Quick Therm

A Versatile, Powerful Remote Body Temperature Monitoring System

Andrew (Guo Ning) Sue, Fred (XianZhi) Hua

06/15/2020

Table of Contents

Abstract

Quick Therm is a powerful, remote human body temperature monitoring system implemented with both a hardware module consisting of a thermistor, a BLE (Bluetooth Low Energy) chip, a microcontroller, and a mobile software data monitoring platform developed with Flutter and based on Google Cloud Firestore. The system is aimed to provide a quick and efficient method for identifying abnormal signs of body temperatures of members in close-proximity communities such as Single-Room-Occupancies(SRO), apartments, and hospitals. The system is organized hierarchically into three different levels: Director, Manager, and Residents. Every individual level has different access to the body temperature data collected and is designed to suit actual job positions in various organizations. The data is organized and stored in a large database and presented in a color-coded manner in the mobile platform for the ease of detecting and reporting abnormal temperatures, thus eliminating the need for close and face-to-face contact of temperature reporting.

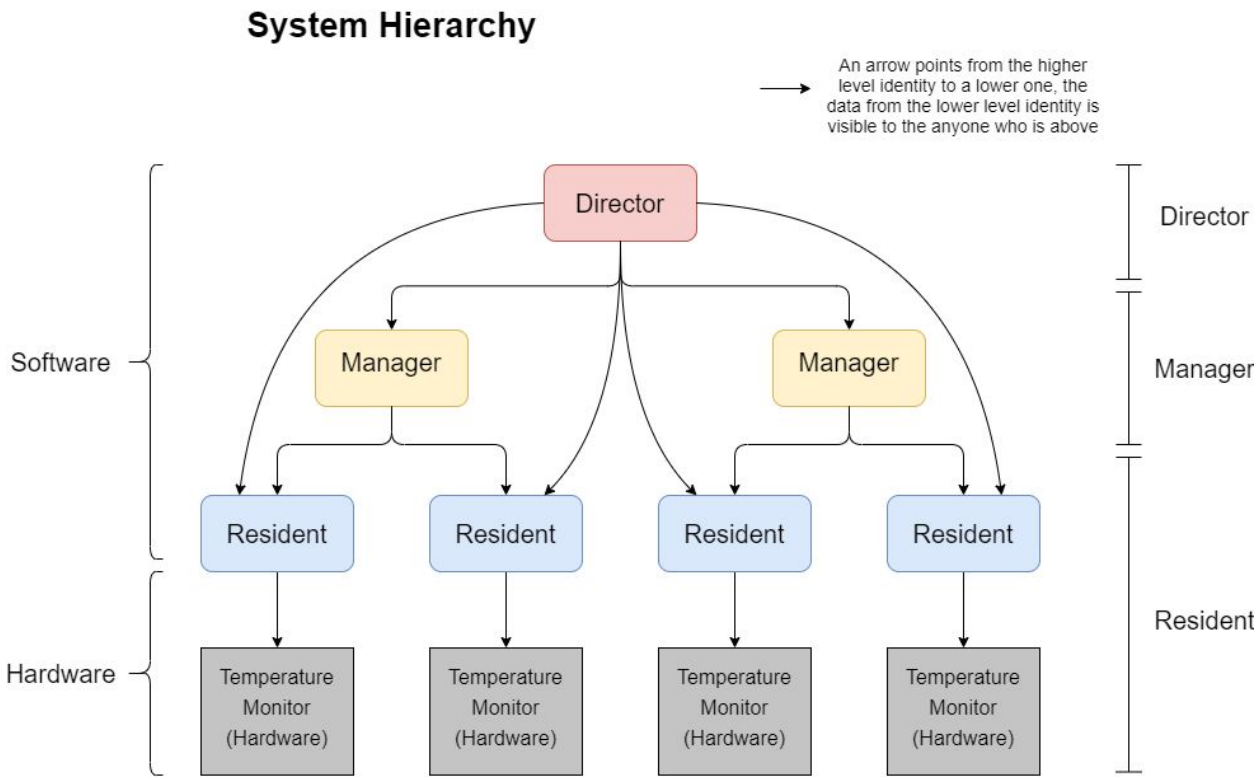
Statement of Need

As of right now, there are over 7.34 million confirmed cases and 400,000 deaths from COVID-19 in the world. These morbid statistics greatly emphasize the need for a method to quickly identify any signs of spread and potential cases for possible quarantine. The consequences of lacking such a method at the beginning of the pandemic, especially in tight dense communities such as senior resident homes and the pressure exerted on the current medical systems had been grave. Take, for example, the Laguna Honda Hospital and Nursing Home located in San Francisco had a total of 21 cases around early March. Though 21 may seem like a small number compared to the total case in the world, it is deadly for the patients in the facility as most already have health issues and are in old age. In addition, they pose a great threat to the health of staff members that are there to care for them as intimate contacts are essentially unavoidable. Thus we are compelled to come up with a solution that has the ability to detect (by body temperature) potential cases of Covid-19. Our solution consists of the utilization of an easy-to-use mobile software application and a small, compact electronic device to measure an individual's temperature and put the measured data on a database to visualize. This solution can greatly reduce the number of intimate contact between healthcare workers and patients since the patients can measure their temperatures by themselves, thus protecting the welfare of healthcare workers and increasing the effects of quarantines. In addition, our simple-to-understand visuals of data allows for quick identification of potential cases, earning more time for making possible decisions of quarantines to contain the spread.

Overview of System

Our system consists of a temperature monitor and a mobile application. The temperature monitor measures the temperature of the user and sends the data to the user's smartphone. The mobile application has three hierarchies of different identities, "Director", "Manager" and "Resident", which correspond to the management hierarchies of most workplaces today. The body temperature of "Residents" will be visible to both the "Director" and "Manager". This allows "Managers" and "Directors" to easily monitor the health condition of "Residents" and take appropriate actions as early as possible.

System Diagram



A diagram that displays the structure of our system (Quick Them)

Director

The Director is the person with the highest position in the organization. This role corresponds to the person who leads the organization and is responsible for the well beings of the Residents and Managers. The Director can see who are the registered Managers under his/her organization and the number of Residents that each Manager manages. By selecting a Manager$_{[1]}$, the Director can see the units and their health status(severe, potentially sick and healthy) under the selected Manager. He/She is also given the option to view all individuals along with their basic information(Name, Age, the unit they belong to) and health condition(last measured temperature, health status) under the management of this Manager. And by selecting a unit, the Director can see Residents living in that unit, and by selecting a Resident, the director can see his/her profile page, which goes in more detail and includes contact, age, a graph of their recent temperature, and other information.

Manager

The Manager corresponds to the person who manages the conditions of the Residents. The Director and the Manager share similar responsibilities, though there is one key difference, the Manager can only see the Residents under his/her management, while the Director can see every Manager and every Resident under this organization.[1]

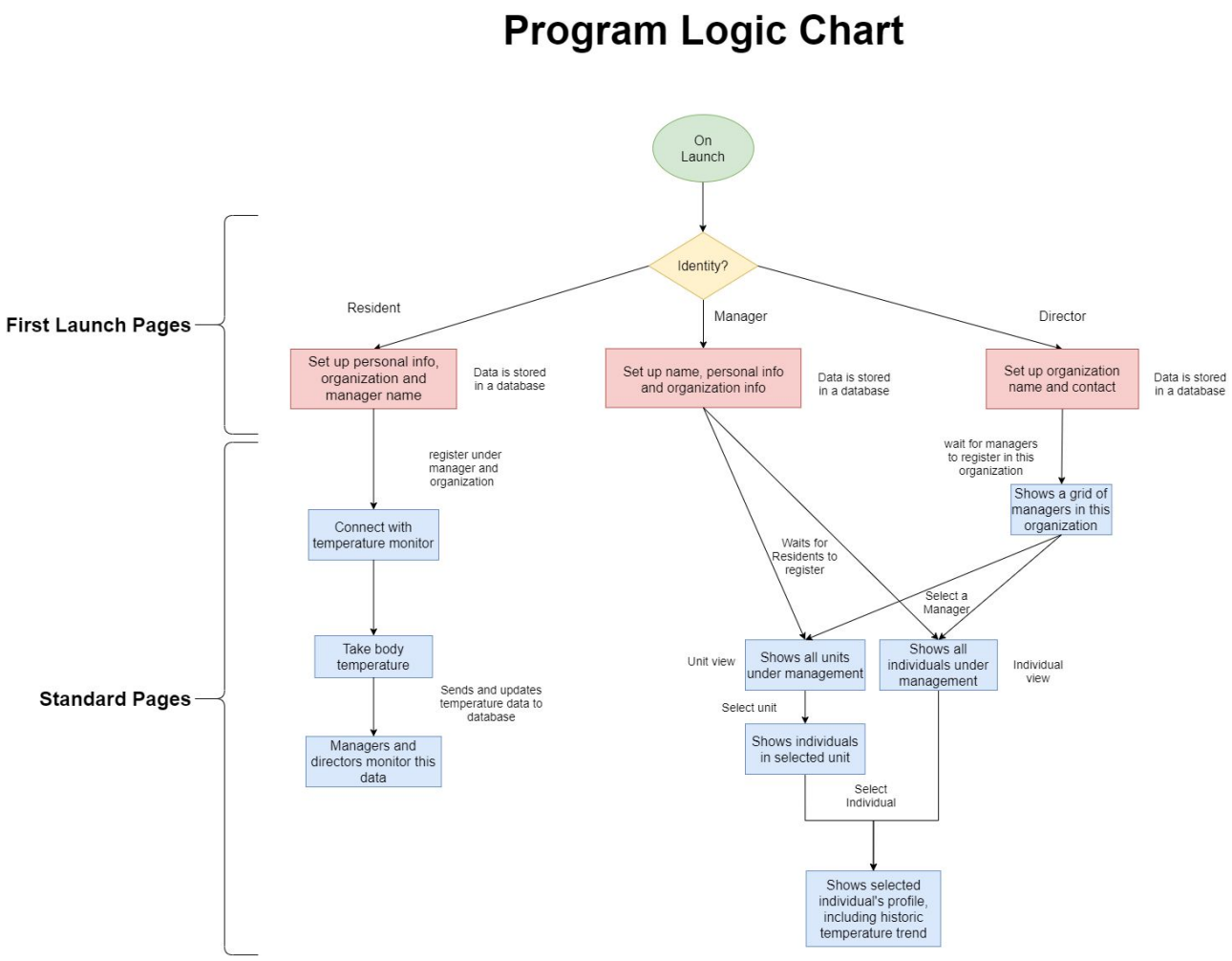
Resident

The Resident corresponds to the tenants of an organization, SRO tenants and patients in a hospital for example. Upon implementation, each Resident will receive a temperature monitoring shoulder strap(Hardware) and this strap is for monitoring the health conditions of the Resident. The Resident can connect to the temperature monitor and monitor their health conditions using the Bluetooth function of their smart-device. The data will be uploaded to an online database along with their personal information regarding their health(age, sex, contact info...etc.). The Manager and the Director can then see this information and contact them if necessary.

[1] For more details, please refer to the Director section starting at the subscript 1.

Software

Diagram

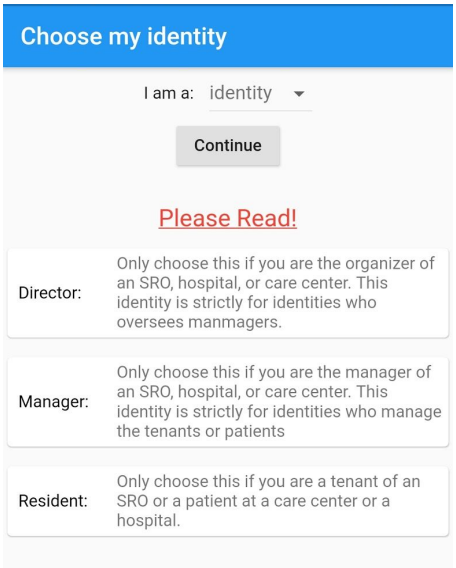


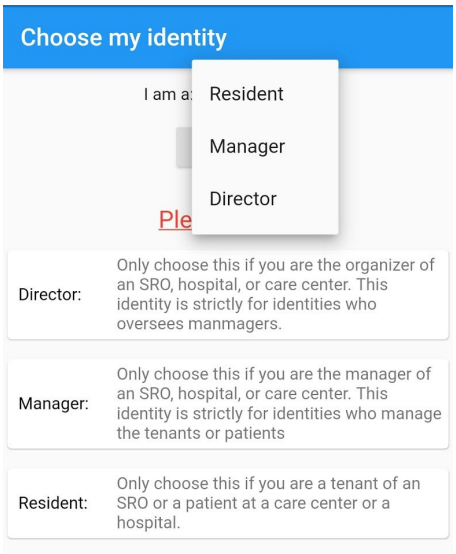
The logic diagram of our software portion of the Quick Therm system

Pages

First Launch Pages

Choose Identity Page

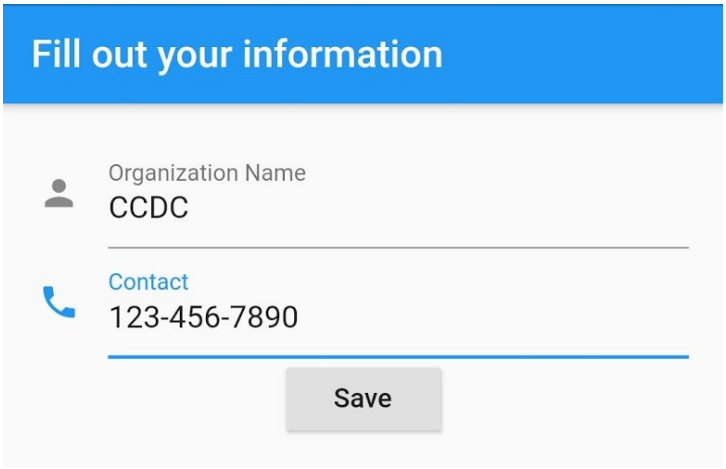




- This is the first step of using Quick Therm for everyone, choosing the identities(Resident, Manager, Director) in Quick Therm according to their positions in an organization in real life.

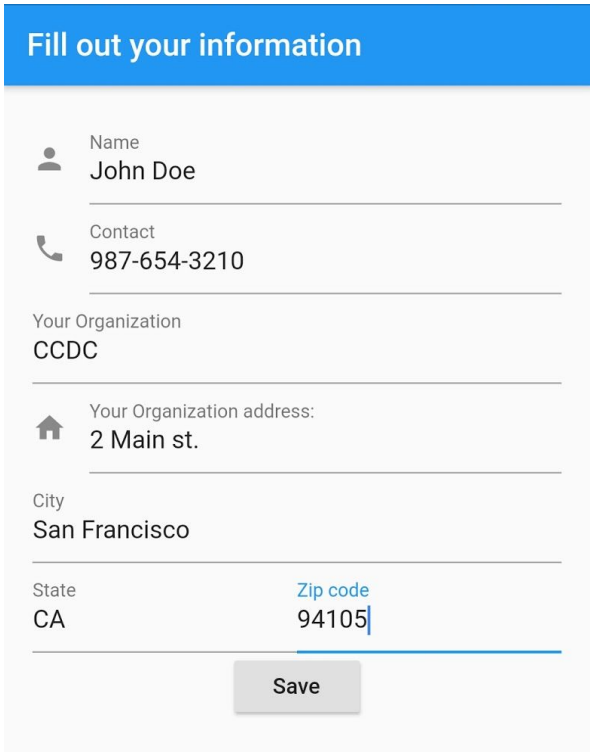
Setup Info Pages

Director Setup Info Page



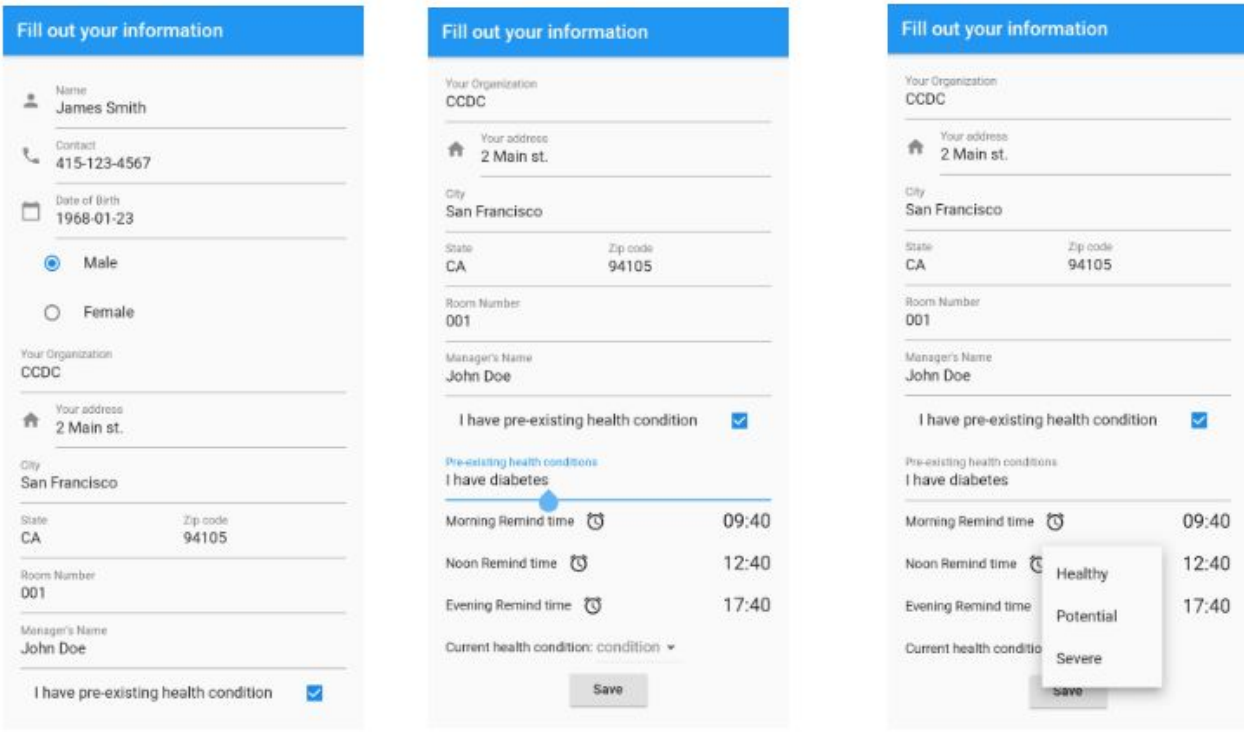
- The Director, or the “head” of an organization needs to set up his/her information **first**; this data is then stored in an online database, so that other identities can store their data accordingly.
- The Director needs to save the name of the organization and their contact information.

Manager Setup Info Page



- The Manager, or the manager of the residents in an organization, needs to set up their information **second**, after the Director. The Manager's data will be stored under a matching organization name in a database that the director had already setup.
- The Manager needs to fill in his/her name, contact information, organization name, the address of the buildings that he/she is responsible for. This information will be helpful for organizing data and connecting with Residents.
- The names of the Managers will appear under the "Director Page", so that the Director can see who the registered Managers are in this organization.

Resident Setup Info Page

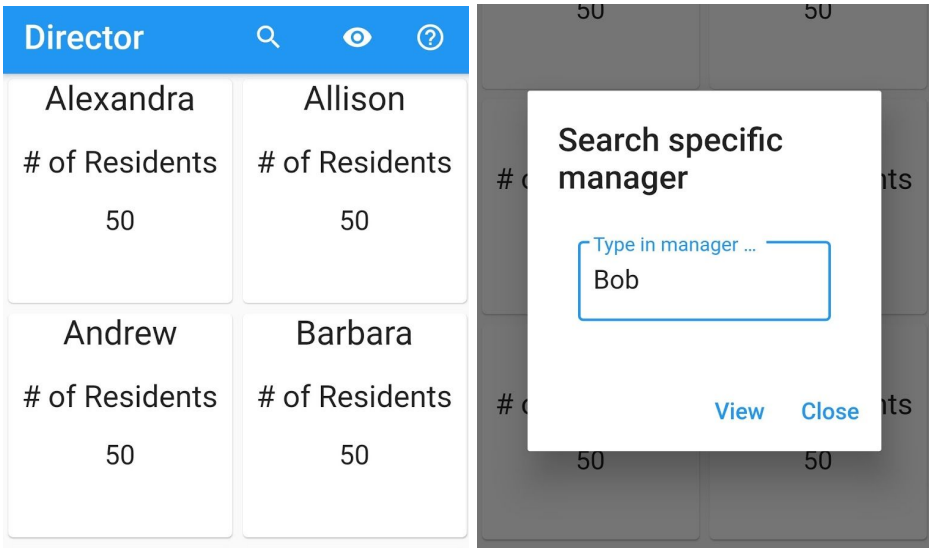


- The Resident sets up his/her information after both the Director and Manager have finished.
- The Resident requires the most, because his/her personal information(sex, age, pre-existing health conditions...etc.) relates to his/her health condition.
- After saving the information, the Resident will be placed under the Manager in the organization that the Resident has just filled out. The Resident will be visible to both the Director and the Manager.
- The Resident also has the option to set reminder times to remind himself/herself to take temperature regularly.

Regular Pages

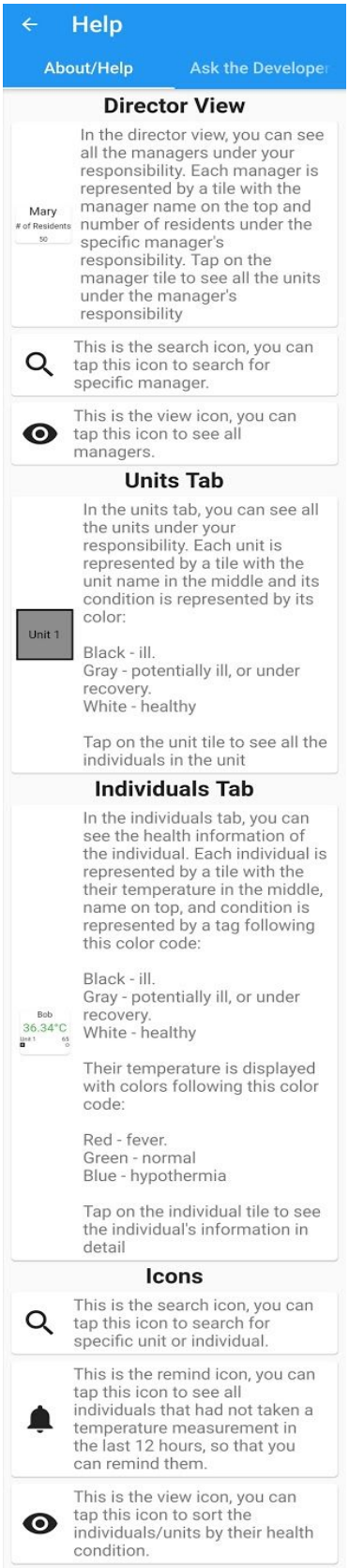
Director Pages

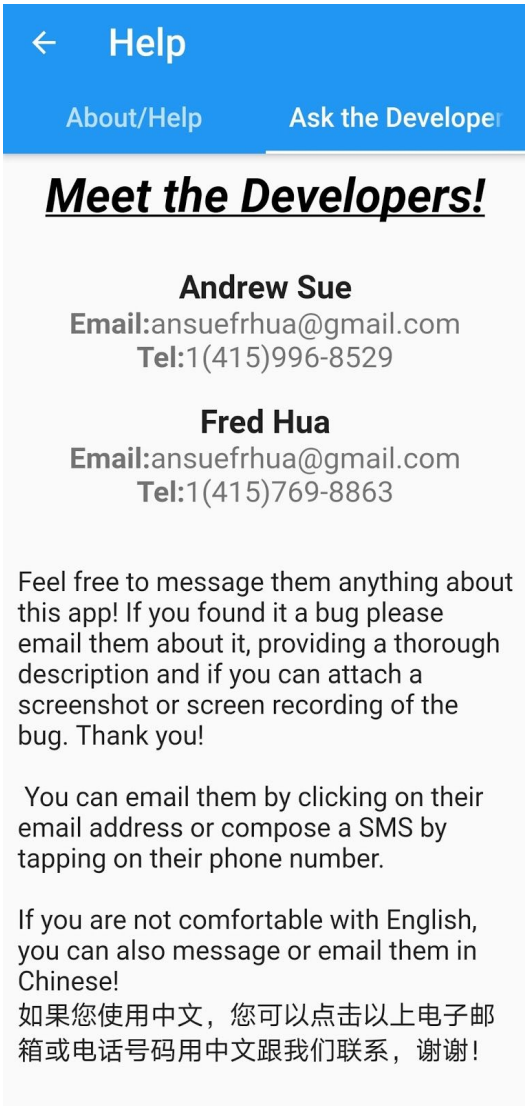
Director Grid



- This is the page that the Director sees after both the Director and Manager have finished setting up their respective "Set Up Info Pages."
- The Director can see who the registered Managers are and the registered Residents under their management.
- The Director can also search for a specific registered Manager by tapping the search button (magnifying glass icon).
- After searching for a specific Manager, the Director can return to viewing all Managers by tapping the View All button (eye icon) on the right of the search button.
- By clicking on a Manager, the Director will go to the "Manager Pages", and view the conditions of the Resident under that Manager.
- The help button (question mark icon) will lead to the help page, which contains information for Directors on how to use this system.

Help Page





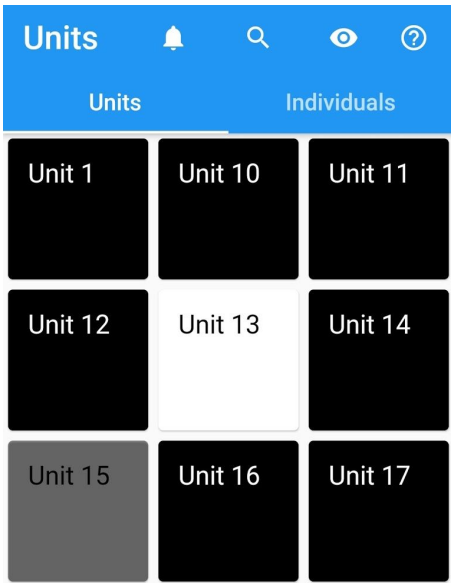
- This page has useful information on using this application.
- Help Pages for each identity are different, providing information that the specific user needs the most.
- If the Director, Manager or Resident encounters an unsolvable problem, he/she has the option to directly contact us, the developer.

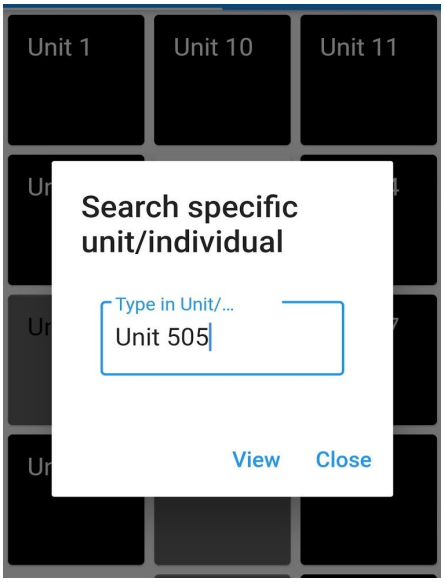
Manager Pages

- After registering, the Manager has two options to view the registered Residents under their management, by units and by individuals.

Units Grid

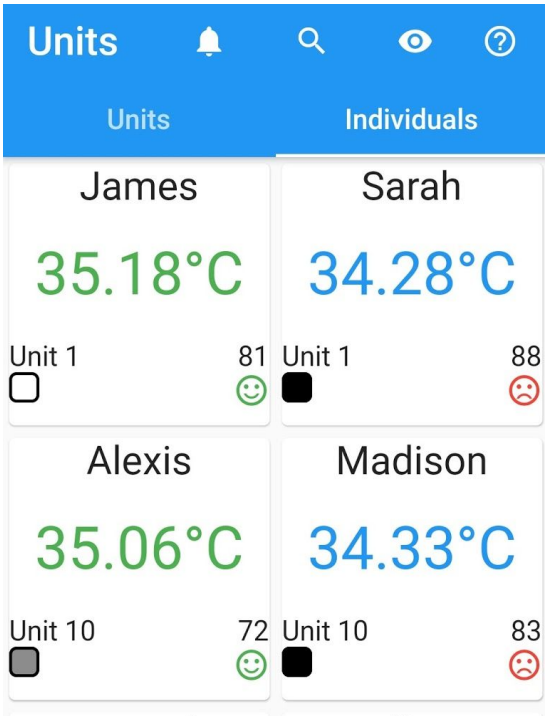
Units Tab

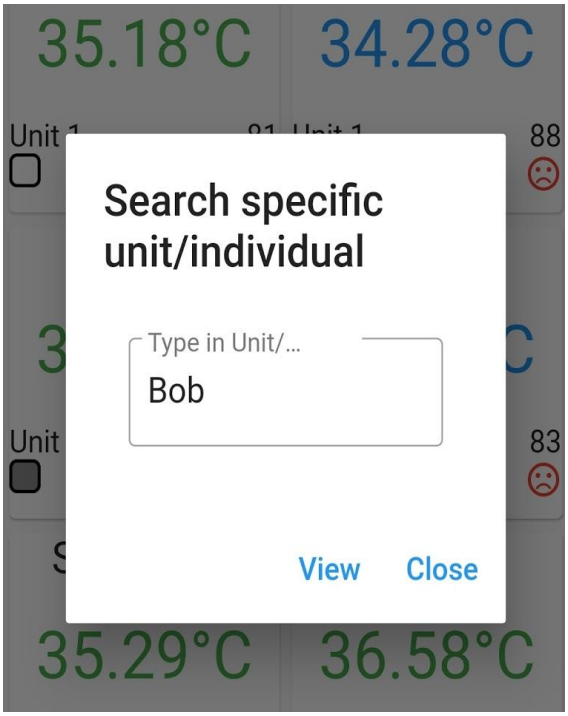




- This is the screen that Managers see after they have finished setting up their information. The units that registered Residents are in will show up in color-coded tiles as shown.
- The Color-code consists of three colors(black, gray, white) to show different conditions(Severe, Potentially sick, healthy) of the residents in each unit.
- The search button(magnifying glass icon) is used to search for a specific unit.
- The manager can select different options to view the units. There are four options: all units, only healthy units, only potentially sick units, and only severe units. The Manager can also use the button to return back after searching for a specific unit.
- The question mark icon on the top right will lead the Manager to the "Manager Help Page"

Individuals Tab

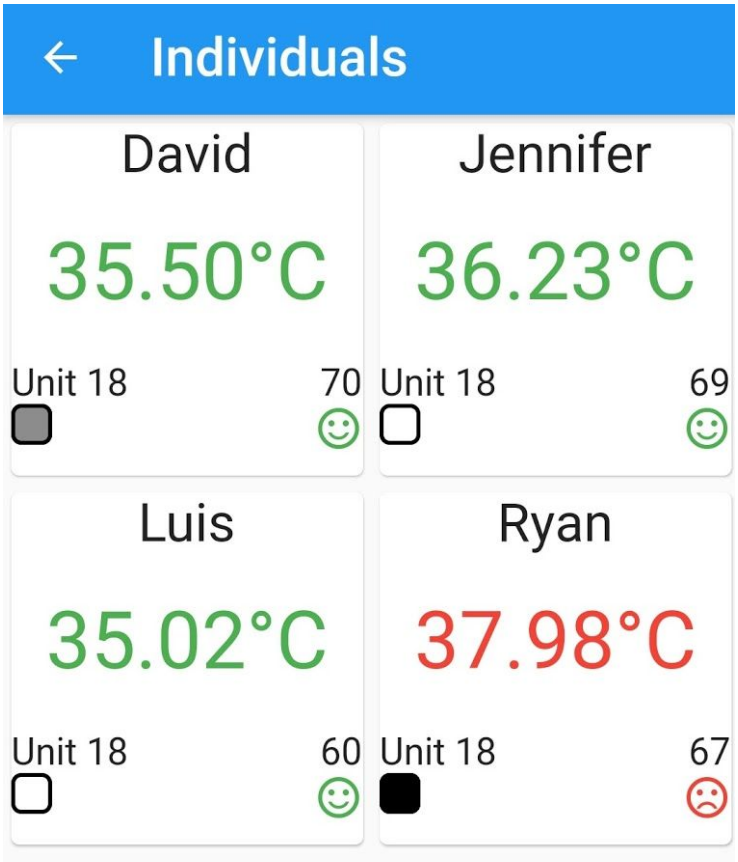




- This is the individuals tab of the Units Grid. One can navigate here through tapping on the text “Individuals” on the tab bar.
- Tapping on a tile[2] with an individual’s name on top brings one to the profile page of the specific individual, as known as “Individual Page.”
- The Manager can tap on the reminder icon(bell icon) to see individuals that had not taken a temperature measurement within the last 12 hours, so the Manager can personally remind them.
- The manager can also tap on the search icon (magnifying glass) to search for a specific individual by name.
- The manager can also tap on the views button (eye icon) to apply a filter to see individuals that satisfy a certain condition. The manager can choose to see all individuals that are all healthy by tapping on “Show all healthy” after tapping the views button, or those that are potentially ill by tapping on “Show all potential”, or tap on those that are ill by tapping on “Show all ill” or everyone under the manager by tapping “Show all.”
- The question mark icon leads the Manager to the “Manager Help Page” that will explain each function in detail.

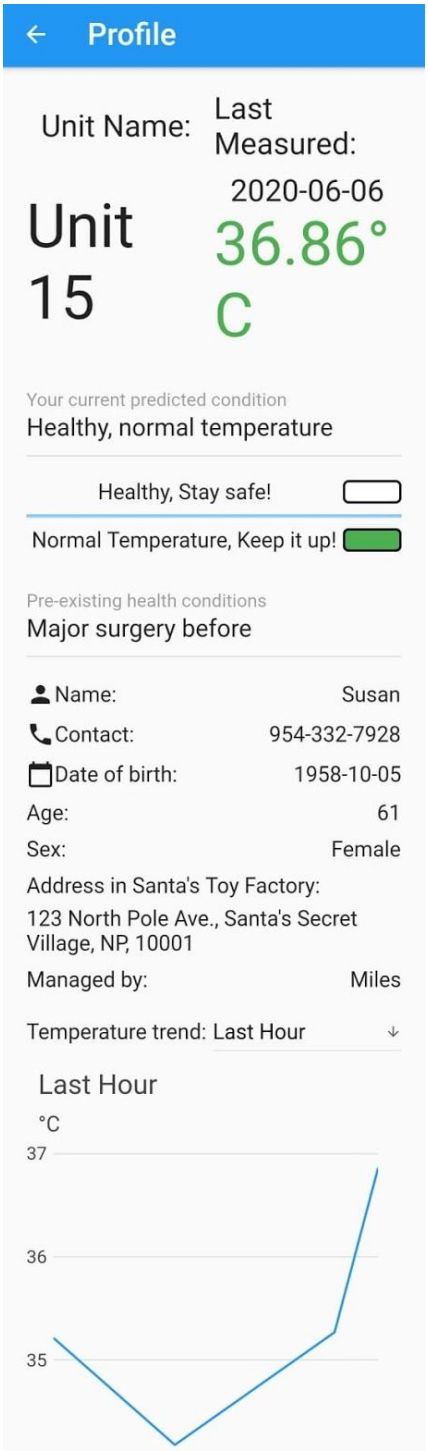
[2] For information on the tiles with individual names, please see the “Individuals Grid” section.

Individuals Grid



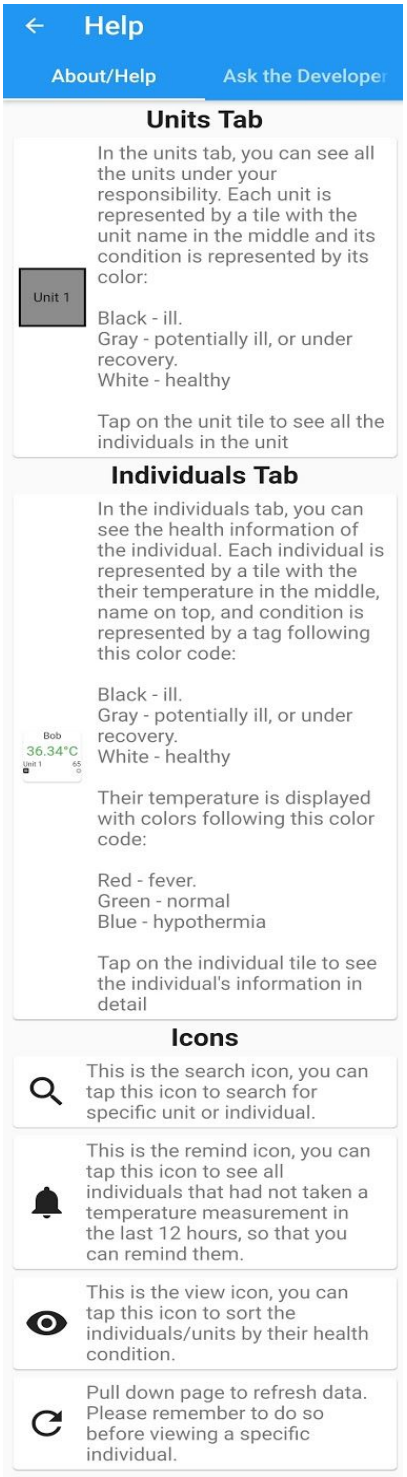
- This is the Individuals Grid. The individuals represented by tiles are the individuals living in the specific unit represented by the unit tile that the Manager had tapped on in the "Units Tab."
- Each individual is represented by a tile with his/her information displayed. The tile includes the individual's name on top, his/her temperature in the middle color-coded with red, green or blue corresponding to fever, normal and hypothermia respectively. The lower left corner displays the unit name that the individual is living in and his/her primary health tag (square with black, gray, white, corresponding to ill, potentially ill, and healthy respectively). On the bottom right corner, the age of the individual is shown and their temperature trend is shown in either a frown or smile. Frowns represent bad temperature trends, such as an increase in temperature during a fever or a decrease in temperature during hypothermia. Smiles represent good trends, a decrease in temperature during a fever or an increase in temperature during hypothermia.
- Tapping on the tile leads to the specific individual's profile page, or "Individual Page."

Individual Page



- The individual page provides a detailed view of the selected Resident's information.
- On the top is the selected resident's unit number and the last taken temperature with its date. The temperature is color-coded into three colors, red for over 37.5℃ (fever) , green for below 37.5℃ and above 35℃(normal), and blue for below 35℃(hypothermia).
- Below is an auto-generated health message, predicting the resident's health condition based on temperatures taken. The colored tag on the top has three possible colors, black if severe condition or abnormal temperatures, gray if there has been an abnormal temperature within the past 3 days, and white if the resident is healthy. There is also another health message that elaborates on the colored tag. The messages provide more details about the temperatures.
- The "Pre-existing health condition" reflects what health condition the resident has currently. The resident would fill this information out in their setup page.
- The resident's basic information is displayed, including name, contact...etc.
- There are six modes for the generated temperature graph, last hour, last day, last three days, last week, beginning of time, and custom. The manager can use the different modes to view temperature trends in those time periods. The manager can use the custom mode to view temperature trends only on the inputted date. And clicking on the graph will show details about temperature specifically on that point in time.

Help Page

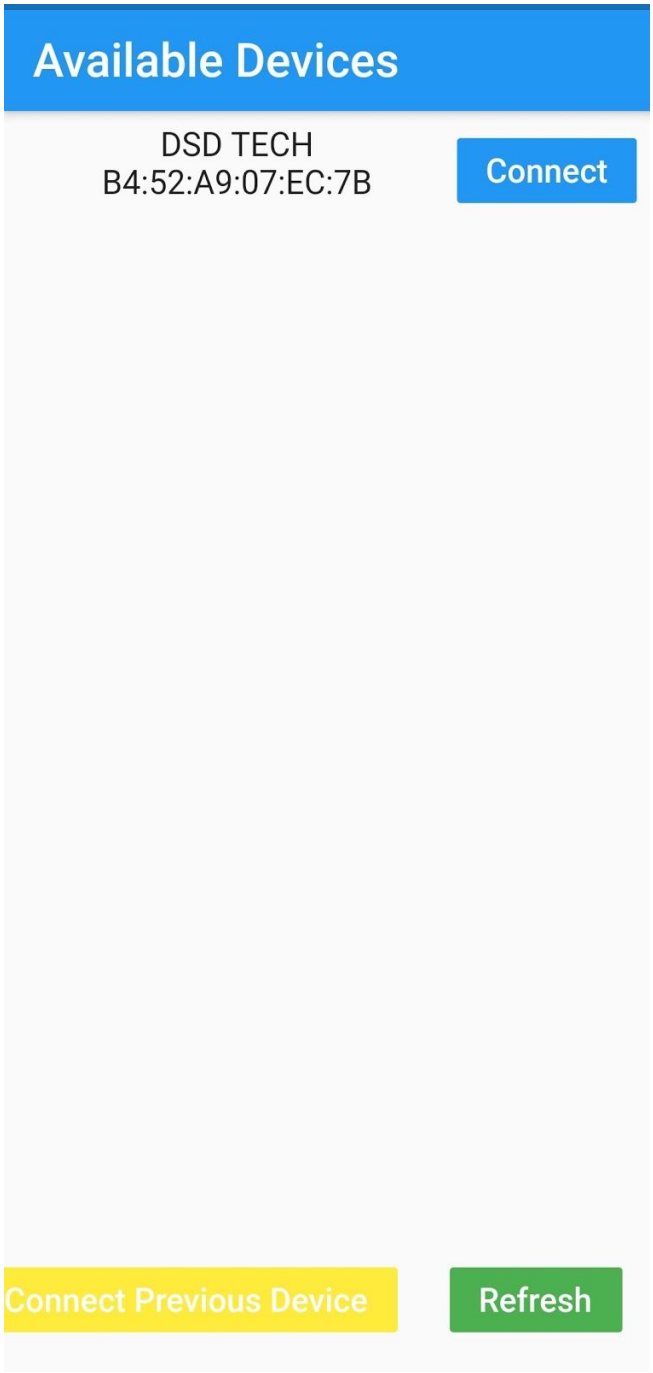


- This is the Manager version of the help page. Similar to the help page for Directors, this page also lists and explains all the icons and buttons available for Managers.
- If there is anywhere the user wants more clarification, or has a question, or found a bug, the user can tap on "Ask the Developer"[3]

[3] For more information about "Ask the Developer", please see the second bullet point under "Help Page" in the section "Director Pages."

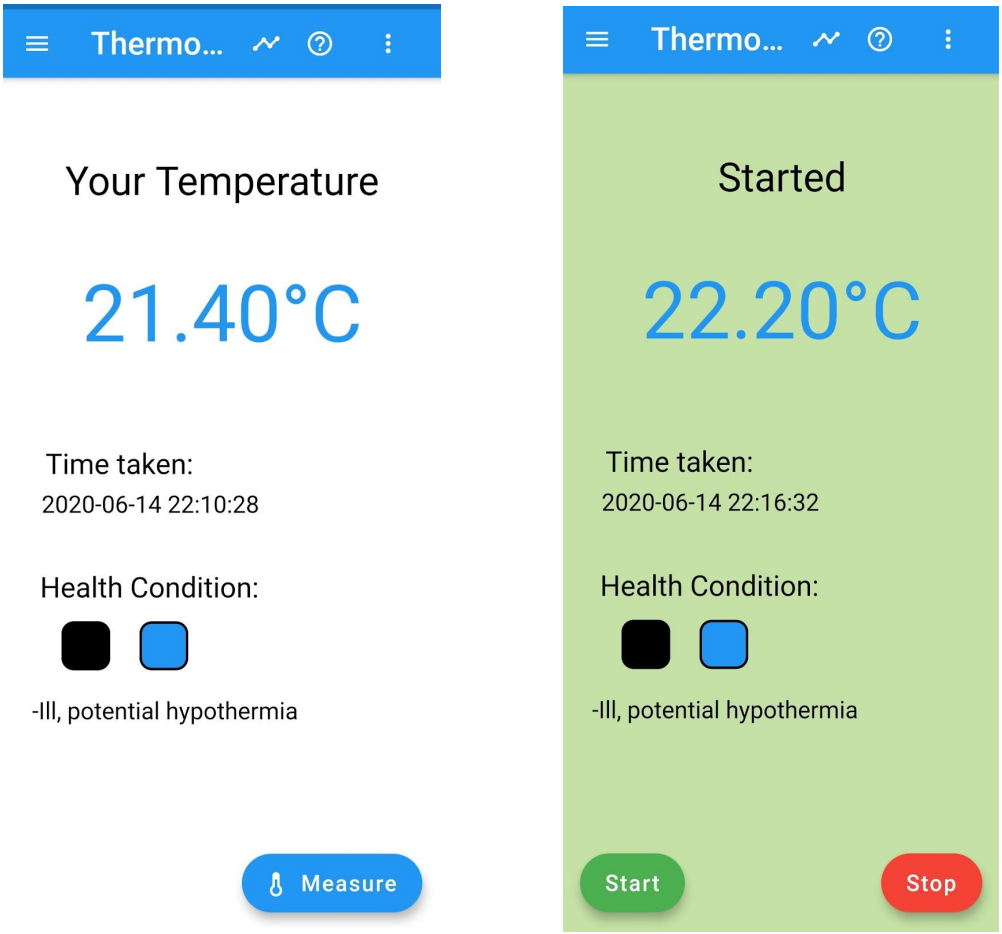
Resident Pages

Connecting Devices Page



- This is where the user can find and connect their physical BLE (Bluetooth Low-Energy) temperature monitor.
- The user can tap on the connect button next to the device name (e.g. DSD TECH) to connect with the device.
- If the desired BLE device is not found, the user can tap “Refresh” to rescan for available devices.
- If the user had connected with a device previously, the user should wait a few seconds and the software should connect automatically with the previous device if the previous device is found. If the previous device is found, but the software did not auto-connect with the previous device, the user can manually connect with a previous device by tapping “Connect Previous Device.”
- After connecting with a device, the software will automatically lead the user to the “Temperature Monitor Page”

Temperature Monitoring Page



Discrete Mode (Screen on left)

- The user can measure his/her current temperature by tapping on the blue "Measure" button.
- Under "Discrete Mode," within the middle of the screen, the user's last measured temperature would be shown color-coded with red, green and blue, meaning fever, normal and hypothermia respectively. The time of last measurement would also be shown.
- The user's health tags (the two colored-coded squares), represents the user's current health condition, which is also described by the small line of text under the tags.
- The first tag (square on left), or primary tag, denotes whether the user is sick or not. It is color-coded with black, gray and white, representing ill, potentially ill/recovering and healthy. The black tag is shown whenever the user's temperature rises above 37.5℃ (fever) or below 35℃ (hypothermia). The grey tag appears when

the user's temperature is normal [35℃-37.5℃] but within the last 3 days the primary tag was black. The white tag appears when the user's temperature is normal [35℃-37.5℃] and the primary tag was not black in the last 3 days.

- The second tag (square on right) or secondary tag, denotes the user's temperature. If the user's temperature is above 37.5℃ (fever), it would be red. If the user's temperature is 35℃-37.5℃ (normal), it would be green, If the user's temperature is below 35℃ (hypothermia) it would be blue.

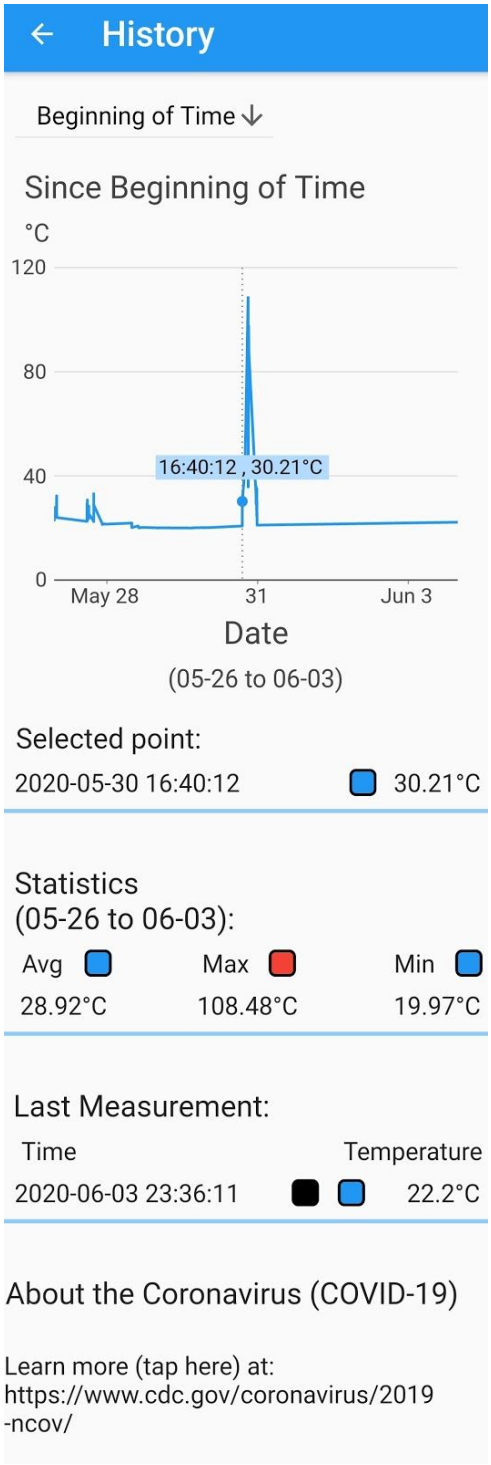
Constant Mode (Screen on right)

- Under this mode, the user can continuously monitor his/her temperature, one measurement per second. The user can press "Start" to start monitoring. During the process of monitoring, the background color would change to green, the text "Started" would display toward the top of the page, and the information such as last measured and the user's health condition would be updated as the measurements change through time. Once the user has finished monitoring, the user can press "Stop" to stop measuring. Once it is stopped, the text on top would display "Stopped" and the background color would change to red. In addition, the number would not update and the information on the screen won't change.
- The information in the middle of the screen during this mode is exactly identical to the information displayed in the middle of the screen in "Discrete Mode," please refer to that section for details.

Buttons/icons

- The Menu button (three horizontal bars) allows the user to switch between "Temperature Monitoring Page" and "Profile Page."
- The History button (trend icon) allows the user to view his/her previous temperature records, and leads him/her to "History Page."
- The Help button (question mark icon) brings the user to the Resident's "Help Page" if he/she has any questions.
- The Options button (three vertical dots) allows the user to:
    - Change mode of monitoring between "Discrete Mode" or "Constant Mode"
    - Disconnect from the current BLE temperature monitor
    - Delete the last measurement from record if the user thinks it is bogus data.

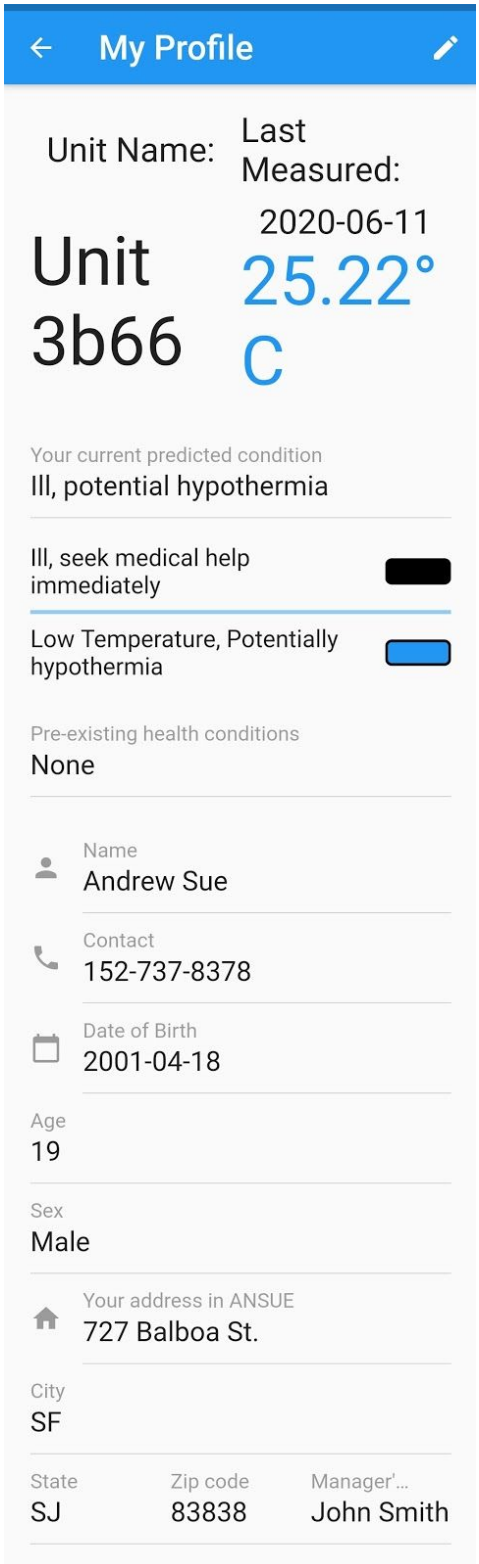
History Page



- The resident can use the history page to check on recent temperature trends, and health conditions.
- The graphs for the Residents are the same as the graphs for the Managers. [4]
- The selected point on the graph will also be displayed under the graph, with the color tag showing the condition of the temperature.
- The statistic shows the average temperature taken, max temperature taken and minimum temperature taking along with color tags showing the condition of the temperature, within the chosen period
- Last measurement shows the data last measured, including the time, temperature, and the color tags representing the user's health condition.
- Lastly, there is a hyperlink that the user can tap on to go to the CDC website for more informations about COVID-19

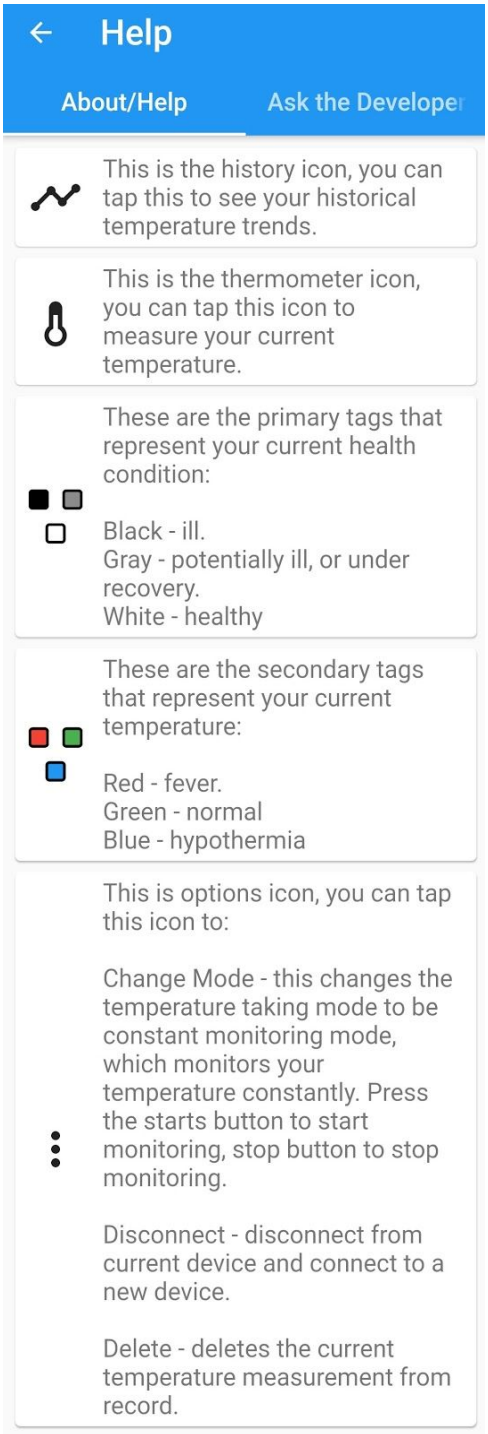
[4] see "Individual Page" for a detailed explanation of the graph.

Profile Page



- This page shows the basic information of the user such as their name, contacts etc.
- This is very similar to “Individual Page”, except this page doesn’t have a graph.
- For more information about the contents, please see “Individual Page” under the “Manager Pages” for more detail.

Help Page

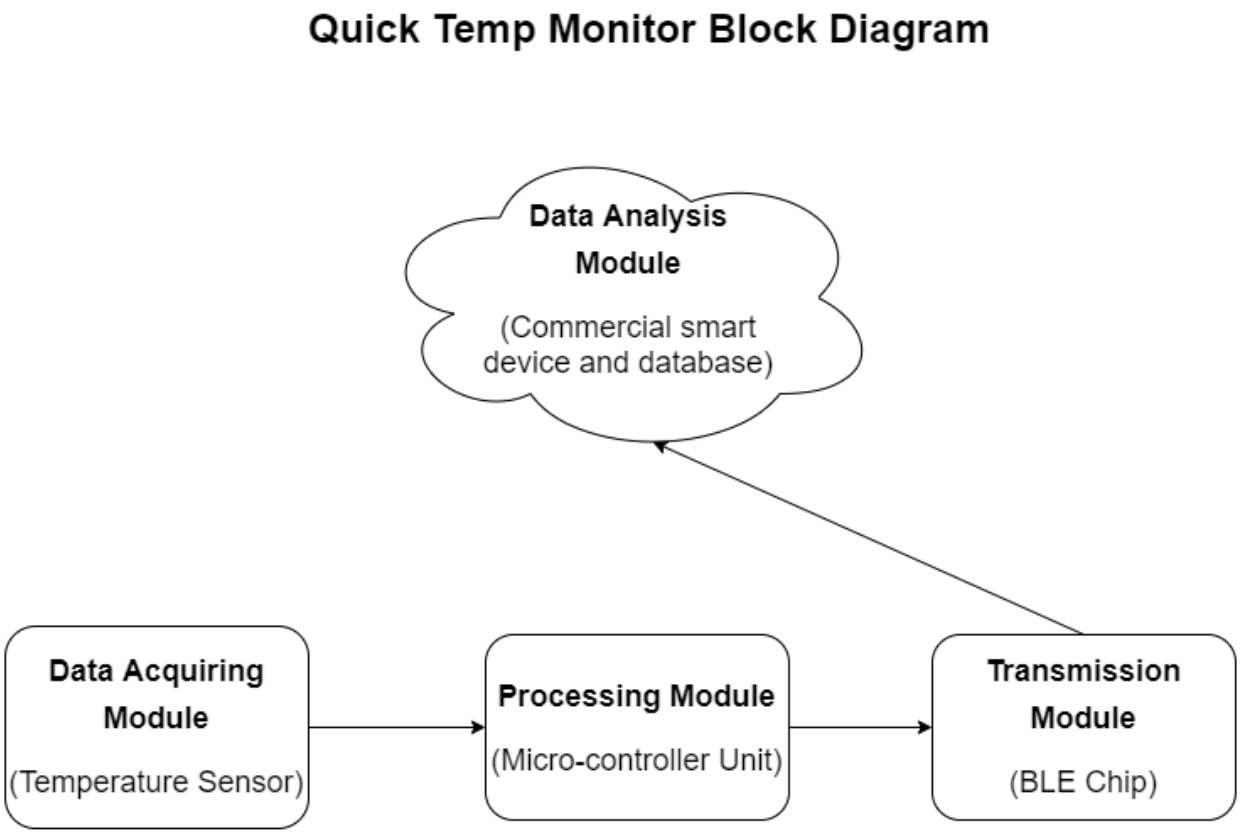


- This is the help page specifically for Residents. Similar to the "Help Page" of both Directors and Managers, this page also describes the function of different buttons with their icons.
- If there is anywhere the user wants more clarification, or has a question or found a bug, the user can tap on "Ask the Developer"[5]

[5] For more information about "Ask the Developer", please see the second bullet point under "Help Page" in the section "Director Pages."

Hardware

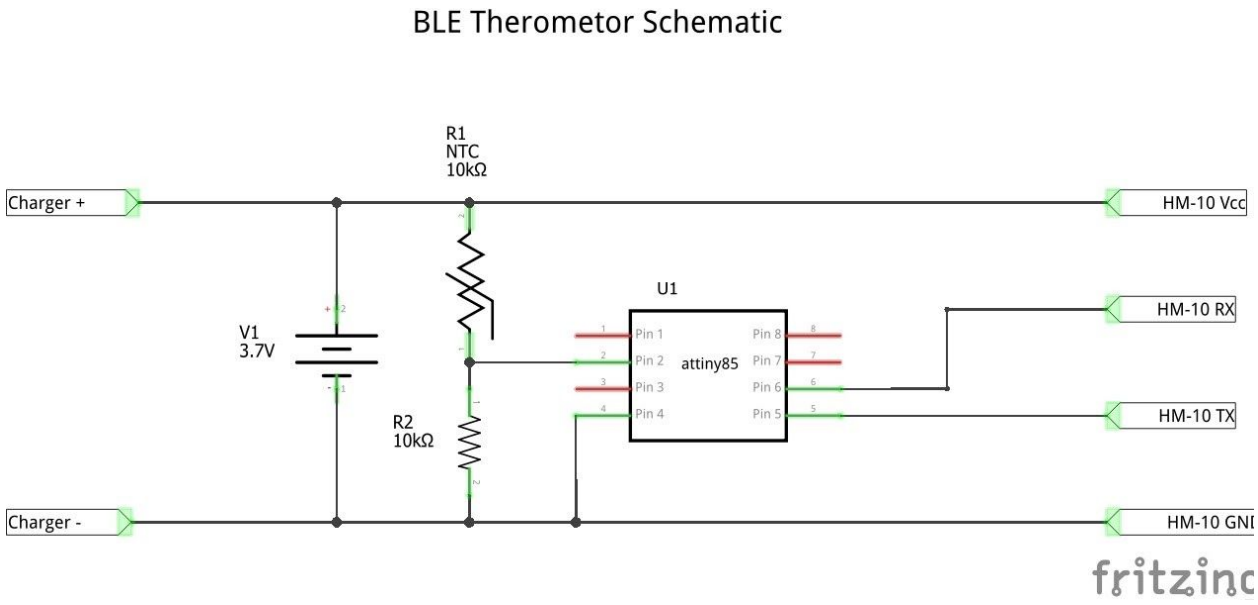
Diagrams and Schematics



This is a generalized conceptual block diagram for the physical part of our device.

The electronic hardware portion of our system Quick Therm consists of 4 main modules, the “Data Acquiring Module”, “Processing Module”, “Transmission Module” and “Data Analysis Module.” The “Data Acquiring Module” is the module that consists of the temperature sensor, and is responsible for taking the raw temperature data and sending the information to the “Processing Module.” The “Processing Module” consists of the microcontroller unit of the device, and is the brain of the entire electronic circuitry. It takes the data from the “Data Acquiring Module” and converts it into temperature readings, which is then sent to the “Transmission Module.” The “Processing Module” is also

responsible for gathering the battery voltage information that is also sent to the "Transmission Module." The "Transmission Module" consists of the Bluetooth Low Energy (BLE) Chip. It transmits the temperature data and battery voltage information already processed by the "Processing Module" to the user's smart-device, which is the "Data Analysis Module" so that the user can easily visualize and see the temperature takings.

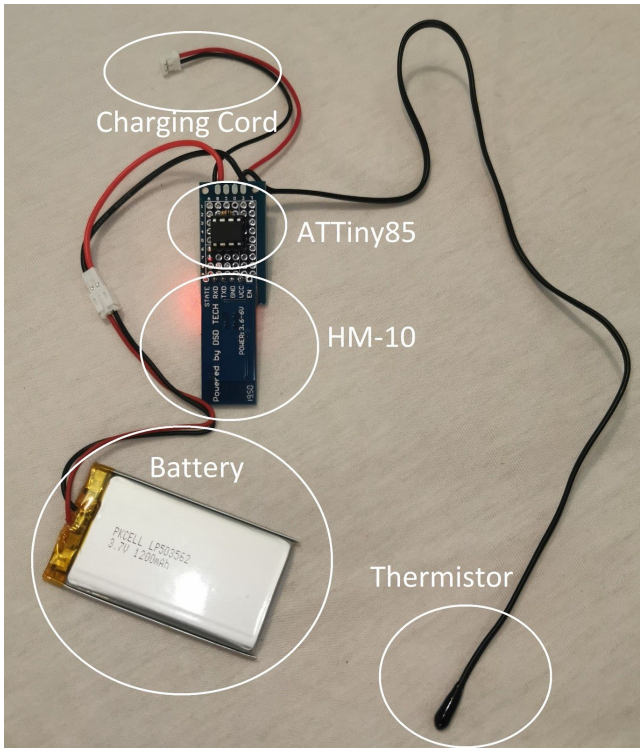


The schematic for the prototype of the physical part of Quick Therm

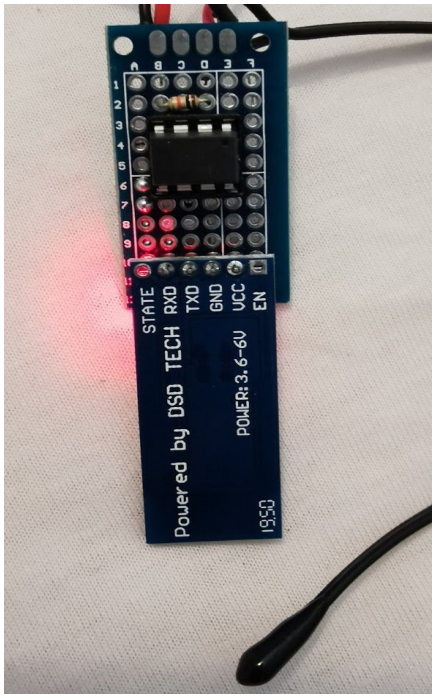
Our prototype, the proof of concept, is built with ATTiny85 as the microcontroller for the Processing Module. A 10k Ohm NTC Thermistor and a 10k Ohm resistor together forms the Data Acquiring module. The HM-10 BLE Chip forms the Transmission Module. The entire circuit is powered by a 3.7 1200 mAh Rechargeable Lithium-ion Polymer Battery.

List of Materials for the Prototype:

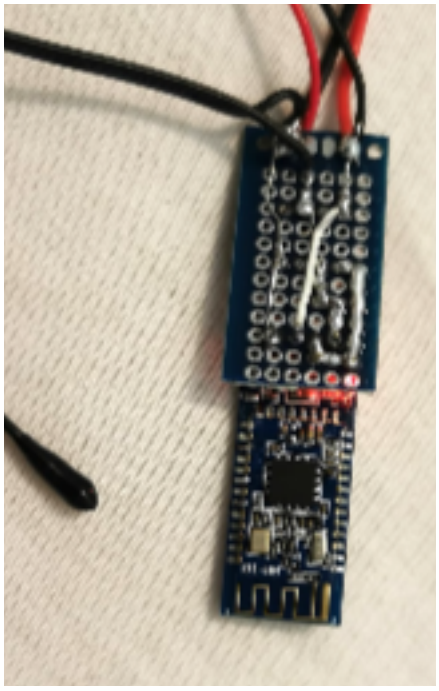
- HM-10 x1
- ATTiny85 x1
- NTC 10kΩ Thermistor x1
- 10kΩ Resistor x1
- 3.7V LiPo Battery + Charger x1
- Wires + PCB



The prototype of the temperature monitor for Quick Therm

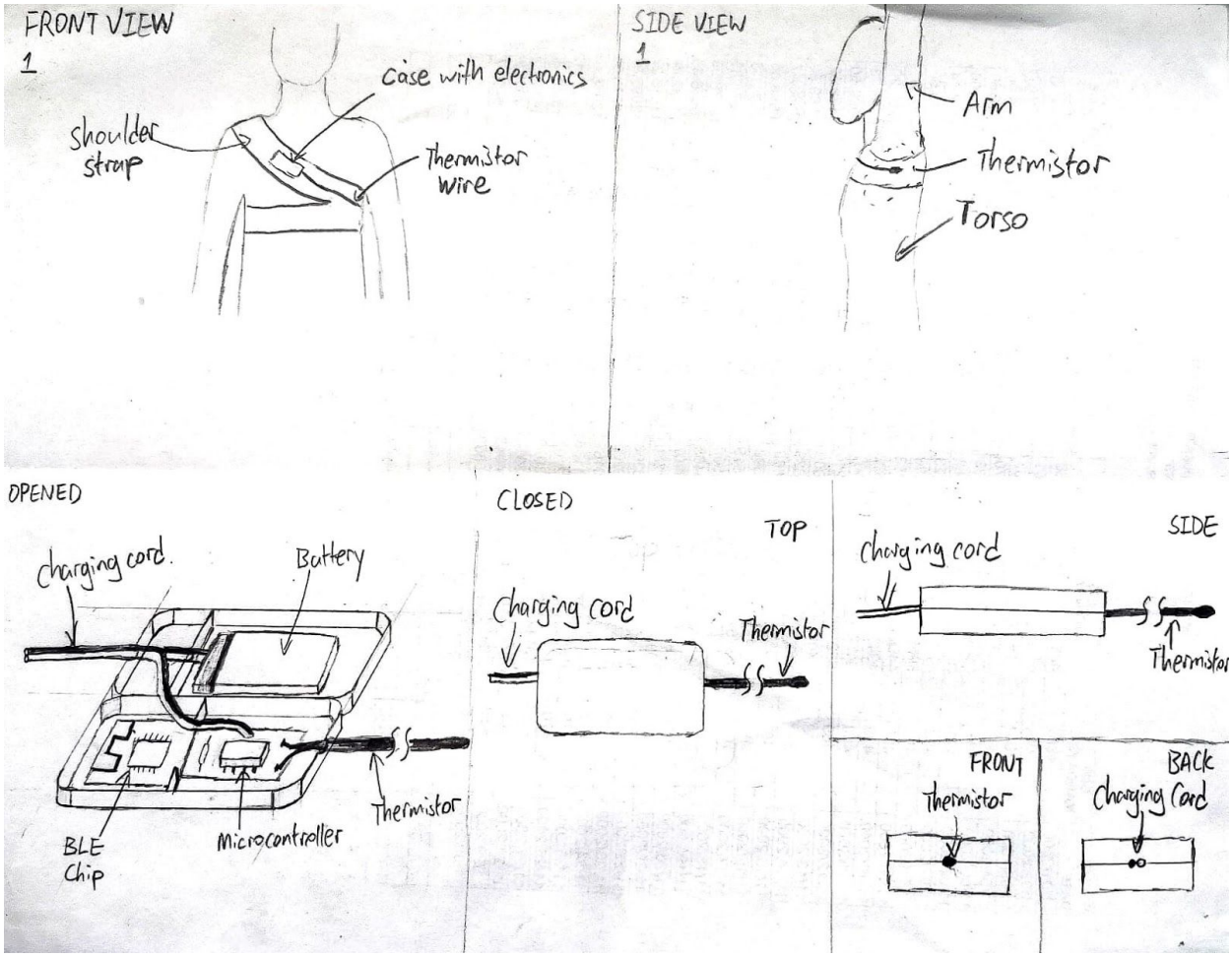


Backside of prototype



Front of prototype

Envisioned Final Product



Our envisioned final product would be worn around one's shoulder like it is described in the upper tiles labeled "FRONT VIEW" and "SIDE VIEW". The electronics would be contained in a plastic casing shown in the lower tiles with the thermistor or temperature sensor and the charging cable coming out the case. The plastic casing would then be inserted in a closed pocket sewed on the shoulder strap with the temperature sensor placed in the user's armpit region for accurate measurements.

We decided on this approach to secure the electronics because it is the least invasive, but the most secure method. Our device doesn't need to change adhesives, unlike other products, therefore, saving cost and can stay on the user's body for as long as they want. This method with shoulder straps also eliminates the chances of irritation caused by

the glue from the adhesives. Also the shoulder strap method makes our device reusable and long lasting. In addition, it guarantees good contact between the temperature sensor and the user's skin under any circumstances, even during arm movements when the user is pursuing their day to day activities, as this is crucial for accurate measurements. Furthermore, the device itself is rather compact and the shoulder straps can easily be hidden under clothing. Thus, the shoulder strap design, in our opinion, is superior to the adhesives or other designs, making our device virtually unnoticeable and non-interfering with user's daily tasks, providing a comfortable and a practical temperature monitoring tool for the users.

Features and Advantages

- Ability to monitor temperature with no contact.
- Relatively cheap to manufacture and produce.
- Easy to set up and use.
- Clear and intuitive data visualization,
- Easy to notice abnormal values.
- Easy to implement within a variety of organizations, such as SROs, hospitals and apartment complexes.
- Suitable for numerous situations such as disease protection, detection and prevention.
- Accurate temperature reading under any conditions, including during daily activities such as doing chores, sleeping, exercising etc.
- Doesn't interfere with normal activities.
- No chance of skin irritation due to adhesive.
- Reusable, and easy to wear and take off.
- Ability to provide data for possible research and studies in the future

Planned improvements

- Support for multiple languages, in addition to English, Chinese, and Spanish.
- Ability to connect to multiple devices.
- Support for people that already own a thermometer.
- Ability to switch units of temperature.
- Managers able to manually remind residents.
- In app communication network for reporting abnormalities.

- Text suggestion for searching existing managers and organizations.
- Web support for usage on computers.
- Better user interface for small screen/large text for the potential visually impaired.
- Apply deep learning algorithms for data analysis, health condition prediction and finding possible obscure correlations.