

**Program: ESE 4009\_2**

**INSTRUCTOR: Prof. Mike Aleshams**

**Group# 2**

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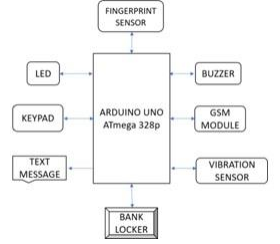
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**Project Proposal**

**Project Title: IOT based Bank Locker Security**

**Description of the previous similar project:** Basic idea of the project is to secure the bank locker using the Finger print sensor. The main objective of the project is to effectively manage and control the bank locker by using a fingerprint sensor. It uses an Automated Safety Vault with Double Layered Defence Mechanism. This project was composed of an Electronic Lock that used fingerprint and password verification tools for scanning and sensing. Both of these two layers helps to avoid any unauthorized entrance to the Vault. Biometric recognition is highly protected as one person's fingerprint never matches the other's as it usually includes fingerprints, ears, iris, recognition of the voice, signature, and hand geometry and confirmation. In this controller to analyse the sensor data and to generate desired controlled variables in order to ensure the security of the vault with the biometric. Pattern recognition is used as it ensures the secondary layer safety to the secured vault after successful adherence to the primary layer of password protection.

**Block Diagram:**



**Figure 1 Block Diagram of Existing project**

**Hardware and Software Requirements:**

* Arduino Uno
* Buzzer
* Vibration Sensor
* Finger Print Sensor
* LCD
* Keypad
* GSM Module
* Locker
* Arduino IDE
* Laptop

**Limitation:**

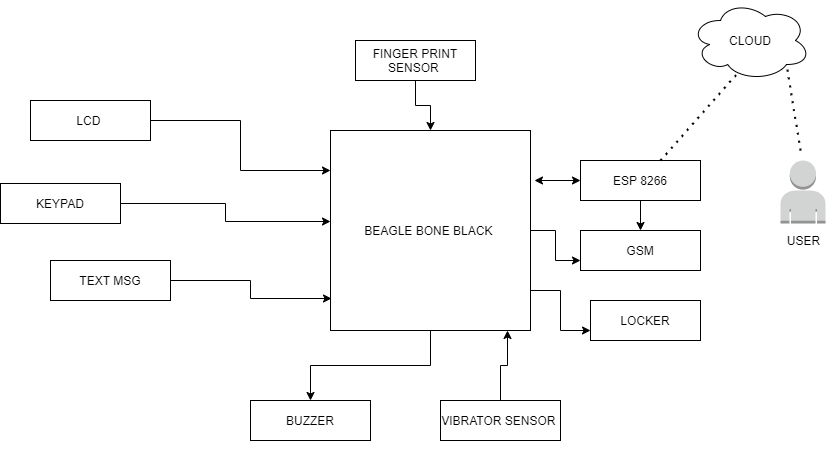
1. This system lacks in IOT.

2. Microcontroller used is the Arduino uno which is less famous nowadays as compared to the latest ones. So, it's a drawback.

3. If any unknown user is trying to access this locker other than the owner, this system fails to identify the person with unauthorized access.

4. As per described above, there is no camera module added in this project. This also leads to the project failure.

**Solution 1:** As per the limitations of the existing project are discussed above, here we are going to replace the Arduino uno which is a main microcontroller in the existing project with the latest microcontroller that is beagle bone black. It is a 32-bit microcontroller, that comes with an inbuilt Debian image and works as a mini computer. As it can handle an operating system on its own. Using beagle bone black as a main microcontroller will definitely change the whole working of the project. More GPIO pins, and the interfacing communication protocols like UART, SPI, I2C make it more usable than Arduino uno.

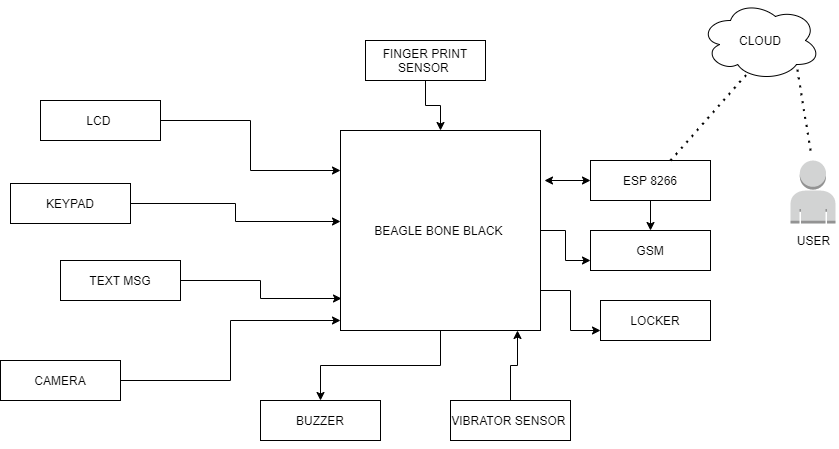


**Figure 2 block diagram for Solution 1**

**Features of solution 1:**

1. Beagle bone black, a 32-bit microcontroller, will be used as a main processing unit.
2. Adding IOT in the proposed project with the help of WIFI module to store data in the cloud.

**Solution 2:** Here, we are adding a camera module in the project. This is why the project will come under the 3-layer security. As if an intruder tries to open the bank locker, then the vibration sensor will start working and the image will be captured in the camera and the message will be directly sent to the owner if someone tries to open the locker. As if the user also tries to open the locker but somehow the fingerprints do match still the camera will take the picture and update the user.



**Figure 3 block diagram for Solution 2**

**Features of solution 2:**

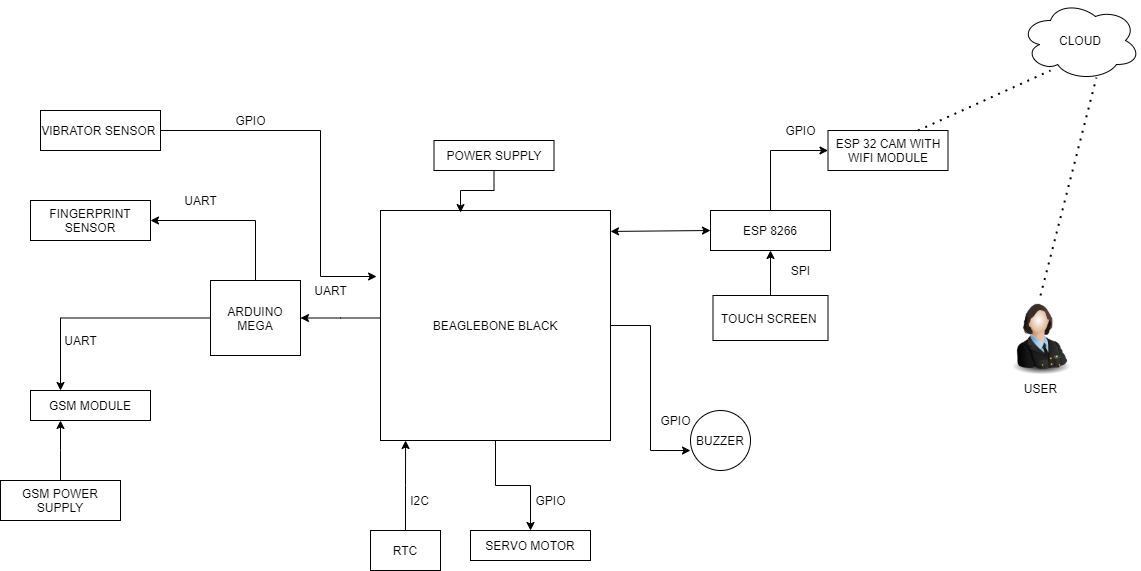
1. Beagle bone black, a microcontroller, will be used as a main processing unit.
2. Adding IOT in the proposed project with the help of WIFI module to store data in the cloud.
3. Using the camera module in the project, to make security high.

**Final Solution:**

For the final solution, we will use ESP 32 Camera module to upgrade the existing the project. As whenever an unauthorized person tries to open the locker then the camera will capture the picture and send it to the concerned person via mail and updating the user via an SMS too.

Initially, the Fingerprint Sensor will be deactivated. Once the use enters the password in the Touchscreen, the Fingerprint module will get activated. If the user then gives correct fingerprint, then the door will open which will be indicated by Servo motor.  
Although if wrong password is entered, or any vibration or loud sound is sensed, the beagle bone will send an alert SMS to the concerned person and also photos will be send via mail to the user.  
Overall, the system is quite reliable because if there’s any issue in Internet connection, the concerned person will still be getting SMS alert.

**Block Diagram:**



**Figure 4 block diagram of proposed project**

**Hardware Requirements:**

* Beagle Bone Black
* Touch screen
* Fingerprint sensor
* Vibrator Sensor
* Power Supply 5V for BBB
* ESP32 Camera module.
* ESP8266 Module
* GSM Module
* Power Supply for GSM
* Servo motor
* Buzzer
* SD card for Flashing of BBB
* Laptop
* Jumper Wires
* Multimeter
* Soldering Kit
* Breadboard
* USB Cables
* 5V and 12V Power adapter
* Real Time Clock
* Arduino Mega

**Software Requirements:**

* **Coding:** mainly preferable languages in our project is C, C++. Although Python Programming may be used in some cases where the feature is limited by C language.
* **PCB designing** PCB Designing will be done on EasyEDA Software.
* **Assembler:** GNU Assembler will be used which is default assembler for GCC Compiler.
* **Linux OS:** Beagle bone Black support LINUX operating system. And we are using Linux to flash the latest image of Debian as per the requirement of the project. Usually, Beagle bone devices come with pre-installed Debian images, but we have to update it to meet our requirement.
* GNU **NANO** is a small and easy to use friendly text editor. This text editor totally supports the Beagle bone black. We can easily write the program and save it using a specific extension. For example, if we are making a txt file, we can save it with .txt extension. And lastly, we can make it executable using GCC command.
* **Gmail:** Gmail is very well-known service by Google. It can used to share message and media both
* **SSH** will be used for execution of commands on Beagle bone via Laptop while development.
* **Arduino IDE** is a coding software that makes the programming world more accessible to beginners with its simple interface and community-driven system.
* **Eclipse IDE** is used for executing the commands that is used in our project as it uses C/C++.

**Features:**

1. Beagle Bone Black, microcontroller, work as master device for project.
2. ESP32 Cam module with camera is used as a slave device and provide connection to cloud and also is used to capture image and sending the mail.
3. Adding Internet functionality which will allow the system to send Email and pictures. And all the pictures will be stored on mail server for reference.
4. Vibration sensor increases the efficiency of the Security System.
5. Touchscreen: Use of Password Authentication using Touchscreen is being used as a first layer of Security.
6. Finger print module: Use of finger print Authentication using finger print sensor is being used as a second layer of Security.
7. ESP 8266: This is used to make connection with touch screen and make the circuit less complex.
8. Arduino Mega: This is used as a salve device to make the communication possible with master device.
9. GSM Module: GSM module is used for sending SMS to concerned person about various information.
10. RTC: The real time clock is not included with the beagle bone and for sending the real time.
11. Buzzer is used to indicate if something wrong happened.
12. Power adapter are used to supply power to the project.

**Use of various peripherals such as touch screens, cameras, microphones and speakers, GPIOs, timers, GPS modules, Bluetooth, Wi-Fi, and ADC/DACs?**

1. Beagle Bone Black, microcontroller, work as master device for project.
2. Vibration sensor: Vibration sensor measure the vibration around. The aim of vibration sensor in our system is to detect any impact or force which may be applied to force open the locker.
3. ESP 8266: ESP8266 is 32-bit microcontroller that works as a slave module in our project to use for interfacing touchscreen.
4. ESP32 Cam: The ESP32CAM is a tiny module based on ESP32 chip and OV2640. We are using it for capturing picture and sending it to mail via internet.
5. Touch Screen: The touch screen will help to enter the password as a first layer security. And also, to show useful information to the user.
6. Piezo Buzzer: Buzzer is used as an audio output/ feedback for our system. The buzzer will start if anything abnormal like vibration, multiple wrong passwords etc. is detected
7. Servo motors: Servo motor in our system is used as the lock/ unlock mechanism.
8. Fingerprint sensor: For providing Biometric Authentication we are using Fingerprint sensor.
9. RTC: RTC (Real-Time-Clock) is being used to keep track of Real-World Time.
10. Camera module: Camera module will be used to take pictures when needed and the same will be sent to mail.
11. GSM Module: GSM module is used for sending SMS to concerned person about various information.
12. Arduino mega: Arduino Mega is being used an intermediate between the Beagle bone and GSM Module to increase the reliability of the system
13. Other Hardware Tools: Other Hardware tools maybe required for completion of project, like Soldering Rod, Multimeter, Wire Cutter etc.

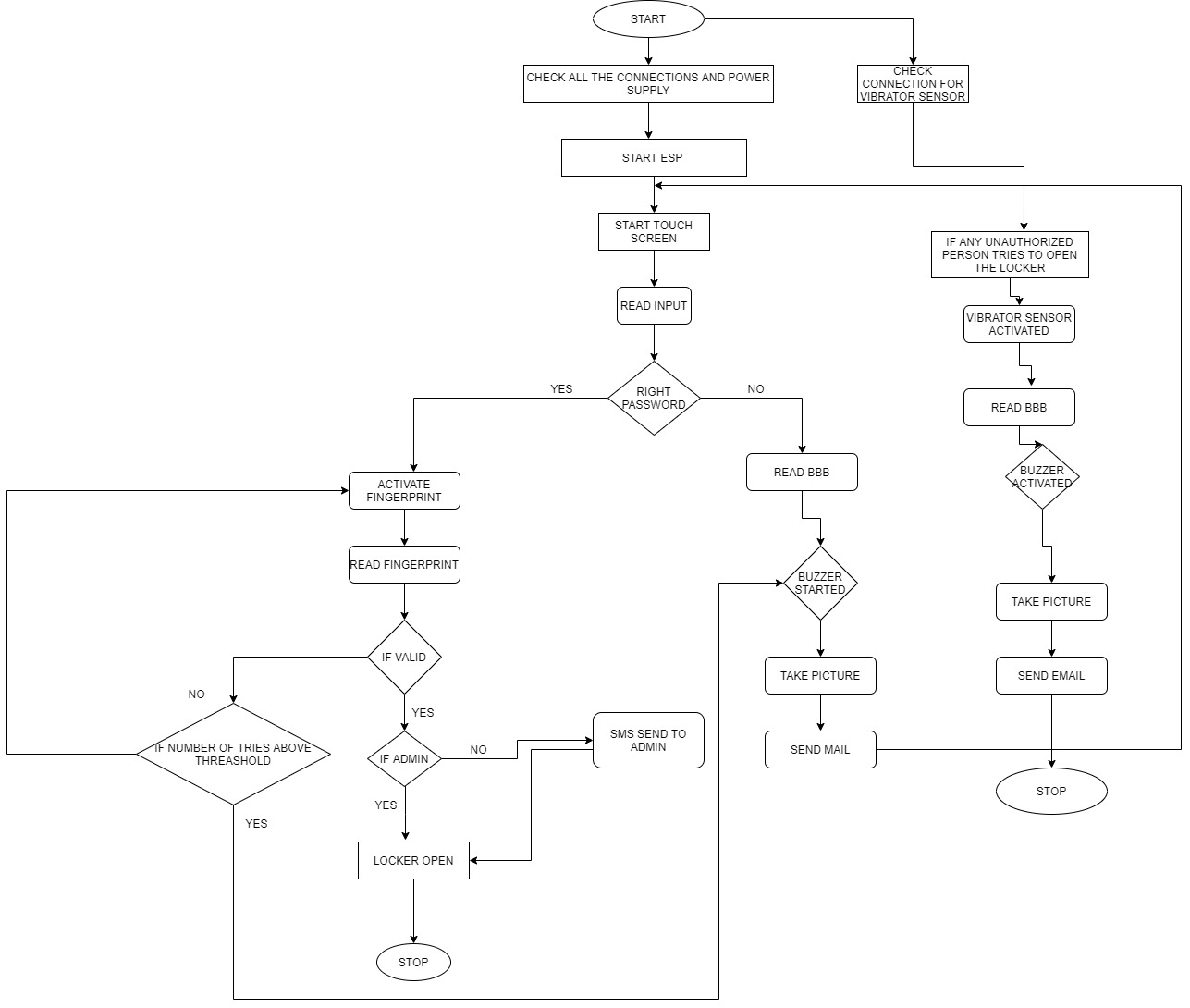
**Use of I2C, SPI, RS232/RS-485, IrDA infrared, JTAG, USB, Bluetooth, IEEE 802.11 Wi-Fi, IEEE 802.3 Ethernet, CAN and GPS protocols and systems?**

1. Internet connectivity will be based on Wi-Fi with the help of ESP32 WIFI module.
2. The WIFI protocol used is IEEE802.11.
3. GSM is connected to beagle bone black through Arduino mega are connected using UART protocol via Arduino Mega.
4. Buzzer is connected to the GPIO pin of the BBB.
5. Fingerprint sensor is interfaced with Arduino mega, a slave device to connect with the master device, beagle bone black. So, the connection is built using UART communication protocol.
6. Vibrator sensor is interfaced with Beagle bone using GPIO pins
7. The cloud service for this project will be Gmail, to store and send data.
8. Camera module ESP32 is interfaced with ESP 8266 using GPIO Feature provided specially.
9. Servo motor is connected to BBB using GPIO pin.
10. RTC is connected to BBB using I2C protocol.
11. ESP 8266 is interfaced with the touch screen using SPI.
12. ESP 8266 is interfaced with the BBB using UART Communication protocol.

**Use of pre-emptive versus cooperative scheduler operation; tick rate and time slicing; critical code; fixed, dynamic and hybrid task priority allocation; application-specific considerations; power management tactics; semaphores, mutexes and queues; debugging strategies; performance estimation?**

1. From the beginning, the project will work step by step like first the user needs to enter the password and then fingerprints. Fingerprint sensor will not be activated until correct password has been entered. So, this is the priority in system. Now, on the output side we have two tasks: One is the text message and the other is sending the camera data to user with the help of real time clock.
2. As we are assigning the SMS sending task to BBB and the Image Sending via Mail is assigned to ESP32. Hence, both the task will happen in parallel.
3. Whenever there is any forceful activity to open the locker, buzzer will be activated and hence the sensor act as an interrupt for the project. The vibration sensor is being given the highest priority.

**FLOW CHART:**

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**Communication Protocols:**

* RTC Module – I2C protocol is used for interfacing the RTC as the module supports I2C protocol. Advantages of I2C – maintains low pin/signal count even with many devices on the bus, adapts to the needs of different slave devices, readily supports multiple master devices and incorporates ACK/NACK functionality for improved error handling.
* ESP8266 – We have multiple protocol options as ESP8266 supports many. However, we are using UART as it has ease of communication. It requires only 2 wires for full duplex communication, and it doesn’t require any address for data. Advantages of UART – hardware complexity is low and for one-to-one connection between devices.
* Wi-fi – ESP32 is a Wi-fi module with camera which can provide internet access to our system. Wi-fi is from the family of wireless network protocols, based on IEEE 802.11 family of standards, which is commonly used for local area networking of devices and internet access. Advantages of Wi-fi – Stable and faster signal than cellular data, ability to move the device while still in use and zero involvement of wires.
* GSM Module: GSM module is interfaced using UART protocol as the module preferable provides UART support, and we are using Arduino mega to make connection between GSM and beagle bone.
* Fingerprint Module: Fingerprint module is interfaced using UART protocol as the module preferable provides UART support, and we are using Arduino mega to make connection between Fingerprint and beagle bone.
* Servo Motor: PWM (Pulse Width Modulation), although it cannot be considered as protocol but PWM is being used to send signal to servo motor for rotating it to specific degree.
* GMAIL: The IMAP abbreviation stands for Internet Message Access Protocol and is one of the two most popular protocols for receiving email messages from the Internet. SMTP is an abbreviation that stands for Simple Mail Transfer Protocol. This protocol allows applications to transmit email messages over the Internet.

**Standards for Coding:**

Coding rules and guidelines ensure that software is:

* Safe: It can be used without causing harm.
* Secure: It can’t be hacked.
* Reliable: It functions as it should, every time.
* Testable: It can be tested at the code level.
* Maintainable: It can be maintained, even as your codebase grows.
* Portable: It works the same in every environment.

There are 4 key benefits of using coding standards:

* Compliance with industry standards (e.g., ISO).
* Consistent code quality – no matter who writes the code.
* Software security from the start.
* Reduced development costs and accelerated time to market.

**Popular Coding Standards for C language:**

1. MISRA - MISRA provides coding standards for developing safety-critical systems.

MISRA C is the most widely used set of coding guidelines for C around the world.

There have been three releases of the MISRA C standard -

* MISRA C:1998
* MISRA C:2004
* MISRA C:2012

2. CERT - CERT is a secure coding standard. It’s developed by the CERT division of the Software Engineering Institute at Carnegie Mellon University. This secure coding standard is available for C and C++.

The standard targets insecure coding practices and undefined behaviours that lead to security risks. Using security rules will help you identify security issues in existing code and prevent the introduction of new issues that pose a security risk.

**Milestones (Deliverable and schedule):**

|  |  |  |  |
| --- | --- | --- | --- |
| **TASK** | **START DATE** | **END DATE** | **PERSON INCHARGE** |
| PROJECT PROPOSAL | 18 Jan | 12 Feb |  |
| FINALISING AND ORDERING THE HARDWARE COMPONENTS | 12 Feb | 17 Feb | GURPREET |
| TESTING THE HARDWARE COMPONENTS(PART-1) | 17 Feb | 19 Feb | AMAN |
| TESTING THE HARDWARE COMPONENTS(PART-2) | 19 Feb | 22 Feb | JASMEET |
| DESIGNING SCHEMATIC | 22 Feb | 26 Feb | SIMRAN |
| INTERFACING BUZZER BEAGLEBONE | 26 Feb | 1 March | KIRAN |
| INTERFACING SERVO MOTOR WITH BEAGLEBONE | 1 March | 3 March | GURPREET |
| INTERFACING FINGERPRINT SENSOR WITH ARDUINO MEGA | 3 March | 5 March | SIMRAN |
| INTERFACING VIBRATION SENSOR | 5 March | 12 March | JASMEET |
| INTERFACING ARDUINO MEGA TO BEAGLEBONE BLACK | 12 March | 15 March | AMAN |
| INTERFACING GSM TO ARDUINO MEGA | 15 March | 17 March | KIRAN |
| INTERFACING ESP8266 WITH BBB | 17 March | 22 March | GURPREET |
| CONNECTING ESP8266 WITH ESP32 CAM, ESP32-CAM WIFI CONNECTIVITY | 22 March | 29 March | AMAN |
| ESP32 CAM PICTURE CLICKING AND STORING SENDING IMAGES FROM CAMERA BY EMAIL | 29 March | 31 March | JASMEET |
| INTERFACING TOUCH SCREEN WITH ESP8266 | 31 March | 2 April | SIMRAN |
| INTERFACING REAL TIME CLOCK WITH BEAGLEBONE | 2 April | 5 April | KIRAN |
| DESIGNING PCB ONLINE | 5 April | 7 April | GURPREET |
| IMPLEMENTATION OF ZERO PCB(PART-1) | 7 April | 9 April | AMAN |
| IMPLEMENTATION OF ZERO PCB(PART-2) | 9 April | 12 April | JASMEET |
| GUI FOR THE TOUCHSCREEN FOR INPUT | 12 April | 15 April | SIMRAN |
| POWER MANAGEMENT | 15 April | 19 April | KIRAN |
| REPORT | 19 April | 23April |  |
| FINAL DEMONSTRATION | 23 April | 28 April |  |

**Legal and ethical ramifications:**

There are several ethical problems that a person can face in project management. An individual (in an organization) can compromise on his or her own ethics depending on the projects, in order to deliver the project on time. Whenever this thing happens, though, it is mostly overlooked by managers and stakeholders. Blown budgets, legal matters and even criminal charges are all too common in today's business environment. Here, we are going to take a look at some of the more common types of ethical dilemmas that can arise in our project, and how we can work through them safely.

**Accountability:**

When things go wrong, it is human nature to try to avoid the consequences and place the blame elsewhere. Not only does this damage employment and reputations, it creates additional project issues by concealing the true source of the problem. The importance of owning their own shortcomings and the circumstances of understanding in which team members or other stakeholders are involved should be understood by project managers.

**Conflict of interest:**

We should make sure that the overall purpose and mission of this project should be known by all project participants. This will make sure that when working together, there is no conflict of interest.

**Health and safety concerns:**

Another important thing when doing the project is pressure to get the job done. However, when doing this, the team members should not feel mentally exhausted. At every moment they see a potentially risky situation, project team leaders should be able to raise the alarm. Even, if anything disturbs them, participants should be able to lift their voice in the organization.

**Legal consequences of the project:**

The legal contract should not be broken by both sides of the project. For our project, we should define the right delivery model, project should be deadline bounded. The laws require completing the project on schedule and budgeting it. Moreover, we need to make sure that the project is safe, stable and reliable. And can be helpful for the future.

**Bill of Material (BOM):**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PART NAME | PART NUMBER | DESCRIPTION | COST | QTY | REMARK |
| Beagle bone Black | BBB01-SC-505 | Embedded Evaluation Board | $85 | 1 | The Beagle Board is a low-power open-source single-board computer produced by Texas Instruments in association with Digi-Key and Newark element14. |
| Buzzer | UTCA-XTMB-2617 | UHPPOTE Mechanical Buzzer Sounder 12VDC Continuous Beep with Leads 75 dB for Access Control and Buzz-in System | $16 | 1 | Buzzer is used as sound indication to user if anything wrong. |
| Arduino Mega | A000067 | Elegoo R3 Board ATmega328P ATMEGA16U2 with USB Cable for Arduino mega | $54 | 1 | Arduino mega is used as a slave device for connecting the GSM Module and finger print sensor. |
| GSM MODULE SIM 900 | Walfrontqb2noh75ka | SIM900A V4.0 Kit Wireless Extension Module GSM GPRS Board | $32 | 1 | Used for Sending SMS and Alerts |
| ESP8266 | ESP8266 Development Board | 32-bit 4MB Flash Microcontroller ESP8266 | $12 | 1 | Used for Touchscreen Interface |
| TOUCHSCREEN | Display Module 3.5" TFT LCD Screen Module 480x320 | 3.5in 480x320 TFT LCD screen, high quality image display and wide viewing angle. | $30 | 1 | For Entering Password and Displaying useful Information |
| Soldering kit | FBA\_Tabiger-86 | TTABIGER Soldering Iron Kit Electronics 60W Adjustable Temperature Soldering Iron, 5pcs Soldering Iron Tips, Solder, Rosin, Solder Wick, Stand and Other Soldering Kits in Portable Toolbox | $28 | 1 | This kit consists soldering iron which is used for soldering components to PCB. And there is a digital multimeter that comes with this kit that can be used for testing of components, power supply etc.. |
| Wires and Breadboard | ESH-PB-01 | 3 Pack Solderless Plug in Breadboard with 3 Pack Jumper Wires, 830 Tie-Point 4 Power Rails Breadboard for Circuit | $19 | 1 | Wires are used for connecting components in breadboard. |
| SD card | SDSQUNS-064G-    GN3MN | Sandisk Ultra SDSQUNS-064G- GN3MN 64GB 80MB/s UHS-I Class 10 microSDXC Card. | $14 | 1 | In case if we want to Flash Beaglebone with latest Debian image SD card can be used |
| Resistor/  capacitor kit | 9687283011 | Electronic Components Kit, Electronic kit | $31 | 1 | Resistor and capacitor kit consist of different varieties of resistors and capacitors used in this project. |
| 5V 1A Power Supply | 5V 1A Power Supply  WSU050-2000 | 5V 1A Power Supply 5V 5W Power Adapter AC 100-240V to DC 5V 1A Wall US Plug | $14 | 1 | To Power up Beagle bone without Laptop |
| 9V 1A Power Supply | 9V 1A Power Supply  A17062 | 9V 1A Power Supply 9V 9W Power Adapter AC 100-240V to DC 9V 1A Wall US Plug | $14 | 1 | To Power Up GSM Module |
| Fingerprint Sensor | R307 SALUTUYAbvnmt8iud2 | R307 Fingerprint Reader Sensor Multifunction Optical Fingerprint Module Optical Fingerprint Reader | $24 | 1 | For Biometric Authentication |
| Servo Motor | SG90  D40O43EJ09X2YP7X11G | ULTECHNOVO 4pcs SG90 Micro Servo Motor Kit Durable Lightweight Digital Servo | $18 | 1 | For Lock Open and Close Mechanism |
| RTC Module | DS3231 Real Time Clock Module | Geekstory DS3231 Real Time Clock Module RTC Sensor High Precision AT24C32 IIC Timer | $19 | 1 | For Keeping track or Real Time |
| Vibration Sensor Module | SW-420  101020586 | SW-420 Normally Closed Alarm Vibration Sensor Module Vibration Switch PCB | $4 | 1 | For Detection of Vibration |
| ESP32 CAM Module | Keenso65cn73iawt | SP32-CAM Board with OV2640 Camera Dual-core Wireless WiFi Bluetooth Development Board DC 5V | $18 | 1 | For taking picture and sending mail |
| ZERO PCB | Pcbboard-9-15-Green-2PC | Mechanically support and electrically connect the components | $11 | 1 | Used to place the components on the board, for final project demonstration |

**Engineering design:**

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**Approaches During Edit-Test-Debug Cycle:**

In order to complete the expansion of a software as a product, several tasks need to be done. A development process consists of different cycles of editing, testing, debugging. When we are working on an embedded project, the hardware we finalize will be same throughout the project. But the software part has to be made perfect by going through multiple approaches.

Phases of a development process in our project:

* Using a target system: We are using a Beagle bone Black as a target system for our project. It is our main microcontroller unit to run this project. It is a low-cost, open source, community- supported development platform.
* Emulator: We are not using an emulator in our project.
* Using target processor and ICE: We are not using a target processor and ICE.
* Simulator: We are not using a simulator in our project.
* Using IDE or prototyping tool:

Eclipse IDE: We are using Eclipse IDE in our project. We are using this tool to write codes and debug them using the inbuilt debugger. As our main coding language is C, we are going to use its C/C++ IDE. Arduino IDE: The Arduino Integrated Development Environment is a cross platform application that is written in functions from C and C++. Arduino IDE is used to write and upload programs to Arduino boards. But also, can be used with some other development boards. (e.g.: ESP32)

**References:**

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* beagle bone black: <https://beagleboard.org/black>
* WIRING SERVO WITH BBB: <https://learn.adafruit.com/controlling-a-servo-with-a-beaglebone-black/wiring>
* Interfacing gsm module with Arduino mega: <https://lastminuteengineers.com/sim900-gsm-shield-arduino-tutorial/> https://www.youtube.com/watch?v=wI-pQyG13ZM
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* Interfacing of servo motor with BBB: [Servo Motor Controlling with Beaglebone Black (Part 6/15) (engineersgarage.com)](https://www.engineersgarage.com/electronic-projects/servo-motor-controlling-with-beaglebone-black-part-6-15/)
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* Protocol used for GMAIL: [IMAP Protocol | Internet Message Access Protocol - javatpoint](https://www.javatpoint.com/imap-protocol)
* About esp32: [Overview of ESP32 features. What do they practically mean? - Tutorials (exploreembedded.com)](https://www.exploreembedded.com/wiki/Overview_of_ESP32_features._What_do_they_practically_mean%3F)
* Interfacing bbb with Arduino mega: [How to Make a BeagleBone and an Arduino Communicate : 4 Steps - Instructables](https://www.instructables.com/How-to-make-a-BeagleBone-and-an-Arduino-communicat/#:~:text=%20How%20to%20Make%20a%20BeagleBone%20and%20an,find%20the%20serial_echo.py%20script%20and%20run...%20More)
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* GSM Module: https://www.amazon.ca/Development-Board-Module-SIM900-Antenna/dp/B07XY79G56/ref=sr\_1\_1\_sspa?dchild=1&keywords=gsm+module+900&qid=1613097634&sr=8-1-spons&psc=1&smid=A2KRDQ1AI5Y5G6&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyWFlCNFUzU1A1SE41JmVuY3J5cHRlZElkPUEwNDEwOTc1MU5JOFRCM1JCMzFMWCZlbmNyeXB0ZWRBZElkPUEwMDI0NDg5MTc4Mlg3M0ZTQ1pZRCZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=
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**Instructor Review:**