CHILD TRACKER FOR AMUSEMENT PARKS

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

ECE 445 Design Document —Spring 2020

Prof: Joohyung Kim

TA: Johan Mufuta

Table of Contents

1. Introduction ……………………………………………………………………………………….. 1

    1.1 Objective……………………………………………………………………………...1

    1.2 Background………………………………………………………………………..….1

    1.3 Visual Aid……………………………………………………………………………..2

    1.4 High-level Requirements List………………………………………………………....3

2. Design………………………………………………………………………………………….4

    2.1 Block Diagram………………………………………………………………………...4

    2.2 Physical Diagram……………………………………………………………………...6

    2.3 Function Overview and Block Requirements……………………………...………...6

    2.4 Flowchart of project workflow…………………………………………..……………16

    2.5 Risk Analysis…………………………………………………………...………....16

3. Tolerance Analysis…………………………………………………………………..……..18

4. Cost Analysis……………………………………………………………..…………...23

5. Schedule…………………………………………………………………….………………..25

6. Ethics and Safety……………………………………………………………….…………27

7. References……………………………………………………………....……………...28

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 worldwide and the anxiety on the parent and the child is unimaginable.

We propose to solve this problem using a combination of bluetooth equipped wearable bands for the parent and the child, and using existing wifi access points in the theme park. 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. The parent has the ability to choose a maximum distance between 10m to 50m within which the two wearables are connected and glow green indicating that the child is within the range of the parent. When the child band goes out of that range, both bands glow red in color so as to alert people that the child is missing. In addition to this, the child wearable scans for nearby wifi access points around the park. The location of these access points is fixed and can be stored in a database. The child wearable communicates its signal strength reading with the server which then looks up the SSID of the wifi access points to determine their location and using the signal strength calculates the distance of the child to the access point. The server then sends the approximate location of the child to the parent.

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.

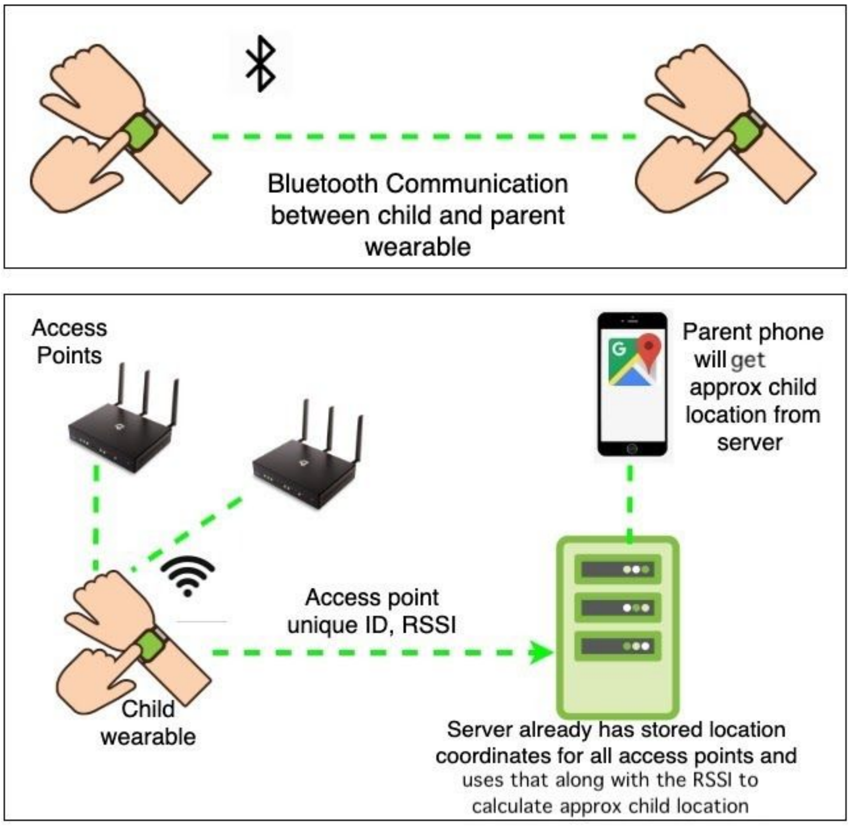
Finally, some existing solutions consist of smart wearable with gps installed inside of them. These wearables firstly are extremely expensive and consume a lot of power because of overkill features such as a wearable and gps. Also gps does not work well indoors and in parking lots which are common places 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.

The Wifi infrastructure is already provided by most theme parks and hence can be readily used for the purpose of this project.

1.3 Visual Aid

This picture represents the two stages of communication between the child and parent. The first stage uses the bluetooth on the wearable devices to establish connection and keep the parent aware that the child is in range(predetermined, which can be set when entering the park) through a green LED.

Once the child is out of range or the connection is lost, the second stage uses the access points (APs) existing throughout the amusement park. The LEDs turn red on both parent and child wearable, thus signalling to the parent that the child is out of range, and to the park agents and security, that the child is lost. The child wearable has a WiFi chip that scans for all close by access points and determines the RSSI (Relative Signal Strength Indicator) from each. This information is then passed to a server that already has the access points location precomputed and stored beforehand. Using the access point location and the signal strength per access point, the server triangulates an area in which the child is present. This information is then used by the parent to know where their child is.



Once connection between child and parent is broken, the child wearable sends information of close access points to a server along with the signal strength for each

Figure 1. Visual Aid of Project Design

1.4 High-Level Requirements

- The wearable should glow green when the child is in the range of 10 to 50m which can be programmed by the parent. If the child is outside this range, the wearable should glow red.

- The wearable must be able to do a wifi scan for nearby access points, establish a connection to the internet and transfer RSSI values to the server at a minimum rate of 1mbps.

- The server should be able to calculate the location of the child based on data from the wearable within an accuracy of 70% and send it to the parent’s phone.

2. Design

2.1 Block Diagram

Our block diagram contains two types of wearables, a parent and child one. The child wearable contains three subsystems, the power supply, control unit and lock mechanism. The power supply contains a 4.2V Li-ion battery which is used to supply the rest of the subsystems with power after passing through a linear voltage regulator to convert the voltage to 3.3V which can be used by the system. The control unit subsystem is used for:

1) Connecting to the other wearable via bluetooth,
2) Communicating to the access points and server via WiFi,
3) LED’s to light up red or green to indicate whether the child is in range of the parent or not, and
4) Microcontroller which handles the processing and logic for our various systems.

The Parent wearable is similar to the child wearable except, it does not include a wifi chip in the Control Unit.

On the software side, we have a server which has vectors of RSSIs stored beforehand for multiple locations and the corresponding coordinates/location for each RSSI vector. When the child WiFi chip communicates with the access points nearby, it will send the RSSI vector for access points it is close to to the server. The server finds the closest matching RSSI vector in the database to the vector sent by the child and uses the stored location for that RSSI vector to calculate the child location. The software application on the parent phone will make requests to the server to get this location when the child is beyond the range the parent selected.

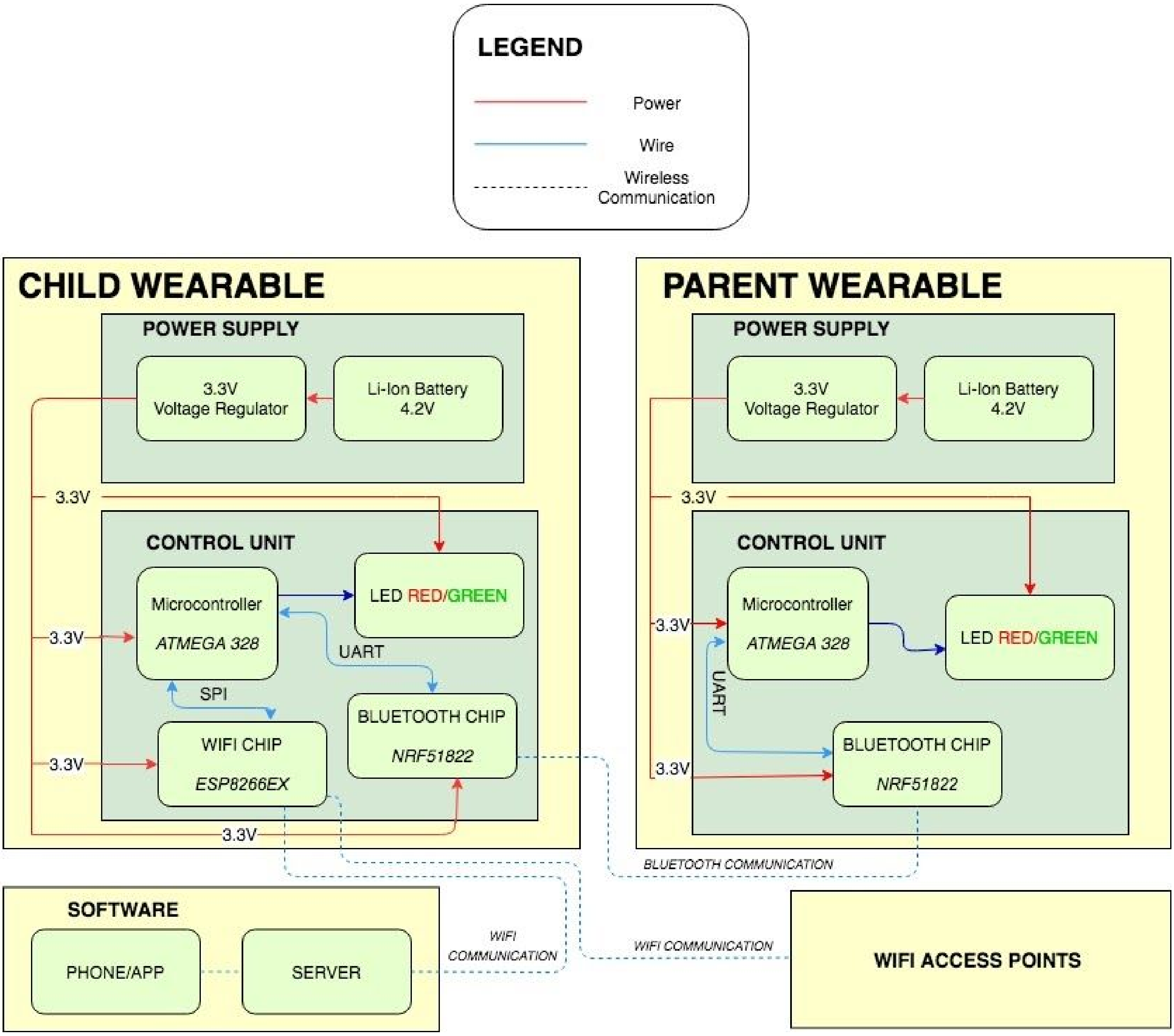


Figure 2. Block Diagram of Wearables

2.2 Physical Diagram

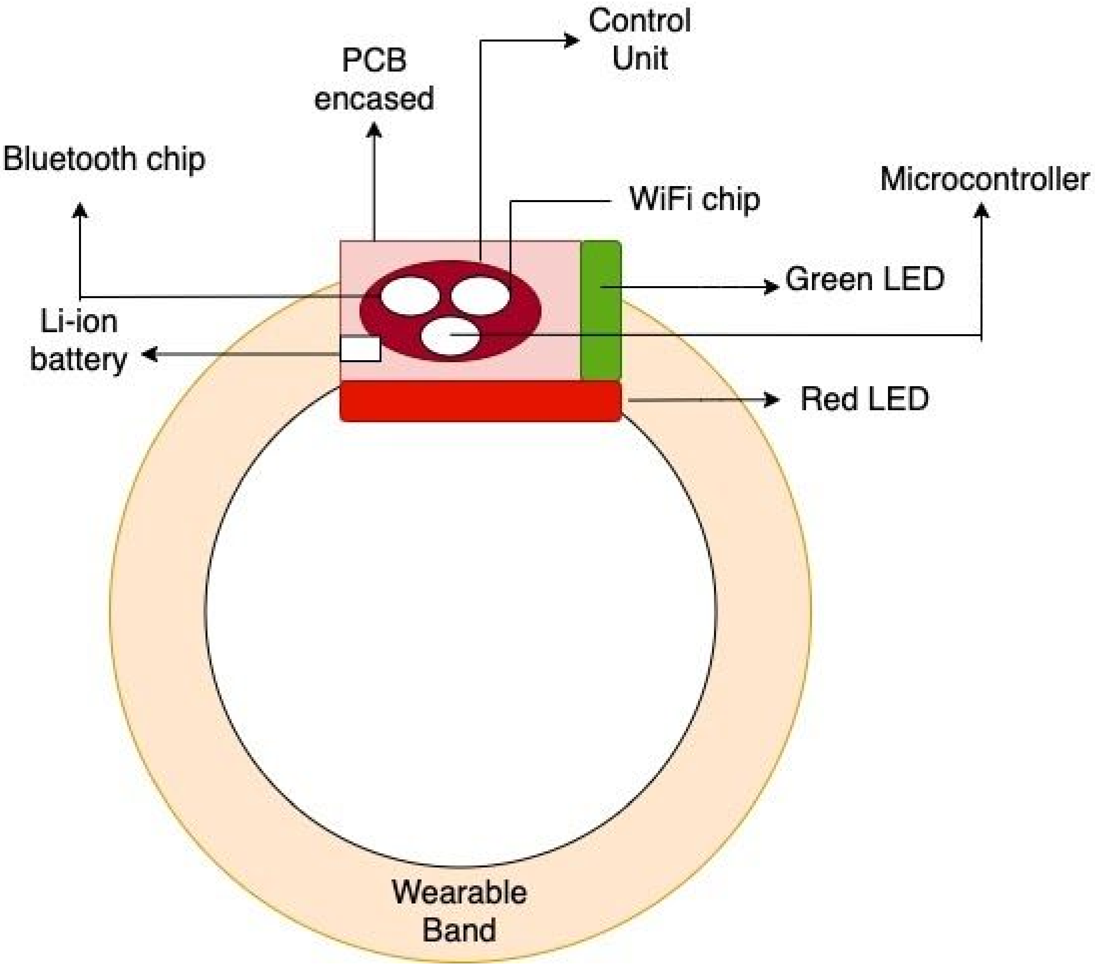


Figure 3. Physical Diagram of Wearable

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.

2.3 Function Overview and Block Requirements

2.3.1 Microcontroller for wearable

The microcontroller (*ATMEGA 328*) is a low power MCU or ARM cortex, 32K flash, upto 24 MHZ speed. The ATMEGA 328 was chosen for its small size which we want so that it can fit on a watch and also for its bluetooth and wifi connectivity.

The microcontroller is the brain of the entire unit and handles the logic for communicating between the various components. It communicates with the bluetooth chip through UART to verify that the connection between wearables is set and within the range specified. If it is not, it signals the wifi chip to start scanning for all close by access points and determines the RSSI (Relative Signal Strength Indicator) from each which is then communicated with the server. It also communicates with the LED's to signal whether to light up the red or green LED.

Requirement	Verification
1. Should light green LED indicating wearable is in range with other wearable. Should light red LED if outside range.	a) Connect microcontroller to two LED's. Attach a NOT gate to the RED LED. Send a 1 high signal in range. Send a 0 low signal when out of range. b) Microcontroller range is set to 50m. c) Confirm that 1st LED lights up and 2nd does not. d) Microcontroller range is set to 60m e) Confirm that 2nd LED lights up and 1st does not.
2. Should be able to receive the RSSI value from the bluetooth chip and calculate the distance from the other wearable using this value.	a) Connect RX of arduino to TX of bluetooth, TX of arduino to RX of bluetooth b) Place the other wearable at a distance of 1m. c) Use the Estimated distance = $10^{(TxPower - RSSi)/(10*2))}$ formula d) Actual Distance = 1m. Ensure that Error percent = ((Estimated Distance-Actual)/Actual*100) is less than 30 %

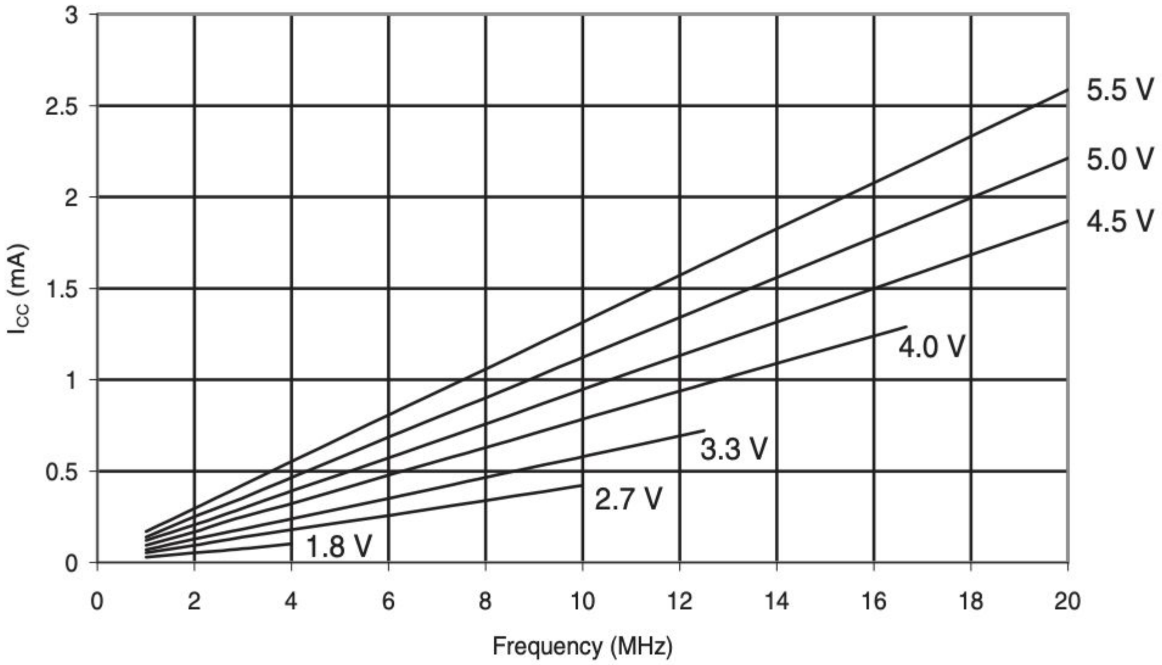


Figure 4. Power consumption of the microcontroller. Reproduced from Datasheet

The microcontroller should operate in the 12-14 MHZ region with the 3.3 supply voltage to meet our battery demands (Listed in Tolerance analysis).

2.3.2 Li-Ion Battery

A lithium ion battery is used to keep the circuit powered with 3.3V throughout. For this we are using the **AdaFruit Industries 2750** which is a 4.2V - 3.7V battery with a capacity of 350mAh. The reason we use this is because we want a small battery that can fit in a wearable device easily and is also rechargeable, preventing the need to change batteries regularly. Since our battery can only provide 3.7V at the lowest, this affects our choice of voltage regulator which needs to be a low dropout one.

For power consumption, we want our wearable to be powered for at least a day before needing to be recharged. Following the calculation in our tolerance analysis, the entire circuit requires 17.3 mA per hour. For our use case, we need the battery to last for 12hours since this is the amount of time an amusement park is open for. So, the capacity should be 208mAh minimum.

Requirement	Verification
1. Should output at least 3.7V.	a) Connect the positive and negative terminals of the multimeter to the corresponding terminals of the battery b) Ensure that the voltage output on

	multimeter is at least 3.7V.
2. Should store 350mAh of charge.	a) Connect the positive terminal of the battery to a voltage source of 3.7V and the negative terminal to ground b) Discharge battery at 100mAh for 3hours. c) Use a digital multimeter to ensure battery voltage is still around 3.7V.

2.3.3 Voltage Regulator

The purpose of the voltage regulator is to ensure that the entire circuit has access to a well regulated 3.3V power supply which it needs to function. This will be used to supply the microcontroller, bluetooth chip, WiFi chip and LED’s with power. For this we are using a L4931 from ST which is a low dropout linear voltage regulator which will provide the 3.3V +/- 2% needed for the circuit. The reason we are going for the low dropout voltage regulator is because we are using a 4.2 - 3.7V battery and regular linear voltage regulators have a dropout which is > 1V which will make the voltage lower than what is required for us. The L4931 has a dropout of 0.4V at 250mA which is perfect for our use and can supply a clean 3.3V output given our minimum voltage from our battery of 3.7V. Also, the peak current supply of 250 mA is more than enough for the use of our circuit.

We will use the following circuit for testing the regulator.

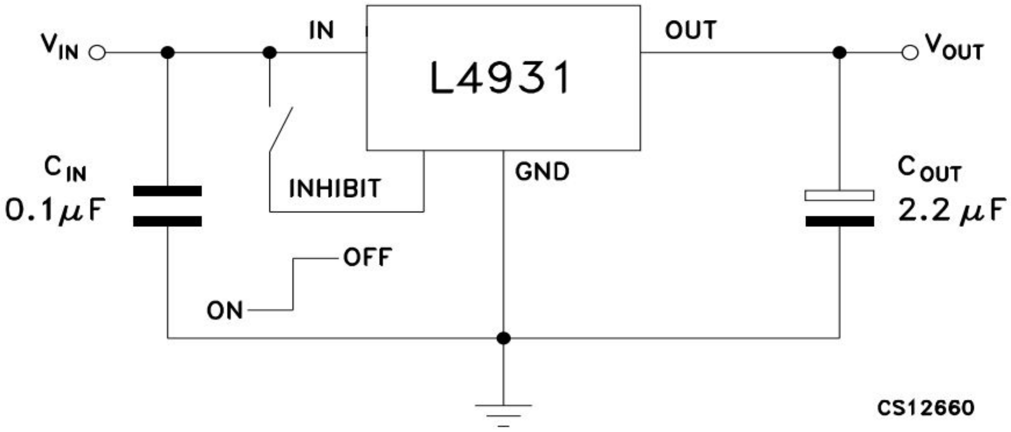


Figure 5. Voltage Regulator Application Circuit [5]

Requirement	Verification
1. 3.3V voltage regulator should be able to output 3.3V +/- 2% from a minimum 3.7V power source.	a) Connect a power supply that set at 4.2V and 3.7V b) Pass this through the voltage regulator and test the output voltage using a oscilloscope to confirm 3.3V output
2. Maintains thermal stability below 125°C.	a) Connect the battery in parallel with a resistor and connect the voltage regulator with GND and VDD across the battery. b) Use an IR thermometer to ensure that temperature stays below 125°C.

2.3.4 LEDs for wearable

There are 2 LED’s, a red and a green one. The green LED lights up when the wearables are within the range specified by the parent. During this period the red LED will remain turned off. When the wearables move outside the range specified, the green LED should turn off and the red one should light up. The signal for when to light up and turn off are sent by the microcontroller based on the bluetooth chip communication.

We are using a simple SLR-56VR3F for its low cost. The brightness and duty cycle of the green LED is reduced to save on battery charge, since this is the LED that is going to be used more. We bring down the power consumption by more than 50% by doing so, thus leaving more charge for the wearable to last longer throughout the day.

Requirement	Verification
1. Green LED should light up when a high signal is sent, while the Red one does not. Opposite happens when a low signal is sent	a) Using the 3.3V power supply and needing a required current of 10ma, From ohm's law, V=IR, we require a resistance of 330 ohms. b) Connect the led in series with the 3.3 V power supply, the 330 ohms resistance. c) Connect two lead of ammeter onto the circuit in series and ensure that the measured current is 10mA. d) The Green led should light up.

2.3.5 Bluetooth Chip for wearable

A NRF51822 Bluetooth Low Energy Chip which was chosen for its low energy consumption and good range. It is used for connecting to the parent wearable, and using the RSSI from the other wearable to calculate distance between the child and parent. This distance is used to ensure whether the two wearables are within the range specified or not and thus signals the microcontroller to light up the appropriate LED.

Our use case requires a range of at least 50m for the bluetooth so that the parents can remain connected to the child at any distance between 10m and 50m, which would be required based on the alert range selected by the parent. We also required the bluetooth to be able to provide this range while functioning on low power since we have small battery size to fit on our wearable. Further, we require a chip that provides good range (at low cost) indoors. The NRF51822 provides all these required functionality at a low cost and so is ideal for us.

Requirement	**Verification**
1. Establish connection between parent and child bluetooth chips within 50m radius.	a) Connect child bluetooth chip to bluetooth on phone via arduino app. b) Place child bluetooth chip 50 m away from the phone. c) Set up a small LED circuit which lights up if the signal sent from the app over bluetooth is 1(high) and turns off when signal sent is 0(low).
2. Extract signal strength (RSSI) from parent bluetooth connection and send it to microcontroller.	a) Establish bluetooth connection between parent and child wearable. b) Connect child wearable to a computer and run function: *sd_ble_gap_rssi_start();* to see the RSSI value from parent connection on terminal.

2.3.6 WiFi Chip for child wearable

The WiFi chip is used for scanning the surrounding areas for WiFi access points. This will be done when the child wearable is outside the range of the parent wearable. This scanning will provide the chip with the RSSI values of the nearby access points and is then sent to the server that we have set up. The WiFi chip will be connected to the internet using the park WiFi and will use this to communicate with the server.

We are using the ESP8266EX WiFi chip, mainly for its high range and low ill effects from noise. Further, it can provide us with the functionality we require, namely the scanning of access points, connection to the internet and fast transfer speeds. Further, the documentation for this chip is detailed and there are a lot of tutorials using it, thus making it easier to work with.

Requirement	Verification
1. Must be able to find access points within a 100m range	a) Place access point and wifi chip at 100 m distance apart b) Run program on chip with *WiFi.scanNetworks();* c) Verify on terminal to see if the access point is detected
2. Send unique IDs and corresponding RSSIs for each access point to server with a bit rate error of less than 10^{-6}	a) Set up two ESP8266EX chips as dummy access points and store locations (x1,y1) and (x2,y2) in server b) Program an arduino to connect the child wearable WiFi chip and scan for networks using *WiFi.scanNetworks();* c) Retrieve ID and RSSI for each network detected i using: *WiFi.SSID(i).c_str();* *WiFi.RSSI(i);* and send to server endpoint d) At the server, compare the information received to the actual information sent and calculate bit error rate to ensure <= 10^{-6}.

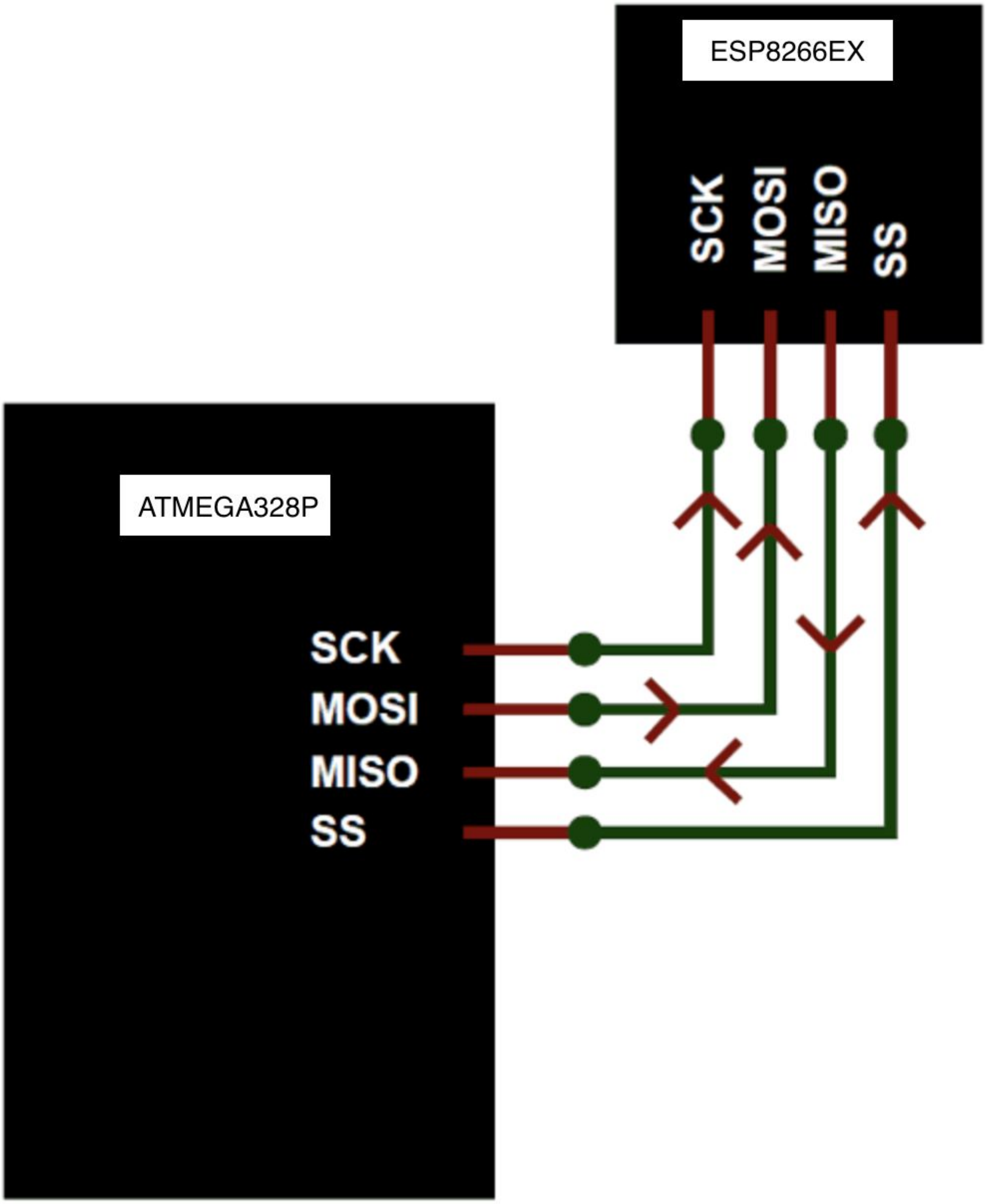


Figure 6. Interface between ESP8266 and ATMEGA328P. Reproduced from [6]

2.3.7 Server on Azure

We will create and set up a server on Azure and create required SQL databases that will store vectors of RSSI values to the corresponding coordinates and latest child coordinates given a parent ID. The server will have the following tasks:

1. Endpoint for child wearable WiFi chip to send in-range access point IDs and corresponding RSSI values along with its parent id which will then be used to update the latest child coordinate.
2. We will also have the server send notifications to the parent phone using the parent ID it receives whenever it detects an update to the child coordinate.

Algorithm:

The server will use **RSSI fingerprinting technique** to compute the approximate child location, and this algorithm consists of two stages.

"The idea is to perform preliminary RSSI measurements instead of using propagation models. It consists of two phases: an offline phase that generates a radio map for the positioning area, and an online phase that estimates client geographical position"[7].

The first stage of fingerprinting involves taking RSSI values at multiple points across the area of interest, in our case, the amusement park, and storing the corresponding coordinates in a database. "If n is the number of access points in the localization area, an n-tuple (RSSI1, RSSI2, ..., RSSIn) containing mean RSSI values is created for each point (x, y) in the map. This information is stored in a database that will be used in the positioning process." [7]

In the second stage, i.e, the estimation of the child position, the WiFi chip on the child wearable scans for access points and gets the RSSI values from each access point. This RSSI vector is sent to the server which does a search in the database to find the closest matching RSSI vector to the one that the child sent. Using this, it returns the most probable child distance.

The more records we have in our database, the better our location estimation would be. For matching the given RSSI vector to the ones in the database, we will use the Euclidean distance formula. The accuracy of this algorithm is further analyzed in the tolerance analysis section.

Requirement	Verification
1. Expose an endpoint that allows WiFi chip to send vector of RSSI values with access points and parent id to server for computation	a) Use Postman to send mock data for parent ID, RSSI vector and access points. Eg. Send ID: 123, RSSI vector: [-10,-20], Access Points: [a,b,c] b) At server, print input received and verify that it matches what was sent
2. Using RSSI Fingerprinting algorithm, predict child location correctly by getting location of closest RSSI value vector	a) Store locations and RSSI values for 16 points across a room b) Send a different RSSI value vector to server and run the fingerprinting algorithm using Euclidean distance on it c) Verify that the coordinates returned

	has RSSI vector closest to the RSSI vector sent in b)
3. Send notification to phone when corresponding child coordinate is calculated	a) From part 2, calculate child location for a known set of access points and RSSI values. Eg. Child coordinate calculated was (10,10) for phone with ID: 123 b) Verify that mock phone app with ID:123, receives notification with correct child coordinate that we calculated by printing output Print(10,10)

2.3.8 Software App

An android application for the parent's phone will be developed which will interact with the server to get the latest child location. Every time a new update is made in the database for a given child-parent id, the server will send a push notification to the software application on the parent's phone. As soon as the bluetooth of the parent and child connect back, the server would stop getting RSSI vectors from the child WiFi and hence the app would stop getting notifications from the server.

Requirement	**Verification**
1. Should receive notification with child coordinate from server when the server gets an update for the ID corresponding to that phone	a) In the database, store multiple locations for different parent ids Eg. ID: 123, Location: (10,10) b) Use Postman to send an update of child coordinate to the database for the parent id corresponding to a mock parent phone app c) Verify that the correct corresponding child location stored on the database is sent to the mock phone app and printed. Eg. With parent ID 123, (10,10) should be sent and printed.

2.4 Flowchart of project workflow:

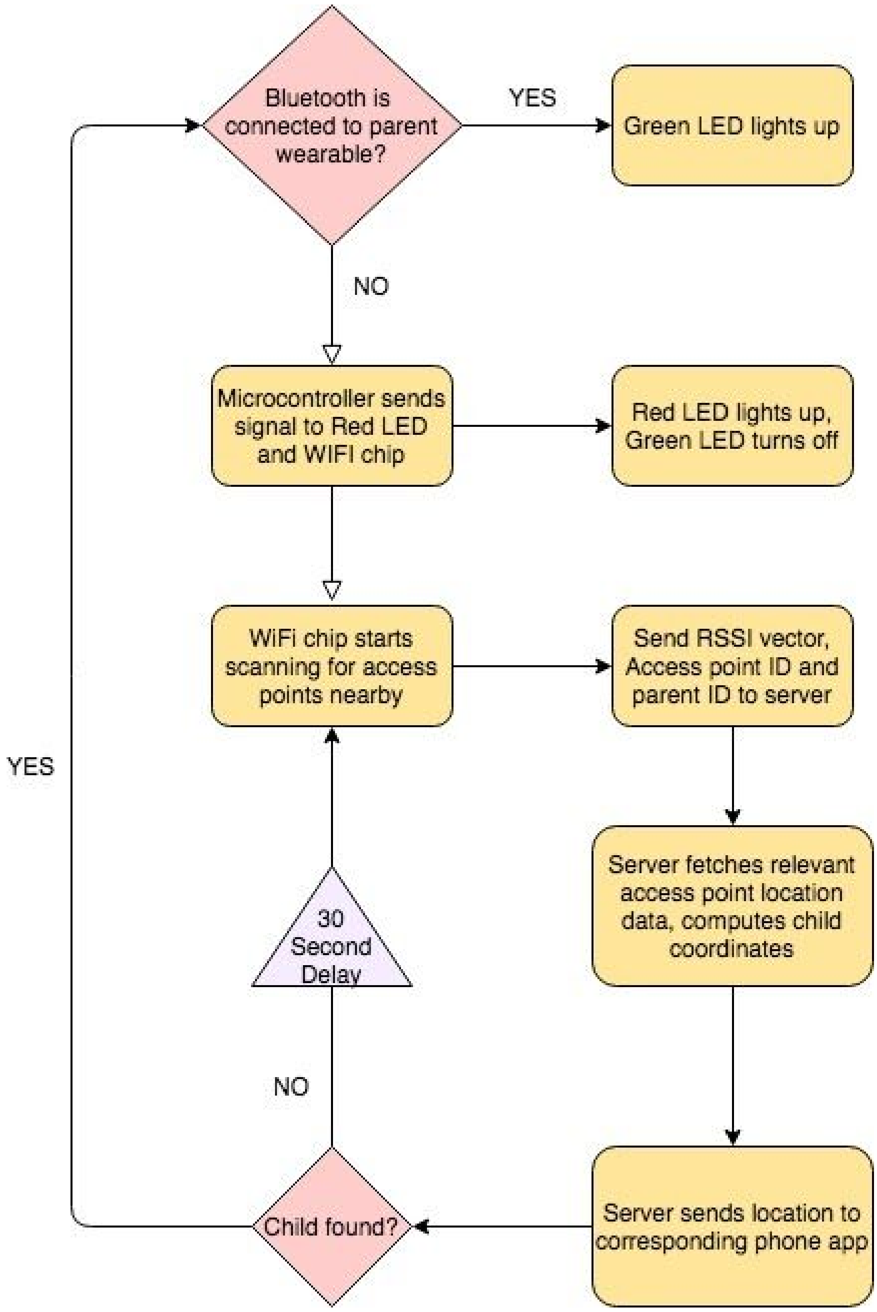


Figure 7. Flowchart of project workflow

2.5 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. 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.

3 Tolerance analysis

3.1 Analysis of the battery life of the child wearable.

Most theme parks operate for about 12-13 hours in a day. Hence our child wearable must have a minimum battery life of 13 hours with a 7% tolerance which indicates that the range of battery life will be between 12 to 14 hours.

In a 12-13 hour period the average time a child goes missing from their family is around 30 minutes. [2]

Component	**Current consumed when connected to parent (95% of the time with an error bound of 2% to 5%).**	**Current consumed when away from parent (5% of the time with an error bound of 2% to 5%).**
2 LEDS with forward voltage of 2V. *brightness, i.e consuming 10ma of current.*	Only green LED is on and operate with a 50 percent duty cycle (it is on only for 30 minutes per hour). It will operate at 80 percent brightness. Hence the current consumed in an our will be 0.8*10*0.5 hours = 4 mAh.	The Red led operates with a 100 percent duty cycle with 100 percent brightness. Hence current consumed per hour is 8mAh.
ATMEGA 328 Microcontroller	Uses 0.2 mA *1 hour = 0.2 mAh	Uses 0.2 ma *1 hour = 0.2 mAh
Wifi chip	Light sleep mode : 0.9 mA	Will use 80 mAh on average
Bluetooth chip	Uses 9.7 mA at 5hz rate	Uses 0.2 mA at 5Hz rate

Table 1: Power analysis

Power consumption 95% of the day (when in connection with parent) : 0.95*(4+0.2+ 0.9 +9.7) = 14.06mAh
Power consumption 5% of the day (when child wearable is disconnected from parent) : 0.05*(80+8+0.2+0.2) = 4.42mAh

Total current consumption = 14.06+4.42 =18.48 ma

Battery Life = Battery Capacity in mAh/Load current in mAh = (350Ah)/18.48 = 18.93 hours

Hence based on our components the power should last for the entire duration of the day that the wearable is used.

If you decide to use 2 Lithium ion batteries instead of 1 then the wearable will be powered for 12.98*2 = 25.96 hours which is more than sufficient for the wearable.

3.2 Analysis of Wifi positioning.

There are four main popular methods of doing wifi positioning which are RSSI and lateration based, fingerprinting based, angle of arrival based and time of flight based.

For the purpose of this project we plan to use the RSSI fingerprinting technique

For the requirement of our project which is an accuracy of 0-40m from true position, we studied known experiments conducted on the ESP8266 WIFI module.

Experiment 1:

In this sample experiment conducted by HAL[7], 3 access points are placed around the room. 16 predetermined locations are decided in the room where the RSSI values will be measured. At each of these 16 points in the grid, Wi-Fi signals are received from the 3 nearby access points and the RSSI value is computed at different times and with different conditions. A 3-tuple structure is computed having the mean RSSI values at each point on the map. These values are then stored in a database. This is the basis of Constrained RSSI fingerprinting.

When a user is in the same region, the RSSI values are computed with respect to each access point. These values are sent to the database and the best match of the RSSI values stored in the database is returned as the position of the child.

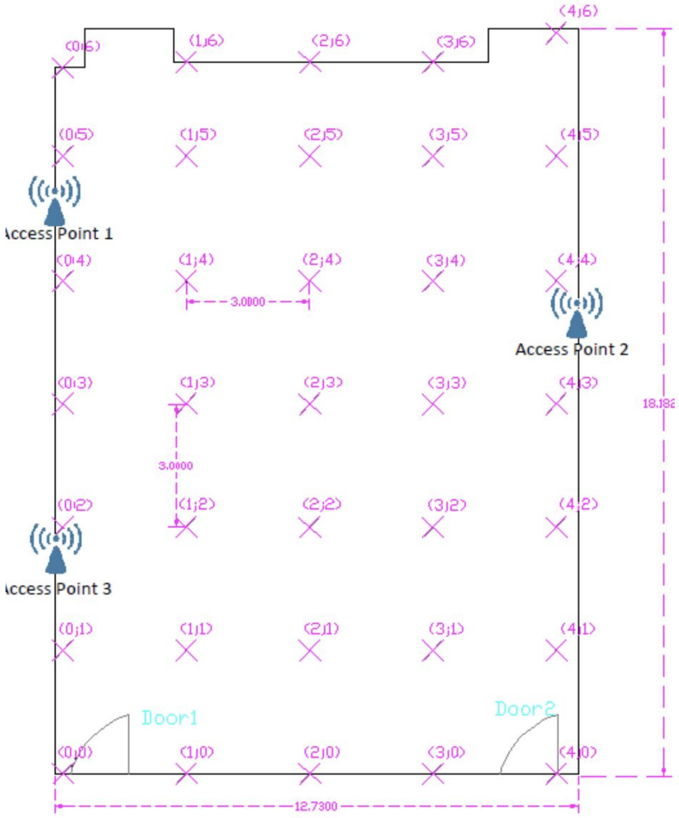


Figure 8: Sample room with 3 access points reproduced from [7]

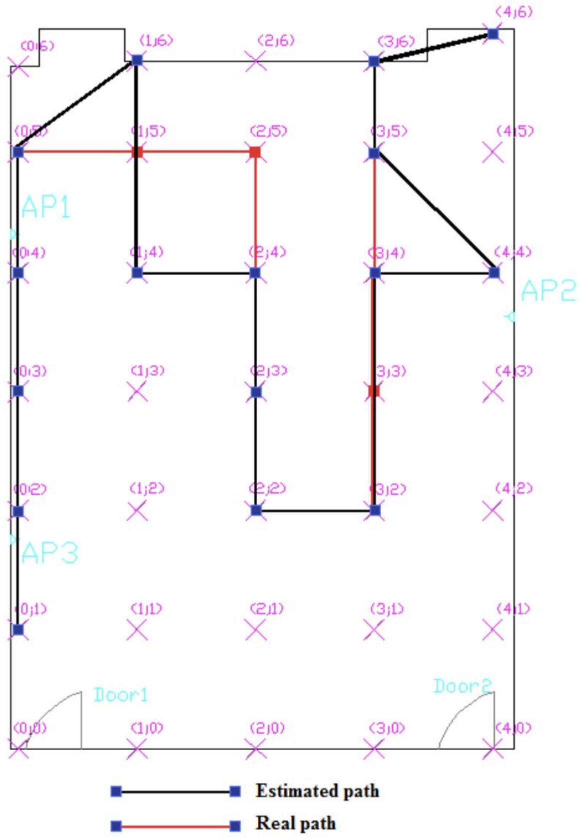


Figure 9: Estimated path computed by fingerprinting RSSI technique reproduced from [7]

This experiment above conducted by HAL [7] shows that the maximum error is between the points (1,4) and the points (2,5).

Euclidean distance = $\sqrt{}((x1^2 - x2^2)\text{-}(y1 - y2^2))$ .....(1)

The euclidean distance between these two points is 1.212 m. This is for an ideal scenario in a small room.

Overall the experiment shows that the accuracy of this technique is 75% which is above our current high level requirement.

Experiment 2:

The experiment conducted using a curve fitting variant of the fingerprinting technique shows the following data by taking measurements of mean rssi (300 measurements) at 17 different positions storing it in a database. When a user is in the same region, the RSSI values are computed with respect to each access point. These values are sent to the database and the best match of the rssi values stored in the database is returned using the curve fitting model of fingerprinting as the position of the child. [8]

The following table shows the results :

Actual Distance	RSSI Value in dbm	Estimated Distance	Error Percent
0.3m	-55	0.2900m	3.333%
0.4m	-59	0.3742m	6.45%
0.5m	-60	0.4029m	19.42%
0.6m	-62	0.4723m	21.283%
0.7m	-66	0.6761m	3.4142%
0.8m	-68	0.8236m	2.95%
0.9m	-69	0.9127m	1.41%
1.0m	-71	1.1293m	12.93%
2m	-74	1.5829m	20.855%
3m	-79	2.9307m	2.31%
4m	-81	3.8387m	4.0325%
5m	-83	5.1232m	2.464%

6m	-84	5.9720m	0.4666%
7m	-85	7.0137m	4.4542%
8m	-86	8.3118m	3.8975%
9m	-87	9.9605m	10.6722%
10m	-88	12.1052m	21.052%

Table 2: Error Percentage of Fingerprinting RSSI technique. Reproduced from [8]

The maximum error computed was 21.283% which means the minimum accuracy was 78.717% which is within the tolerance for our accuracy of 70% in the high level requirement.

4 Cost analysis

4.1 Labor

According to the official website of the Grainger college of engineering the average starting salary for Engineering graduates is $78,159. This equates to an hourly wage of 37.58 USD.

Hence the labor cost is given by:
37.58 USD x 2.5 x 70 = 6576.5 USD per person
Hence the total cost for 3 people = 19729.5 USD

4.2. Part analysis

4.2.1 Child wearable cost

Component	Manufacturer	Product ID	Quantity	Cost
Leds	Rohm semiconductor	SLR-56VR3F	2	2*0.60 = 1.20 USD
Microcontroller	Microchip technology	ATMEGA-328P	1	2.08 USD
Wifi chip	Espressif Systems	ESP8266EX	1	6.95 USD
Bluetooth chip	Nordic semiconductor	NRF51822	1	2.48 USD
Lithium ion rechargeable battery	Adafruit Industries	ADAFRUIT 2750	1	6.95 USD
TOTAL PRICE				19.66 USD

Table 3: Child wearable cost

4.2.2 Parent wearable cost

Component	Manufacturer	Product ID	Quantity	Cost
Leds	Rohm semiconductor	SLR-56VR3F	2	2*0.60 = 1.20 USD
Microcontroller	Microchip technology	ATMEGA-328P	1	2.08 USD

Bluetooth chip	Nordic semiconductor	NRF51822	1	2.48 USD
Lithium ion rechargeable battery	Adafruit Industries	ADAFRUIT 2750	1	6.95 USD
TOTAL COST				12.11 USD

Table 4: Child wearable cost

4.2.3 Server cost

Component	Cost
Azure Server	55.8 USD per month
TOTAL COST	55.8 USD

Table 5: Child wearable cost

4.2.4 Grand Total

Labor : 19729.5 USD
Child Wearable cost : 19.66 USD
Parent Wearable cost : 12.11 USD
Server Cost : 55.8 USD

Grand Total : 19817.07 USD

5. 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)	Research more about wifi scanning for access points and receiving RSSI information	Design PCB for early bird order	Design PCB for early bird order
3 (03/09 - 03/16)	Start setting up server and api endpoints which perform the distance calculation using wifi RSSI information and location	Continue PCB design if required. Test connection between bluetooth chips and verify extraction of RSSI information between bluetooth chips	Test connection between bluetooth chips and verify extraction of RSSI information between bluetooth chips
SPRING BREAK (03/16 - 03/23)	Catch up if behind on schedule	Catch up if behind on schedule	Catch up if behind on schedule
4 (03/23 - 03/30)	Test wifi scanning, information gathering, sending to server and triangulation code Create barebones phone app to receive location information	Verify information transfer between microcontroller and bluetooth chip	Write code for range checks between wearables and verify correct LED's light up (Integration test of bluetooth, microcontroller and LED's)
5 (03/30 - 04/06)	Build mock access points. Finalize power supply build and testing	Finalize power supply design, build and testing	Finalize power supply design, build and testing
6 (04/06 - 04/13)	Integration, testing and future work if	Integration, testing and future work if	Integration, testing and future work if

	time permits.	time permits.	time permits.
7 (04/13 - 04/20)	Mock Demo/ Final Report/ Final Demo/ Final Presentation Preparation. Tie up any loose ends and test thoroughly	Mock Demo/ Final Report/ Final Demo/ Final Presentation Preparation. Tie up any loose ends and test thoroughly	Mock Demo/ Final Report/ Final Demo/ Final Presentation Preparation. Tie up any loose ends and test thoroughly
8 (04/20 - 04/27)	Mock Demo/ Final Report/ Final Demo/ Final Presentation Preparation. Tie up any loose ends and test thoroughly	Mock Demo/ Final Report/ Final Demo/ Final Presentation Preparation. Tie up any loose ends and test thoroughly	Mock Demo/ Final Report/ Final Demo/ Final Presentation Preparation. Tie up any loose ends and test thoroughly
9 (04/27 - 05/02)	Final Demo preparation	Final Demo preparation	Final Demo preparation

6 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 batteries. This exposes the human wearing it to being exposed to electrical current shocks, and poses 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 [9]. 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 [10].

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, the wearable could 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 is not a feature of our project but could be added to make sure that the child wearable cannot be fidgeted with or misplaced, and can only be removed under parent supervision.

Through the access points spread throughout the amusement park to track a child's location, we will be sending approximate child coordinates to the parent all across the park via the server. 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. We will also respect the privacy of the users and not use the location data without user permissions.

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 [10]. 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 [11]. All the features we implement in our project will be designed to help humans and the environment and keep them safe.

7 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] L4931 datasheet: https://www.st.com/resource/en/datasheet/l4931.pdf

[6] https://circuitdigest.com/microcontroller-projects/arduino-spi-communication-tutorial.

[7]Mohamad Yassin, Elias Rachid, Rony Nasrallah. Performance Comparison of Positioning Techniques in Wi-Fi Networks. 10th Int. Conf. Innovations in Information Technologies, Nov 2014, Al Ain, United Arab Emirates. ff10.1109/INNOVATIONS.2014.6987565ff. ffhal-01310660f [Accessed: 02/27/2020]

[8] Barai, Suvankar & Biswas, Debajyoti & Sau, Buddhadeb. (2017). Estimate distance measurement using NodeMCU ESP8266 based on RSSI technique. 170-173. 10.1109/CAMA.2017.8273392.

[Accessed: 02/27/2020]

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

[10] 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].

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

Datasheets Used:

Wifi Chip : https://cdn-shop.adafruit.com/product-files/2471/0A-ESP8266__Datasheet__EN_v4.3.pdf

Bluetooth chip : https://infocenter.nordicsemi.com/pdf/nRF51822_PS_v3.1.pdf

LED : https://www.digikey.com/product-detail/en/rohm-semiconductor/SLR-56VR3F/511-1264-ND/636992

Microcontroller: https://www.sparkfun.com/datasheets/Components/SMD/ATMega328.pdf