CNAT

Design Document

Sdmay20-51
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Executive Summary

Development Standards & Practices Used

Software practices used in this project include using Agile development methods to complete bi-weekly sprints.

Applicable Engineering standards to this project are:

- IEEE 15939-2017 - ISO/IEC/IEEE International Standard - Systems and software engineering--Measurement process
- IEEE 12207-2017 - ISO/IEC/IEEE International Standard - Systems and software engineering -- Software life cycle processes
- IEEE 14764-2006 - ISO/IEC/IEEE International Standard for Software Engineering - Software Life Cycle Processes - Maintenance
- IEEE Std 11073-10201-2018 Health Informatics—Point-of-care medical device communication Part 10201: Domain Information Model
- IEEE 29119-4:2015(E) Software and Systems engineering —Software testing — Part 4: Test Techniques

Summary of Requirements

- Design a dashboard to present a summary of data accumulated.
- Generate a playback feature on the dashboard that would allow us to select a data set and play it back.
- Implement a strategy that will help determine an improved anchor placement to achieve more accurate location information.
- Come up with some potential logic that will help better determine the room a healthcare staff actually went into.

Applicable Courses from Iowa State University Curriculum

- COMS 309
- SE 319
- SE 329
- COMS 363
- CPRE 489
- CPRE 430

New Skills/Knowledge acquired that was not taught in courses

New skills acquired throughout this project include familiarity with a React framework, knowledge of RF wireless communication, signal depreciation through walls and other objects, small business entrepreneurship, healthcare limitations and practices in relation to engineering, and project development standards.

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1 Introduction

1.1 Acknowledgement

We would like to acknowledge the contributions of the following organizations and individuals towards our successes during this senior design project:

In Motion Care, Iowa State University, Green Hills Retirement Community, WISER Systems, and Dr. Daji Qiao.

1.2 Problem and Project Statement

Currently, healthcare staff at Green Hills Retirement Community receive individual resident care plans, detailed information on individual residents and their needs, through paper packets. These packets are often updated multiple times throughout the day, causing these packets to be reprinted just as often as they were updated. This can cause multiple issues as employees may not be getting the most updated packet, meaning they may not be giving the proper care to a resident.

Each packet has approximately 27 pages, and one packet is printed for each employee. With 75 employees, printing the care packets multiple times a day consumes a large amount of paper.

This project sets out to create a system that will track the healthcare staff throughout their facility. Based on their location, the system will give workers real time updates on the requirements of patients' needs as they enter rooms. There are a number of tracking devices called anchors placed around the facility that actively look for another set of passive devices called tags that are carried by the staff and anything else that needs to be tracked throughout the building. The data from the tracking system is displayed to the staff in real-time and historical information is stored for later reference.

As part of this project, we will be creating a dashboard application that will display the location of resources within Green Hills in real-time. This application will be a map of the facility with markers accurately reflecting where people and equipment are at the current time. Additionally, our application will display statistics requested by Green Hills that reflect which rooms require the most attention over any given period of time. Our application will also have the ability to display historical location data, in which a user can view where faculty and equipment were at a given date and time. Finally, we will be including In Motion Care's Care Plan application into our dashboard.

1.3 Operational Environment

Our system will be implemented into Green Hills Retirement Community in Ames, IA. This facility is completely indoors, however hazards to consider are resident and healthcare staff interaction with the hardware.

1.4 Requirements

As our dashboard application will be used primarily by the healthcare staff and administrative personnel, our focus is to make the application intuitive and user-friendly so that it may improve the staff's day-to-day tasks.

Our application needs to grant the healthcare staff on duty an active map that is paired with In Motion Care's current WISER tracking sensors. The real-time map portion of our project will display the location of all tagged personnel and equipment within the tracked area in Green Hills Retirement Community. Green Hills has a policy that rooms must be visited at least once every two hours. The map will alter the color of the rooms to signify when a room needs to be visited, similar to an order tracker in a fast food restaurant.

The statistics portion of our dashboard application will display room activity over a selected period of time. Green Hills has requested that the information be presented in a priority-based manner, in which the rooms with more faculty-resident interactions are presented first.

Our playback feature, which will allow a user to view location data from a given date and time, will utilize the stored data from the tracking sensors inside our database. This will display similar to the real-time map, in which the path data is tracked over a given time interval.

The dashboard will acquire its data from anchors placed in the facility and tracker tags placed on the asset we will be tracking. The anchors and tags we are dealing with are by a company Wiser Systems. The tags cost $69 and the anchors cost $209. Accuracy of the data collected is directly proportional to the number of anchors. Data management systems are maintained on Google Cloud.

The anchors will be strategically placed in locations that will not disturb the patients or the health care staff's daily routine. The anchors require power through wall-outlet or ethernet. Implementing a method for tags to be carried with the least chance of damage while maintaining optimal accuracy.

Software Implementation Requirements:

Front-end:

ReactJS

HTML 5

Google Chrome

Jest (Unit testing)

Back-end:

Spring Boot Server

MySQL on Google Cloud

Wiser Systems API

Mockito (Unit testing)

1.5 Intended Users and Uses

Our intended users are Green Hills healthcare staff and administrative personnel. The administrative and healthcare staff would have the ability to view a real-time map of the facility, displaying the location of all tracked personnel and equipment.The map would be used by the healthcare staff to know when a room needs to be visited. The healthcare staff also has access to update the care plan using the integrated application from In Motion Care.

The administrative staff would have additional privileges to view statistics of healthcare administration over a selected period of time. These statistics will be used to determine where the facilities resources are being used the most among the residents. Also, the administrative staff will have the ability to access the playback feature. The playback feature serves as a way for Green Hills to look back on the location data if an audit is required, or to gain a better understanding of a time period following an event.

1.6 Assumptions and Limitations

Assumptions:

- The dashboard will not be used in any facility other than Green Hills Retirement Community.
- Users of the dashboard speak english.
- The facility has a consistent supply of power.

Limitations:

- No tag carrier can accurately be tracked if traveled between more than two rooms in less than .2 seconds.
- For power, anchors need to be placed near a power supply when wireless or be tethered to each other via ethernet cable when not.

1.7 Expected End Product and Deliverables

Statistics Dashboard

> A React-based web application that acts as a dashboard to present applicable summary statistics to the user. This dashboard will display a cumulation of time spent by staff within resident rooms over several intervals of time. This list will then be sortable to showcase which rooms most visited.

Real-Time Facility Map

> The facility map will display the current location of all tracked entities within the anchored zones in Green Hills. The map will have the capability to be running at all times. Rooms will display as a gradient of color over a two hour period. If a room is not visited within the two hour period, the color will gradually shift to an alarming color, denoting the room must be visited.

Location Playback feature

> A playback feature implemented through the web application that displays historical movement of targeted individuals. This feature allows the user to view archived location data of all tracked personnel and equipment. This feature will be a modal that will display the tracked location over a selected time interval, similar to watching a video.

Integrate Care Plan Application

Our dashboard will integrate In Motion Care's care plan application into our functionality. A separate webpage will allow the user to view/edit/audit the care plan of a resident directly from our web application.

Design Deliverable Concept: Bringing together statistics dashboard, real-time facility map, location playback module. Our system yields a conceptual design as shown in the figure below.

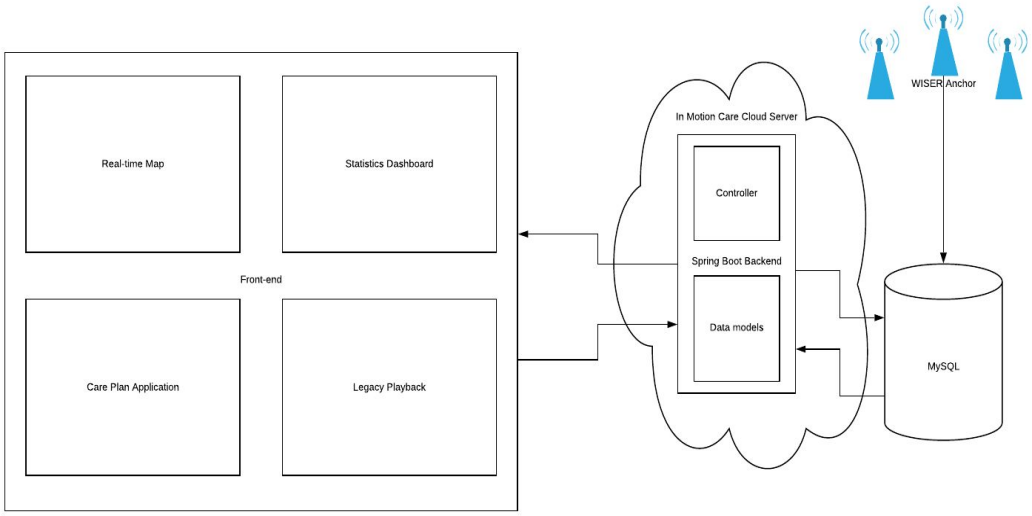

Figure 1: System Conceptual Design Diagram

2. Specifications and Analysis

2.1 Proposed Design

Thus far, we have researched the use of the WISER Systems tracking system and its normal use cases. These typical use cases are far different from those that represent the current project. We have discussed with our client their current shortcomings and how they have set up their system.

Our client has had many of the other students working on his project come to our meetings to show what they have been working on and the currently developed systems. Our team has started to learn the currently implemented system's technologies like React JS.

2.2 Design Analysis

We conducted meetings to gain a full understanding of our client's requirements over the course of the first few weeks. We discussed In Motion Care's requirements and what we as a team believe we can deliver. We broke down the system's use cases and specifically tailored questions for our client to get the most details and requirements to properly define our scope. We are drafting our front-end screen designs which will be brainstormed with our client and passed on to his partners. Based on the data our client is gathering, we are designing an intuitive database design that we will be able to query from efficiently.

So far, we have been using an iterative design philosophy with our client, going back and forth with different ideas as we come up with and further refine them. This process helps us understand each

use case and ideate and prototype a perfect goal. We identified that our sessions of scoping as a team needed an affirmation or guidance and in this case, our client has been a great mentor. We have seen that our methods help keep us from producing redundant work and that our ideas are in line with our client's vision.

2.3 Development Process

For this project, an Agile/Scrum development process is to be implemented. This development style was chosen as it allows developers to focus on an iterative approach to development where all requirements, solutions, and goals are decided through collaboration of the entire team. Agile and scrum help to create a strongly structured project management process where issues are handled as they arrive and progress is consistently made. Furthermore, the development process strongly encourages teamwork, self-organization, and accountability

2.4 Design Plan

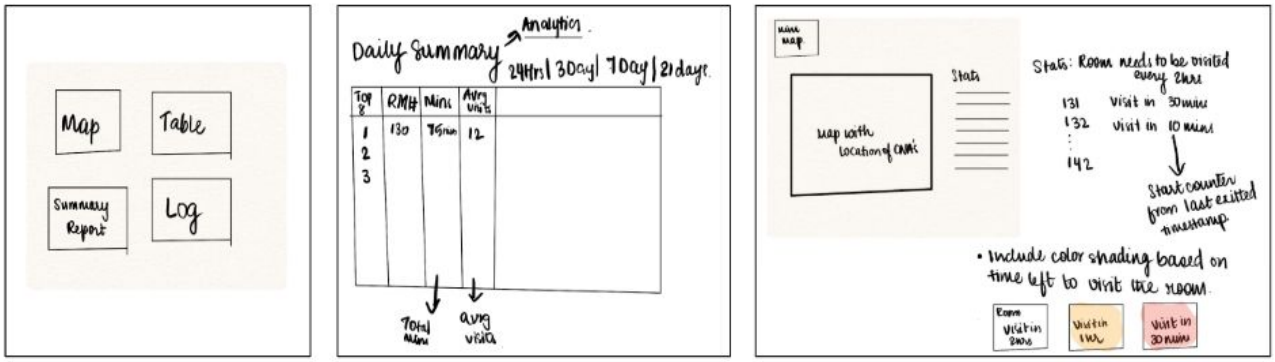

Figure 2: Webpage conceptual design

The above conceptual sketch shows the requirement of features and functions requested by our client. Based on the above requirement our project is broken into the following modules:

1. Front-end Design

   UX Design:
   a. Use design software to create mock-ups of application views.
   b. Look for client approval of designs to move on to implementation.

   Implementation:
   a. Use the React Javascript library to build the graphical user interface for the dashboard.
   b. Application.
2. Back-end Design
   a. Database design
      i. ER Diagram
      ii. Begin by creating a detailed diagram high-lighting the dependencies between our data. Aim is to create an efficient database.
      iii. Propose database to client. Add any further dependencies or tables based on feedback.
   b. Implementation
      i. Create a back-end with direct connection to the database.
      ii. Build in functionality to access multiple sets of data for playback program.

iii. Using Ajax, create a connection to the back-end to accept requests from the front-end to query and process information from the database.

c. Deployment
   i. Begin data collection within Green Hills utilizing create back-end and database.

3. Statement of Work

3.1 Previous Work And Literature

Currently, Centrak offers a similar product to what In Motion Care hopes to deliver. Centrak's "Real Time Tracking System" uses a combination of IR, RFID, and other technologies to create a personnel and equipment tracking system specifically for healthcare facilities. Their combination of multiple sensor technologies allows for accurate tracking of personnel, even within non-optimal environments for signal propagation.

In Motion Care's technology currently only utilizes WISER System's RFID sensors. Where their product differs, is they hope to deliver updated care plans to nurses based on proximity to a patient's room alongside the personnel and equipment tracking capabilities that Centrak currently provides.

Our project for In Motion Care is wto create the UI and back-end to support real-time and legacy viewership of location data, along with the integration of the care plan updating application. We will be using In Motion Care's current database, which stores location data, to populate our web application.

3.2 Technology Considerations

We are implementing a web-based interface for our application that needs to update in real-time. To implement a real-time web-based application, the application should use javascript. There are many javascript frameworks that can be used for applications like this.

For this application, the decision was made to use ReactJS because of its single-page application design. Because the application is broken down into a few sub-applications, making each of those their own page will give the user a feeling of separation between each despite being on the same website.

Another front-end frameworks we could use was Vue JS, but because there was already existing work on the project done in React, it made more sense to not change the system.

We have decided to work with Java and the Spring Boot framework to construct the back-end for our project. This decision was made due to the client's own preference towards the system, as they have used it before we came on to the project. We are also using a MySql database connected to the Google Cloud Platform (GCP) as the client already had the database in their possession.

3.3 Task Decomposition

This project is broken up into a front-end and a back-end with about half the team on each.

The front-end is broken up into three separate sections that can each exist mostly independently, but they are tied together with the front-end framework. The front-end makes API calls to the back-end to get data to present to the user on the front-end and do processing that is considered too taxing for a web browser.

The back-end has to connect to the client's database and conglomerate data when the front-end requests it.

3.4 Possible Risks And Risk Management

The inherited portion of this project is spread across several separate applications with only one or two people who are knowledgeable on their use and implementation. Our team does not have a solid understanding of how each piece fits in with all of the other pieces despite them playing a major part in the end-product.

The desired outcomes of the project change readily and quickly and it invokes a lot of discussion between the client and team members. The discussions involve feasibility and scoping issues because of the number of things currently involved in the creation of the product.

3.5 Project Proposed Milestones and Evaluation Criteria

The project milestones can be broken up between the front-end and the back-end and even more within each of those.

Front-end:

> One of the biggest milestones is to create the map interface. The interface has to be intuitive and able to seamlessly transform into other views and maps. Along with that, the application needs to create a connection with the live-data server to update the nurses position in real-time. The application also needs to make API calls to the historical data server for replay capability. The APIs should return the data for each tracked asset and each room along with the playback we want.
>
> Milestones on the front-end of our project:
>
> - Complete implementation of logs
> - Complete implementation of summary reports
> - Complete implementation of statistics view
> - Implement room indicators based on data
> - Implement playback feature

Back-end:

> To test this our system, we will first use mock data on local systems. Later, we will use live data from our client and validate the information onsite and historical data from their database.

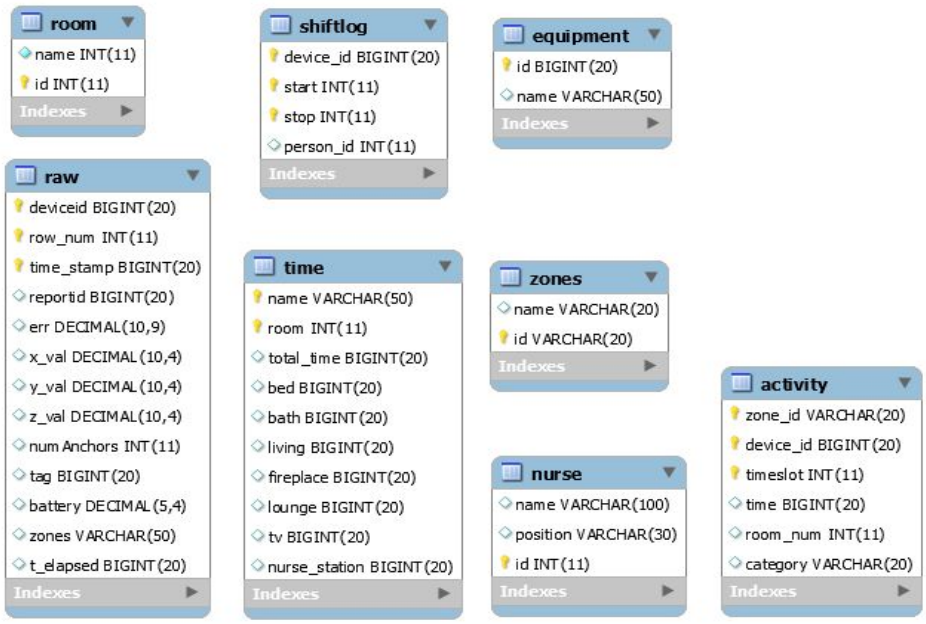

Figure 3: Current database structure of In Motion Care LLC

The above figure shows the current database structure for In Motion Care, currently we are in the process of redesigning and altering the database to achieve the required functionality.

Milestones for back-end are simultaneous to front-end since back-end provides the data and relations implemented on the webpage but also include:

- Back-end rendering of playback videos
- Rewrite database
- Complete API implementation

3.6 Project Tracking Procedures

To track our progress throughout this project, our team is utilizing the issues feature on GitLab. Using this, we are developing our application in an Agile process, creating issues to be completed in short two week sprints. These issues are assigned to certain members of our group, so individual contributions are tracked by tracking the completion of issues on the GitLab issue board.

3.7 Expected Results and Validation

We expect our system to provide a real-time view of tracked assets in Green Hills and a way to view historic data points. It will also show the care plan for each patient and a log of the changes made to them for bookkeeping and audit purposes.

The system is set to be used at Green Hills and will be tested live by the staff on premises and the administrative staff behind the scenes.

4. Project Timeline, Estimated Resources, and Challenges

4.1 Project Timeline

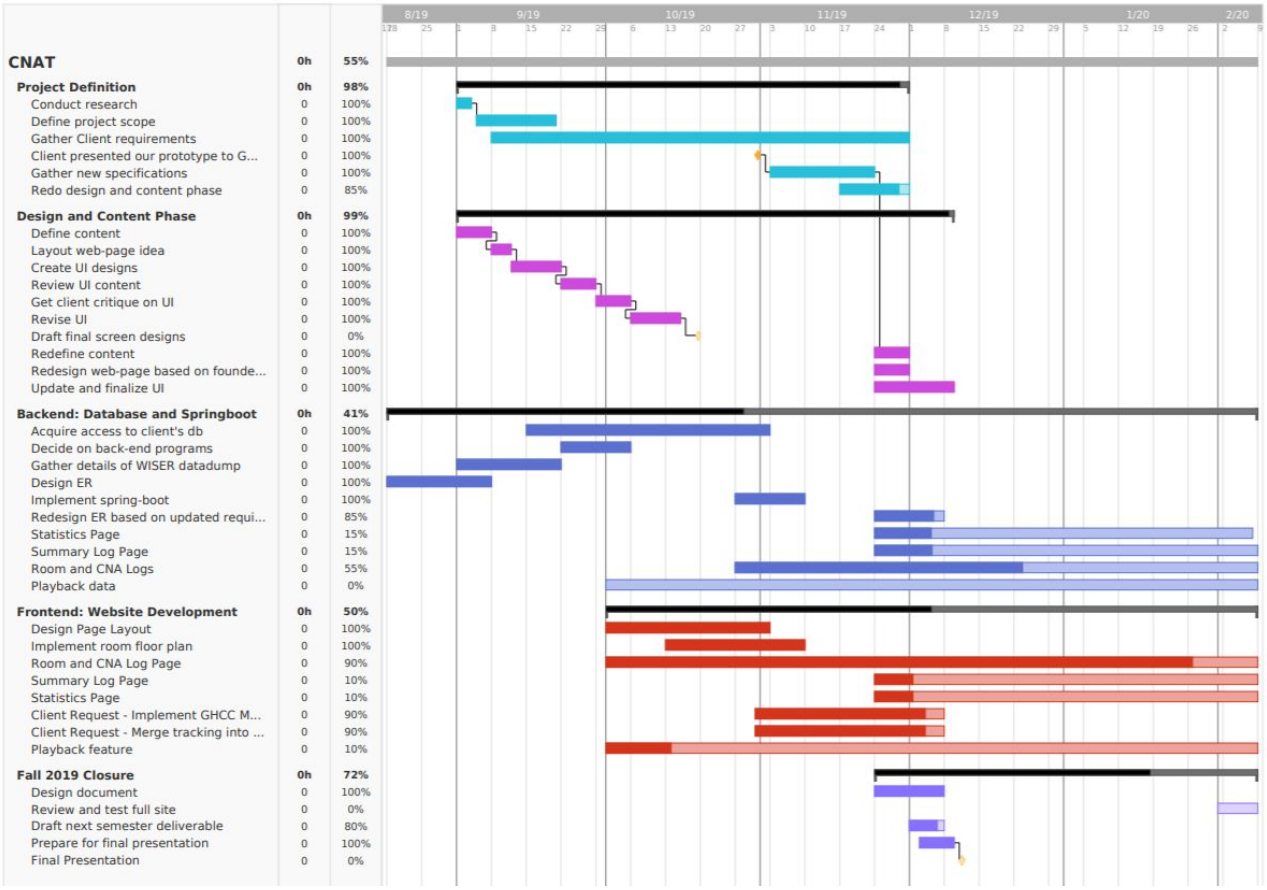

Figure 4: Gantt Chart v2

We planned our semester to deliver our client a structure of the website the fall semester and we spend the spring semester working on improving the accuracy of parameters displayed on our dashboard. We are mapping our semester planning in an agile approach. We had a planning phase where we included our client to draft ideas and set the exact requirements for our project analysis and design phase. As shown in the above Gantt chart our team has laid out tasks after our design phase strategically to account each activity enough time for implementation and testing.

Project definition was the starting point of our project where we had meetings to kickoff the team and kickoff with our client. During the later meetings we outlined our client's requirements and understand the scope for our project. Debated on our team's possible deliverables through the two semesters with our client and advisor. We defined the scope of our project.

As we mentioned above we split our team into front-end and back-end. Front-end team is working on developing the web application and our back-end team is working on cleaning up the data dump by WISER Systems data dump and use spring boot to help with the playback feature of ur

website. Within the groups we broke down tasks to track different features of the website like maps, nurse location and time tracking, activity in a room and location playback.

Our timeline for the front-end will be developed simultaneous getting the data and the support from back-end. We set our timelines for back-end based on the data required for our front-end applications to play out tasks simultaneously, this way we avoid either groups stalling due to requirements from the other group.

Much of our development's skeleton will be tackled over the fall semester and we will utilize the spring semester to upgrade the esthetics, features and then work up to improve accuracy as much as we can to build a reliable tracking system. One task for example and the most challenging crucial feature is the nurse playback data where the front-end will play the nurse's path within the period selected where back-end provides the exact route coordinates.

4.2 Feasibility Assessment

Realistically, our project will be a fully-implemented dashboard specified in sections 1 of this design document. This deliverable will be done by the end of April 2020. By the end of December 2019, a working dashboard will be implemented with minimal functionality and minimally tested. Some challenges we might face going forward include the project specifications changing from our client, inadequate access to resources, and failure of the Wiser system.

4.3 Personnel Effort Requirements

Table 1: Personal Effort Table

	Project Definition	Design and Content	Database	Website Development	Back-end Development
Kirkland Keith	20%	5%	30%	0%	45%
Suzanna Gudivada	20%	15%	5%	60%	0%
Brandon Elizondo	10%	5%	5%	80%	0%
Austin Sehnert	20%	20%	0%	60%	0%
Benjamin Zaley	20%	10%	30%	0%	40%

Based requirements of our projects we have broken down tasks and divided how our team addresses these challenges. Based on our individual interests and demand for the task, we have listed our efforts divided in areas listed above. Austin, Brandon and Suzanna form the front-end team, thus focusing most of their effort on website development and design. Benjamin and Kirkland are tackling back-end, resulting in them focusing their efforts in back-end development and database. Based on demand of a task, we will switch around and handle the issue. Making all of us involved in every part of the project.

4.4 Other Resource Requirements

This project requires the tracking equipment from Wiser Systems for its tracking and a server with a database to store the information. The client has already provided this and a platform to host systems created for this project on the cloud.

4.5 Financial Requirements

Our project was stated as no financial support from our client. Foreseeing our deliverables, implementation and testing we are not expecting any financial resources.

5. Testing and Implementation

Testing is an extremely important component of most projects, whether it involves a circuit, a process, or a software library

Although the tooling is usually significantly different, the testing process is typically quite similar regardless of CprE, EE, or SE themed project:

1. Define the needed types of tests (unit testing for modules, integrity testing for interfaces, user-study for functional and non-functional requirements)
w2. Define the individual items to be tested
3. Define, design, and develop the actual test cases
4. Determine the anticipated test results for each test case 5. Perform the actual tests
6. Evaluate the actual test results
7. Make the necessary changes to the product being tested 8. Perform any necessary retesting
9. Document the entire testing process and its results

Include Functional and Non-Functional Testing, Modeling and Simulations, challenges you've determined.

5.1 Interface Specifications

There is no hardware/software interface we have or will create that will be used in testing.

5.2 Hardware and software

Postman - This software is used to send http requests to our back-end endpoints for testing purposes. This allows the verification of the endpoints' accessibility and correctness.

5.3 Functional Testing

We will be using Mockito as our unit testing suite for the back-end of our system. The integration testing for this project is done by both developers and Green Hills Retirement Community workers. The data moving between the front-end and the back-end will need to be validated during testing to make sure there are no issues during transmission or translation.

Our system and acceptance testing is done by the workers of Green Hills Retirement Community where the staff has been using the project while it is in development. They are also the people that will be using the product when it is completed, so the problems they find and the modifications they want are incredibly useful to the development and testing processes.

5.4 Non-Functional Testing

As stated previously, the staff of Green Hills Retirement Community will be working with the system while its in development and after it is released. They will be providing feedback on performance and usability throughout the entire process which will be taken into account during concurrent development cycles.

The application is being designed to run on one platform currently and at the moment there are no plans to provide compatibility with other platforms. Security access control has also not been defined by the client yet meaning it has not been implemented yet, but it has been discussed.

5.5 Process

Due to our requirements changing so much and our design changes, testing hasn't been a large priority because of a lack of a complete product till this point.

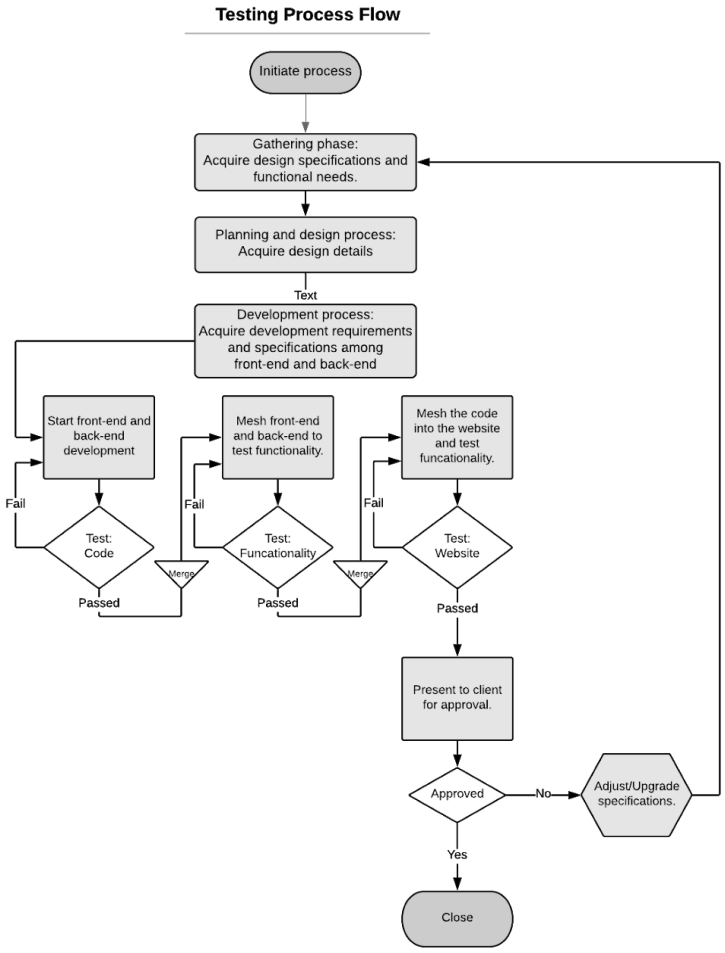

Figure 5: Testing Process Flow

5.6 Results

This project has not reached the point of aggressive or extensive testing due to being in its early stages of development. We have been doing testing of the portions being implemented as we develop which has been driving changes that fix issues or prevent foreseeable ones. This testing is done on an individual developer basis and doesn't involve defined test cases.

6. Closing Material

6.1 Conclusion

We are striving to provide our client with a fully functional and reliable web application. To do so, we have set multiple goals including: setting up the facility map in order to track staff and equipment as well as implementing a previously developed webpage into our own application.

Throughout this semester, our group has accomplished a large amount of work. On the front-end, we have developed a strong basis for our web application. This includes a login page where you can select your specific facility and then enter your credentials. Upon logging into the website, we have access to a homepage that currently showcases a map to the facility with (at present) moving dots to imitate CNAs that are being tracked by the system. For the previously developed webpage, we have chosen to completely rewrite the site using React.Js as it was originally built using raw JavaScript.

On the back-end, we have developed a Spring Boot Server to contain our controllers, models, and repositories for all information to be sent to the front-end. This server has been accompanied by a brand new database that correctly stores all information we determined was needed to build a strong, working application.

We have chosen both React.Js and Spring Boot as they have offered us the ability to properly design and implement all requested features of our application in an easy and efficient manner. Furthermore, these frameworks are being used elsewhere in our client's company, allowing our group to give them working code that they should successfully be able to maintain and update.

6.2 References

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