University of Nevada, Reno

MailSnap: Upgrade Your Mailbox

A thesis submitted in partial fulfillment
of the requirements for the degree of

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

by

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MailSnap: Upgrade Your Mailbox

Zach Hadsell (CEO)
Anita Savell (VP)
Addison Bogardus (CTO)
Renjith Moolakatt (CFO)
Andrew Patti (CSO)

Abstract

With their product MailSnap, SimpliSecure aims to increase security and convenience of users' mailing experience. Ambient light sensing is used to determine if the mailbox door has been opened or closed and if new mail has been added. After each time mail has been added to a user's home mailbox, a flash photo is taken of the mail and the photo is sent to the user. The false back in which all hardware is contained helps secure the user's device and conceal the MailSnap service.

By sending the user a photo of their mail, they will be able to determine both if they need to go to their mailbox and if a piece of mail has been taken. Future development of an access log will allow users to identify if unauthorized access of their mailbox has occurred, enabling them to make more informed choices about when to pick up their mail.

Acknowledgements

SimpliSecure would like to thank Dr. Shen and Tony Piazza for their guidance during the design process as well as the Nevada Small Business Development Center for their guidance in making financial projections.

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1. Executive Summary

SimpliSecure introduces its flagship product, MailSnap, at an opportune time for customers. With the wide spread use of smartphones and other "smart devices," Internet connectivity and product integration is at an all-time high. The next trend in the realm of interconnectivity is the aptly named "Internet of Things," which simply refers to small, embedded devices that will allow users to automate systems and receive immediate notifications using the Internet.

MailSnap wants to take the centuries old "snail mail" experience and launch it into the 21st century using ambient light sensors, a microcontroller, and Wi-Fi connectivity. The MailSnap product is a streamlined, self-contained package which can be discreetly placed at the back of a standard USPS mailbox. Once inside the mailbox, MailSnap will monitor the mailbox continuously and detect when the mailbox door has been opened and closed. If mail has been added, the system will take a picture of the contents of the mailbox and send the photo to the owner of the mailbox via email in less than two minutes.

Not only does MailSnap ride the current wave of Internet of Things products, it also comes at a time when mail theft is on the rise. MailSnap can help to deter mail theft by promptly notifying its customer of exactly when their mail arrives ("Identity Theft"). Thus, the customer has the information needed to pick up their mail more promptly, reducing the window of opportunity that a thief can steal their mail.

2. Company Overview

SimpliSecure, founded in January 2017, is a new LLC located in Reno, Nevada, which is becoming a hub for new industry, especially engineering. Reno is an ideal startup location as it features low traffic, low population density, and exciting outdoor attractions

such as Lake Tahoe all with the resources of Silicon Valley just a short drive away. SimpliSecure is competitively positioned to enter the home automation market. SimpliSecure employees are known for their strong work ethic and innovative ideas and they are ready to enter industry.

MailSnap is an innovative solution to drawbacks of mail delivery. E-Commerce has transformed the lives of American consumers as many shoppers now conduct much of their shopping online and have their purchases shipped to their homes and businesses. Major shipping companies such as FedEx, UPS, and USPS offer tracking services to their customers. However, these tracking services can be unreliable and expensive and do not reliably provide immediate notification of delivery. MailSnap fills the gaps in these services by sending the user a personal notification every time mail has been added to the mailbox. MailSnap will give users peace of mind in knowing exactly when their packages and letters arrive.

MailSnap has a significant competitive advantage over similar products in the market due to its self-contained, false back configuration that is easily placed inside a standard mailbox. The false back design keeps the MailSnap presence unobtrusive and secure. Current mailbox monitoring products on the market are easily seen and accessible, making them an easy target for thieves.

3. Products or Services

3.1. MailSnap

SimpliSecure has created MailSnap to increase the convenience of consumer's mailbox experience. MailSnap is a mail delivery notification system that will notify users via an email and attached photo when mail has been added to their home mailbox outside

their residence. MailSnap has completed the prototyping phase. A series of tests have been conducted to verify that the product meets SimpliSecure's standards of performance excellence including speed of photo sending and low power consumption. The novel combination of MailSnap's features makes SimpliSecure's product patentable.

MailSnap has several competitive advantages in the field. First, other products are plainly visible. This fact means the user would have to see the clunky product every single time they open their mailbox. Further, being so easily seen would leave the product itself vulnerable to theft. MailSnap avoids these problems by containing all hardware in an aesthetically pleasing false back. A second advantage MailSnap has over competitive products is Wi-Fi connectivity. While other products may send an auditory notification to the user's home much like a doorbell, the product will only be effective if the user is home (SmartHome). If the user is not home, they will not be notified of their mail, thus defeating the purpose of the system. No matter where the user is, MailSnap's email notification system will alert the user of their mail delivery with a photo of their actual mail. A third advantage is that MailSnap is designed to be added to the user's existing mailbox. Many other products require alteration to an existing mailbox or the installation of an entirely new mailbox which may present a huge inconvenience and cost to potential consumers. The simple upgrade of MailSnap will allow users who are part of strict homeowner's associations or apartments (i.e. people who cannot replace or alter their existing mailbox) to benefit from a mail notification system.

MailSnap will be manufactured for $20, and sold to the consumer for $79.99. The $80 price-point is the ideal price for the product based on current conditions, but the cost

may be reduced depending on the amount of product manufactured and the location of manufacturing.

3.2. Future Products and Improvements

Add-ons to MailSnap will be made available to the consumer after SimpliSecure has entered the smart mail market. These add-ons will include items such as a Wi-Fi booster which will enable individuals who have a mailbox farther from their home to utilize MailSnap. Future plans also include the development of a cellphone application for Apple and Android phones which will manage MailSnap notifications. Additional features such as on demand photo requests will allow users to request a photo of their mailbox, making it easy to check if their mail has been picked up before making a trip to the mailbox. This feature will be especially useful for individuals who work long hours and rely on roommates, children, or a significant other to pick up their mail.

In the future, SimpliSecure plans to release several related home convenience products to complement MailSnap. PackageWatch will utilize the same basic features of MailSnap (home Wi-Fi connectivity, discreet packaging, and photos sent to the user), but be placed at the user's doorstep instead of in their mailbox. PackageWatch will be a motion activated photo taking system that alerts users of new packages placed at their front door. With an increase in both package delivery from online retailers such as Amazon as well as package theft, PackageWatch will give the user peace of mind that they will know exactly when their package has arrived.

4. Market and Competitive Analysis

The market for home automation will rise to a $78.8-billion-dollar industry in 2022 (Market Research Firm). The market was $32.11 billion in 2015, therefore, it is expected

to rise 12.46% every year. This increase is due to factors from growing the Internet of Things and cost reduction of electronics. SimpliSecure will competitively market MailSnap as low-cost and differentiated. MailSnap will also address the needs arising from growing trends by connecting the user's email to the camera inside the mailbox at a low cost.

MailSnap's ideal primary target market consists of people living in the United States who are 25–34-year-old homeowners who have a combined income of over $75,000 and are "tech-savvy". The number of 25-34-year-old homeowners in the United States totals about 32 million people (Summary Population and Housing Characteristics). This includes both genders of all incomes and professions since the product advertises security and convenience (Howden and Meyer). Furthermore, the market consists of technically inclined individuals that have access to smartphone technology. The target market grew up in an increasingly automated world and will be more inclined to accept an automated feature in their mailbox than older Americans (Brown). It is important to note that the members of this market consume a large volume of digital media.

MailSnap's secondary market consists of a similar demographic as the primary market, but also includes 35-64-year-olds. While some advertisement strategies will be able to target both markets effectively, SimpliSecure plans to use targeted advertisements for each market as well through home security blogs, home automation websites, and smart home conventions to advertise MailSnap. Search Engine Optimization (SEOs) strategies will also be utilized to put MailSnap information and advertisements on top pages of most frequently used search engine websites. MailSnap will have a website through which the product can be ordered instead of requiring shelf space at local home improvement stores.

With the combination of technically inclined homeowners and a rise of IoT and home automation systems, this product introduces a differentiated and low-cost solution to the need of connectivity and home security devices. The market has strong potential for the next five years, and this product will expand into a flourishing market of hyper connected customers.

5. Management Team

In order to ensure successful and efficient completion of the MailSnap prototype, SimpliSecure assigned specific responsibilities to each member of the management team.

Chief Executive Officer (CEO) Zach Hadsell

The chief executive officer is responsible for:

- the implementation of the company's long and short term plans,
- day-to-day operations such as meeting agendas

Zach Hadsell grew up in Reno, Nevada and will graduate with a BS in electrical engineering and a minor in computer science from the University of Nevada, Reno in May of 2017. Throughout his undergraduate studies, Zach has developed a strong background in computer programming, analysis and design of electrical circuits, and embedded system design. Prior to his undergraduate studies, Zach served for six years in the U.S. Air Force where he worked as a mission manager and a full-time instructor on complex systems. Throughout his military experience Zach had the opportunity to develop skills in written and verbal communication, conflict resolution, prioritizing mission objectives, and executing identified objectives in accordance with strategy.

Vice President (VP) Anita Savell

The vice president is responsible for:

- optimizing and improving the product development process
- maintaining awareness of consumer needs

Anita Savell has a history of both technical excellence and effective communication, making her a strong choice for SimpliSecure VP. A demonstration of her technical excellence, Anita was selected as the University of Nevada Reno College of Engineering's Senior Scholar for Spring 2017 as well as the Herz Gold Medal recipient, the university's oldest and most prestigious award. Further, Anita's success in grant writing, including an American Heart Association (AHA) grant ranked highest priority for funding in the western region, demonstrates her ability to clearly communicate technical details to both experts and donors. The successful execution of the AHA grant and her subsequent research has given her experience in designing meaningful experiments that help move projects forward from a technical standpoint. Anita's experience in the laboratory setting enables her to communicate effectively with others on product development to optimize the process.

As an Honors Ambassador for the University of Nevada, Reno and a peer advocate, Anita has years of experience conveying information concisely and effectively to a variety of audiences. Presentations at the University of Nevada, Reno's Best and Brightest student recruitment events to hundreds of prospective students and parents has prepared her to identify topics important to clients and address any concerns. These experiences will allow Anita to effectively monitor and improve customer satisfaction with the product.

Chief Technical Officer (CTO) Addison Bogardus

The Chief Technical Officer is responsible for:

- reviewing existing technologies
- optimizing company products through application of latest research
- finding the best balance between affordable and advanced products

Addison Bogardus has graduated with honors from the College of Southern Nevada in 2013 with an Associates of Science. He moved from Las Vegas and has continued his education at the University of Nevada, Reno and will be graduating with a BS in electrical engineering in May 2017. He has had extensive leadership experience from Culver Summer Schools and Military Academies. He has also traveled to Germany, Netherlands, France, Great Britain, and completed a student exchange program to Kanazawa University in Kanazawa, Japan. Addison has extensive knowledge of digital control theory, single board computers with real time operating systems, and passive infrared sensor arrays integrated into an embedded AVR microcontroller unit. Further, he has shown exemplary technical fortitude by completing graduate level course work as an undergraduate.

Chief Financial Officer (CFO) Renjith Moolakatt

The Chief Financial Officer is responsible for:

- strategic planning for all financial operations
- ensuring sure all the parts arrive
- ensuring the project stays within the budget

Renjith Moolakatt has worked on a multitude of projects that require a budget and has yet to go over budget on any of his projects. His most recent project involving a budget

occurred during an internship in the summer of 2016 in which he redesigned an entire solar energy system, created a new housing unit, and found a better battery technology. He completed the project with approximately $30,000 left in the budget. He is also responsible for maintaining the financial spreadsheet within his current living situation, verifying that everybody pays for their fair share of rent and utilities. Renjith is a senior in electrical engineering with an emphasis in renewable energy. He contributes his creativity, passion, and a strong work ethic to the team. He has effective communication and presentation skills that have been honed through his curriculum.

Chief of Sales and Operations (CSO) Andrew Patti

The CSO's responsibility is to:

- provides aid to the hardware and software team

Andrew Patti, the CSO for SimpliSecure, has been an undergraduate student in the University of Nevada, Reno Electrical Engineering program since 2014. He has also worked as an engineering tutor and as an intern at Sierra Nevada Corporation. In addition to his coursework, he has had extensive experience in soldering.

6. Operating Strategies

As previously described, MailSnap's market consists of technologically inclined customers. Therefore, advertising efforts will utilize websites this demographic frequently visits. There are four types of websites that will be targeted: the blogs of home security influencers, gadget websites, and social media websites, and online retailers. Home Security influencers will blog about the product. Gadget websites, such as CNET, Yahoo! Tech, and Gizmodo will also have advertisements (eBusiness).

Targeted YouTube, Amazon, and Facebook advertisements will also be utilized. These ads will consist of two messages of "convenience" and "security". The major theme of the advertisements will be "connection of the customer to their home". The goal is to target the audience of people who are interested in home automation and security will be interested in MailSnap's features.

SimpliSecure currently consists of an advertisement team and a small engineering development team. The engineering team develops new products and improves existing products. The use of a small engineering team is made possible by use of printed circuit board (PCB) hardware and software development environments. Many low-cost resources already exist to research and produce new products, so SimpliSecure can feasibly outsource manufacturing, reducing company investment in manufacturing. By reducing investment of time and capital in manufacturing, SimpliSecure can devote more employee hours to research potential markets and develop new strategies to reach customers. SimpliSecure's financial priority is to quickly develop products and market those products.

7. Critical Risks

SimpliSecure has performed a careful assessment of the potential risks and problems that could arise from marketing the MailSnap product. Critical risks are those risks that could potentially threaten the viability of the company's short and long term goals.

7.1. Product risk – low risk

The risk that the MailSnap product will not be able to be produced due to material and manufacturing shortages is low. Microprocessors and sensors are continually produced

and sold and MailSnap does not require any components that are rare or are high in demand. These availability of MailSnap parts is expected to remain high for the foreseeable future.

7.2. Market risk – moderate risk

The market risk for the MailSnap product has been deemed as moderate because the market could potentially be subject to change depending on how well the product adapts to the housing market in the United States. Currently, MailSnap is designed to fit the standard USPS mailbox, but has not yet been designed to allow for use in other types of mailboxes, such as community mailboxes that are commonly found in newer housing developments. A large proportion of homes in the United States still have a standard mailbox and the potential market is therefore in the millions. Furthermore, a simple modification to the housing of the MailSnap product will allow for simple integration into the new community style mailboxes. Another potential market risk is ensuring that the MailSnap product stays relevant in an ever-changing technological world. Since technology is constantly improving and changing, SimpliSecure intends to continually adopt the latest techniques and protocols that are related to new technologies to maintain a high level of quality and relevance to its customers.

7.3. People risk – low risk

One of the advantages of building a product that uses technology which is relatively user friendly is that a niche expert is not a requirement to ensure proper functioning of the product. All employees of SimpliSecure are professionals and experts in their respective fields, but their skills are not irreplaceable, thus potential departure of key personnel would not leave the company in jeopardy.

7.4. Financial risk – moderate risk

There are several factors driving the financial risk of the company that need to be assessed. In terms of production, the financial risk of the company is believed to be relatively low. In fact, the availability of the microprocessors and sensors that SimpliSecure intends to use is becoming ever more prominent in industry, a trend that will continue to drive down the cost of components that are used in the MailSnap product. Additionally, SimpliSecure intends to hire out production to an OEM so that marketing may be pursued almost exclusively. The cost of marketing is where most of the financial risk lies. Since the product intends to serve a niche market, MailSnap marketing campaigns and strategies may need to incorporate more expensive options to reach the potential market most effectively.

7.5. Competitive risk – moderate risk

The competitive risk is likely to be the highest risk that SimpliSecure faces as a company. With the wide availability of microprocessors and sensors, a product like the MailSnap design could be produced. To reduce the competitive risk, a utility patent should be obtained to prevent other companies from encroaching on the MailSnap market. A utility patent, also known as a patent for invention, prohibits other companies or competitors from producing and selling the patented product for a period of 20 years. In the long term, SimpliSecure intends to produce new and related products that will integrate with the use of MailSnap and create a one-stop-shop network of interconnected home improvement devices.

8. Financial Analysis

8.1. Cash Flow Statement

The first year for SimpliSecure will have the standard financial challenges startups face. To alleviate some of these expected problems, the founders of SimpliSecure have all

decided not to take any income from the business until it starts to turn a substantial profit. They will be funding themselves through other jobs to meet their personal expenses. Before the company can ask investors for money, bank loans will be the primary source of funding for the company. The first year's (Table 1) and fifth year's (Table 2) cash flow statements are shown below.

Table 1: Cash Flow Statements for the year one of SimpliSecure

	Year 0
Beginning Cash Balance	-
Cash Received	
Governors Cup Competition Prize Winnings	25,000.00
UNR Electrical & Biomedial Engineering Department Funding	600.00
Total Cash Received	25,600.00
Expenses	
Accounting	-
Business Licenses/Permits	-
Legal Fees	-
Marketing	-
Payroll	-
Prototyping	337.40
Rent	-
Web Hosting, Updates, & Maintenance	-
Total Expenses	337.40
Net Cash Flow	25,262.60
Ending Cash Balance	25,262.60

Table 2: Cash Flow Statements for the year five of SimpliSecure

Year 5 Cash Flow Statement				
Beginning Cash Balance	272,393	312,663	355,720	401,564
Cash Received				
Cash from Operations	112,000	120,000	128,000	136,000
Total Cash Received	112,000	120,000	128,000	136,000
Expenses				
Returns and Discounts	2,240	2,400	2,560	2,720
Accounting	-	-	-	-
Business Licenses/Permits	-	-	-	-
Cost of Goods Sold	28,000	30,000	32,000	34,000
Income Tax	23,890	25,543	27,196	28,850
Insurance	-	-	-	-
Legal Fees	-	-	-	-
Marketing	12,000	13,000	14,000	15,000
Miscellaneous	2,240	2,400	2,560	2,720
Payroll	-	-	-	-
Processing Fees	3,360	3,600	3,840	4,080
Rent	-	-	-	-
Utilities	-	-	-	-
Web Hosting, Updates, & Maintena	-	-	-	-
Total Expenses	71,730	76,943	82,156	87,370
Net Cash Flow	40,270	43,057	45,844	48,630
Ending Cash Balance	312,663	355,720	401,564	450,194

The production and assembly of the MailSnap product is relatively cheap, so the primary hurdle will be expanding the market and increasing awareness of the product. As such, the company will place a large portion of its funds into advertising, as reflected in the cash flow statements.

8.2. Income Statement

SimpliSecure expects that there will be a negative income for the first year as production increases and the MailSnap inventory builds up. There is also marketing that is required get MailSnap off the shelves and into the mailbox of the consumers. It is predicted that MailSnap will not earn a net profit until the seventh quarter (Table 3).

Table 3: Income Statement Sheet for SimpliSecure years 1 and 5.

Year 1 Income Statement	1	2	3	4	5	6	7	8	9	10	11	12	
	August	September	October	November	Decebmer	January	February	March	April	May	June	July	Year 1
Revenue	-	-	-	100	100	100	267	267	267	533	533	533	2,700
Returns and Discounts	-	-	-	(2)	(2)	(2)	(5)	(5)	(5)	(11)	(11)	(11)	(54)
Net Revenue	-	-	-	98	98	98	261	261	261	523	523	523	2,646
Cost of Goods Sold	-	-	-	25	25	25	67	67	67	133	133	133	675
Gross Profit	-	-	-	73	73	73	195	195	195	389	389	389	1,971
Expenses													
Accounting	-	-	-	-	-	-	-	-	-	-	-	-	-
Business Licenses/Permits	-	-	-	-	-	-	-	-	-	-	-	-	-
Depreciation & Amortization	-	-	-	-	-	-	-	-	-	-	-	-	-
Insurance	-	-	-	-	-	-	-	-	-	-	-	-	-
Legal Fees	-	-	-	-	-	-	-	-	-	-	-	-	-
Marketing	-	-	-	333	333	333	333	333	333	333	333	333	3,000
Miscellaneous	-	-	-	2	2	2	5	5	5	11	11	11	54
Payroll	-	-	-	-	-	-	-	-	-	-	-	-	-
Processing Fees	-	-	-	3	3	3	8	8	8	16	16	16	81
Rent	-	-	-	-	-	-	-	-	-	-	-	-	-
Utilities	-	-	-	-	-	-	-	-	-	-	-	-	-
Web Hosting, Updates, & Maintenance	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Expenses	-	-	-	338	338	338	347	347	347	360	360	360	3,135
Earnings Before Interest and Taxes	-	-	-	(265)	(265)	(265)	(152)	(152)	(152)	29	29	29	(1,164)
Taxes Incurred	-	-	-	-	-	-	-	-	-	-	-	-	-
Net Income	-	-	-	(265)	(265)	(265)	(152)	(152)	(152)	29	29	29	(1,164)

Year 5 Income Statement	Quarters						
	1	2	3	4	Year 5	Revenue Growth	
Revenue	112,000	120,000	128,000	136,000	496,000	35%	
Returns and Discounts	(2,240)	(2,400)	(2,560)	(2,720)	(9,920)	Returns & Discounts Rate	
Net Revenue	109,760	117,600	125,440	133,280	486,080	2%	
Cost of Goods Sold	28,000	30,000	32,000	34,000	124,000	Cost of Goods Sold	
						25%	
Gross Profit	81,760	87,600	93,440	99,280	362,080		
Expenses							
Accounting	-	-	-	-	-		
Business Licenses/Permits	-	-	-	-	-		
Depreciation & Amortization	-	-	-	-	-		
Insurance	-	-	-	-	-		
Legal Fees	-	-	-	-	-		
Marketing	12,000	13,000	14,000	15,000	54,000	Miscellaneous	
Miscellaneous	2,240	2,400	2,560	2,720	9,920	2%	
Payroll	-	-	-	-	-	Processing Fee Rate	
Processing Fees	3,360	3,600	3,840	4,080	14,880	3%	
Rent	-	-	-	-	-		
Utilities	-	-	-	-	-		
Web Hosting, Updates, & Maintenance	-	-	-	-	-		
Total Expenses	17,600	19,000	20,400	21,800	78,800		
Earnings Before Interest and Taxes	64,160	68,600	73,040	77,480	283,280		
Taxes Incurred	23,890	25,543	27,196	28,850	105,479		
Net Profit	40,270	43,057	45,844	48,630	177,801		

8.3. Balance Sheet

The current balance sheet for SimpliSecure is shown in Table 4 below.

Table 4. Balance Sheet for the SimpliSecure for the first five years

Pro Forma Balance Sheet						
Year	0	1	2	3	4	5
Assets						
Current Assets						
Total Bank Accounts	25,262.60	24,098.60	45,467.60	137,926.96	272,393.36	450,194.16
Total Acounts Receivable	-	-	-	-	-	-
Inventory	-	-	-	-	-	-
Total Current Assets	25,262.60	24,098.60	45,467.60	137,926.96	272,393.36	450,194.16
Fixed Assets						
Total Furniture & Equipment	-	-	-	-	-	-
Accumulated Depreciation	-	-	-	-	-	-
Total Fixed Assets	-	-	-	-	-	-
Other Assets						
Intangibles	-	-	-	-	-	-
Accumulated Amortization	-	-	-	-	-	-
Total Other Assets	-	-	-	-	-	-
Total Assets	25,262.60	24,098.60	45,467.60	137,926.96	272,393.36	450,194.16
Liabilities & Equity						
Total Liabilities	-	-	-	-	-	-
Owners Equity						
Common Stock	25,600.00	25,262.60	24,098.60	45,467.60	137,926.96	272,393.36
Retained Earnings	(337.40)	(1,164.00)	21,369.00	92,459.36	134,466.40	177,800.80
Total Owners Equity	25,262.60	24,098.60	45,467.60	137,926.96	272,393.36	450,194.16
Total Liabilities & Equity	25,262.60	24,098.60	45,467.60	137,926.96	272,393.36	450,194.16
Net Worth	25,262.60	24,098.60	45,467.60	137,926.96	272,393.36	450,194.16

During this prototype phase, there are no plans currently on the table for expansion into large-scale production, and all lab facilities, materials, and tools necessary for the prototype design and construction effort are provided by the department. This is reflected in the lack of any current liabilities, equity, or fixed assets. This information is subject to change and may be updated as the project progresses further.

8.4. Funds Required/Used

The initial cost of parts for the prototyping effort is $337.40. Subtracting this amount from the $600.00 of funding provided by the UNR Electrical and Biomedical Engineering Department, SimpliSecure retains a cash reserve of $262.60 after the completion of the prototyping phase (Table 5). If SimpliSecure elects to proceed with a go-to-market plan for MailSnap, additional funding will be required for production assets, marketing, distribution, and loans. However, until such a plan is implemented, the $600

fund provided by the UNR EBME department is sufficient to cover all costs to create MailSnap.

Table 5: Compilation of all inventory including quantity and cost for MailSnap

Item Number	Product	Qty.	Cost Ea.	Cost Ext.
1	**Mailbox**	1	$18.98	$18.98
2	**Raspberry Pi Zero**	1	$5.00	$5.00
3	**PIR Motion Sensor**	2	$9.95	$19.90
4	**IR Sensor**	2	$2.55	$5.10
5	**Battery Charger**	1	$41.20	$41.20
6	**Secondary Type Battery**	2	$42.40	$84.80
7	**UBEC DC/DC Step-Down Converter**	2	$9.95	$19.90
8	**Wi-Fi module**	2	$11.95	$23.90
9	**8GB micro SD card**	3	$13.66	$40.98
10	**2.4 Amp 5V Power Supply**	1	$7.50	$7.50
11	**Arduino Pro Mini**	2	$9.95	$19.90
12	**MOSFET to switch the Pi on and off**	2	$1.23	$2.46
13	**Raspberry Pi Zero Camera Cable**	1	$5.95	$5.95
14	**Raspberry Pi Zero Camera**	1	$29.95	$29.95
15	**HDMI cable**	1	$3.50	$3.50
16	**LEDs**	1	$0.48	$0.48
17	**Wires (male to male)**	1	$3.95	$3.95
18	**Wires (female to female)**	1	$3.95	$3.95
	Total (Estimated):			**$337.40**

9. Technical Overview

9.1. Prototype Overview

The MailSnap prototype is a completely autonomous system which can detect a mailbox being opened and closed, detect a change in the contents of the mailbox, take a picture of the contents of the mailbox, and send an email notification to the owner of the device via their home Wi-Fi network.

An ambient light sensor will be connected to the Arduino Pro-Mini. Once the ambient light passes a predefined threshold which indicates an addition of mail, the Pro-Mini will send a signal to a relay, which will then turn on the Raspberry Pi. This means that the sole purpose of the Arduino is to sleep until it detects the door opening and increase in mail (Figure 1).

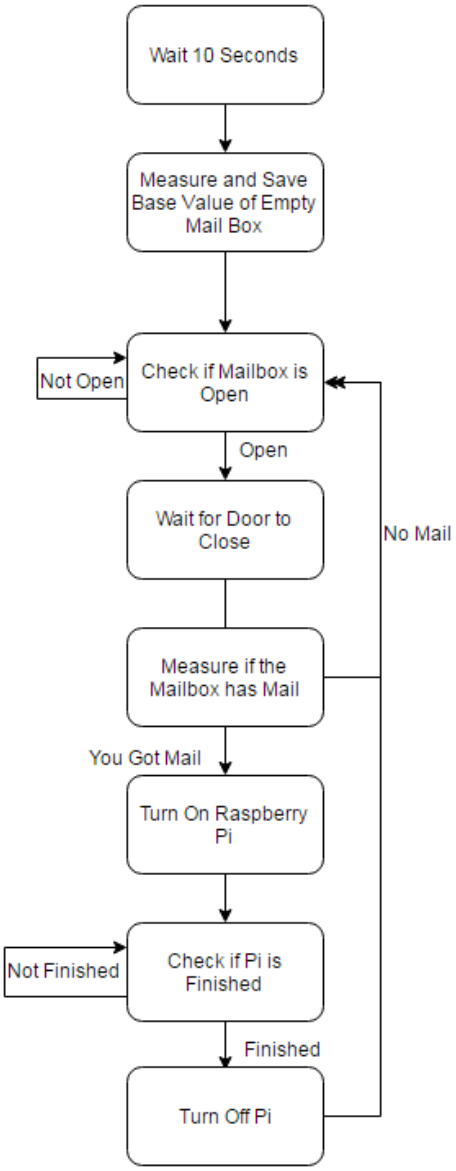

Figure 1. Arduino logic flow chart.

Once the Raspberry Pi turns on, it uses a camera to take a photo of the mail, connect to Wi-Fi, and send the photo to the user's defined email. After sending the email, the Pi sends a signal back to the Arduino to turn the relay off, at which point the Raspberry Pi will be turned off and the Arduino will revert to sleep mode (Figure 2).

Figure 2. Raspberry Pi logic flow chart.

The entire system is contained in a discreet and easy-to-place package. All of the components of the prototype are contained in a single custom housing which can be pushed to the rear of a mailbox and act as a false back. This false back feature keeps the device

secure, hidden, and in a convenient location. The functional MailSnap prototype is shown in Figures 3, 4, and 5.

Figure 3. MailSnap prototype with letter.

Figure 4. MailSnap prototype with standard USPS mailbox.

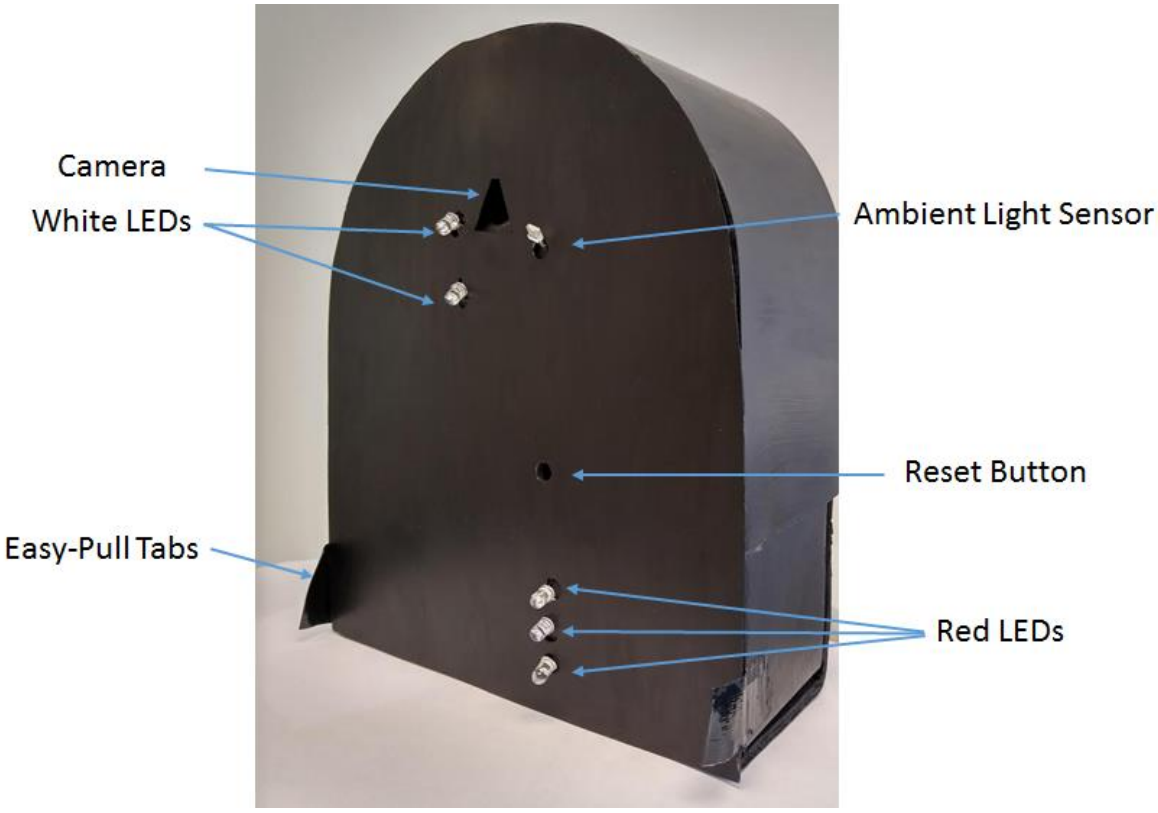

Figure 5. Functional MailSnap prototype with labeled parts.

9.2. Technical Methods

Combining the low power consumption of the Arduino products, however, allows interfacing with sensor data and wireless communication. Therefore, these two systems satisfy the needs of the MailSnap product.

The Raspberry Pi was chosen to transmit data wirelessly. The Arduino is a product that can interface input/output ports to control and measure sensors, which can include Wi-fi transmitters. Data would need to be packaged using TCP/IP and general FTP libraries to be sent through email. This approach would provide the engineering team with thorough library functions that allow access to the Internet for email. Alternatively, Raspberry Pi can support an embedded Linux operating system, which includes Internet Protocol libraries. Due to these factors, the Raspberry Pi was used for file transfer since the Arduino does not have the embedded hardware for wireless transmission.

The Arduino was chosen for ambient light sensing. Comparing the two systems of interest shows a large disparity in processing power. Both the Atmel ATmega328 16MHz microcontroller unit and the Broadcom ARM1176 1GHz processor are single core processors, meaning they run all processes in a linear sequence. The Raspberry Pi runs on the Linux kernel, which allows access to many libraries. However, the Arduino has analog-to-digital converters that can interface with many analog sensors. Also, the Arduino Pro Mini requires less current to operate its microcontroller unit. Unfortunately, the Arduino would require about 100 times more time to process a picture when compared to the Raspberry Pi so the Arduino could not be used for both purposes.

Power save mode was implemented in the Arduino design to reduce power consumption. The advantage of the Arduino Pro Mini is its small presence. The Arduino

IDE gives SimpliSecure engineers dedicated libraries to easily access all the peripheral I/O ports. Therefore, the development costs for the sensor network will be miniscule. The ATmega328 has a power consumption of 0.2 mA at 1 MHz. With a battery pack of a capacity of 3.5 Ahr, this sensor product will theoretically last 720 hours. This can be greatly improved by implementing timing registers to activate the Arduino once every second with power-save mode. The power-save mode operates at 75 µA. The ADC measurement takes exactly 12 instruction cycles. The C compiler and the instruction pipelining in the ATmega 328 causes an IF statement to execute in one instruction. This is the same with the power down (SLEEP) command. Therefore, the time it takes to execute 14 instructions at 1 MHz is 1.75 µs. If the period of sensing is exactly one second, then the power save mode operates at 0.99999825 second duration, shown in equation (2). The total current draw for one second is 23.03 µA (Equation 3). Therefore, a 3.5 Ahr battery pack will theoretically last approximately 152,500 hours with a power-save state function. This is equivalent to 17.35 years.

$$Base\ Current\ Draw = 17mA$$

$$T = f^{-1} = \frac{14\ instructions}{8 * 10^6 Hz} = 1.75 * 10^{-6}s \quad (1)$$

$$1\ \text{second} - 1.75 * 10^{-6}s = 0.99999825\text{s} \quad (2)$$

$$\frac{0.023mA * 0.99999825\text{s} + 17mA * 1.75 * 10^{-6}s}{1s} * \frac{1A}{1000mA} = 2.303 * 10^{-5}A \quad (3)$$

$$\frac{3.5Ahr}{2.303 * 10^{-5}A} = 151977.6\ hours \quad (4)$$

An ambient light sensor was chosen for detection of environmental change due to its low power consumption. This product absorbs ambient red light and creates a variable internal resistance based on the amount of light that is absorbed. A change in light changes

the output voltage, so someone accessing the inside of the mailbox would create a large disturbance with this sensitive sensor. The resultant voltage is amplified so the Arduino can measure the change in the environment. The ambient light sensor datasheet specifies the current draw as 200μA, making the sensor a strong choice due to its low power consumption.

A battery pack coupled with a battery eliminator circuit was chosen as the power supply method for MailSnap. The battery pack has a high capacity of 3.5Ahr, producing a long-lasting product. The battery pack is the most expensive part in the MailSnap product; however, investing in a reliable power supply will create a more convenient product for the customer as the battery will have to be replaced less often. The battery eliminator circuit will provide a consistent 5V output to the system. The input can vary from 5.5V to 12V. The only output parameter that changes is the amount of current that can supply the circuit. These characteristics allow the batteries to vary significantly in voltage when they are being drained. Rechargeable nickel metal hydride batteries at a capacity of 7.2V and 3.5Ahr will allow the customer to recharge the MailSnap product infrequently.

Taking the above described factors of minimizing power consumption, maximizing battery life, and simplifying the photo sending process, the MailSnap circuit was designed (Figure 6).

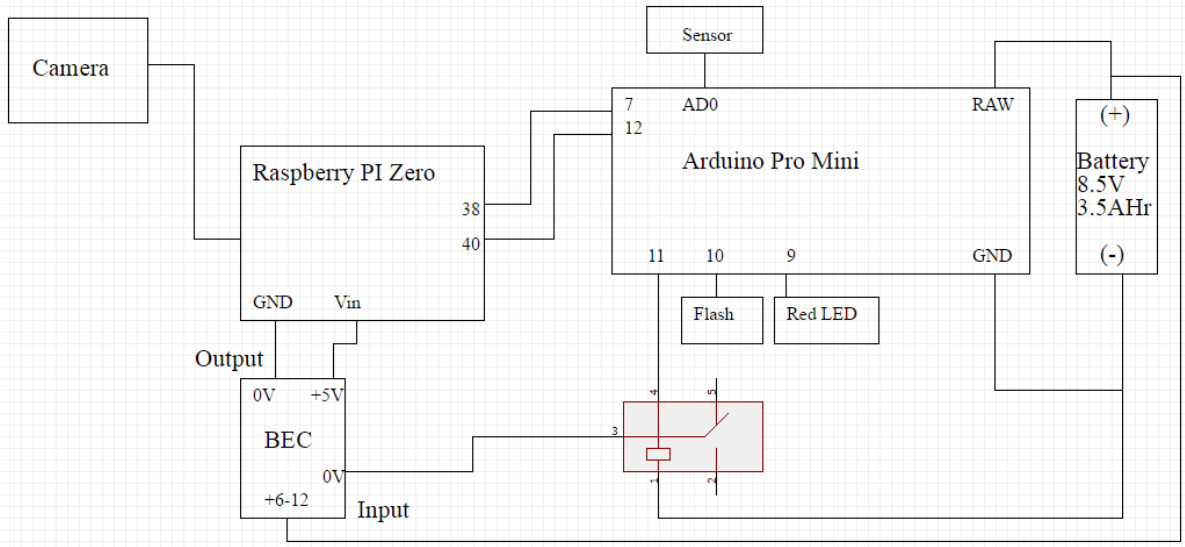

Figure 6. MailSnap design schematic.

9.3. Prototype Results

The MailSnap prototype performs as desired. Results of continuous ambient light monitoring is analyzed by the Arduino. When the mailbox is opened, the ambient light increases. When the door is closed again the ambient light decreases. After any door opening and closing event, the ambient light in the mailbox is measured with the use of three red LEDs and the ambient light sensor. If the new ambient light value is significantly greater than the last threshold stored by the Arduino, then the system determines that mail has been added (Figure 7).

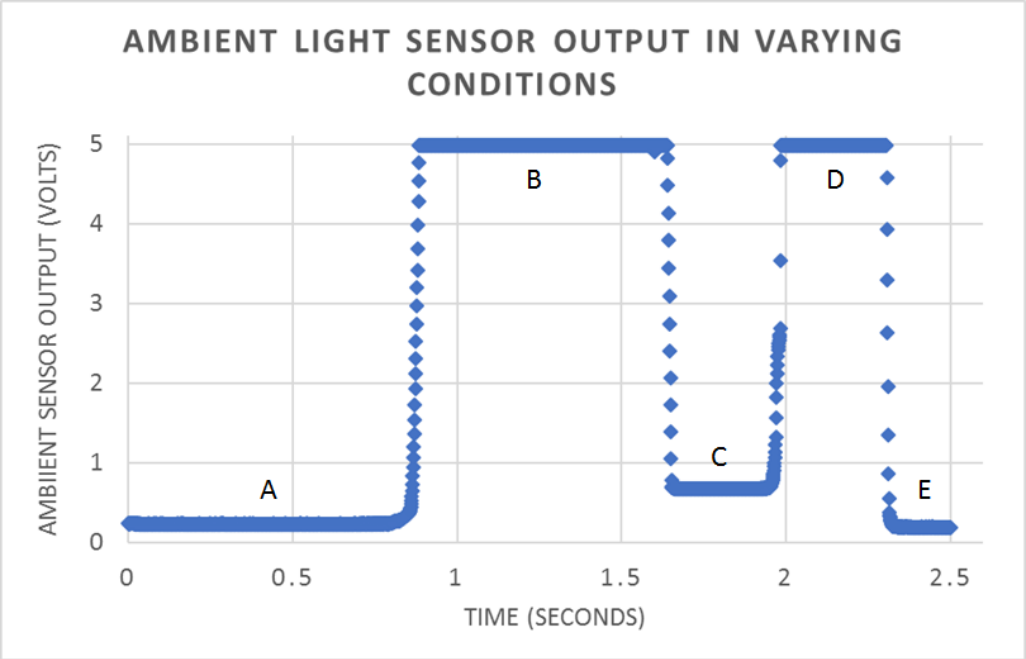

Figure 7. Voltage output of the ambient light sensor in MailSnap prototype. The differences in the output levels from the sensor while the door was closed (sections A, C, E) were used to determine if mail was added. Because the value of sensor output in section C is greater than the output in section A, the system correctly determines that mail was added. Because section C is greater than the value of section E, the system correctly determined that mail was not added. Sections B and D represent an open mailbox.

In the event that mail has been added, Arduino powers on the RaspberryPi and a photo is taken using 2 white LEDs for lighting (Figure 8). The photo of the mail is then sent to the user's email address via Wi-Fi (Figure 9). The entire process takes 65 seconds.

Figure 8. MailSnap turns on the white LEDs to produce a high quality photo.

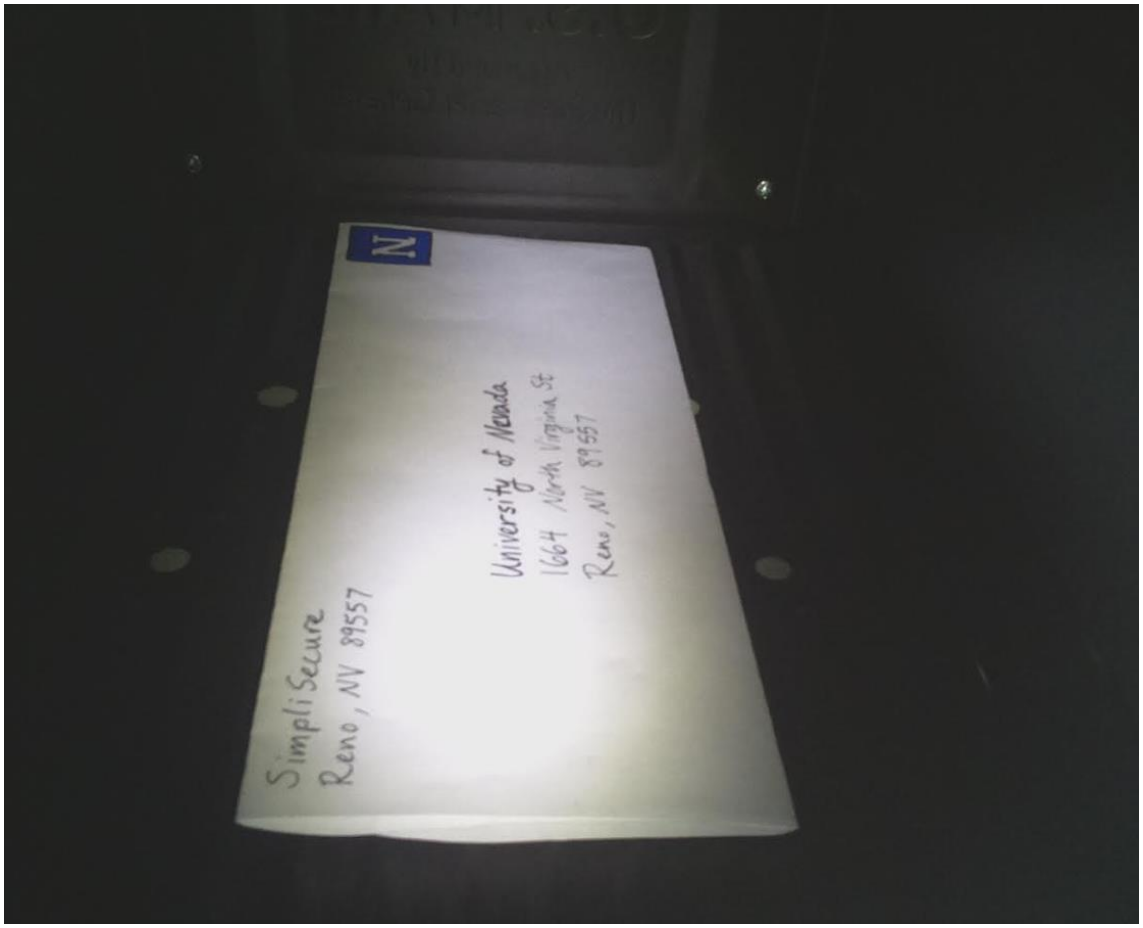

Figure 9. Photo taken with MailSnap received via email from the Raspberry Pi.

10. Facilities, Equipment, and Other Resources

The facilities to be used during the development of MailSnap include the Senior Capstone Lab for Electrical Engineers located in Scrugham Engineering and Mines Building Room 341. Equipment used within the Capstone Lab included a signal generator, oscilloscope, power supply, and soldering iron.

Another resource SimpliSecure used was the Nevada Small Business Development Center located within the University in the Ansari Business Building. Their expertise in growing a business and insight on how to market MailSnap was valuable.

11. Conclusion

MailSnap achieved the desired functionality of creating a self-contained, autonomous, discreet mail notification system. In less than a two minutes, MailSnap can notify a user of new mail within their mailbox via an email with a photo attachment. Through the use of ambient light sensors and Wi-fi connectivity, MailSnap aims to change the way people interact with their residential mailbox.

Appendix A. References

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Appendix B. Arduino Code

```
/*
The difference between 2.0 and 2.1 is that this algorithm uses a
for loop for collecting a baseline value instead of using the clock
through use of the millis() command.

Latest version Mailwatch 3.1 3/29/2017 by addison
--ver 3.1 turns on the pi and waits until a signal goes high on pin 3, then turns the pi off.
-- it also turns on the 4 LEDs so the pi can take a picturem
*/

#include <avr/sleep.h>
#include <avr/power.h>
// Set variables to read voltage of IR sensor
volatile unsigned char *TIMSK_2;
volatile unsigned char *P_RR;
volatile unsigned char *TCCR_1A;
volatile unsigned char *TCCR_1B;
volatile unsigned char *TCNT_1H;
volatile unsigned char *TCNT_1L;
volatile unsigned char *Overflow;
volatile unsigned char *SMC_R;
double preEventAvg = 0;
double postEventAvg = 0;
double checkVoltage = 0;
unsigned long timeStart = 0;
unsigned long endTime = 0;
int counter = 0;
int index = 0;
int IRSensorPin = A0;
const bool preCheck = false;
const bool postCheck = true;


void setup()
{
// Set address for registers used for power reduction
P_RR = (unsigned char*) 0x64;
TIMSK_2 = (unsigned char*) 0x70;
TCCR_1A = (unsigned char*) 0x80;
TCCR_1B = (unsigned char*) 0x81;
TCNT_1H = (unsigned char*) 0x85;
TCNT_1L = (unsigned char*) 0x84;
Overflow = (unsigned char*) 0x36;
```

```
SMC_R = (unsigned char*) 0x53;

// Set proper bits for registers
*P_RR &= 0xBF;

// Set timer control register A to 0x00
*TCCR_1A = 0x00;

// Enter power save mode and wait for one second
//*SMC_R = 0x06;

// Initialize the serial port and set it with a baud rate of 9600
Serial.begin(9600);
// Set pin with IR sensor to read
pinMode(IRSensorPin, INPUT);
// Set GPIO pin to output to LED for testing
pinMode(3,INPUT); //NEW LINE OF CODE
pinMode(4,OUTPUT);
pinMode(5,OUTPUT);
pinMode(6,OUTPUT);
pinMode(7,OUTPUT);
pinMode(8,OUTPUT);
pinMode(9,OUTPUT);
pinMode(10,OUTPUT);
pinMode(11,OUTPUT);
pinMode(12, OUTPUT);
pinMode(13, OUTPUT);
// Get baseline value of inside of mailbox
getBaseline( preCheck );
}

void loop()
{
// digitalWrite(13, LOW);
// sleep();                  //commenting these out in verison 3.1
// digitalWrite(13, HIGH);
 //sleep();

 // Get value
 checkVoltage = analogRead(IRSensorPin);

 // Check if door is open
 if ( checkVoltage > 100 )
 {
   Serial.print("Door has opened ");
```

```
    Serial.print(checkVoltage);
    Serial.print('\n');

    // Wait two seconds
    delay(2000);

    checkVoltage = analogRead(IRSensorPin);

    // Wait until door closes
    while ( checkVoltage > 100 )
    {
      checkVoltage = analogRead(IRSensorPin);
    }

    Serial.print("Door has closed ");
    Serial.print(checkVoltage);
    Serial.print('\n');

    getBaseline( postCheck );

// || ( postEventAvg < ( preEventAvg - 5 ))

    if ( ( postEventAvg > ( preEventAvg + 5 ))  )
    {
       Serial.print("You've got mail ");
       Serial.print(postEventAvg);
       Serial.print('\n');

      // Turn on the raspberry pi

      digitalWrite(4, HIGH);
      digitalWrite(5, HIGH);
      digitalWrite(6, HIGH);
      digitalWrite(7, HIGH);
      digitalWrite(8, HIGH);
      digitalWrite(9, HIGH);
      digitalWrite(10, HIGH);
      digitalWrite(11, HIGH);

      Serial.print("Pi is on");
      Serial.print('\n');

      // For testing. We need to turn off in event of GPIO controlled by Pi
      //delay(500000);
```

```
      ////////////////NEW CODE////////////////
     digitalWrite(12, HIGH);
     digitalWrite(13, HIGH); //turn on LED


      while(digitalRead(3) ==LOW){} //wait until the picutre is taken

      digitalWrite(12, LOW);
      digitalWrite(13, LOW);  //turn off LED

     digitalWrite(4, LOW);
     digitalWrite(5, LOW);
     digitalWrite(6, LOW);
     digitalWrite(7, LOW);
     digitalWrite(8, LOW);    //turn off pi
     digitalWrite(9, LOW);
     digitalWrite(10, LOW);
     digitalWrite(11, LOW);

   }

   else
   {
    Serial.print("You don't have mail ");
    Serial.print(postEventAvg);
    Serial.print('\n');
   }
   // Update baseline
   preEventAvg = postEventAvg;



  }

}

void getBaseline( bool state )
{
  if ( !state )
  {
     // Wait 10 seconds
    delay(10000);

     // Turn on LED
     digitalWrite(12, HIGH);
```

```
    digitalWrite(13, HIGH);

     // Loop for one second
     for( counter = 0; counter < 20; counter++ )
     {
       // Get value of voltage from pin
       preEventAvg = preEventAvg + analogRead(IRSensorPin);

       // wait for 1/10 of a second
       delay(100);
     }

     // Get average
     preEventAvg = preEventAvg / counter;

     // Turn off LED
     digitalWrite(12, LOW);
     digitalWrite(13, LOW);


     Serial.print(preEventAvg);
     Serial.print(' pre event ave\n');
}

else
{
    // Wait one second
    delay(1000);

    // Turn on LED
    digitalWrite(12, HIGH);
    digitalWrite(13, HIGH);

     // Loop for one second
     for ( counter = 0; counter < 20; counter++ )
     {
       // Get value of voltage from pin
       postEventAvg = postEventAvg + analogRead(IRSensorPin);

       // wait for 1/10 of a second
       delay(100);
     }

     // Get average
     postEventAvg = postEventAvg / counter;
```

```
      // Turn off LED
      digitalWrite(12, LOW);
      digitalWrite(13, LOW);
  }
}

void sleep()
{
 // stop timer
 *TCCR_1B = 0x00;

 // reset overflow flag
 *Overflow |= 0x01;

 // Set counter registers to wait for one second
 // This is found with the following formula:
 // Prescaler of 1024 / 16000000 Hz = 0.000064 usec
 // 1 second / 0.000064 usec = 15625
 // 16 bits in counter registers = 65535
 // 65535 - 15625 = 49910 = 0xC2F6
 *TCNT_1H = 0x0B;
 *TCNT_1L = 0xDB;

 // start timer with prescaler of 1024
 *TCCR_1B = 0x05;

 set_sleep_mode(SLEEP_MODE_ADC);
 sleep_enable();

 // Wait for proper time
 while( (*Overflow & 0x01) == 0 )
 {

 }

 sleep_disable();
}
```

Appendix C. Raspberry Pi Code

Note: Emails and passwords were removed for privacy

```
import smtplib
from email.mime.multipart import MIMEMultipart
from email.mime.text import MIMEText
from email.mime.base import MIMEBase
from email.mime.image import MIMEImage
from email.mime.multipart import MIMEMultipart
from email import encoders
import RPi.GPIO as GPIO
import os
GPIO.setmode(GPIO.BOARD)

from picamera import PiCamera
from time import sleep
camera = PiCamera()

GPIO.setup(38,GPIO.OUT, initial = 0)
GPIO.output(38,1)
camera.start_preview()
sleep(3)
camera.capture('/home/pi/Desktop/image.jpg')
camera.stop_preview()
GPIO.output(38,0)

msg = MIMEMultipart()
msg['Subject'] = 'Testing Pi Camera and Email'
msg['From'] = 'name'
msg['To'] = 'email'
fp = open('/home/pi/Desktop/image.jpg','rb')
img = MIMEImage(fp.read())
fp.close
msg.attach(img)

server = smtplib.SMTP('smtp.gmail.com', 587)
server.ehlo()
server.starttls()
server.ehlo
server.login('email','password')
server.sendmail('email','email',msg.as_string())
server.quit()
GPIO.setup(40,GPIO.OUT, initial = 0)
GPIO.output(40,1)
```