IoT Sensor Integration and Back-end Development for Sequoia

Project Plan

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1 Introductory Material

1.1 Acknowledgement:

Team 36 Client: Andrew Guillemette
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1.2 Problem Statement

With a large number of baby boomers becoming older there is a large need for systems to monitor the health of our senior citizens. Most senior citizens have habits that they follow every day, and a lot of information can be learned about them from these habits. The goal of the Sequoia project of our clients company is to put sensors in seniors homes to monitor their habits, and be able to tell when a senior might be ill based on changes in habits before they are showing other symptoms.

Our group's specific goal of this project is twofold. First we will add a smart outlet that will track when different appliances are being used to the suite of sensors that is already in place for the system. Second we will use a wearable device such as a smartwatch to track the the location of the senior within the apartment and use the sensors to monitor their health in more traditional ways.

1.3 Operating Environment

The sensor network will be placed in a seniors apartment or home in order to collect data on their habits so they will not be subject to any harsh weather conditions. The wearable tracking device will be worn both inside and outside of the residence so it should be able to function in some unfavorable weather conditions such as rain.

1.4 Intended User(s) and Intended Use(s)

The overall system has 3 intended users the senior that is being monitored, the loved ones of the senior, and the seniors doctors. However the two parts of the system that our team is focusing on (the smart outlets, and the wearable tracking device) the user will only be the senior.

The smart outlet will be used to track which appliances are being used at which times, and when this information is combined with information for other sensors to know what times the senior is eating, and what they are eating. All the senior will have to do is not unplug the appliance from the smart outlet as the appliances will be plugged in correctly when the system is installed. The only thing the senior will have to do to use the wearable tracking device is make sure that it gets changed, and to wear it.

2 Proposed Approach and Statement of Work

2.1 Statement of Work and Deliverables

The expected end product of this project is a smart outlet that can transmit data to the hub of the already existing system, and a program that will interface with an existing wearable smart watch that can track the location of the senior citizen, and keep track of other traditional health information and transmit that information to the hub of the already existing system.

Along with this we will provide any information and documents needed about the setup of the devices that will be needed to set up the system in more units, and scale up the use of the system.

2.2 Functional requirements

FR.1: The data from the smart outlet shall be sent to the existing AWS server

FR.2: The tracking system shall track the senior to within 1 meter accuracy

FR.3: Data from the smart watch shall be sent to the existing AWS server

2.3 Constraints and Technology Considerations

The tracking system will be limited in accuracy depending on the solution chosen. Using systems involving wifi or bluetooth can get an accuracy between one and three meters, whereas systems involving rfid or ultra wideband can get an accuracy under one meter. Another constraint consideration is the amount of wiring required for these tracking solutions. Ideally, the less wiring required for the solution, the better. Systems involving RFID would involve extensive wiring, while systems using bluetooth or ultra wideband would only need wires for 4 to 5 beacons. For the smart outlet, its size cannot be too large to make use of the outlet inconvenient.

2.4 Assumptions and Limitations

2.4.1 Assumptions:

- The senior will not take off the wearable tracking device
- The senior will not plug appliances to non-smart outlets
- The weable will be some kind of watch because the results of a survey of seniors showed they were must open to wearing that type of device.

2.4.2 Limitations:

- The smart outlets must not greatly restrict outlet usage
- Not all appliances run on standard 120 volt outlets
- The amount of data we can get is restricted by the API of the chosen wearable

2.5 Related work and Market Survey

This solution for our client's problem revolves around combining existing technologies and combining them to create a solution that has value than any of the one components. Research was conducted in the following categories: active tracking, passive tracking, and smart outlets.

As research was conducted about active tracking, it was determined that the two best high-level options would be to either have the senior use a wearable device or use ultra-wideband radio. When considering wearable devices, we needed to look at the features of each device available on the market, as well as consider if the senior would enjoy the device. If the wearable had all of the correct features, but the seniors did not like wearing it, useful data would not be able to be collected. On the other hand, if the most liked wearable option didn't have the necessary sensors, useful data would also not be able to be collected. To determine the interest of the seniors, the client conducted a market survey at Green Hills Community. The result showed that most seniors would be open to using an Apple Watch or a Fitbit device.

At the same time as our client conducted the market survey, we did research to see what kind of availability there was for the different wearables as well as what capabilities each one had, and how easily we could utilize those capabilities. We determined that the APIs for WearOS and the Apple Watch were the easiest to interact with since developers have the ability to get direct sensor data on the device, whereas the Fitbit API only allowed developers to access data from the Fitbit servers rather than locally on the devices. This narrowed our search down to the Apple Watch and WearOS. The sensors available on the Apple Watch, combined with the market interest, makes it the most promising option as a wearable device for our application.

Our client has an existing relationship with a company who develops ultra-wideband tracking solutions called Red Point Positioning. The client requested that we conduct research on Red Point Positioning's tracking solution to see if it could be a viable option for active tracking instead of a more intrusive wearable device. At this point in research, we are still waiting on a development kit to evaluate the effectiveness of the tracking as it relates to the constraints of the environment of the Green Hills Community apartments.

2.6 Proposed Design

This project consists of a major technical component involving tracking and a minor technical component of implementing data collection with a smart outlet. The tracking component design will consist of researching and selecting a system for tracking the resident and guests. This will be used to verify event identification for tasks such as opening drawers, using appliances, laying in bed, etc. The method of doing this however, is still undecided. In addition, this will need to incorporate some kind of wearable device. The smart outlet design includes selecting a smart outlet to use and relaying data to a central collection point such as a database. The selection for the outlet will depend on cost, availability, and workability in terms of retrieving data from the outlet in a simple manor.

The selection of a method of patient and guest tracking is the first major design factor to consider. There are several methods for tracking users indoors: Wi-Fi, Bluetooth, RFID, and ultra-wideband. All of these solutions need a tag or receiver possessed by the user for tracking. This then prompts the need for some kind of wearable device to contain the tag or receiver. Various smart devices such as phones or watches can incorporate Wi-Fi or Bluetooth tracking systems, while RFID and ultra-wideband would require a chip tag attachment to the wearable. The accuracy of the tracking system needs to be at the most within a meter. Most wifi tracking systems alone only achieve an accuracy of around 3 meters, but they can be improved by bluetooth beacons. Using RFID chips could get accuracy under a half meter, but would require installation of numerous rfid chips. Finally, ultra wideband can get accuracy well under a meter, but along with RFID, would require a separate attachment to a wearable if the wearable doesn't solely consist of the tag or receiver.

Once the method for tracking guests and the patient is selected, the tracking data needs to be sent to the web server for event identification. The established part of the overall system this project is a part of already has sensors for event identification, but it lacks a way to identify whether a guest or the patient triggered the event. By tracking location, we can identify which user triggered the event based on their proximity to the sensors

sending the data. This is why accuracy is important, as events triggered by different users at the same time can happen in the same room. With the accuracy under a meter, the system could correctly differentiate the resident opening the fridge and a guest sitting at a table in the same room.

The smart outlet will be part of the numerous sensors in the residence. This sensor needs to track electrical usage in order to identify between usage of electrical appliances such as a stove, a toaster, or a microwave. Data from this outlet then needs to be sent to the web server for event identification. This narrows down the exact requirements needed to select a smart outlet: the smart outlet should be cheap enough to make including many smart outlets in each residence viable, it should track specific data such as current or voltage to identify the appliance used, and it should have accibabily to facilitate sending the data to the web server.

2.7 Security Considerations

As personal data involving the patient's health will be stored in a central database, security needs to be taken into consideration. For the scope of this project, the data only needs to send and store the data securely.

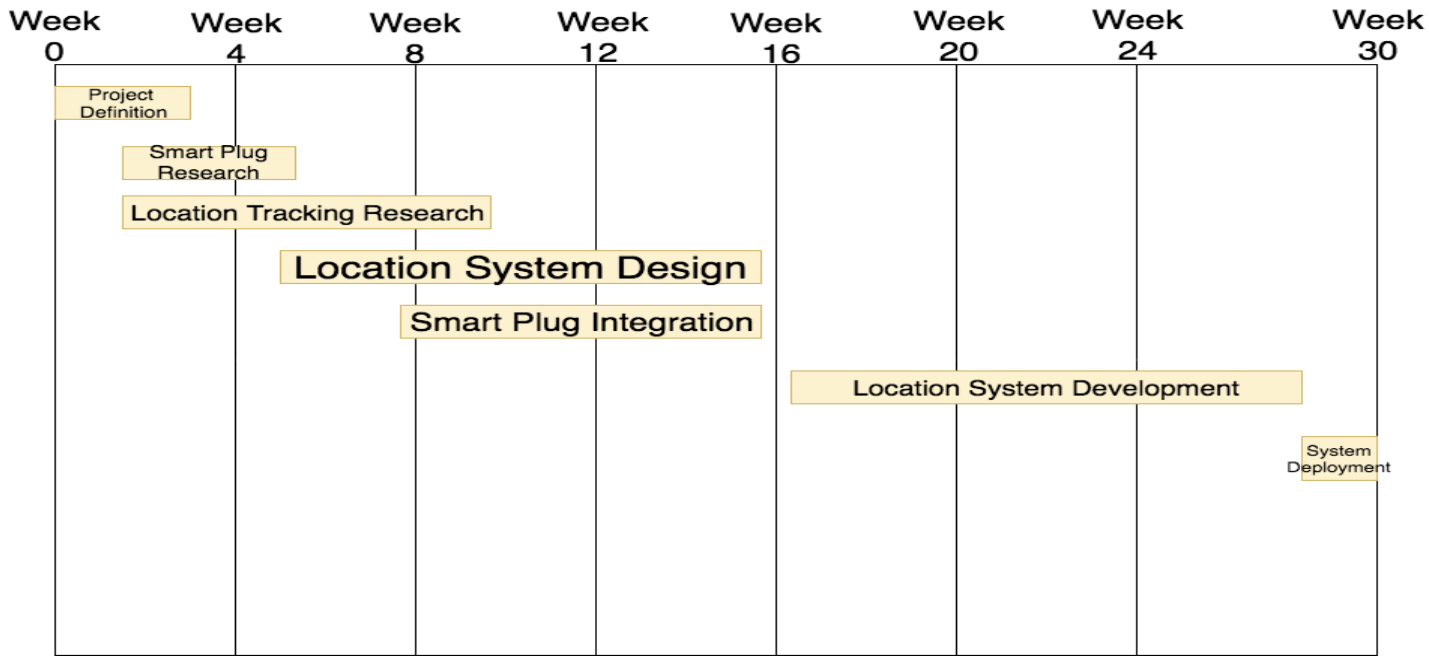
2.8 Safety Considerations

As we will be working with electrical outlets in this project, precaution will have to be taken with using the smart outlet to avoid a shock from the outlet.

2.9 Possible Risks and Risk Management

Title: Health Data Security
Risk: Mitigate
Information: As data will be sent for collection on a web server, we need to verify that the data is securely sent to the web server and is then therefore kept secure when on that web server. This can be challenging when using simpler devices such as rfid or ultrawide band that would not have established security protocols that things like smart devices could have.
Mitigation: We should verify data is only sent to the web server without the possibility of outsiders receiving the data. In addition, we should verify that the web server has specific control over which devices can send and receive data.

3 Project Timeline, Estimated Resources and Challenges



[Figure 3.1: Project Timeline]

Task	Description	Work Estimate
Project Definition	Understanding project problem. Coming up with requirements.	10 hrs
Smart Plug Research	Research what smart plug should be used in our system. Do market survey and cost analysis. Buying best available smart plug.	10 hrs
Location Tracking Research	Research for how we are going to track the senior. Figuring out what hardware is necessary.	20 hrs
Smart Plug Integration	Finding a way to integrate off the shelf smart plug into current sensor system.	20 hrs
Location Systems Design	Designing a system that can accurately track a senior.	40 hrs
Location System Deployment	Implementing system design. Using hardware to track senior. Sending location data to server. Writing program to identify resident or guest in house.	200 hrs
System Deployment	Giving system over to client for pilot program. Final documentation	20 hrs.

[Table 3.1: Estimated Time Resources]

3.1 Standards

3.1.1 Testing and Test Plan

FR.1: The data from the smart outlet shall be sent to the existing AWS server.

Test case:

For this requirement we want to be able to test the appliances with the outlets to see if we can see how much and when the power is being drawn. Also, we must see if the data is being sent to the AWS server when the plug is taking data.

Test steps:

1. Make sure the smart outlet API is integrated in the program.
2. Turn on an appliance with the outlet and determine if any data was recorded.
3. Ensure all recorded data is feasible for the appliance being used.

Expected result:

Data from the outlet should be sent to the AWS server, and be correlated to the appliance.

FR.2: The tracking system shall track the senior to within 1 meter accuracy.

Test case:

Find a test user to wear the device and walk around the apartment to test location tracking. Have the device record location of the wearer and determine if it is feasible for this project.

Test steps:

1. Have the test user wear the device and move around the apartment.
2. Track location of the tester and determine if it is correct.

Expected result:

Be able to determine where the user is up to a meter. For example, whether the user is at the fridge or the stove.

FR.3: Data from the smart watch shall be sent to the existing AWS server.

Test case:

Have a test user wear the device for a set time period and and determine all wanted data is being taken. For specific data like location we will have to plan out specific test cases and see if the data taken matches with real world results.

Test steps:

1. Find a test user to wear the watch until data collection is completed.
2. Make sure all traditional health information is being sent to the AWS server and all data is correct.

3. Test specific data, like location, manually to see if it matches what is being sent to the server.

Expected result:

All data sent from the watch to the AWS server must be correct and taken whenever it is needed.

3.2 Feasibility Assessment

The project involves numerous hardware components, such as the selected smartwatch, the smart outlets, the potential ultra-wide band systems, along with the company's current smart-home ecosystem. Due to the nature of each hardware component, and the different methods of sending and processing information between devices, there exists multiple risks with integrating each component into the smart home ecosystem. Currently the company is working on a backend service that all of these devices will be connected to, but the senior design team does not have control over how it is programmed or designed. As a result, it may prove to be difficult to interface with the company's' backend services without implementing another hardware interface.

Utilizing the smartwatch and the various hardware sensors in the current smart-home ecosystem to identify specific user actions is also an anticipated challenge. The objective is to successfully identify when a user may have performed certain actions - identifying the circumstances when these actions are performed may prove to be difficult, as there is potential interference from guest's visiting the user. The team will have to consider ways to determine the user from visitors.

3.3 Other Resource Requirements

Depending on the smartwatch selected, the project will require specific operating systems and development environments to work with. If the project utilizes the Apple watch, the team will require MacOS devices and the XCode IDE. If the project utilizes an Android Wear smartwatch, the team will require a device with Android Studio installed.

The team will also need to utilize the company's current sensor hub to successfully integrate the smart watch tracking and smart outlets into the smart home ecosystem.

3.4 Financial Requirements

The project requires a few hardware components to be successfully. The project requires a smartwatch for tracking which value may range from $150 - $500 depending on the platform and device specified by the team and client.

The project will also require funding for the specified smart outlets. The amount needed depends on the amount of smart outlets purchased for the pilot location.

Finally if the RFID or ultra wide band sensors are implemented, funding will also need to secured to purchase the sensors and detectors for them.

4 Closure Materials

4.1 Conclusions

In conclusion, the goal of the Sequoia project is to use sensors to monitor the daily habits of senior citizens, and use that data to see when those habits change, possible indicating a heath issues before other symptoms are showing. This will allows seniors to stay in their homes longer and have a better quality of life.

In support of this goal our team will integrate a smart outlet into the already existing sensor network in order to monitor what appliances are being used. This will help monitor the seniors eating habits. The goal is to have this implemented by mid-October to have it ready for trails. We will also implement the use of a smartwatch to track the senior when they are in their residence to make sure their activity level is normal. This is the bulk of the project and is expected to be done by the end of the project.