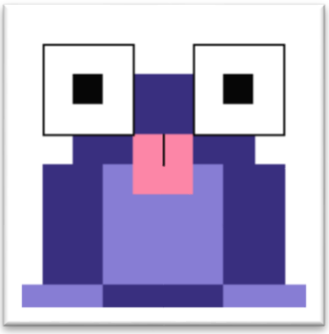
Ribbit

A Cost-Effective iOS Hearing Aid App



Requirements Document v3.2

Computer Science Department
Texas Christian University
May 2, 2016

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Revision Signatures

By signing the following, the team member is stating that he has read the entire document and has verified that the information contained within this document is accurate, relevant to the project, and void of errors.

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Revision History

Version	General Description of Changes	Date Completed
V1.0	Initial Draft	10/28/15
V1.1	Added requirements, updated prototypes, adjusted use cases, and changed formatting and spelling.	11/18/15
V1.2	Added a new system architecture diagram and changed formatting	11/20/15
V1.3	Changed formatting on system architecture diagram	11/22/15
V2.0	Changed minor formatting	1/31/16
V3.0	Updated fonts, requirements, and title	4/25/16
V3.1	Updated system architecture diagram and updated architecture descriptions.	5/1/16
V3.2	Updated the system architecture diagram description	5/2/16

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1 Introduction

1.1 Purpose

This document is a detailed description of the requirements of the Ribbit application. This document is intended to give the user an overview of the requirements of the application, both the functional and non-functional, as well as giving them several use cases.

This requirements document is designed to give the project team define and deal with the detailed requirements of the project. In addition, it will give use case and diagrams detailing the interaction between the users and the application, as well as between parts of the application itself. Finally, it will give the team a clear cut list of the requirements.

1.2 Intended Audience

This document is intended to give the team the intended requirements given by the client. This document can also be used by the customer to make sure that the requirements have been fulfilled as per their instructions.

1.3 Scope and Objective

The objective of Ribbit is to create a low-cost hearing aid replacement utilizing the iPhone device.

1.4 References

De Gotzen, A., Bernardini, N., & Arfib, D. (2000). TRADITIONAL (?) IMPLEMENTATIONS OF A PHASE-VOCODER: THE TRICKS OF THE TRADE. *COST G-6.* Verona.

Laroche, J., & Dolson, M. (1999). Improved Phase Vocoder Time-Scale Modification of Audio. *IEEE TRANSACTIONS ON SPEECH AND AUDIO PROCESSING* (pp. 323-332). IEEE.

McLeod, P., & Wyvill, G. (2005). A SMARTER WAY TO FIND PITCH. *Proceedings of International Computer Music Conference.*

Swift 2.1 Documentation - https://developer.apple.com/swift/

Acclelerate vDSP Reference - https://developer.apple.com/library/prerelease/tvos/documentation/Accelerate/Reference/vDSPRef/index.html#//apple_ref/doc/uid/TP40009464

iOS platform audio mechanism reference - https://github.com/ooper-shlab/aurioTouch2.0-Swift

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1.5 Overview

- Section 2: This section goes over the description of the product, including its characteristics, functions, requirements, assumptions, and dependencies.
- Section 3: This section specifies the system architecture of the product.
- Section 4: This section details all external requirements of the software system.
- Section 5: This section details the functional requirements of the software system.
- Section 6: This section details the non-functional requirements of the software system.
- Section 7: This section defines the terms used within this document.

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2 Overall Description

2.1 Project Background

The Ribbit application is an iOS application that allows a hearing impaired person, the User, to continue hearing within normal ranges. Specifically, the application utilizes a microphone to capture sound, compares this signal's frequencies to that of the User's prescription, processes the signal as needed, then plays this processed signal back to the User.

2.2 Product Functional Requirements

The product shall require user identification to verify the correct prescription to the patient.
The product shall easily process the signal without introducing latency.
Signal shall be processed in real time to allow spontaneous communication.

2.3 Product Non-Functional Requirements

Has to be run on an iOS device.
Development must end by April 2016.
The application package must be small enough to fit on a mobile device.
The application requires a Bluetooth compatible device or a pair of standard headphones.

2.4 User Characteristics

There are two intended users for this application: The Audiologist and the Patient-User. The following table outlines the various abilities of either of the users.

Authorized activity	Audiologist	Patient-User
Hearing sample collection and diagnosis (not an app feature)	X	
Prescription Embedded QR code generation	X	
QR code load into application	X	X
Working modes and i/o routes setting		X
Application usage		X

2.5 Assumptions and Dependencies

We assume the user has a valid hearing deficiency and has access to an Apple iPhone running at least iOS 7.

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3 System Architecture

This diagram explains the architecture of the overall system, incorporating all parts and moving pieces.

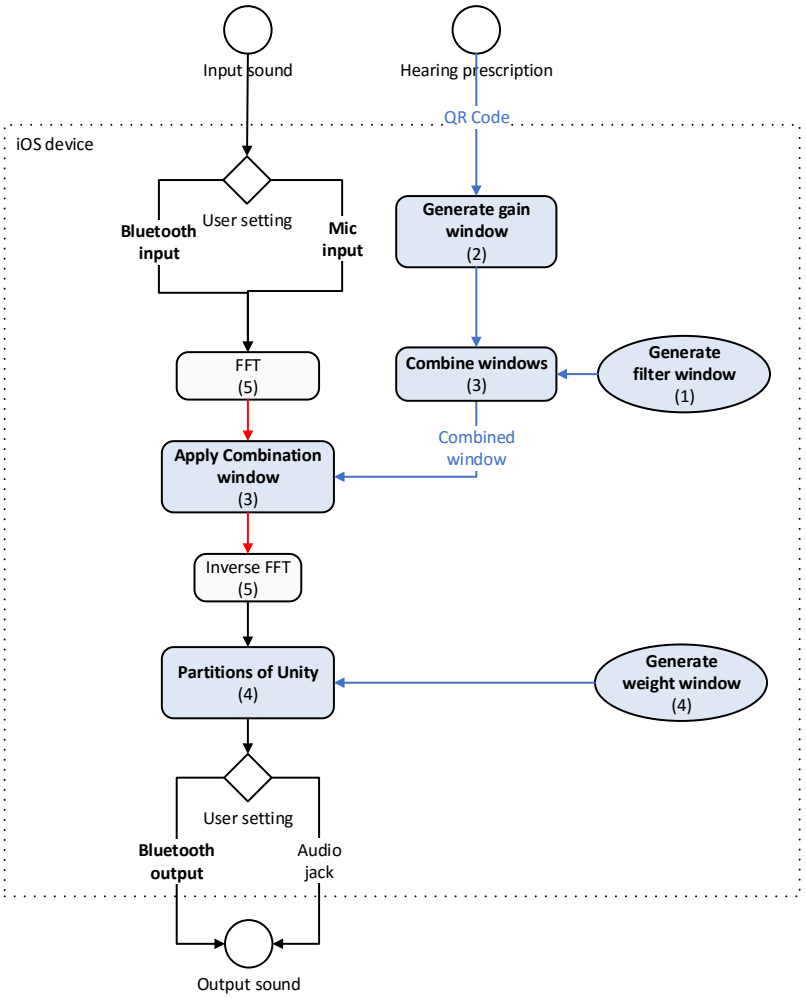

Diagram notations:

- Circles represent input and output
- Diamonds represent decision making
- Round-cornered rectangles and ovals represent processes/activities (the ones with background color are implemented in software)
- Ovals represent processes/activities that are done only once at application's start
- Bold words represent the contribution areas of this project
- Dotted line rectangle represents system boundary
- Black arrows represent sound in time domain
- Red arrows represent sound in frequency domain
- Blue arrows represent other types of input

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This system architecture satisfies the requirements of our client, Dr. Liran Ma. In order to function as a hearing aid, the physical device will need to be able to handle the computationally intensive task of signal processing in real-time. This is why we propose to use the iPhone instead of Android as the iOS platform provides a high level framework for digital signal processing.

Considering that a standard hearing aid is capable of increasing the amplitude of individual frequency components of the speech differently, we determined that the use of the Fast Fourier Transform and the Inverse Fast Fourier Transform is necessary to modify the signal in the frequency domain, in real-time.

There are two transformations applied to the input signal by our application: filtering, and gain amplification of frequency components based on the user's audiogram. Both of these transformations are achieved by multiplying the signal in the frequency domain by the Combination window.

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4 External Interface Requirements

4.1 User Interfaces

The user shall interface with the application on an iPhone running at least iOS 7.
There shall be a way to read in the prescription via a QR code reader.
There shall be a settings menu that will allow the user to change the environment that they are in.

4.2 Hardware Interfaces

The application shall use a microphone, either contained within the iOS device or connected to it.

4.3 Software Interfaces

The application shall interface with all iPhone devices running at least iOS 7.

4.4 Communication Interfaces

The application shall interface with compatible Bluetooth devices.

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5 System Functional Requirements

5.1 Application Requirements

The application shall get the input signal from built-in microphone or Bluetooth connection based on user's settings.
The application shall read in hearing prescription data in QR code form.
The application shall play the processed sound to earphone or Bluetooth connection based on user's settings, adjusting the sound to be audible by the hearing impaired.
The user shall be able to start and stop signal processing.
The audiologist shall be able to easily alter the prescription by reading in another QR code.
The user shall be able to choose between different profiles to alter the difference in prescriptions.
The user shall have to give some form of authentication to use the application.
The application shall contain a debugging mode to allow developers the ability to change the reference thresholds used in gain amplification.

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6 System Non-Functional Requirements

6.1 Product Requirements

The application must support a sampling rate of at least 44.1 kHz.
The application shall be able to constrain to different prescriptions for the left and right ear of the patient.
The application shall make the user enter credentials by way of fingerprint scanning to access the application.
The playback latency shall be at most 50ms.

6.2 Organizational Requirements

All development shall take place on iOS devices and Mac OSX computers.
All code development shall take place within the Apple Xcode development environment.

6.3 External Requirements

All patient (user) data shall be secured according to HIPAA requirements.
User must not be allowed to modify hearing prescription data.

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7 Glossary of Terms

Amplitude - the power of the air vibration that can be perceived as volume

Audiogram - graphical hearing diagnosis produced by audiologist

Audiologist: a health care professional specializing in identifying, diagnosing, treating and monitoring disorders of the ear

Clipping - a situation in which the peaks and/or troughs of the sound wave are cut off

DSP - Digital Signal Processor; a microprocessor specially designed to handle continuous analog signal

Decibels - a unit of measurement used to represent a signal's amplitude

FFT - Fast Fourier Transform; an algorithm used to transform a signal from the time domain into the frequency domain

Frequency - equivalent to the inverse of the period, frequency is a rate. Frequency is generally measured in Hz (hertz)

iOS - the operating system for Apple's mobile device product line

QR code - a data encoding mechanism in which bits are transformed into camera-recognizable (camera friendly) visual representation

Sound Profile (prescription profile, user profile) - a system that manages user's preferences and hearing prescriptions

Touch ID - a security mechanism on iPhones to maintain exclusive access based on a user's fingerprint

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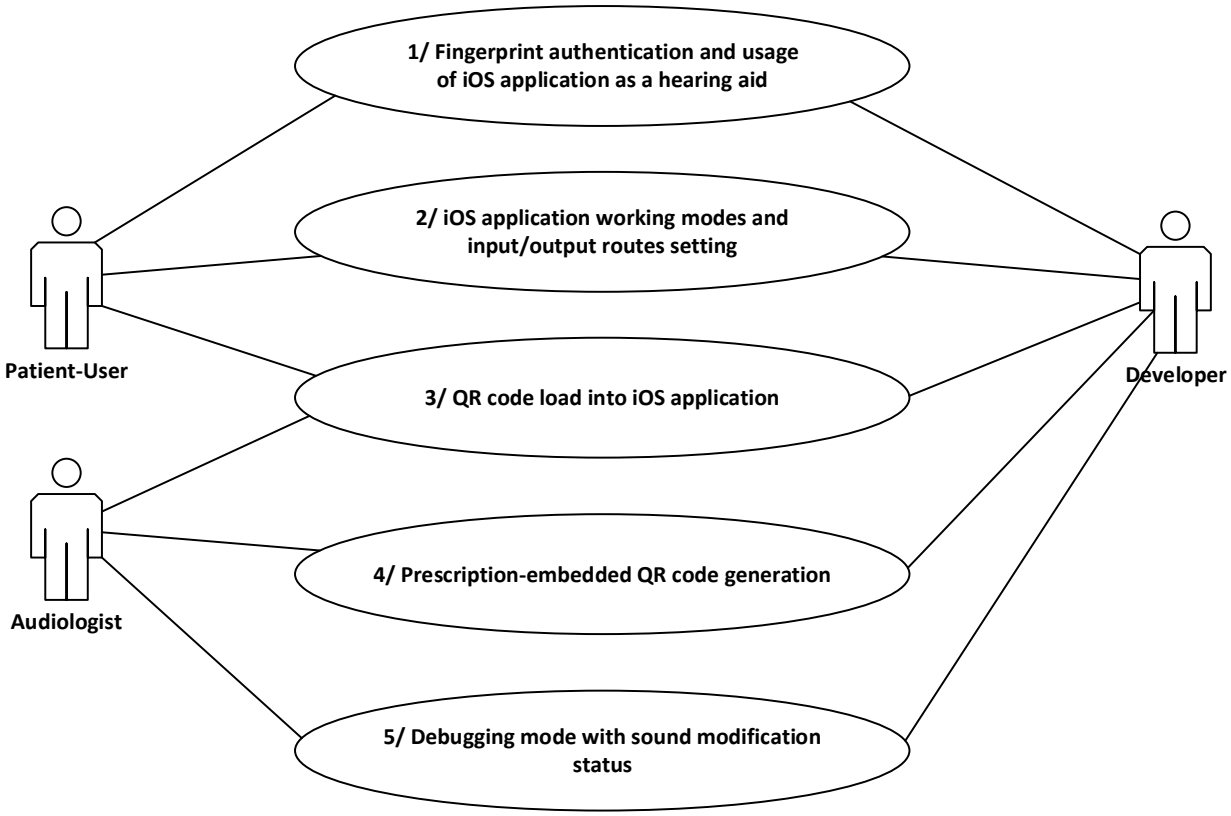
Appendix A: Use Case Models

Use case model



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1/ Fingerprint authentication and usage of iOS application as a hearing aid	
Actors	Patient-user, Developer
Description	The patient-user swipes his/her fingerprint on the phone's fingerprint reader to gain access to the application. After getting access, the patient-user is authorized to perform use case 2 and 3 as well as using the iOS application as a hearing aid. Developer will have access to all use cases to do application testing and enhancement.
Pre-condition	The patient-user has provided the phone's operating system platform with his/her fingerprint. The iOS application has been loaded with user's personal hearing prescription provided by an audiologist (use case 3).
Post-condition	None.
Data	Patient-user's fingerprint is confirmed through the phone's fingerprint reader. Input sound is recorded into the iOS application, which is then return the processed output sound.
Stimulus	Because the iOS application acts as a personal hearing aid for patient-user, it needs to be safe from external interference. In other words, unauthorized people must not have access to the iOS application installed on the patient-user's phone. The patient-user's hearing condition requires a hearing aid for effective communication.
Response	A form of authentication is needed to prevent unauthorized access. The patient-user uses the iOS application as a personal hearing aid.
Comments	None.

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2/ iOS application working modes and input/output routes setting	
Actors	Patient-user, Developer
Description	Patient-user can specify the input routes (built-in microphone or Bluetooth connection) and output routes (earphone or Bluetooth headset) in settings. Patient-user can specify the currently surrounding environment to let the iOS application choose the most appropriate processing modes. Developer will have access to all use cases to do application testing and enhancement.
Pre-condition	The iOS application usage authorization has been confirmed through fingerprint reading (use case 1). The iOS application has been loaded with user's personal hearing prescription provided by an audiologist (use case 3).
Post-condition	None.
Data	Plugging in headphone/earphone or connecting to Bluetooth device(s) Working mode selection in settings.
Stimulus	Different users may prefer different input and output routes. Different environments may require different types of processing to make the output sound most suitable for the patient-user.
Response	The user needs to be able to change the input/output routes as well as processing modes in order to get the most effective output sound.
Comments	None.

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3/ QR code load into iOS application	
Actors	Audiologist, Patient-User, Developer
Description	The audiologist or the patient-user uses the iOS application to scan the prescription-embedded QR code, which will automatically update the prescription data in the iOS application. From then on, the new prescription data will be used in sound modification process. Importantly, the audiologist may choose to load temporary prescription data into the iOS application, let the patient-user try hearing through the application, and implement final change on the prescription based on the patient-user's feedback. Developer will have access to all use cases to do application testing and enhancement.
Pre-condition	The prescription-embedded QR code has been generated.
Post-condition	If a new prescription is released, this use case should be repeated as soon as possible.
Data	Hearing prescription data includes, but is not limited to, different frequency ranges and the corresponding decibel levels required to effective hearing.
Stimulus	This use case is needed when: -The iOS application is used for the first time -A new prescription is released -The audiologist wants to test a temporary prescription with the patient-user
Response	The audiologist or the patient-user loads the prescription data in the form of QR code into the iOS application.
Comments	None.

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4/ Prescription-embedded QR code generation	
Actors	Audiologist, Developer
Description	The audiologist input prescription data into a special application, which will automatically generate QR code containing the input data. Developer will have access to all use cases to do application testing and enhancement.
Pre-condition	The audiologist has already diagnosed the patient-user and generated a traditional hearing prescription.
Post-condition	None.
Data	Prescription data from a traditional hearing prescription.
Stimulus	QR code adaptation aims at increasing convenience and preventing human error in the process of loading prescription data into the iOS application.
Response	Traditional hearing prescription data is transformed into QR code before being loaded into the iOS application
Comments	None.

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5/ Debugging mode with sound modification status	
Actors	Audiologist, Developer
Description	Audiologist can take a look at the real sound modification done by the iOS application to get a hint at the properties of the sound that will get to the patient-user's ears. Developer will have access to all use cases to do application testing and enhancement.
Pre-condition	None.
Post-condition	None.
Data	Visual (graph) and numeric representations of input and output sound as well as the modification parameters.
Stimulus	Audiologists and developers need a convenient way to evaluate the performance of the prescription and the iOS application.
Response	The debugging mode is an easy and accurate way of demonstrating the influence of the application on the input sound as well as the quality of the output sound.
Comments	None.

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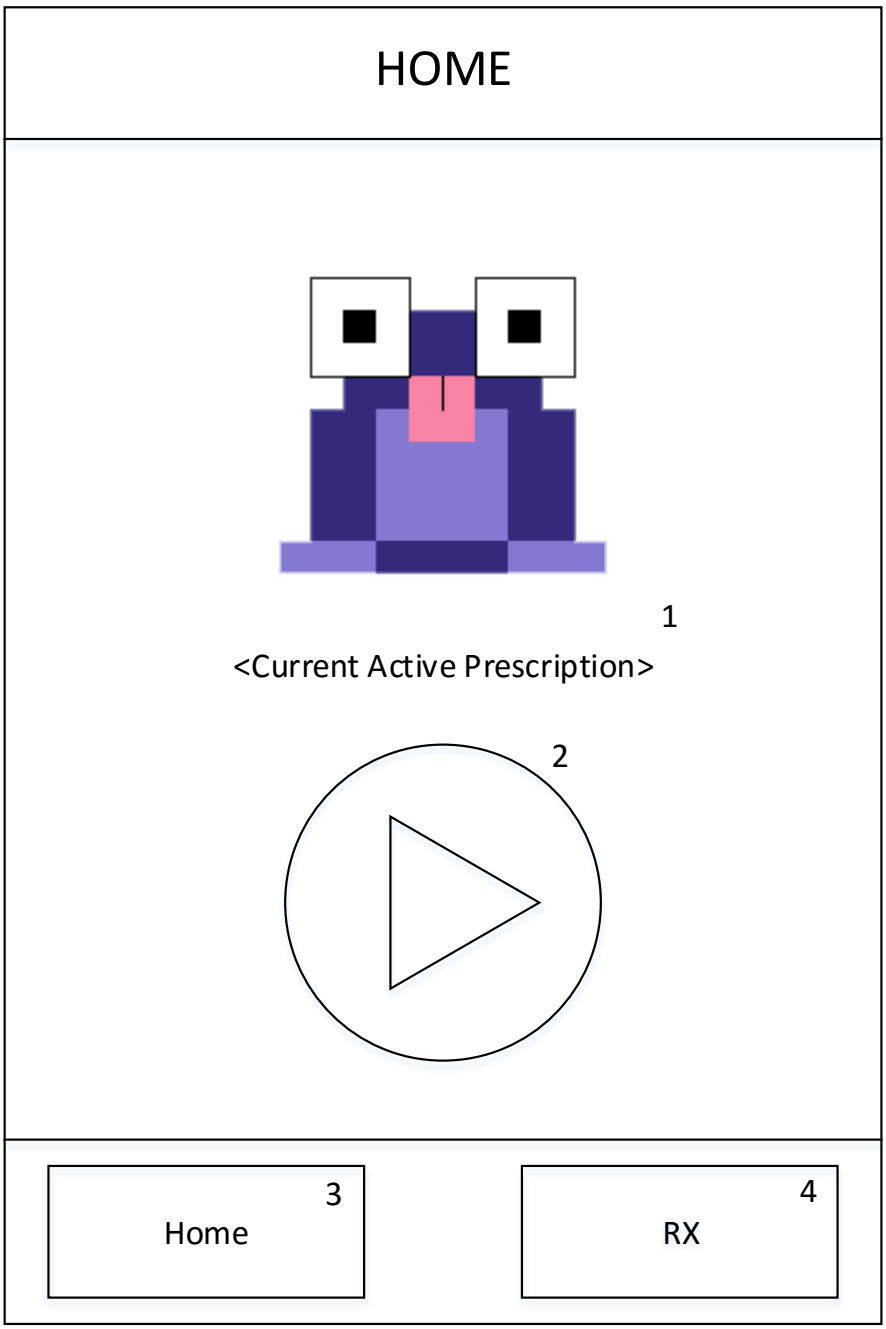
Appendix B: User Interface Prototypes



This is the home page of the application. It contains the play/pause button that will allow the user to play/pause sound playback.

1) This label will show the user what prescription is currently active.
2) The play/pause button will allow the user to pause and resume sound playback.
3) The “Home” button on the bottom of the application will bring the user back to the Home screen of the application.
4) The “RX” button on the bottom of the application will take the user to prescription table of the application.

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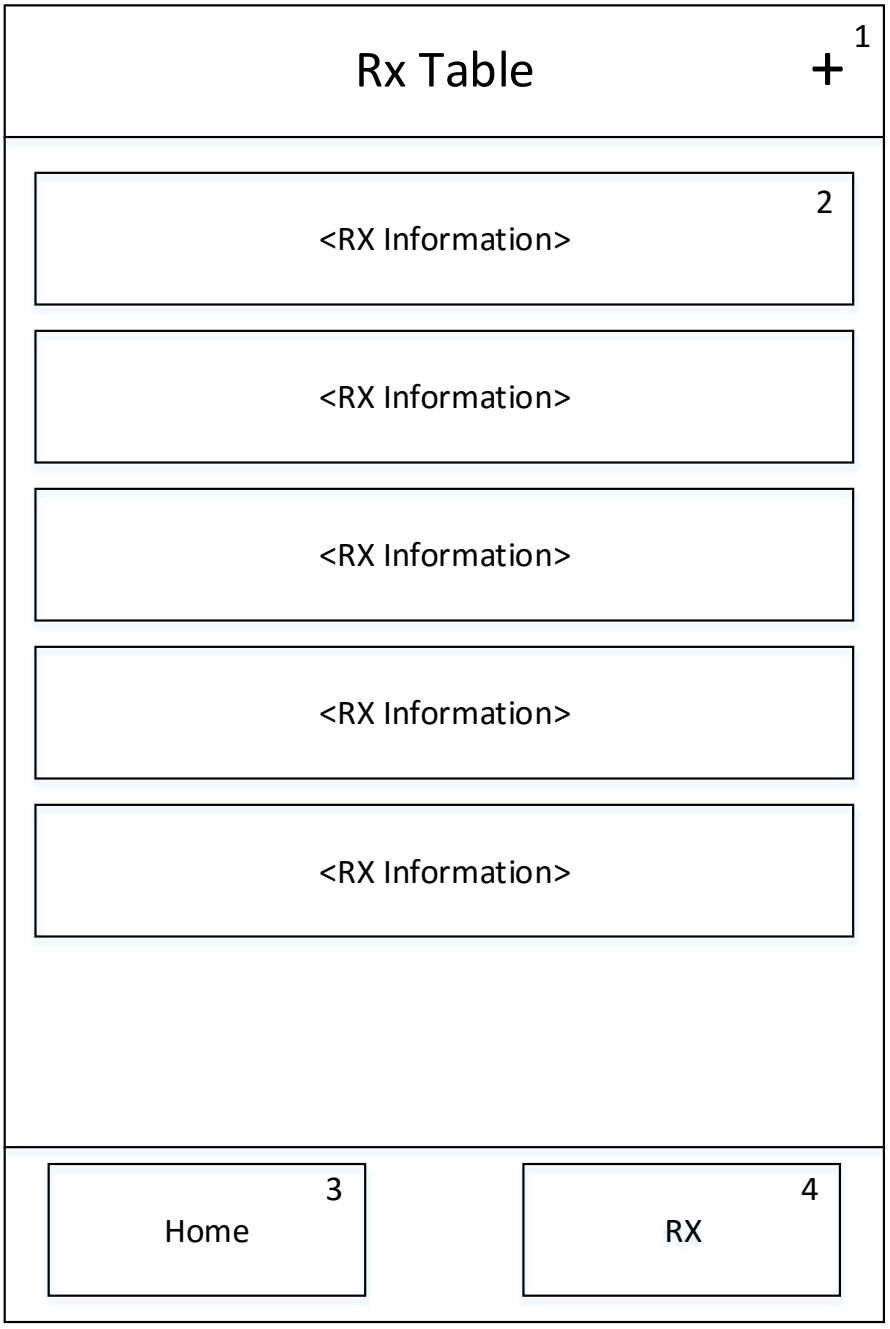

This is the Prescription Table, which will allow the user to change their prescription based on the environment around them, be it loud, like a sporting event, or quiet, like a coffee shop.

1) This “+” button will allow the user to load in another prescription in the form of a QR code.
2) The patient’s prescription history, along with different environments, are listed here to be easily switched to.
3) The “Home” button on the bottom of the application will bring the user back to the Home screen of the application.
4) The “RX” button on the bottom of the application will take the user to prescription of the application.

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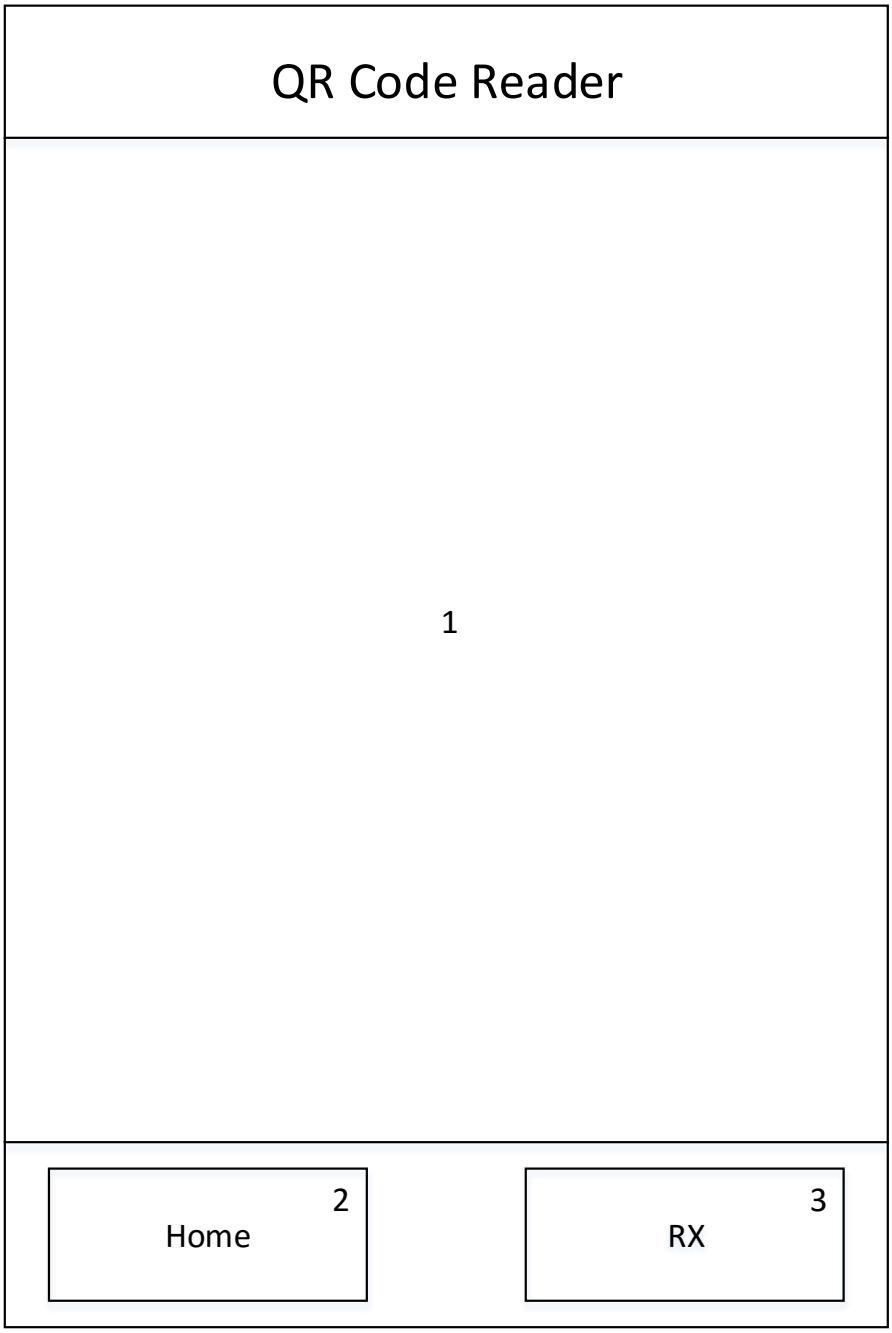

This is the QR reader, which will allow both the user and the audiologist to load in new prescriptions. This is also where the developer loads in a debug capable QR code.

1. The information within the QR code will be displayed here.
2. The “Home” button on the bottom of the application will bring the user back to the Home screen of the application.
3. The “RX” button on the bottom of the application will take the user to prescription of the application.

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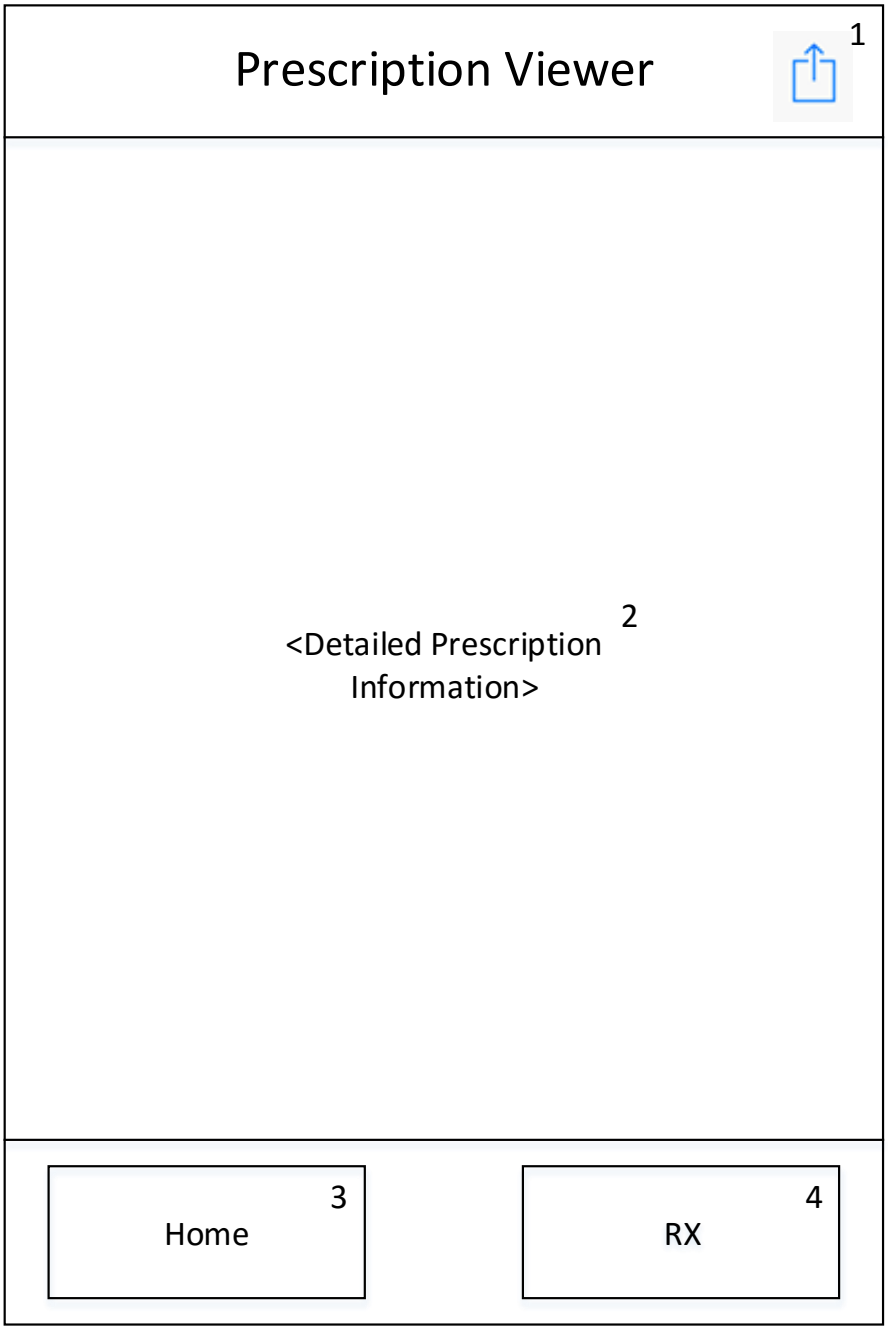

This is the view for seeing more detailed information about a particular prescription. The user can get here by selecting a prescription on the Prescription menu.

1. The “Load” button will allow the user or audiologist to set the currently viewed prescription as the active working prescription.
2. Detailed prescription information will be displayed here, including the prescription itself, the name of the prescribing audiologist, and which environment the prescription is intended for.
3. The “Home” button on the bottom of the application will bring the user back to the Home screen of the application.
4. The “RX” button on the bottom of the application will take the user to prescription of the application.

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