

# 5.3.1 User Interfaces

* Dashboard for the teachers to view attendance.
* Interface for the teachers for manually provide attendance if the sensor fails.
* Controls for the teachers to perform analysis on the intake of students on a per subject basis.
* Controls for the system admin to oversee the registration and authentication of each student.

# 5.3.2 Hardware Requirements

* UART Capacitive Fingerprint Sensor
* Absolute Native Electronics W1209 50~100 digital temperature controller thermostat
* Tolako 5v Relay Module
* PIR Motion Detector Sensor Module HC-SR501
* Microcontroller: Raspberry Pico/ Raspberry Pi
* Transmitter and Receiver for 1km range.

# 5.3.3. Software Requirements

|  |  |  |
| --- | --- | --- |
| Wireless Connectivity | 1 | Wi-Fi Module Specifications:   * Model Number: ESP8266 * Colour: Black * Form Factor: All-in-One * Item Weight: 60.0 grams |
| Server | 1 | * ThingSpeak: Home License * Number of messages: 33 million/year per unit (~90,000/day per unit) * Message update interval limit: Every second * Number of channels: 10 per unit |

# 5.3.4. Communication Interfaces

* Wi-Fi: Connectivity of each of the microcontrollers on every floor will be ensured through Wi-Fi.
* Bluetooth: Connectivity of the fingerprint scammer to the microcontroller will be ensured through Bluetooth.

# 5.4 Non-Functional Requirements

# 5.4.1. Performance Requirement:

Our product is designed to be extremely versatile, and it doesn’t have any specific conditions to work under and no external factors are going to affect the performance of the product. The fingerprint scanner is also extremely reliable as it will still be able to take a reading regardless of external factors. As for the smart classroom system, the sensors are easily available and are very effective for the use that we are putting them to and are not that easily affected by external factors.

# 5.4.2. Safety Requirements:

Our project uses a 5V relay which allows a relatively low voltage to easily control higher power circuits. A relay accomplishes this by using the 5V outputted from a microprocessor pin to energize the electromagnet which in turn closes an internal, physical switch to turn on or off a higher power circuit.

# 5.4.3. Security Requirements:

Security is not an issue with our product as the device will always be in the possession of the teacher and all the microcontrollers for the electricity saving model will be in the possession of the floor admin.

The data collected will be stored safely on a server which is only accessible by the system admin.

**CHAPTER-6**

**SYSTEM DESIGN**

**6.1. Design Considerations**

**6.1.1. Design Goals**

* **Attendance:**

1. Attendance can be taken electronically by means of a biometric optical fingerprint scanner.
2. Security and integrity can be ensured by making the biometric module portable and modular - a small phone sized module carried by the teachers.
3. The teacher can pass around/have each of the students scan their prints and register their attendance with no manual intervention.

Diagram

Description automatically generated

* **Electricity Optimization:**

1. Spatial sensors placed at the edges of classrooms will notify the system of movement and activity in the room.
2. Edge computed algorithms ensure that the lights and fans are turned on only at specific portions of the room incase of a large classroom/hallway.
3. In case of manual fans, temperature monitors are used to add a level of cost-effective automation.

A picture containing diagram

Description automatically generated

* We are trying to build a fool-proof system in this project considering the ways students can bypass these systems.
* Real-time implementation of the project that is independent of wiring system of the institutions.

**6.1.2. Architecture Choices**

Multiple alternate ways to take attendance were considered however, none of them proved to be as reliable and as viable as our solution as most of them proved to be too unwieldy or posed a security concern or straight up could be tampered with:

* *Attendance Logging via Face Detection:*
  + Attendance to be logged in via a camera that would use algorithms that would detect faces.
  + Pros:
    - Simple and easy for students.
    - Seamless attendance by just showing your face in the camera as you walk in.
    - Zero Time wasted as attendance is taken as students walk in.
  + Cons:
    - Very unwieldy, may not work accurately.
    - Lot of variables deciding its effectiveness such as lighting etc.
    - Twins and lookalikes may pose an issue.
    - Actual logging may take time as algorithms take time to recognize faces.
* *Attendance Logging via Single fingerprint scanner:*
  + Attendance to be logged in via a single fingerprint scanner placed at the entrance of the classroom.
  + Pros:
    - Makes the teacher’s life easier as students can manage taking their attendance themselves.
    - Less expensive as fingerprint scanner to be considered doesn’t need to be portable or high tech.
    - No inaccuracies as fingerprints are an extremely reliable means of identification.
  + Cons:
    - Easier to tamper: Students can just log in to the attendance and walk out of the classroom, hence registering a false attendance.
    - No overseeing by the teacher as she has no control over classroom-based sensors.

Eventually, our system was devised which provided the maximum balance between functionality and cons:

* Attendance taken via individual scanners held by teachers:
  + Pros:
    - Teachers have full control over when they can take attendance as the device is constantly with them.
    - Students cannot fake attendance as the teacher decides when the attendance can be taken, once everyone has been settled in the class and the door has been closed.
    - Students can’t log in attendance and walk out of the class as the device would be passed along in the classroom.
    - Teachers can give explicit attendance under their own discretion such as when a student walks in late etc.
  + Cons:
    - Expensive: Involves the purchase of high-end scanners that can be condensed into portable modules for easy handling.
    - Involves some time wastage as students need to log in attendance one by one once everyone has settled in.
    - The device may be prone to damage if it has been extensively being passed on.

# 6.1.3. Constraints, Assumptions and Dependencies

* Availability of Raspberry Pico:

Raspberry Pico is very new to the market and needs to be tested whether it satisfies all the requirements for the project. As per the documentation, it does seem to satisfy them. As a backup, we would still have Raspberry Pi ready, but the cost would be more if we use Raspberry Pi instead of Raspberry Pico.

* Server systems in the Institutions:

Our project also highly depends upon how the server system exists at a particular institution. If there is no existing server, it would be very easy to implement. If there exists a server, then we have to check how exactly we will be able to implement our project on it.

* Existing Wiring in Institutions:

It depends which wiring system exists at the institution because our project would work on almost every existing wiring system unless it’s very old.

# 6.2. High Level System Design

* *Logical User Groups:*
  + Teachers:
    - The teacher is given dashboard permissions to view and manage the attendance and given regular updates as to when the students come to class. The teacher is also given notifications in case of any outliers and can also edit attendance as and when necessary.
  + Students:
    - The students have permissions to only log in the attendance via fingerprint under the teacher’s discretion when the teacher so allows it. The student has no further permissions and if he/she wishes to edit her attendance due to any issue/manual logging, they can only approach the teacher and the teacher can do so under her discretion. The student can also control the temperature of the room and its lighting.
  + Administrator:
    - The administrator oversees all the attendance and the database functions. Only the administrator has full access to the database and its core. Every single operation undertaken by the teacher and the student is logged into an audit log. The admin has access to this log and in the event of any emergency/malpractice, the administrator has a clear view of what is happening at all times. He/she also has access to the database and its connections and can undertake any database operations if necessary.
  + *Data Components:*
    - Raw Fingerprint Data:
      * This is the raw fingerprint values which registers every time a student scans his/her fingerprint.
    - Power Consumption Values:
      * These values are logged for database analysis purposes. They are the total power consumption values on an hourly basis per classroom.
    - Current Room temperature:
      * This stat is the current room temperature which will be monitored. It is according to this stat that the appliances such as fans will be modulated.
    - Database connectors:
      * All data and actions taken by the device will be relayed onto the database via database connector which will be running on the microcontroller. Every action including the actions of all users in the user groups will be logged via an audit log.

# 6.3. Design Description

**6.3.1 Master Class Diagram**

Diagram, schematic

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**6.3.2 Reusability Considerations**

* The assortment IoT sensors installed in the classrooms are durable and need not be replaced often.
* The server installation too is a one-time process. However, the ThingSpeak and Firebase backends need to be paid for on a yearly basis depending on the usage.
* The ML models used for attendance summarization and fan speed detection are reused and some extra layers(mechanism) have been added on top of that. These models are constantly learning from manual user intervention.

**6.4. State Diagrams**

* Attendance:

Diagram

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* Electricity Optimization:

Diagram

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**6.5. User Interface Diagrams**

Diagram

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**6.6. External Interfaces**

**User Interfaces**

• Dashboard for the teachers to view attendance.

• Interface for the teachers for manually provide attendance if the sensor fails.

• Controls for the teachers to perform analysis on the intake of students on a per subject basis.

• Controls for the system admin to oversee the registration and authentication of each student.

**Hardware Requirements**

• UART Capacitive Fingerprint Sensor

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• PIR Motion Detector Sensor Module HC-SR501

• Microcontroller: Raspberry Pico/ Raspberry Pi

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**Software Requirements**

|  |  |  |
| --- | --- | --- |
| Wireless Connectivity | 1 | Wi-Fi Module Specifications:  • Model Number: ESP8266  • Color: Black  • Form Factor: All-in-One  • Item Weight: 60.0 grams |
| Server | 1 | • ThingSpeak: Home License  • Number of messages: 33 million/year per unit (~90,000/day per unit)  • Message update interval limit: Every second  • Number of channels: 10 per unit |

**Communication Interfaces**

• Wi-Fi: Connectivity of each of the microcontrollers on every floor will be ensured through

Wi-Fi.

• Bluetooth: Connectivity of the fingerprint scammer to the microcontroller will be ensured through Bluetooth.

**6.7. Packaging and Deployment Diagram**

Packaging Diagram:

Diagram

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Deployment Diagram:

* Attendance System

Diagram

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* Electricity Optimization

Diagram

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# 6.8. Help

A User Manual Page will be provided along with the guidelines and related diagrams for easy installation of our system. It would also contain the maintenance procedure on how to go about using the application and preventing the end user from stalling at any point.

As the admin will be the only point of interaction, a proper documented API documentation will be provided to the administrator. This will be generated using the POSTMAN software.

**6.9. Design Details**

**6.9.1 Novelty**

* Fool proof solution is important keeping in mind the innovative ways students find to bypass attendance systems.
* Real-time implementation that is independent of the wiring system.

**6.9.2. Innovativeness**

* Dashboard for the teachers to view attendance.
* Interface for the teachers for manually provide attendance if the sensor fails.

**6.9.3. Interoperability**

* Controls for the teachers to perform analysis on the intake of students on a per subject basis.
* Controls for the system admin to oversee the registration and authentication of each student.

**6.9.4. Performance**

* Our product is designed to be extremely versatile, and it doesn’t have any specific conditions to work under and no external factors are going to affect the performance of the product.
* The fingerprint scanner is also extremely reliable as it will still be able to take a reading regardless of external factors.
* As for the smart classroom system, the sensors are easily available and are very effective for the use that we are putting them to and are not that easily affected by external factors.

**6.9.5. Security**

* Security is not an issue with our product as the device will always be in the possession of the teacher and all the microcontrollers for the electricity saving model will be in the possession of the floor admin.
* The data collected will be stored safely on a server which is only accessible by the system admin.

**6.9.6. Reliability**

* The fingerprint scanner is very reliable and will be able to take the readings irrespective of the external factors and conditions.
* The temperature sensors too are not that easily affected to external factors.

**6.9.7. Maintainability**

* The fingerprint scanners would be checked regularly.
* The students also can report to the teachers if there is some problem with the fingerprint scanner.
* The temperature sensors can be replaced occasionally and the best way to know that a sensor is not running is when it does not send any data across or it sends irregular data.

**6.9.8. Portability**

* The fingerprint scanner is attached with the mic and will be carried by the respective teachers to the classes they visit.

**6.9.9 Reusability**

* After implementation, we can extend this project to various other institutions and organizations.

**6.9.10 Application compatibility**

* This system is compatible with any organization and institution since it is independent of the wiring system.

**CHAPTER-7**

**IMPLEMENTATION AND PSEUDOCODE**

**CHAPTER-8**

**CONCLUSION OF CAPSTONE PROJECT PHASE - 1**

**CHAPTER-9**

**PLAN OF WORK FOR CAPSTONE PROJECT PHASE - 2**

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**APPENDIX A:DEFINITIONS, ACRONYMS AND ABBREVIATIONS**

* ThingSpeak: Open-source IoT application and API to store and retrieve data from things using the HTTP and MQTT protocol over the Internet or via LAN.
* Capacitive Fingerprint Scanner: uses capacitance to gauge the depth of the finder and collect the fingerprint.
* Relay: A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals.
* Thermostat: A thermostat is a regulating device component which senses the temperature of a physical system and performs actions so that the system's temperature is maintained near a desired setpoint.
* Microcontroller: A microcontroller is a small computer on a single metal-oxide-semiconductor integrated circuit chip.

**APPENDIX B: USER MANUAL**