Academic Analysis of an Android Based Student Project: Remote Medical Monitoring Station

Danyang Li, Qiao Zhen, Albert Gordon, Bhaskar Raj Sinha, Marcos Turquetti, Mohammad N. Amin
National University, San Diego, California

Abstract

First responders provide urgent care to patients in medical emergency. Such care must be initiated as quickly as possible in order to maximize the survivability of the patient. Since first aid procedures are often needed, early information on the patient's overall condition is an asset to the responders. Advances in wireless communication data collection have occurred on several fronts. In the healthcare field, it is almost standard now to use sensors of many types to collect information and to send it to a patient's phone. Multiple instances of such data collection can occur via the Bluetooth standard, the Healthcare Device Profile (HDP), etc. This project utilizes some of these sensors, together with Bluetooth communication standards, to create a remote medical monitoring station. A new mobile app was developed using the Android platform to collect, display, and store biometric data on a mobile phone, and integrate it with WiFi and cellular networks. Relevant information is forwarded to a relational database developed for storage, or can also be directed to the first responders in case of emergency. Elderly patients, who are at home, or perhaps live far away from their physicians, are at risk when it comes to their health. This system will enable them and their physicians a daily look at their vital signs without having to leave their home or office. A prototype of this system was designed, developed, and tested by students under the guidance of faculty members. This project was analyzed on how it fulfilled the program objectives. Students made a formal presentation to the Faculty Judging Panel for official approval of this capstone project and the project was approved for the degree requirement. The final report and the presentation were graded and it was ensured that they covered and reinforced the academic objectives and met the Program Learning Outcomes (PLOs).

Introduction

The Master of Science in Wireless Communications (MSWC) program at National University (NU) is a professional degree that integrates communication techniques, problem solving strategies, simulation skills and mathematical foundations with hands-on training required to solve real world problems in telecommunications[29]. The program is designed for professionals and managers to facilitate the learning and application of skills in the field of wireless communications, and uses a distinctive and challenging curriculum that emphasizes multidisciplinary knowledge. The program integrates theory through applications and design concepts. Classes combine lectures, case and hands-on studies, individual and team projects, research papers and participant presentations. With NU's MSWC program, faculty, students, and employers are assured that the graduates are proficient in analytical, technical and critical thinking skills. They have a sense of professionalism that is instilled with a strong set of values

essential for success in the wireless communications field. This program reflects current and future industry needs, and graduates from the MSWC program are trained and prepared to assume a leadership role in the field. The MSWC program prepares students to achieve professional success in both theoretical and practical aspects of communication fields. Graduates are equipped to seek employment in research organizations, computer centers, or wireless communications businesses and enterprises. This program also prepares students for further education in wireless communications enabling graduates to pursue doctoral studies, if they choose to do so. It is assumed that candidates seeking admission to the program possess a baccalaureate degree in engineering, engineering technology, or physical/computational science from an accredited university. Projects have been undertaken at NU that read a single channel of sensor data using Bluetooth into a phone and transferring that information to the web. These are centered on providing a system for reading vital signs of patients in a remote location. This capstone project, named Remote Medical Monitoring Station (RMMS), enhances the idea under an entirely different category by adding information such as GPS location, name, age, and sex, together with the ability to read multiple sensors simultaneously, having the database make decisions as to whether readings are in or out of expected parameters, and having the data create separate files for each user on the web server. First responders would find this product very useful, and hence, the focus is towards utilizing this product as an emergency medical device.

Literature review suggests some past work in this area. Heart Rate App[1], recently renamed to Instant Heart Rate, is a tool to monitor a person's heart rate, but the information obtained is kept locally on the phone. Health-Manager Pro[2] keeps track of body movements throughout the day and makes decisions, but the information obtained is kept locally as well. There are also quite a few apps that store a person's medical needs and history, such as ICE (In Case of Emergency)[3] and also ones that explore pharmacology prescription conflicts. Emergency Backpack[4] gives GPS information, but that is the extent of the data that is processed after offering some stored "survival tips". Skyscape, Medscape, Epocrates RX, and MedCalc[5,6,7,8] offer calculators, medical news alerts, and practice guidelines but provide no hard data about the current condition of the patient. This project, RMMS, provides a reasonable path to opportunity based upon its functions and how it can transmit information from people who have a need for help to people who can provide it. In the case of its use in a mass emergency, the new ability to pinpoint the victims who are in the worst conditions and who should be helped first is a way that lives could be saved, and RMMS provides a path to opportunity from that perspective.

This paper is an analysis of this capstone project (RMMS) and determines how it addresses the objective of this program and individual Program Learning Outcomes (PLOs), here at NU.

The Project: Remote Medical Monitoring System (RMMS)

This device is designed to read vital signs from sensors placed on a subject's body. There are a number of such devices available that collect this kind of information and send it to a receiver using Bluetooth. This project utilizes two such devices, a device for taking blood pressure (A & D Model UA-767 Plus BT-G) shown in Figure 1, and a device for measuring the temperature of the body (FORA IR20b Ear Thermometer with Bluetooth), shown in Figure 2.

Figure 1: A & D Model UA-767 Plus BT-G

These devices, together with the Android phone, create a piconet within the local area up to about 30 feet using Bluetooth connectivity. The newly emerging Health Device Protocol (HDP), an open standard agreed-upon by manufacturers, makes it possible to stack multiple, formerly incompatible devices that used the older serial socketing standard. The HDP resides on the core specification for Bluetooth. The Android phone application is designed to process data from the three sensors to which it is paired: the thermometer, the blood pressure monitor, and the pulse rate indicator.

Figure 2: FORA IR20b Ear Thermometer with Bluetooth

The key component in the design is the Android application within the phone. This application functions to display the collected information from the sensors and to provide decision-making capabilities such as whether the data parameters measured are far enough removed from normal range to warrant further attention (green coloring of the data on the display if the readings appear normal and red coloring if the data appears to be either above or below the range that is considered normal). Another important feature of this Android application is to integrate the information from the sensors with GPS location, time and date, and keyboard information where the patient's name, age, and sex is entered. The application sends all of the information through the cellular system link using SMS to an internet server having a database where a physician or other health professionals can access the information. This internet web page displays on a single screen the patient's name entered from the keyboard, the GPS location where the patient is

located, the date and time the measurements are made, the heart pulse rate most recently measured, the systolic and the diastolic blood pressure readings, and the body temperature. These measurements also include the indication of whether or not they were in the normal range, similar to the display on the Android phone. As a new set of data arrives, the old data is added to other prior data in a separate file for that patient on the server. This enables the physician to see how a patient's condition has changed over time.

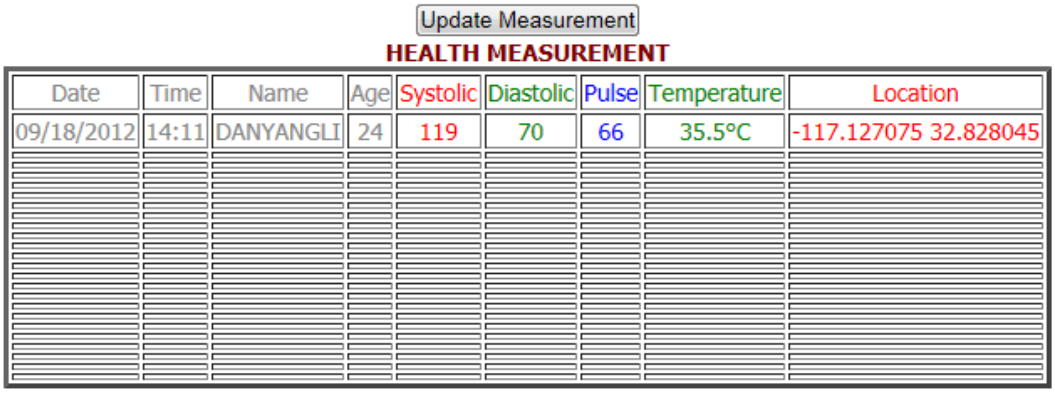

Figure 3: Example of the Server Display

Figure 3 is one line of the typical screen display readout for the server. This server display shows one patient's vital signal readings, together with their name, age, and GPS location bearings to find the victim quickly, if necessary. Machine-to-Machine capability and process comes about through the automatic saving of old data on the server and replacing it with new data whenever new data arrives, completely under control of the Android device[24].

A block diagram of the basic operations is shown in Figure 4. The three sensors pair and send data to the Android device. The Android phone uses its database and external input from the GPS, the keyboard, and the real-time clock to send a package of information to the server that saves the previous data into the patient's file and replaces it with the new incoming data. The data on both the phone and the server has decision information about the patient's data; specifically, whether it is within range or out of expected range based on the patient's age and sex. Technical objectives and/or problems addressed in the implementation of this project include assembling and processing the incoming data from the Bluetooth devices into a single stream that is suitable for the Android device using Java in its application. This goal entails the Bluetooth data interfacing with the Java platform - API and the Java Virtual Machine for Android[10], the storage of the data for a time, and the conversion of the data to a form compatible with the Java programming language. Another technical feature is the decision-making by the Android device database on incoming data from the sensors and displaying it in a useful form, together with the name of the patient and the GPS location, the date and time of collection, and the patient's age and sex, all of which appears on the Android device display. To achieve this, Android-SDK using Eclipse as the Android Virtual Device (AVD) which emulates an Android device on a computer in order to write and then test code are both utilized[17].

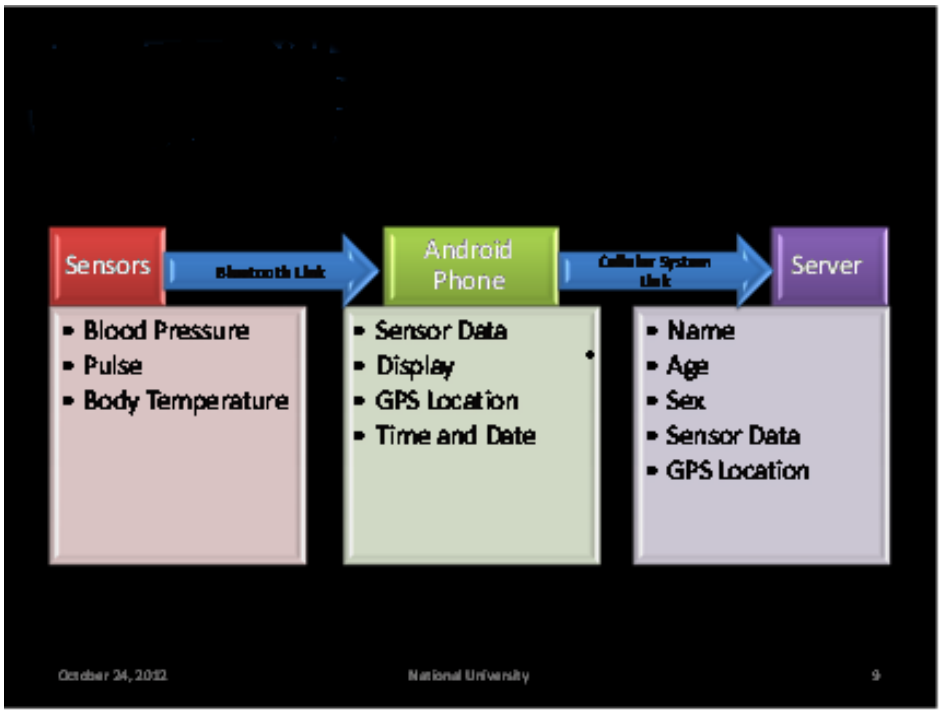

Figure 4: System Functional View: Sensors, Android Phone and the Server.

An implementation challenge was to solve the problem of integration of the data coming from the Bluetooth devices, the computer keyboard (for entry of patient's name, age, and sex), the GPS device on the phone, and the day/date of the real-time clock. The incoming Bluetooth data arrives at different times. The implementation in this regard is to buffer the information, holding it until all of the data can enter the database with the current time stamp and processed as a single unit. Other technical objectives relate to the Android phone's database having the ability to make decisions on the data in addition to the keyboard and GPS integration. For example, if the vital signs data arriving at the Android phone falls outside certain range for a patient's age and sex, the data is flagged by changing color. Another technical objective involves setting up a server that holds information accessible to EMT personnel in transit to an emergency or physicians who are interested in caring for a patient who are homebound, monitoring their vital signs on a daily basis. This database reads the date/time stamp sent from the phone along with the data, and when the data and time change (indicating new data), the server self-saves into the patient's file the prior data, and the new data is displayed, along with the GPS information, the time/date stamp, and the patient's name, age, and sex. In other words, the server displays much the same information as the phone displays at the patient's site at approximately the same time[22]. Another technical feature includes the successful implementation of data conversion from Java strings into data suitable for HTML/XMS data, such as using SMS. Also, the Eclipse IDE, while useful as an emulator for most applications, cannot emulate a Bluetooth link. Such development must be done completely on a suitable phone and a technical objective is to provide such an environment. The project website page is shown in Figure 5. This page has links leading to medical entries test tables. The website architecture schematic in Figure 6 shows the main page and the subpages.

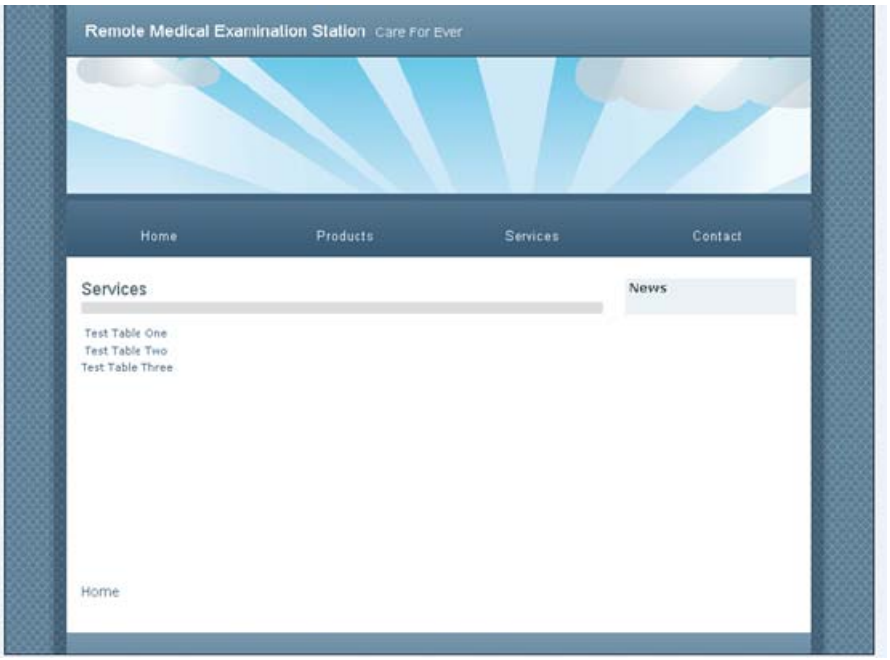

Figure 5: Project Website

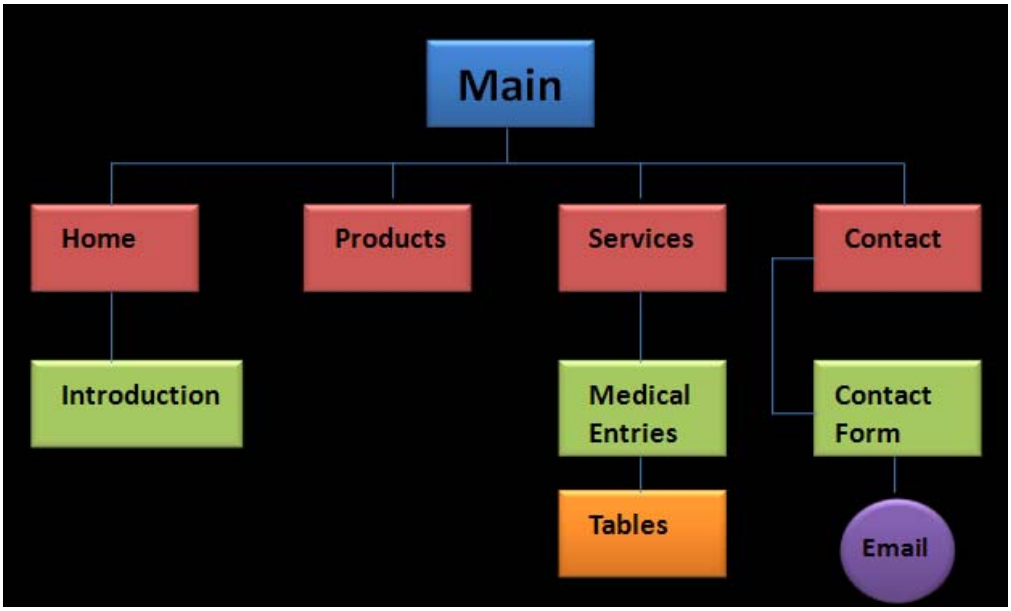

Figure 6: Website Architecture

The main page has four subpages: Home, Products, Services, and Contact. The Home page gives the general introduction to this project. On the Products page, the user can find which kind of medical devices are used for this project. The Services page shows the information table access page to reach the "Medical Entries", and the last page is Contact which provides the contact information of builders, which allows users to email builders quickly and easily. The Contact page is shown below in Figure 7.

Figure 7: The Contact Page

In addition to learning how to create HTML, CSS and possible a server side language like PHP, it is important to use the proper tools to create the website, upload them and maintain them. The first one is Testing server. Since this project not only created HTML/Javascript/CSS files but also needed to use server side languages such as PHP and databases, it was necessary to download a server which was installed on the local machine. Some subpages on the website are dynamic pages, so there is also code from a programming language like PHP which the servers turns into HTML before serving the page to the user. A tool was found which allowed creation and editing of pages. In order to test the website properly, it was necessary to see how it looks on all the major different browsers. FTP client helped upload files to the server (assuming an existing local web host). Some web tools were used to develop this project: XAMPP was the test server; Notepad++ was the webpage editor; GIMP was the graphics editor; Firefox, Chrome, Internet Explorer, and Safari were the test browsers; and FileZilla was the TP client. 000webhost was the web host on the Internet. There are four main languages used for web programming. PHP is used for developing the dynamic pages; HTML is the basic language when designing the web page. Cascading Style Sheets (CSS) defines how to display HTML elements and these were added to HTML 4.0. External Style Sheets are stored in CSS files. Finally, SQL is a standard language for accessing databases.

Recommendations for Future Research

There is a concern that sending a person's name along with the medical data over the internet might violate HIPA (Health Information Privacy Act) requirements. Therefore further work needs to be done with a patient's code number in the SMS data packet instead of the name. To make this product more marketable, another area of research is to port this onto different platforms, besides the cellular phones, that are more robust and are unlikely to be affected by earthquakes, fire, or other similar emergencies. An example of such an alternate platform might be the satellite phones that communicate with satellite repeaters that travel far above the area

affected by such a disaster and would most likely be intact during such an emergency. Another recommendation for future work is to do a Google maps directly from the coordinates presented on the server that locates a victim. This feature might include having the coordinates appearing as hyperlinks on the webserver, and clicking on the hyperlink opens up a new screen with the map locating that victim instead of using the raw coordinates for location purposes. Finally, future work needs to be undertaken to not mix HDP (Health Device Profile) and SPP (Serial Port Profile) in the same application. This project was looking for a singular device (one monitor) that was Continua certified and that stood alone as a second, singular monitor. The research discovered that all the other HDP devices not only contained several monitors but were also quite expensive. In the future, a stand-alone SPP device could be used instead of an HDP device. The recommendation is that HDP and SPP profiles not be mixed in the same application. As a practical matter they could be mixed using a time multiplexing polling loop that is not too large and that does not spend a lot of time during the loop away from either one or the other device to be managed. During testing of the app, it was determined that approximately 30% of the time one of the devices failed to get read into the application. Therefore, it is recommended not to mix the two profiles in a code rewrite in order to address this reliability issue.

Academic Analysis of the Capstone Project

The NU MSWC program is a professional curriculum developed in 2004. This was based on modern digital communication techniques and it facilitates students in wireless communications to learn problem solving techniques, advanced system design, and simulation. The mission of this program is reflected in the Program Learning Outcomes (PLOs) as follows:

1. Evaluate wireless networking, protocols, architectures, and standards to the development and design of wireless communication systems.
2. Evaluate and select the appropriate kinds of coding and decoding schemes for constructing, detecting and filtering wireless communications signals.
3. Build security into wireless communications systems and contrast ethical and legal issues in the global telecommunications industry.
4. Plan, integrate and implement multiple types of Second (2G) and Third Generation (3G) wireless networks.
5. Create strategic analysis software and tools to develop wireless, networks and service plans.
6. Develop simulation models of the radio components of wireless systems using MATLAB, SIMULINK and its communication tools.
7. Evaluate and forecast economic impact of continually advancing technologies on wireless service, equipment, application providers, and consumers.
8. Conduct research into a specific wireless communication topic, including finding and integrating relevant research results of others.
9. Demonstrate critical thinking and ability to analyze and synthesize wireless communications concepts, project management principles, and ethical standards.

In this program, students have the opportunity to learn theory, principles, and hands-on activities in the field through twelve courses. At end of the program, all students are required to take two project classes (Capstone) which allow them to apply technology and solution theories in various new and innovative applications. PLOs are achieved in the two project classes: WCM611A and

WCM611B. Duration for completing this project is three months. Students are encouraged to work as a team to gain valuable experience needed by most industries in the 21st Century. In the first month, students form teams (2-4 students per team), select research topics, conduct literature search, analyze critical aspects, and plan to reach a viable solution. In the second and third months, students perform the necessary tests/experiments, data collections, build prototypes, prepare project reports, make formal presentations, and prototype demonstration. All MSWC projects are subject to assessment by a Faculty Judging Panel (two faculty members and two industry professionals) using a "Assessment of Learning Outcomes" shown in Figure 8, that contains all the assessment criteria.

Validation of Graduate Program and Success

In this 'Remote Medical Monitoring Station (RMMS)' Capstone project (Group#2), an extensive literature search was conducted by the students in order to identify the critical user requirements, and identify a viable and cost-effective solution. Students completed the project in three months. During the first month, three students formed a team based on their common interest, elected a team leader, assigned each member tasks and responsibilities, and collected the required materials and equipment/resources. During the next two months, students were engaged in accomplishing the following: 1) design and development of different software using the appropriate tools and platforms, 2) integration of hardware and software for building a prototype, 3) testing and evaluation of the prototype, 4) collection of data and information, 5) organizing ideas and thoughts, and 6) preparing for the presentation and the written project report. At the end of the third month, students submitted their project report (first draft) to the Faculty Judging Panel of five members (two internal and three external) for review and made a formal presentation followed by a successful demonstration.

After observation of this project presentation and careful review of the written report Panel Members submitted their evaluation reports using a set of rubrics to the MSWC Program Lead Faculty. The summary of these average evaluations for this project is displayed in the Figure 8. All evaluations and comments received from the Faculty Judging Panel indicate that students did very well in the project, gained appropriate graduate level knowledge and practical experience in the field. The findings of this study confirm that student learning is aligned with the program missions and program learning outcomes.

NATIONAL UNIVERSITY

School of Engineering, Technology and Media

Assessment of Learning Outcomes by Faculty Judging Panel

Academic Program: Master of Science in Wireless Communication

Research Project I and II [WCM611A and WCM611B]

Directions: *Based on each project team's presentation and submitted materials, please indicate - for each measurable outcome included in column 2 - a number of assessment points (up to max. indicated in column 2) and a percentage of students in the team that demonstrated respective competency. For example, if, for the team #1, the measurable outcome titled "Communication Tools" was assigned 22 out of 25 points and the percentage of students in this team who demonstrated respective competency was 80%, then the number 22/25 should be written in the respective (in this example, the first) row for the Team 1 column.*

Use the blank areas to make notes of questions you wish to ask at the end of the team presentation.

PLO	Program Learning Outcomes	Assessment Criteria and Measurable Outcomes	TEAM GRADE [25 MAX]			
			1	2	3	4
1	Evaluate wireless networking, protocols, architectures, and standards to the development and design of wireless communication systems.	Report		24		
		Prototype Demonstration		23		
		Presentation		24		
2	Evaluate and select the appropriate kinds of coding and decoding schemes for constructing, detecting and filtering wireless communications signals.	Report		25		
		Prototype Demonstration		22		
		Presentation		24		
3	Build security into wireless communications systems and contrast ethical and legal issues in the global telecommunications industry.	Report		23		
		Prototype Demonstration		21		
		Presentation		22		
4	Plan, integrate and implement multiple types of Second (2G) and Third Generation (3G) wireless networks.	Report		24		
		Prototype Demonstration		23		
		Presentation		23		
5	Create strategic analysis software and tools to develop wireless, networks and service plans.	Report		25		
		Prototype Demonstration		24		
		Presentation		24		
6	Develop simulation models of the radio components of wireless systems using MATLAB, SIMULINK and its communication tools.	Report		24		
		Prototype Demonstration		23		
		Presentation		22		
7	Evaluate and forecast economic impact of continually advancing technologies on wireless service, equipment, application providers, and consumers.	Report		21		
		Prototype Demonstration		24		
		Presentation		23		
8	Conduct research into a specific wireless communication topic, including finding and integrating relevant research results of others.	Report		22		
		Prototype Demonstration		25		
		Presentation		24		
9	Demonstrate critical thinking and ability to analyze and synthesize wireless communications concepts, project management principles, and ethical standards.	Report		22		
		Prototype Demonstration		23		
		Presentation		24		

Figure 8: PLOs and Project Grading for Team 2 [RMMS]

Conclusions

A prototype of the RMMS system was designed, developed, and tested by students under the guidance of faculty members. Goals with regards to this project and meeting the program PLOs were accomplished, and the project was successfully demonstrated at a gathering of National University personnel, including faculty. A random person from the audience was selected during the demonstration, sensors were strapped on the subject, and vital signs read the were read on, not only the cellphone, but also sent the person's vital signs, name, age, sex and location successfully via the internet to one line of our monitoring program on the webserver. Based on the above successful demonstration of the project prototype, it is suggested that this application could be made marketable in at least two general areas: (1) as an assistance to first responders in an emergency that requires critical care to a large number of patients being served by a limited number of medical personnel, and (2) as a device to be sold to doctors and/or patients who need to be monitored often but who live in a remote area not having means of transportation to a medical professional for the purpose of being examined. In the latter case, such monitoring would not replace assistance by a professional but only enhance the care being offered by being able to more closely watch a patient. This project was analyzed on how it fulfilled the program objectives. Students made a formal presentation to the Faculty Judging Panel for official approval of this capstone project and the project was approved for the degree requirement. The final report and the presentation were graded. This paper demonstrates an academic analysis of this capstone project and determines how it reinforced the academic objectives and addresses the objective of this program and individual Program Learning Outcomes (PLOs), here at NU.

References

1. App Brain Online. *App Brain Report: Instant Heart Rate*. (2012).July 28, 2012 from http://www.appbrain.com/app/instant-heart-rate/si.modula.android.instantheartrate
2. Androlib Online. *Androlib Report: Healthmanager Pro*. (2012). July 28, 2012 from http://www.androlib.com/android.application.jp-ievolution-healthmanager-pro-niiE.aspx
3. Google Play Online. *Google Play Report: In Case of Emergency (ICE). (2012). July 28, 2012 from* https://play.google.com/store/apps/details?id=com.appventive.ice
4. Latest Android Apps Online. *Emergency Backpack App Review*. (2012). July 29, 2012 from http://latestandroidapps.net/apps/tools/emergency-backpack/
5. Skyscape Online. *Free Skyscape Medical Resource App*. (2012). July 29, 2012 from https://www.skyscape.com/index/home.aspx
6. Medscape Mobile Online. *Medscape Mobile Application*. (2012). July 29, 2012 from http://www.medscape.com/public/mobileapp
7. Epocrates Online. *Epocrates Medical Application for Android*. (2012). July 29, 2012 from http://www.epocrates.com/mobile/android
8. AppsZoom Online. *Android Zoom Report: MedCalc*. (2012). July 30, 2012 from http://www.androidzoom.com/android_applications/medcalc
9. Wikipedia Online. *Android (operating system)*. (2011). Aug 2, 2012 from http://en.wikipedia.org/wiki/Android_(operating_system)

10. PR Web Online. *Blood-pressure Monitor*. (2012). Aug 2, 2012 from http://www.prweb.com/releases/blood_pressure_monitoring/BP_measurement_instrument/prweb4720184.htm
11. WebMD Online. *Body Temperature Thermometer*. (2011). July 20, 2012 from http://firstaid.webmd.com/body-temperature
12. Kickstarter Online. *Pulse Sensor: An Open Source Heart-rate Sensor that Rocks.* (2011). Retrieved July 27, 2012 from http://www.kickstarter.com/projects/1342192419/pulse-sensor-an-open-source-heart-rate-sensor-that
13. App Brain Online. *Number of Android Applications.* (2012). July 27, 2012 from http://www.appbrain.com/stats/number-of-android-apps
14. Youtube Online. *Programming for Android, Part 1, Installing Everything You Need.* (2012). July 25, 2012 from http://www.youtube.com/watch?v=z_vC0RLryuo&feature=related
15. Rural Assistance Center Online. *Emergency Medical Services.* (2012). August 1, 2012 from http://www.raconline.org/topics/ems/
16. Hubbard, John R. (2004). Programming with Java, 2nd edition. Schaum's Outline Series. McGraw-Hill. 303-311.
17. Zakhour, Hommel, Royal, Rabinovitch, Risser, and Hoeber. (2006). The Java Tutorial, 4th edition. Sun Microsystems. 261-276.
18. Jackson, Wallace. (2011). Android Apps for Absolute Beginners. Apress Publishing. 147-166.
19. Android Medical Apps. *Android Medical Apps.* (2012). Retrieved July 22, 2012 from Google
20. Goodman, John. (2012). *Medicine by Remote Control*. National Center for Policy Analysis. http://healthblog.ncpa.org/medicine-by-remote-control/
21. Huang, Randolph. (2007). Bluetooth Essentials for Programmers. Cambridge University Press. 41-50
22. Mercer, David. (2001). Schaum's Outline of HTML. McGraw Hill. 212-216
23. Mills, Elanor. (October 16, 2011). *Report: Android App Market Growing Faster Than iPhone Apps"*. CNET Reviews.
24. Tasooji, Matthew. (3/17/2012). Lecture on new areas of technology, WCM607, Day7. National University.
25. Conversations with proclaimed Bluetooth/Android programming "gurus". 7/2012–9/202
26. Le Bodic, G. (2003, January). Mobile Messaging Technologies and Services: SMS, EMS and MMS, *John Wiley & Sons*. West Sussex, England
27. Stichbury, J. (2004). Symbian OS Explained: Effective C++ Programming for Smartphones. *John Wiley & Sons*, Hoboken, NJ.
28. Barker, R. & Edwards, L. (2004, July). Getting Started With C++ SDKs and Symbian Development. *Addison-Wesley Professionals.* Indianapolis, IN. Retrieved August 20, 2009 from http://www.informit.com/articles/article.aspx?p=176459&seqNum=3
29. Amin, M. (2010). Master of Science in Wireless Communications. *National University.* San Diego, CA, Retrieved December 26, 2010 from http://www.nu.edu/OurPrograms/SchoolOfEngineeringAndTechnology/AppliedEngineering/Programs/720-816.html
30. Jenefsky, C., Bresciani, M., Buckley, L., Fairris, D. & Kasimatis, M. (2009, September). WASC Resource Guide for "Good Practices" in Academic Program Review. *Western Association of Schools and Colleges.* Burlingame, CA. Retrieved December 3, 2010 from http://www.wascsenior.org/findit/files/forms/WASC_Program_Review_Resource_Guide_Sept_2009.pdf
31. Wikipedia Online. (2012). *Location-based Service*". October 12, 2012 from http://en.wikipedia.org/wiki/Location-based_service
32. Wikipedia Online. (2012). *Short Message Service*. October 17, 2012 from http://en.wikipedia.org/wiki/Short_Message_Service
33. Wikipedia Online. (2011). *Global Positioning System*. October 12, 2012 from
34. http://en.wikipedia.org/wiki/Global_Positioning_System

Authors' Biographies

Danyang Li

Student, MS Wireless Communications Program, School of Engineering and Technology, National University, San Diego, California, onlyifyy@gmail.com
Major research interests: Wireless communications, sensors

Qiao Zhen
Student, MS Wireless Communications Program, School of Engineering and Technology, National University, San Diego, California, joshua002@126.com
Major research interests: Wireless communications, sensors

Albert Gordon
Student, MS Wireless Communications Program, School of Engineering and Technology, National University, San Diego, California, al.gordon@roadrunner.com
Major research interests: Wireless communications, sensors

Bhaskar Raj Sinha, Ph.D.
Professor and Lead for the BS Information Technology Management Program, School of Engineering and Technology, National University, San Diego, California, bsinha@nu.edu, Tel: (858)309-3431, Fax: (858)309-3419
Major research interests: Computation, digital systems, database, software engineering.

Marcos Turquetti, Ph.D.
Adjunct Faculty, MS Wireless Communications Program, School of Engineering and Technology, National University, San Diego, California, Marcos.Turqueti@natuniv.edu
Major research interests: Wireless communications, database, sensors

Mohammad N. Amin, Ph.D.
Professor and Lead for the MS Wireless Communications Program, School of Engineering and Technology, National University, San Diego, California, mamin@nu.edu, Tel: (858)309-3422, Fax: (858)309-3419
Major research interests: Wireless communications, database, sensors