Updated Divide and Conquer V2


UNIVERSITY OF
CENTRAL FLORIDA

# Increasing Immersion and Interactivity in Themed Entertainment Environments Through the Usage of RFID Technology


Group 15

Darren Yong - Electrical Engineering

Kalindi Desai - Computer Engineering

Rebecca Casimir - Computer Engineering

Trey Sandefur - Electrical Engineering

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# Project Narrative

The world of Pokémon has long been a staple in the entertainment industry. Being evaluated at a rough estimate of $92.1 billion, it is the most valuable franchise in existence. Their products and stories range from card trading to graphic novels, movies, video games, television, and more. Not yet have they breached into the world of themed entertainment, and physical immersive experiences. This project serves as a proof of concept for how the world of Pokémon could theoretically breach into this industry. The background of this project lies in a fictitious themed land corresponding to the world of Pokémon, and serving as a celebration for all this property has to offer. This themed land would feature various attractions that would include a high level of immersion and interactivity from the guests that enjoy them. How they immerse the guests, and request the interaction of the guests is where this project plays in.

The core idea is to create an interactive physical Pokéball that allows for certain low level control from guests throughout this fictitious land, and on the interior of the varying attractions. The varying attractions could consist of a gym battle based experience, where guests get to utilize their own acquired Pokémon on the ‘inside’ of these Pokéballs. Then proceed to battle with computer controlled Pokémon on the back-end of this attraction to earn “gym badges”. The following is a breakdown of how a guest can acquire their first Pokéball, and utilize it throughout this fictitious land.

The guests would enter a merchandise location called the ‘Pokécenter’, where they can purchase their first Pokéball. On the completed purchase, the operator of the sale would initialize the Pokéball with key information that would be necessary to interact throughout the themed land. The initialization would be completed through RFID means, and would write to an embedded memory element located on a PCB on the interior of the Pokéball. The information held on the Pokéball would consist of a unique guest ID (string of characters designated by the company operating the themed land), Pokémon ID (each Pokémon would be given a set ID designated by the company operating the themed land), and ID equated to the Pokéball itself. These three pieces of data would be initialized on a database privately controlled by the company operating the themed land, along with initializing it to a set memory element embedded on the Pokéball as previously stated.

Once this initialization is complete, and both database and Pokéball are stored with the proper data, the guest is then escorted through the process of gaining their first Pokémon. This would update the database to notify the attractions of what pokéball ID is being utilized, what guest ID is equated to it, and what Pokémon ID is embedded in this specific Pokéball. The Pokéballs

would be limited to one Pokémon per unit. After this, the guest is free to utilize the Pokéball at the differing experiences the land offers.

When entering the gym battle attraction; the guest would follow through a set queue, and enter the specific gym room they are instructed to by the operator. Once inside of the set gym room, an RFID reader would send a power and message signal to the Pokéball to retrieve certain data. The pieces of data that have previously been stored on the Pokéball would be used to initialize a certain battle scenario based on set parameters by our team. Some parameters could include the type of Pokémon that can be used to battle against the Pokémon the guest has selected to battle with. Once the battle has concluded, the guest can be rewarded a certain progression level to evolve their Pokémon of use during the battle. This progression system allows for the land to always be evolving alongside the guests, and the Pokéballs to be the key figure in the guests' interaction with this land.

The only other product that features a similar level of interactivity would be the Disney MagicBand system, and the Universal Studios Wizarding World Wand system. The levels of interactivity of these products are utilized in different means, and through different subsystems than what group 15 is portraying. The audience is a broad range of guests from numerous generations. Those who enjoy the world of Pokémon in any facet would find joy and excitement in this advancement of immersion and interactivity to the themed entertainment industry.

This project is meant to act as a proof of concept for how portable handheld RFID based products can be used to increase immersion and interactivity in the themed entertainment industry. This will be a challenging design to accommodate for aspects such as: weight, reliability, environmental consciousness in choice of material, longevity, and ease of use. This goes to show that RFID can also be used in more than one property. The use of property in this project is for academic purposes only, and will not be used in any commercial sense.

Design aspects in weight and reliability come majorly into play with the casing in which our PCB and RFID tag will be embedded in. Systems will need to be in place to assure that mishaps such as dropping the handheld RFID device won’t break, and still operate. Longevity will be crucial from a themed entertainment perspective. Guests who utilize and purchase these items will ideally be traveling from around the world to interact and immerse themselves in the environment in which they can interact with. Ease of use is needed on both front and back ends of this project. Guests of all ages will be interacting on the front end, and operators of the themed environments will be initializing systems while potentially troubleshooting on the back end. These aspects will need to be in mind while approaching the design and build of this project.

# Project Requirements

| **Specifications** | | |
|---|---|---|
| **Activation Time** | The Pokéball shall be able to activate within a specified amount of time | $\geq 5\ minutes$ |
| **Active Time** | The Pokéball shall be able to run for a specified amount of time | $\geq 12\ hours$ |
| **Wirelessly Transmit Data** | The Pokéball shall be able to transmit data wirelessly within a specified amount of distance | $\geq 25\ feet$ |
| **Weight** | The Pokéball shall be lightweight and within the specified weight parameters | $\geq 3\ pounds$ |
| **Dimension** | The Pokéball shall be portable and within the specified size parameters | $\geq 5\ inches\ in\ diameter$ |
| **Unit Connection** | The Pokéball shall only be able to connect to a specified number of units | $= 1\ Pokéball$ |
| **Accuracy** | The Pokéball shall be able to access a specified amount of data from the Pokéball database | $\approx 98\%$ |
| **Progression** | The Pokéball shall be able to determine a winner between two units within the specified amount of time | $\geq 10\ minutes$ |
| **Unique Identifiers** | The Pokéball shall be able to be identified with a specified number of identifiers | $= 3\ unique\ identifiers$ |
| **Maximum Pokémon Connection** | The Pokéball shall only be able to connect to a specified number Pokémon | $= 1\ Pokémon$ |
| **Durability** | The Pokéball shall be able to withstand dropping from a specified amount of distance above the ground | $\geq 5\ feet$ |

Table 1: Engineering Specifications

# Project Constraints

- Design
    - The project's design must be relatively light, portable and reliable. It also requires a PCB and RFID tag embedded inside. Also the design must withstand possible droppings so the weight should be light and durable.
- Price
    - As this project is not sponsored, one of our constraints is the price. We do not require too many parts. For the parts we will use, we will split the cost and the project will be self funded.
- Time
    - This project is still in the beginning stages and will require a lot of time dedication.We will individually prioritize this project and its requirements.

# House of Quality

The house of quality is displayed in Figure 1 below. This is an essential tool for demonstrating requirements for our Pokéball. It easily demonstrates the combination of the engineering requirements as well as the marketing requirements for the project. The figure below will show that cost is an important requirement for both marketing and engineering requirements. All of the other requirements are negatively correlated with cost. The engineering requirements of the Pokéball are efficiency, weight, quality, dimensions, and cost. The marketing requirements are durability, usability, portability, cost, and long lasting. The house of quality demonstrates the correlations, relationships, and direction of improvements for all the requirements mentioned above. Table 2 will demonstrate the positive, negative, strong, and weak aspects of each requirements connection.

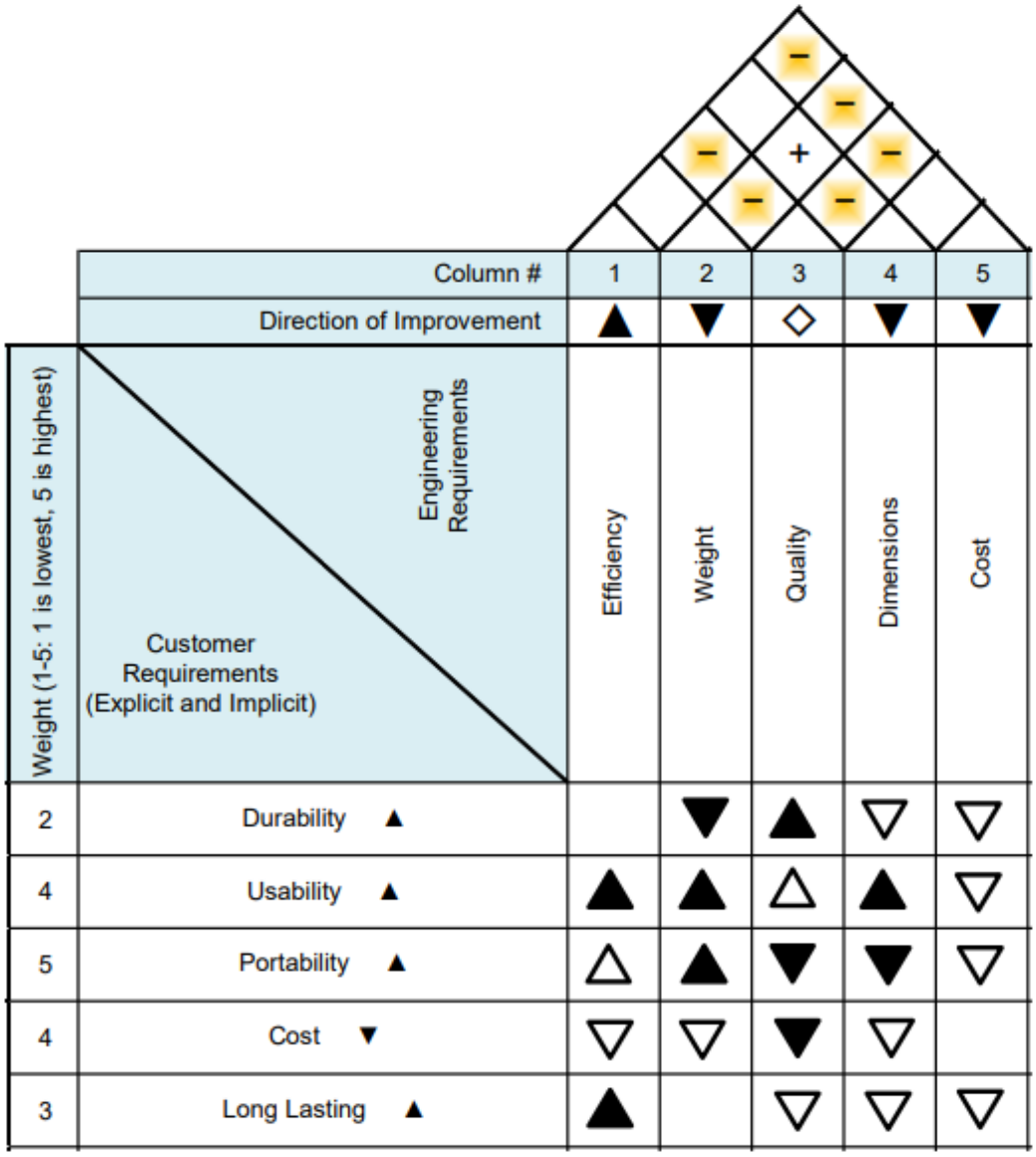


Figure 1: House of Quality Specifications

## Legend

| Correlations | |
|---|---|
| Positive | + |
| Negative | − |
| No Correlation | |

| Relationships | |
|---|---|
| Strong Positive | ▲ |
| Positive | △ |
| Negative | ▽ |
| Strong Negative | ▼ |

| Direction of Improvement | |
|---|---|
| Maximize | ▲ |
| Target | ◇ |
| Minimize | ▼ |

Table 2: House of Quality Legend

# Project Prototype Illustration


Figure 2: Pokéball Interacting with RFID Reading Device

# Project Hardware Block Diagram

**Legend**

Assigned Members
(Electrical Engineers)
Trey and Darren

(Computer Engineers)
Kalindi and Rebecca

Block Status
To be acquired (TBA)
Acquired (A)
Research (R)
Design (D)
Prototype (P)
Completed (C)

## RFID Device Design Block Diagram

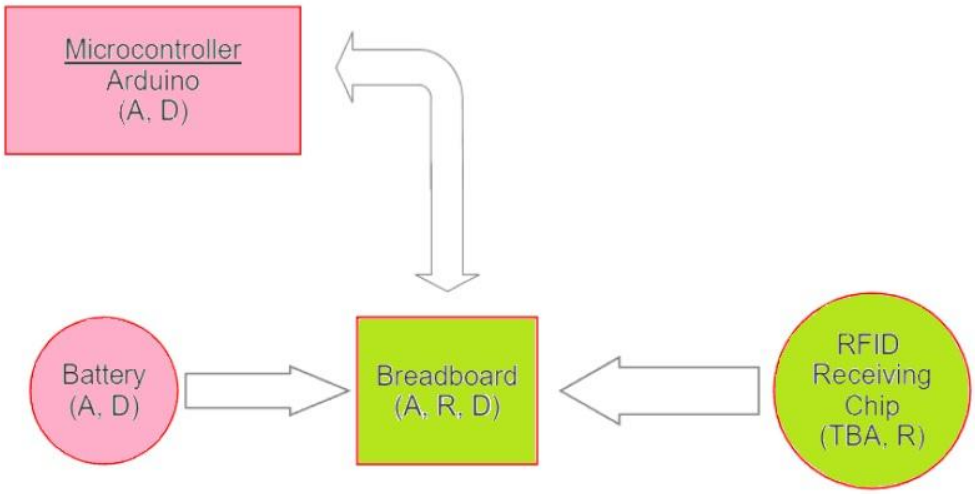


Figure 3: RFID Device Design

# Pokéball Design Block Diagram

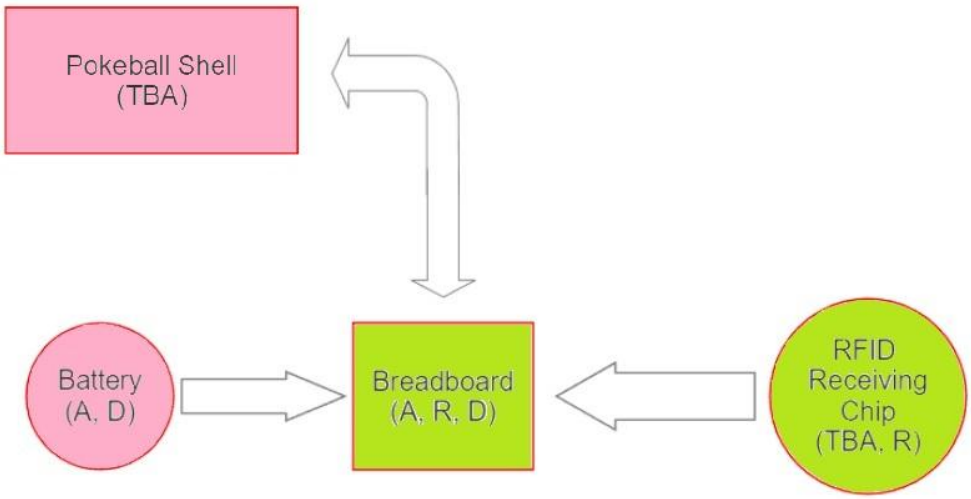


Figure 4: Pokéball Design

# Project Software Block Diagram

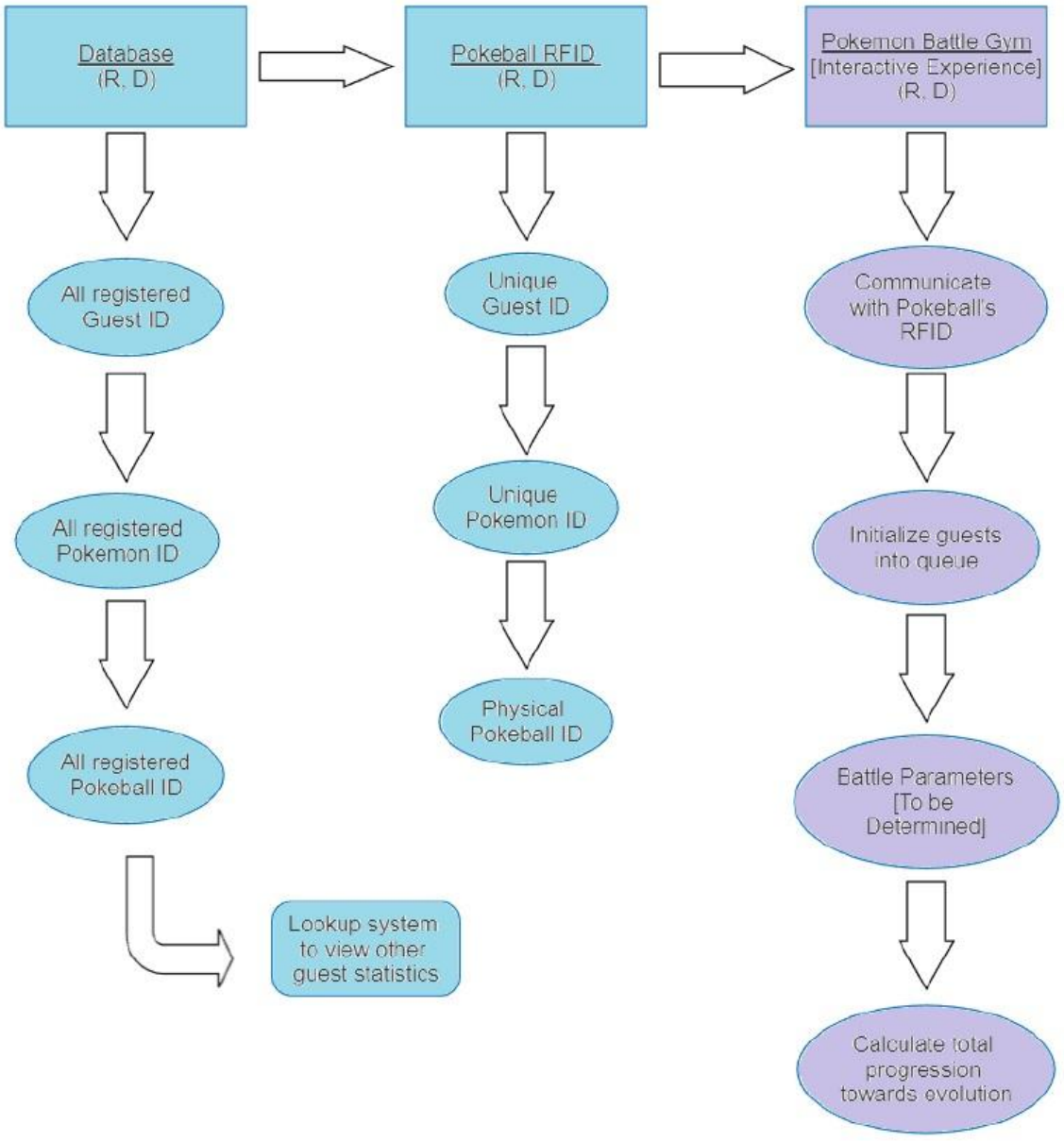


Figure 5: Software Design

# Budget Estimate

| **Item** | **Quantity** | **Cost Estimate** |
|---|---|---|
| RFID Reader | 1 | $20=< |
| 3D Printed Shell | 1 | $0 |
| Additional Programming Software | TBD | $0-$20 |
| Microcontroller | 1 | $20=< |
| Battery | 1 | $5-$10 |
| BreadBoard | 1 | $0 |
| PCB | 1 | $10-$50 |
| LCD Display | 1 | $12-$50 |
| Buttons | 1-3 | $5-$10 |
| Brother & Sister wiring | TBD | $0-$10 |
| **Total Estimate** | | **$92-$190** |

Table 3: Budget Estimate

# Project Milestones

**Senior Design 1**

| | |
|---|---|
| **Brainstorm and Project Selection** | **Week 1 & 2** |
| **Divide and Conquer** | **Week 3** |
| **Divide and Conquer V2** | **Week 4** |
| **Technology Research and Material Requests** | **Week 4 - 9** |
| **Rough Draft** | **Week 9** |
| **Revise and include missing Pieces** | **Week 10** |
| **Final Draft** | **Week 11-12** |

Table 4: Senior Design 1 Project Milestones

**Senior Design 2**

| | |
|---|---|
| **Order Materials** | **Week 1 & 2** |
| **Build ⅓ of Prototype** | **Week 3 - 5** |
| **Test and adjust** | **Week 5** |
| **Build ⅔ of Prototype** | **Week 6-8** |
| **Test and adjust** | **Week 8** |
| **Build completer Prototype** | **Week 9-13** |
| **Test and adjust** | **Week 13** |
| **Add any additional elements & create framework of report** | **Week 14** |
| **Final Report at presentation** | **Week 15-16** |

Table 5: Senior Design 2 Project Milestones

# X.0 Research

The following sections included in this chapter discuss the research committed to numerous aspects of this project. When discussing how a project of this type can be completed, many considerations must be made. How the handheld device will communicate with the overall system, what materials will be used for the shell of the Pokéball, what microcontroller will act as a network hub, and other considerations are included.The research discussed in this following section has been gathered from scientific articles, textbook research, and higher education literature.

## X.1 Existing Products

The Pokeball fills the void in the market for Pokemon enthusiasts. Although there are various types of Pokeballs in the market, they are all meant solely for display and have no real function associated. Our Pokeball is intended to be connected with the experience of a Pokemon World. There are other products in the market currently that resemble this function but none that match the format we are trying to achieve as well as the Pokemon aspect. The two products that are most closely related to what we are trying to achieve would be Disney's MagicBands and Universal's Interactive Wands. We will analyze how our Pokeball is different from the other two products in terms of intention and design.

### X.1.1 Disney MagicBand

Disney's MagicBand intention is to significantly reduce the amount of items individuals need to carry. Prior to the MagicBand creation, park goers would have to carry an ID, payment card, hotel key, fastpass tickets, park tickets, and various other things. It utilized RFID chips in the same way we intend to. Although MagicBand achieved its goal of minimizing the necessary items to carry, it has become less desirable due to the growth of integrating the same cards into one's smartphone. In figure 6 below, the comparison between the MagicBand and smartphone connection can be seen. In this day and age, everyone is guaranteed to have their smartphone with them especially when going to a theme park. It is easier to simply carry a smartphone that has the capabilities to hold all of the items the MagicBand can hold virtually. Also, in order to pay with the MagicBand, you must first tap and then enter a passcode whereas you must simply tap with a smartphone.

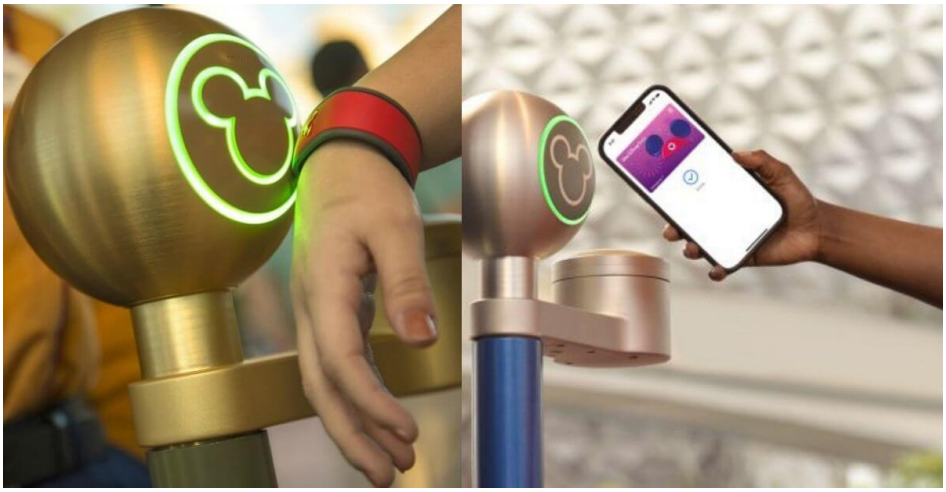

Figure 6: MagicBand vs Smartphone connection

The MagicBands do not necessarily have a core connection to the Disney characters the way the Pokeball does. Figure 7 below shows the way MagicBands integrate various of their characters into the product and shows how irrelevant the design of the MagicBand are. Any variation of designs can be used for the bands to curate towards their current product whereas the Pokeball is a constant design with a strong familiarity to those who enjoy the Pokemon franchise. The Pokeball has a direct connection to the Pokemon world where it is recognizable by many. Disney's MagicBand and our Pokeball do not have the same intention for use. Our Pokeball is intended to be an integral part of our Pokemon world not an add-on as the MagicBands are. Although the MagicBands utilizes the same technology our Pokeball is based around, the MagicBand is intended for different uses and therefore cannot be fully comparable to our Pokeball product.


Figure 7: Variety of Disney's MagicBands

## X.1.2 Universal Interactive Wands

Universal's Interactive Wands are representative of the wands from the Harry Potter series. The interactive wands have a strong connection to the Harry Potter series. Each of the interactive wands comes with a map of the replica Diagon Alley and Hogsmeade created in Universal, two locations in the Harry Potter series. The map and a photo of one of the wands is shown in figure 8 below. The variety of wands offered are replicas of the wands described in the books and shown in the films. There are also a set of interactive wands known as unclaimed wands that have a unique design not related to a character. This direct connection to the franchise connects the user with the product resulting in higher enjoyment.


Figure 8: An Interactive Wand from Universal

The variety of interactive wands and integration of the locations that are within the Harry Potter franchise excites Harry Potter fans as they feel closer to the series. The Pokemon franchise is substantially larger than that of Harry Potter's in terms of gross revenue and global following. In figure 9 below, we can see that, as of January 2021, the Pokemon franchise is the most valuable franchise and the Harry Potter franchise is tenth valuable. Even in mid to late 2022, this fact still holds true, the Pokemon franchise continues to be the most valuable. According to this data, a similar if not better reaction should be expected for our Pokeball along with the associated Pokemon world.

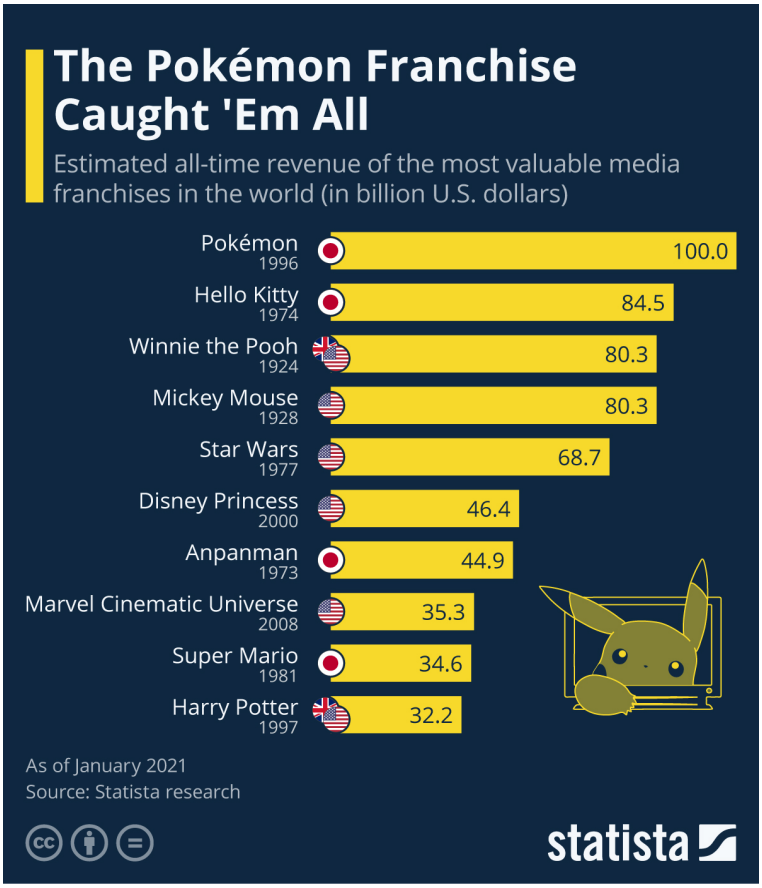


Figure 9: Chart of Top 10 Media Franchises

In order to use the interactive wands, park goers must locate the various medallions on the map and correspond it to the location at the park. These medallions are on the ground that have an arrow pointed towards the location of where the park goer should cast the spell. In the center of the medallion, there is an image of the motion that the park goers must perform for their spell to work. The image of the motion is surrounded by the words that the park goer should say to cast the spell. A photo of the medallion can be seen below in figure 10. The spell names are directly correlated to the Harry Potter series and are meant to replicate in the window where the spell is being cast. The window is equipped with infrared cameras designed to replicate the spell motion and cleverly hidden in the window to not diminish the experience. Due to the cameras' positions, the range of motion is limited so the park goer must be relatively close to the window and perform the spell in a relatively small motion. As the camera is picking up the reflection from the tip of the wand, there is no reason to speak the spell but it does make the park goers feel further integrated in the series.


Figure 10: A Medallion at Universal

In comparison with our Pokeball project, Universal's interactive wands have a similar aesthetic appeal. It allows the users to feel connected to the franchise they so passionately follow. The success of the interactive wands shows that our idea for Pokeballs should be just as successful considering the substantially larger following. The interactive wands however do not use the same system we plan to implement. We intend to utilize the RFID chips similar to that of Disney's MagicBands. We also intend to implement an additional feature of interacting between two Pokeballs that neither the MagicBands nor the interactive wands have.

# X. Standards and Constraints

## X..1 Related Standards

## X..2 Realistic Design Constraints

Every project must have realistic design constraints to successfully implement the design. The constraints have a firm understanding of the project's details and realistically demonstrate the restrictions. The Pokeball's design and production will be examined and each of the constraints below will reflect the design and production. Each of the constraints below are broad categories that will be examined in detail in relation to the Pokeball's design and production in order to be realistic.

### X..2.1 Functional Constraints

Functional constraints will provide realistic design constraints for the project. A requirement of the Pokeball relies on its portability component. This restricts the potential of the Pokeball to be too heavy as well as too large in surface area. In order to abide by this constraint on the overall geometry and weight, the project set the appropriate requirements.

In addition to the constraints revolving around portability, there are also concerns for durability. As the audience for this project in ideal circumstances is broad and expected to be operated by various individuals, the Pokeball should be able to withstand a fair amount of wear and tear. The concept of the Pokeball revolves around the thought of a Pokeworld theme park, comparable to the relation of Harry Potter wands and Universal Studios, where individuals can interact with the Pokeball at the theme park. With this assumption, the park-goers would potentially drop the Pokeball while riding the attractions or accidentally drop it in a highly populated area. This concept that the Pokeball was based around requires it to be durable. Although it does not necessarily need to be the strongest material used, the Pokeball must have enough reinforcements to protect the hardware inside it. This constraint requires the materials to be relatively heavy-weight. The materials on the outer layer of the Pokeball must be stable enough and also affordable.

Individually these constraints are important and have a lot of influence on the design and production of the Pokeball. The functional constraints of this project also have a great effect on the other constraints that will be clarified deeper later.

The functional constraints are very important especially to the initial design of the Pokeball as it clarifies the importance of the parameters it must follow.

### X..2.2 Safety Constraints

In the hands of younger children, the Pokeball can be considered dangerous. Although the Pokeball is based on a franchise revolving around games and toys, that should not result in the Pokeball to be considered as a “game”. Due to the functional constraints, the Pokeball will be light but still have the capability to hurt an individual using it improperly. This constraint is not necessarily of relevance to the design or production but should be noted as it is a part of the business and marketing requirements.

The Pokeball should also have warnings regarding high heat and long water exposure. If exposed to high temperatures for a long period of time, the Pokeball may overheat and malfunction. Also one of the main concerns for the initial Pokeball design does not revolve around its capabilities to withstand water contact. For this reason, the excessive heat and water constraints are important to note for safety. This will prevent individuals from having their Pokeball malfunction. These circumstances should be preventable as the intended use for the Pokeball does not revolve around these constraints.

### X..2.3 Quality Constraints

As previously mentioned in the functional constraints, the intentions of the Pokeball have great importance on the design constraints. To restate, the intentions are for use as a Pokemon related theme park. The majority of park-goers typically intend to go to a theme park for a full day’s worth. For these concerns, the Pokeball requires reliability. The Pokeball at the minimum must last the majority of a day on low power mode. With the assumption that the Pokeball will not be in constant use for the entirety of the day, it should be able to function at various points of the day at a minimum. Due to this constraint, we must be conscious about the design and the lasting impacts. Considering our intentions for this project, this is a very important constraint revolving around the design of the Pokeball.

### X..2.4 Manufacturing Constraints

Manufacturability constraints require the components of the Pokeball to be limited to a simple build and easy to acquire materials. Due to the intention of the Pokeball, it should be easily manufactured as it will be mass produced for the majority of the park-goers. The manufacturing constraints are directly related to the economic constraints that will be detailed below. The Pokeball should be

relatively simple to assemble for a higher turnover rate. The production of the Pokeball is what the manufacturing constraints directly affects. In order for our project to be successful in the long run and be a lasting product, the manufacturing constraint is important.

### X..2.5 Economic and Time Constraints

Economic constraints limit the potential parts and have a direct impact on the other constraints. As our project is funded by four students, we do not have access to certain desirable components. The budget for the Pokeball is ideally under $200. Considering the required components, this budget is overestimated as some components are already in possession of some members and available for use for the Pokeball. Also for the desired requirements of the Pokeball, some of the components are potentially inexpensive. The cost aspect of the Pokeball is better if maintained as low cost due to the manufacturing constraints. Ideally if used for its intention, the low cost nature of the product will assist the manufacturing constraints to be a nonissue. The economic constraints are correlated to the functional and quality constraints. These requirements expect for the Pokeball to be of higher quality. The economic constraints are important to many of the other constraints and important to the engineering requirements as well as the marketing requirements.

In addition to the economic constraints, the time constraints are as important and also connected to the other constraints. The research portion of this project is to be completed by early August 2022. This should allow for the team to decide on the proper parts to purchase and determine the exact specifications and constraints to follow. After mid August 2022, the Pokeball design should be finalized and begin the production and testing phase. The Pokeball should be fully built by late October 2022. The initial design flaws should be solved by that point. Then the testing portion can begin to prepare for the product presentation in late November-early December. Considering the time constraints, it is important to realistically determine deadlines for the project to ensure a better product.

### X..2.6 Aesthetic Constraints

For our project, the aesthetic constraints are very important. The Pokemon franchise was established in 1996 and is well-defined and has a proper following. As our project is a component of the Pokemon industry, it must be reflected as well. If the Pokeball is not properly portrayed with its defining characteristics, it will not be well received by the public. The Pokeball has a distinguishable design and our product must reflect said design. It is a sphere where the top half is red

and bottom half is white. The two halves meet at a black line going horizontally across with a white button in the center. When properly designed, this will reinforce our project's intentions. Pokemon is known by everyone, not only individuals involved with the franchise. It is very important to implement this design correctly. This constraint is also associated with functional constraint. The Pokeball is portable in all of the Pokemon franchise's works therefore to mimic this our Pokeball must also be equally as portable. This constraint requires the Pokeball to have a specific design and requirements to meet rules of portability.

# X.1 Communication Networks

The communication network is crucial in two aspects for this project. When communicating from the Pokéball to the Pokémon gym battle experience, and the major network of the themed land itself that initializes and updates information in both itself and the Pokéball. When deciding what type of networks to utilize for both aspects, we investigated various network types. Some of the key features we require are: robust, reliable, private, and responsive. All of these requirements are discussed in the following subsections.

## X.1.1 Wired LAN

A local area network (LAN) had to be researched for the ‘back-of-house’ system that is integrated on the larger scale of the entire land. When researching different LAN networks, certain aspects of differing LAN connections stuck out amongst others. Wired LAN provides precisely what is needed on the backside of this project on the basis of reliability, privacy, and responsiveness. Wired LAN is the ‘most common’ connection for LAN usage. This connection ties to a central server, which is utilized for communication between differing experiences to update the set parameters necessary for guests to utilize them properly. This network type also provides access to only those physically connected through an ethernet connection. Other network types, such as the peer to peer (P2P) LAN were found to be less powerful and didn’t provide a centralized server that is necessary for the backend control needed.

## X.1.2 Wireless LAN

Wireless LAN has the potential to be utilized in numerous avenues for this theorized themed land. This network configuration allows for radiofrequency as the basis for data communication, but is also open to numerous security threats if not configured properly. This network configuration is also highly unreliable with factors such as location, number of users accessing it, and others. Wireless LAN is utilized in nearly every public location, and theoretically will be utilized in many ways on both front and backend applications for guest use. The practical utilizations for wireless LAN in this project is unfortunately exterior to the scope of this project.

## X.1.3 Infrared Communication

Infrared (IR) communications are based on infrared radiation that utilizes wavelengths neighboring those of visible light on the electromagnetic spectrum. Wavelengths of IR communications are larger than those of visible light, but smaller than those utilized in radio wave communications. The range of

wavelengths that infrared occupies is typically defined from 700nm - 1mm in length, while the frequency range is roughly 300 GHz - 400 THz. Interior to the wavelength range, IR can be separated into subcategories of near, mid, and far communications. Near IR is typically designated to 700nm - 3μm, mid IR designated 3 - 50μm, and far IR designated from 50μm - 1mm.

When designing the interior of the Pokéball, communications that can penetrate walls & general rigid geometry is crucial for the success of this project. This is in-part to the communication system being embedded on the interior of the Pokéball, but also due to the nature of interacting with attractions and other users utilizing the interactive Pokéball system. Unfortunately, IR communications do not process these necessary requirements. IR communications require line-of-sight (LOS) clearance to communicate with the intended receiver, and also fail to penetrate through surfaces that are necessary to see this project come to fruition. If infrared communication was to be utilized, the design of the Pokéball vessel would be drastically changed to no longer match the world of Pokémon, as well the project would require complete overhaul. The physics and engineering specifications that describe further as to why IR communications are limited in use are exterior to the scope included in this project.

## X.1.4 Bluetooth Communication

Bluetooth communication methods were the next progression in the research for how the Pokéball vessel can communicate with both other users, and the interactive experiences that are being pitched in this project. Bluetooth communication utilizes short-range radio wave communications, situated in the ISM band of 2.4GHz designated by the Federal Communications Commission (FCC). The true range that Bluetooth is designated to operate in is 2,400 - 2483.5 MHz, and typically reaches a range of 30 meters in commercial usage. While extensive design could take place to increase the range to accommodate for utilization throughout an entire experience or themed land; the time allotment to design, test, and implement would extend further than the deadline of this project. Other factors also made Bluetooth incompatible with this project, such as the security risks that occur when utilizing this communication system on a large scale. Considering this item can not only communicate with an internal database, but also with other users leaves room for potential cybersecurity issues if a cyberattack were to take place. While this project is intended to store no personal information of the guests in its realization, room for security issues can still arise with Bluetooth systems in place. Utilizing Bluetooth as a proof of concept in this project would suffice, but for actual deployment other communication means would be necessary. Therefore, we have decided to forgo the utilization of Bluetooth, and rely on other communication means as the basis of this project.

## X.1.5 Radio Frequency Identification

Continuing the research of how our Pokéball system will communicate with the overall experiences of our themed land and the neighboring users; we further navigated through the electromagnetic spectrum to reach Radio Frequency Identification (RFID) systems. RFID systems include two major subsystems: readers/writers & tags. Unlike IR communications, RFID does not require LOS for communication, nor is it as limited in penetrating rigid geometry. There are major positives to the deployment of RFID communication means in a project such as this. Some of the positives include the lacking requirement of LOS communications, as well as the capability of robust control of reading/writing terminals to initialize and identify numerous differing tags at one time. Just as with IR communications, RFID systems consist of numerous frequency ranges. Low frequency (LF) ranges from 30 - 500KHz, and can operate within ~1 meter of the reader/writer. High frequency (HF) operates from 3 - 30MHz, and within ~1 meter of the reader/writer, similar to LF. Ultra-high frequency (UHF) occupies the frequency range of 300 - 960 MHz, and can be read from much farther distances of +8 meters. While RFID provides numerous upsides for a project of this caliber, there also comes concerns that could arise.

In the previous section discussing Bluetooth, the concerns of cyberattacks was brought up. This concern also arises with the implementation of RFID. There are concerns that potential attacks could occur to corrupt, transform, and overall distort the data that is being transmitted by the RFID tags, readers, and writers. These concerns are hyperspecific in context though, as this would require guests in range of the devices to own and operate personal RFID readers and writers. This risk can also be taken under control by two main measures: the prohibition of personal RFID readers and writers interior to the themed experience, and not utilizing any personal information in the transfer of data during the experiences themselves. Enacting these two measures can reduce the risk of potential cybersecurity issues to a negligible percentage value.

Continued research into RFID implementation shows differing subcategories further than frequency band range. Passive and active methodology in RFID communications also inform major design decisions for this project. The discussion of passivity and activity are featured in the following subsections.

### X.1.5.1 Passive Tags

There are two major types of tags that can be embedded in our vessel, passive and active tags. Passive tags are constructed and designed to feature no internal power system. The power required to transmit data from the antenna comes in the form of the electromagnetic waves sent by the reader/writer and induces a magnetic field in our passive tag. Under Ampere’s law this induces a current in the tag system to then return information requested by the RFID reader. There are both positives and negatives to the deployment of this system. Some negatives include the lack of range due to no internal power system, and lack of

scalability memory sizes due to the same reasons. Positive aspects of this tag type are more financially based, as the tags are far cheaper to manufacture and last far longer due to not relying on other parts for operation. This option deployed in the proper size and scale can be tolerated for a project of this sort, but these types of tags would require more output power and reading locations across the differing experiences. Financial analysis could be completed to compare different system deployments, but that is vastly outside the scope of this project.

### X.1.5.2 Active Tags

Included in the active tag category lies two other subsets; beacons and transponders. Though similar in design and completion, the realization of these two subsets of active tags provide differing results. Active tags differ from passive as previously stated, due to an onboard power system. Thus allowing for greater storage capabilities, and faster sending & receiving times at the request of a reader. This system does cause for higher cost per unit, and an overall larger system, but does allow for a robust level of control and far greater transmitting ranges due to that additional power system. When concerning the idea of active tags, safety and security must be in the conversation. Active tags do introduce the concept of tracking the Pokéball's movement when in range of a reader. When away from a reader set to the designated frequency specified for the Pokéball tags, the idea of tracking becomes a nonissue. When in the range of readers surrounding the theorized land, the understanding of where guests go, at what time, and in what volume provides necessary data to continually improve the efficiency & effectiveness of this land. This data can be compiled for numerous utilizations, but the detailed description is outside the scope of this project.

Stated above are the two major subsets of active tag systems; beacons and transponders. Beacons are active tags that continually operate at a certain clock cycle frequency, usually every 3-5 seconds transmitting outward. These systems do not operate at the control of a reader antenna, but operate on that cycle regardless of whether the transmission is heard or not. These systems can be utilized in numerous industrial industries, but if the system is battery operated (as this project will be) you run the risk of wasting energy even when at a far range from the experiences that best utilize the Pokéball. Transponders are similar in fashion to beacons, but with much higher efficiency than that of its counterpart. Transponders will sit in an idle state, wasting far less energy than that of a beacon, until the reader antenna requests information from the specific tag. These systems are remarkable at wasting little to no battery life when far from the reading range radius.

# X.2 Microcontrollers & Microprocessors

The purpose of the microcontroller in this project is to be the base of our RFID transmitting, writing, and receiving. This can be realized by utilizing a specified microcontroller unit (MCU) with the correct number of general purpose input/output (GPIO) pins connected to a purchased RFID reader/writer. With varying MCU manufacturers, extensive research was completed to ensure the proper unit was selected; along with the proper RFID module that is compatible with our selected MCU. The following sections provide a breakdown and in-depth look into the decisions surrounding the MCU & RFID units.

## X.2.1 Microcontroller Selection

The search for a base microcontroller began with looking into the product line that is provided by Texas Instruments of Dallas, Texas. The primary reason of searching into the products of Texas Instruments (TI), was due to the following:

- Supply chain availability
- Expansive product line with varying MCUs
- Experience gained in relation to the manufacturer through varying coursework
- General ease of use

These features among numerous others guided us to begin the search here. The main MCU that TI has available to purchase is the MSP430 microcontroller, a 16-bit general use analog microcontroller that was first introduced into the electronics market in 1992. This MCU encompasses over 2000 variations, under four major categories:

- General purpose
- Sigma-Delta Analog-to-Digital Conversion
- Capacitive Touch Sensing
- Ultrasonic Sensing

Of the four major options, general purpose is where the vast majority of their products land, and where this project will also land under. Two primary families of MCUs live under the MSP430 general purpose umbrella that fit into our project potential:

- MSP430FRXXXX
- MSP430G2XXX

The major differences of the MSP430FR and MSP430G series of MCUs lie in their price point, communication systems, memory size, speed, and overall capabilities. Though both are named MSP430’s and operate under 16-bit systems, both vary in operation.

The MSP430G series is a staple of the ‘value line’ greater-value MCUs that TI has to offer, as where the MSP430FR series is included in the more robust

FRAM series of MCUs. FRAM, Ferroelectric Random Access Memory is a specialized category of non-volatile flash memory that has a much faster reading/writing capability than traditional RAM. This type of memory can accommodate for many other features that normal flash memory cannot account for.

| **Comparisons** | **FRAM** | **FLASH** |
|---|---|---|
| Non-Volatile | Yes | Yes |
| Write Durability | 1x10^15 | 1x10^6 |
| Write Speed (per cell) | 50ns | 0.05ms |
| # of Processes to Write | 1 | 2 |
| Operating Voltage | ~1.5V | 10-14V |
| Safe to Solder With? | Yes | Yes |

Table X.2.1 FRAM vs. Flash Comparisons

The advantages in lifetime, speed, and capabilities of the FRAM based MSP430 MCUs versus those of the traditional flash memory based MCUs guided us to then proceed with further research into the MSP430FR MCUs. The MSP430FR series of MCUs features over 130+ distinct microcontroller units on the TI catalog. The scope of this project does not allow for extensive search into this number of differing units, so experience with specific FR series units was needed to guide the research completed in this stage of the project. Through differing courses and personal development, experience was gained with the MSP430FR6989 microcontroller unit that TI offers. This distinct product includes numerous features that allow for endless general purpose projects, and with those features we are able to complete this project as defined by our set scope.

| **MSP430FR6989** | **Data Sheet** | **Research** |
|---|---|---|
| **Specifications** | **Data** | **Interpretation** |
| Architecture | 16-Bit RISC | Fast operating with low power consumption |
| Minimum Operating Vcc | 1.8V | Informs battery choice |
| Maximum Operating Vcc | 3.6V | Informs design decisions |

| | | |
|---|---|---|
| Minimum Operating Temperature | -40C | Meets required spec for this project with ease |
| Maximum Operating Temperature | +85C | Meets required spec for this project with ease |
| Max Clock Frequency | 16-MHz | Required for use with the RFID module |
| FRAM Memory | 128KB | Informs design choices |
| SRAM Memory | 2KB | Informs design choices |
| GPIO Pins Available | 63 / 83 Pins | Depends on the package of PN or PZ |
| Active Power Use | 101.25 µA/MHz | Informs design choices for other modules tied to MCU |
| Clock Systems Available | DCO<br>HFXT<br>LFXT | Informs design decisions on backend / software interpretation of data |
| ADC | 12-bit SAR | Useful conversion knowledge to be used in design. |
| UART | 2 | Informs design choices. |
| I2C | 2 | Informs design choices. |
| SPI | 4 | Informs design choices. |
| Data Bus Width | 16-Bit | Informs design choices. |
| Price | $12.80 per unit | Major consideration. |

Table X.2.2 MSP430FR6989 Datasheet Specifications

Through discussion and design collaboration within the group, we found this MCU to meet all specifications defined by the scope of this project. Although, to ensure the due diligence and proper research defined by an engineering project was met, we continued to explore other MCU options that were provided by different vendors and manufacturers. This led to searching into other widely known MCUs such as the Arduino UNO.

The Arduino UNO is a highly popular MCU designed and manufactured by Arduino. The central processing unit (CPU) that is utilized in the UNO MCU is the ATmega328P designed by Atmel. The Uno comes with its own integrated development environment (IDE) that allows for the MCU to be programmed. The current version of the Uno that has been researched is the Rev3 model that is available for purchase directly from the Arduino catalog. Similar to the search beginning with the catalog of TI, the search into the catalog of Arduino was informed from key factors such as:

- Supply chain availability
- Current availability through group members personal inventory
- Applicable experience gained through personal & research projects
- General ease of use & a lower learning curve than other MCUs

Arduino as a manufacturer features an expansive catalog of boards with differing MCUs to choose from. Some of the more popular boards (from quantity sold) are the:

- Arduino UNO
- Arduino Nano
- Arduino Due
- Arduino Mega

As mentioned previously with the research discussion on TI MCUs and boards, the scope of this project does not allow for the extensive research into every Arduino board that is manufactured. Understanding and refining the scope of this project allowed for the search into the UNO to represent the catalog of Arduino.

There are many aspects to the UNO and the Atmega328P that allow for the scope that we did define to be completed. Just like the MSP430, the Atmega328P features an advanced RISC architecture, but rather 8-bit than 16-bit control. The board features of the UNO are also accounted for in the decision for this project.

| **Arduino UNO Board Specifications** | |
|---|---|
| Operating Voltage | 5V |
| Input Voltage Minimum | 6V |
| Input Voltage Maximum | 20V |
| Input Voltage Recommended Range (Recommended by Arduino) | 7-12V |
| Digital I/O Pins | 14 |
| Flash Memory | 31.5KB (From Atmega328P) |

| | |
|---|---|
| SRAM | 2KB (From Atmega328P) |
| Clock Speed | 16 MHz |
| Power Jack | Yes |
| USB | Yes |
| Price | $27.60 |

Table X.2.3 Arduino UNO Board Specifications

Along with these specifications, the UNO board features other specifications that were kept in mind as research continued. Some of these factors included the layout of the board, the I/O pins, and how those pins can be configured. The board of the UNO includes both a +3V3 and +5V pins, along with 6 other pins that are configurable with pulse width modulation outputs (PWM). The PWM output pins can be configured separately to obtain different duty cycles on each of the pins if desired. Although this feature proves useful for many other general purpose projects, the PWM pins provide no expansive use in the scope of this project.

The Atmega328P microcontroller as stated is an 8-bit advanced RISC architecture, but created with CMOS. Just as the RISC architecture of the MSP430 of TI, most instructions on this MCU are executed in a single clock cycle. With sacrificing 16-bit architecture for 8-bit architecture, the main difference would be speed of the processes and arithmetic involved in the processes. Even though our data-bus is only 8-bits in width, the Atmega328P does include registers that feature true 16-bit design for timers. The TCNT1, OCR1A/B, and ICR1 registers are all designed and implemented into the Atmega328P as 16-bit registers that can be accessed via the 8-bit data bus through the CPU. Also featured is 32 x 8 general purpose registers in the MCU.

| **Atmega328P Data Sheet Research** | | |
|---|---|---|
| **Specifications** | **Data** | **Interpretations** |
| Architecture | 8-bit RISC | Half the bit value of MSP430, held in consideration with processing power |
| Minimum Operating Vcc | 1.8V | Informs battery choice |

| | | |
|---|---|---|
| Maximum Operating Vcc | 5.5V | Informs design decisions |
| Minimum Operating Temperature | -40C | Meets required spec for this project with ease |
| Maximum Operating Temperature | +85C | Meets required spec for this project with ease |
| Maximum Clock Frequency | 20MHz | Higher than MSP430, held in consideration for design decision |
| Flash Memory | 32KB | Much less than the MSP430, and not FRAM |
| SRAM | 2KB | Matches that of MSP430 |
| GPIO Pins Available | 23 | Informs design decisions |
| Active Power Use | 0.2mA/MHz | Higher than that of MSP430, but not a make-or-break number in design process |
| Power-down Power Use | 0.1µA/MHz | Informs design decisions |
| Clock Systems Available | Low Power Crystal Osc.<br>Full Swing Crystal Osc.<br>Low Frequency Crystal Osc.<br>128kHZ RC Osc.<br>External Clock | Numerous sources for the clocks that can be designated to various elements in the MCU |
| ADC | 10-bit | Informs design decisions |
| UART | 1 | Informs design decisions |
| I2C | 1 | Informs design decisions |
| SPI | 2 | Informs design decisions |
| Data Bus Width | 8-bit | Informs design decisions |
| Price | $3.11 per unit | Major consideration |

Table X.2.4 Atmega328P Datasheet Specifications

Arduino features a full SCH, PCB, and 3D view of the UNO board on their online catalog. When exploring the schematic view, certain elements of the existing engineering efforts put into the board were both apparent and appreciated. The Atmega328P features an analog VCC pin named AVCC that separates the analog from the digital to reduce noise in the overall MCU. The AVCC pin ties into a +5V source that then ties directly into a 2nd order
low-pass filter with a 10μH inductor and 100nF capacitor. The normally established VCC pin ties directly to a 100nF capacitor through the +5V source to act as a bypass capacitor to element noise in the system. Being able to analyze both AVCC and VCC pins as examples of the noise management engineering of the MCU compels an argument to show the quality of the MCU that is being researched during this phase of the project.

When arriving at the selection point for our MCU, considerations that have been stated previously and others were kept fully in mind. The comparisons for the two units presented and those considerations are featured here:

| **MCU Comparisons** | | |
|---|---|---|
| **Comparison** | **MSP430** | **Atmega328P** |
| Clock Frequency | | X |
| Op. Voltage Range | | X |
| Memory Size | X | |
| Power Usage | X | |
| Price | | X |

Table X.2.4 MCU Comparisons

The final decision was made to be the Atmega328P and the components thereof found in the Arduino UNO as the basis for our MCU utilized throughout the finality of this project. The price, clock frequency, and range of voltage operation compared to that of the MSP430 stood out as the specifications we required for this project. Other factors, such as the open-source nature of the Arduino IDE and variety of usage found within the board and MCU, led us further into confidence with the decision of the Arduino UNO utilizing the Atmega328P. With the current situation as of Summer 2022 and the supply chain of most electronic goods and the global economy, group availability of both MCUs that were researched was found to be an extreme gift and is felt with immense gratitude amongst all members. Having the lead time of 0 days on a major component defined by the scope of this project provides for the immediate advancement of

the design, and realization of this project to not be further constrained into the future of both Senior Design 1 & 2.

## X.2.2 RFID Module

WILL also include a discussion on soldering & decisions for throughole vs surface mount for the MCU & other components.

# X.3 Pokéball Shell Material

This following section describes and walks through the research and development on the material selection for the hard shell casing that the Pokéball will be constructed of. The PCB containing the RFID receiver will be encased in the interior of the Pokéball once the final showcase installation is made for Senior Design 2 in the Fall 2022 semester. The following discussion details how the world of Pokémon and the story we are telling is the driving force of this project, and how that integral story informs all of the design decisions that are made along the course of this semester and next. A crucial element to the project's success is the fidelity in which we present the world of Pokémon and how immersed a user can be once inside of this fictitious land that is presented here. The core idea that RFID items can be controlled in the palm of the guests hand adds a layer of care that was highly regarded during the design of the Pokéball.

## X.3.1 Staying True to the World of Pokémon

Beginning with the design of the Pokéball itself, the source material was treated as a guiding light for how this design can not only function as intended, but stay true to the world of Pokémon at the same time. When discussing the project during the proposal phase, the stretch goal of creating more than one Pokéball was mentioned and fleshed out. This allows for more room to explore the world of Pokémon itself, and the differing Pokéballs that are offered inside of this universe. Although enticing to those who are fans of the Pokémon franchise, staying grounded to the scope of this project was necessary. A decision to create one type of 3D printed shell, but spend more time on that design to ensure thematic requirements were met was agreed upon. Rather than design 2-4 differing shells and produce a product that is less than 100% up to standards. Once the decision to create a hard shell that is reproducible was made, the study of the world of Pokémon and the Pokéball itself was required.

### X.3.2.1 Brief History on the Pokéball

Defined by the Pokémon Group and a verified online encyclopedia named “Bulbapedia”, the Pokéball is a critical item to a user's quest to catch and store Pokémon. The term is used as both a blanket term for all varieties of Pokéball, but also the proper name to the basic starting item to begin the trainer’s journey. This basic item is the one that is defined by the scope of our project.

Figure X.3.1 Pokéball Reference (Provided by The Pokémon Group)

In the base Pokémon world, there are 27 variants to the base Pokéball. The core design is an upper red shell and lower white shell combined together with a black internal case that features a white button at the center. The white button is a momentary push button that allows for the Pokéball to then attempt to either capture or release the Pokémon in question. In the printed and onscreen media for Pokémon, the entire Pokéball glows as the momentary switch is triggered and transforms the Pokémon into or out of an energy state that allows for the containment of the creature. Unfortunately due to the current laws of physics, creating an orb that can transfer items into and out of the 4th state of matter is currently outside of the scope of this project. We hope as a group to revisit this feature in the future, and hope that innovation has provided for safe usage in a commercial environment. Until the change in natural law, this aspect of the Pokéball must be overlooked and proceed to delve into the color choices and why the shapes are presented in the form they are.

The Pokéball base item that is designed and produced for this project has seen various forms throughout the various media that Pokémon has been presented in. The early printed literature for the world of Pokémon presented the base Pokéball in a similar fashion to that of the figure above, but featuring slight variations that inform differing design decisions. On-screen media such as the numerous television series and feature films based in the world of Pokémon show a near identical Pokéball to that of the figure above. The beginnings of Pokémon were found in the video game industry, and feature a base Pokéball that has been presented identical to the one featured in the figure above. With the television and video game produced Pokémon media being the most recognizable (as well as the origin), the design for the item itself was then proceeded with grounding in the representation found in that media source.

With the custom PCB having to fit into the interior of this Pokéball, a design decision was made to differ from the world of Pokémon that is presented in the television media. In that form, the Pokéball itself can open up and the internal mechanisms that tightly cling to the interior walls can be viewed in various episodes. The hinge mechanism that allows for the upper red half of the shell to open away from the lower white half of the shell are never shown. In this media form, it appears as if no hinge is actually visible. This causes for a few differentiations from the world of Pokémon that are required to see the realization of this project in a safe and reliable manner. Those major differenations are:

- The shell WILL NOT open on a miniscule hinge function as presented in the television series'
- The shell WILL open in a different manner to allow for servicing as seen fit throughout the operational and troubleshooting phase of this project
- NO visible internals will be designed in high fidelity as to not impede on the scale restraint for the custom PCB that will fit interior to this item

With these major considerations kept throughout the design phase of this shell, the next milestone in the Pokéball shell research and design was to decide how the shell was to be realized to meet requirements defined by our scope.

## X.3.2 Material Research

When beginning material research, one guaranteed factor was the necessity for this material to be manufactured through 3D printing means. The required shapes and configurations of the shell are not available through off-the-shell products, so 3D printing is the default course of action to construct the assembly.

## X.3.3 Design of the Pokéball

# X.4 Programming

## X.4.1.1 Programming Language

Programming languages that would be best suited for this project at this specific scale are C and C#. Equipment like microcontrollers, smaller grade PCBs and RFIDs do not require high level languages for the technology to function.

Why not any other languages? Embedded projects and applications typically need a quick runtime. This project would require simple tasks from the actual code like retrieving, storing, and displaying data. Object Oriented (OO) languages such as Java could potentially slow down the device. It can also lead to other internal issues because OO programming requires larger memory space than our hardware can possibly handle.

## X.4.1.2 RFID Programming

For a successful implementation of an RFID tag/card, there must be a successful programming of the RFID reader which is projected to be in or on the Pokeball shell. Each tag needs to be assigned an ID which will essentially be the ID of the player. When using the tag to access any system, the algorithm must be able to find the existing tag ID within the system and then move on to “if” the ID exists, “then” assign this pokeball. Another useful practice would be to also implement a program that is able to read foreign/stolen RFIDs and freeze the ID with the same “if, then” algorithm. The figure below displays a general software flow of the RFID.

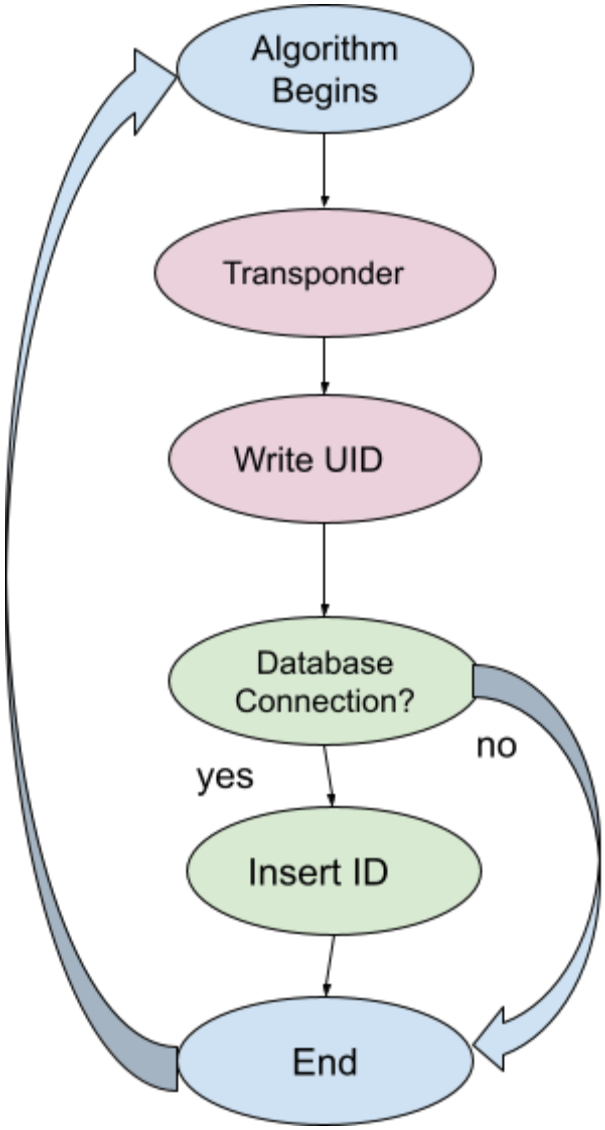


Figure 5: RFID software flow

## X.4.2 Database Design

For configuring the device for the necessary aspect of this project, we must first establish a database in which the pertinent information and identifiers will exist. The figure shown below is a flowchart regarding the necessary steps regarding configuring the Pokeball and Pokemon. This step in the software will require the assistance of SQL programming to properly integrate the database. The database will hold vital information about the Pokeballs, including but not limited to the unique guest ID, unique Pokeball ID, unique Pokemon ID and the overall Pokeball score. The program will first distinguish between three options the user could potentially make: new pokeball configuration, pokemon configuration, or

updating scores. New pokeball configuration is only meant for initial activation by the supervisor. This will start the connection with the RFID and continue to record statistics. It will also store the guest ID and the Pokeball ID during this initial step. The secondary option is for when the user “catches” a Pokemon. This will connect the chosen Pokemon ID with Pokeball ID. After the Pokemon is connected, it will not allow for another Pokemon to be connected. Only one Pokemon can be connected to the Pokeball at a time. The last option is only to occur after the first two have been configured. The Pokeball will store statistics of the Pokeballs and the Pokemons. As the user interacts with different activities, it will collect points. The database will store the individual score of the Pokemon and the overall score of the Pokeball. This information will be stored in the database and will be accessible to determine any pertinent information relating to an individual Pokeball or Pokemon.

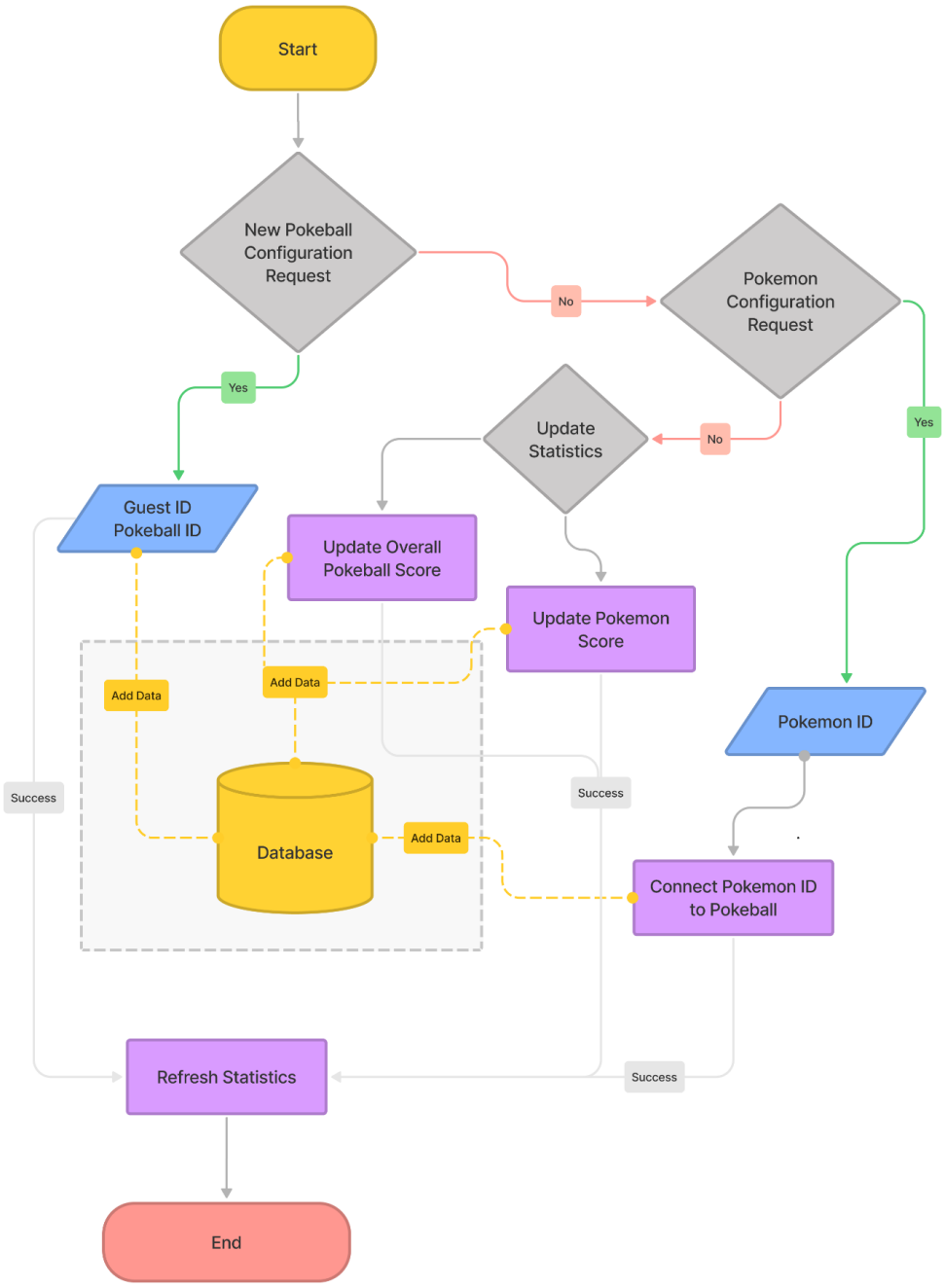


Figure 6: Backend Software Flowchart

## X.4.3 Software Security

From a security perspective, there needs to be a few components placed into our program to not only ensure that the PokeBall software is safe, but also that the user/admin information is safe as well. A couple of software requirements that can be implemented into the design could be (but not limited to): 2 Factor authentication, minimum password length, restricted and tiered admin, and location based login. In order to have full functioning and seamless security measures the front-end UI will have to be coded in Javascript (JS). This should have no effect on the pokeballs itself but only make the user/admin experience easier.

### X.4.3.0 Minimum Password Length

Minimum password lengths are quick and simple to implement. This security measure lowers the probability of attackers guessing passwords and having access to restricted information. The code itself should not go beyond the HTML layer. In HTML, there are certain parameters that can be placed on input form. For an example if there was a need to have a 16 digit passcode (in which in 8 digit will be fine) then the input tag would look to something like:

<input type = “password” minlength - “16” required>

The required tag will trigger a warning message to the user informing that they should be using a 16 digit password. There is also a technique to implement password requirements in JavaScript, but for this project it will not be necessary since we want to keep a balance between programming languages and not make anything more advanced than it needs to be. We also don’t need to stop at just the password lengths, but the type of characters that are being put into place. A lot of common requirements can be but not limited to: a mix of numbers and letters, special characters, and lower/capital case letters. Specific password requirements are also a new attribute that can easily be done in HTML, the syntax would just have to look like:

<input type = “password” minlength =“16” required passwordrequirments = “required: upper; required: lower; required>

### X.4.3.1 2 Factor Authentication (2FA)

2 factor authentication is a common practice when it comes down to securing information. While it is not bulletproof it does add an extra layer of security. Because players will not really have access to UI themselves, the 2FA will mostly be directed towards admin. While also considering that the whole design will most likely be programmed in a low-level language, the best case scenario of having 2FA will be generating a random pin that the admin will have to input before accessing any sort of data. To implement this, we will have general login data that is pulled from the database (normal login) and in between the layer of the logged in page and actual UI, there will be a place to input a 4-6 digit pin. Ideally the 2FA portion will most likely have to be coded in Javascript. The key will be to keep any front-end facing code away from the hardware itself, that way it will not mess up the functionality of the RFID and pokeball. Javascript is also able to implement email verification, so in order to add a seamless transition between pin and input, the code itself can generate a random pin that will be sent to a work email in which the admin can access. The header to achieve any kind of email validation in Javascript would be “email.js”. This header contains the file that holds all the necessary components needed to. Email.js is mostly used for email validation which is necessary if we are going to incorporate any kind of email structure. With this being said, the code itself must go through an algorithm that checks if the email is within the right syntax and also if it even exists.

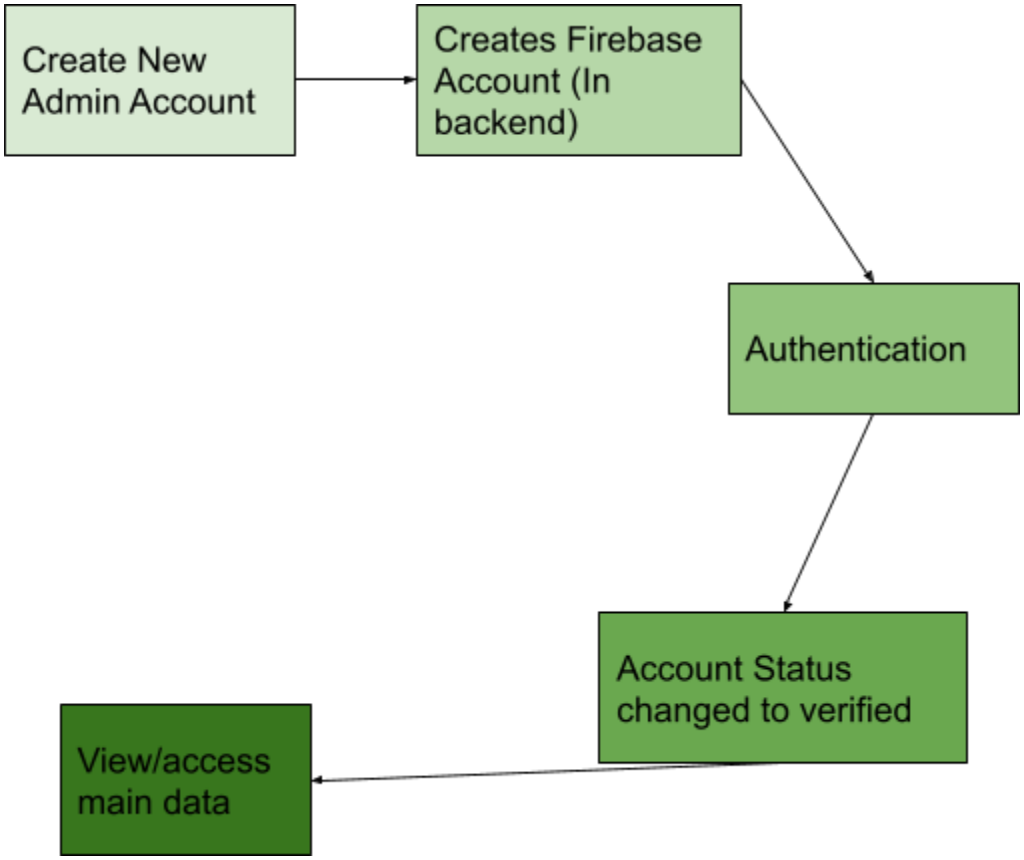


Figure:

Dependencies for email verification should be installed into the packages as well. Firebase is a free tool accessible to developers that will take out any complexities to send an email authentication with JS. In the code itself a function will be created that will call Firebase to create a new profile that is provided from the user input. When Firebase has successfully created an account, it will send a link to the email requesting that it authenticates the email. This will change the status of the admin's account and they will be able to access whatever they have permissions to access. While it sounds as if the software flow is becoming complex, these are all simple components that will not weigh down the program, just added security measures.

### X.4.3.2 Tiered Admin

In most entertainment and technology industries, admin are typically designated specific roles to limit misuses of the technology. Our system Ideally should contain a minimum of three roles labed: gray, red and gold. These roles will be established and designated into our database. When an admin with certain permissions access the frontend facing UI, any changes that they are to make

will either be inaccessible or unsavable. An example of tiered admin will be displayed below.

| | Gray | Red | Gold |
|---|---|---|---|
| View Scoreboards | ✓ | ✓ | ✓ |
| Update Scores | ✓ | ✓ | ✓ |
| Edit Code | | | ✓ |
| Block users | | ✓ | ✓ |
| Delete History | | | ✓ |
| Create User | ✓ | ✓ | ✓ |
| Delete User | | ✓ | ✓ |
| View User Information | ✓ | ✓ | ✓ |
| View Game Status | ✓ | ✓ | ✓ |

Table : Tiered Admin

### X.4.3.3 Location Based Login

Location based login will be a feature used on the UI to ensure that no one who is not currently in the park or near the Pokemon attraction will have access to any on-going battles and players. Even the admin will not be able to access the software if they are not on the grounds of the attraction. A possible way to set up this security measure would be to grab the geolocation at the time of user login. The way that geolocation works in JS is similar to email.js in the sense where it takes the longitude and the latitude of an ip address and it returns the location based on those variables. A simple technique would be to define a range of longitude and latitude pairs and compare the logged in geolocation to anything that is in those pairs. If it falls outside of those ranges, then the program will not allow the user to successfully login. These methods also can be used to find time zones' so in the case that an attacker from another country or even a state like texas, then the UI will still be inaccessible if the comparison does not match. It may also be more accurate because it can be an added measure to confirm if the geolocation is in fact what it pulled up to be. A concern may be usage of a VPN, but in a hypothetical scenario that this Pokemon is integrated in a park like Universal, then the cyber security resources that can be provided will be much more advanced that hardcoded security measures.

There is also another technique to enable geolocation detection in javascript without the use of longitude and latitude variables. HTML5 / JS has a header called geolocation. When you call the attribute within the code, it should be able to pull the user ip address location. Below would be the pseudocode to (in theory) execute this action.

```
Function getlocation ()
 {
nav.geolocation.getCurrentPossition(x, y);
}
```

After the program has received the geolocation or at least attempts to, the program should then run through a few switch cases that hold error functions/codes to ensure that the programming is not pulling user location for no reason and letting them through. Error codes will range from what is shown in X.4.3.4

### X.4.3.4 Error Codes

In addition to ensuring that there will be added security measures, we need to understand what error codes will be in place so that both admin and user understand why they may run across issues. These error codes are also supported by Firebase which will be used to authenticate emails. Now what normally happens when a request is made (example: entering the domain of a website to access content) a status code HTTP 200 is returned. Some do not know this because it is typically not visible to the user. But When a request is made, and something has gone wrong on either end point, a status code of HTTP 400-500 is returned back to the user. This is why one may receive the common “Error 404 Not Found”. These error codes will be implemented an either security component, whether passwords, email validation, and geolocation data.

| Error | Meaning |
|---|---|
| ALREADY_EXISTS | Request has an existing duplicate |
| INTERNAL | Firebase server has returned an error (check firebase) |
| INVALID_ARGUMENT | Invalid parameter, or input |
| NOT_FOUND | Request has attempted to edit or update a page or component that |

| | |
|---|---|
| | does not exist |
| PERMISSION_DENIED | User does not have access to make the request |
| UNAUTHENTICATED | Request does not have the appropriate credentials to move forward |
| TIMEOUT | Request has exceeding time to appropriately move forward |
| UNKNOWN_ERROR | Unexpected and unknown error |

Table : Error Codes

## X.4.4 Software Tools

Our project requires various software tools to assist in our project. In order to properly coordinate within the group, there are important software tools to consider. In a project such as this one, communication, planning, and developmental tools are all equally as important.

### X.4.4.1 Communication

In order to accomplish the tasks to work towards our Pokeball, we must use a dedicated communication tool. There are many choices to consider for communication. Ultimately we decided to use Discord and Google Drive.

#### X.4.4.1.1 Discord

For general communication, we choose Discord to be our main source of contact. Discord allows for private servers and the creator of the server must invite members to join said server. Another benefit to using Discord is the cost. It is free and allows us to communicate with no financial commitment. Unlike other options, Discord is available on all platforms and allows for easy communication through phone, laptop, and web. All of the team members have Discord installed originally and did not have to allot additional storage space to a new app. As we all already owned the app, we were familiar with Discord's environment. Discord also has a voice chat capability to allow us to easily conduct team meetings within the app. When we begin developing the Pokeball, if any individual runs into an issue that requires assistance from another team member, Discord also has screen share capabilities. It allows for all of the members to view the screen

of another's without being together in person. Due to all of Discord's capabilities, Discord was the best platform to conduct our communication.

#### X.4.4.1.2 Google Drive

Google Drive is the most efficient platform to share files. It is very easy to create a shared folder in which all necessary files pertaining to our project can exist. Google Drive has various softwares with it to assist us in our project. Google Docs allows us to seamlessly write our reports together online. This way we do not have to share documents and merge information, but rather it is already all in one location to begin with. Google Drive is all accessible on all platforms and is easier to use and understand.

### X.4.4.2 Planning

### X.4.4.3 Development