Department of Electrical and Computer Engineering
HowardUniversity
Fall 2011

EECE-401 Senior Design

Swallowable Capsule Technology:
Prototype of Swallowable Capsule with pH sensor and Camera

Team Members:
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Advisor: Gary L. Harris, Ph.D.

SUBMISSION AND APPROVAL

This project report is submitted for partial fulfillment of the Senior Design course describing the design and implementation of our project.

Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date

I approve this project report

Advisor's Name	Signature	Date

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The Matters of the Heart: Swallowable Capsule Team #1, would like to express an immense amount of gratitude and appreciation to the following people:

- *Dr. Charles Kim*
- *Dr. Gary Harris*
- *Mr. James Griffin*
- *Ravi Jaglal*
- *Chidi Ekeocha*
- *Ms. Nefertiti Jackson*
- *Ms. Dezerine Wallen*
- *2011-2012 EE/CpE Senior Design Class*
- *Staff of the Nanotechnology Lab, Howard University*
- *Electrical and Computer Engineering Department, Howard University*

We truly thank you and we are forever grateful for all of your help.

We would not have been able to complete this year successfully without you.

Take care and God bless!

Executive Summary

The objective of this report is to highlight the design experience of Team Swalloable Capsule #1 during our matriculation through Senior Design. This report will present the design challenge, the requirements needed to satisfy the design, along with the solutions generated to initially solve the problem, leading to the final solution. The objective of this design was to highlight the impact that swallowable capsule technology has had in the medical field, thus far, as well as the impact that it could potentially have in the future.

Within this report, the primary cause of the problem will be defined, as well as our motivation for deciding to design this prototype. In addition, we will describe how we as a team decided to implement our design, and conduct a performance analysis of our design through experimentation/simulation. Finally, the report will conclude with our recommendations/suggestions for follow on work.

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Introduction

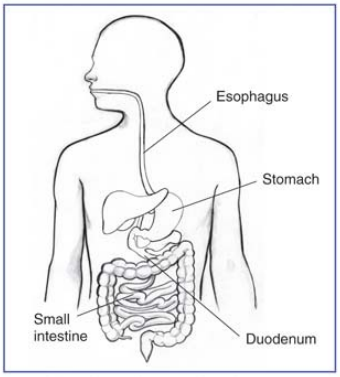
Objective

The objective of this proposal is to emphasize the impact that swallowable capsule technology has had in the medical field, thus far, as well as the impact that it could potentially have in the future. Also, within this final report, the design challenge will be presented, the requirements needed to satisfy the design will be outlined, along with the solutions generated to initially solve the problem, leading to the final solution, will be conveyed.

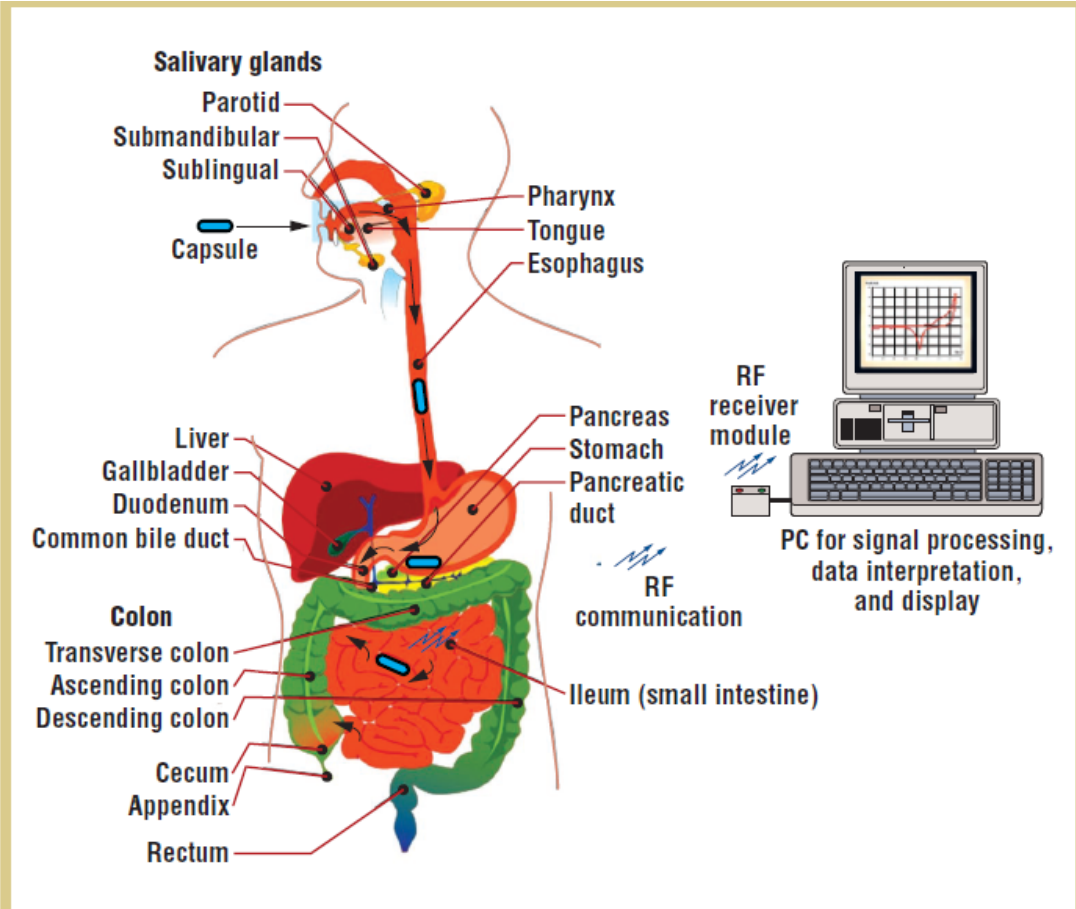
Background

Gastrointestinal (GI) diseases, also known as, digestive diseases, are ailments that affect over 3 million people in the United States alone. These diseases refer to ulcerative disorders of the upper gastrointestinal tract. The swallowable capsule technology is helping reveal GI tract mysteries in therapeutic and diagnostic applications, which has proven to be an exceptional breakthrough. These electronic microcomputer systems are now able to explore the GI tract and can transmit the information (temperature, images, pressure, and pH data) that was obtained through the sensors to an output.

The challenge for this swallowable capsule technology is to be able to design a micro-system that will eliminate the need for Endoscopy procedures, along with surgical procedures that could potentially follow. Endoscopy procedures have the capability of detecting stomach ulcers, abnormal growths, precancerous conditions, bowel obstruction, inflammation, and hiatal hernias. Although through the Endoscopy procedure, many ailments within the gastrointestinal tract can be discovered, there are risks that are accompanied with this procedure. Endoscopy and surgical procedures are extremely invasive. The procedure utilizes anesthesia and by using anesthesia there is a risk that the doctor may give the patient to much anesthesia and could negatively affect the patient's body. Utilizing the Endoscopy procedure also faces the risk of potentially puncturing the esophagus and/or lining of the stomach, which could then lead to internal bleeding.



[i]**Figure 1 – The following is a gastrointestinal image of esophagus, stomach, small intestine, and duodenum.**



[ii]**Figure 2 – The process of the capsule within the GI tract.**

Outline

Within this proposal, the primary cause of the problem will be defined, along with the necessary requirements for the design and constrictions on our final solution. In addition, we will emphasize the affects this technology has already had on the human body by revealing some of the mysteries of the GI tract.

Problem

Problem Definition

To design a large prototype of a swallowable pill, that will be intended to give a more accurate diagnosis than the endoscopy procedure, will eliminate the endoscopy procedure, and eliminate the need for surgical procedures that detect certain issues within the body. The largeprototype of the swallowable capsule will be focused primarily on two classes of diseases:

- Vascular and blood related
    - Cholesterol Levels, Stomach (Internal) Bleeding
- Digestive related
    - Stomach ulcers, Acidity in stomach

Current Status of Art

One of the first successes in swallowable technology was the Ingestible Thermometer Pill, developed, with support from NASA, in the late 1980's at John's Hopkins University. The intent was to monitor the core temperatures of astronauts in space. This pill later came to be known as CorTemp, and was used to monitor body temperatures of those in more strenuous situations such as fire-fighters, deep sea diving, and the military. Along with the success in development of the pill there was success in retrieving real time data by holding a data recorder at the small of the back.

There has also been success with imaging in capsule endoscopy. One company, Olympus Optical, was one of the first to receive a patent in this area for their capsule. The Olympus capsule used a magnetic field outside of the body to control tracking. Issues with Olympus' first capsule were proper illumination of the area and the capsule needed to be open to retrieve images. Since then Olympus has made some strides in capsule endoscopy with the EndoCapsule. Although this capsule isn't guided, retrieving data is much easier with the

use of the portable data recorder that accompanies it. This new EndoCapsule pill is currently on the market in Australia and New Zealand.

RF Systems Lab has had success with two capsules, the first being the Norika 3 RF Endoscopic Robot capsule. This capsule is known as “battery free”. This capsule contains a 1/6 inch colour 410,000-pixel CCD camera and is successfully able to be controlled through the use of rotor coils and a joystick. This pill is “battery free” because it is powered by wireless transmission through a vest embedded with a coil, this “battery free method was needed due to the increased power needed for illumination.

Another company with success in capsule endoscopy is Given Imaging founded by Dr. Gavriel D. Meron. Given Imaging has produced a number of pills; PillCam SB, PillCam Eso, PillCam Colon2, PillCam Express. The PillCam SB is used for the small bowel and was cleared by the U.S Food and Drug Administration in 2001. PillCam ESO is developed specifically for the esophagus. It contains a camera and light source on each end which allows it to take 18 images per second. The PillCam COLON2, like the PillCam ESO, is equipped with a camera on both ends, allowing for a full 360^{o} view. The PillCam Express is delivered to a patient through the stomach with the use of an endoscope. This is necessary for patients who have trouble swallowing large pills.

Looking at new ways of tracking nowadays, the University of Calgary, has developed a capsule that contains a capacitive MEMS accelerator. The capsule transmits the signal conditioned from the accelerometer to an external module for processing. “Through successive mathematical integrations, the propagation velocity and the capsule’s displacement can be retrieved.” The problem with this development right now is the acceleration levels of the stomach limits the capsule to currently only being used in the esophagus. Acceleration in the stomach exceeds the micro-accelerometers’ monitoring range. Some techniques of determining location include placing antennas around the body and measuring signal strength at the antenna.

Also there is another technique that involves the use of ultrasound waves, “the capsule can emit ultrasound waves for external detection, or echo waves emitted externally.”

Currently Swallowable Capsule Technology is spreading across the medical field. The main vendors are Olympus Optical, Given Imaging, and the RF System Lab. Capsule endoscopes couple one or more imaging devices with a lighting source to capture images of the GI tract, including the small intestine. For the patient, such capsules offer a convenient examination with minimal preparation and immediate recovery.

Constraints and Criteria of the Design Requirements

The original constraints imposed on this project require that our proposed design must meet the following requirements:

- **Internal Design of the Capsule:**
  - pH sensor
    - Communication Standards
      - Medical Implant Communication Service: Operations in the 402-405 MHz range
      - Industrial Scientific and Medical bands such as 433.92 MHz are acceptable
    - Microcomputer
    - Communication system
    - Camera/ Video Camera
- **Ember 250 Development Kit**
  - ZigBee System on chip
  - 16 bit Microprocessor
  - Flexible antenna interface
  - Surface Mount Technology package
  - Integrated Memory
    - 128 kB of Flash
    - 5 KB of SRAM
  - 2 serial controllers
  - 2 sleep modes

- Interfaces
    - 1 UART
    - 1 Mbps
    - ADC: 4 Inputs
    - 13 Digital Inputs/Outputs

- **Temperature:**
    - Capsule must be able to withstand temperature greater than 98.6° F
- Wireless communication
- **Size**:
    - Capsule:
        - 1 cm wide
        - 15 mm long
        - Area: 2.6 cm^3
    - Thickness of Camera: 1.4 mm
- Regulations and Standards:
    - FDA
    - HHS
    - ROHS
        - Restricts the use of certain hazardous substances in electrical and electronic equipment such as, Lead, Mercury, and Cadmium.
    - IEEE
        - 802.11 is a set of standards for implementing wireless local area network computer communication in the 2.4, 3.6 and 5 GHz frequency bands

The design requirements established for the large prototype of the swallowable capsule are as follows:

- **Size**
    - Due to the delay of our EM250 kit, camera, and pH sensor we had to resort to a bigger prototype to implement our design
        - Material used: Acrylic and Plastic

        - Length 12in.
        - Width 4in.

- **Communication Standards**
    - Medical Implant Communication Service: Operations in the 402-405 MHz range
    - IEEE 802.15.4 which is the standard for Wireless Compliance
- **Regulations**
    - Not swallowable
    - Can not contain hazardous materials such as: Lead, Mercury, and Cadmium

Engineering Approaches for Solution Generation

The complex and detail design of the swallowable capsule brings many challenges from the engineering perspective. The size, weight, and the durability of the capsule play a major role in tackling the tasks of constructing the swallowable capsule. The initial idea was for the internal design to be constructed of sensors, a signal conditioner, power supply, and a communication system. Due to constraints of having a small power supply within in a small capsule doesn't necessarily follow the idea of "safety". Having a sensor can also lead to challenges, such as how small can we make the sensor in order for it to work and withstand the body temperature without malfunctioning.

There are various aspects that go into making sure that all the devices that make up the system can withstand the body temperature of the human and still function properly. The first step encounters what materials are needed, for instance a camera, fiber optic cables, and, LEDs. With those materials arise the challenge size and how one is able to fit this complicated system in an item small enough to swallow. By understanding the meaning of the capsule many look at the Nanotechnology point of view having something so small yet powerful to produce proper efficiency. One point of consideration is whether the capsule is reusable. Can engineers make a product that can be reused and still produce an efficient output? Hence the approaches of using fiber optic cables, and LEDs within the design; which can withstand numerous trials and still return accurate results.

Alternative Solution #1

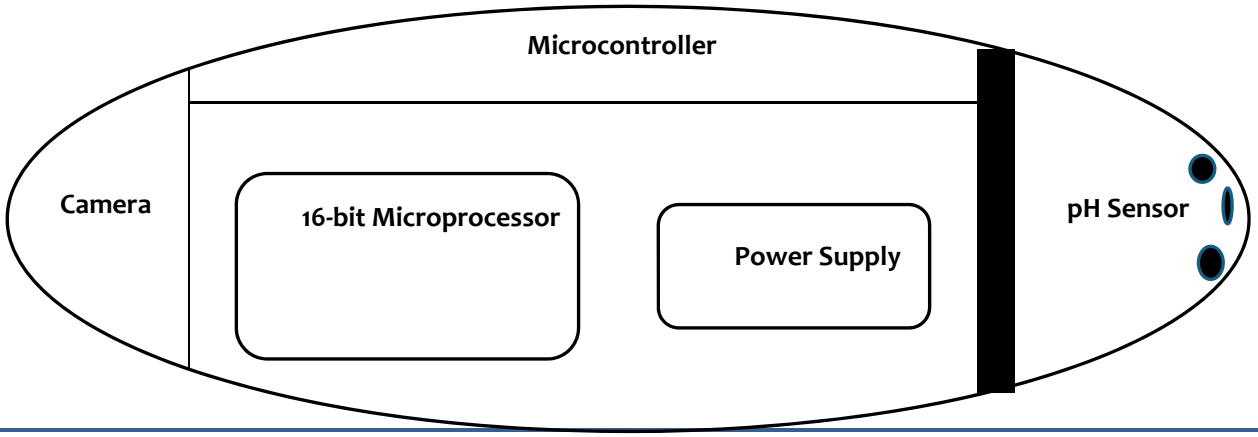
Finding a solution to complete the swallowable capsule generated numerous ideas in order to put forth our efforts into completing our project. In turn our first alternative solution included a camera, a 16-bit microprocessor, power supply, microcontroller and pH sensor. Given that we chose many components the breakdown of every job that each component will perform made sense as to why we should use this solution in building our swallowable capsule. The microprocessor would act as both the transceiver and receiver allowing data to be generated back and forth between the capsule and the doctor station. The 16-bit microprocessor is the main source of the capsule because this is where all data is processed, allocated, and released. Dealing with various components brings up the question of how to power all components in a safe manner. The power generated throughout our swallowable capsule would be provided by a small battery watch. Battery watches have a life span of 8 to 10 hours of continuous productivity, which in digestive tract traveling is efficient enough to complete the necessary task. It takes 8 hours for one particular item to travel throughout the digestive tract. When it came to a camera we were looking for something that could both record and take pictures. The camera had to be a powerful miniature camera that is able to do the duties requested. The microcontroller is there for guidance of the capsule. We had the idea of building a remote or some sort of device that would give us the privilege of guiding the capsule through the digestive tract with just the push of a button, but later on decided that we would control it by a magnet. The pH sensor is the component that brings the important factor in detection of health factors. We wanted to design a sensor that sends back readings of your current pH level in certain areas of your body. This alternative solution generated design put all of our ideas into one and produced a properly well put together solution.

Alternative Solution #2

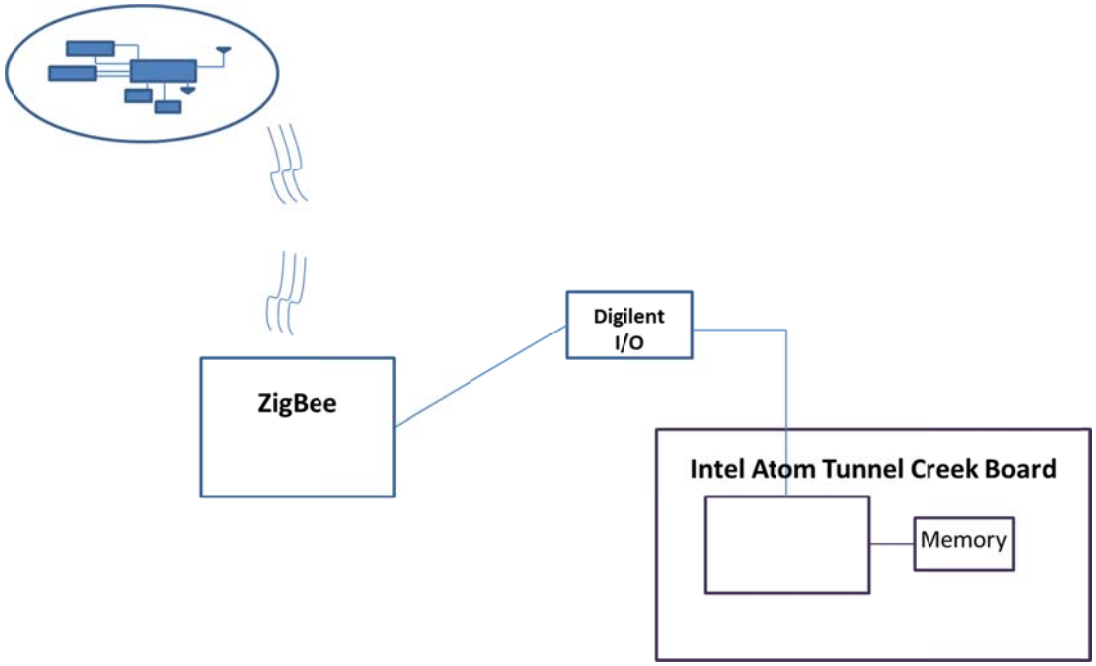
Another design option would add more detail into generating what we want our swallowable capsule to produce. This design included a camera, power supply, EM250 RCM, and a pH sensor. Deciding on using the

EM250 generated various factors because it acts as both a receiver and a transceiver not including that this component in itself has wireless capabilities with a built in Zigbee wireless protocol chip. The EM250 also generated its own power supply which was an excellent motive for us seeing as that we no longer need the battery watch. The utilization of the camera still contributed to recording and taking pictures. The pH sensor is designated to produce a current reading of your pH level at certain areas of your body as well. This design was the right direction we felt like we needed to take to ensure our capsule would be able to produce what we designed it to produce.

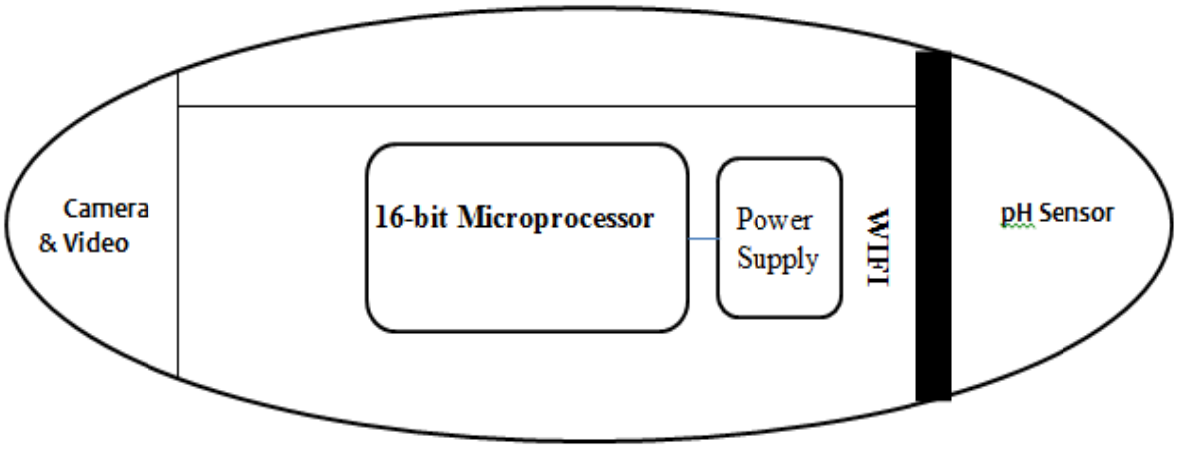
Potential Solution #1 Capsule Design:



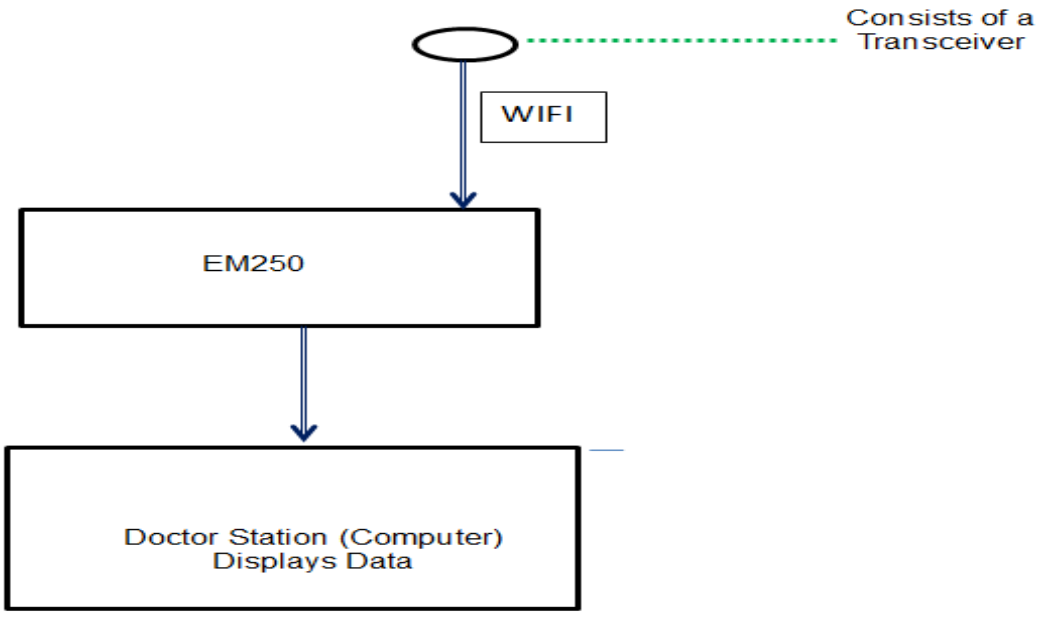
Potential Solution #1Transmitting and Receiving Data Process:



Potential Solution #2 Capsule Design:



Potential Solution #2 Transmitting and Receiving Data Process:



Implementation of the Top Design

EM250 Development Kit

There is always a certain difficulty in searching for the perfect components to complete a project. It's always the problem of making sure that one component can communicate and work together with your other components. The EM250 Development Kit is able to perform the entire task that we are working towards. It comes with wireless connectivity Zigbee chips already configured within its development environment, sensors, and its own software to development without reaching out to outside sources. We chose this development kit due to the fact that we could get everything we needed in this one kit. The EM250 is a fairly new product in the field of technology, but is widely used within the commercial aspect of technology.

Zigbee Wireless Connectivity

In any design that's geared into advancing the next generation of technology, wireless connectivity is an important factor. Wireless connectivity can take your project to a new level of distinction that sets you apart from the rest. In our capsule design wireless was the main concept of our focus as far as transmitting and receiving data. With the selection of using the EM250 kit it is developed with the Zigbee protocol which enables you to use wireless by using a simple C language program. The RCM which stands for the Radio Communication Module is designed with Zigbee on each of our breakout boards in our development kit. The RCM grants us the option within our development environment to go wireless. In turn Zigbee in our development kit acts as both a transceiver and a receiver for data. Which is a great attribute as far as our project is concerned. Figuring out the code for the Zigbee protocol was a challenge for our group. Seeing as though Zigbee is a new in the field of technology that deals with wireless network connectivity, it was extremely difficult in finding help for programming the wirelessprotocol. The EM250 development kit is created with programming language C so our main goal for wireless was finding a relatively simple programming code in C that will give us access to wireless. Dealing with the secured wireless network on Howard University campus served as a problem as well. But by using the Howard network through Ethernet we were able to use the Zigbee wireless component on our breakout boards. As well as using a sample program from the EM250 kit were we added a couple of lines to the code to make it unique with our design. After successfully being able to find the correct code and hurdle over the obstacle of the secured network we had our wireless connectivity.

pH Sensor

The pH level in a human's body gives relevant information on how the body reacts to certain levels. The ideal level for a human pH level is between 6.4 and 6.8 these are considered normal. If the level falls below or higher than that it could be critical and sometimes even fatal. Given that this is what we will be using in our project we wanted a sensor that would send back the current reading of your pH level at certain times. Once that information is received the pH sensor will then send the data to the EM250 which in turn will send it to the doctor station via wireless connectivity.

The Camera

In figuring out the details on how we wanted to project the use of our camera we wanted to be able to record and snap pictures as the capsule travels throughout the digestive tract. We had to find the smallest camera that is able to produce these given function and making sure that it is compatible with the EM250 communication.

Tasks and Deliverables

Tasks

Task	Member(s) Assigned to Task	Date of Task Assignment	Expected Date of Completion	Actual Date of Completion
Research Swallowable Capsule Technology	Ashley	October 2011	On-Going	
Evaluate Potential Solutions	Michelle	October 2011		
Select Best Solution for Problem	All	October 2011	Late November 2011	Early December 2011
Develop Slides for Proposal Presentation	Randall	November 2011	November 1st, 2011	November 2nd, 2011
Presentation Run Through	All	November 2011		
Go to Nanotechnology Lab	Cimoya	January 2012		
Develop Capsule	All	February/ March 2012		
Test Capsule	All	March 2012		

Deliverables

We will have designed and built a working swallowable capsule tested by a team member. Images taken from the team member will also be shown. Along with the model and images we will have:

- Budget Analysis
- Report on Swallowable Capsule Technology

Budget Analysis

Item	Estimated Price	Actual Price
EM-250 Development Kit	**$2500***	**$2500***
SMT Components (i.e. transistors,resistors)	**$50**	X
Fiber Optic Cables	**$25**	X
Camera/Video Camera	**$10**	**$10**
Pill Capsule	**$5**	**$5**
pH Probe	**$ 55**	**$30**
pH Stamp	**$25**	**$25**
Cost of Etching	**$50**	X
Arduino Board	X	**$55**
Total	**$2720**	**$2625**

Project Management

Milestone	Scheduled Date
Initial Proposal: Version I	November 2011
Initial Proposal: Presentation	November 2011
Written Proposals: Version II	November 2011
Written Proposal: Version III	November 2011
Final Proposal Presentation	December 2011
Evaluation/ Selection of Design	December 2011
Final Written Proposal	December 2011
Peer Evaluations	December 2011
Finalize Design	December 2011
Ordering of Components	December 2011
Commencement of Development of Design	January 2012
Testing of Project	March 2012

Documentation of Project	March 2012
Presentation Slides	March 2012
Draft Project Presentation	March 2012
Final Project Presentation	April 2012

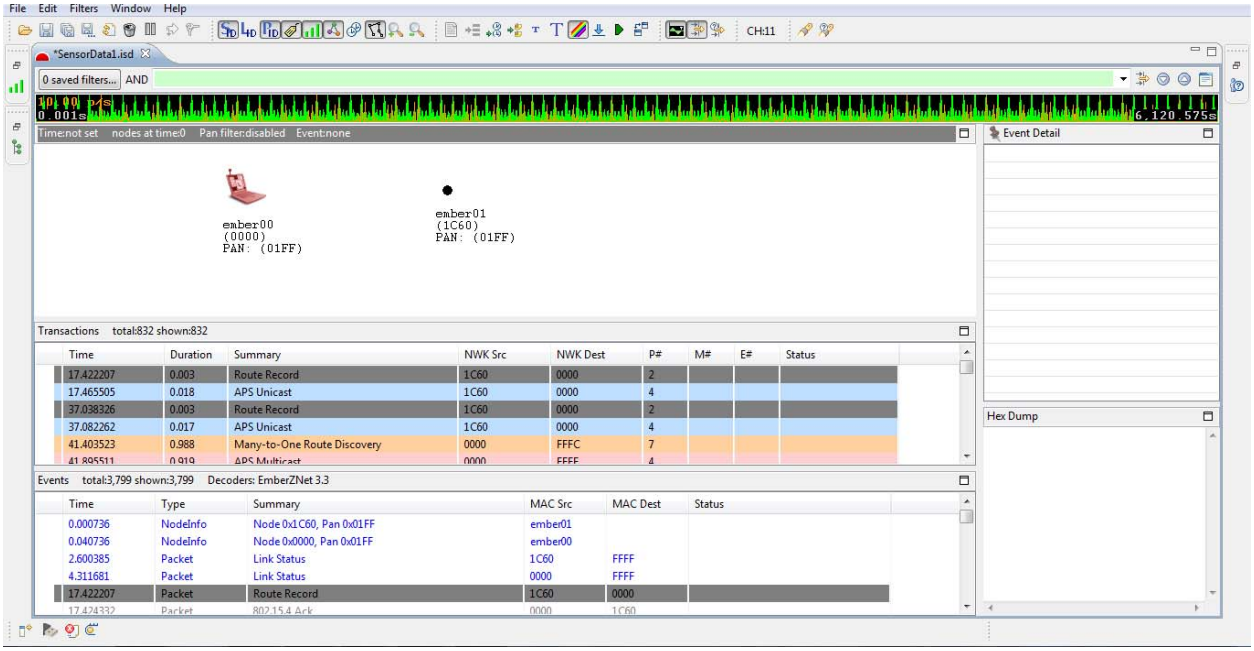
Capsule 1: Matters of the Heart Implementation Evaluation		
Week	**Tasks**	**Member**
Feb 5 - 11	Finalize PH Sensor selection (2-9-12)	Ashley
	Finalize Battery selection (2-9-12)	Gilbert
	Finalize Camera selection (2-9-12)	Cimoya
	Meet with Dr. Harris and/or Dr. Kim	Gilbert
	Programming Research - retrieve analog data - convert analog to digital - writes signal to file	Michelle
	Schedule Safety Test with Dr. Griffin in the Nanotechnology Lab	Michelle
	Talk to Dr. Harris to see if EM250 has been ordered (2-8-12)	Michelle
	EM250 Kit was ordered by Dr. Harris (2-10-12)	
Feb. 12 - 18	Talk to Dr's. at different hospitals (2-14-12) - HUH - Georgetown/Providence - George Washington - Children's Hospital	Gilbert Ashley Michelle Cimoya
	Talk with Dr. Anderson in regards to wireless transmission of signals	Michelle &Cimoya
	Meet with Dr. Harris to discuss progress (2-14-12)	Gilbert, Ashley, Cimoya, Michelle
	Begin working with EM250 development kit	
	Install Digilent Packages on Intel Board	Gilbert
	Begin Programming Digilent Board	Michelle, Cimoya, Gilbert
	Rough Draft of Circuit Design	Gilbert
	Circuit Design Review by Dr. Kim & Dr. Harris	Michelle
February 19 - 25	Final Revision of Circuit Design	
	Send Printed Circuit Design to SMT company for printing (Electric is used in our case)	Cimoya
	Continue Programming Digilient Board	Michelle, Cimoya, Gilbert
	Meet with Dr. Harris and/or Dr. Kim	Gilbert, Ashley, Cimoya, Michelle
	Take Safety Test	

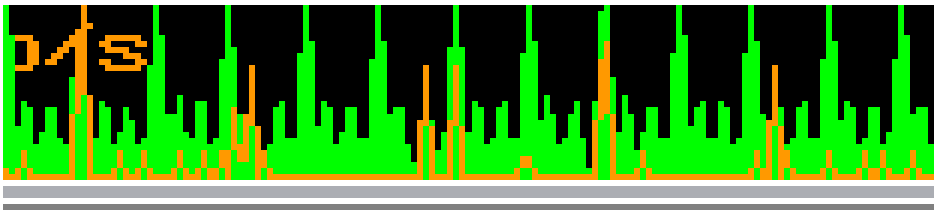
	Build microcontroller that corresponds with EM250 development kit, that controls the WiFi of the pill	Cimoya
	Receive Printed Circuit Design that was sent to Electric	
	Progress Presentation	Gilbert & Ashley
February 26 - March 3	Meet with Dr. Harris and/or Dr. Kim	Gilbert, Ashley, Cimoya, Michelle
	Program Digilent Board	Michelle, Cimoya, Gilbert
	Program EM250 (Zigbee) --- with a focus on the WiFi	Michelle
	Program EM250 (Zigbee) --- with a focus on the WiFi	Michelle
March 4 - 10	Meet with Dr. Harris	Gilbert, Ashley, Cimoya, Michelle
	Begin altering programs to ensure compatibility with other program functions of the swallowable capsule	
	Progress Presentation (Demo Required)	Michelle &Cimoya
	Ensure individial components work independently	Gilbert, Ashley, Cimoya
	Battery and Camera compilation completed	Gilbert &Cimoya
March 11 - 17	Battery and Camera compilation tested	Gilbert &Cimoya
	Continue to Program EM250 (Zigbee)	Michelle
	Meet with Dr. Harris and/or Dr. Kim	Gilbert, Ashley, Cimoya, Michelle
	Program EM250 (Zigbee)	Michelle
	Begin building reciever	Michelle
	Battery and Camera compilation and PH sensor completed	Gilbert & Ashley
March 18 - 24	Continue to Program EM250 (Zigbee) --- with a focus on pH sensor	Michelle
	Meet with Dr. Harris and/or Dr. Kim	Gilbert, Ashley, Cimoya, Michelle
	Battery and Camera compilation and PH sensor tested	Gilbert & Ashley
	Continue to Program EM250 (Zigbee) --- with a focus on pH sensor	Michelle & Ashley
	Microcontroller for Reciever needs to be completed by now	Cimoya& Michelle
	Test built Reciever with Intel Atom Board and microcontroller	Cimoya& Michelle
March 25 - 31	Bring all aspects of design together	
	Test all aspects of design together	
	Make maintenance and revisions	
	Meet with Dr. Harris and/or Dr. Kim	Gilbert, Ashley, Cimoya, Michelle
	Program EM250 (Zigbee)	Michelle
	Testing & Maintenance Phase (Should have all components of the swallowable capsule by now; PCB with ASMT)	
April 1 -7	Testing & Maintenance Phase	
April 8 - 14	Complete final product	
April 15 - 21	Week of ECE Day	

Performance Analysis and Evaluation of the Project

Simulation/ Experimental

SensorData1.isd





Transaction Detail List

Time:233.201491s nodes at time:2 Pan filter:disabled Event:Zigbee Unicast Command

Transactions total:832 shown:832

Time	Duration	Summary	NWK Src	NWK Dest	P#	M#	E#	Status
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233.244605	0.016	APS Unicast	1C60	0000	4			
252.816945	0.002	Route Record	1C60	0000	2			
252.861835	0.017	APS Unicast	1C60	0000	4			
272.432260	0.002	Route Record	1C60	0000	2			
272.476246	0.018	APS Unicast	1C60	0000	4			
276.631837	0.981	Many-to-One Route Discovery	0000	FFFC	7			
277.126696	0.922	APS Multicast	0000	FFFF	4			
292.046323	0.003	Route Record	1C60	0000	2			
292.091004	0.018	APS Unicast	1C60	0000	4			
311.664423	0.003	Route Record	1C60	0000	2			
311.707796	0.017	APS Unicast	1C60	0000	4			
331.279205	0.003	Route Record	1C60	0000	2			
331.324874	0.018	APS Unicast	1C60	0000	4			
335.438078	0.951	Many-to-One Route Discovery	0000	FFFC	7			
335.932077	0.926	APS Multicast	0000	FFFF	4			
350.894134	0.003	Route Record	1C60	0000	2			
350.937254	0.017	APS Unicast	1C60	0000	4			
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370.553307	0.016	APS Unicast	1C60	0000	4			
390.126240	0.003	Route Record	1C60	0000	2			
390.169948	0.017	APS Unicast	1C60	0000	4			

Events Summary List

Events total:3,799 shown:3,799 Decoders: EmberZNet 3.3

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0.000736	NodeInfo	Node 0x1C60, Pan 0x01FF	ember01		
0.040736	NodeInfo	Node 0x0000, Pan 0x01FF	ember00		
2.600385	Packet	Link Status	1C60	FFFF	
4.311681	Packet	Link Status	0000	FFFF	
17.422207	Packet	Route Record	1C60	0000	
17.424332	Packet	802.15.4 Ack	0000	1C60	
17.465505	Packet	APS Unicast	1C60	0000	
17.468847	Packet	802.15.4 Ack	0000	1C60	
17.481476	Packet	APS Ack	0000	1C60	
17.483381	Packet	802.15.4 Ack	1C60	0000	
18.336698	Packet	Link Status	1C60	FFFF	
21.577135	Packet	Link Status	0000	FFFF	
33.251457	Packet	Link Status	1C60	FFFF	
35.928871	Packet	Link Status	0000	FFFF	
37.038326	Packet	Route Record	1C60	0000	
37.040469	Packet	802.15.4 Ack	0000	1C60	
37.082262	Packet	APS Unicast	1C60	0000	
37.085621	Packet	802.15.4 Ack	0000	1C60	
37.096914	Packet	APS Ack	0000	1C60	
37.098800	Packet	802.15.4 Ack	1C60	0000	
41.403523	Packet	Route Request	0000	FFFF	
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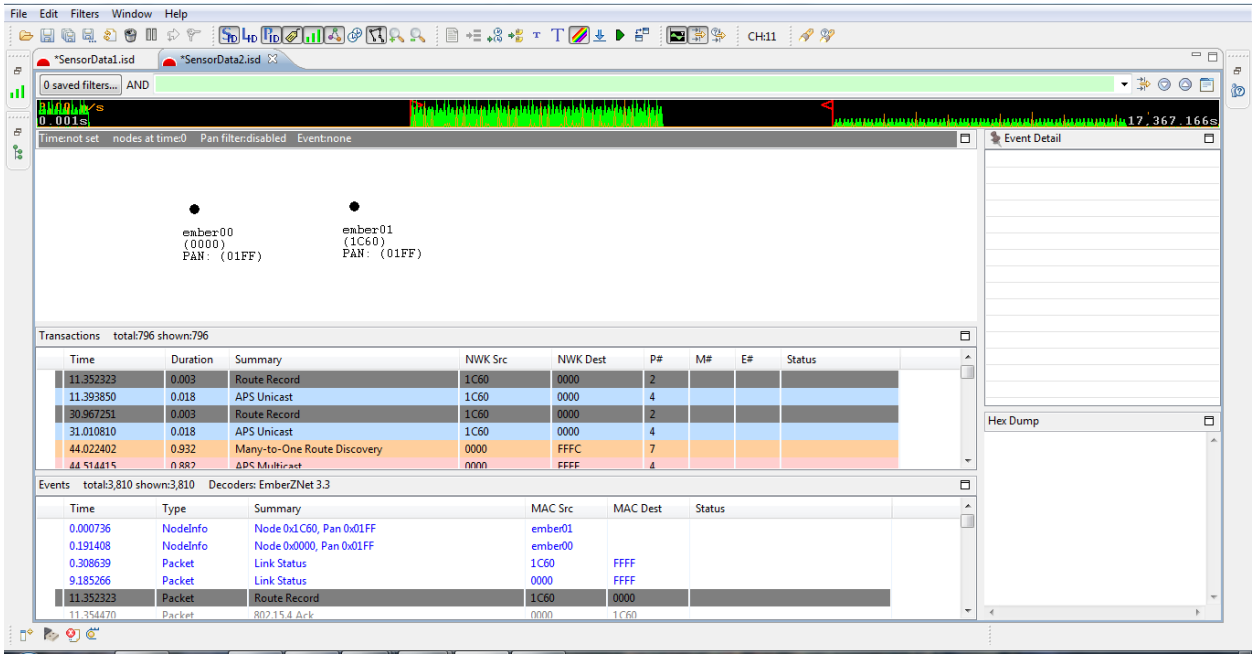
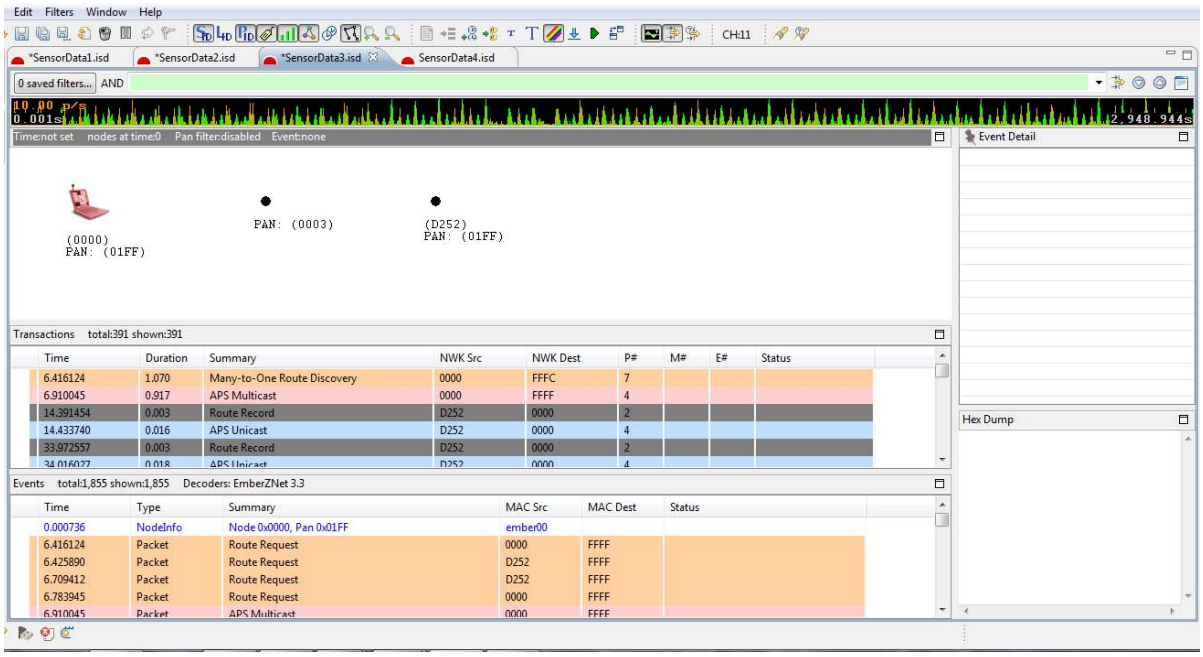
41.682563	Packet	Route Request	0000	FFFF	

SensorData2.isd



SensorData3.isd



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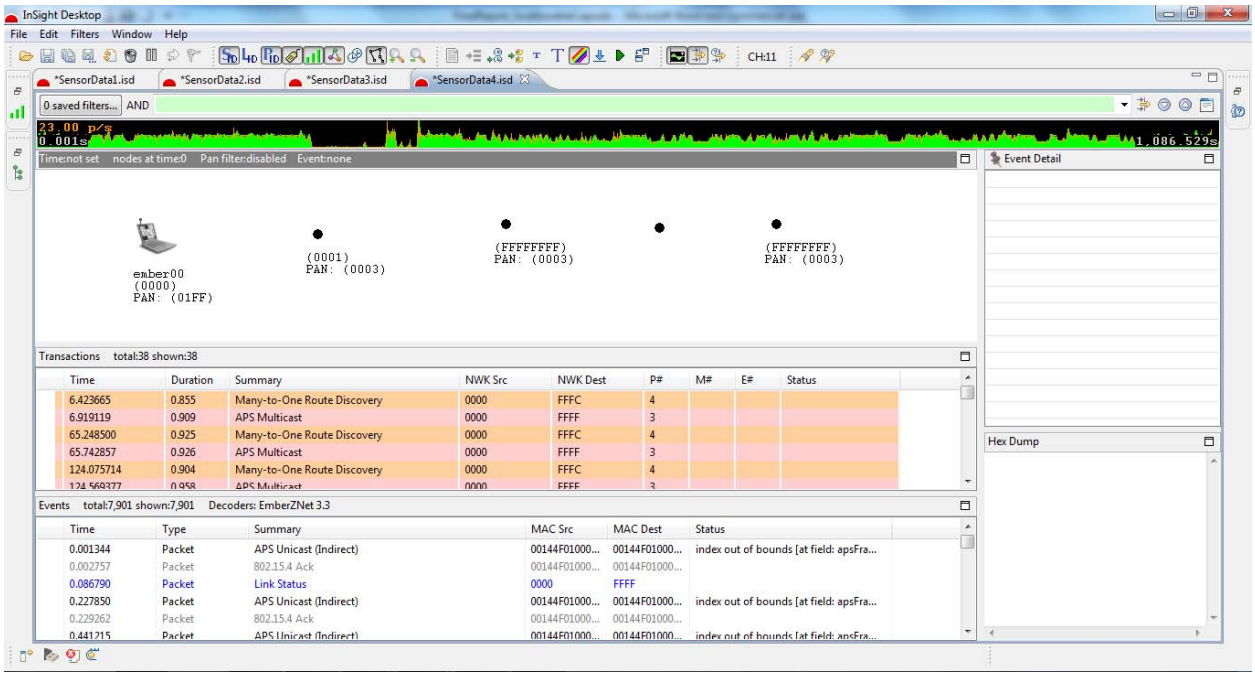


Evaluation against the Design Requirements

The designing of our swallowable capsule dealt with various constraints and regulations. Certain regulations dealt with size and materials which in turn made producing the necessary components difficult. The swallowable capsule technology is embarking on a new level that most are not familiar with. Going into an area of unfamiliarity can cause problems of not producing a reliable or within regulation product.

Conclusion

Swallowable capsule technology is currently on the rise to being a form of biomedical technology being used to make grand impacts in not only the science and engineering fields of study, but definitely how problems in the health and medical fields are handled as well. There are many successes and advantages that go along with this swallowable capsule technology. Some of these pros include the diminution in unnecessary invasive operations. Also, the images taken from inside the body will allow the site of the problem to be more easily identified and the necessary steps can be taken. The challenge for this swallowable capsule technology is to be able to design a micro-system that will give a more accurate diagnosis than the endoscopy procedure, will eliminate the endoscopy procedure, and eliminate the need for surgical procedures that detect certain issues within the body.

Our goal was to design a swallowable capsule that focused on vascular and blood related diseases such as, cholesterol and internal stomach bleeding, and digestive problems such as ulcers. The original design was to be a miniaturized capsule with a camera on one end and a pH sensor on the other end. Although there were a few setbacks, we were able to build a prototype that focused on detecting pH levels. With this prototype we were able to communicate wirelessly and detect pH levels and output the results to a monitor. Although we did not complete the miniaturization of the capsule, we did learn a lot about the work that goes into producing one of these pills.

Recommendations

For suggested follow on work, we Team Capsule #1 recommend that the design be expanded to implement a functioning camera with some kind of lighting source, as well as miniaturizing the prototype several orders of magnitude to a size that may be swallowed safely.

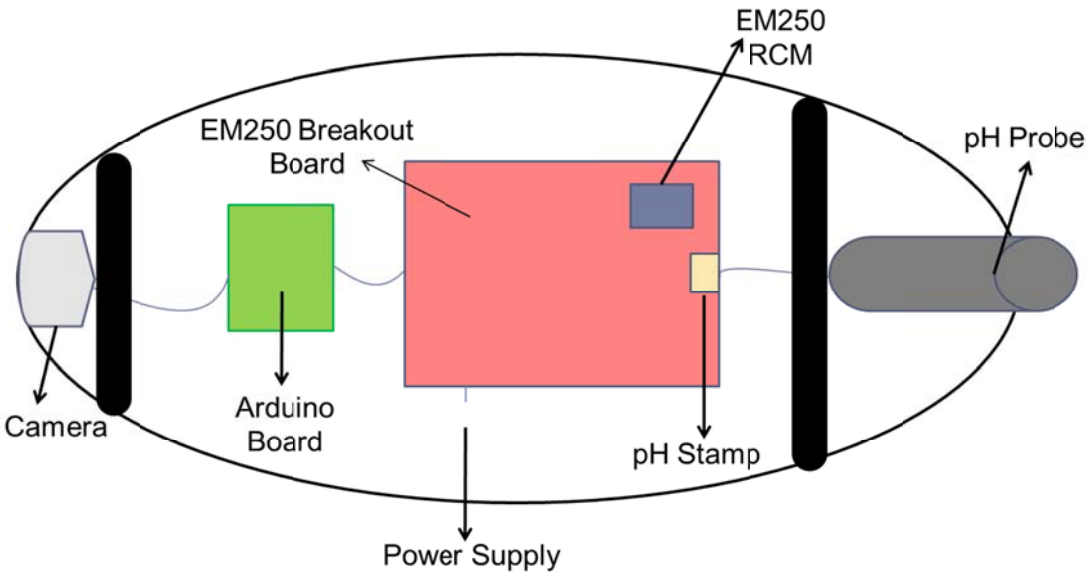
Appendixes

Final Design Requirement

Large Prototype of Swallowable Capsule:

- Size
  - Length: 12 inches
  - Width: 4 inches
  - Materials used: Acrylic and Plastic
- Communication Standards
  - Medical Implant Communication Service: Operations in the 402-405 MHz range
  - IEEE 802.15.4 which is the standard for Wireless Compliance
- Regulations
  - Not swallowable
  - Cannot contain hazardous materials such as: Lead, Mercury, and Cadmium

Final Design Proposal



Source Code Listing

Design Details

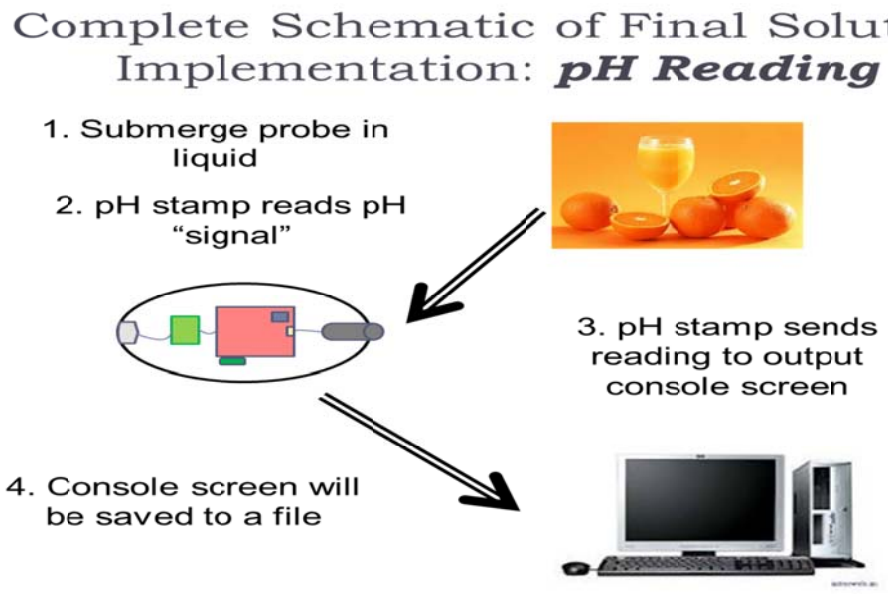
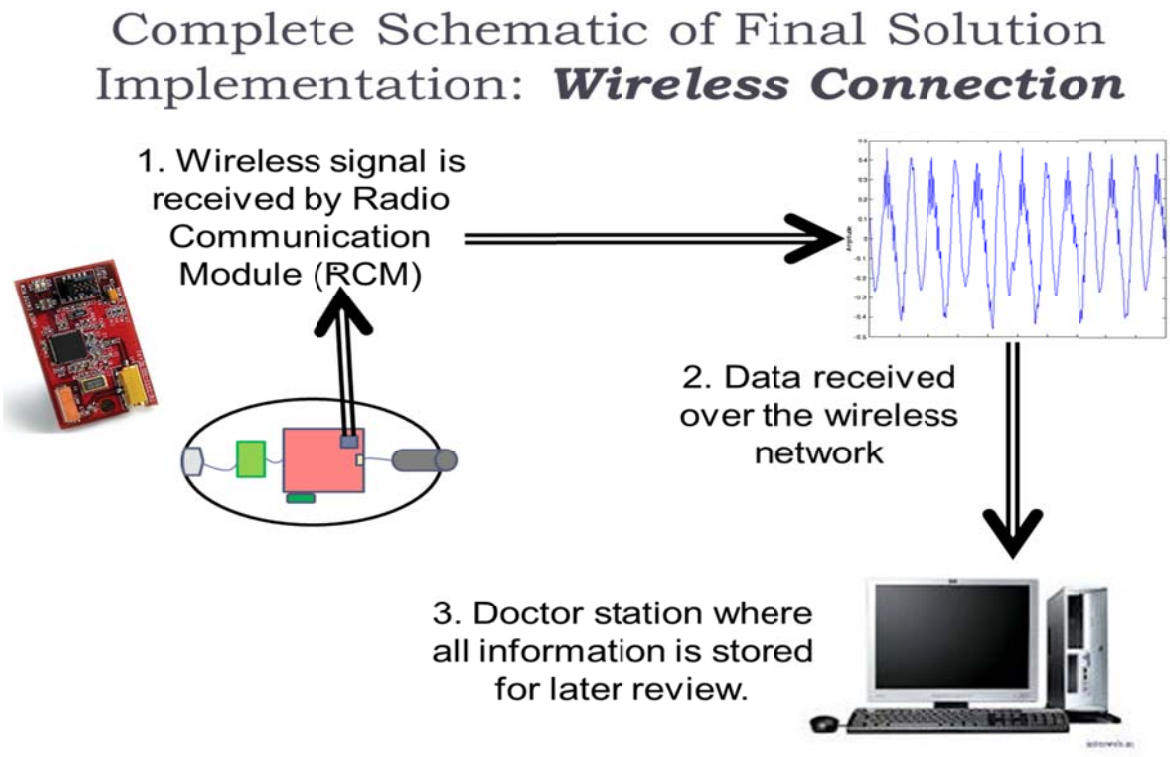


Figure:



Figure

Resumes

CIMOYA I. ARNOLD-COLLINS

PO Box 5994
Hyattsville, MD 20782

Collins87@hotmail.com
(682)558-5819

SUMMARY OF QUALIFICATIONS

To obtain a position in the field of Computer Engineering, where I can utilize and expand my knowledge and skills, gained through education and work experience.

EDUCATION

Howard University, Washington D.C
Bachelor of Science, Computer Engineering — Expected Graduation: May 2012
Major GPA: 3.09

RELATED COURSEWORK

Network Analysis
Operating Systems
Database Programming
Embedded System Design
Advance Digital Systems
Microprocessor & Microcomputer
Computer Systems

RELATED EXPERIENCE

Howard University Transportation Research Center- *Washington, D.C* — **May 2009 to Present**
Engineer Research Assistant

- Conducted traffic engineering studies on volumes, speeds, pedestrians, intersection level of service, and intelligent transportation systems
- Prepared professional and technical reports documenting study findings
- Proficient in Jamar Technologies, MS^2 (Midwestern Software Solution), and Petro Pro

Bank of America- *Washington, D.C* — **December 2007 to September 2010**
Branch Teller

- Assisted customers with various financial transactions
- Promoted new services and products to customers
- Implemented top of the line customer service to every client

Bolling AFB – *Washington, D.C* — **March 2008 to January 2011**
Commissary Night Stocker

- Requisitioned merchandise from supplier based on available space, merchandise on hand, customer demand, or advertised specials
- Stocked shelves, racks, cases, bins, and tables with new or transferred merchandise

21st Century Scholars Program(HUSEM)-*Washington, D.C.* — **August 2006 to May 2007**
Student Researcher

- Researched the community as a whole to implement a new technology to better assist students with learning disabilities

SKILLS

Microsoft Office
Intel Atom Processor
Linux
Assembly Language

AFFILIATIONS

President of Society of Women Engineers — August 2009 to May 2011

Member of National Society of Black Engineers	August 2009 to May 2010
Big Brother Big Sister	August 2007 to May 2009

GILBERT RANDALL HOPKINS

5318 Grand Forest Dr.
Houston, TX 77084
ghopkins@bison.howard.edu

SKILLS

- Design experience with programmable logic devices and logic design/simulation software.
- C/C++, JavaScript, VHDL, and Java programming knowledge
- SQL on Oracle 11g
- MySQL on Fedora 11
- Microsoft Office Suite.
- Relational database modeling, implementation, and design experience.

EDUCATION

Howard University - Washington D.C. **Expected Graduation Date: May 2012**
Computer Engineering
Major GPA: 3.0 / 4.0
Relevant Coursework: Digital Systems & Design, Operating Systems, Advanced Digital Systems, Telecommunications, Microprocessors & Microcomputers, Principles of Economics I, Computer Science I & II, Database Systems.

EXPERIENCE

CETLA - Washington, DC **August 2011-Present**
Instructional Tech Assistant

- Provide instructional support to staff and faculty at Howard University who utilize instructional software such as PowerPoint, Blackboard, Prezi, and TurnItIn
- Conduct one-on-one and small group workshops to help instructors teach more effectively with technology
- Assist with server and network maintenance, preventative maintenance, and software updates

Smithsonian Institution - Suitland, MD **Summer 2010**
Office of Facility Management and Reliability Intern

- Researched inventory, organized design and reference documents for assets in the Suitland Zone
- Created a database reference center of facility data/reports and project proposals using Microsoft Access
- Presented final project to OFMR senior staff (including process used, results obtained, benefits to OFMR and suggested follow-on work) and ensured that documentation was available to all zone staff

Nike Factory Store - Katy, TX **May 2008-August 2008**
Sales Associate

- Utilized customer service skills, basic sales techniques, and product knowledge to connect customers with the right product and drive sales
- Performed shipping and receiving duties, stocked the floor, performed cleaning duties, and built visual displays when necessary
- Served as a product knowledge resource for consumers and entry level associates

LEADERSHIP

New Breed **November 2009-Present**
President (2011-2012)

- Bible Study organization on the campus of Howard University
- Executed and enforced all decisions relating to the policies and general welfare of the organization
- Official spokesperson for the organization

Jubilee Christian Church Intl. **March 2010-Present**
IT Department - Church database system management
Jubilee Cafe Planning Committee

Turning the Page **Spring 2009**
Community Nights Family Mentor

- Engaged children in fun learning activities and encouraged children to be excited about reading

ORGANIZATIONS

Game7 Mentorship Program **Spring 2011**

- Mentored African-American male high school students

$(CP)^2$ **Fall 2009**

- Academic enrichment program for students in STEM domains

Capstone Institute's Program for Academic Student Support (Pass) Project **Spring 2009**
NSBE Howard University Chapter **October 2008-May 2009**

CBM Capital City Cares Mentoring Program **October 2008-February 2009**

- Mentored a young middle school student in Southeast, Washington, DC

INTEREST

Finance, Sports, Saxophone, Guitar, Traveling, Mentorship, Poetry, Exercise and Outdoor Activities

Michelle L. Lilley

363 Mae Road, Glen Burnie, MD21061
(443) 631-3194
mlavernel@gmail.com

Objective:

To obtain working experience in order to enhance my knowledge in computer engineering and enhance my analytical skills.

Education:

Howard University, Washington, D.C. 2008 – Present
2400 Sixth Street, NW, Washington, DC20059
B.S. in Computer Engineering
GPA: 3.3
Expected Graduation Date: May 2012

Old Mill High School 2004 – 2008
High School Diploma
Millersville, MD21108
GPA: 4.05
Graduation Date: June 2008

Experience:

Technology Summer Analyst, **Goldman, Sachs and Company** June – August 2011

- Worked on the Operational Analytics team within the Operations Technology Division
  - Reviewed large sets of data and analyzed various trends, patterns, and/or outliers in order to determine possible risks that could be caused within systems and how to possibly improve those systems
  - Designed and built a predictive modeling tool, using the R programming language, that classified documents

Computer Engineering Intern, **National Security Agency** May – August 2010

- Assisted in the derivation of strategies pertaining to the constellation
- Learned required and necessary tools used to develop constellation strategies

Computer Engineering Intern, **National Security Agency** May – August 2009

- Analyzed and reported current development projects
  - Would include learning, as well as, hands-on operation with documentation, demonstrations, briefings, data, hardware, and software related to assignment
- Researched different methods of coding for existing development tasks
- Embarked on a basic beneficial C^{++} program to enhance the data records of LOBs through the compression and decompression of data
- Investigated essential methods used on computers and computer systems
- Acquired basic knowledge on Subversion and simple Unix systems and commands

Office Assistant, **National Security Agency** 2007 – 2008

- Accountable for answering phone calls along with taking proper messages
- Liable for acquiring and distributing imperative mail and packages
- Responsible for ordering essential supplies in order to maintain a proficient working environment
- Consistent in establishing critical documents for the empowerment and betterment of the office's mission and for its employees

Skills:

- Adept in Word Processor, Microsoft Word, PowerPoint, Excel, and various Internet browsers
- Learned basic C^{++} and R Programming Languages
- Superior in communication techniques

Leadership:

- President of Living Stones Worship and Arts Ministry (2011-2012)
- Vice-President of Eta Kappa Nu (HKN) Electrical and Computer Engineering Honor Society, Gamma Lambda Chapter (Howard University) (Spring 2011-2012)
- Chaplain of the Tom Skinner Noonday Campus Ministries (2010-2012)
- Member of the National Honor Society (2008)

Honors/Awards:

- ***Cleared TOP SECRET (TS)/ Sensitive Compartmented Information (SCI)***
- Received a full scholarship to attend Howard University
- Annual Honor Roll Student
- Received the Martin Luther King, Jr. Drum Major Award

Service:

- Represented the Old Mill High School senior class of 2008 as a Student Ambassador
- Volunteered to speak at the AnneArundelCounty (Maryland) Women's Commission Forum
- Assisted in creating "Care Packages" for soldiers in Iraq
- Participated in the Annual "Walk for Homelessness" in Washington, D.C. every November

Ashley Wells
6511 Woodpoint Drive
Glenn Dale, MD 20769
240-461-0565
AshleyWells06@yahoo.com

Education

Seeking degree in Electrical Engineering
Howard University, Aug 2006-present
Expected graduation, May 2012

Georgetown Visitation Preparatory School
Washington, DC, Aug 2002- June 2006

Work Experience

Mentor
Walter Reed Army Institute of Research(2010 - present)
Planned and implemented a science and engineering based curriculum for high school and middle school students to help further their interest and increase the potential of entering a science field of study.

Receptionist(Summer 2010)
Vector Marketing
Receptionist for a multibillion dollar company. Worked in office doing data entry, clerical, filing, and as a recruiter

Volunteer(June 2009-July 2009)
For Love of Children
Summer math tutor for grades K-12. Met with students twice a week to help improve their math skills. Prepared lesson plans and helped students pass different level tests.

Server(June 2008-December 2008)
The Carolina Kitchen Bar and Grill
Assisted customers in all their needs, ensured their comfort, maintained cleanliness throughout the restaurant

Hostess(June 2007- June 2008)
Greenbelt Marriott
Work as a cashier, assist guests with problems, and assist servers with any extra work.

Volunteer(Summer 2005)
Fairland Nursing and Rehabilitation
Assisted in Activities Department; planned and assisted patients in activities and assisted in filing

Clerk(Summer 2004)
Women's Health Initiative
Assisted in filing, data entry, and mailing, answering phones

Activities

Changó Spanish Club(January 2009- Present)
Club designed to reinforce Spanish classes and broaden cultural awareness

IEEE(Fall 2008- 2009)
The Institute of Electrical and Electronics Engineers, organization based on electricity and helps gain knowledge in the field

NSBE(Fall 2006 -2008)
Organization for engineers to gain more knowledge in their field.

Track and Field(November 2003-May 2006)
Attended meets in the area

Black Women's Society(Fall 2002– May 2006)
Organization that raised cultural awareness on campus. Organized events such as assemblies, fashion shows, girls night out("spa day") .

Programs

People 2 People Student Ambassador

Visited Australia, traveled up the east coast, to gain knowledge of other cultures. Participated in a home stay and farm stay, visited the Great Barrier Reef, and the Sydney Opera House, and an aboriginal experience

Computer Skills

C++, Java, Microsoft Office

References

McCaffrey, C.; Chevalerias, O.; O'Mathuna, C.; Twomey, K. (2008, Jan.) "Swallowable-Capsule Technology." *Pervasive Computing, IEEE*. [Online]. 7.(1), pp. 23-29. Available: http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4431853[October 2, 2011].

[i] National Digestive Diseases Information Clearinghouse."Upper GI Endoscopy." Internet: http://digestive.niddk.nih.gov/ddiseases/pubs/upperendoscopy/, May 2009 [October 3, 2011]