IoT Passive Monitoring for Assisted Living Homes

Design Document

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List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1. Introductory Material

1.1 Acknowledgement

If a client, an organization, or an individual has contributed or will contribute significant assistance in the form of technical advice, equipment, financial aid, etc, an acknowledgement of this contribution shall be included in a separate section of the project plan.

1.2 Problem Statement

The families of elderly people can often have a hard time keeping track of their elderly family members health, in order to get them the care they need. Elderly people want their family to think that they are in good health, so they lie or mislead their family to keep them from worrying. If they are not doing well and need medical attention, it is imperative that the family is able to get them that attention in a timely manner. In the case where the elder has misled their family, it is nearly impossible for the family to even know that such medical attention is required.

We are proposing a new product to designed to solve this problem. Essentially, we want to use passive, non-invasive sensors to collect and store data about the elderly persons habits. In order to help the family know if their elderly relative is doing well we will collect data about eating/drinking habits, sleeping habits, and personal hygiene. This data will be analyzed to see if the elderly relative is staying within normal ranges, and the family will be notified if, for example, the elderly relative stops eating. With the family notified of developments like this, they can get their elderly relative timely medical attention.

1.3 Operating Environment

The end product that we are working on will be used indoors and will not be exposed to any extreme temperatures. Our sensors will be placed in either assisted living homes or residential homes, so they will need to be able to withstand the normal wear and tear of similar objects in homes.

1.4 Intended Users and Intended Uses

The end users will consist of an elderly person being non-invasively monitored, and a caring relative of theirs being notified of any problems. The sensors will not be interacted with- as they are passive monitoring sensors. Relatives of those living in the homes or ?caretakers? will be the intended users of the interface we create. These users will monitor trends from the tenant's data and be alerted of any irregularities that may warn of an underlying health issue.

1.5 Assumptions and Limitations

One assumption we've made is that there will be wifi in the home. Raspberry pi's have bluetooth but we assume the living space would be large enough that this would not be an option. Additionally, we assume this product would not be used outside the United States so medical considerations for other countries have not been taken into account, nor has the difference in building materials and styles or methods.
Tentative assumption: the sensors will be installed in an environment with only 1 subject.

Limitations:

Non-wearable sensors.
Passive sensors.

1.6 Expected End Product and Other Deliverables

The end product will be a platform that consists of three parts: the server, data collection, and an application. These will be delivered by April 1st 2018 to our client. We have broken the project up as follows because

The server will used to store and possibly analyze any collected data sent from other node servers.

The Data collection portion of this project will be a bit trickier. We will have to create a simulated environment to collect data or find someone willing to have sensors installed that will log when they eat or drink, use the bathroom, take a shower/bath, and sleep.

The application will simply be a way to see the historical data graphically.

2. Specifications and Analysis

2.1 Proposed Design

This project has many possibilities for implementation. These include: sensor monitoring, camera monitoring,or having a live-in-caretaker. For the sake of this class and having a project to complete, the last option of a live-in-caretaker is out of the question, not to mention grossly inefficient. This left us with cameras and sensor monitoring. After several discussions with the client, it was determined that using cameras would be too invasive for comfort and the idea was cast aside leaving us with just sensor monitoring. With left us with just the decision of whether or not to use a wearable.. Initially, the decision was made to not use a wearable. This decision has since changed but will not be affecting the parts of the project we already have laid out.

At present, we have selected the sensors that will allow us to monitor the areas of bathroom usage, opening and closing of doors in the kitchen, sink usage for the purpose for getting a drink, we are also in discussion with the client about how to monitor sleep. These sensors will take care

of our functional and non-functional requirements in terms of monitoring. The sensors we have picked out are a flowmeter, load cell,

We have also selected the cloud platform, services, and mobile framework we will be using that will help us satisfy the requirements.

2.2 Design Analysis

So far, our design is still mostly theoretical; at the time of writing, we are in the process of procuring the hardware, and we are working to start the server/software backend.

The weaknesses of our solution include:

- Imprecise
    - The sensors merely give a stream of data, it is up to our interpretation that states if events occur; if our interpretation is flawed, the whole system can be flawed.
- Potentially infeasible to install
    - Depending on the area layout, the wired sensors may prove problematic to install: concealing the wires, routing the wires.
    - Necessary power supplies may not be readily available in ideal locations: some sensors/pi hubs may be located far from an outlet.

The strengths:

- Cost-effective
    - This project specifically targets a Minimum Viable Product: we seek to accomplish our solution using as little capital as possible
- Modular
    - Based on our designs: each pi has a “loadout” applicable for certain areas, e.g. a bathroom or kitchen loadout. Thus a loadout is independent of others and is easily scalable.

3. 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
2. 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.

3.1 Interface Specifications

To test the sensors our team will construct prototype environments to gather test data. The hardware in the environments we create will mimic apartments or homes similar to those that the tenants will be in. The first prototype will be a cabinet door to gather test data for opening and closing the door. We will also have a toilet seat to test the load cell and a hose and valve contraption to test the flow meters for the sink and the shower. All of these hardware tests are still in the design phase and have yet to be finalized.

The prototypes for the sensor testing are hardware interfaces used for initial tests. During the summer our Client will go into assisted living homes and test the sensors while gathering real data to test the Cloud storage. There is no need for testing interfaces for other areas of the project as we will be able to test using the products themselves and mock data.

3.2 Hardware and software

The hardware and software each have significant hurdles that will need to be overcome in order to implement testing of the systems. In terms of hardware we will need a test environment to collect data from:

- The Sensors performing the data collection
- The Raspberry Pi units aggregating the data
- The Cloud backend storing the data.

In terms of software we will need to ensure that our backend is able to store information in a SQL database. For this semester we plan on displaying the raw data via an android application. The data visualization will take the form of a spreadsheet like document for this semester, but next semester we will begin to analyze the data and be able to give feedback on its meaning that will be displayed on the android application. There will have to be software created to allow the raspberry pi's connected to our sensors that will then transmit data to the central raspberry pi located in the assisted living location. Finally creating a program that will simulate data from specific sensors would be ideal, because certain sensor may not be attainable initially because of monetary constraints.

3.3 Functional Testing

- For the hardware component of our project it will be important to simulate a test environment for our sensors. These tests would include making sure that the door sensors are able to accurately detect when a door has been open or closed, we would need to set up some sort of mock piping, possibly with PVC, to detect the flow of water through a flow sensor. We will also need to simulate a toilet seat so that we can test the load cells.

- The second part of hardware testing will pertain to placement of the sensors around an assisted living facility. The client plans on finding a facility in which we can place the sensors around the living facility and get a feel for where we would place these sensors around the actual environment.

- For software testing we plan on implementing an automated test script that will send data to the local server that would resemble that of the sensors. We can then set up automated queries to the cloud database to ensure that the information was sent and stored correctly.

- The final part of our software testing plan will be testing the mobile application platform to ensure that the HTTP points can be hit and successfully deliver the required information.

3.4 Non-Functional Testing

- Azure Cloud Services provides a tool that allows us to see the metrics of our online services. This way we can constantly view the performance of the services and see where there are any bottle necks. We also plan on using Azure's Virtual Firewall that allows us to track all traffic across our cloud network. By doing this we will be able to attempt to access the data through a client that does not have, or rather should not have, access to the information. We could then derive where we need to strengthen security.

- For Non-Functional Testing of the sensors, we plan on both taking sensors away from the system as well as adding new sensors to it. This way we can check the systems behavior for when there is either data that is lacking from the system or new data being added. By doing this we will know how our system responds to the addition or removal of a sensor and how we can better automate such events.

3.5 Process

Initially the first method we thought of after hearing the problem was to use cameras to collect data. Unfortunately this method was quickly decided to be not viable for several reasons. Most importantly it would be a violation of privacy to install cameras in a person's home and collect video of everything they do inside their own home. Our client agrees with this assessment and led us in a brainstorming session to find less invasive ways to passively collect health data.

The next idea we had was to use a wearable sensor to collect data as one of our primary sensors. The client was also not enthusiastic about using a wearable sensor and asked us to focus on other solutions. The reasons for it included trying to keep the sensors as non-invasive as possible as well as try to keep the cost down.

Our current solution consists of:

- a flowmeter to measure drinking water intake
- door sensors on pantries and refrigerators to measure food intake
- flow sensors and a load cell on the toilet to track bathroom habits
- motion detectors to analyze sleep patterns

We chose these specific sensors after several weeks of research, and after securing funding for the prototype we plan to put the sensors through rigorous testing as described in Section 3.3.

Because our other methods of solving the problem were dismissed in their early stages by the client we don't have need of a flow diagram to describe this process as this time.

3.6 Results

Presently, no testing has been performed on the system as it has not yet been assembled or completely procured.

4 Closing Material

In future iterations of this project, it may be possible to view average statistics for all users, in addition to some trend analysis for individual users.

4.1 Conclusion

The elderly currently have two options, get a live-in nurse, or move to a nursing home to live out the rest of their days. Our plan is to create an internet of things that will allow for remote monitoring of their health. This will create peace of mind for family members as well as be able to provide some insight to a doctor should one be necessary. Our solution will consist of sensors sending data to a local server. This server will perform any formatting or interpretation of the data and will then send the data to the cloud server for analysis. The cloud server will have to handle requests for that information and will have to send it in such a way that the application will be able to display it textually or graphically. By implementing this solution to the growing problem of people getting old, we hope to improve the quality of life and happiness of our elderly loved ones as they move from this life to the next.

4.2 References

This will likely be different than in project plan, since these will be technical references versus related work / market survey references. Do professional citation style(ex. IEEE).

4.3 Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc. PCB testing issues etc. Software bugs etc.