IoT Passive Monitoring for Assisted Living Homes

Project Plan

Team 14
Andrew Guillemette

Advisers
Goce Trajcevski

Team Members/Roles
Austin Sudtelgte: Co-Team Lead
Joshua Blanck: Report Manager
Austin Kerr: Co-Team Lead
Ryan McCullough: Meeting facilitator
Nick Schneider: Meeting scribe
Trevor Lee Henderson: Test Engineer

Email:
sddec18-14@iastate.edu

Website:
http://sddec18-14.sd.ece.iastate.edu/

Table of Contents

List of Figures

Figure 1: Proposed Design Diagram
Figure 2: Flowmeter Testing Apparatus

List of Tables

Table 1: Project Timeline
Table 2: Personnel Effort
Table 3: Financial Requirements

List of Definitions

HIPPA: Health Insurance Portability and Accountability Act of 1996

1 Introductory Material

1.1 Acknowledgement

Our team would like to thank Andrew Guillemette and Dheeraj Nalluri for their guidance and assistance throughout our project. Andrew was crucial in helping obtain parts for the project and conducting research with local assisted living homes. Our team would also like to extend our thanks to Dr. Goce Trajcevski who helped with our research by finding articles related to our project and contributed feedback and constructive criticism on our documentation.

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 the tenant is not doing well and needs medical attention, it is imperative that the family is able to get the tenant that attention in a timely manner. In the case where the tenant 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 designed to solve this problem. Essentially we want to use passive, non-invasive sensors to collect and store data about the subjects 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 help for health issues.

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.

- We will track when a person eats by using door sensors. The door sensors will be placed on refrigerator and pantry doors or even cabinets doors for cabinets containing dishes for eating. The data of these doors opening and closing can be interpreted to show when a person is eating. The exact door sensor we have picked out can be found here: https://www.adafruit.com/product/375. We chose this sensor because it operated as desired and integrates well with the rest of the sensors.

- To track when a person is drinking we will put a flowmeter on the sinks. Based on how long the sink is on we can figure out what the sink was used for. The flowmeter that we have picked out can be found here: http://www.hobbytronics.co.uk/yf-s201-water-flow-meter. This sensor was chosen because it performed the desired task, required only a basic setup, and worked well with the other sensors.

- We will use load cell sensors to keep track of toilet usage. The load cells will be placed under the toilet seat and will be able to detect when a person sits on the toilet seat, in theory they will also detect how much waste has left the persons body. We are also considering attaching a flowmeter to the toilet to help account for the case of a male urinating standing up. The load cell we will use can be found here: https://www.sparkfun.com/products/10245.

- Another health variable we want to track is how much sleep a person is getting. To collect that data we will use a ballistic-cardiogram: https://www.murata.com/en-us/products/sensor/accel/sca10h_11h/sca11h. This sensor was chosen because it is the only sensor that has these capabilities currently on the market. The BCG can be simply placed underneath a mattress and will collect respiratory and heart rate data, which will help in the analysis of how much sleep and the quality of the sleep a person is getting.
  - The ballistic-cardiogram is wi-fi enabled and thus can send the data straight to the server. All of the other sensors will be wired into raspberry pi 0ws. The raspberry pi 0w will send the collected data on to an in-home hub server located on a raspberry pi 3. The in-home hub will then send the data on to the cloud server.
  - Due to issues acquiring the BCG, practical testing of the BCG will be postponed until the second semester.

1.4 Intended Users and 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:
        Passive sensors

1.6 Expected End Product and Other Deliverables

The end product for the first semester will be a platform that consists of: a cloud server, data collection, and an application. These will be delivered by April 22nd 2018 to our client. I

In order to collect data we will create a simulated environment and install sensors designed to passively track when a person eats or drinks, uses the bathroom, takes a shower/bath, and sleeps. Further detail on the types of sensors involved can be found in the operating environment section.

The cloud server will used to store and analyze the collected data sent from node servers. We will use Azure cloud services for this project, because they provide an abundance of services including services for everything we need. For the first semester we will be using Azure Cosmos DB to store data collected by the sensors and Azure app services to help create the app.

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

In the second semester we will work on analyzing our collected data so that it can identify health risks. We plan to work with Azure's analytics services: specifically the Stream Analytics and Machine Learning Services. We will also expand the application to focus on delivering the analyzed data.

2 Proposed Approach and Statement of Work

2.1 Objective of the Task

The final product will include several sensors placed strategically around a house to collect data on the health habits of the person living there. These sensors will send data to a local server, which will act as middleware to a cloud server. There the data will be analyzed for trends. When an outlier is detected (signifying a health concern) a notification will be sent to the mobile app to alert relatives or caretakers.
Most of the project is clearly feasible.

2.2 Functional Requirements

Note: These requirements are very much in flux and are subject to change.

The project and system developed are required to
Function passively; without any direct input from the subject being monitored.
The solution we have developed does this intrinsically.

Sensors must be passive and non-intrusive.
Discussion of basic testing of sensors is in section 2.12.

Collect data securely into some central location.
Our chosen central location is an Azure cloud server, which will have the security protection of microsoft. Further security measures are not a deliverable for the prototype we are making.
Tentative requirements include:
Analytics performed on the data to determine trends.
This will be designed and tested during the second semester.

A mobile application to alert user based on certain events, as found from the data.
Tests will be done to confirm that the app displays correct data from the cloud server.

2.3 Constraints Considerations

Constraints

- **Security requirements-** The final product should limit access to sensitive information about individuals to those who need it. Be that a family member, member of staff, or a doctor.
- **Testing-** Testing will be done on basic sensor functionality and extensive details about it can be found in section 2.12.
- **Cost-** cost is a consideration in all of our design choices in an attempt to make the most affordable end product in addition to the expense of hosting a cloud server with as minimal traffic as possible.
- **Software Licenses-** Because this product is likely to enter the commercial market, it is necessary to be sure that we have the right to use any external software libraries we choose.

Non-Functional Requirements

- System must record an instance of someone eating/drinking
- System must record an instance of someone sleeping
- System must record bathroom activity
- App is responsive
- Data visualization
- Secure
- Report loss of sensor
- Report loss of power/low battery

Ethics

This project will not be unethical unless proper steps are not taken to ensure anonymity or that an individual's data isn't protected as that would violate the HIPAA.

2.4 Previous Work And Literature

While this project is in its infancy, the idea is not. As such, our work is not based on a previous senior design project. However, it is important to look for existing research or implementations of this idea that are already on the market. These findings will help shape our design decisions as well as help to identify potential problem areas before they arise.

There are a few existing projects that attempt to capture the goal of this one. The existing projects have all included some type of wearable sensor(*Torres, Roberto L. Shinmoto, et al.*) to

monitor various aspects of a person's health or their physical state. This project is attempting to stay way from technologies of that nature but the information provided may yet prove useful.

In one case, the research and implementation into this type of elderly monitoring system was performed before the age of so-called 'smart-technology' and references being able to receive notifications via PDA device[1]. While that particular paper seems like it would be too antiquated to be of use, it is still fairly relevant. Many of its block diagrams are similar to what we've already come up with.

2.5 Technology Considerations

Because the sensors are passive it is important to preserve a degree of transparency such that the tenants in the assisted living facility don't feel that their privacy is being invaded. This leads to the decision that the sensors we select need to be smaller and thus more easily concealed.

In this project there will be a large amount of sensors sending information at any giving time. Due to the fact that there will be a vast amount of information being sent at any given time we feel that the best solution is to have a local server for each facility or home, such that information is sent to the local server and then relayed to the cloud server. The cloud server will store all of information for each individual sensor, as well as which person the sensors correlate to.

How the sensors communicate will also be an issue to address in this project. If we choose to go with wifi communication, the sensors will have both faster communication times and will communicate with the sensors more easily. Using Wifi we also have the ability to send out a pulse to ensure that a given sensor is still functional. The downside to using Wifi is that for the each facility of home there will need to be an internet connection.

Instead of using Wifi another option is to use ZigBee for communication between sensor. While this doesn't require a Wifi connection it makes it less efficient to communicate with a local server and limits the ability to check if a sensor is still functional.

Finally, the issue of which cloud service to use in the end product. Having experience in Amazon Web Services we know that setting up a cluster, which is crucial for big data analytics, can be implemented easily and works well with Java in the event we choose to use Hadoop for big data.

There is also the choice of using Google Cloud. Having no previous experience with Google Cloud there would be a learning curve and is harder to secure than Amazon Web Service, which is important due to the fact that we are sending personal information across the network.

2.6 Safety Considerations

Due to the nature of passive sensors, there are virtually no physical safety concerns in our project. However, the quantity and nature of the data collected provides some potential privacy concerns. Thus, we will need to ensure the data transmission and storage is secure.

2.7 Possible Risks And Risk Management

One possible risk would be edge cases that may prevent the sensors from collecting data that is useful. This could include inconsistencies to how tenants eat or differences in faucet usage that could lead to inconclusive data about drinking habits. Our team will have to consider all possibilities for these various use cases to ensure that the sensors we use are collecting data that is meaningful and can provide insight to a tenant's health trends.

Another risk for our project is investors having different ideas or plans regarding software or hardware than we come up with for the project. A unique aspect our our project is that it is in the early stages of development to becoming a business. That presents specific challenges when it comes to capital that could dictate what our final product turns out to be. It was pointed out by our Client that the software solution we use could change if an investor comes onboard the project and needs to interface with a specific program. This would nullify the work that we would have put into the other solution and mean that we would need to start from scratch in some portion of the project. Our team will need to stay prepared for risks such as these and be aware of other options than our chosen solution.

2.8 Project Proposed Milestones and Evaluation Criteria

The first key milestone is buying the sensors we propose. For the first portion of the semester we have been researching and compiling a list of possible sensors to use for the project. After comparing different sensors with similar functionalities to each other and finding the strongest candidates, we presented a finalized list of sensors we need for the project to the client with justifications of why they are the best and why they are necessary. The client will discussed the list with us and eventually approve a finalized list of sensors to buy.

The next step for the project is testing the sensors. A list of the chosen sensors can be found in 1.3. The initial basic testing plan for the sensors can be found in Section 2.12.

The next major milestone is successfully storing data from the sensors on our cloud server. For this to happen we will need to set the sensors up in an environment, either an actual assisted living home or a simulated environment. The flow sensor will be attached to a sink, the door sensors will be attached to cabinets in a kitchenette, and the load cell will be under/within a toilet seat attached normally to a toilet. All of these setups will be within the same building where the client works. The objects the sensors are attached to will be used routinely throughout the

day, with a analog log kept of the times they were used. The analog log and the cloud server data will be compared for discrepancies, and smaller tests will be proposed to isolate any discrepancies discovered.

The final milestone of the first semester will be when the application successfully shows a visualization of the collected data. To test this a simple comparison between the data in the server that the app is getting information from will be compared to the data visualization. If necessary further testing to isolate small discrepancies will be done.

2.9 Project Tracking Procedures

Our client presented us with a tentative schedule at the beginning of the semester. In our first meeting with the client we refined the tentative schedule and have been keeping up with it since. To keep track of progress we are discussing it in our meetings and it is recorded in our meeting notes as well as weekly reports. We intend to stick with our planned schedule and falling behind that schedule in any area will result in discussion about how to catch back up.

2.10 Task Approach

The proposed design is to use door sensors attached to cabinets, pantries, and refrigerators to monitor the subjects eating habits, A flowmeter attached to the sink the subject uses to drink from, and a load cell attached to toilet seats as well as possibly a flowmeter attached to the toilet pipes to monitor hygiene. These small sensors will be attached to small raspberry pi 0ws which will collect the data from the sensors. The data will be sent over wifi to a raspberry pi 3 which will function as in home hub for one subject's data. The data will be sent from the in-home hub to an Azure cloud server, where analytics will be performed using Azure analytics services, and the analyzed data for a user's loved one will be available to the user on a Xamarin powered mobile app.

We chose to use passive sensors as our method of collecting data because other methods were to invasive and compromised the subjects privacy. The sensor's that we chose will be able to collect data that will be helpful in discovering health risk factors without being too invasive. We spent the first several weeks of the project researching sensors, and another few weeks will be spent testing the sensors and getting them calibrated. A major weakness of this approach is that we will not be able to collect some important health information that would be helpful in identifying health risks such as the current heart rate.

We chose to use raspberry pi's in this prototype because they were the easiest and cheapest option for small local controllers and servers. Part of testing the sensors will involve getting the raspberry pi 0ws hooked up to the sensors and receiving data from them. An important weakness of this approach is that the product won't look as nice as if we used an embedded

system for this functionality. This is unavoidable because designing an embedded system would be too costly and difficult for this project.

Azure was chosen as our cloud server because it gives us access to a lot of useful services. Additionally, some of the other frameworks work well with the Microsoft ecosystem including Xamarin and our IDE of choice Visual Studio. One weakness of this approach is that many of us had never used Visual Studio before and Azure was new to all of us.

Our team chose to use Xamarin development software because we were impressed by its ability to use mostly shared code for the development of IOS, Android, and windows apps. Initially we want to focus on making an android app, but in the future it will make expansion easier. A clear weakness of Xamarin is that it can make IOS apps but only from a mac computer.

We chose to use a mobile app to display the data to user's because it is more convenient to use at any time and receive notifications.
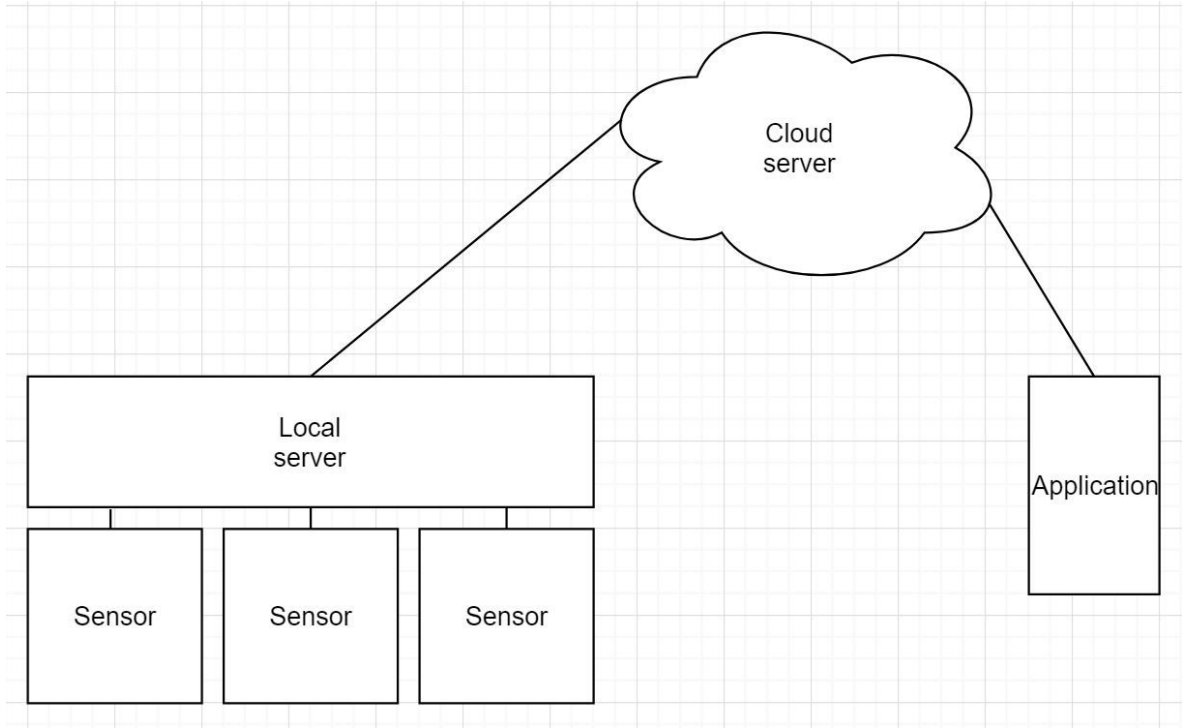

Figure 1

2.11 Standards

We will be building a simulated testing environment for each of the sensors described further in section 2.8. Initial testing of the sensors this environment poses no ethical dilemmas. However, our client has discussed testing our product in an assisted living home on residents for an extended period of time.

One ethical concern with our project is that collecting this health data will be a gateway into other forms of monitoring. Our sensors are only capable of collecting data on what they are currently designed to, so there is not a possibility of sensors becoming more invasive as time goes on. As the company grows and expands it is likely that there will be more sensors added to the platform to monitor more things, but tenants or their caretaker will always have the option to opt out of sensors that they are uncomfortable with.

Another ethical concern is that the sensors are an invasion of the tenants privacy, but our team argues that the sensors actually give the tenants more privacy. People in assisted living homes have more personal freedom and are granted considerably more privacy than those in retirement homes. Our solution allows tenants in assisted living homes to prove to their family that they are staying healthy and capable of living on their own. In many cases the alternative that these tenants would have is to go into a retirement home which, as mentioned above, is much more invasive and restrictive.

2.12 Testing

Our simulated test environment will be structured as follows:

Door sensors:
Attach two sensors to cabinets to insure they can function in parallel. Success includes not disrupting the use of the cabinet and sensor collecting accurate data for each sensor independently. The door sensor will be left installed and then data will be collected over the course of a day.

Load Cell:
Initial testing will involve putting objects of various sizes and weights on top of the cell (between 5-50lbs) and checking that the weight data is correct. After we have determined that the load cell is accurate and can handle the preliminary weight without fault we will test with human subjects.
The load cell will be put under or within a toilet seat, then a test subject (various team members) will sit on the toilet seat. For success the load cell must collect accurate data and allow the toilet seat to lie flat.

Flow Meter:

Construct an apparatus consisting of a bucket and a valve attached to a flow meter with an additional bucket to collect the water. First check that the sensor picks up the time that the water is going through. Next check that the amount of water can be collected accurately. Let water flow through at different rates and see if the metrics received in various combinations are accurate.
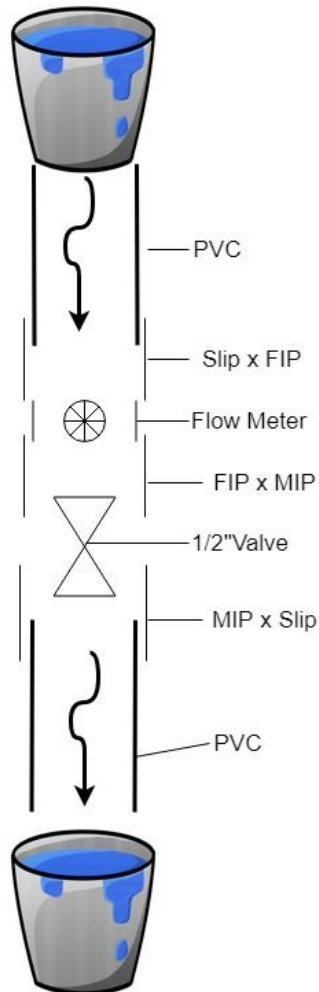
Figure 2. Flowmeter testing apparatus

Application:

       Ensure that the application can display the data stored in the database.

3 Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline

High level timeline:

January	February	March	April
-Brainstorm various sensor use cases -Determine what data will be useful to health monitoring -Generate and justify list of sensors to collect data	-Work on hardware and software flowcharts -Research cloud/ local server solutions -Brainstorm ways to bypass selected sensors -Begin work on data visualization solution	-Present and finalize sensors and use cases -Design and build tests for sensors -Implement interface between sensors and storage -Work on storage system (cloud and local)	-Refine storage solution -Begin collecting test data -Finish MVP of app prototype -Prep for in depth testing over the summer (done by Client)

September	October	November	December
-Will be determined at the end of August	-Will be determined at the end of August	-Will be determined at the end of August	-Will be determined at the end of August

Detailed timeline:
*See Section 4.3 for Gantt Chart

For the second semester we will begin implementing analytics to find health risk factors in the collected data. This analysis will then become the focus of the mobile app. We may also begin using additional sensors to collect a wider range of data, for example sleep is an important factor for health but we will not be using a sleep sensor in the first semester.

Deliverables:

1. Server
    1.1. Research into upscalable cloud platforms capable of storing and performing data analysis
    1.2. Implementation of a cloud server based on research
2. Data collection
    2.1. Research into passive, non-invasive sensors to monitor sleep, eating/drinking, and bathroom habits
    2.2. Create a simulated testing environment to demonstrate data collection functionality
    2.3. Research into and implementation of a data transmission solution
    2.4. Establish a local server to handle communication with the sensors and the cloud platform for scalability and simplicity.
        2.4.1. The local server solution is a tentative plan. Further work and research may deem it necessary to use something else as a relay between the sensors and the cloud server.
3. App
    3.1. Research data visualization techniques and libraries
        3.1.1. Initially, a simple textual display of available data will be implemented.
        3.1.2. Time permitting, more research into graphical visualization of usage history will be performed. An implementation will be provided, should research prove sufficient.
    3.2. Provide a prototype implementation of data visualization based on research

3.2 Personnel Effort Requirements

Task	Amount of Personal Effort
Compile and Finalize List of Sensors	High
Hardware Flowchart	low
Project Plan	low
Design Document	low
Design and Implement Sensor Testing	High
Implement Data Storage System	Moderate
Implement Data Visualization	Moderate

The three tasks that will take the least amount of effort are the hardware flowchart, project plan, and design document, but this is not to understate the importance of these documents in the least. These are tasks that we have been directly or indirectly working on since the beginning of the project as we have been meeting as a team, with our client, or with our advisor. Once the content is discussed as a team we each completed each of our assigned parts of the Project plan with relative ease. The same will go for the hardware flowchart and the design document, although these we be created together as a team to an even greater degree.

Implementing a data storage system and implementing data visualization will require a moderate amount of effort. While these are serious roles for the project they will take a smaller amount of effort than other tasks because there are pre-existing systems for both areas that we can learn from and model our designs after.

Finally, compiling and finalizing sensor list and designing and implementing useful sensor tests will most likely be our greatest challenges. The reason for this is because these are new areas that we will be able to find little to no information for our specific project. We may have to go through several rounds of debate and reasoning to come up with the best solutions that we are able to implement for these tasks.

3.3 Other Resource Requirements

There are several things that we will need to acquire to implement our project and the first are the sensors. This is the heart of our project and because of that it is the first thing on our agenda. This sensor list will be scrutinized over and over again that the sensors being bought are in fact the best sensors that we will be able to afford for our application.

Another important resource we will need is a raspberry pi. As it stands now the raspberry pi will be our device that will have our data from the sensors funneled into. This will be our point in between the sensors and our storage device.

Lastly, we will need to have testing environments for our sensors. There will be two different directions that testing can go. 1.) We attached sensors to existing infrastructure that would be identical or similar enough to our use cases that we could accurately test the sensors. 2.) We create our own test environment for our sensors(e.g. Have water flow through a pipe that a flow meter could then measure).

3.4 Financial Requirements

Resource	Cost
Sensors	Displayed in table below
Cloud server subscription	Initially free
Building materials for simulation environment	Unknown

Sensor Type	Part/Model Number	Quantity	Price per Unit
Flowmeter	YF-S201	2	$8.20
Load Cell	SEN-10245	4	$9.95
Load Cell Combinator	BOB-13878	1	$1.95
Load Cell Amp	SEN-13879	1	$9.95
Door Sensor	375	2	$3.95
BCG	SCA-11H	1	$154
Pi's			
Type	Part/Model Number	Quantity	Price per Unit
Pi 3	RASPBERRYPI3-MODB-1GB	1	$35.64
Pi Zero W	Product ID: 3708	2	$14.00
Misc.			
Item	Part/Model Number	Quantity	Price per Unit
SD Card	x2 16gb /SDSDB2-016G-AFFP	2	$12.99
SD Card	8gb/ SDSDUN-008G-G46	3	$5.99
Power Supply	Product ID: 1995	3	$7.50

4 Closure Materials

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 consists of non-invasive sensors passively collecting health habit data and sending it to a cloud server. The data stored on the cloud server is analyzed to find health risk factors and the data as well as risk notifications will be displayed to users on a mobile app. 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

Context-Aware Wireless Sensor Networks for Assisted Living and Residential Monitoring - IEEE

Journals & Magazine, ieeexplore.ieee.org/document/4579768/?reload=true.

Torres, Roberto L. Shinmoto, et al. "A Battery-Less and Wireless Wearable Sensor System for

Identifying Bed and Chair Exits in a Pilot Trial in Hospitalized Older People." *PLOS ONE*,

Public Library of Science,

journals.plos.org/plosone/article?id=10.1371/journal.pone.0185670.

4.3 Appendices

Gantt Chart

SE 491 Schedule

Highlighted period is the current phase in development

| | Period Highlight: | 41 | Plan Duration | Actual Start | % Complete | Actual (beyond plan) | % Complete (beyond plan |

Sprints are 2 weeks — Sprint 1: 01/29 — Sprint 2: 02/12 — Sprint 3: 02/26 — Sprint 4: 03/12 — Sprint 5: 03/26 — Sprint 6: 04/09

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Set up Communication	15	4	15	3	100%
Formulate and Sign Deliverables	15	10	15	11	100%
Come up with Sensor Use Cases	15	20	15	15	100%
Brainstorm Sensor Edge Cases	20	13	22	10	80%
Harware/Software Flowcharts	26	8	26	8	10%
Sensor list w/ documentation	17	20	17	20	60%
Research Cloud/ Database Solutions	30	7	28	9	100%
Design Tests for Sensors	41	5	37	4	95%
Implement Interface: Sensors & Storage	37	15	37	13	20%
Implement Stoarage System	34	15	36	15	30%
Collect Data from Testing	52	9			0%
Document Work Throughout Project	15	46	15	46	25%

PERIODS: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

Services to
be added for
Fall 2018

Analytics makes use of
Machine Learning to identify
Anomalies in behavior

Stream Analytics

Services in
use at Spring
2018 delivery

Machine Learning
Studio

Data continually fed from
DB to analytics module

Generates diagrams (TBD) based
on the data/trend analysis

Creates and dispatches notifications
when an Anomaly occurs

Notification Hub

HDInsight
(VIsualization)
(Spark)

Cosmos DB
(Database for data
storage)

Sends notification to a user

Pull data to view
on mobile application

Provides visualization of
behavior trends to the app

Information
Protection
(Ensures security for
all components)

App Service

Azure Cloud Service

Data collected from sensors
is stored into the Cosmos Database

Mobile Application

Hardware/Local Server