Wifi Analyzer Cleveland State University Campus

SOFTWARE PROJECT FINAL REPORT

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1. Introduction

In recent years, there has been a lot of demand for Wi-Fi hotspots. In this work, we examine the impact of different internal environmental factors on the coverage of Wi-Fi strength across campus building. We see a visual illustration of the wireless signal coverage and strength with the help of Wi-Fi heat map. With heat map, we can easily identify the specific position with poor signal reception and determine effective router positions [1].

In large building areas with the help of heat map, we can easily troubleshoot signal fluctuations. Wi-Fi heat maps are considerably useful in revealing potential sources of signal interference, such as walls, furniture, large appliances, and other wireless devices.

Heat maps are quite popular these days. A properly configured Wi-Fi network improves communication between the devices that connect using it, which, in turn, assist productivity in a business. That is why it makes sense to ensure stable, well-built, and protected signal strength across the whole campus or area. One can find multiple Wi-Fi heat map software available on internet e.g. solar winds, Ekahau, Acrylic Wi-Fi etc. Some of them are paid and some are fully free. You can easily install it in your laptop or smart phone and use it. In few easy steps like install app , upload the map of the building or area you want to check then start moving from one location to other to capture the signal strength and see the color coded results.

1.1. Purpose and Scope

Building a website, which represent a Wi-Fi access points (APs) coverage heat map in the city of Cleveland at the periphery of the Cleveland State University. With the help of the heat map, we can easily identify the specific position with poor signal reception and determine effective router positions [2].

Since APs deployed inside the college campus, we will investigate if coverage is sufficiently dense around the college building, on what conditions depend its performance, which area has lowest signal reception and which part has acceptable signal propagation.

We will show the results for the college campus, highlight the weakest and strongest coverage area through a heat map. Data collection for input will be done via measuring WIFI signal strength around the college building including basement, where we have car parking. The smart phone uses application to measure Wi-Fi signal strength at a specific area.

Data collection for input will be done via measuring WIFI signal strength using mobile App around the college building (including basement where we have car parking). The smart phone uses application to measure Wi-Fi signal strength at a specific area.

Using this data as Input, we will send to our code. Using logics and functions our code will generate heat map and display through website as output.

We are planning to display heatmap of different floors on the website for the Berkman Hall of the Cleveland State University.

With our website one can determine and analyze the weakest and strongest signal reception areas across the Cleveland State University campus.

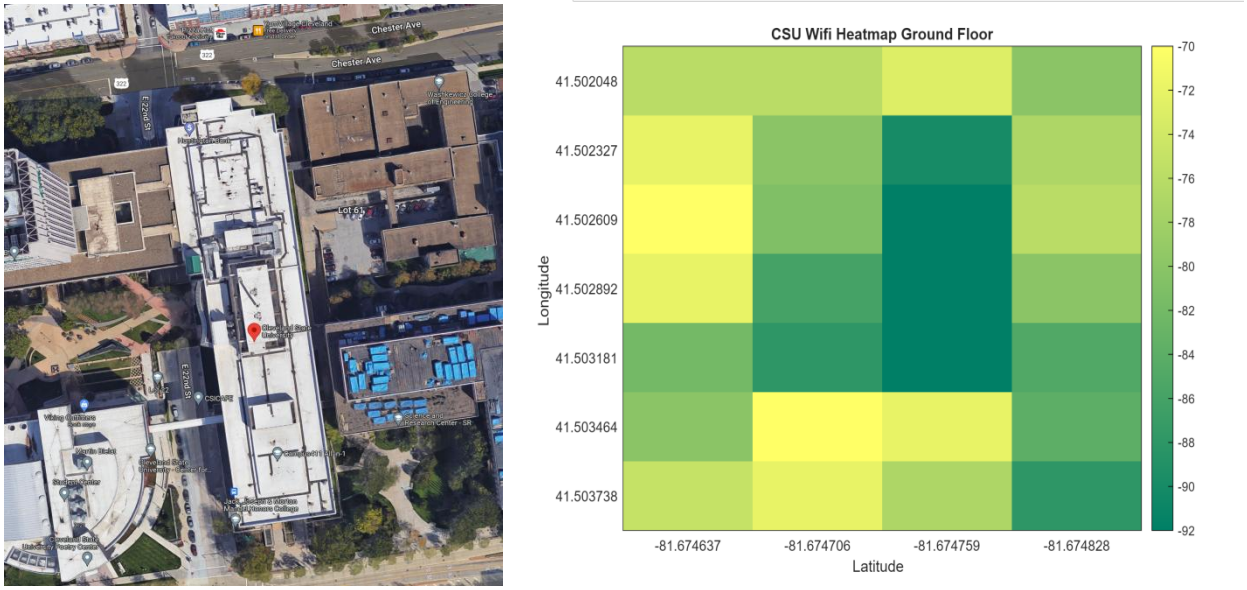

Figure: BH College campus map and Wi-Fi signal strength heat map, deep green showing weakest signal reception zone, light yellow is good signal reception.

1.2. Terms, Acronyms, and Abbreviations

APs - Access points

Wi-Fi – Wireless Fidelity

CSU – Cleveland State University

BH – Berkman Hall

Heat map is a color-coded graph, which helps in determining the strength of the signals from high to low at different areas. Visual representation is easy to understand and locate specific area with poor signal strength. Rather than blindly guessing and installing routers at wrong place, heat maps really works efficiently to figure out the specific location [3].

1.3 Major constraints

- With *limited time and limited resources*, **Real time signal strength measurement is out of the scope** of this project and will not be displayed via website

- Data collection for the entire campus of the Cleveland State University is also not possible with limited resources and it is not in scope of this project. **Website will be limited to display heat map of one of the building of Cleveland State University Berkman Hall only.**

2. Project Management Plan

2.1. Project Tasks

High level project tasks involve Documentation, Design Finalization, Technical Documents Generation, Data Collection for input, Web Development , Testing, Verification , Presentation and demonstration and finally Submission as mentioned below

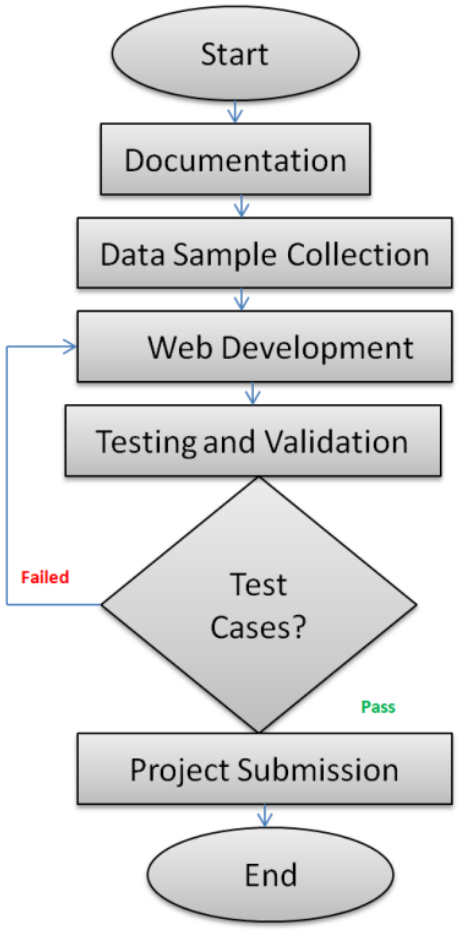

Figure: High level project task

2.2. Risk Analysis

Wi-Fi Signal strength keeps on changing all the time, resources tried to find most stable data to collect efficient sample for the input.

Project Risks

Technology risk: As resources are implementing this project first time, it might require extra training and lead to delays.

Operational risk: As resources are not well trained & inexperienced thus there is chance of poor implementation of the code.

Performance risk: With limited time and limited resources, project code might have performance issues.

Resources Availability risk: As developers are college students, need time for other subjects. Along with that location constraints and availability constraints are also there.

2.3. Project schedule

SR Numner	Tasks	Status	Start Date	End Date
1	Documentation Proposal , Project plan	Done	1-Oct-22	10-Oct-22
2	Design Finalization	Done	11-Oct-22	20-Oct-22
3	Technical Requirements Documents Generation	Done	21-Oct-22	25-Oct-22
4	Data Collection for input	Done	25-Oct-22	5-Nov-22
5	Web Development	Done	6-Nov-22	17-Nov-22
6	Test plan creation ,Testing, Verification	Done	17-Nov-22	28-Nov-22
7	Presentation	Done	28-Nov-22	1-Dec-22
8	Submission	Done	9-Dec-22	9-Dec-22

Test schedule

Serial Number	Tasks	Days	Start Date	End Date
1	Test Planning	1	11/1/2022	11/2/2022
2	Test Specification Document preparation	1	11/2/2022	11/3/2022
3	Test Environment Preparation	1	11/4/2022	11/5/2022
4	Testing Features	6	11/6/2022	11/12/2022
5	Bug Reporting	6	11/12/2022	11/18/2022
6	Fixing Issues	6	11/19/2022	11/25/2022
7	Finalizing Test Results Report	3	11/25/2022	11/28/2022

3. Requirement Specifications

3.1. Stakeholders for the system

- Cleveland State university staff
- Webb developers
- Cleveland state university professors
- Cleveland state university students

3.4. Functional & Non-functional requirements

Each Functional & Non functional requirement is uniquely identified as below -

FUNCTIONAL REQUIREMENT LIST			
Requirement ID	**Must/ Want**	**Requirement Statement**	**Explanation**
FR004.1.1	Must	User should be able to see the homepage on accessing the website, it should show menu list on the page , Figure 1 in 3.5 Mock Screens section	When User will access the website link, he/she should be able to see menu on the page load showing different floors.
FR004.1.2	Must	Menu items should have below options - Current Location - BH Ground Floor - BH First Floor - BH Second Floor - BH Third Floor - BH Fourth Floor - BH Map	Check Figure 1 in 3.5 Mock Screens section
FR004.1.3	Must	User should be able to select one of the menu (for the floors) to see heatmap	After selecting the value from the menu, User should be able to see the heatmap of that specific floor, showing what are the strongest & weakest WIFI reception areas.
FR004.1.4	Must	User should be able to Download the heatmap, Figure 3 in 3.5 Mock Screens section	User should see a download button, so that he can download the heatmap on their system.
FR004.1.5	Must	User should be able to see current location WIFI strength as well Figure 2 in 3.5 Mock Screens section	Once user will connect to a WIFI network, website will display current signal strength of that connection along with other information

FR004.1.6	Must	Current location will also be one of the options in the Menu, will be selected default	Current location will be the default option to display WIFI signal strength.
FR004.1.7	Must	All the Heat Map should display the ranges of strongest and weakest signal strength areas, Figure 1 in 3.5 Mock Screens section	Heat map should have legends, which should clearly elaborate which area has strongest WIFI signal strength and which area has weakest. Along with that how it is gradually changing the WIFI strength.
FR004.1.8	Want	In Current location menu WIFI signal strength of the current signal should show channel, frequency, signal level etc.	In Current location menu WIFI signal strength of the current signal should show channel, frequency, signal level etc.
FR004.1.9	Must	Home Page header should have below text "Cleveland State University Wifi Analyzer"	

NONFUNCTIONAL REQUIREMENT LIST		
Requirement ID	**Must/Want**	**Requirement Statement**
NFR004.1.1	Must	Home Page Menu should have background color #FFFFFF
NFR004.1.2	Must	Home Page Menu should have fonts color #000000
NFR004.1.3	Must	Home Page header should have below color: #006f51
NFR004.1.4	Must	User should be able to Download the heatmap
NFR004.1.5	Must	Screen should load in <1 second
NFR004.1.6	Must	When User will access the website link, menu should be left aligned.
NFR004.1.7	Must	User should see a download button at the bottom of the page

3.5 Mock Screens

Below screen shots are from our website to provide an idea how will be the look and fields.

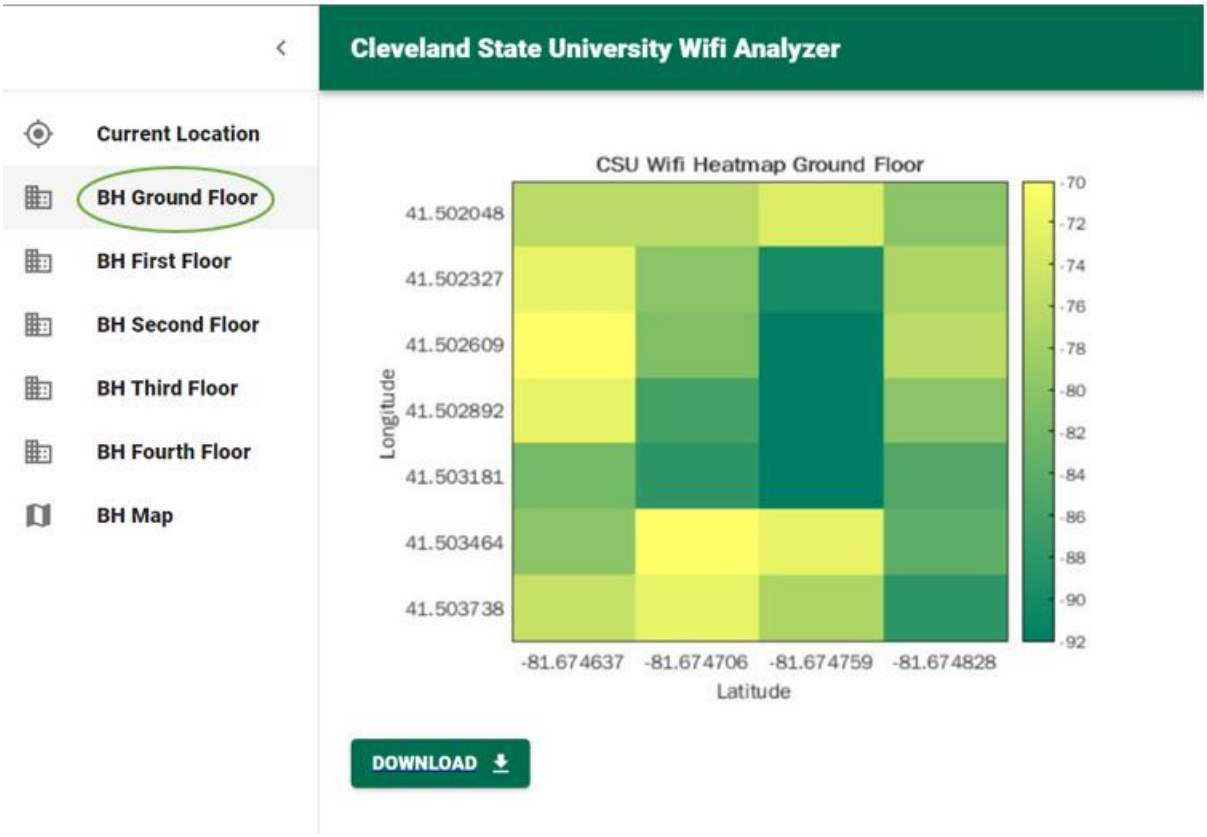

Figure: Mock screen for WIFI – heat map of the ground floor

Figure: Mock screen for current signal

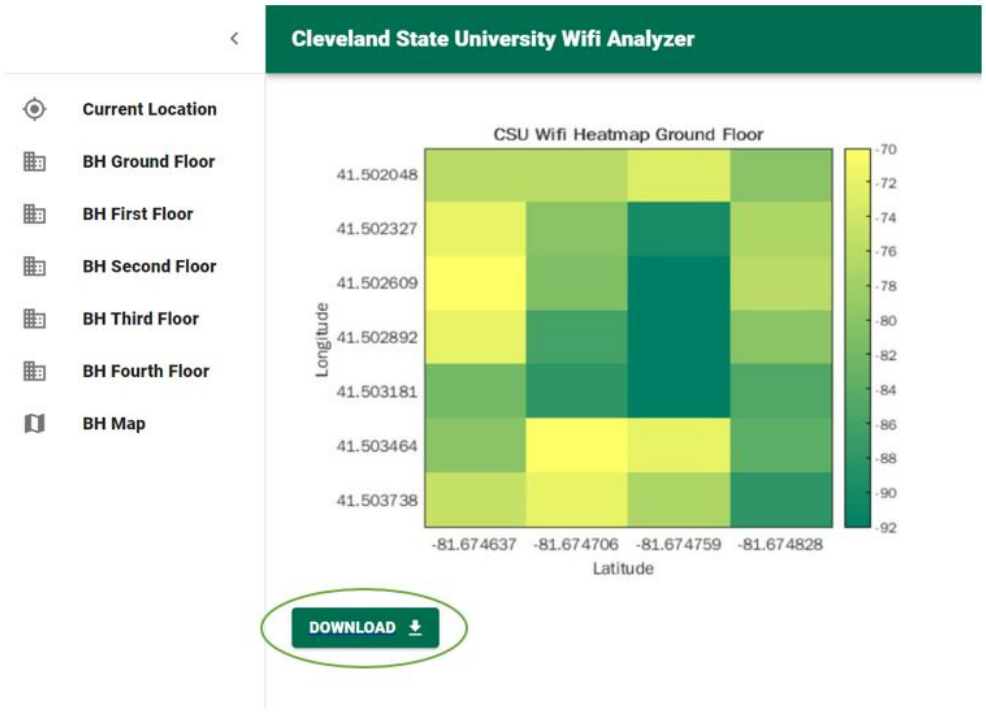

Figure: Mock screen for heat map , download button

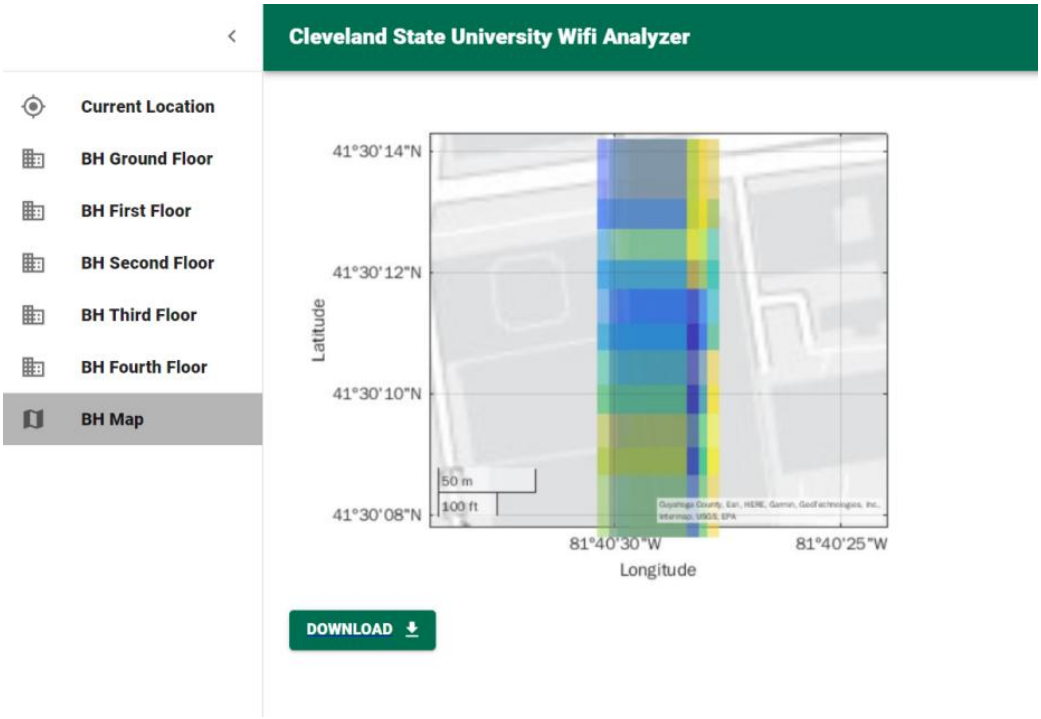

Figure: Mock screen for BH map

4. Architecture

4.1. **Architecture**

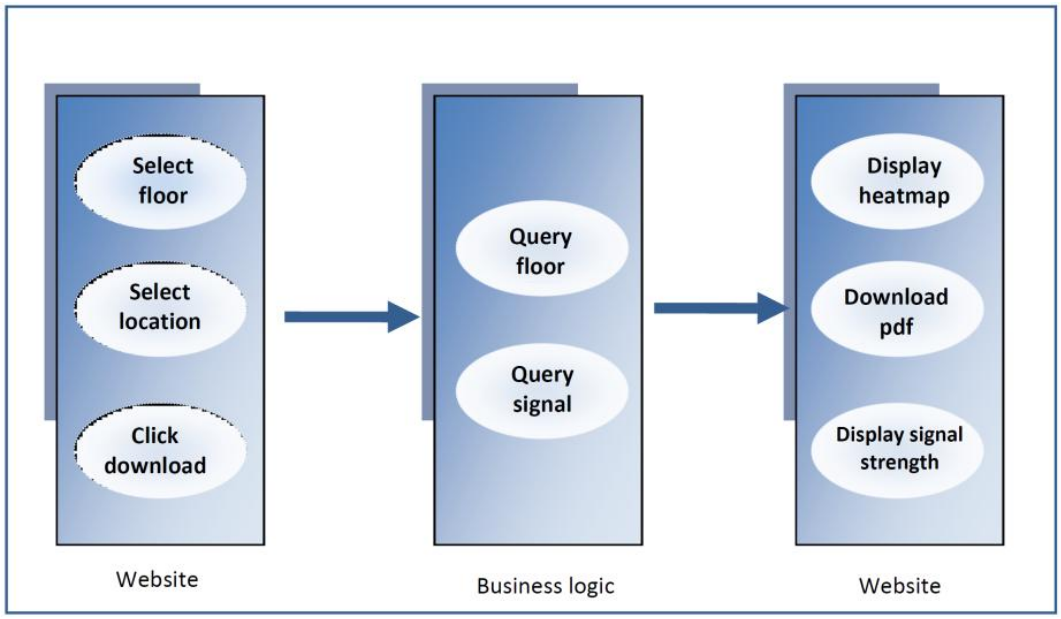

Figure: Architecture Diagram

- **Input**: Input section will be web portal, where a user can access the website link and user will have option to either select the floor, or select the location or else user can click download button.
- **Process**: Process section is only for internal processing of the user requests. , if user has selected the floor or location, system will generate heatmap for the specific floor or system will get the WIFI signal strength of the specific location and send the result to the portal.
- **Output**: Once again this time, frontend web port6al will serve as output as it will display the results to the user. If user has requested for the heatmap, it will show heatmap. Else if user has selected the current location, then it will display the real time WIFI signal strength of the heatmap. Or else if user has requested for the download pdf, it will generate pdf and download on the user's machine.

4.2. Architectural model

For this project we captured all the data in a spreadsheet initially, like latitude and longitude along with WIFI signal strength. Then using MATLAB will generated heat map graphs. Based on each floor heat map images displayed on the website for the selected floor.

Relationships among data objects are described using an Entity-Relationship Diagram (ERD) like form as mentioned below –

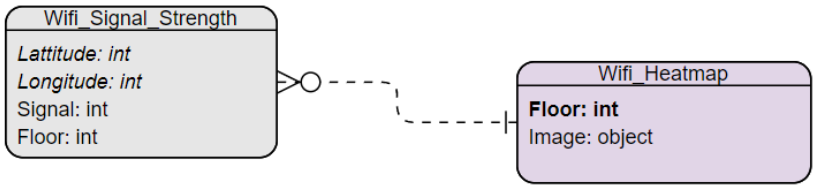

Figure: Architectural model

4.3. Technology, software, and hardware used

- **React** for the frontend GUI Development
- **Node.js** for the backend
- **Mat lab** to generate the heat map and verify the data quickly
- **Airport Wi-Fi scanner** to measure the WIFI signal strength
- **Excel** to capture the data

5. Design

5.1. User Interface design

There is user interfaces for the frontend and for generating heatmap backend logical process

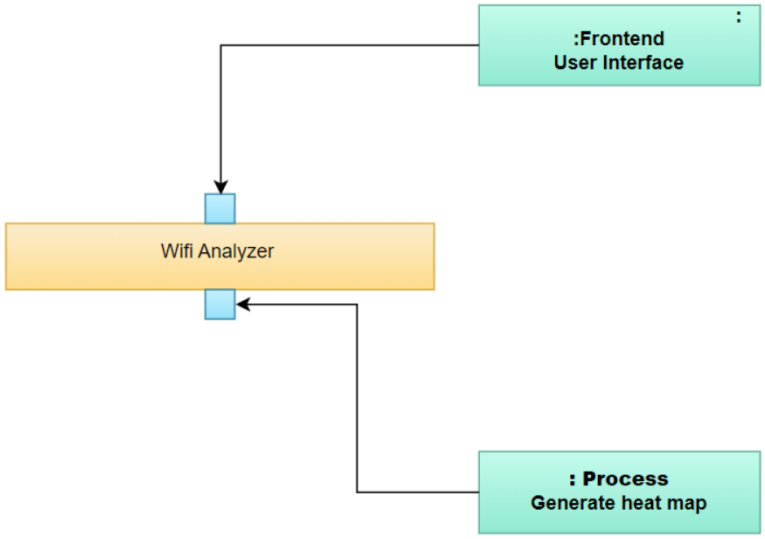

Figure: User Interface design

Interfaces to other systems, products or networks are described-

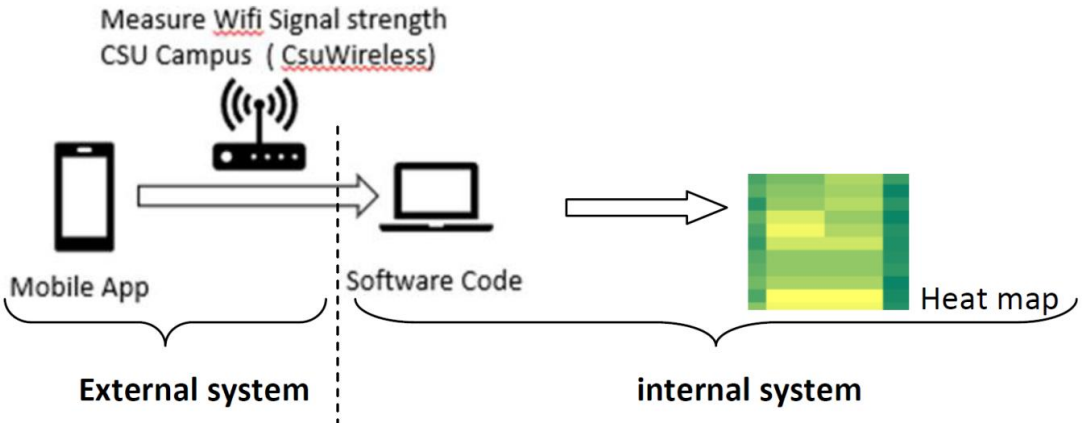

Figure: External - Internal Interface design

- **Front-end** – ReactJS with Typescript
- **Back-end** – NodeJS with Express and Typescript , MATLAB

5.2. Components design

We are using Material UI for the component designing and we have segregated our design view in a various functional views. As the application has been developed using React, this follows Functional Component conventions for the front-end. Below are the parts that are involved as reusable functional components which are inherited from Material UI:

AppBar, SideNavigationBar or Drawer, Dropdown, Image Component

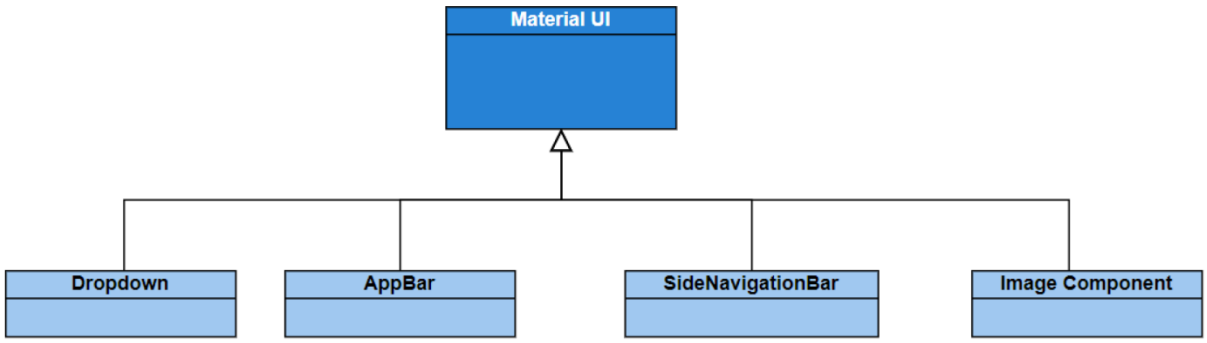

Figure: Material UI

Apart from this every Floor components are inherited from the same class where the values get changed based on the Floor type.

On next page is the sequential model for Wi-Fi Analyzer for one scenario, where user is requesting for heat map for one of the floor –

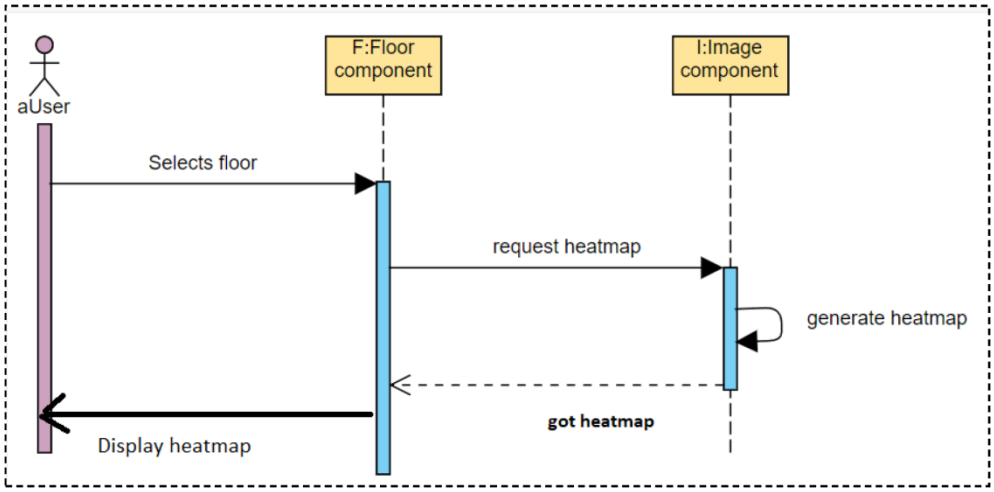

Figure: Sequence Diagram

6. Test Management

6.1. A complete list of system test cases

ID	Test case	Expected output	Description
TS3001.1	**User accessing website link**	Home Page should be loaded with -header should have label : "Cleveland State University Wifi Analyzer" User should be able to see menu on the page load showing different floors - Menu items on left side - Current Location - BH Ground Floor - BH First Floor - BH Second Floor - BH Third Floor - BH Fourth Floor - BH Map	Current location will be the default option to display WIFI signal strength. Menu should be left aligned.
TS3001.2.1	**User accessing menu options 1**	After selecting the first value from the menu Current Location, WIFI signal strength of the current signal should show channel, frequency, signal level etc.	(system connectecd to wifi)
TS3001.2.1	**User accessing menu options 1**	After selecting the first value from the menu Current Location, WIFI signal strength of the current signal should not display anything if system is not connected to WIFI	(system not connected to wifi)
TS3001.2.2	**User accessing menu options 2**	After selecting the first value from the menu BH Ground Floor, User should be able to see the heatmap of that first floor, showing what are the strongest & weakest WIFI reception areas.	Heat map should have legends, which should clearly elaborate which area has strongest WIFI signal strength and which area has weakest. Along with that how it is gradually changing the WIFI strength.
TS3001.2.3	**User accessing menu options 3**	After selecting second of the value from the menu BH First Floor, User should be able to see the heatmap of that specific floor, showing what are the strongest & weakest WIFI reception areas.	
TS3001.2.4	**User accessing menu options 4**	After selecting third of the value from the menu BH Second Floor, User should be able to see the heatmap of that specific floor, showing what are the strongest & weakest WIFI reception areas.	
TS3001.2.5	**User accessing menu options 5**	After selecting fourth of the value from the menu BH Third Floor, User should be able to see the heatmap of that specific floor, showing what are the strongest & weakest WIFI reception areas.	
TS3001.2.6	**User accessing menu options 6**	After selecting one of the value from the menu BH Fourth Floor, User should be able to see the heatmap of that specific floor, showing what are the strongest & weakest WIFI reception areas.	

ID	Test case	Expected output	Description
TS3001.3	**User validating heatmap**	User should be able to locate specific area with poor signal strength and strong signal strength	Usually covered areas show poor signal strength (<-85 dbm) and open area show good signal strength (~ -45dbm to -70 dbm) check appendices section 4.1 for more WIFI signal strength details
TS3001.4.1	**Download button click on each menu pages**	User should see a download button on BH ground floor page , so that he can download the heatmap on	User should see a download button at the bottom of the page, so that he can download the heatmap on
TS3001.4.2		User should see a download button on BH first floor page , so that he can download the heatmap on their	User should see a download button at the bottom of the page, so that he can download the heatmap on
TS3001.4.3		User should see a download button on BH second floor page , so that he can download the heatmap on	User should see a download button at the bottom of the page, so that he can download the heatmap on
TS3001.4.4		User should see a download button on BH third floor page , so that he can download the heatmap on their	User should see a download button at the bottom of the page, so that he can download the heatmap on
TS3001.4.5		User should see a download button on BH fourth floor page , so that he can download the heatmap on their	User should see a download button at the bottom of the page, so that he can download the heatmap on
TS3001.4.6	**User accessing menu options 7**	User should see BH map	
TS3001.5		User should be able to see current location WIFI strength In Current location menu WIFI signal strength of the current signal should show channel, frequency, signal level etc.	In Current location menu WIFI signal strength of the current signal should show channel, frequency, signal level etc.

6.2. Test results and assessments

ID	Test Input/Action	Expected output	Actual output	Results
TS3001.1	**User accessing website link**	Home Page should be loaded with -header should have label : "Cleveland State University Wifi Analyzer"	Home Page loaded with header should have label : "Cleveland State University Wifi	Pass
		User should be able to see menu on the page load showing different floors - Menu items on left side - Current Location - BH Ground Floor - BH First Floor - BH Second Floor - BH Third Floor - BH Fourth Floor - BH Map	Left aligned value appeared with menus - Current Location - BH Ground Floor - BH First Floor - BH Second Floor - BH Third Floor - BH Fourth Floor - BH Map	Pass Pass Pass Pass
TS3001.2.1	**User accessing menu options 1**	After selecting the first value from the menu Current Location, WIFI signal strength of the current signal should show channel, frequency, signal level etc.	WIFI signal strength of the current signal displayed	Pass
TS3001.2.1	**User accessing menu options 1**	After selecting the first value from the menu Current Location, WIFI signal strength of the current signal should not display anything if system is not connected to WIFI	WIFI signal strength was not displayed	Pass
TS3001.2.2	**User accessing menu options 2**	After selecting the first value from the menu BH Ground Floor, User should be able to see the heatmap of that first floor, showing what are the strongest & weakest WIFI reception areas.	Proper heat map loaded with legends	Pass
TS3001.2.3	**User accessing menu options 3**	After selecting second of the value from the menu BH First Floor, User should be able to see the heatmap of that specific floor, showing what are the strongest & weakest WIFI reception areas.	Proper heat map loaded with legends	Pass
TS3001.2.4	**User accessing menu options 4**	After selecting third of the value from the menu BH Second Floor, User should be able to see the heatmap of that specific floor, showing what are the strongest & weakest WIFI reception areas.	Proper heat map loaded with legends	Pass
TS3001.2.5	**User accessing menu options 5**	After selecting fourth of the value from the menu BH Third Floor, User should be able to see the heatmap of that specific floor, showing what are the strongest & weakest WIFI reception areas.	Proper heat map loaded with legends	Pass
TS3001.2.6	**User accessing menu options 6**	After selecting one of the value from the menu BH Fourth Floor, User should be able to see the heatmap of that specific floor, showing what are the strongest & weakest WIFI reception areas.	Proper heat map loaded with legends	Pass
TS3001.3	**User validating heatmap**	User should be able to locate specific area with poor signal strength and strong signal strength	Proper heat map loaded with legends	Pass

ID	Test Input/Action	Expected output	Actual output	Results
TS3001.4.1	Download button click on each menu pages	User should see a download button on BH ground floor page , so that he can download the heatmap on their system	heatmap downloaded successfully	Pass
TS3001.4.2		User should see a download button on BH first floor page , so that he can download the heatmap on their system	heatmap downloaded successfully	Pass
TS3001.4.3		User should see a download button on BH second floor page , so that he can download the heatmap on their system	heatmap downloaded successfully	Pass
TS3001.4.4		User should see a download button on BH third floor page , so that he can download the heatmap on their system	heatmap downloaded successfully	Pass
TS3001.4.5		User should see a download button on BH fourth floor page , so that he can download the heatmap on their system	heatmap downloaded successfully	Pass
TS3001.4.6	User accessing menu options 7	User should see BH map	BH map displayed	Pass
TS3001.5		User should be able to see current location WIFI strength In Current location menu WIFI signal strength of the current signal should show channel, frequency, signal level etc.	In Current location menu WIFI signal strength of the current signal should show channel, frequency, signal level etc.	Pass

7. Conclusions

7.1. Outcomes of the project

- Walls, furniture and other objects are potential sources of signal interference
- With the help of this heat map, we can plan the hotspot position within the campus for full coverage
- Open/Unrestricted spaces creates a robust coverage
- Signals are weak in the basement (CSU parking lot)
- We can easily troubleshoot in case of issue

Figure : closed space and open space WIFI propagation

7.2. Future development

As of now this experiment was performed only on one building of the Cleveland state university campus, which can be expanded to entire campus.

Also at present website displays static heat maps , which can be further enhanced to proved real-time data.

References

[1] Sangkusolwong, Wanchai & Apavatjrut, Anya. (2017). Indoor WIFI Signal Prediction Using Modelized Heatmap Generator Tool. 1-5. 10.1109/ICSEC.2017.8443928

[2] Valenzano, Andrea; Mana, Dario; Borean, Claudio; and Servetti, Antonio (2016) "Mapping WiFi measurements on OpenStreetMap data for Wireless Street Coverage Analysis," Free and Open Source Software for Geospatial (FOSS4G) Conference Proceedings: Vol. 16 , Article 5. DOI: https://doi.org/10.7275/R5G44NHC Available at: https://scholarworks.umass.edu/foss4g/vol16/iss1/5

Conference Name:ACM Woodstock conference

[3] X. Liu, B. Lu, J. Niu, L. Shu and Y. Chen, "HMF: Heatmap and WiFi Fingerprint-Based Indoor Localization with Building Layout Consideration," 2016 IEEE 22nd International Conference on Parallel and Distributed Systems (ICPADS), 2016, pp. 324-331, doi: 10.1109/ICPADS.2016.0051.

Appendix

Ideal Signal Strength

Below table describes the probable values of the WIFI signal strength

Signal Strength	TL;DR		Required for
-30 dBm	Amazing	Max achievable signal strength. The client can only be a few feet from the AP to achieve this. Not typical or desirable in the real world.	N/A
-67 dBm	Very Good	Minimum signal strength for applications that require very reliable, timely delivery of data packets.	VoIP/VoWi-Fi, streaming video
-70 dBm	Okay	Minimum signal strength for reliable packet delivery.	Email, web
-80 dBm	Not Good	Minimum signal strength for basic connectivity. Packet delivery may be unreliable.	N/A
-90 dBm	Unusable	Approaching or drowning in the noise floor. Any functionality is highly unlikely.	N/A