Developer Design Document

Our project consists of two different applications. One is a front-end application that is intended to be used by medical personnel and their managers. The other is an Android- based smart-phone application that will be primarily used by the workers in the field. Since Android applications are written in Java, we had no choice but to use that for that side of the application. We then decided to implement the front-end in Java as well. Doing so allowed us to take full advantage of the wealth of information of the team, the abundant number of libraries available, the fantastic GUI builders, and most importantly, it allowed us to share common code between the front-end application, and the Android application.

Both applications talk through a centralized platform Windows Azure. We chose to use Windows Azure, due to its large amount of interoperability that was pre-implemented, that we would have otherwise have to implement ourselves. Another nice feature of Windows Azure is that we can have multiple users administrate the services at the same time; something that is necessary when dealing with multiple developers. It also allowed us to easily implement data encryption, as all data transmitted to and from Windows Azure is encrypted with SSL. By doing so, we could skip potentially risky step of encrypting all of our data using a shared public key.

We currently use four services from Windows Azure:

- SQL Database
- Cloud Storge
- Mobile Services
- Website

The SQL Database is our primary database where all records are stored and transactions take place. It utilizes SQL Server in the back-end. We use the Cloud Storage to regularly back up our database in case of accidents, either from a hardware failure, or a temporary lapse in human judgment. The Mobile Service is what is used in order for the Android application to be able to communicate with the SQL Database. Without it, Android lacks the abilities to communicate with an SQL Server-based database. We utilize the website to host a user-registration page running on CodeIgniter, as well as endpoints to the database for the Android application to connect to, which was necessary as the Windows Azure Mobile Services library has issues with tables being touched by anything other than itself.

We use a third-party authentication provider, Auth0, which allows us to easily create and manage multiple users. Using this third party, we had a full API exposed to us that took care of user creation, deletion, key management, and password hashing. We chose Auth0, as it had a web-based API that we could connect with our own scripts and the front-end through traditional HTTP request, as well as an out-of-the-box solution for authenticating with Android devices, linked with Windows Azure Mobile Services.

When authenticating, the user’s email address and password is sent to Auth0 for verification. If the username and password is accepted, an ID token is passed back. A typical ID token looks like the following:

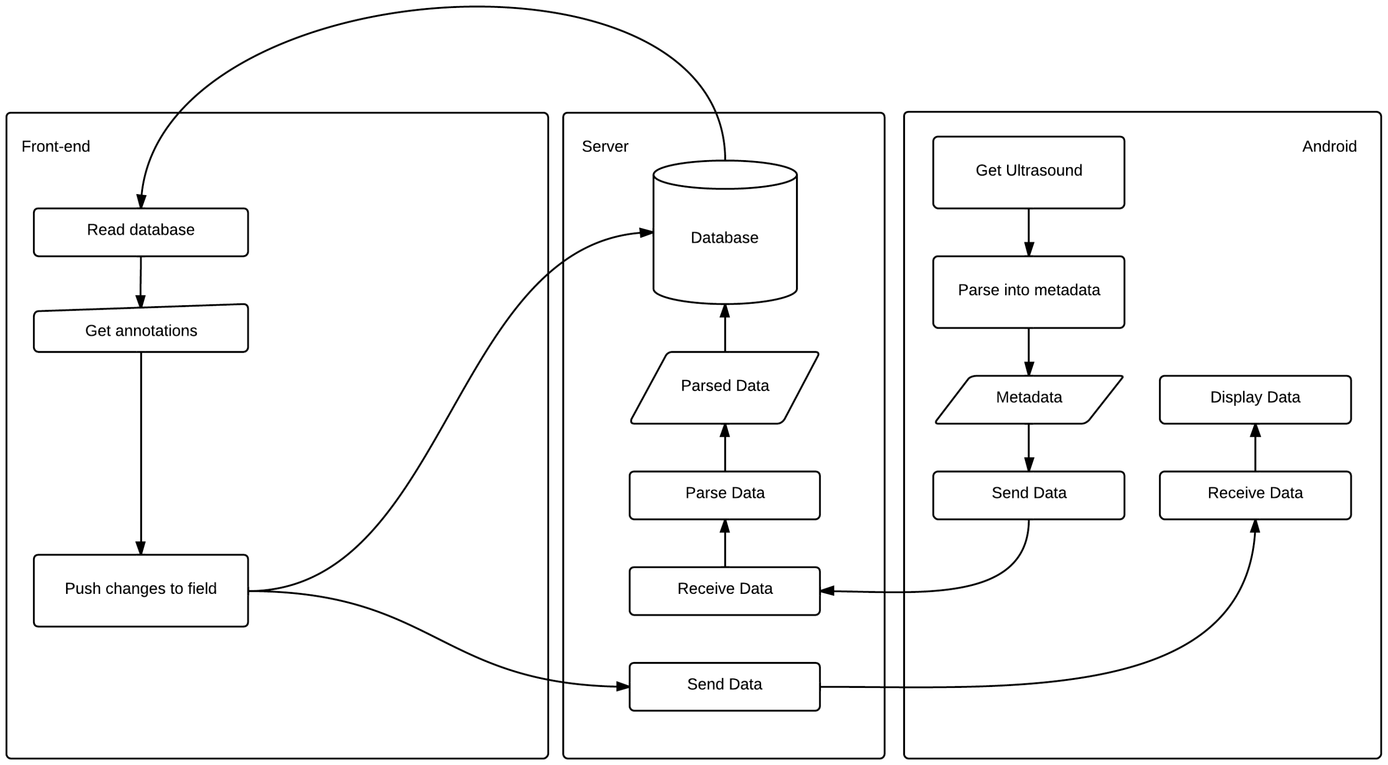
```
{
    "iss":"https://login.auth0.com/",
    "sub":"auth0|int",
    "aud":"--",
    "exp":int,
    "iat":int,
    "activated":1,
    "authlevel":4,
    "banned":0,
    "clientID":"--",
    "created_at":"--",
    "email":"--",
    "identities":[ {
        "user_id":int,
        "provider": “auth0",
        "connection":"Username-Password-Authentication",
        "isSocial":false
    } ],
    "location":"--",
    "myuidtoshow":int,
    "name":"--",
    "nickname":"--",
    "phone":int,
    "picture":"--",
    "uid":"auth0|int",
    "user_id":"auth0|int",
    "username":"--"
}
```

From this information, we can uniquely determine every user using our application. One thing to notice is the authlevel parameter. This is where we store the user’s privileges. Depending on the user’s privileges, they are able to do certain things within our application. For example, create new users, delete users and tasks, etc.

We have also included a number of third-party libraries with our front-end application.

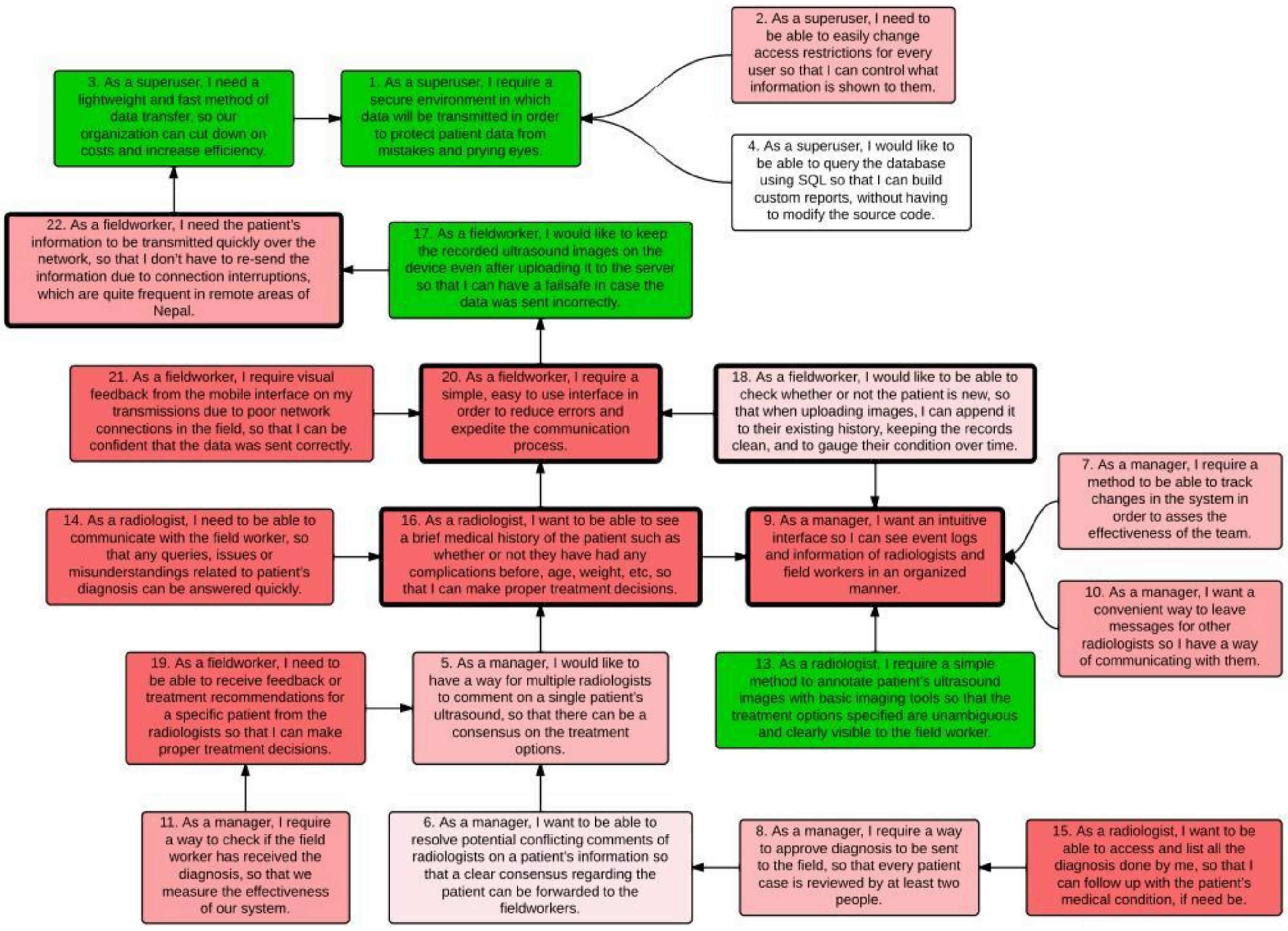
- Windows Azure SDK – For access to Azure-based services
- Apache Commons Codec – For decoding Auth0 base64-encoded json responses
- Google Gson – For parsing json responses from Auth0
- Sqljdbc – For connection to SQL Server based databases
- JGoodies FormLayout – Library for building enhanced form layouts
- MiG Layout – Graphical Interface Layout designer

The interchange between the two applications can be seen in the following diagram (ignoring authentication):



The client software works directly on the database, except for when an image needs to be uploaded or downloaded. In the Records table, the images are pointed to by a link. (We were unable to insert an image directly into the database as Azure Mobile Services would stop seeing the table if we did so) This link is to where the file resides on the server. To retrieve or upload a file to the database, we connect through an endpoint on the server, and issue either an HTTP request, or post command. The images are stored in the PNG format, as they are lossless, as well as compressed by default. This compression can save a large amount of bandwidth when sending images overseas. This is one of our constraints, as prolonged network connectivity is an issue in remote locations. Once the data has been saved into the server, and the link established, the front-end queries the database for updates. If an update is found, it pulls the metadata from the database, and presents it to the user. If a user is interested in working on the request, the relevant image is then pulled from the server. Once the image has been annotated by the user, the annotations (without the original image, as we will overlay the two on the mobile device) are sent back to the database, as well as any addition metadata that was added, before flipping a completed flag in the database. When the Android client sees this flag, it will pull the annotations from the database, as well as any additional metadata added by the client user, overlay the annotations overtop the original image, which was saved in internal memory, and display the new metadata.

To help us determine the order in which we should implement our technologies, and to see the whole picture, we created a dependency graph of our user stories, where every block is color-coded to it’s estimated size. White is smallest, red is largest, and green is completed. When choosing our technologies and frameworks, we referenced this chart in order to keep a realistic perspective on the relative importance of that task. We made the decision early on, that if we could find something that was already built, instead of building out own components, such as the authentication system, it would allow us to allot more time to things such as the UI, and the communication between the database and the clients.


2. As a superuser, I need to be able to easily change access restrictions for every user so that I can control what information is shown to them.
3. As a superuser, I need a lightweight and fast method of data transfer, so our organization can cut down on costs and increase efficiency.
1. As a superuser, I require a secure environment in which data will be transmitted in order to protect patient data from mistakes and prying eyes.
4. As a superuser, I would like to be able to query the database using SQL so that I can build custom reports, without having to modify the source code.
22. As a fieldworker, I need the patient's information to be transmitted quickly over the network, so that I don't have to re-send the information due to connection interruptions, which are quite frequent in remote areas of Nepal.
17. As a fieldworker, I would like to keep the recorded ultrasound images on the device even after uploading it to the server so that I can have a failsafe in case the data was sent incorrectly.
21. As a fieldworker, I require visual feedback from the mobile interface on my transmissions due to poor network connections in the field, so that I can be confident that the data was sent correctly.
20. As a fieldworker, I require a simple, easy to use interface in order to reduce errors and expedite the communication process.
18. As a fieldworker, I would like to be able to check whether or not the patient is new, so that when uploading images, I can append it to their existing history, keeping the records clean, and to gauge their condition over time.
7. As a manager, I require a method to be able to track changes in the system in order to asses the effectiveness of the team.
14. As a radiologist, I need to be able to communicate with the field worker, so that any queries, issues or misunderstandings related to patient's diagnosis can be answered quickly.
16. As a radiologist, I want to be able to see a brief medical history of the patient such as whether or not they have had any complications before, age, weight, etc, so that I can make proper treatment decisions.
9. As a manager, I want an intuitive interface so I can see event logs and information of radiologists and field workers in an organized manner.
10. As a manager, I want a convenient way to leave messages for other radiologists so I have a way of communicating with them.
19. As a fieldworker, I need to be able to receive feedback or treatment recommendations for a specific patient from the radiologists so that I can make proper treatment decisions.
5. As a manager, I would like to have a way for multiple radiologists to comment on a single patient's ultrasound, so that there can be a consensus on the treatment options.
13. As a radiologist, I require a simple method to annotate patient's ultrasound images with basic imaging tools so that the treatment options specified are unambiguous and clearly visible to the field worker.
11. As a manager, I require a way to check if the field worker has received the diagnosis, so that we measure the effectiveness of our system.
6. As a manager, I want to be able to resolve potential conflicting comments of radiologists on a patient's information so that a clear consensus regarding the patient can be forwarded to the fieldworkers.
8. As a manager, I require a way to approve diagnosis to be sent to the field, so that every patient case is reviewed by at least two people.
15. As a radiologist, I want to be able to access and list all the diagnosis done by me, so that I can follow up with the patient's medical condition, if need be.

Technologies Used:

Android Application:
Programming Language: Java
IDE: Eclipse
Libraries: Android API (SDK), Auth0, Windows Azure Mobile Services
Android OS MIN Version Required: 3.0

Database: MSSQL hosted on Windows Azure

Website: PHP 4.4 hosted on Windows Azure Server
Framework for web development: CodeIgniter

Standalone Java Client:
Libraries: See page 2
IDE: Eclipse
Language: Java

Android Client Design Details:

Modules:

AuthenticationActivity.java: First thing to load to allow user to login.
Login Screen.java: Secondary Login to Launch Interface
WalkthroughScreen.java: Shows Tutorial video to user
WelcomeScreen.java: Loads Main Menu System in android device.
UltrasoundImageScreen.java: Loads Camera application in android to click picture.
MetadataScreen.java: Allows user to enter details about patient and upload them.
PatientRecords.java: Displays a list of patients added by the fieldworker.
PatientData.java: Displays a profile of specific patient.
Search.java: Displays search interface on mobile device to search a patient and calls PatientData.java to search
ImageDisplay.java: Displays Ultrasound Image downloaded from database on mobile device screen.

- All Code Files call functions provided by Android API (library).
- Android Client Follows Model View Controller Design throughout the code implementation.
- XML files are displayed as views and activity classes act as controllers monitoring user input and manipulating the view. Patient data involved in the app acts as model.

Features that we would like to include in future:

- Allow android app to take multiple pictures of patient ultrasound from different angles and then send all those pictures tagged with one record.

Java Client Design Details:

Packages:

- Frontend – Contains all components related to the UI
- Global – Components that can be used between Android and Client, or between packages.
- Model – General purpose types to hold or manipulate data.
- Tests – Automated tests

Java Client Bugs & Weaknesses

- Storing the Auth0 client ID and client secret in Secrets.java is a potential security risk, as decompiling the application would expose this. It would be best to protect this file by encrypting it, and storing it into a read-only, hidden system file.
- Storing the database connection string in Transmission.java is a potential security risk, as decompiling the application would expose this. It would be best to protect this file by encrypting it, and storing it into a read-only, hidden system file.
- Communicating directly with the database is a potential security risk. It should be moved server-side, where encrypted JSON tokens are exchanged.

Server/SQL Bugs & Weaknesses

- Patient details are not encrypted.
- There is no access control when downloading or uploading images to the server. We could pass the user's Auth0 JSON token for authentication, along with the HTTP request, as the token is signed. (See: JSON Web Token)

Android Bugs & Weaknesses

- Patient Records are not updated automatically.