CHILD TRACKER FOR AMUSEMENT PARKS

Team 13 — Rohan Khanna, Pooja Kankani and Cherian K Cherian

ECE 445 Project Proposal —Spring 2020

TA: Johan Mufata

Table of Contents

1 Introduction

1.1 Objective

Amusement parks are popular destinations for family vacations. It is a dream for children to interact with their favorite characters at Disney and go on some thrilling rides at Universal. However, this magical experience can turn into a nightmare for parents if their child goes missing. Teachers that take their students on a school trip can also have a tough time keeping the group together and it is a very traumatic experience when a child goes missing. With summer season bringing in bigger crowds to the world-famous disney park, the numbers of lost children can climb into the hundreds, Disney officials say [1].For commercialized parks such as Disney World, an average of 11 children go missing each day. The average time they spend missing from their family is around 30 minutes.The situation is much worse for less established theme parks. [2]. Blogger Leslie Harvey states in her blog on safety in amusement parks that " I remember losing sight of my 5 year old daughter in Disneyland for maybe 90 seconds, but it felt like an eternity"[3]. There are many unreported cases worldover and the anxiety on the parent and child is unimaginable

We propose to solve this problem using a combination of bluetooth equipped wearable bands for the parent and the child, and certain low cost bluetooth signal receiver nodes and WiFi transmitter nodes placed throughout the amusement parks. The wearable band will be worn by both the child and the parent on the hand. The band on the child acts as a beacon and transmits signals to the parent band over bluetooth, as a way of telling the parent that the child is close by and connected. When the child band is in a certain predetermined range of the parent band, both bands will glow green. When the child band goes out of that range, both bands begin to vibrate and glow red in color so as to alert people that the child is missing. Finally, as soon as the child band loses connection with the parent band over bluetooth (due to its limited range), it will start sending out signals to the bluetooth receiver nodes which will be placed at park help desks throughout the park. These receiver nodes will be placed at predetermined locations and will calculate a rough distance to the child using the bluetooth signal strength of the child's wearable. They will then send this location over WiFi transmitters to a software application on the parents phone and alert the parents of the child's approximate location. A red LED on the receiver node will automatically alert the staff that there is a child missing. The child wearable will have a metal belt that can only be opened by an "unlock" button on the parent's phone. This is done to ensure that the child band is not misplaced or removed forcibly.

1.2 Background

Currently, the way most amusement parks aim to solve this problem is by creating a designated lost and found zone where the park officials can drop missing children off to. Although, in large and established theme parks like DisneyLand this prevents the loss of children, there is no guarantee that the parent and the child can be reunited in a certain amount of time. This can be a traumatic experience for the child as at times it may take hours before he/she is reunited with his/her parents or guardians. In less established parks, there is a threat of kidnapping. In HersheyPark, for example, a woman trying to manage a group of five kids filed a report of abduction of one of the kids.[4] Those 30-60 minutes of staying away from each other and potentially never being reunited can be a devastating experience for a family as a whole on what should be a dreamlike experience at a theme park.

Finally, some existing solutions consist of smart wearable with gps installed inside of them. These wearables firstly are extremely expensive and consume a lot of power because of overkill features such as a wearable and gps. Also gps does not work well indoors and in parking lots which are common places to lose children in parks. Finally there is no holistic system that connects together the three entities of the problem : the child, the parent and the staff who care about the safety of the children. Through our proposed solution, all three are actively informed about the location of the child and act actively to ensure the safety of the child.

1.3 High-Level Requirements

- Both child and parent wearables should glow green when they are connected and glow red when they get disconnected

- When disconnected from the parent wearable, The child wearable should be able to send parent id to the receiver nodes indication that it has been disconnected

- The receiver node should send the approximate location coordinates of the child to the parents phone.

2 Design

2.1 Block Diagram

Our Block diagram is split up into 2 parts, the first is of the wearable device and the second for the receiver/transmitter box. The wearable contains 3 parts : The control unit, which is where the decision making is made through the use of the microcontroller and bluetooth. Based on the connections made from the bluetooth, the microcontroller communicates with the other 2 subsystems. The LEDs are used to indicate whether the child is in proximity to the parent. If the Bluetooth is disconnected from the other wearable, it lights up red. If it is connected it is green. The lock subsystem ensures that the wearable cannot be removed by any random person. It receives information from the microcontroller on when to lock or unlock.

The second part of our block diagram is the Receiver/Transmitter box. This has the control unit which contains the microcontroller, bluetooth chip(Receiver) and WIFI chip(Transmitter). The bluetooth chip receives signals from the wearable and passes this on to the microcontroller. The microcontroller approximates the distance and uses the wifi chip to send the location to the parents app.

We also have a software app which interacts with the wearable through Bluetooth for locking and unlocking. It receives location info from the receiver through wifi.

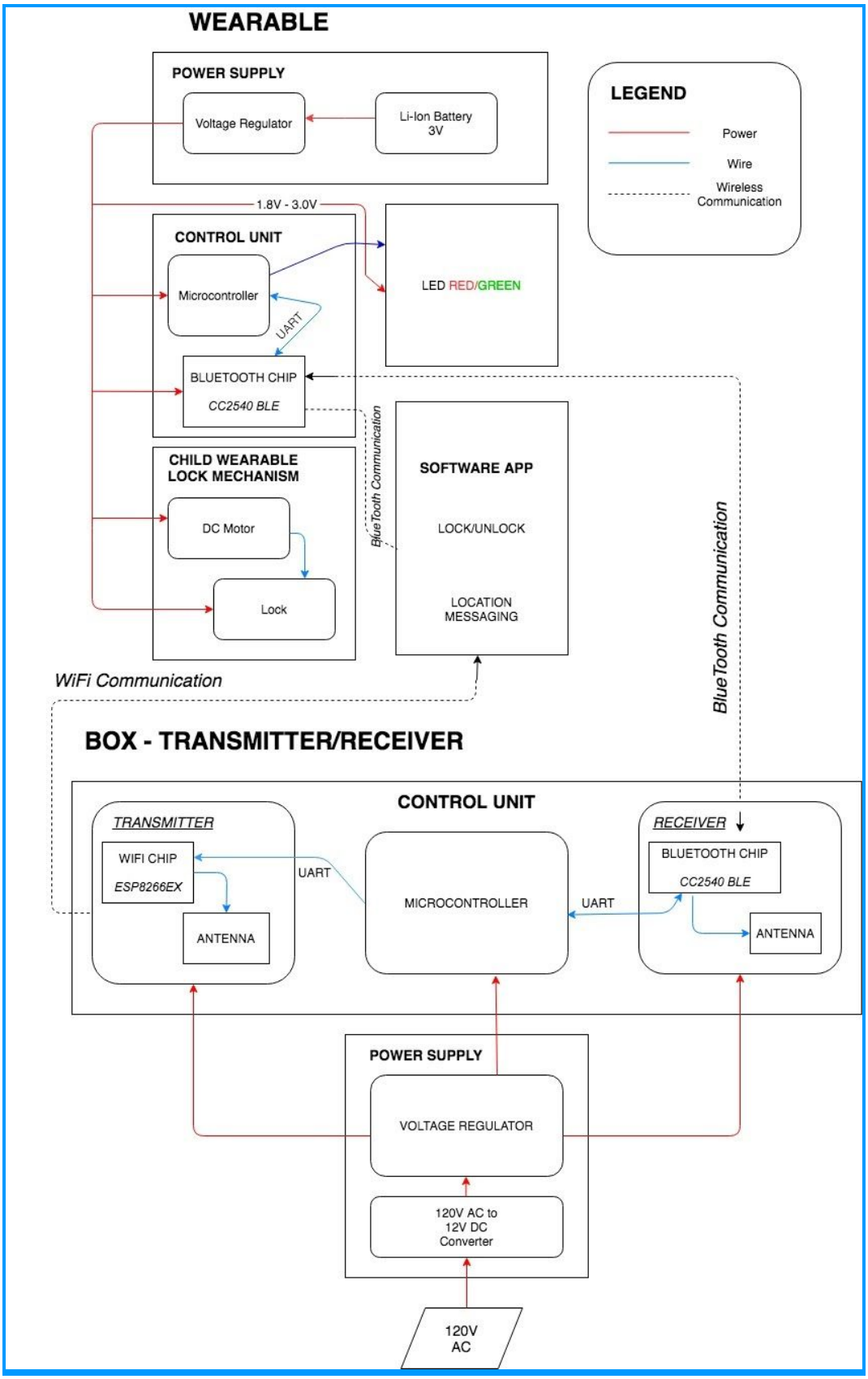
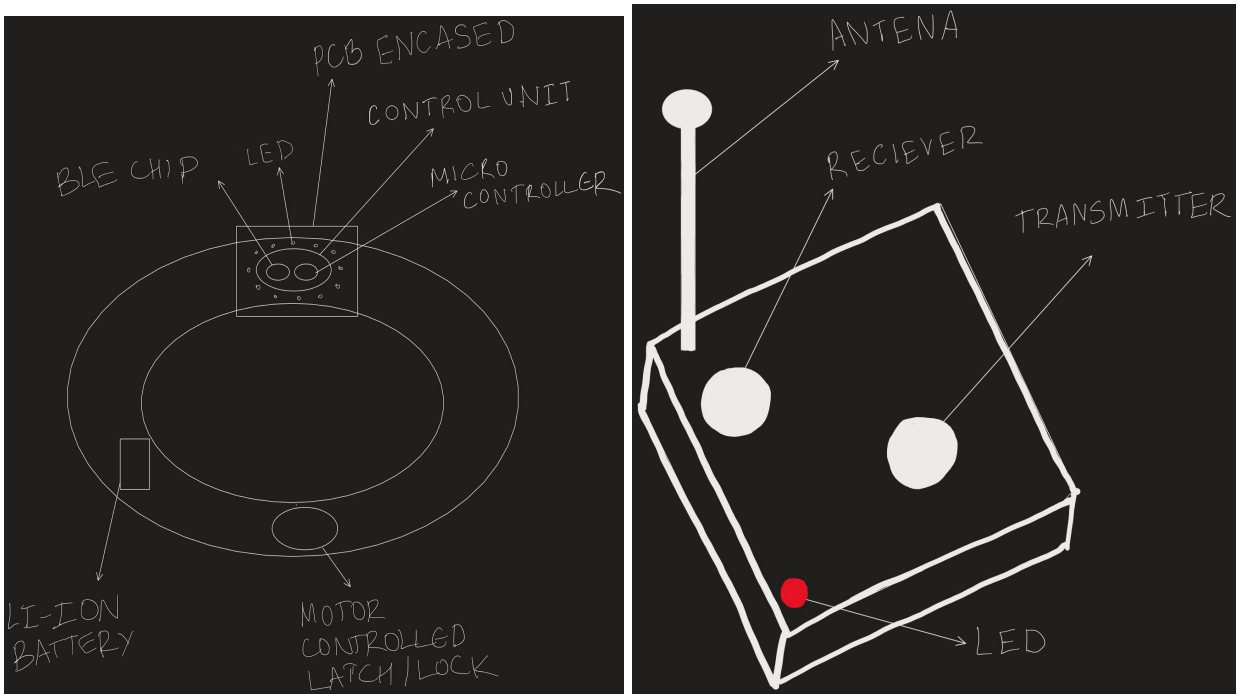


Figure 1. Block Diagram

2.2 Physical Diagram



We choose a wearable band because this is a design choice adapted by theme parks such as disney (Ex: disney band which is used for virtual lines, as a key etc). So our design could, in the future, be integrated into these devices or our device could be extended to perform more features through the software app. Hence, to keep scope for future developments and features, we choose a wearable band design.

The box is designed to be as small as possible for easy installment all over the park. An antenna is used to ensure the bluetooth beacon signals can be received from as far as possible. An LED is placed to alert park officials when the beacon has received a signal from a child wearable.

Figure 2. Physical Diagram of Wearable

2.3 Function Overview and Block Requirements

1) Wearable

I. Power Supply

The power supply will be provided through rechargeable batteries and is used to power the different components/subsystems required for the wearable

a) Battery

Specifications: VL-2330/F3N lithium coin cell 3V battery

A rechargeable Lithium ion 3V coin battery due to relatively lower power consumption by the wearable that provides the power for the wearable

Requirement 1: Last for at least a year without having to be recharged
Requirement 2: Be able to power all the other components on the wearable

b) Voltage Regulator
Is used to convert the 3V power supply from the battery to the requirements of the LED's, Bluetooth and SOS button.

Requirement 1: Be able to provide 1.8V - 3V for LED
Requirement 2: Be able to provide 3V for the rest of the chips

II. Control Unit

Will be used to detect connection between parent and child wearables, light up appropriate LED's based on connection, receive Lock/Unlock commands from Software App, and activate the lock mechanism on the child's wearable based on the App command.

a) Microcontroller
Specification : low power MCU or ARM cortex, 32K flash, upto 24 MHZ speed

Requirement 1: Receive signals using bluetooth, and send signals to the LEDs and motor appropriately

b) Bluetooth Chip
Specification: CC2540 Bluetooth Low Energy Chip

A CC2540 Bluetooth Low Energy Chip will be used for 1) Connections between parent and child wearables which indicated they are close 2) Connection to the parents phone for a child wearable to be used for unlocking the child wearable 3) Sending signals to receivers for child wearables when they are disconnected from the parents wearables

Requirement 1: Should be able to establish a connection to the parent wearable when within a predetermined distance
Requirement 2: (Child Wearable) Should be able to connect to parents phone when in range so that it can unlock the child wearable from the app.
Requirement 3: (Child Wearable) Should have the capability to send out signals using the beacon protocol to receivers with help from the microcontroller

III. LED

A 2V green and a red LED will be attached to the wearable to signal child proximity from parent, green for within range, red for outside range.

Requirement 1: Light green LED to signal the child is within range of the parent(Connected to parents wearable)
Requirement 2: Light red LED to signal the child is outside specified range(Disconnected from parents wearable)

IV. Child Wearable Lock Mechanism

A locking mechanism for the wearable so that it can only be removed from the software app and not by anyone. This will be activated using the software app when the child is in range with the parents phone

a) DC Motor
A small motor that can open and close the metal band around the child wearable based on signals from the microcontroller

b) Metal bands
To be wrapped around the child's wrist as part of the wearable which locks and unlocks based on signals

Requirement 1: Securely placed around child's arm and cannot be removed by force
Requirement 2: Unlocks the child band on the "unlock" signal from the parent's app

V. Software App

A software app on the parents phone that will be linked to the wearable of a child. The app can be used for 1) Locking and unlocking the wearable to which it is linked. This will be done through Bluetooth. 2) Receive messages about the location of the child's wearable when it is not in range to be connected to the parent bluetooth. These messages will be sent from the receivers that find the child wearable signal and will contain links to google maps with the coordinated fitted in.

Requirement 1: Should be able to send the signal to child wearable through bluetooth for locking and unlocking the wearable when in range
Requirement 2: Be able to receive messages from the receivers with location of child wearable when the child and parent wearable are not connected

2) Receiver/Transmitter Box

I. Power Supply

The power to the transmitter/receiver unit will be supplied through a plug outlet to supply 120V AC.

a) AC to DC Converter:
Used to convert the 120V AC power supply to 12V DC

b) Voltage regulator:
Used to convert the 12V supply to what is needed for the various subsystems

Requirement 1: Supply necessary power to the microcontroller, receiver and transmitter modules

II. Control Unit

Used to determine the approximate location of a child using info from the bluetooth signal and current predetermined location of the box. This information is sent to the transmitter along with the parent phone to whom the location should be sent

a) Microcontroller
Specification: Arduino

The bluetooth info received is used to approximate the child's location using the known location of the box. This is then sent to the parents phone through wifi.

Requirement 1: Transfer parent and child id from receiver to transmitter
Requirement 2: Calculate child's distance using Relative Signal Strength Indicator (RSSI) with the receiver

b) Receiver - Bluetooth
Specification: CC2540 Bluetooth Low Energy Chip

Used to receive signals from any child wearable that is sending them out through the beacon protocol. Sends info to microcontroller when it receives these

A CC2540 Bluetooth Low Energy Chip will be used to receive signals from the wearable device. When it receives the signal from a wearable, with the child's id and associated parent phone number, the information will be passed on to the WiFi module.

Requirement 1: Receive signals along with parent id from child wearable and pass that information to transmitter through the microcontroller

c) Transmitter - WiFi
Specification: ESP8266EX (Tiny Wireless 802.11 B/G/N WiFi chip)

Used to transmit location of child to the parent phone that it is linked to

An ESP8266EX (Tiny Wireless 802.11 B/G/N WiFi chip) will be used for WiFi capabilities. The WiFi chip will be used to communicate with the app on the parent's phone to transmit the location

Requirement 1: Use relative signal strength (along with microcontroller) to determine distance of child and send those coordinates to the parent's app over WiFi

2.4 Risk Analysis

Networking knowledge is an essential component to the success of this project. Unfortunately no one in the team has taken a class or had experience working with network protocols. The Team has at best a basic understanding of the bluetooth technology and how exactly it is going to operate in a dynamic and outdoor environment such as a theme park. We will need to be on top of our work at all times and put in extra effort to self study many aspects of networking. In addition, we must wisely use the help of the course staff personnel that have had experience in networking.

Secondly, Significant Noise in the environment can create havoc for this project. Some bluetooth transmitters have a clean air range of 100m but in extremely noisy environments this can come down to as low as 10m. Hence, this can cause a weak bluetooth signal between the child's wearable to the parents wearable leading to lots of false positives. Moreover, if the child is far away from the parent the noise could prevent its signal reaching the receiver nodes and hence fail to alert the parents of the location of the child. To prevent the false positives we could have some retry protocols in place in the childs wearable that try to establish a connection with the parents wearable a few times before turning red. In case of extremely noisy environments we could potentially need to integrate an amplifier into the circuit design of the wearable. Another potential way to mitigate the effects of a noisy environment may be to ensure that the antenna position in the pcb design for the receiver of the receiver nodes is away from components that may cause interference such as metal.

Finally, all team members are majoring in computer engineering. We have minimal experience in core electrical engineering concepts and that could hamper our progress. Understanding power systems, circuit design and many other hardware concepts would be challenging in the short span and could pose a risk to the project.

2.5 Extension Goals

1. Ability to send messages from child to parent and vice versa using the wearable. A lot of kids don't have phones, so messaging through the wearable would help with staying in touch with each other in large parks.
2. Having a walkie-talkie feature using the *SA818 Walkie talkie module with RDA1846S chip* which has a 5km range and can be used for communication since people usually do not like

carrying around their phones in amusement parks, especially water parks. Also, in most rides they ask you to remove phones.

3. Adding more features like the Virtual Queue system to skip long wait lines at parks, having a LCD screen to integrate google maps on it and payments through the wearable

3 Safety and Ethics

There could be quite a few potential safety and ethical issues with a wearable device, such as ours. The wearable will be worn directly on the hand by both a parent and a child, and will contain a lot of electrical components (LEDs, senors, chips, microcontroller and power supply) being powered by Li-ion coin cell batteries. This exposes the human wearing it to being exposed to electrical current shocks, and pose a serious threat to their life. To ensure safety, we will guarantee to make sure that the electrical current flowing through the wearable is within a certain range that a human body is not affected by. We will also have a failure detection method to cut off current supply if any issues in the circuit are detected. The Li-ion batteries are also dangerous because they could explode on the user's hand due to reasons like overcharging and overheating. While working on the project, we will adhere to the specifications of the manufacturer for storing and using the batteries. For the user's safety, the employees at the amusement park will be trained and instructed on the correct procedure for charging these batteries, and minimizing the risk [5]. Following the IEEE Code of Ethics, #3, we will be honest and transparent to the user about the potential risks, and realistic about our data and estimations that we share [6].

Our project helps tracking children, using wearables on the child and the parent, but the child wearable can be removed, as a mistake by the child, or intentionally by a stranger, and give the parent false information about the location of the child. In the same way, it could be misused by someone to take the child away from the park. To prevent this from happening, our project will have a metal belt around the child wearable that will be controlled by a motor, and can only be removed by pressing the "unlock" button on the parent phone. This feature of our project makes sure that the child wearable cannot be fidgeted with or misplaced, and can only be removed under parent supervision.

Through the transmitters and receivers placed at various locations throughout the park to track a child's location, we will be sending approximate child coordinates to the parent all across the park. All this data transferring has to be secure, so that the child's location cannot be read by a third person and used for the wrong reasons. The child coordinates should only be available to the parent, and the help desk staff, but should not be hacked into by anyone else. To ensure this, we will have to make our data transferring robust and secure.

According to IEEE Code of Ethics, #1, we will keep the health, welfare and safety of the public as paramount, while designing and developing our project [6]. As we are not storing any user health information on the wearable or the application, we do not have any concerns with rules for wearables stated in HIPAA, the Health Insurance Portability and Accountability Act [7]. All the features we implement in our project will be designed to help humans and the environment and keep them safe.

4 References

[1] Los angeles times [Online] Available: https://www.latimes.com/archives/la-xpm-1994-06-12-mn-3422-story.html [Accessed: 02/12/2020]

[2]Trackimo [Online] Available: https://trackimo.com/list-common-places-kids-get-lost/ [Accessed: 02/13/2020]

[3]Harvey, L. (2019, April 5). Tips for Keeping Your Family Safe at a Theme Park. Retrieved February 13, 2020, from https://thepointsguy.com/guide/theme-park-safety/ [Accessed: 02/13/2020]

[4] Griffaton, G. (2019, July 8). 'Unacceptable': Parent frustrated with how Hersheypark handled report of attempted child abduction. Retrieved February 13, 2020, from https://www.fox43.com/article/news/local/contests/unacceptable-parent-frustrated-with-how-hersheypark-handled-report-of-attempted-child-abduction/521-32e3d76a-ab6d-4f55-a011-be42b6176606 [Accessed: 02/13/2020]

[5]GenRe Publications [Online] Available: http://www.genre.com/knowledge/publications/pmint1709-1-en.html [Accessed: 02/12/2020]

[6] Institute of Electrical and Electronics Engineers, 'IEEE Code of Ethics', 2020. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 02/12/2020].

[7] HealthItSecurity [Online] Available: https://healthitsecurity.com/news/how-does-hipaa-apply-to-wearable-health-technology [Accessed: 02/12/2020]