CHILD TRACKER FOR AMUSEMENT PARKS

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1 Introduction

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.

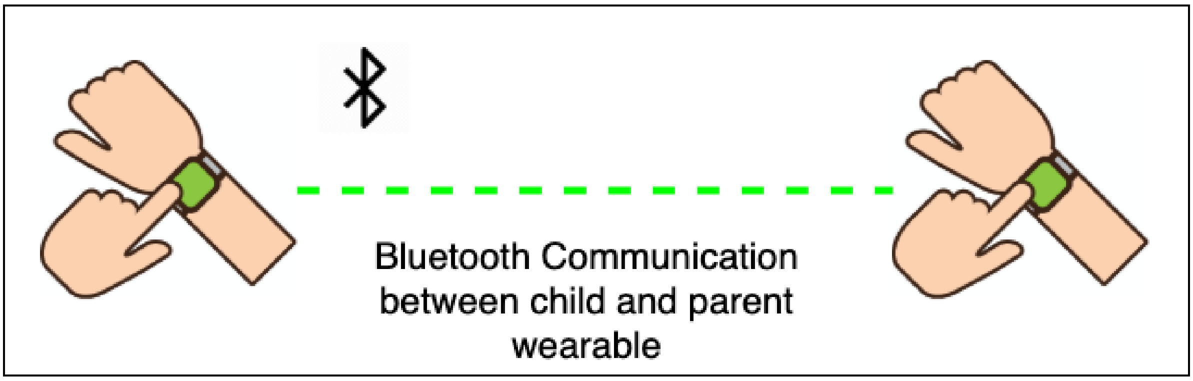
Background

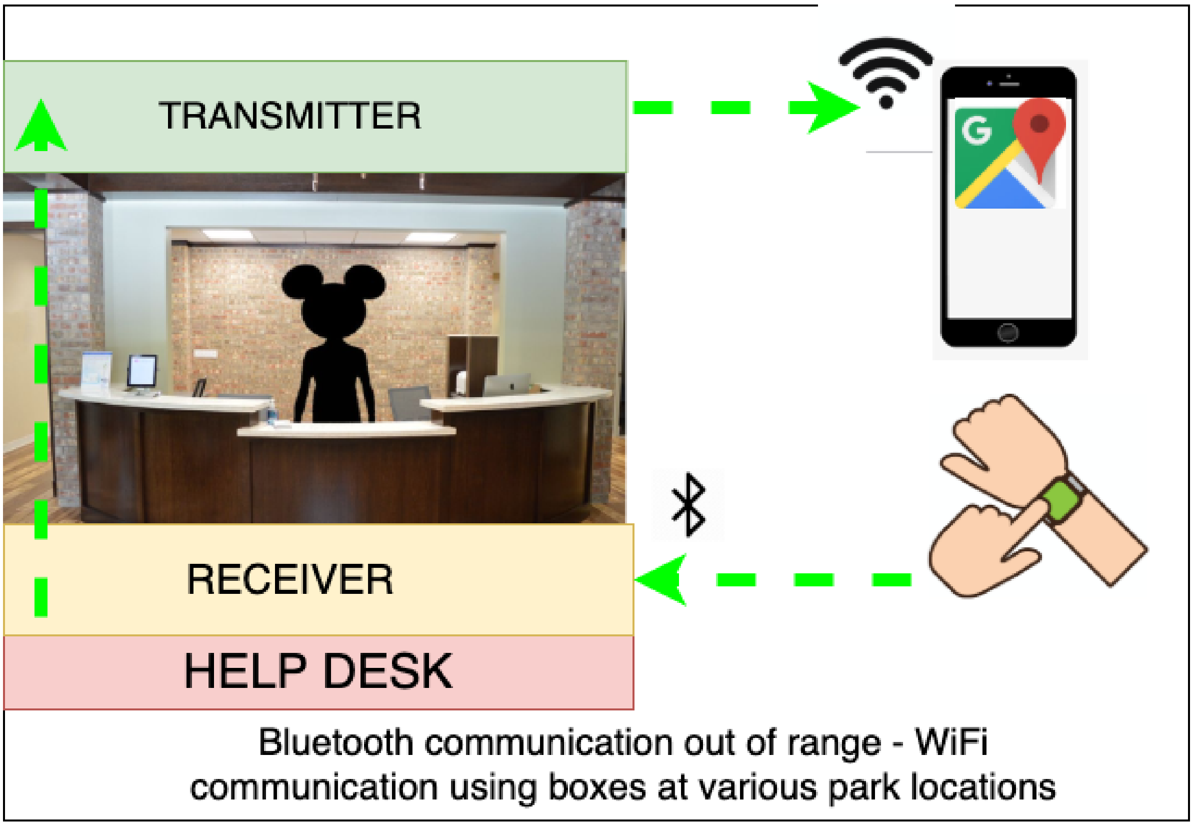
Currently, the way most amusement parks aim to solve this problem is by creating a designated lost and found zone where the park officials can drop missing children off to. Although, in large and established theme parks like DisneyLand this prevents the loss of children, there is no guarantee that the 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.

Visual Aid

This picture represents the two stages of communication between the child and parent. The first stages uses the bluetooth on the wearable devices to establish connection and keep the parent aware that the child is in range through a green LED. Once that connection is lost, the second stage uses the transmitters and receivers placed throughout the park to send the approximate child locations to the parent. This uses the child wearable's bluetooth to send information to the receiver and then the receiver sends that information to the transmitter. The transmitter uses WiFi to send those coordinates to the application on the parent's phone.





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 indicating that it has been disconnected
- The receiver node receiving the child's signal sends its approximate distance from the child to the parent.

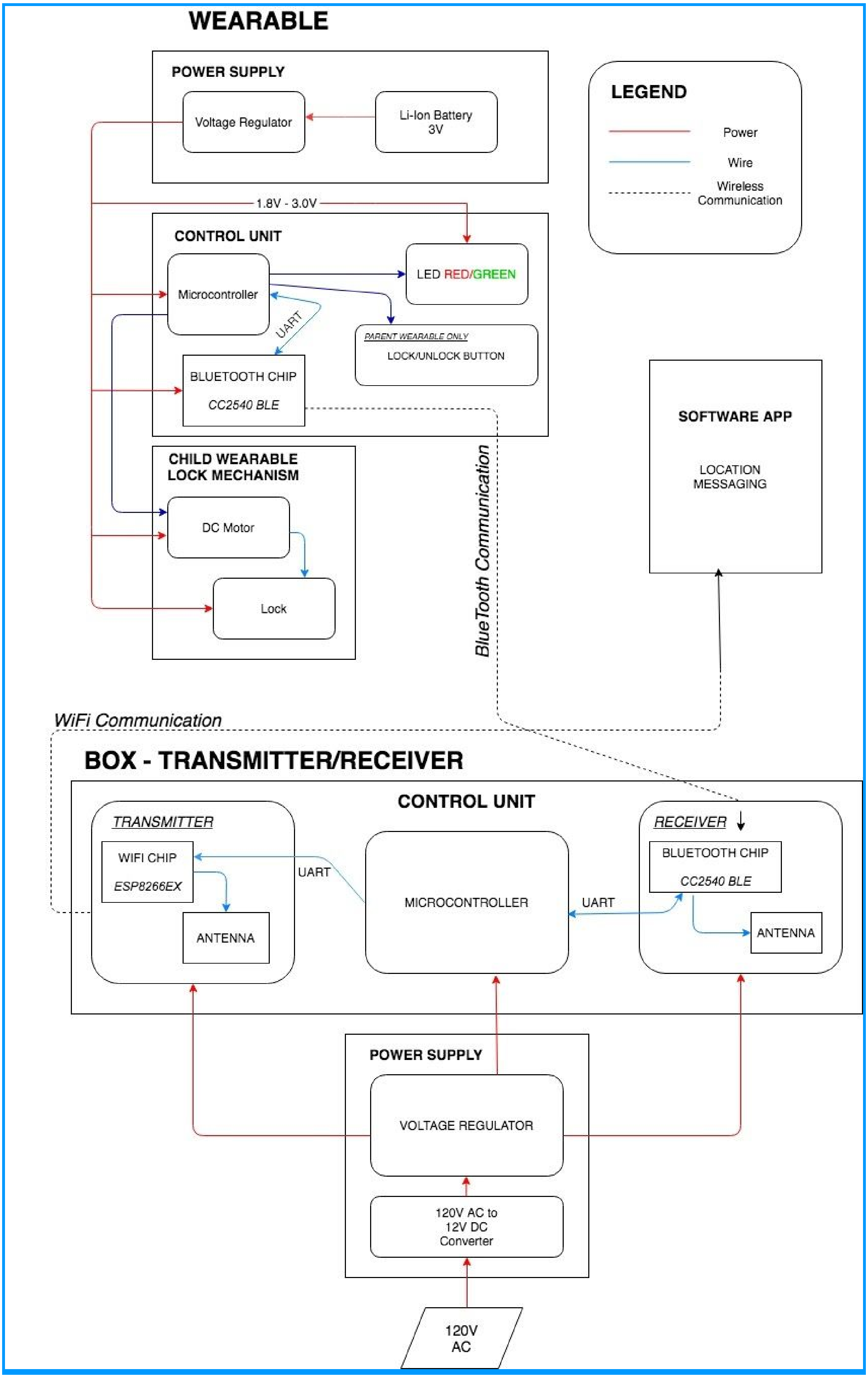
2 Design

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.


WEARABLE
POWER SUPPLY
Voltage Regulator
Li-Ion Battery
3V
LEGEND
Power
Wire
Wireless
Communication
1.8V - 3.0V
CONTROL UNIT
LED RED/GREEN
Microcontroller
UART
PARENT WEARABLE ONLY
LOCK/UNLOCK BUTTON
BLUETOOTH CHIP
CC2540 BLE
SOFTWARE APP
LOCATION
MESSAGING
CHILD WEARABLE
LOCK MECHANISM
DC Motor
Lock
BlueTooth Communication
WiFi Communication
BOX - TRANSMITTER/RECEIVER
CONTROL UNIT
TRANSMITTER
WIFI CHIP
ESP8266EX
ANTENNA
UART
MICROCONTROLLER
UART
RECEIVER
BLUETOOTH CHIP
CC2540 BLE
ANTENNA
POWER SUPPLY
VOLTAGE REGULATOR
120V AC to
12V DC
Converter
120V
AC

Physical Diagram

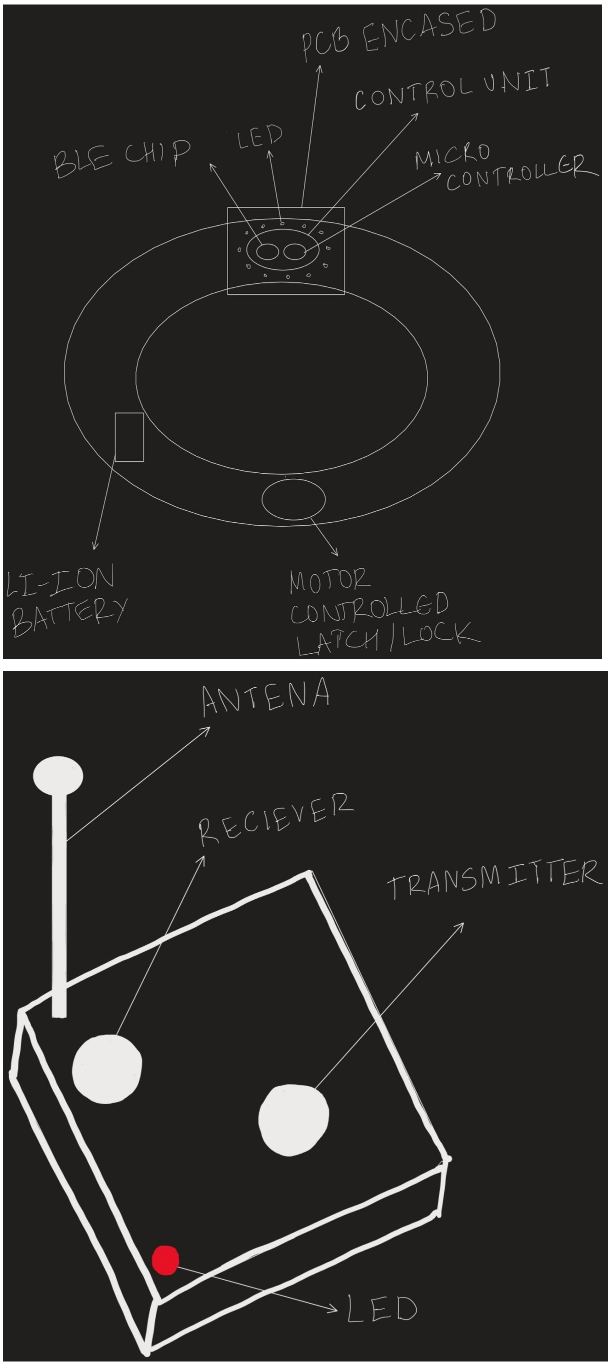


Figure 2. Physical Diagram of Wearable

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.

Function Overview and Block Requirements

2.2.1 Microcontroller for wearable

The microcontroller, a low power MCU or ARM cortex, 32K flash, upto 24 MHZ speed.
This was chosen for its small size which we want so that it can fit on a watch and also for its bluetooth connectivity. It communicates with the bluetooth chip through UART to verify that the connection between wearables is set. If it is not, it signals the bluetooth chip to start the beacon protocol. It is also responsible for storing info about the parents phone to ensure that the receiver knows which phone to send the child wearable location to.
Current microcontroller chosen:

Requirement	Verification
1. Send signal to light LED to green if bluetooth connection with other wearable is maintained and turn LED red if connection is broken 2. Send opening signal to motor if an unlock signal is sent from parent wearable.	1 a) The RX port of the antenna equipped bluetooth chip of the slave wearable module is connected to the TX port of the microcontroller and the RX port of the microcontroller is connected to the TX port of the bluetooth chip. b) using the connection above the bluetooth chip communicates serially to the microcontroller (1 if paired with master and 0 if disconnected from master). If the value is 1, the LED should light up green. If the value is 0. Put a wait time of 5s and recheck the value. If the value is still 0. the LED should light up as red. 2 a) When the button is pressed on the parent wearable, the data is sent through the established bluetooth channel between the parent and child wearable. The child bluetooth module and the microcontroller are connected via UART communication as described in 1 a). b) using a suitable USB bridge the microcontroller is connected to the PC. Set the baud rate to the default baud rate on the datasheet of the microcontroller.

	c) When the button is pressed on the parent watch verify that the signal 1 is received at the pc from the microcontroller. d) Finally, the microcontroller communicates transmits the high signal to the motor which shifts the position of the latch.

2.2.2 Bluetooth Chip for wearable

A Nrf51822 (beacon capable) Bluetooth Low Energy Chip which was chosen for its low energy consumption and fairly good range. It is used for connecting to another wearable, or send out beacon signals when disconnected. It will be alerted to send out the beacon signals by the microcontroller. The bluetooth connection will also be used to lock or unlock the child wearable from the parent phone app.

Requirement	Verification
1. Once the pairing of the child breaks with the parent wearable, the child wearable should start following beacon protocol	

2) Receiver/Transmitter Box

2.2.1 Microcontroller

AtMega48A will be used to handle the communication between the two chips. The microcontroller communicates with both the bluetooth and the WiFi chips through UART. The bluetooth chip receives the signal from the child wearable and the phone to communicate with. This info is passed to the microcontroller which attempts to locate the child using relative signal strength and passes this information to the Wifi Chip.

Requirement	Verification
1. Calculate child's approximate location using Relative Signal Strength Indicator (RSSI) from the bluetooth receiver 2. Transfer information from the bluetooth receiver to the wifi receiver	

Tolerance Analysis: Through discussions with your TA, identify the block or interface critical to the success of your project that poses the most challenging requirement. Analyze it mathematically and show that it can be feasibly implemented and meet its requirements. See the Tolerance Analysis guide for further guidance.

The most fundamental part of our project is the interface between the child wearable and the receiver nodes stationed at staffed locations in the park as this component is used to get the approximate distance of the child from the receiver node.

Depending on the how accurate we require this distance to be and the datasheet of the bluetooth chip [4] there are three requirements for the chip:

1. It should have a clear line of sight range of at least 100m with tolerance of x %
2.
3.

There are three scenarios in which the bluetooth chip can be called upon:

1. In case that the end user only cares about an approximate range of the child's location say within a 10 m radius of a receiver node, then the receiver node could operate in low power mode and listen to signals only within 10 m range. For any child wearable signal it receives below within 10m range its sends its location plus a radius of 10 m as the child's location to the parent. The bluetooth chip chosen would have a line of sight range of 100m with tolerance of x% and hence even in very noisy environments should easily be able to send across a 10m radius.
2. For greater accuracy, The RSSI can be used to compute the exact distance with tolerance +- (error rate for the formula) using the formula :
   Distance = 10^((Measured Power -RSSI)/10*N)) where N (Constant depends on the Environmental factor).

   Based on the distance calculated the child is within a circle of radius Distance with the receiver node at the center. Hence the maximum error in the exact location of the child is 2*Distance.

3. (Theoretical). Since the sensors are capable of monitoring upto 100m in sight. If there is overlap between the range of the two receiver nodes and the child is in the overlap region,then the maximum error in the exact location of the child is area of the region of overlap.

Distance = 10 ^ ((Measured Power – RSSI)/(10 * N))

N (Constant depends on the Environmental factor. Range 2-4)

Schedule:

Week no. (days)	**Pooja**	**Rohan**	**Cherian**
1 (02/24 - 03/02)	Design Doc - requirements and tolerance analysis Speak with machine shop to finalize parts	Design Doc - Verification, Tolerance analysis Speak with machine shop to finalize parts	Design Doc - subsystem description, tolerance analysis Speak with machine shop to finalize parts
2 (03/02 - 03/09)	**Beacon protocol**	**PCB design**	**Bluetooth**

			communication between wearables
3 (03/09 - 03/16)			
4 (03/23 - 03/30)			
5 (03/30 - 04/06)			
6 (04/06 - 04/13)			
7 (04/13 - 04/20)			
8 (04/20 - 04/27)			
9 (04/27 - 05/02)			

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.

Citations:

Any material obtained from websites, books, journal articles, or other sources not originally generated by the project team **must be appropriately attributed with properly cited sources** in a standardized style such as IEEE, ACM, APA, or MLA.