EDSGN100 Design
Project #2
Final Design
Report

VitalWatch

Introduction to Engineering Design
EDGSN 100
Section 004

The Think Tank
Tom Devenney, twd5204@psu.edu
Riley Gaibler, rsg5177@psu.edu
Ryan Cwik, ric5185@psu.edu
Creed Reilly, cwr5313@psu.edu

Submitted to:
Professor Thomas H. Colledge, Ph.D.
Date:
05/02/2014

Executive Summary

AT&T challenged this semester's class with creating a device that could better human life through machine to machine communication. The Think Tank recognized the opportunity to benefit the lives of others by creating a safer environment. We conducted research, and performed customer needs surveys in order to define our specifications. Using these results, thorough brainstorming and evaluations were conducted. It was decided the best way to accomplish this was to create a wearable device that could accurately measure and monitor vital signs. If the wearer were to suffer from a medical emergency, the device would recognize the emergency, search for potential causes, and relay its findings to emergency services. Emergency services would then respond to aid the user. This modular system can be updated to keep up with future demand, and the team is extremely pleased with its feasibility and the future of this product.

Table of Contents

Topic	Page Number
1.0 Introduction	3
2.0 Project Background	4
3.0 Project Objectives	6
4.0 Conceptual Designs	8
4.1 Descriptions	8
4.2 Research and Analysis	8
4.3 Concept Review and Selection	9
5.0 Detailed Design	11
6.0 Conclusions	13
7.0 References	14
Appendix A	15
Appendix B	16
Appendix C	18
Appendix D	19

1.0 Introduction

Ever since the creation of cellular communication technology by Siemens in 1995, machine to machine communication has played a critical role in society. Ideas such as wireless fidelity, or Wi-Fi, and Bluetooth allow for easy communication between devices, such as laptops and cell phones, thus creating a more connected space. In recent years, innovators have chosen to push the envelope further. Building on the "Internet of Things", which represents the passive interconnected network of all things through technology, very few people have connected all aspects of their home, creating an 'integrated nest' purposed to make one as comfortable as possible. The potential of this integrated space was recognized, and this project will attempt to take it one step further. Along with providing comfort to the user, an integrated space could also provide safety. Products such as Life Alert and special monitoring devices for people with pre-existing conditions provide an increased level of safety and peace of mind in the home, but these devices fail to both integrate with other parts of the home and provide passive monitoring and constant protection. This team, after learning of the project objective provided by AT&T, saw the opportunity to create a safer space for all people by developing a system that could recognize indicators of potentially disastrous conditions and report its findings to local emergency services.

The following Gantt chart outlines the timeline of our work distribution for the entirety of this project.

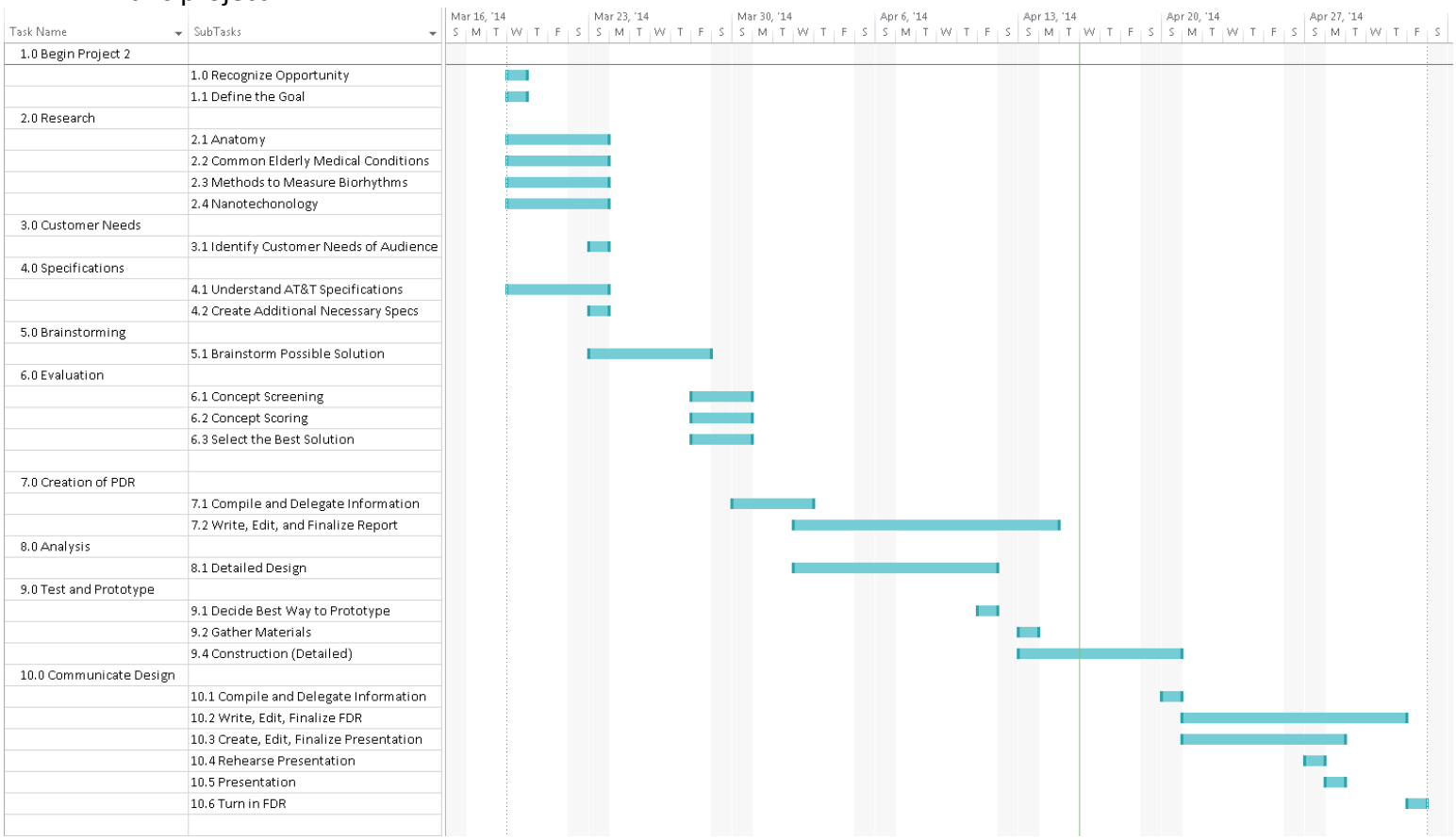

Figure 1: Gantt Chart

2.0 Project Background

The rapid growth of the elderly population becomes ever more apparent as nursing homes seem to be sprouting up from the ground. Nursing homes restrict the freedoms that elderly people would normally have living on their own. For worrying families, a fair tradeoff is hiring a nurse to be around the house or using a service, such as Life Alert or Med Alert, which could notify services in case of an emergency. Hiring a nurse can be extremely expensive and Life Alert or Med Alert will not necessarily help in the event of an elderly person becoming incapacitated. This project recognized the opportunity to incorporate an autonomous sensor that could measure important biological markers and the capacity to communicate with a central hub to notify proper health services of specific symptoms and changes in health markers in a wearable device.

Because this project is associated with monitoring the elderly from afar for safety reasons, Life Alert seems to be the most closely related commercial product to this idea. Life Alert uses a necklace or wristwatch connected through Bluetooth communication to a central Life Alert hub which is connected to a landline. If the button is pushed and no response is rendered, Life Alert sends an ambulance from the nearest hospital to make sure the customer is safe. Life Alert's wristwatch or necklace has a button that sends a Bluetooth pulse to the hub when pressed. The central hub has a very sensitive microphone capable of picking up sounds from throughout the house. The central hub uses the landline to communicate with the Life Alert panel. This panel communicates in the exact opposite direction using the same connections in the reverse order.

To make this process more efficient, the concept of the "Internet of Things" can be applied to this communication process. The Internet of Things has four major qualifications: unique addressability, wireless communication, sensors, and controls. Unique addressability refers to how each device can be identified universally using a code. Wireless communication is the communication of the internet with another device using a wireless signal to connect them. Sensors act as the quality control of the device. They check the performance of the device regularly. Controls refer to how the device can have functions altered autonomously or from afar after the sensors alert someone with the ability to change the functions.

Since the Internet of Things is incorporated in our device, it is necessary to determine which qualifications the device could fulfill and which ones the device could not. Control is the only qualification that cannot be fulfilled because this device is not designed to alter anything, but rather just monitor. Unique addressability with any wireless device is necessary in today's world. Internet Protocol, or IP an address, is the most commonly used device identification system. IP addresses work as tiny email addresses, sending packets of data from the source IP address to the destination IP address. IP version 6, the latest update to the Internet Protocol series, has $3.4*10^{38}$ available addresses, enough for everyone and their devices for the foreseeable future. IP addresses function as the "to whom" and "from whom" part of the Internet of Things dilemma.

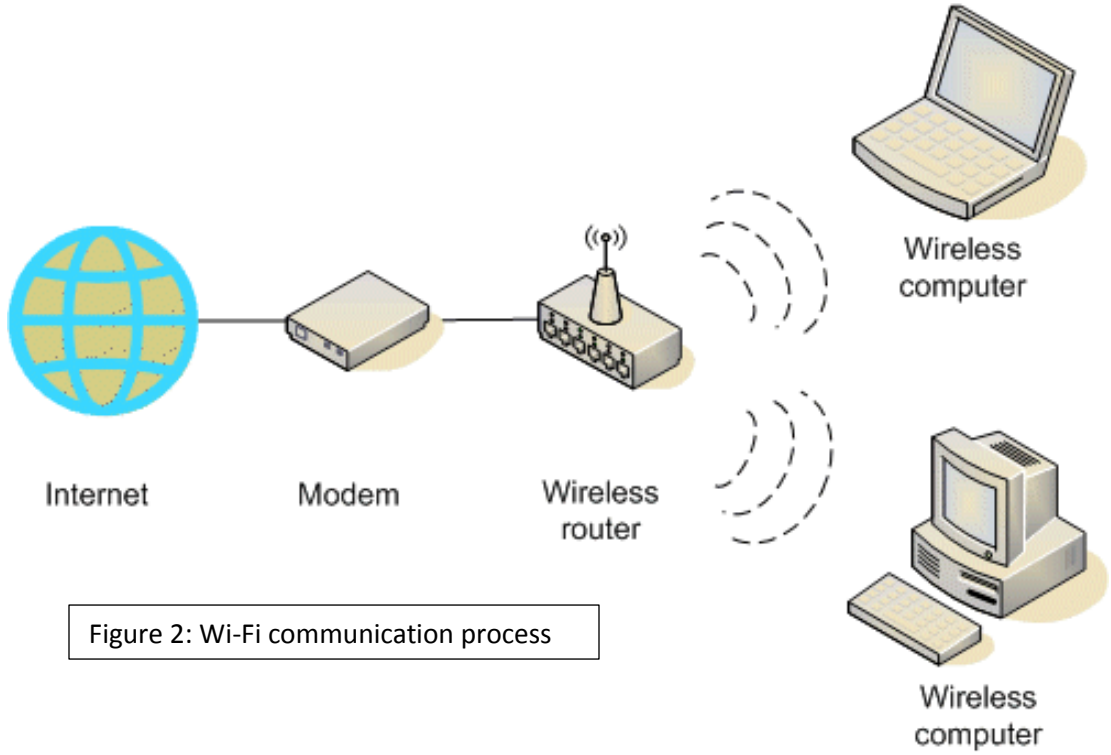

Figure 2: Wi-Fi communication process

Wireless communication functions as the “how to” part. Wireless communication is broken up into wireless internet and Bluetooth communication. Wireless internet is supplied by an internet service provider (ISP), which supplies a modem that sends and receives signals from a radio tower. These signals are sent from the radio tower to the modem, then the router. The router sets up a firewall, makes a private network, and transmits radio frequencies to devices connected to the router. Through the processes of modulation— superimposing information onto radio frequencies— and demodulation— reading information from radio frequencies, wireless communication is established (see Figure 1 above).

Figure 3: Bluetooth Interconnectivity

Bluetooth is the connection of two devices. Bluetooth devices communicate through radio waves at a frequency between 2.40 and 2.48 gigahertz (see Figure 2 above).

Sensors read information and display it in a certain format. This device calls for a sensor that measures biological markers. An electrocardiogram (ECG) can accurately measure the motion of the electrodes in response to various biological processes, such as blood pressure, heart rate, and respiratory rate. Other sensors that can do the same are a bastillocardiogram, and the combination of an accelerometer and light sensor.

With unique addressability addressing the “to whom” and “from whom,” wireless communication addressing the “how to,” and the sensors providing the “what” aspect of the Internet of Things, the efficient combination of these provides a feasible means to measure biological markers and communicate them to the necessary health services in case of an emergency.

3.0 Project Objectives

AT&T presented our Engineering Design 100 class with a challenge: to identify opportunities that leverage real-time connectivity and new and emerging technologies to collect information that can be used for products and systems that benefit our lives. The group took this statement and recognized an opportunity to help the growing elderly population live a more free and independent life. The group considered the stakeholders for this problem to be AT&T, the elderly wanting to live independently at home, the families of the elderly, and people wanting to live alone. Once the stakeholders were considered, the needs of the customer were addressed. To read the full Q&A surveys the team conducted, please see Appendix A.

Through surveys, the group defined the major customer needs (see Figure 1).

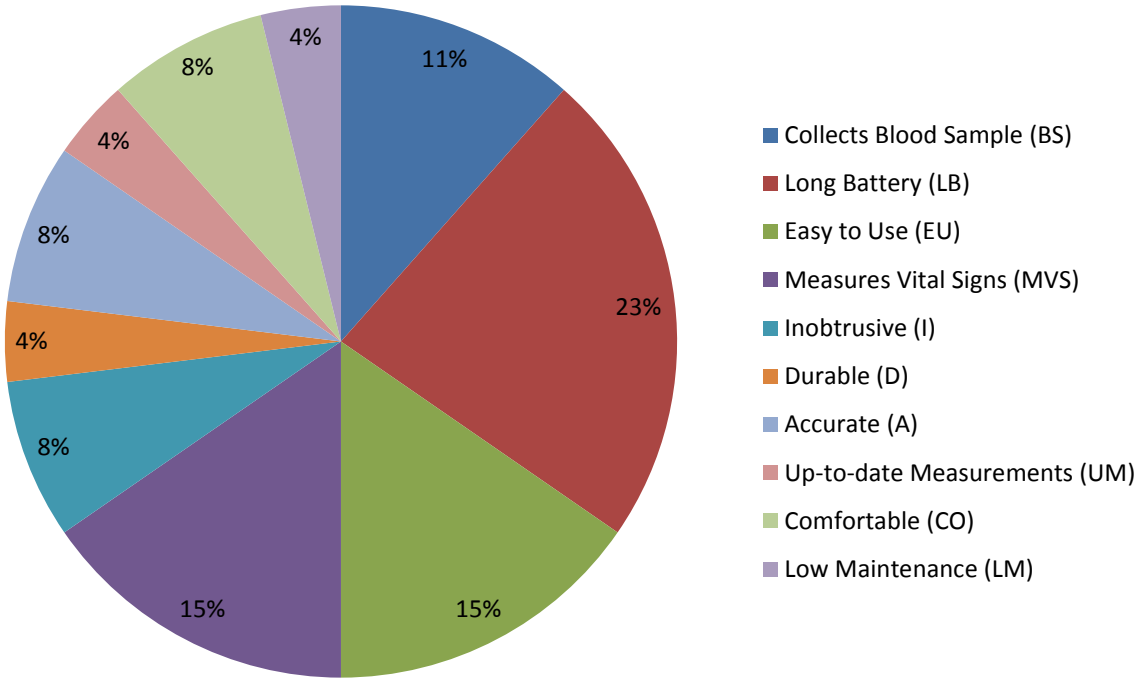

Figure 4: Customer Review Results

From the customer review surveys, the team was able to discern needs, and then convert them into technical preliminary specifications with corresponding metrics. To see how the customer needs surveys were converted to preliminary specifications, see Appendix B.

The specifications are as follows:

- Must be easy to use
    - Defined by a customer review after 6 months of use, rating the ease of use on a scale of 1-10. A score of 6 or higher is considered successful
- Must measure certain health markers on the individual
    - The health markers that must be measured are heart rate, blood pressure, and respiratory rate
- Must be able to communicate with other pieces of technology
    - Needs to be able to connect to other devices via Bluetooth capability within a 100 ft. radius of the other receiver
- Low maintenance
    - Must be able to function properly without human intervention for a minimum of 2 weeks.
- Durable
    - Must be shockproof, waterproof, and contain a battery that lasts a minimum of 6 months
- Unobtrusive
    - Must not take up more space on the body than a large wristwatch
- Accurate
    - Must give correct readings for 1 full year without error, within 5% of correct reading
- Up to date measurements
    - Measurements must refresh every 5 minutes
- Comfortable
    - Must not bother the user to wear, as defined in a customer review after 6 months of use
- Within the price range of the target audience
    - Must cost less than 2% of the government mandated fixed income to operate
- Must utilize technologies and services provided by AT&T
    - Metric defined by AT&T
- Must be able to search for possible ailments based off of symptoms.
    - Must be able to accurately predict possible causes of changes in vital signs 75% of the time.

4.0 Conceptual Designs

In the following sections, the brainstorming and evaluation process of the team is documented, starting from the open brainstorming session, continuing to the consolidation and analysis process, and ending in the final decision for the continuation of our design.

4.1 Descriptions

The team started to brainstorm ideas based on the specifications. Many different ideas were created, each with the ability to help the customer live a more independent life. We were told by the customers that the device had to be unobtrusive, so the ideas brainstormed had to utilize small-scale technology.
First, the housing for our sensor had to be defined. The three main ideas that were thought of were:

1. A wristband that measures vital signs
2. A wearable patch that sits on the chest that relays health markers
3. An implant in the inner ear to accurate measure body temperature

During early evaluation, it was found that the inner ear sensor would be too obtrusive, which violated a preliminary specification, and it was promptly rejected. The team next brainstormed ideas on what these wearable devices would do. The ideas included:

1. A setup that relays health markers to local physicians, who diagnose abnormalities
2. A system that displays up to date vital signs inside the home
3. A multitasking device that measures both vital signs and displays time
4. A device that utilizes GPS so the user can easily be found
5. An apparatus that employs Bluetooth to communicate with emergency services
6. A product that uses Wi-Fi to communicate emergency services

See Appendix C for full list of brainstorming.

4.2 Research & Analysis

After the brainstorming and benchmarking, ideas were combined to create several different preliminary products. These products were synthesized while taking into consideration the objectives, customer needs, and specifications. In the end of this process, four different ideas were constructed:

1. Version I
    a. wristband
    b. waterproof
    c. measures blood pressure, heart rate, and respiratory rate
    d. has a centralized hub in the house that is connected to the internet
    e. vitals are transmitted to a panel service
    f. vital levels are displayed on the hub
    g. communicates with hub via Zigbee protocol

    h. searches online databases for possible causes of conditions
    i. runs on a battery
    j. contains a help button similar to Life Alert
2. Version II
    a. wristband
    b. waterproof
    c. measures blood pressure, heart rate, and respiratory
    d. has a centralized hub that is connected to the telephone lines
    e. communicates with hub via Bluetooth
    f. hub initiates a call to a service if there is there is a disturbance
3. Version III
    a. patch
    b. ECG around the chest
    c. solar powered
    d. daily summary display on hub
    e. connected via Wi-Fi to the control center
4. Version IV
    a. patch
    b. measures blood sugar, blood pressure, heart rate, and oxygen levels
    c. runs on a blood battery
    d. transmits information to the hub via Bluetooth
    e. hub transmits information to the panel service.

4.3 Concept Selection

Instead of evaluating designs for final implementation, the team had to instead analyze systems. These systems each consisted of multiple subsystems, or branches. These included:

1. Sensors
2. Physical Aspects (Housing)
3. Power
4. Communication with Hub
5. Hub Communication with AT&T
6. Measurements

Each subsystem will be operated with various components, and it was through thorough research that the best solution was chosen for each subsystem's success.

SENSORS

Many different sensors can be used for the purposes of this project. The sensor must be able to measure health markers at 2 different locations, the wrist and the chest, and must be accurate. The sensors that fulfill these criteria best are the electrocardiogram, the ballistocardiogram, and an accelerometer and light sensor combination. The benefits of the electrocardiogram are that it is accurate and collects electronic data, but even the smallest ECG systems are about the size of a cell phone. The ballistocardiogram is accurate when stationary, but it is much too large for our possible design, and it works through physical means (action and reaction forces). Also, the accuracy can be decreased when there is "noise", or external movement. The accelerometer and light sensor combination is, like the ballistocardiogram,

accurate when stationary, but diminishes in accuracy when it is moving. It was decided that the ECG would be the optimal sensor once we found a way around the bulkiness of the device.

ECGs use 'leads', or connectors to the skin to pick up electrical signals in the body. By putting a lead in the system, the data collected could be transmitted to a secondary device, one with the capabilities of analyzing the software and converting it into recognizable output.

HOUSING

The next part of the system the team had to optimize was the housing of the product. That is, whether the system would be contained in a patch or a wristband. The benefits of a patch would be lowered movement on the body, which would create a more accurate reading. The downside would be more discomfort and a more obtrusive design. The benefits of a watch would be less obtrusiveness, more comfort, but the downside would be more movement. The team decided a wristband would be best because it would better compress the sensor against the skin's surface and a patch would need to stick to the skin for long periods of time, which would be uncomfortable and less reliable.

POWER

Third, the team analyzed the power supply of the system. The options were a blood battery or a high power lithium battery. A blood battery is very small and runs off of the electrolytes in bodily fluids (blood) and powers a resistor indefinitely. This fulfills the long lasting battery specification, but is very obtrusive. A lithium ion watch battery can power a system for up to 10 years, but is a little bit bulkier. After consideration and reference to the customer reviews (see Appendix A), it was decided a bulkier, less obtrusive battery would be best, so the high power lithium watch battery was included in the system.

COMMUNICATION WITH THE HUB

Fourth, the team evaluated the possible ways the system would communicate with the secondary receiver, or hub. The options were Wireless Fidelity (Wi-Fi), Bluetooth, Zigbee, or Ultra Wideband. Wi-Fi has a large range, and is wireless internet communication between devices. Bluetooth is device to device communication, has a high data rate, but has a relatively short range. Zigbee is a high level communication protocol, has a large range, low power requirements, but has a relatively low data rate. Finally, Ultra Wideband has a very large data rate, but a very small range. Since our system will only be sending a single stream transmission from the sensor to the receiver without any need for an internet connection, and that the system has to have communication reception throughout the entire user's house, Zigbee was decided to be the best communication protocol between the system and the central hub.

HUB COMMUNICATION WITH AT&T

Next, the hub's means of communication with AT&T was evaluated. The same communication methods as stated before were evaluated. This time, internet access would be required for the system's processes, so Wi-Fi, the only option with internet connection, was selected to be the best form of communication with the company.

MEASUREMENTS

Finally, the team needed to decide which measurements were to be taken and why. Some possible health markers that could have been measured were heart rate, blood pressure, temperature, respiratory rate, plaque levels, cancer markers in the blood, and insulin levels. For this decision, an expert was called in to comment.

The Village at Penn State, a local nursing home, was called to best answer this question because they monitor sample populations from our intended audience. Our target age range is 65 years and above, or senior citizens. The health markers measured by this establishment are then to be the standard measurements used, as all nursing homes have to follow a standard set of

requirements in care. According to this nursing home, the markers they measure are heart rate, blood pressure, respiratory rate, and temperature.

The team decided to measure these markers listed, except temperature. The reason is that the placement of the temperature sensor (inner ear, under the tongue, rectum) would be too obtrusive for the user.

EVALUATION

After the consolidation process, five selection criteria were chosen. These were selected based on the most important specifications, as defined in Figure 3— the ones which most directly affected the success of the device. Using these criteria and the four ideas created by the consolidation process, concept screening, pairwise comparison, and concept scoring sheets were created (see Appendix D).

Concept screening compared the final ideas against the selection criteria by discerning if the idea was neutrally, positively, or negatively related to the criteria. The concept screening ruled out Version IV because it was the least aligned with the decided selection criteria. The blood battery patch would be very accurate, but it would also be too invasive, costly, and high maintenance to make a profitable and marketable device.

By once again referring to the research, customer needs, and the objectives, a pairwise comparison was made in order to determine the weight of each criterion to the overall success of the device. These weights played an integral role in the final step of evaluation, concept scoring. Concept scoring was used in order to gauge the relation between the criteria and the model more in depth. Through meticulous evaluation using this concept scoring, one idea shined brighter than all of the others. By aligning with the selection criteria the closest, **Version I** was chosen as the idea to develop more thoroughly in analysis.

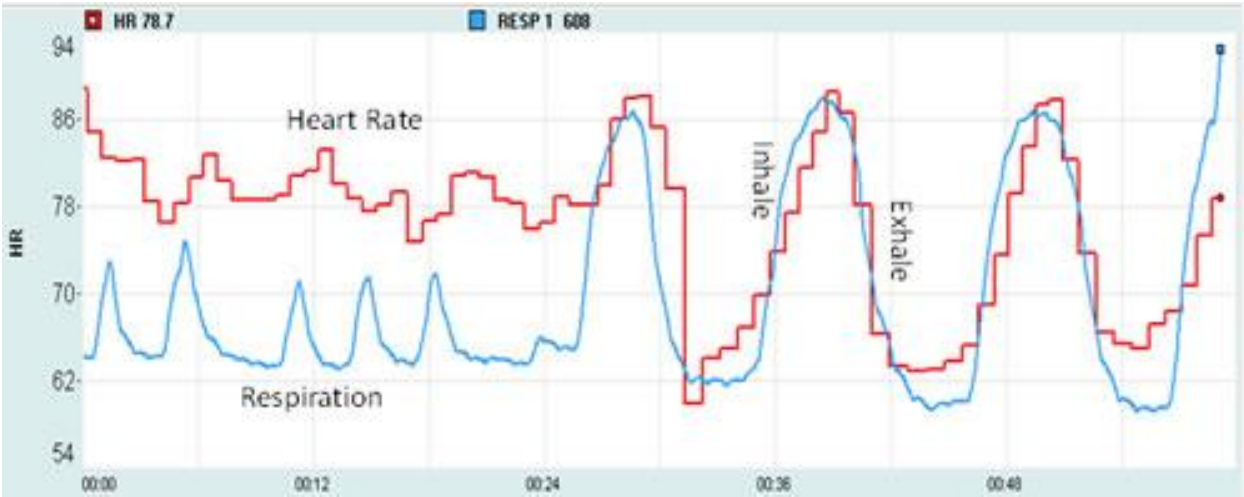

Figure 5: How respiratory rate is derived from ECG data

5.0 Detailed Design

With Version I chosen to be developed further, a detailed diagram of the system was created in order to see which components were needed for production. The VitalWatch product will operate as followed:

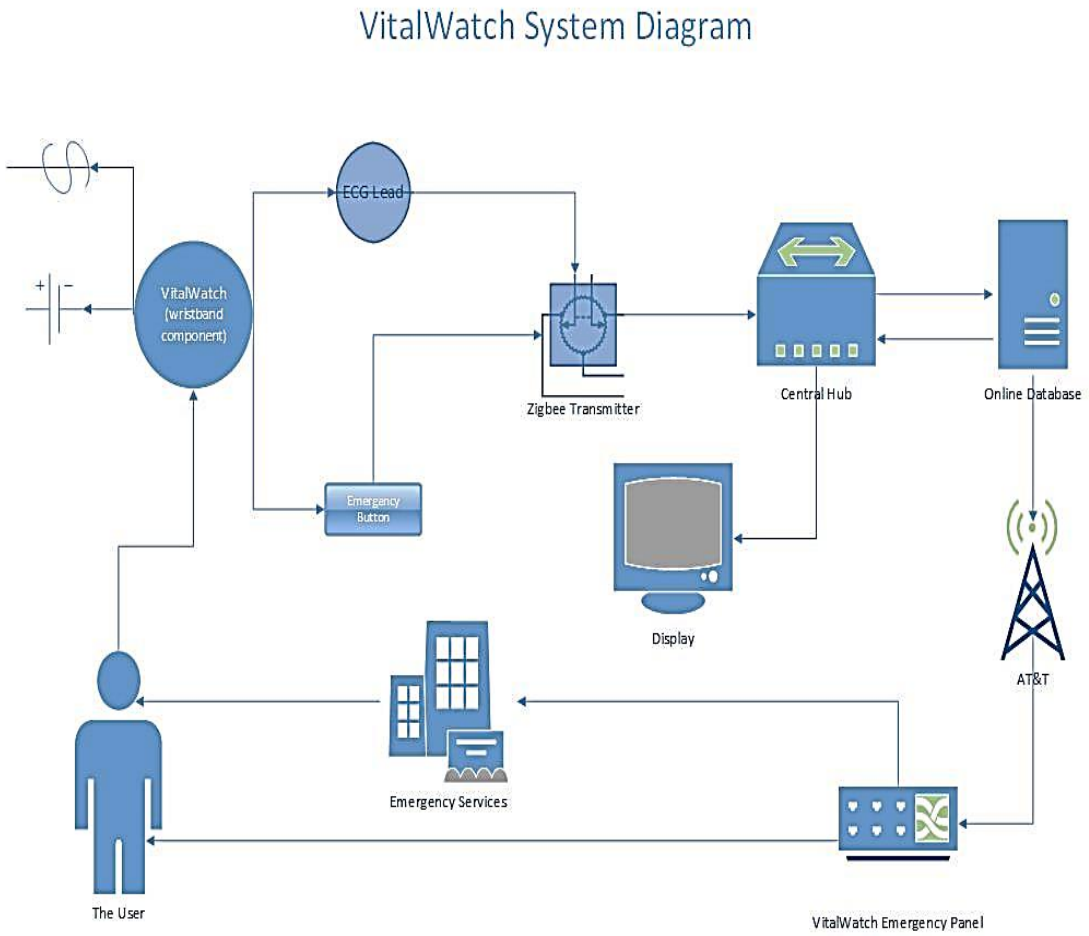

Figure 6: Detailed System Diagram

The main aspect of the system is the wristband component. Contained within this component is a battery and ECG lead, with an exterior on/off switch and emergency button. The switch allows the user to turn off the sensors when it is not in use to save power, and the emergency button allows the user to directly notify emergency services of an emergency. The ECG lead connects information from the skin's electrical signals, and it transmits raw data via Zigbee transmission. The data is then received by the central hub and analyzed by the ECG software held within. The ECG results are then simultaneously displayed on the hub's screen and run through an online database to search for possible causes of changes in the user's vital signs. If a possibly harmful condition is found, the symptoms and potential cause are sent to an emergency panel, which then alerts the user. If the user is found to be in no imminent danger, the process is discontinued. However, if the user is found to be in trouble or doesn't respond, emergency services are contacted and told the user's location, condition. The services then respond and will help the user with their specific emergency.

After the system diagram was created, final specifications were made so that the system could be created. The final specifications are as follows:

- Housing
  - Silicone Gel wristband
    - Allows for tight fit around wrist, and waterproof surrounding of the interior technology.

    - Nanocoating
        - Waterproofs ECG leads that are on contact with skin.
- Sensors
    - MidMark Custom ECG leads and software
        - One of the top rated producers of ECG software and sensors, these products will last for years to come and are tested and found to be very accurate.
- Power
    - Energizer CR1632 Button Cell Battery
        - This lithium ion battery has a battery life up to ten years, in accordance with our “Long lasting battery” specification.
        - Battery will be able to be changed by unscrewing the top face of the wristband. Band will stay waterproof using gasket technology with the removable face.
- Communication with Hub
    - Circuit Board- TinyDuino TinyShield USB and ICP modular circuit board
        - Upgradable circuit boards allow for low cost changes in the future, promoting sustainability.
    - CC2530 2.4G industrial embedded Zigbee transmitter
        - Small dimensions can easily fit in the wristband.
    - F8913 industrial wireless long range Zigbee transmitter and receiver
        - Multiple transmitters and receivers to create ‘mesh network’ in the home.
    - WZB-01USBDC-3 receiver/transmitter/Module coordinator wireless Zigbee
        -
- Hub communication with AT&T
    - 2.4 GHz 1km digital wireless Wi-Fi transmitter and receiver
        - Small volume, easy to fit inside hub console Also has a large transmission radius, so as to easily transmit information to nearby AT&T cellular towers.
- Hub Screen
    - Touchsystems Intuitive Touchscreen LCD Monitor ET1525L-8SWC-1
        - Touchscreen display lets the user read more in depth about the listed condition, as well as interact with the displayed data. Also decreases complexity by reducing buttons on the Hub.
- Hub Processor
    - single intel i5-4570
        - Keeps model current for years to come, increases sustainability.

6.0 Conclusions

This final product is a coalition of the best ideas that the Think Tank could bring together. The final solution was evaluated and analyzed in such a way that this end product satisfies the goals, objectives, and specifications formed for this project. The goal of this project was to create an unobtrusive, autonomous sensor for the senior population that continuously measures one’s biological markers, and conveys any major irregularity to services that can intervene in a potentially life-threatening situation. The watch-sized, unobtrusive system achieves the goal and efficiently meets the needs of all stakeholders by measuring the vital signs of the users

autonomously and by aiding them if a crisis is detected. When an inconsistency or spike in any of the biological markers (heart rate, blood pressure, and respiratory rate) is recognized, the system searches an online database for possible causes of the abnormality and relays this information to a panel service. This panel service then attempts to contact the user, and if no response is rendered, emergency services will be dispatched. This monitoring process will increase the independence of the elderly by keeping them safe in their own homes, and it has inspired the product to be named VitalWatch.

7.0 References

Bowers, EJ, A. Murray, and P. Langley. "Respiratory Rate Derived from Principal Component Analysis of a Single Lead Electrocardiogram." Computers in Cardiology, n.d. Web. 30 Mar. 2014. <http://cinc.mit.edu/archives/2008/pdf/0437.pdf>.

"Derivation of Respiratory Signals from Multi-lead ECGs." Derivation of Respiratory Signals from Multi-lead ECGs. N.p., n.d. Web. 25 Apr. 2014. <http://www.physionet.org/physiotools/edr/cic85/>.

"ECG." Blood Pressure : Electrocardiogram and High Blood Pressure. N.p., n.d. Web. 25 Apr. 2014. <http://www.bloodpressureuk.org/BloodPressureandyou/Medicaltests/ECG>.

""How Bluetooth Operates"" HowStuffWorks. N.p., n.d. Web. 25 Apr. 2014. <http://electronics.howstuffworks.com/bluetooth2.htm>.

"Internet Protocol." Wikipedia. Wikimedia Foundation, 25 Apr. 2014. Web. 5 Apr. 2014. <http://en.wikipedia.org/wiki/Internet_Protocol>.

"Looking for Answers about Energizer® Coin Lithium 2032 Battery?" Energizer® Coin Lithium 2032 Battery: Questions, Answers, How To, FAQs, Tips, Advice, Answers, Buying Guide. Energizer®, n.d. Web. 2 Apr. 2014. <http://answers.energizer.com/answers/3026-en_us/product/watch-electronic-coin-lithium-2032bp/energizer-energizer-coin-lithium-2032-battery-questions-answers/questions.htm?sort=recenta)>.

"Murata Introduces World's Smallest Bluetooth® Smart Wireless Module." Murata Manufacturing Co., Ltd. N.p., n.d. Web. 25 Apr. 2014. <http://www.murata.com/new/news_release/2013/0912/index.html>.

The Official Watch Station Fit Guide. Watch Station International, n.d. Web. 18 Apr. 2014. <http://www.watchstation.com/wcsstore/WatchStation/content/en_US/sizeGuides/WatchStation_SizeGuideSquare.pdf>.

"Shock (Circulatory)." Wikipedia. Wikimedia Foundation, n.d. Web. 3 Apr. 2014. <http://en.wikipedia.org/wiki/Shock_%28circulatory%29#Signs_and_symptoms>.

"Zigbee USB Interfacing Board." Campus Component. Campus Component Pvt. Ltd., 2011. Web. 12 Apr. 2014. <www.campuscomponent.com>.

APPENDIX A

CUSTOMER REVIEWS

The following people were interviewed for this product because they are included in the intended audience of this product.

Questions:

1. What is most important to you about your health? *Alt. Is there any aspect of your health that you're worried about?*

2. If you could monitor your health frequently, what markers would you measure?

3. How often do you visit the doctor?

4. How capable are you at learning new technology?

5. Would you ever wear a device that monitored certain health markers wirelessly?

6. What would you like to see in a device such as this?

Stakeholder 1: Clay Reilly, male, father of Creed Reilly, age 56. Has had previous medical conditions, health conscious. Potential future consumer.

1. Antibody levels
2. Antibody levels
3. Once every 6 months
4. Very good
5. Yes
6. Small device (wristband) that grabs sample of blood, measures lymphocyte and antibody levels.

Stakeholder 2: Village at Penn State, nursing home. Monitors sample population of intended audience. Considered experts.

1. High blood pressure, diabetes, dementia
2. Vital signs (basis for mostly everything)
3. Changes weekly
4. Pretty willing
5. Yes
6. Small and doesn't look obvious (watch)

Stakeholder 3: Kerri Wallace, female, mother of Creed Reilly, age 52. Multiple hip surgeries, previous cancers, health conscious. Potential future consumer.

1. Fitness level…
2. Blood pressure, weight, cancer screening
3. As needed
4. Iffy- Decent

5. Yes
6. Customize look, user friendly, not a lot of effort

Stakeholder 4: Mark Hulswit, male, age 47. Avid cyclist, health conscious, potential future customer.

1. Weight, possibility of cancer
2. Blood pressure, heart rate
3. Less than once a year
4. Very good
5. Yes
6. Wristband, out of the way, calorie count, step counter, e-mail user results at end of day

Stakeholder 5: Sally Wallace, female, age 74. Current potential consumer.

1. Overall health
2. Blood Pressure
3. Every 6 months, if not sooner
4. For age 74, "I think I'm pretty damn good"
5. No- doesn't embrace change until urgency makes us
6. N/A

Stakeholder 6: Angus Wallace, male, age 71. Current potential consumer.

1. Overall health, lack of mobility
2. Blood Pressure, cholesterol & plaque levels
3. Every 6 months
4. Not very good, doesn't have the capacity
5. No- doesn't embrace change until urgency makes us
6. N/A

APPENDIX B

	Specification 1	Specification 2	Final Specifications			
Clay Reilly			Collects Blood Sample (BS)			
1	BS	A	Long Battery (LB)			
2			Easy to Use (EU)			
3	LB		Measures Vital Signs (MVS)			
4			Inobtrusive (I)			
5			Durable (D)			
6	I		Accurate (A)			
Village at Penn State			Up-to-date Measurements (UM)			
1	BS		Comfortable (CO)			
2	UM	MVS	Low Maintenance (LM)			
3	LB					
4						
5						
6	I					
Kerri Wallace						
1	D					
2						
3	LB					
4	EU					
5						
6	LM	EU				
Mark Hulswit						
1	A					
2	MVS					
3	LB					
4						
5						
6	CO					
Sally Wallace						
1						
2	MVS					
3	LB					
4	EU					
5						
6						
Angus Wallace						
1						
2	MVS	BS				
3	LB					
4	EU					
5						
6	CO					

APPENDIX C

BRAINSTORMING

1. Wristband that measures vital signs
2. Benchmark- Life Alert
3. Benchmark-http://www.technologyreview.com/news/524376/this-fitness-wristband-wants-to-play-doctor/
4. Device that relays health markers to local physicians, who determine if abnormalities need to be looked into
5. System that displays up to date vital signs inside the home
6. Adapting/Transient period, where "average" health markers are determined, to better and more accurately detect abnormalities in the future (1 week?)
7. Wearable device that utilize alternative energy use (solar power, thermal)
8. Multi-tasking device that measures both vital signs and displays time (doubles as watch)
9. Wristband that utilizes Bluetooth to communicate with emergency services, in case of an emergency
10. Wristband that utilizes GPS, so that if in danger, emergency services can pinpoint the user's location quickly.
11. Wristband that utilizes Bluetooth to communicate vital signs to central "hub" in the house, which then relays information to emergency services if necessary.
12. Device that transmits health markers to panel service (such as OnStar), who monitor individual for any abnormalities.
13. Waterproof and shock absorbent
14. 10 year lithium battery (benchmark, http://answers.energizer.com/answers/3026-en_us/product/watch-electronic-coin-lithium-2032bp/energizer-energizer-coin-lithium-2032-battery-questions-answers/questions.htm?sort=recenta)
15. daily summary on hub
16. Wearable patch that relays health markers.
17. Using bio-batteries to power the wearable device.
18. Implant in the inner ear to accurate measure body temperature, and then relay temperature to display.
19. Put nanobots in a pill, and let the elderly ingest the robots. The bots will then record vital activity in the body, and transmit readings to a central display.
20. ECG (Electrocardiogram) patch over the chest that measures very accurate pulse, changes in blood pressure, and respiratory rate

http://www.bloodpressureuk.org/BloodPressureandyou/Medicaltests/ECG - blood pressure
http://www.physionet.org/physiotools/edr/cic85/ - derivation of respiratory rate
http://cinc.mit.edu/archives/2008/pdf/0437.pdf- derivation of respiratory rate

22. Battery hookup to thermal cell- proven to be inefficient at average skin temperature

http://hypertextbook.com/facts/2001/AbantyFarzana.shtm

23. Watch battery with hookup to solar cell, so that the device is charged during the day, and the stored energy is used during the night.

APPENDIX D

CONCEPT SCREENING

	Concept Variant				
Selection Criteria	I	II	III	IV	Reference
Ease of Use	+	+	0	0	0
Accurate	0	0	+	+	0
Inubrusive	-	-	0	-	0
Cost	0	+	0	-	0
Low Maintance	0	+	-	-	0
Easy Communication	+	-	0	0	0
Pluses	2	3	1	1	0
Neutral	3	1	4	2	0
Minuses	**1**	**2**	**1**	**3**	**0**
Net	1	1	0	-2	0
Rank	1	1	2	3	
Continue	Yes	Yes	Yes	No	

PAIRWISE COMPARISON

	Ease of Use	**Accurate**	**Inubrusive**	**Cost**	**Low Maintance**	**Easy Communication**	**Row Totals**	**Row Total/ Total**	**Percentage**	
Ease of Use	1	1/5	2	1/6	1	1/8	4.491666667	0.060883316	6.09%	
Accurate	5	1	1/6	1/5	6	1/3	12.7	0.172145036	17.21%	
Inubrusive	1/2	6	1	1/4	1/3	1/6	8 1/4	0.111826499	11.18%	
Cost	6	5	4	1	1/3	1/2	16.83333333	0.228171241	22.82%	
Low Maintance	1	1/6	3	3	1	3	11.16666667	0.151361121	15.14%	
Easy Communication	8	3	6	2	1/3	1	20.33333333	0.275612787	27.56%	
						Totals	**73.775**			

CONCEPT SCORING

		Concepts							
		I		II		III			
Selection Criteria	***Weight***	***Rating***	***Weighted Score***	***Rating***	***Weighted Score***	***Rating***	***Weighted Score***		
Ease of Use	0.0609	5	0.3045	5	0.3045	3	0.1827		
Accurate	0.1721	3	0.1827	3	0.1827	4	0.2436		
Inubrusive	0.1118	2	0.1218	2	0.1218	2	0.1218		
Cost	0.2282	4	0.2436	4	0.2436	3	0.1827		
Low Maintance	0.1514	3	0.1827	3	0.1827	2	0.1218		
Easy Communication	0.2756	5	0.3045	3	0.1827	4	0.2436		
Total Score		1.3398		1.218		1.0962			
Rank		1		2		3			
Continue?		Develop		No		No			