CS-308-2015 Final Report

Smart Luggage

Team 8

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1. Introduction

Smart luggage is a device for luggage security during travel. This involves an anti-theft mechanism and reasonable cover from accidents such as misplacement of luggage. It can be enabled before a journey and disabled when the luggage has been placed in a safe location.

The device comes with an Android app which provides several features such as a lock, unlock mechanism for control. It also displays the status of the luggage in real-time, which includes distance of luggage from client, flap open or closed etc. The embedded device itself is designed to be an independent unit which can be placed in any luggage.

2. Problem Statement

Frequent travellers may have to carry precious luggage over long distances. In many cases, the luggage of the client is hidden from sight. For example, when the client is travelling by train and has an upper berth, or when travelling by a bus with a seperate cargo hold. In crowded areas, the luggage is susceptible to theft or improper handling. The device aims to protect the client from such issues.
The objectives of the device are as follows:

1. Distance : The device must be able to provide accurate distance of luggage in real-time over small distances
2. Safe radius : The device must allow the user to set a safe radius for luggage, and notify the client if it is breached
3. Tampering : Device must notify the user of an attempt to force open the bag

Taken together, the above features make for a fairly secure system.

3. Requirements

3.1 Functional Requirements

1. Authentication to allow device to recognise client
2. Estimate distance of device from client using Bluetooth signal strength
3. Set safe radius for luggage and lock/unlock luggage from client device
4. Maintain status of luggage flapusing IR sensors to prevent tampering
5. Send notification to client device if safe radius is exceeded or in case tampering occurs

3.2 Non-Functional Requirements

1. Robustness of device to allow portability
2. Low Power consumption to allow device to last journey
3. Compact size so that device can fit in luggage

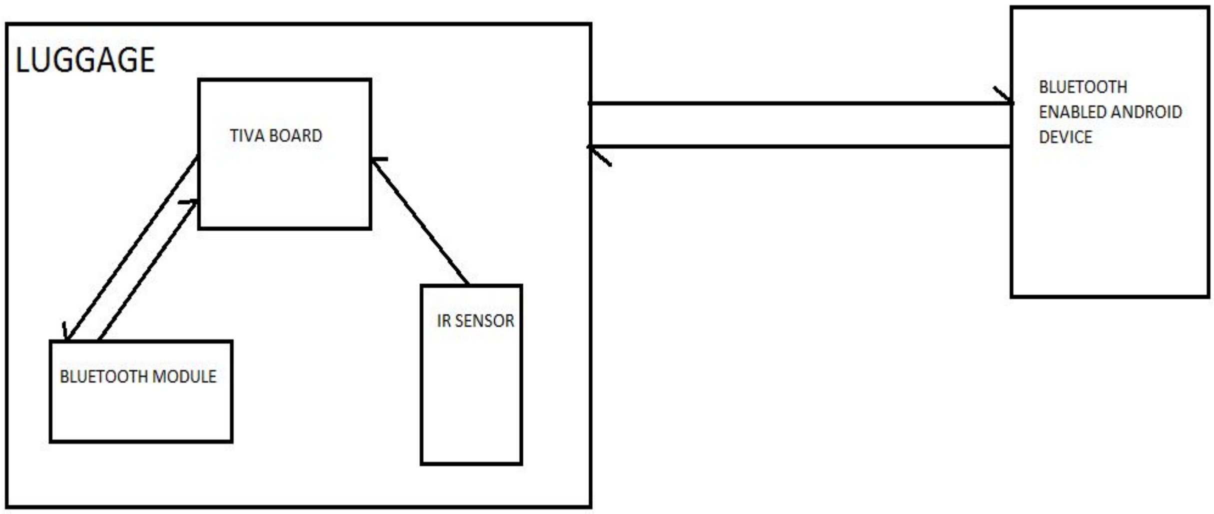
3.3 Harwdare Requirements

1. Bluetooth module
2. IR/Proximity sensors
3. TIVA C Series board
4. Potable power source (eg. Power Bank)
5. Android device with Bluetooth functionality

3.4 Software Requirements

1. Android system to support the Smart Luggage Application

4. System Design

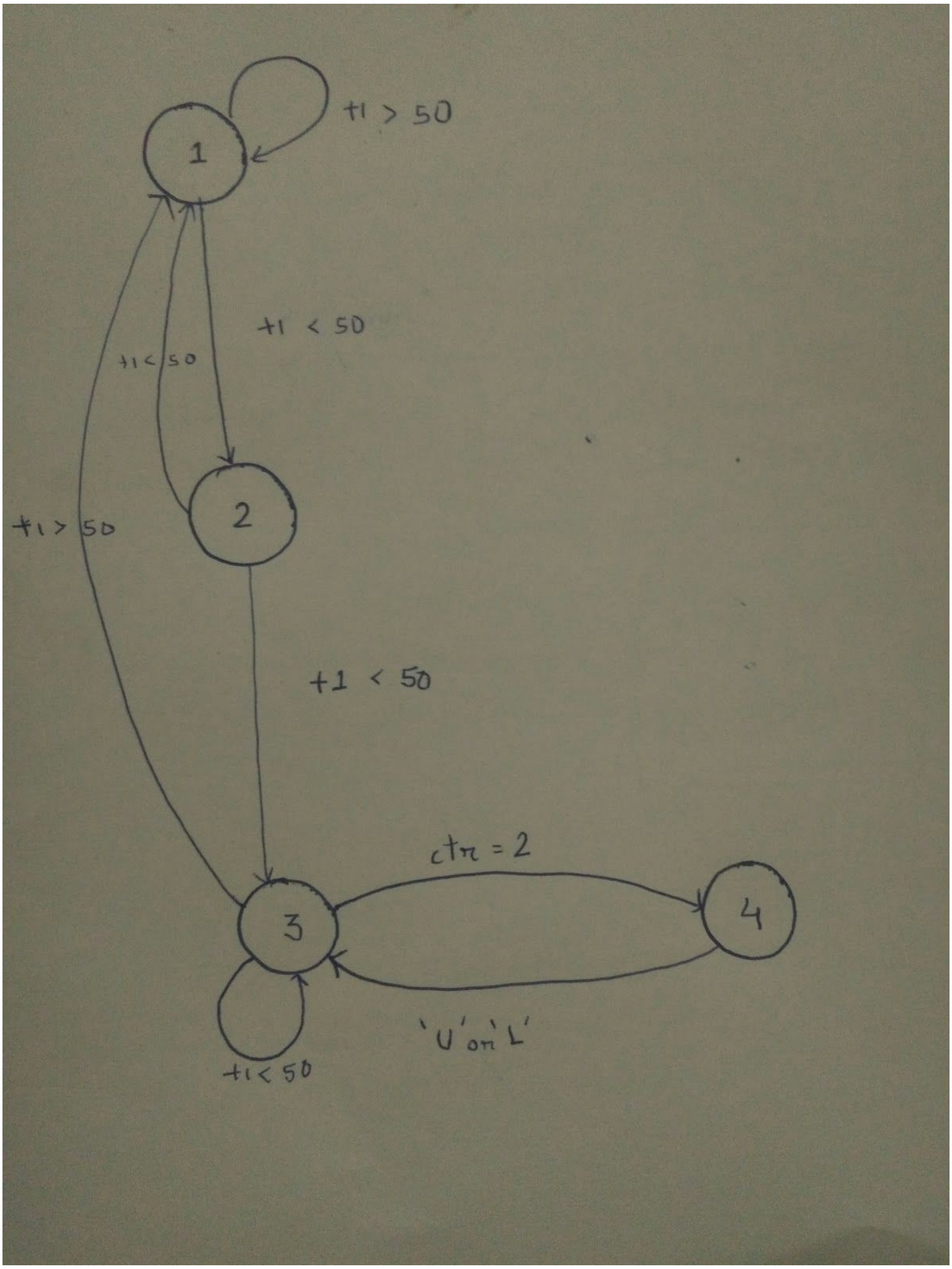


The system has two principal components:

1. Embedded device placed in luggage :
    a. BT module
    b. IR sensor
    c. TIVA board
2. Android Application for device control

<u>Signals</u>

1. Lock (L) : Sent by client to deice. Indicates that luggage is locked and any tampering must be reported to client with a signal
2. Unock (U) : Sent by client to deice. Indicates that luggage is unlocked
3. Open (O) : Sent by device to client when the bag is tampered with in Lock status
4. ‘t1’ : Variable which signifies distance of suitcase flap from device. It is the reading from IR sensor obtained through a ADC module
5. ctr : Number of Lock signals recieved by device, avoids repeated Open signals for efficiency



<u>States</u>

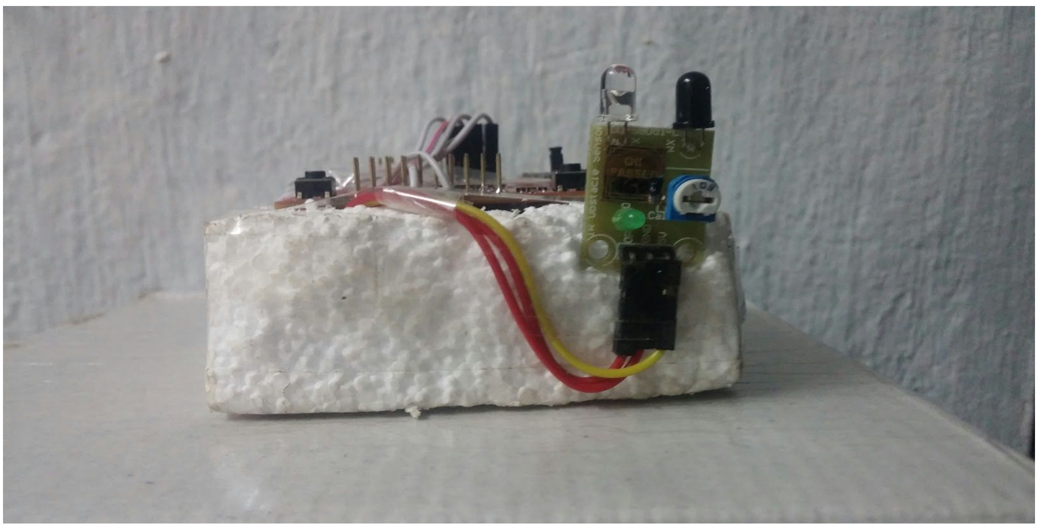
1. State 1 : Bag is closed
2. State 2 : Intermidiate state to register that bag might be open
3. State 3 : Bag is closed
4. State 4 : Open bag notification sent, device will wait for bag to close before resending the notification

Thus, the embedded device implements a state machine which can be thought of as debouncing of IR signals. However, there are additional states to maintain efficiency of sent signals, and to read other global status such as Lock/Unlock mode.

The Android application interacts with Bluetooth feautures of the client device. It initiates pairing with the embedded system. On pairing, it sends a Lock signal to the system by default. It then alternates between the data transfer and Bluetooth discovery cycle. In the data transfer cycle it sends a Lock/Unlock signal based on the status set by user, and reads back a Open/Closed status of the luggage sent by the system. It then enters the discovery cycle, where device is unpaired, several readings of Bluetooth RSSI strength are taken, averaged and mapped to distance.

Device design

Top view of device shows TIVA board connection with Bluetooth module



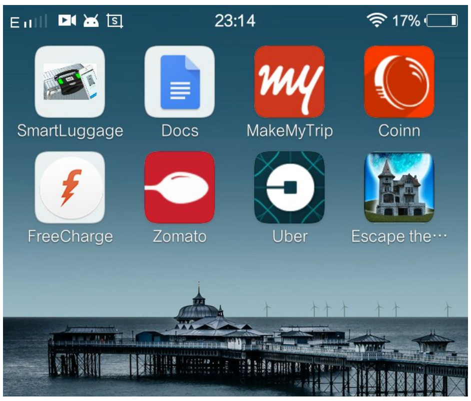
Front view of device showing IR proximity sensor pointing upwards to sense luggage flap

5. Working of the System and Test results

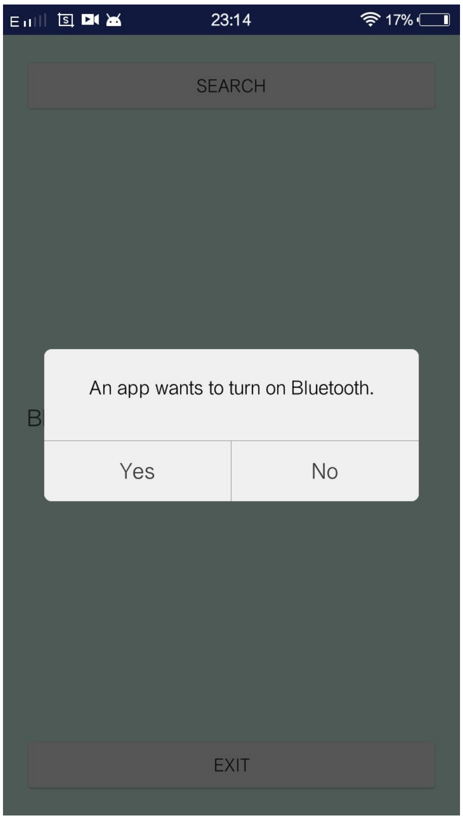
Device connected to removable power source, enabled and placed inside luggage

<u>Setup</u>

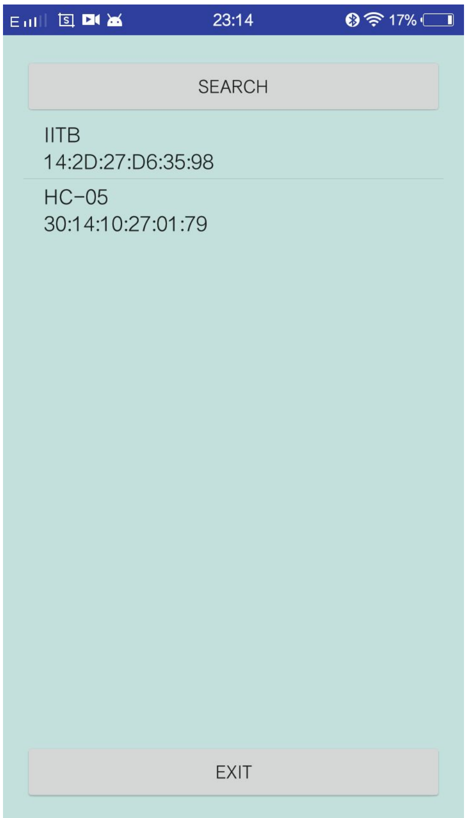
On placing the device in the luggage, all further control is possible through the Adnroid App. Here are the available features :



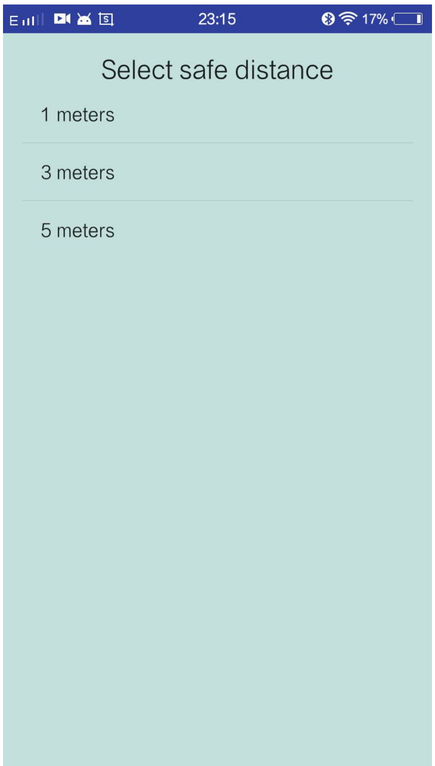
Android Device showing Smart Luggage Application (Top Left)



Application asking for permission for using bluetooth

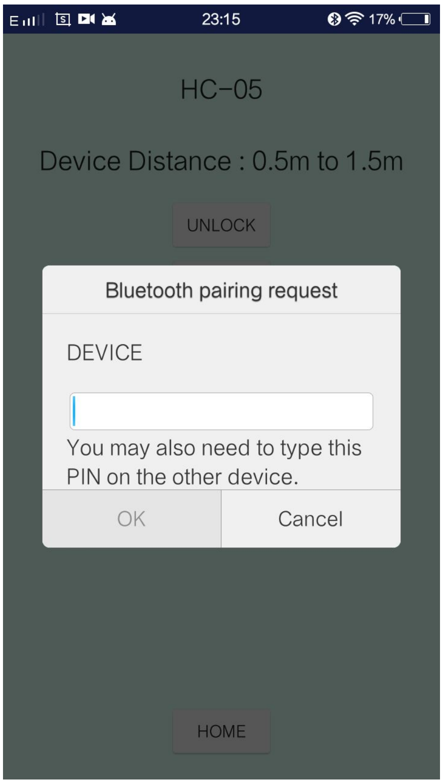


Search button: On press, searches for nearby bluetooth devices
Our device is HC-05



Application provides the user an option of setting threshold for safe distance

This completes the setup for a device. Now the app initiates authentication with the device.



Application asking for device BT PIN before proceeding

Authentication for connecting to device is handled by using existing Bluetooth authentication infrastructure. Bluetooth PIN is needed to communicate Lock/Unlock signals to the luggage.

Authentication :

1. We tried to connect to device with wrong password/ PIN
2. We tried connecting to device after unpairing it to check that PIN is asked again
3. We connected the de

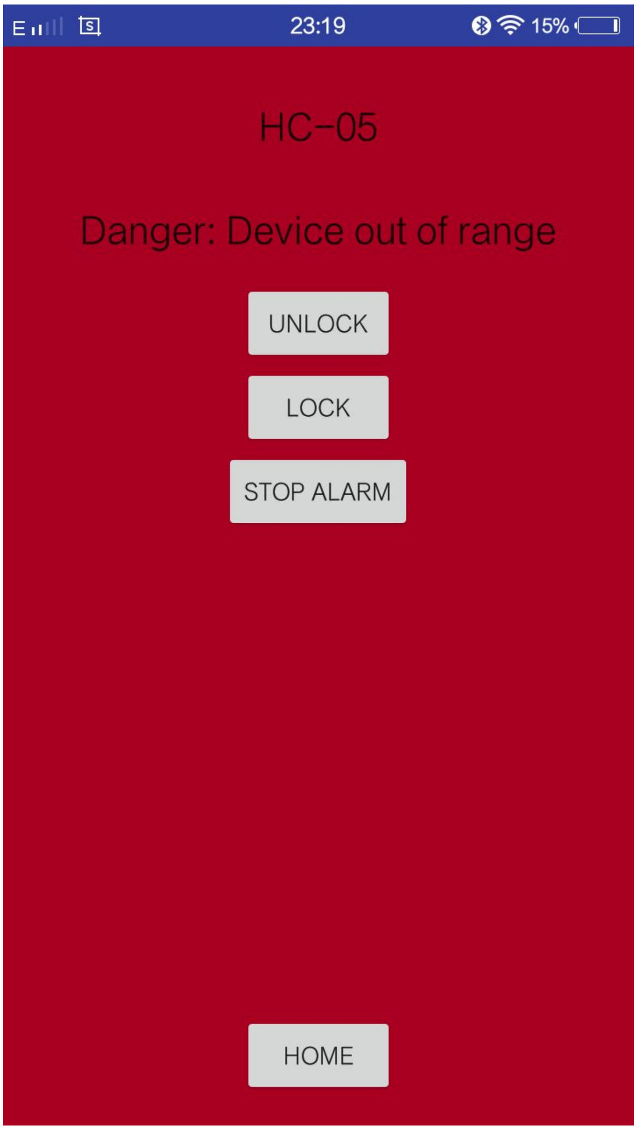
Succesful authentication takes us to the device control screen, with device name listed on top.

Device screen shows device distance which is updated in real-time
Provides option for setting the device in lock/unlock mode and for stopping failure Alarm

Device distance was obtained by experimentally observing RSSI signal strength values. A conservative map between the signal strenght and distance was then created.

Failures

1. Device out of safe radius set during the setup

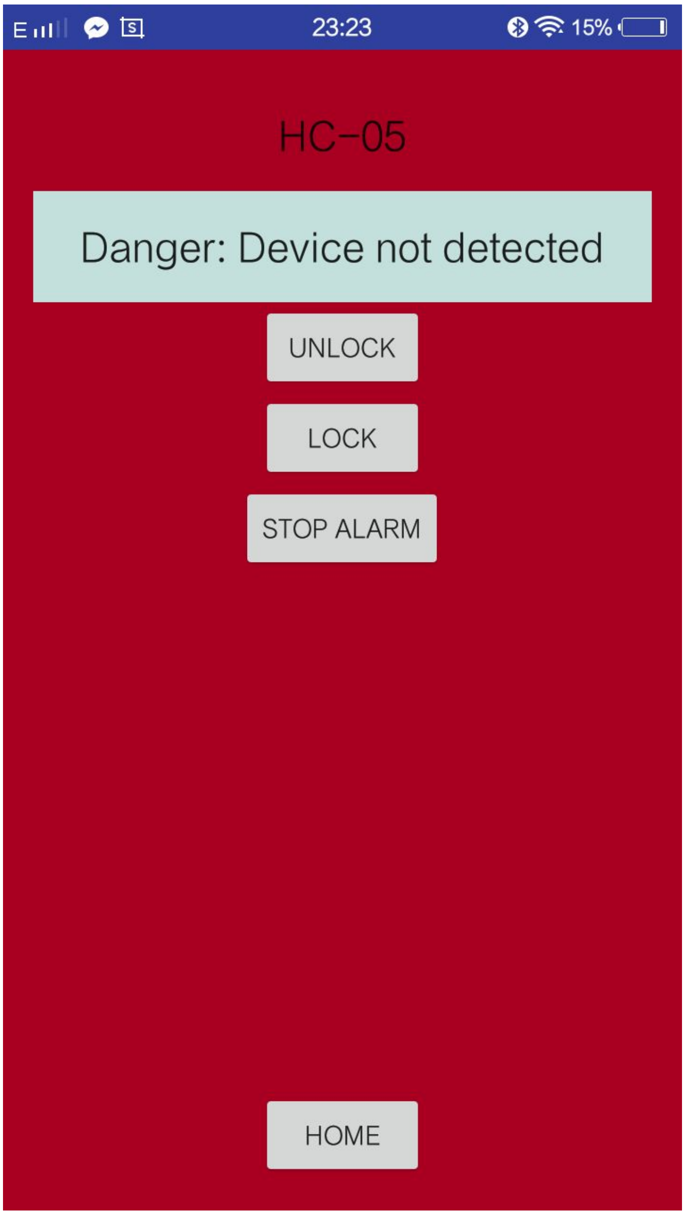


Device notifies user when device is out of range set by user

This feature was tested extensively by placing device in a box and carrying it out of range. Response time and distance accuracy were noted.

We also checked that proper reconnection took place when device came back inside the safe radius and that no status was lost.

2. Device not detected



Device notifies user when it cannot connect to device

We decide conservatively if device cannot be detected by setting a time period in which repeated Bluetooth discovery sessions are run. If a Locked device is not visible in any of them, we raise a failure Alarm.

This feature was tested by abruptly turning off the module when in Lock/Unlock mode. We also tried to turn on the device in the safe period to see if proper reconnection took place and no status was lost

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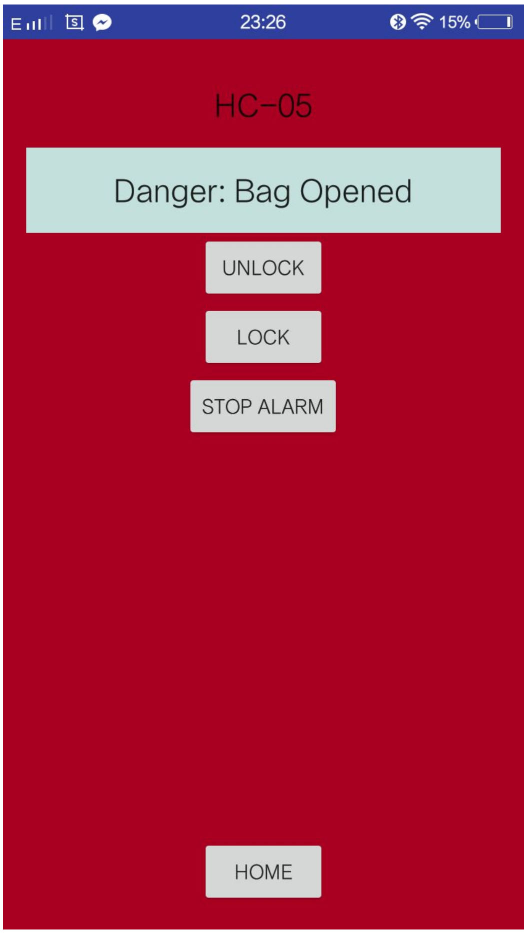
3. Luggage tampering

Device when the bag is almost closed from above, as can be seen by the white flap. IR sensor pointing upwards indicates that bag is closed. When the flap is raised, the IR sensor will register it.



Device also alarms user when bag is opened in Lock mode

We placed the deice inside a box and simulated tampering by opening and closing the box flap. We checked that appropriate signal was sent only in Lock mode but not in Unlock mode. We aslo checked that repeated signals were not sent until the bag is closed again.

6. Discussion of System

a) What all components of your project worked as per plan?

The device manages to fulfill all the requirements as laid out in the project plan.

1. Device distance : We are able to read bluetooth strength and estimate distance of device from client
2. Authentication : We can authenticate device bluetooth and transfer lock/unlock data to proper device
3. Luggage tampering : We are able to report flap movement using properly placed IR sensors inside the bag
4. Android Application : Created a user-friendly interface that can control client device bluetooth, transfer data to the embedded device and notify user in case of any failures

b) What we added more than discussed in SRS?

1. Distance smoothing : Bluetooth signal strength and IR sensor readings have a tendency to fluctuate. We employed smoothing using averaging for Bluetooth signals and debouncing for IR to avoid false positives.
2. Corner cases : Handled cases such as sudden power failure in embedded device tto ensure notification is sent in all situations which might possibly be dangerous

c) Changes made in plan from SRS:

1. Protocol for alternating periods of data transfer and signal strength capture. This was necessary as Bluetooth prevented simultaneous pairing and discovery
2. Device is permanently aware of status of the bag irrespective of whether it is in lock/unlock mode. The decision of whether an alarm should be raised is made at the client device. This provides us with more information about the device

7. Future Work

The Smart Luggage application works as a standalone product in the sense that it can be used to bind any Bluetooth device to itself. Features such as real-time display of approximate distance are not limited to the embedded system designed for Smart Luggage.

Some of the possible extensions to the project are as follows :

1. Extend the application to monitor multiple devices at the same time, and allow the client to lock/unlock each one independently
2. Extend the embedded system to force an alert message to any nearby devices with the Smart

Luggage application in case of an alarm raised. Thus if the bag is dragged out of the safe radius, people near it would be in a position to spot it
3. Attach a GPS/GPRS module to log the time and location in case of any alarm raised. It will also help to track the luggage over long distances
4. Data gathered about time and location thefts as discussed above, can be used to make customers vigilant when they enter a suspicious area

8. Conclusions

The Smart Luggage system as designed by us manages to fulfill all the requirements laid out in the project plan. Furthermore, it has evolved into a power-efficient, compact and relatively cheap product which is not attached to the luggage it is tracking. The issues we have faced are primarily related to the slightly buggy nature of Bluetooth communication, but we have migitated them using smoothing and debouncing. Thus, the test results are very encouraging.

The device has widespread use as there is no restriction on the size, form or type of luggage with which it can be used. Furthermore, the App is a standalone product which can connect to, and bind, any Bluetooth device.

There is aslo scope for a variety of additional features such as GPS/GPRS tracking, data analysis etc. as described in the section on Future Work.

9. References

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https://e2e.ti.com/support/microcontrollers/tiva_arm/