Final Design Document

Project 07: International Darth Vader

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Product Requirements

The International Darth Vader is a global education tool for students to share music, ideas, and inspire creativity. This product is designed to increase communication between international classrooms and break the isolation of creativity. It will help inspire students to take part in media education and creation, which in turn will help them develop and succeed. This section of the document outlines the met requirements of the final project design. These requirements were determined based on the product's intended use, target market, and original specification. Some requirements have been reworded slightly due to minor changes in implementation since the design phase, but are still classified as being met.

2.1 User Interaction Features

This section details the list of achieved user interaction requirements for the final International Darth Vader product. The list of features is provided in a numerical list below with each list item giving a description of the provided requirement. The requirements in red were not achieved with the final product.

1. The system shall connect to a router using 802.11 Wi-Fi technology to communicate with a backend server.
2. The system shall be able to play-back 15 seconds of voice and music uploaded from a client session.
3. The system shall be easy to configure and connect to a network.
4. The system shall use an Android application for user input.
5. The backend application shall support an archive feature for stored sound clips.
6. The backend application may be adaptable to physical memory upgrades. Amazon S3 will dynamically allocate memory as needed with an associated cost.
7. The database shall support a tagging system for clip filtering and administration.
8. A client shall be able to upload voice and audio clips to the backend.

2.2 Size, Weight, Look, & Feel

This section details the list of achieved size, weight, look, and feel requirements for the final International Darth Vader product. The list of features is provided in a numerical list below with each list item giving a description of the provided requirement. The requirements in red were not achieved with the final product.

1. The system shall be housed in a Darth Vader figurine.
2. The system shall be light enough to be carried by one person (i.e. less than twenty-five pounds).

2.3 System Behavioral Features

This section details the list of achieved system behavior requirements for the final International Darth Vader product. The list of features is provided in a numerical list below with each list item giving a description of the provided requirement. The requirements in red were not achieved with the final product.

1. The system shall interface with 802.11 a/b/g/n Wi-Fi network connections.
2. The system shall have rechargeable lithium polymer batteries to help address areas with electricity limitations.
3. The system shall be able to be switched off to save power when it is not being used or is being transported.
4. The system shall have high quality 3W, 4-ohm speaker for audio playback.

2.4 Required Documentation

This section details the list of achieved documentation requirements for the International Darth Vader product. The list of features is provided in a numerical list below with each list item giving a description of the provided requirement. The requirements in red were not achieved with the final product.

1. The system shall have setup documentation.
2. The system shall have usage documentation.
3. The system shall have support and troubleshooting documentation if it needs to be serviced by the user.
4. The product shall have documentation detailing instructions and interaction between client, cloud, and product.

2.5 Maintenance Requirements

This section details the list of achieved maintenance requirements for the International Darth Vader product. The list of features is provided in a number list below with each list item giving a description of the provided requirement. The requirements in red were not achieved with the final product.

1. The system shall be easily and minimally maintenance.
2. The system may have simple diagnostic programs to verify system integrity. *The system can be debugged and checked for system issues. This requires knowledge of Linux operating systems and the removal of embedded components or knowledge of network SSH access.*

2.6 Compatibility Constraints

This section details the list of achieved compatibility requirements for the International Darth Vader product. The list of features is provided in a numerical list below with each list item giving a description of the provided requirement. The requirements in red were not achieved with the final product.

1. The system shall be compatible with common IEEE 802.11 a/b/g/n network standards.
2. The system shall be compatible with Android mobile platform.
3. The system may be compatible with other mobile platforms. *The server and embedded system can easily accept different clients if an application were developed for other systems.*
4. The backend server application shall be compatible with a UNIX based operating system.
5. The backend server application may be compatible as a Windows server application.

2.7 Cost Constraints

This section details the list of achieved cost constraints for the International Darth Vader product. The list of features is provided in a numerical list below with each list item giving a description of the provided requirement. The requirements in red were not achieved with the final product.

1. The product shall be under $50 excluding the Darth Vader figurine. *Excluding the cost of the Darth Vader figurine, the product comes in at just under $90.*
2. The client phone app shall be free to download. *The application is not currently published to the Google Play store, but is completely ready for publication.*

2.8 Design Constraints

This section details the list of achieved design constraints for the International Darth Vader product. The list of features is provided in a numerical list below with each list item giving a description of the provided requirement. The requirements in red were not achieved with the final product.

1. The design and implementation shall refrain from severely altering original Darth Vader appearance, retaining the shape and structure.

2.9 Interface Constraints

This section details the list of achieved interface constraints for the Darth Vader product. The list of features is provided in a numerical list below with each list item giving a description of the provided requirement. The requirements in red were not achieved with the final product.

1. The client interface shall be simple and straightforward so that it can easily be used by people of all ages.
2. The interface shall be accessible on the Android mobile platform.
3. The backend shall be easily managed from the server application. This will allow sound clip approval before forwarding to the Darth Vader system. *The backend is managed through an Amazon management application specifically for the S3 service.*

Prototype Pricing

The International Darth Vader product utilized a combination of many different components to achieve functionality. The tables below show the list of components used in the creation of the prototype including the part's name, quantity, manufacturer part number, vendor part number, price for one component, and total price for the sum of components. Each table below contains parts provided by the vendor whom supplied them. This material list includes all costs to get started with development and does not represent the price to create one International Darth Vader product.

ADAFRUIT

Part	Quantity	Manufacturer Part Number	Vendor Part Number	Price (for 1)	Total
Diffused Rectangular 5mm RGB LEDs	1	2739	2739	$5.95	$5.95
Colorful Square Tactile Button Switch Assortment	1	1010	1010	$5.95	$5.95
Bakelite Universal Perfboard Plates	1	2670	2670	$4.95	$4.95
Adafruit Perma-Proto HAT for Pi Mini Kit	4	2310	2310	$4.95	$19.80
Lithium Ion Battery - 3.7v 2500mAh	2	328	328	$14.95	$29.90

AMAZON

Part	Quantity	Manufacturer Part Number	Vendor Part Number	Price (for 1)	Total
Kingston Digital 16 GB Class 4 microSDHC Flash Card	2	SDC4/16GBSP	B00DYQYLQQ	$5.58	$11.16
Micro USB Cable, TeckNet&reg 6 Premium 1ft / 0.3M Micro USB Cable Pack High Speed USB 2.0 A Male to Micro B Sync and Charge Cables	1	78559	B00WMCIHEK	$7.99	$7.99
Star Wars 48" Darth Vader Motion Acitvated Light Sound Battle Buddy	1	90832-COM-P	B00XC3AWMS	$94.97	$94.97

DIGIKEY

Part	Quantity	Manufacturer Part Number	Vendor Part Number	Price (for 1)	Total
4 Ohm Magnetic Speaker 3W	2	AS04004PR-R	668-1359-ND	$7.65	$15.30
MAX98357A - 1-Channel (Mono) Output Class D Audio Amplifier Evaluation Board	2	3006	1528-1696-ND	$5.95	$11.90
TPS61090 - DC/DC, Step Up 1, Non-Isolated Outputs Evaluation Board	2	2465	1528-1349-ND	$19.95	$39.90

Newark

Part	Quantity	Manufacturer Part Number	Vendor Part Number	Price (for 1)	Total
RASPBERRYPI3-MODB-1GB. Raspberry Pi 3 Model B	2	RASPBERRYPI3-MODB-1GB.	77Y6520	$35.00	$70.00

Final Bill of Materials

The table below illustrates the approximate cost to create one International Darth Vader toy using the exact quantity of parts to assemble one of the product. This includes the cost of a Darth Vader figurine.

Star Wars 48" Darth Vader Motion Acitvated Light Sound Battle Buddy	$94.97
RASPBERRYPI3-MODB-1GB. Raspberry Pi 3 Model B	$35.00
MAX98357A - 1-Channel (Mono) Output Class D Audio Amplifier Evaluation Board	$5.95
TPS61090 - DC/DC, Step Up 1, Non-Isolated Outputs Evaluation Board	$19.95
Lithium Ion Battery - 3.7v 2500mAh	$14.95
Blazedisplay 8GB class4 Micro SD SDHC Flash memory card	$3.95
4 Ohm Magnetic Speaker 3W	$7.65
Total:	**$182.42**

References

Below are a list of datasheets and various other documents used to implement the International Darth Vader project.

Datasheets

Raspberry Pi 3	https://www.raspberrypi.org/documentation/hardware/computemodule/RPI-CM-DATASHEET-V1_0.pdf
Adafruit Powerboost 1000C	https://learn.adafruit.com/adafruit-powerboost-1000c-load-share-usb-charge-boost/overview
Stand-alone System Load Sharing and Li_Ion/ Li-Polymer Battery Charge Management Controller	https://cdn-shop.adafruit.com/datasheets/MCP73871.pdf
Synchronous Boost Converter with 2A Switch	https://cdn-shop.adafruit.com/datasheets/tps61090.pdf
MAX98357A PCM Input Class D Audio Power Amplifiers	https://cdn-shop.adafruit.com/product-files/3006/MAX98357A-MAX98357B.pdf
Polymer Lithium-ion Battery Model 785060 2500 mAh	https://cdn-shop.adafruit.com/datasheets/785060-2500mAh_specification_sheet.pdf
AS04004PR-R 40mm Speaker	http://www.puiaudio.com/pdf/AS04004PR-R.pdf

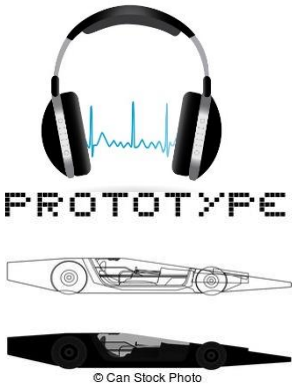
Useful Resources

Raspberry Pi – Installing Operating System Images	https://www.raspberrypi.org/documentation/installation/installing-images/
Raspberry Pi – How to setup Bluetooth on a Raspberry Pi 3	https://www.cnet.com/how-to/how-to-setup-bluetooth-on-a-raspberry-pi-3/
Raspberry Pi – How to Install FFmpeg	http://tecadmin.net/install-ffmpeg-on-linux/#

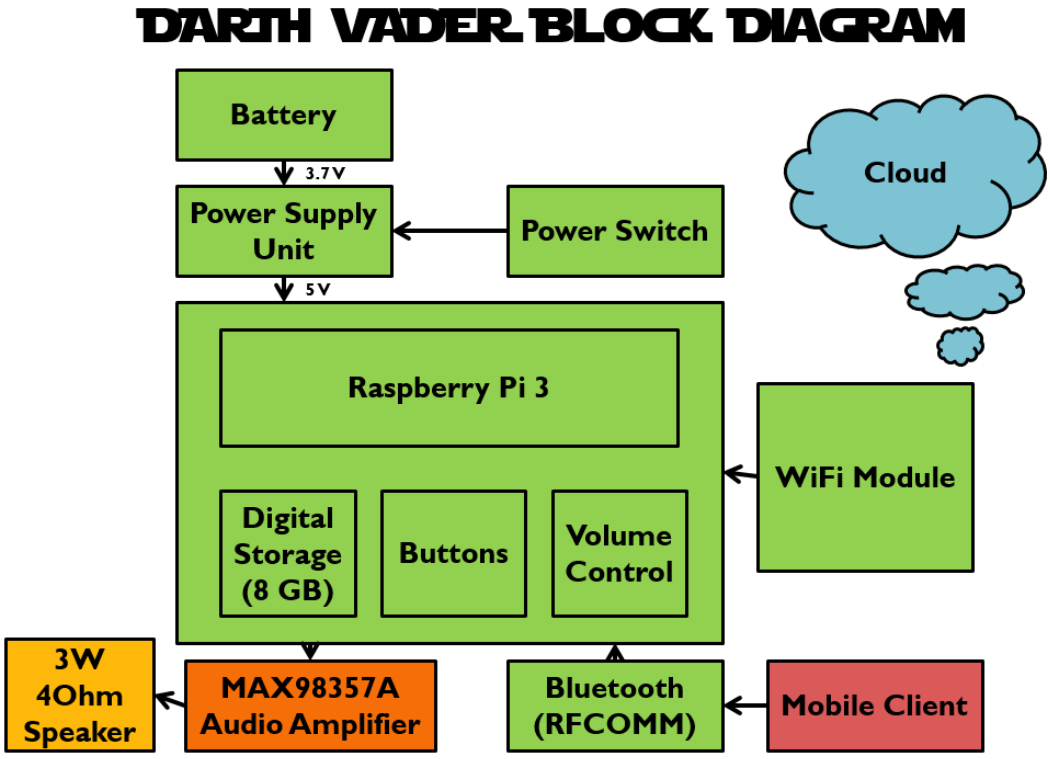
Raspberry Pi – Startup Scripts	http://www.raspberry-projects.com/pi/pi-operating-systems/raspbian/scripts
Raspberry Pi – Audio Board Setup	https://learn.adafruit.com/adafruit-max98357-i2s-class-d-mono-amp/raspberry-pi-usage
Raspberry Pi – Board Pinout	http://pinout.xyz/#
Python – Rpi.GPIO Module Basics	https://sourceforge.net/p/raspberry-gpio-python/wiki/BasicUsage/
Python – Bluetooth Programming	http://people.csail.mit.edu/albert/bluez-intro/c212.html
Android – Getting Started	https://developer.android.com/training/index.html
Android - Bluetooth	https://developer.android.com/guide/topics/connectivity/bluetooth.html
Amazon Web Services – Mobile SDK	https://aws.amazon.com/mobile/sdk/
Amazon Web Services – Getting Started with AWS IoT on Raspbery Pi	http://docs.aws.amazon.com/iot/latest/developerguide/iot-device-sdk-node.html
Amazon Web Services – S3 Documentation	https://aws.amazon.com/documentation/s3/

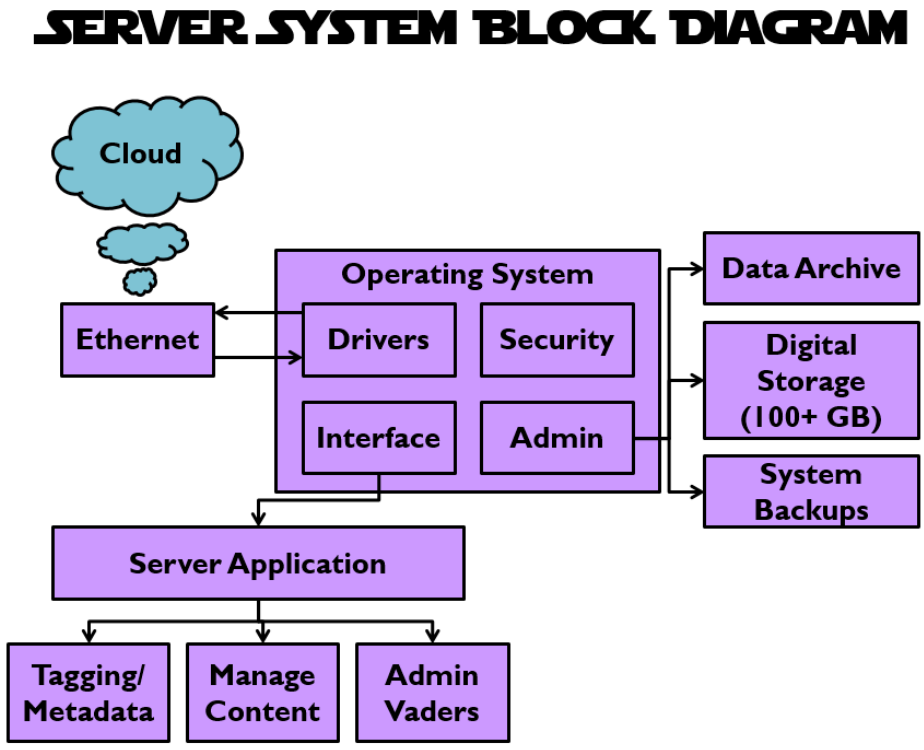
Lessons Learned

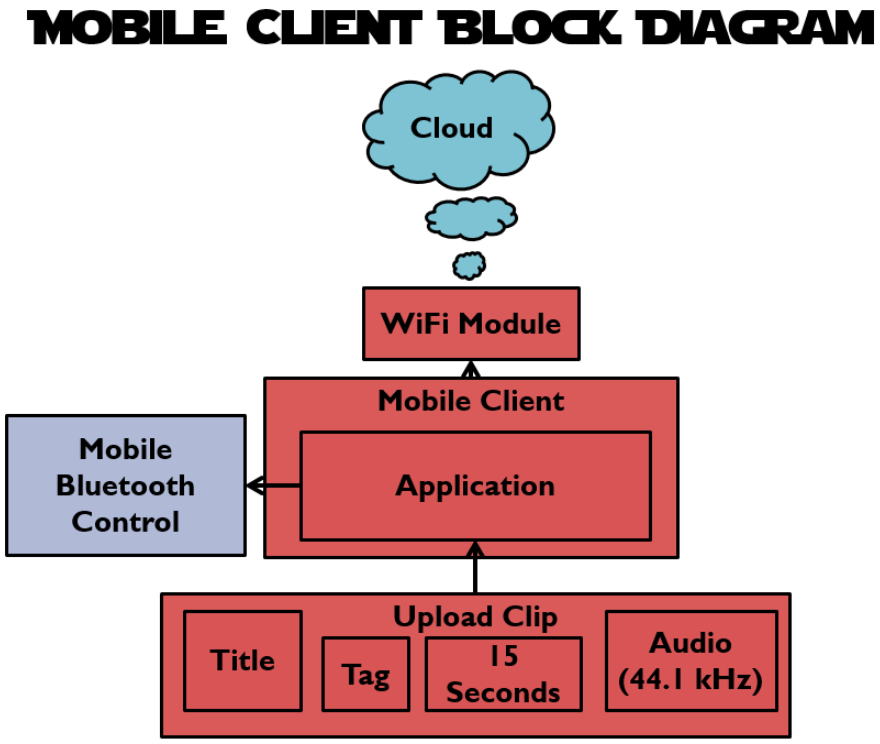
- Audio modulation better executed on Raspberry Pi compared to Mobile Client.
- Easy to have a prototype, but difficult to migrate to a standalone design.



High-Level System Block Diagrams







Power Budget

Component	Quantity	Standby current	Active current	Voltage	Active power
Raspberry Pi 3	1	260 mA	730 mA	5 V	3.7 W
MAX98357A Amplifier	1	350 microA	3.35 mA	5 V	16.75 mW
Speaker	1	5.5 mA	600 mA	5 V	3 W
Total		**265.85 mA**	**1333.35 mA**		**6.717 W**

Size & Weight

Darth Vader Figure

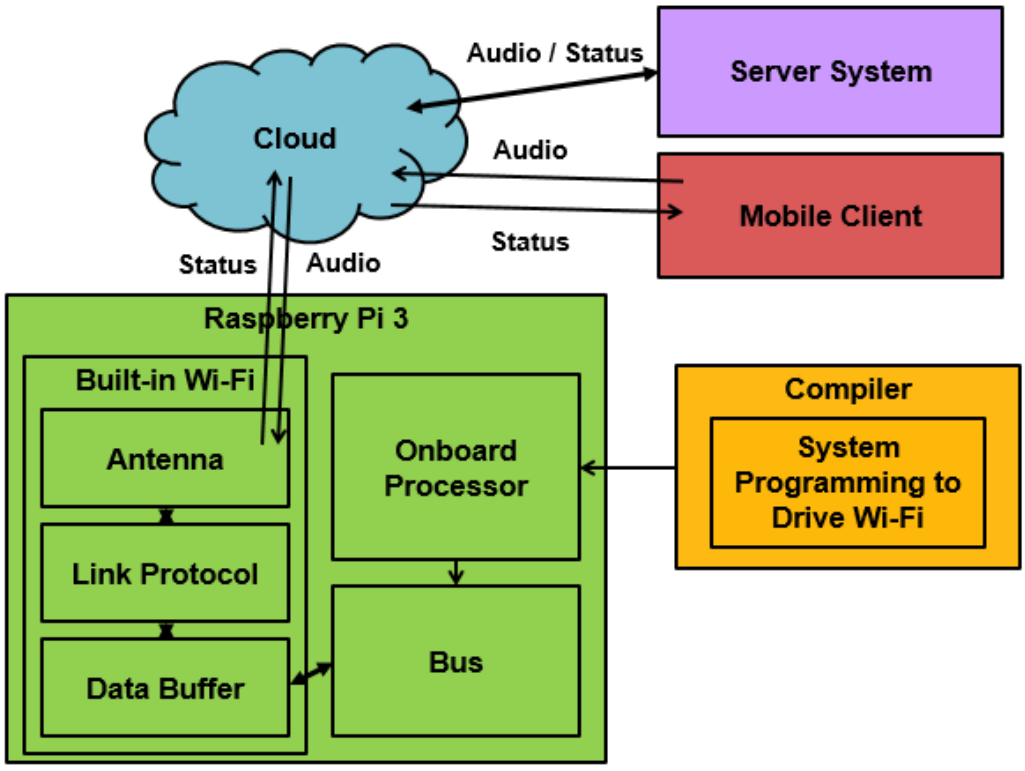
- 10 x 20.5 x 48 inches
- Approximately 8.7 lbs.

Raspberry Pi Apparatus

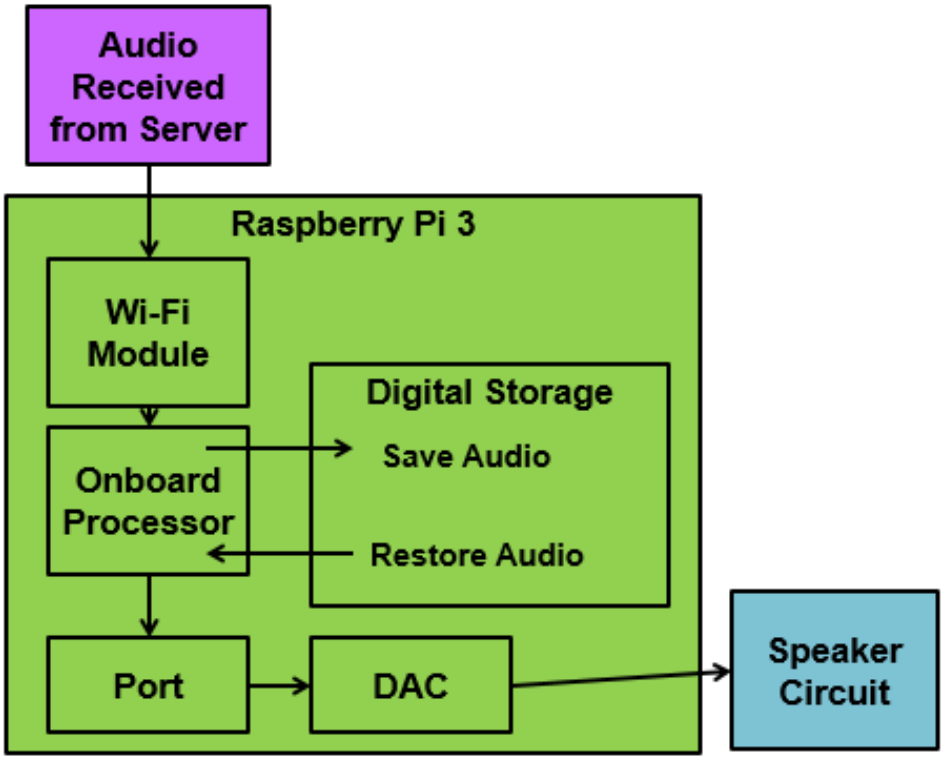
- 5.5 x 3.3 x 8 inches
- Approximately 0.5 Lbs.

System Block Diagrams

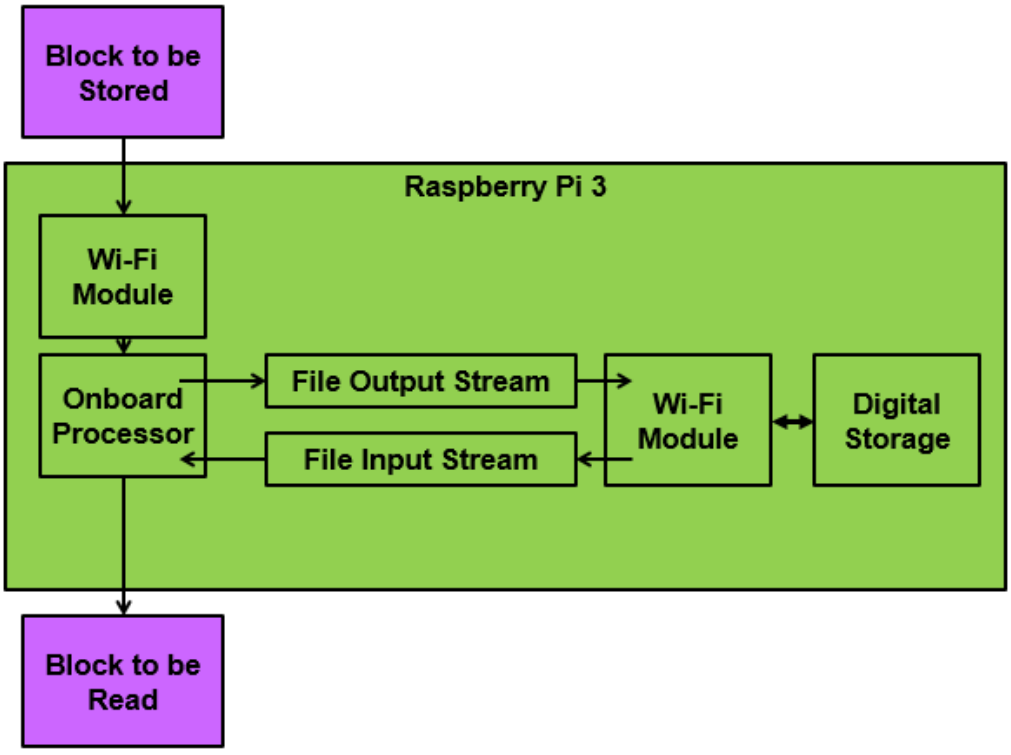
9.1 Wi-Fi



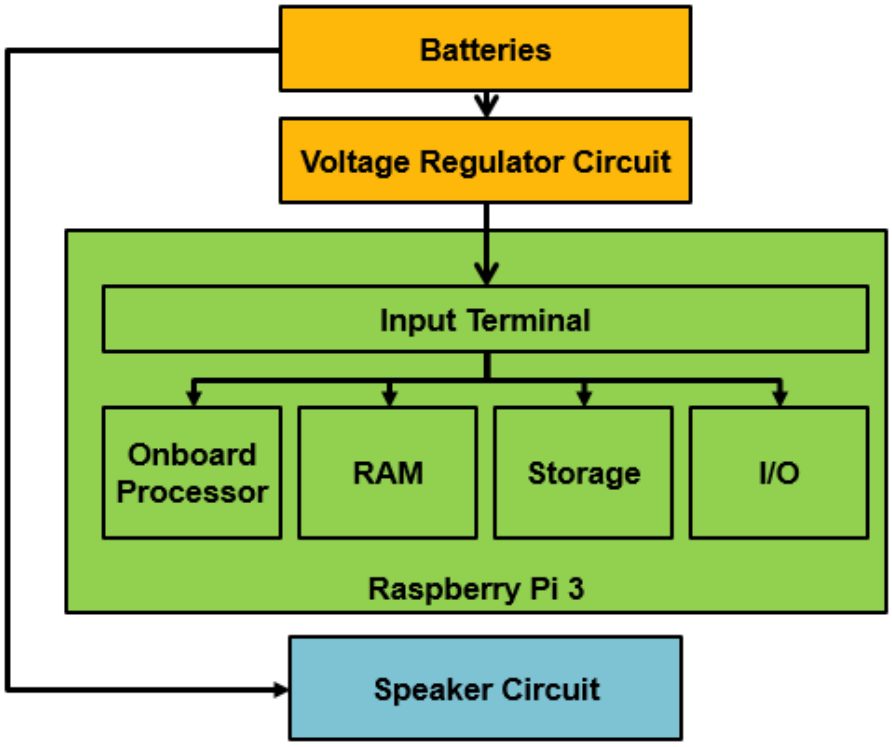
9.2 Audio



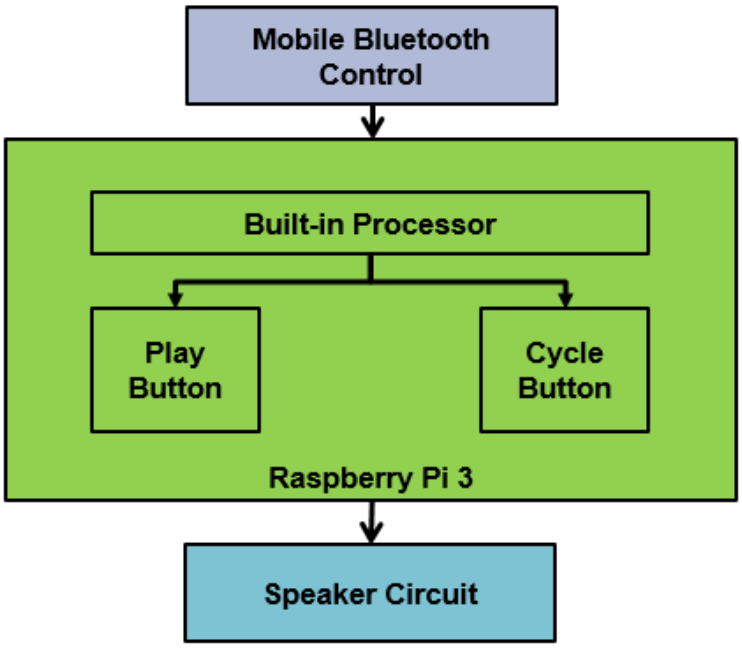
9.3 Storage



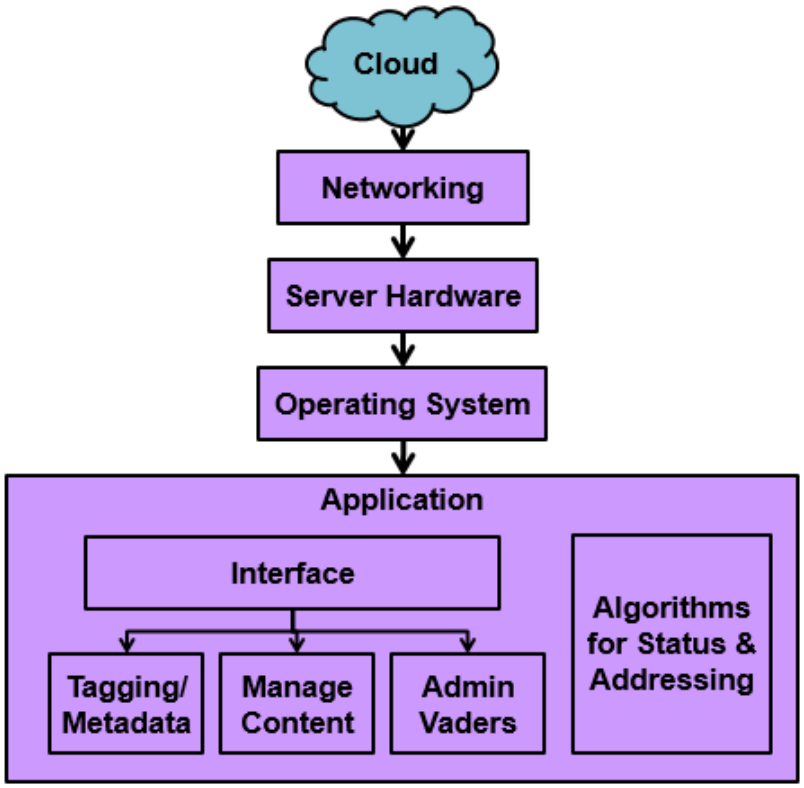
9.4 Power Supply



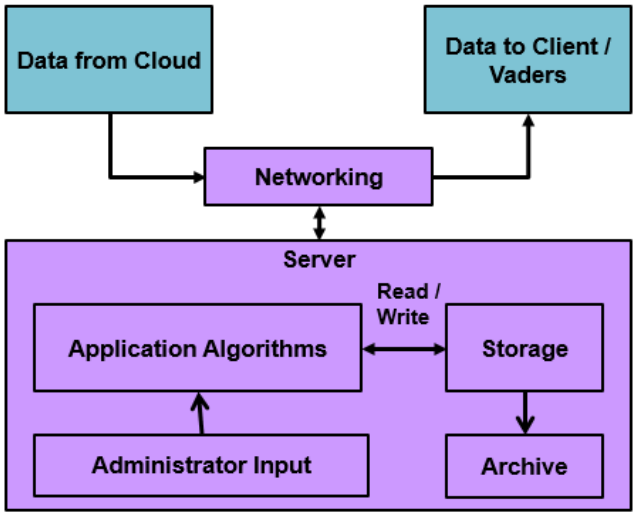
9.5 Interface



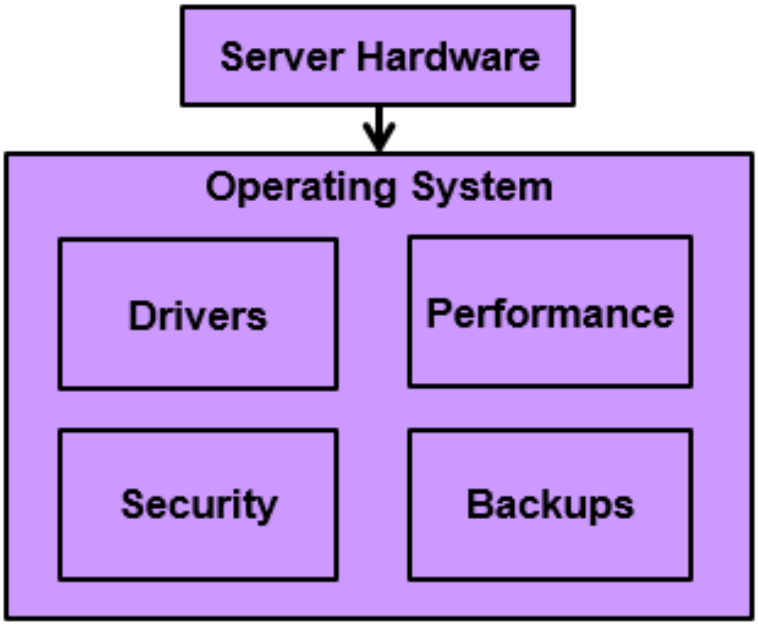
9.6 Server Application



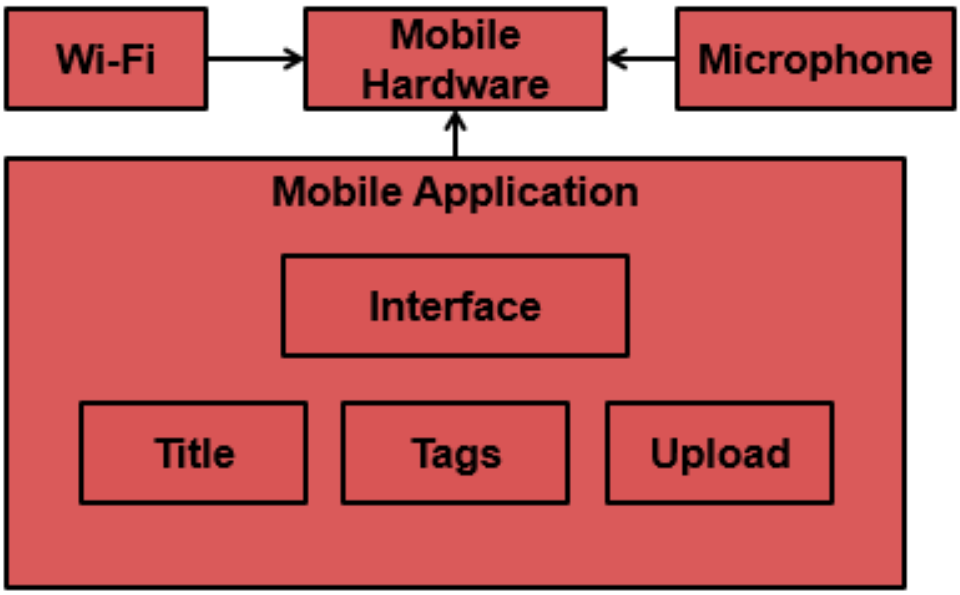
9.7 Server Storage



9.8 Server Administration

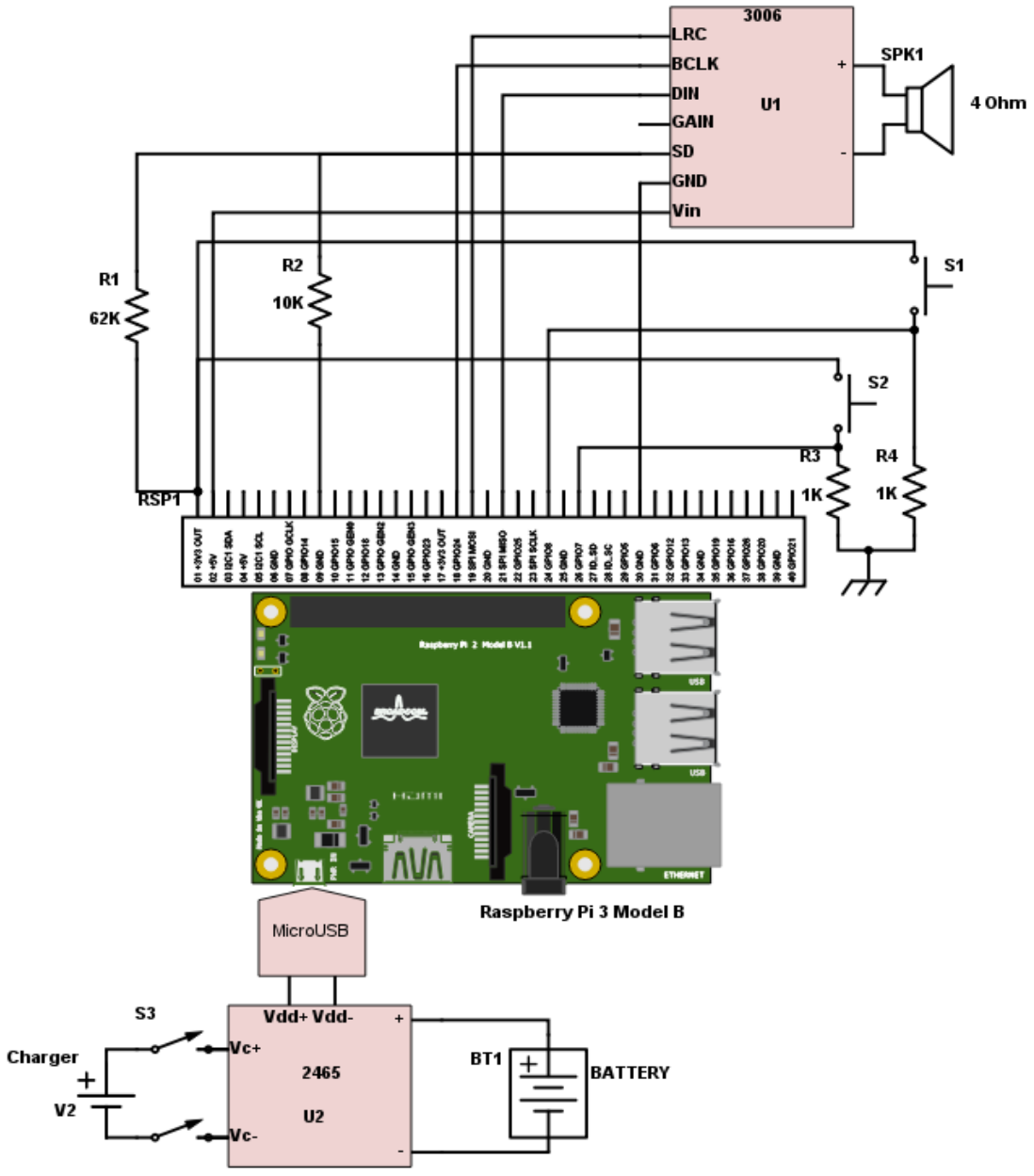


9.9 Mobile Application

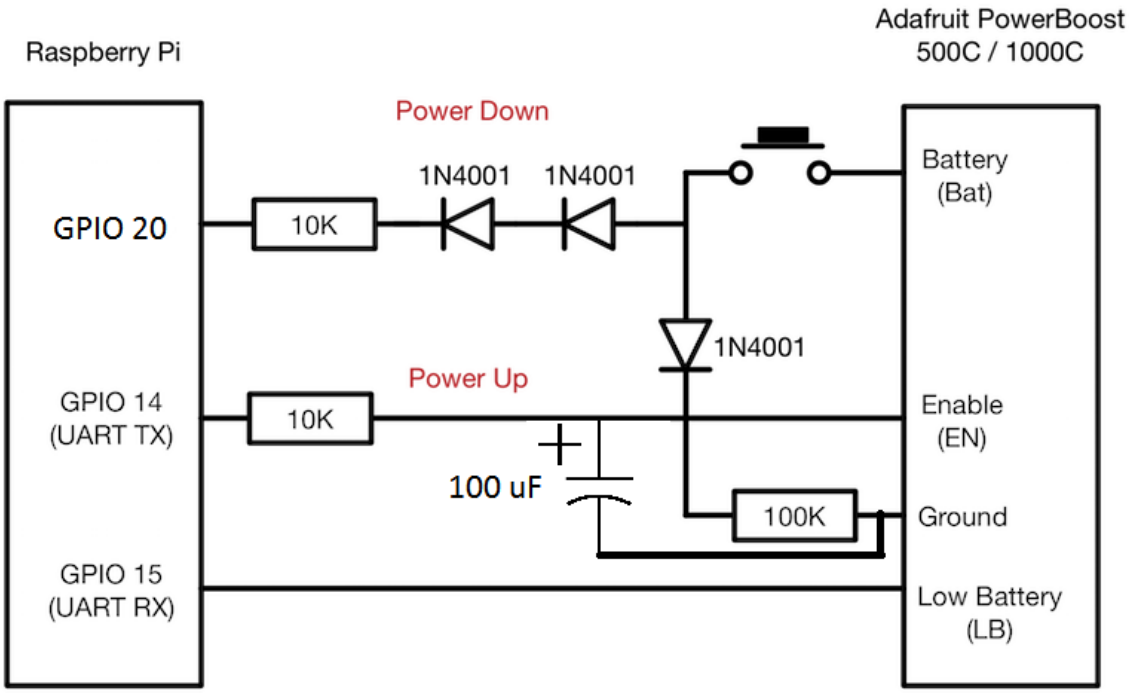


Schematics

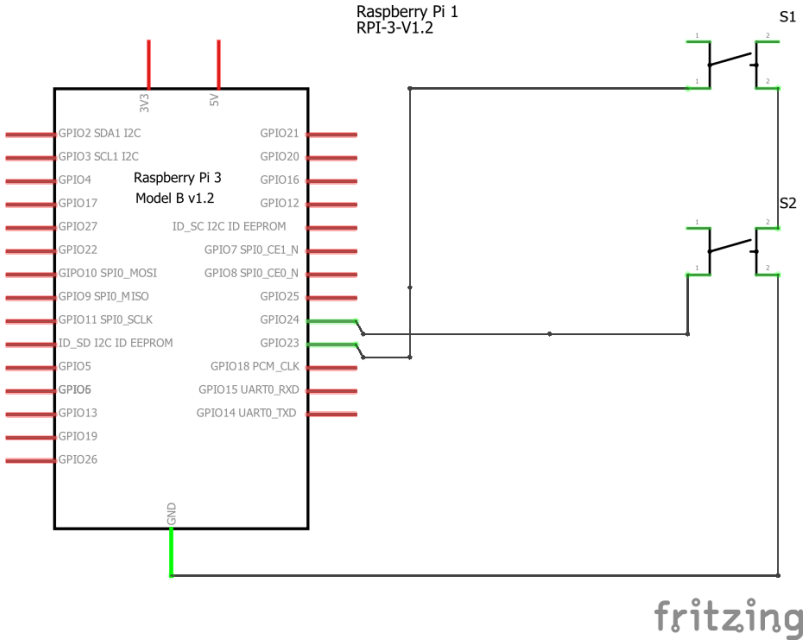
Overview Schematic



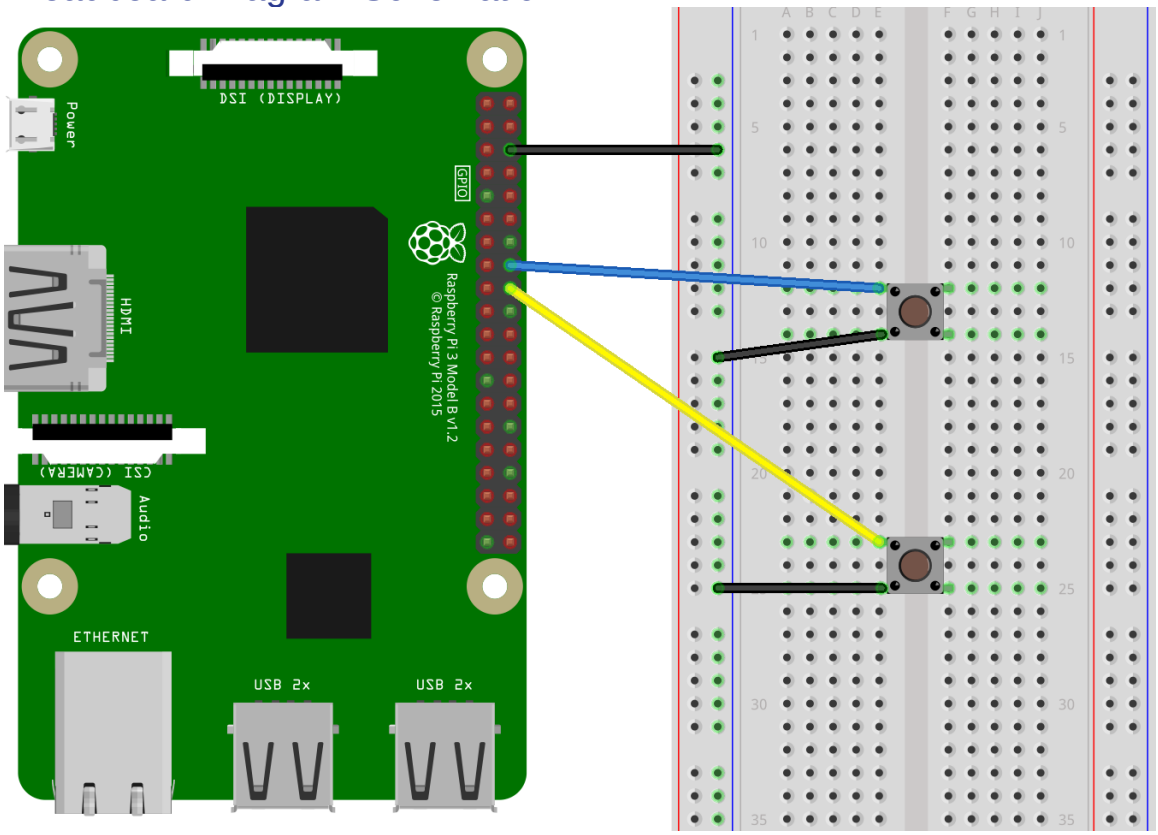
Detailed Power Schematic



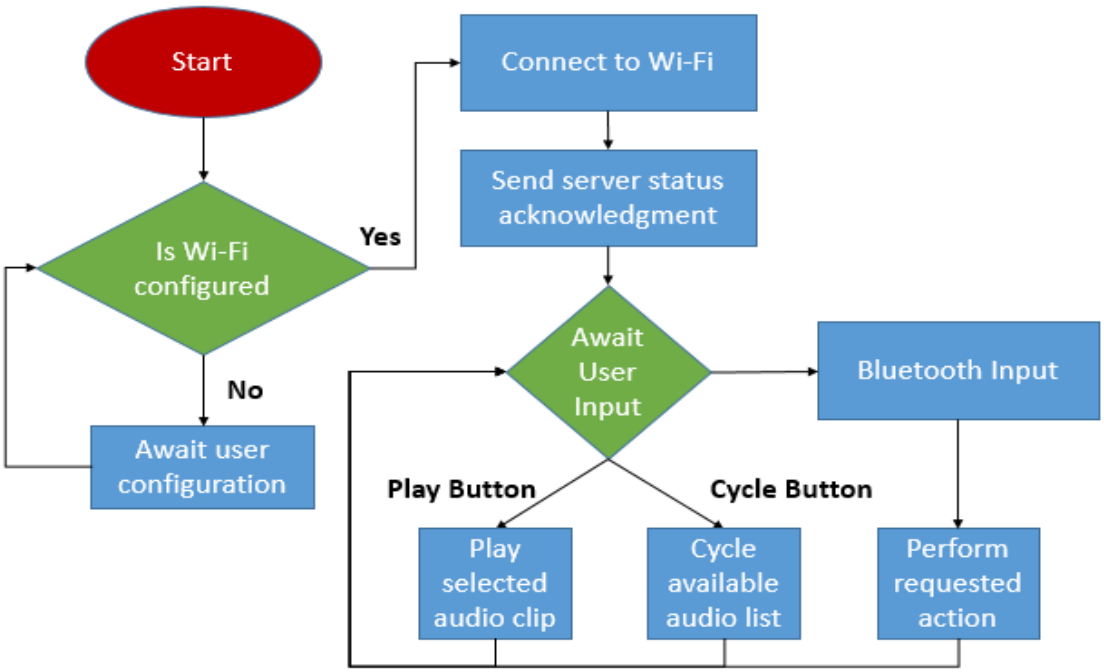
Button Interface Schematic



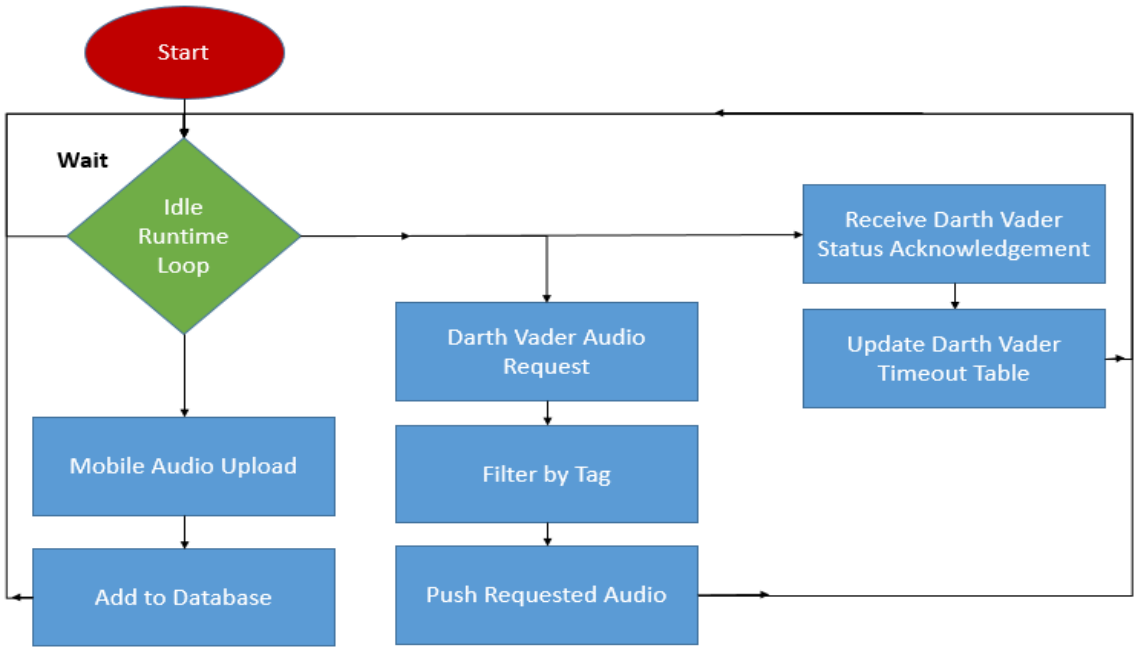
Breadboard Diagram Schematic



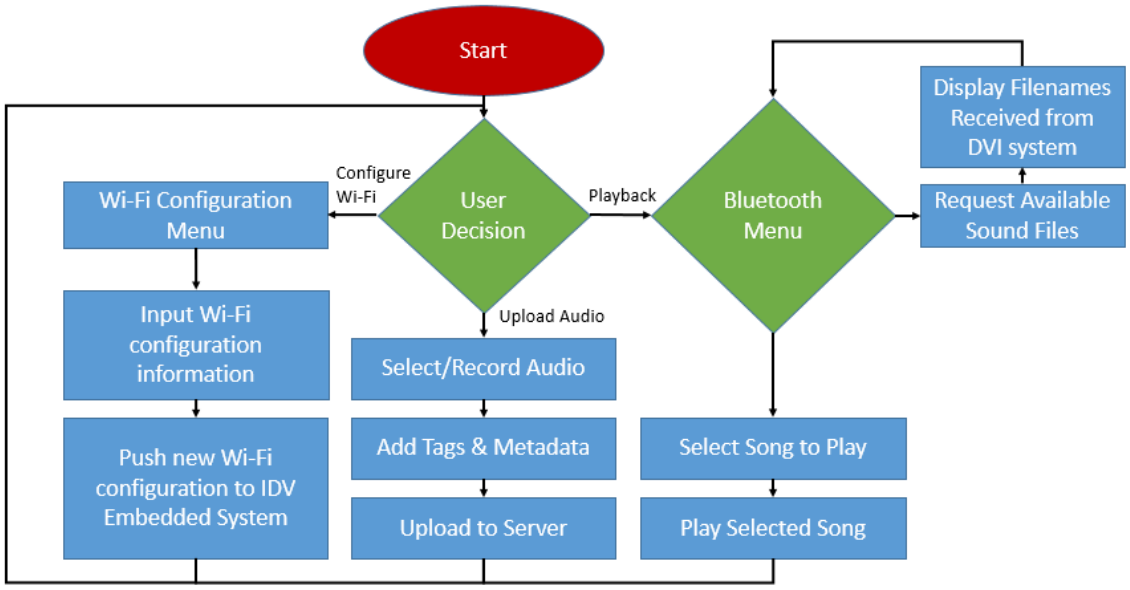
Darth Vader Embedded System Flowchart



Server Software Flowchart



Darth Vader Mobile Client Software Flowchart



Communication Protocol

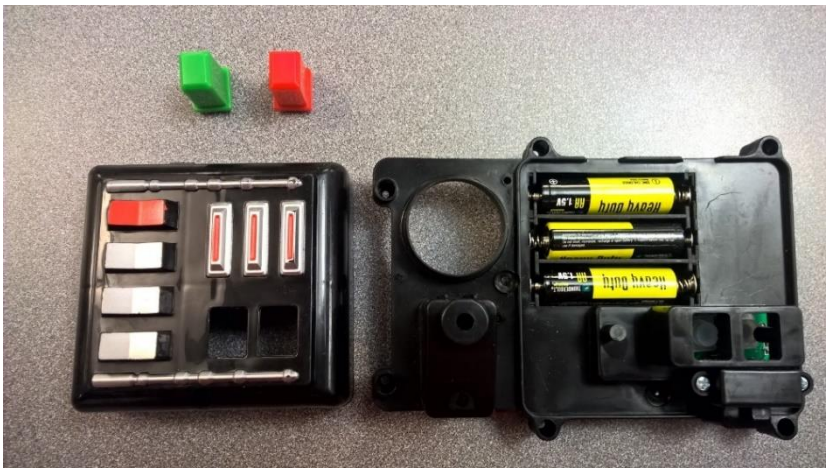
Wi-Fi

- IEEE 802.11 Standard
- Wireless n default
- a/b/g compatibility
- HTTP & FTP Protocols

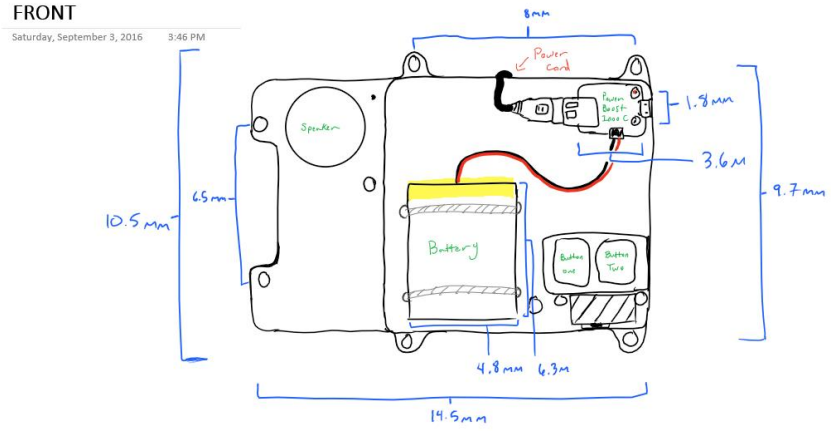
Bluetooth

- IEEE 802.15.1 Standard
- Bluetooth 4.1 BLE

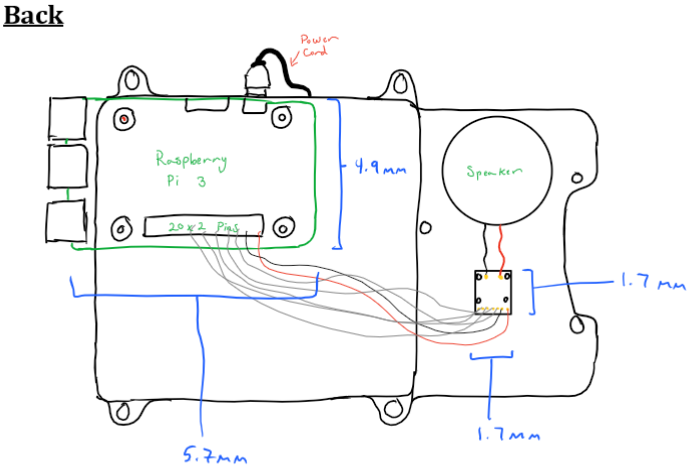
Original Packaging



Mechanical Concept Design - Front



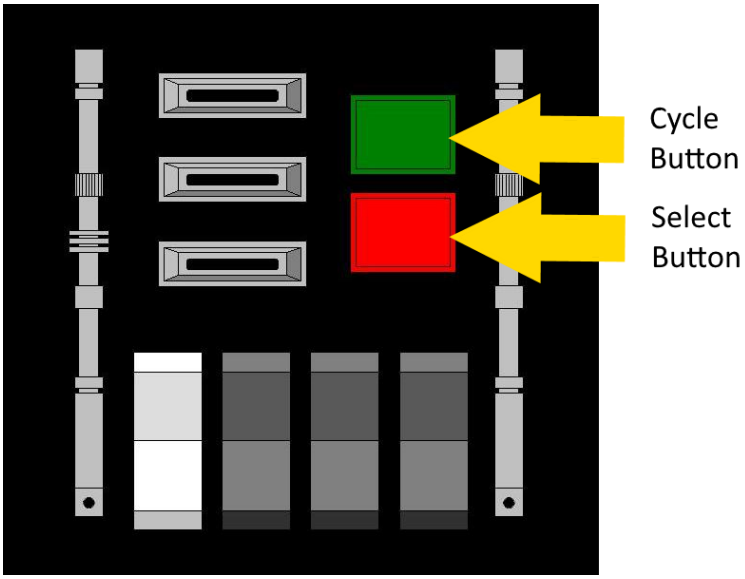
Mechanical Concept Design - Back



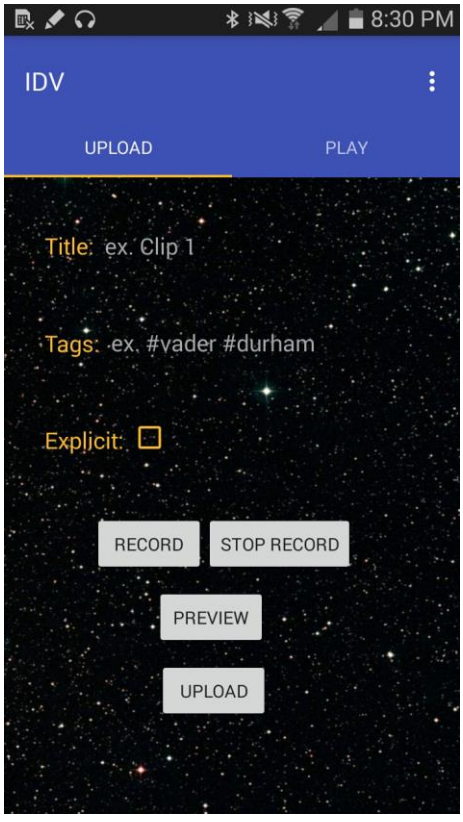
Final Mechanical Packaging

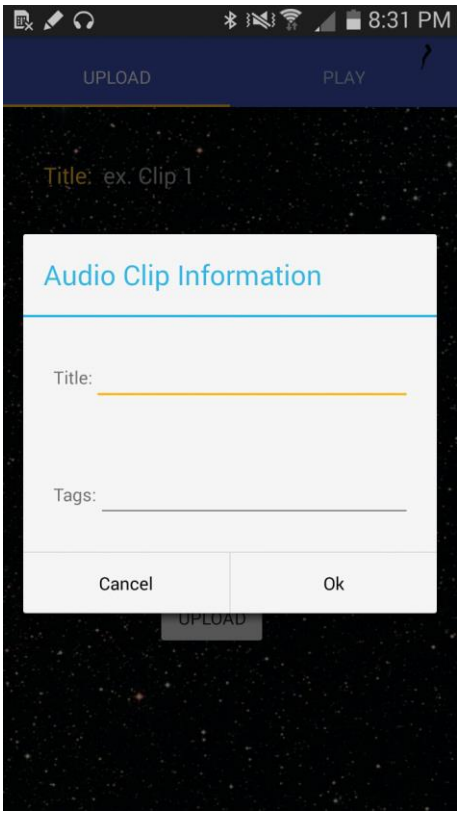
Original packaging included for comparison.

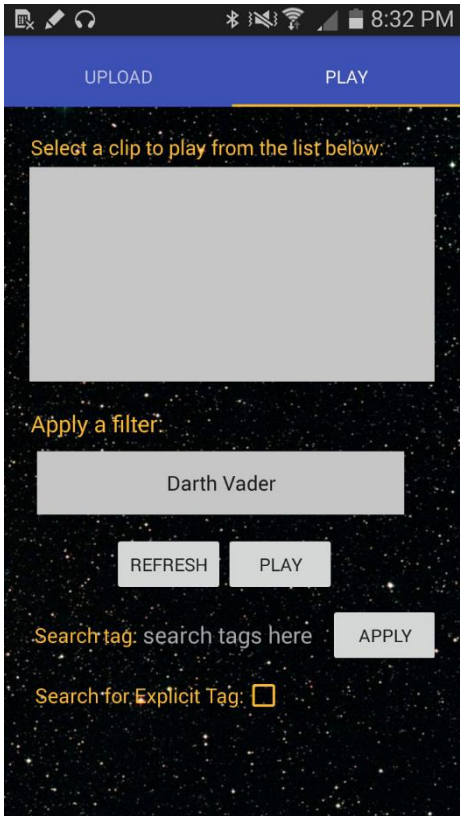
Darth Vader User Interface

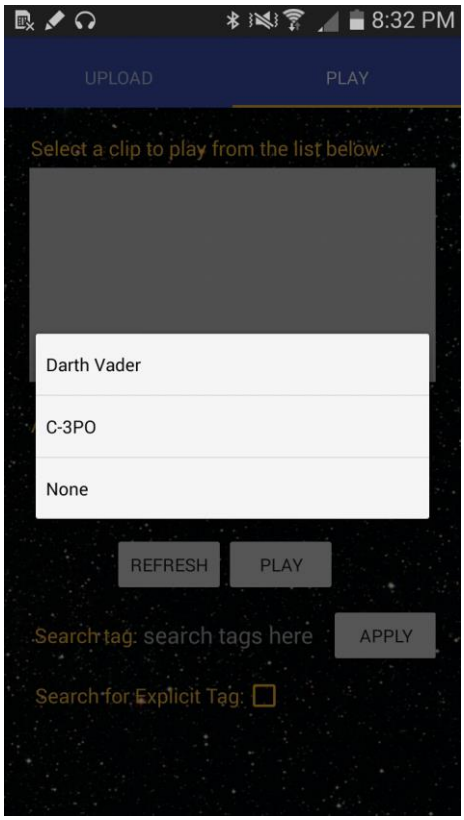


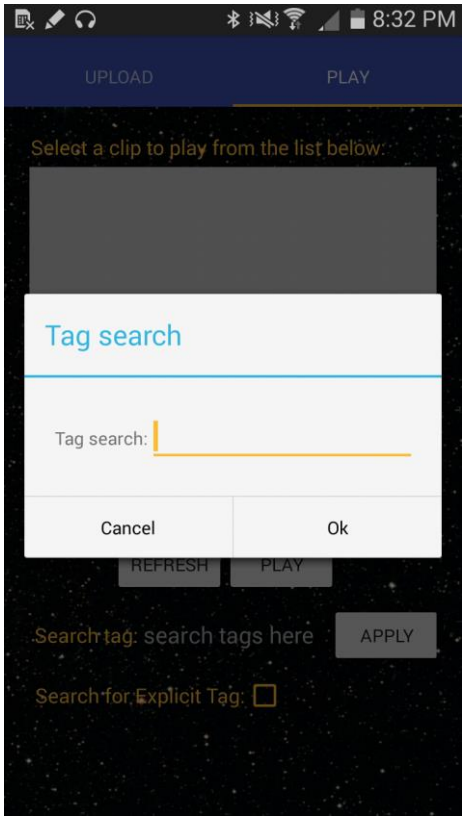
Mobile Client User Interface






8:32 PM
UPLOAD
PLAY
Select a clip to play from the list below:
Apply a filter:
Darth Vader
REFRESH
PLAY
Search tag: search tags here
APPLY
Search for Explicit Tag:


8:32 PM
UPLOAD
PLAY
Select a clip to play from the list below:
Darth Vader
C-3PO
None
REFRESH
PLAY
Search tag: search tags here
APPLY
Search for Explicit Tag:


8:32 PM
UPLOAD
PLAY
Select a clip to play from the list below:
Tag search
Tag search:
Cancel
Ok
REFRESH
PLAY
Search tag: search tags here
APPLY
Search for Explicit Tag:


8:34 PM

System Verification

- Internal Group / Real-time development testing
- Post alpha demo, post beta demo, and right-before design day

Alpha Demo

All major subsystems had shown either rudimentary functionality or operational behavior. The subsystems were not fully functional.

- Demonstrated data management techniques
- Major Bluetooth commands were functioning
- Hardware interfaces were working outside of the housing
- Server connection could be established
- Major product requirements were met

Beta Demo

All major subsystems were functional and connected. The system was ready for debugging, verification, and polish.

- All wireless and Bluetooth communications between server, mobile, and embedded systems had been established.
- The embedded system could be instructed to play sound files via Bluetooth and hardware commands
- Mobile clients could upload to server database
- Embedded system could pull from server database

Milestones

Alpha Demo

- Power Supply, Android Framework - **September 11th, 2016**
- Integrate Bluetooth control into Mobile, Implement enclosure - **September 25th, 2016**

Beta Demo

- Upload audio from mobile, database tagging, stabilize subsystems - **October 16th, 2016**
- Connect subsystems, finalize enclosure, system debugging - **October 30th, 2016**

Design Day

- Testing with Pierce, debugging and qualification, scalability, and usability optimization - **November 27th, 2016**

Code Freeze - November 29th, 2016