21/04/2016

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby British Columbia
V5A 1S6

Re: ENSC 305/440 Project Post Mortem for the Omega Key

Dear Dr. Rawicz,

The following document will review and reflect upon the process our team took to develop our dynamic display keyboard, the Omega Key. The Omega Key is a keyboard with display screens on each key that update to reflect the current usage of the keyboard. The Omega Key can also be customized to provide special functionality for each key press.

This document will summarize the our motivations for producing this product, its purpose, and how our team worked to create it. This document will also examine how well our initial plans translated to reality and provide a brief economic analysis for the Omega Key. As well, personal learning reflections and team agendas and minutes are included in the appendix.

Breakthrough Innovations Group (B.I.G) has six very talented engineering students: David Pallmann, Chase Kwak, Steven Liu, Steven Timotius, Steven Luu, and Frank Tran. If you have any questions or concerns about our post mortem, please feel free to contact me by email or phone at dpallman@sfu.ca or (604)-928-9269.

Sincerely,

DPallmann

David Pallmann
President and CEO
Breakthrough Innovations Group (BIG)

ENSC 305W/440W

Post Mortem:

Omega Key

Team Members:

David Pallmann
Frank Tran
Chase Kwak
Steven Luu
Steven Timotius
Steven Liu

Contact Person:

Chase Kwak – ckwak@sfu.ca

Submit to:

Dr. Andrew Rawicz – ENSC440W
Steve Whitmore – ENSC305W
School of Engineering Science
Simon Fraser University

Issue Date: 21/04/2016

Revision: 1.0

Executive Summary

This report contains post mortem of the Omega Key made by Breakthrough Innovations Group. It covers high level system overview, materials used, budget, schedule, market analysis, and challenges. System overview shall provide a detailed description of our proof-of-concept model as well as justifications for parts chosen. It will further elaborate on the hardware and firmware design and why such designs were preferred over other options.

Budget and schedule section will include a comparison between the estimated costs and schedule versus the actual costs and schedule. In problems and challenges section, unexpected issues in the planning and integration stages of the project will be discussed followed by decisions made to deal with such issues. Finally, each group member's reflection on the project and meeting minutes will be provided in Appendix A&B.

BREAKTHROUGH INNOVATIONS GROUP

Go BIG or Go Home

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Introduction

The Breakthrough Innovations Group has spent the last 4 months developing the Omega Key. The Omega Key is a keyboard with an OLED display screen on each key. The screens update its visuals depending on the current usage scenario of the user. As well, the Omega Key can customize the functionality of each key, allowing for non standard inputs. This is meant to help in situations where the user's input does not reflect the standard labels on a keyboard; or if standard keyboards simply do not have the functionality for specific input, such as special characters. Such use cases include typing in another language, inputting symbols for sciences and mathematics applications, and computer gaming.

For the proof of concept that we built, we decided to limit ourselves to a 12 key model instead of a full keyboard. Due to time, budget, and facility constraints, it was not viable to do a full keyboard so we decided on a smaller version, similar to a keypad. The proof of concept model comes with 3 pre-sets, which completely alter the functionality of each key in order to showcase the versatility of the design.

This document will discuss a system overview, the team dynamics, the product's business case, timeline, budget, problems encountered, and work breakdown. Finally, it will conclude with a quick summary of the project and our accomplishments.

System Overview

The Omega Key's basic design includes keys, display screens, and a microprocessor. When a user presses a key, the microprocessor will check the key's corresponding input data, and then transmit that to the computer through a USB connection. When the keyboard's layout changes, by pressing a layout switch button, the microprocessor will update all the displays with new images and load different input data for all the keys. A full, production version would include computer software for the user to define their own key layouts and functionality.

The proof of concept model has several deviations in functionality. First and most obvious, it is a 12 key, keypad sized model. Secondly, instead of having computer software to define layouts, the layouts will be predefined. From a design perspective, all the size dimensions of the model are also larger than a production version. For ease of development, we compromised to utilize two Arduino boards instead of a single microprocessor.

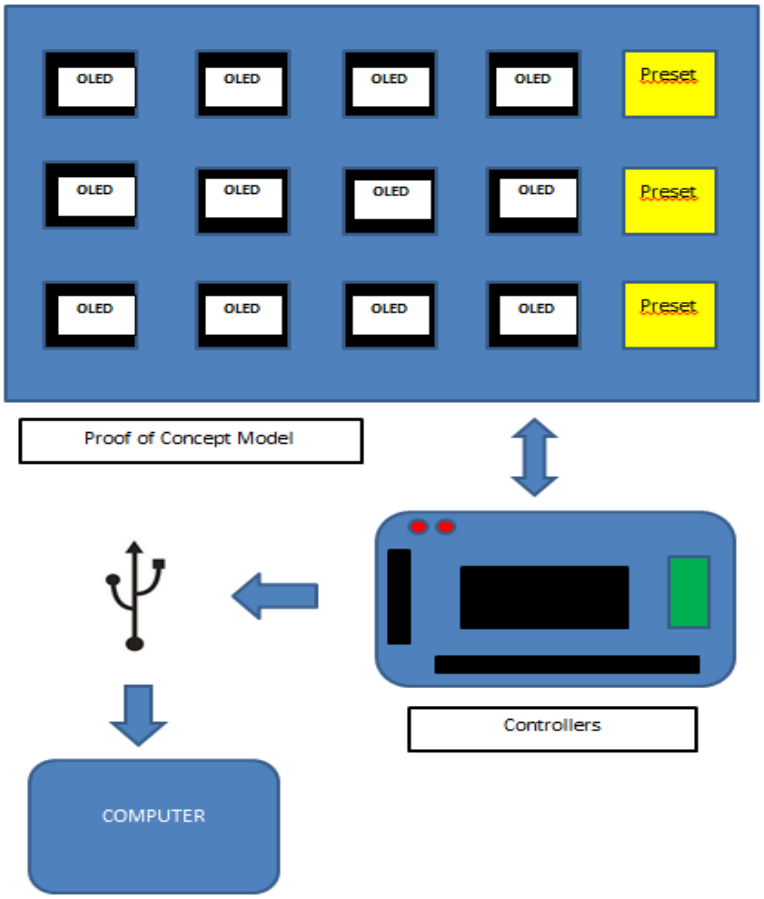

Figure 1: System's concept diagram

Display Screens

The display screens used were Diymall OLED Display Modules. We chose this because of its small size and I2C communications protocol. The I2C protocol uses fewer wires, reducing our wiring complexity.

Switches

The switches used for the keys were Cherry MX Blue keyboard switches. We chose this because of its tactile feedback when pressed.

Key Caps

The key caps that sit on the switches and hold the display screens were designed using CAD software and 3D printed.

Arduino Leonardo

The Arduino Leonardo board was chosen as one of our microcontrollers due to its special chipset. The chipset facilitates USB communications with computers, allowing the Omega Key to act as a keyboard and communicate using the HID protocol. The Leonardo was also used to handle all the key press detection.

Arduino Mega

The Arduino Leonardo does not have enough IO pins to support all the displays, so the Arduino Mega board was chosen as the second microcontroller. The Mega has a vast amount of IO pins and larger memory to store image bitmaps. The Mega was used to control and update all 12 display screens.

Team Roles

David Pallmann

David was Breakthrough Innovations Group's CEO and development team leader. Through his vision, dedication, and leadership, the team was able to accomplish the ambitious goals of producing the Omega Key proof of concept. David also took on the role of mechanical engineer, creating most of the CAD diagrams for the physical parts.

Frank Tran

Frank had the role of software engineer, writing the firmware running on the Arduino Mega board. The Mega board was used to control all the display screens, and Frank was tasked with researching the protocol and interface for the displays and writing the software to control them. Also, Frank was the quality assurance lead, ensuring proper functionality of the system.

Chase Kwak

Chase performed the role of communications liaison, being the primary contact with stakeholders of the project. Chase was also responsible for ensuring the team was up to date with important information. He also contributed as a mechanical and electrical engineer, assisting with hardware design and wiring of the system.

Steven Luu

Steven Luu was the financial director, ordering parts and keeping track of spending with regards to our budget, ensuring the project's financial stability. Luu also performed a significant amount of market research for the Omega Key. As well, he performed some duties as an electrical and mechanical engineer assisting in the hardware integration.

Steven Timotius

Steven Timotius took on the role of software architect, designing the high level software logic. He researched the communications protocol for USB keyboards to implement in the Arduino Leonardo board. Timotius developed the firmware running on the Leonardo and assisted with firmware development for the Mega. As well, he assisted in some electrical design.

Steven Liu

Steven Liu performed the duties of mechanical engineer and machinist. He completed the measurements and machining of mechanical parts, including the casing. As well, he acted as a secondary procurer, purchasing parts.

Budget

The actual cost of the Omega Key was within the range of our proposed cost however there were some issues that caused us to be over budget. We were funded $395 from the ESSEF to build the Omega Key and currently we are over the budget by $81. This was mainly due to our decision to replace our initial OLED displays with a different model as we ran into issue working with it. The new OLED displays are costs roughly four times more than the old displays. Fortunately we are able to return the old OLED displays to obtain a refund of roughly $60 which makes us roughly $20 over budget when it is processed.

Another big cost was due to changing our system from having ten keys to twelve keys. The additional two keys increased our costs as we had to purchase additional displays, switches, and materials. This change took a toll on our budget as we initially purchased ten displays, ordered extra displays, and then return them.

Our proposed cost had a mechanical keyboard listed as an expense to be used as a reference for our project however we decided not to purchase one. Instead we were able to obtain a couple of old membrane keyboards to use as a reference. We were also able to borrow some keycaps from a typical mechanical keyboard to used in our model.

Initially we were considering 3D printing the switch bed and the casing to hold the wiring and components of the system. The cost of 3D printing is fairly expensive so we instead decide to make our own using some wood from a home hardware store. This allowed us to save a lot of money while creating a sturdy structure.

Additionally some of the extra costs were due to the current exchange rate of Canadian currency as some components had to be purchased from sellers in the United States or priced in USD.

Parts	Total Cost (CAD)
Microcontrollers	150
LCD graphic displays	40
Blue Cherry MX Switches	50
Mechanical Keyboard	150
3D printing	60
Total	550.2

Table 1: Proposed Cost

Parts	Total Cost (CAD)
Arduino Mega	68.04
Blue Cherry MX Switches	27.20
Test Display	15.99
Old OLED Displays	88.00
New OLED Displays	164.89
Solderable Breadboard	11.99
MCP23017 Chip	1.82
3D Printing	43.00
Jumper Wires	11.00
Plastic for Keycap	7.60
Wood (Pine)	3.83
Shipping	35
Total	476.32

Table 2: Actual Cost

Market Analysis

The Omega Key is in a class of products that presents interesting and diverse challenges. These types of products are ones where there has been no real breakout into consumer markets. In other words the consumer does not know that they need our product. What this generally means is that a large amount of money will have to be spent on marketing to essentially teach consumers that they need the product. This being said the research we have done leads us to the fact that a lot of consumers would want this product. It would have to be a high end device for successful people wanting to improve the way they do business and their personal lives.

Some of the potential applications are:

- Typing in Languages other than English
- Creating macros for gaming
- Specialty keys for technical reports
- A doctor who said she could use something like that in her reports as she has to repeat a lot of the same jargon

These are the applications that we have thought of or that have been presented to us however the exciting thing is that our product is one that will have applications that we haven't dreamed of.

It would be ideal for the Omega key to be paired with an existing company like logitech or razer that would be able to spend the capital to break this product out onto the market and defend against the copycats that will spring up.

Schedule

Below is the originally proposed timeline for the project.

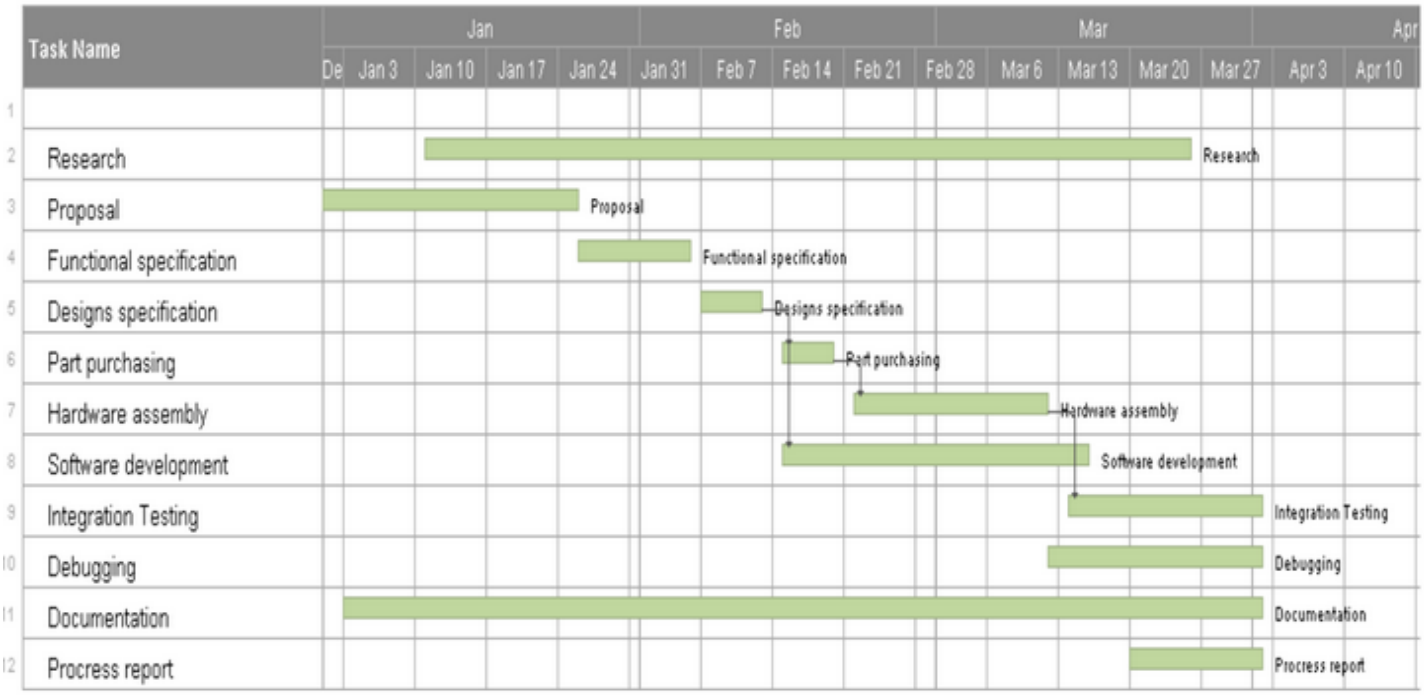

Figure 2: proposed schedule for Omega Key development

Taking into account the actual final deadline that is around April 11, the proposed schedule give some leeway of about one week to tackle unexpected problem at the end by setting the final deadline on April 03.

However, the proposed deadline could not be followed, below is the actual timeline for various tasks during the project

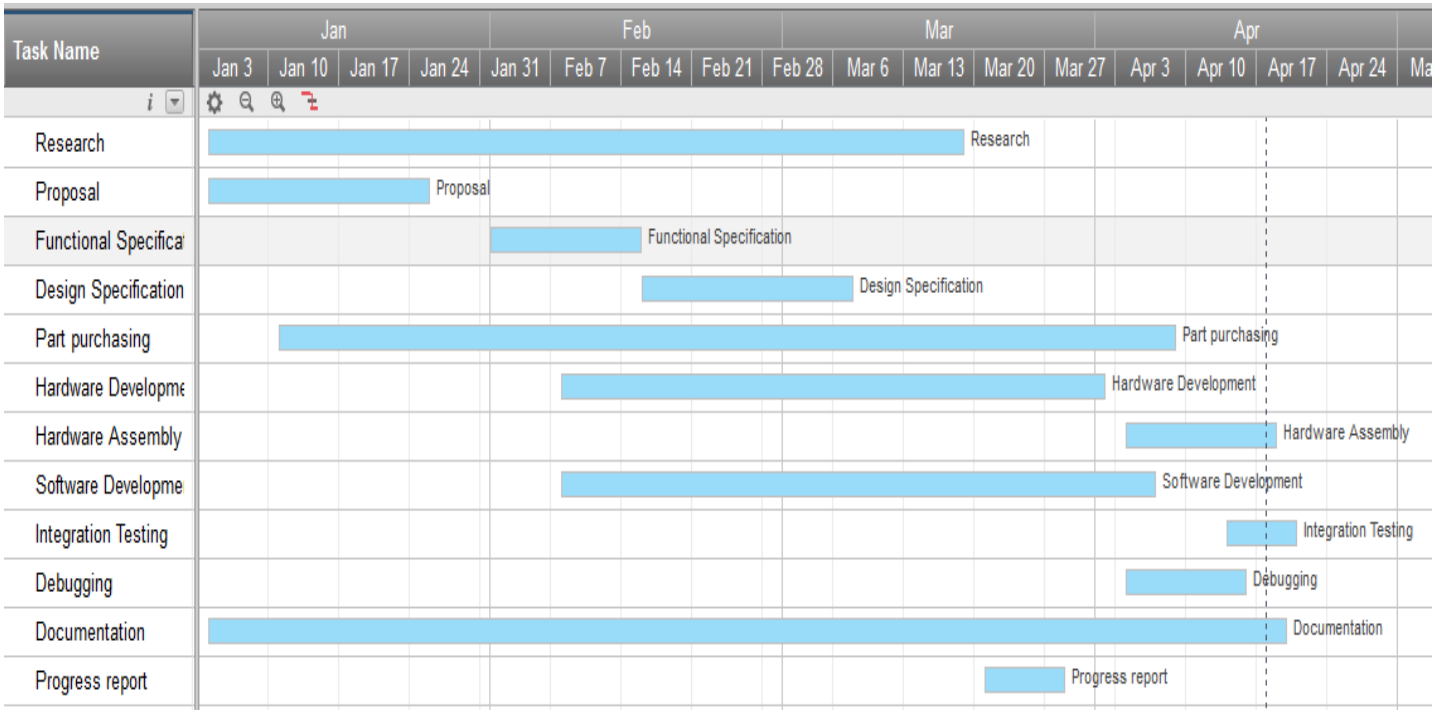

Figure 3: Actual timeline for Omega Key development

As shown in figure 3, certain documentation tasks such as functional and design specification started and finished later than in the proposed timeline. The main reason is that the proposed timeline did not take into account the lecture content and other deadlines set by the course.

Furthermore various problems occurred with the OLED displays which delayed the hardware assembly step and caused it to finish later than expected. Integration testing was also delayed due to hardware not being available.

The software/firmware development started as planned but was delayed due to the display screen parts being late which also delayed the testing/debugging period.

Problems and Challenges

Throughout our journey to create the Omega Key, we encountered several perilous challenges that we had to overcome. Early on, during our design specification, we identified that all our peripherals, the display screens and switches, would require many connection pins. No Arduino board would have that many pins by default. Initially, we planned to use a GPIO expander, an extension that would let fewer physical pins on the board connect to multiple peripheral pins. However, there were several flaws to this plan. First, it would significantly overcomplicate the wiring and code. Secondly, we were unsure if a single board could power so many peripherals. Eventually, we changed the design to use two Arduino boards, in part due to the relative low cost of an extra board. The downside of this method is that the Omega Key proof of concept will require 2 USB cables to power it.

The second problem we encountered was the first set of displays we ordered. We mistakenly assumed that we would be able to solder the connections, but we discovered that it required machine soldering and we did not have access to such facilities. We had no choice but to return the displays and order a different kind. This was a significant hit to our budget. The new model of screen was larger, and therefore required a redesign of the other parts to accommodate the different size. As well, we had to wait weeks for the new displays to arrive. As mentioned in the scheduling section, this resulted in about a 2 week delay in our schedule. The new displays also draw more power, and we found that the Arduino Mega board may heat up more than anticipated. We recovered but our system test time was greatly reduced.

There were several other minor issues that we encountered. For example, deciding on how to make the box to house the product. We initially planned on 3D printing, but figured it was cheaper and stronger to make it out of wood. Software development for the Arduino boards was also a challenge, as we had to consider the significantly weaker specifications compared to a normal desktop computer. In order to compress the image and translate the data into code, we had to write auxiliary Python scripts. As well, an efficient yet extensible format had to be designed to hold the key data. Several modifications had to be made to the libraries used to fit our requirements.

Finally, our last challenge was one we faced throughout the development process - time management. Early on, it was difficult to commit to our planned timeline, due to personal reasons and scheduling conflicts with a relatively large group of 6. It later became impossible due to shipping times and the issue with the displays. The result was significant amounts of stress when nearing the project deadline. Overall, our team faced many challenges together, but there were no significant problems with the team dynamic.

Work Breakdown

	David Pallman	Chase Kwak	Steven Luu	Steven Liu	Steven Timotius	Frank Tran
Documentation	xx	xx	xx	xx	xx	xx
Meeting Minutes			xx			
Financial management	x	x	xx	x		
Hardware design	xx	xx	x	x		
Software development (Leonardo)					xx	x
Software development (Mega)					x	xx
Manufacturing	x		x	xx		
Wiring and Soldering	xx	x	x	x	x	x
Casing and Assembly	x	x	xx	xx	x	x
Testing and QA	x				x	xx

Table 3: Team contribution

Conclusion

The Omega Key proof of concept was a success from a technological standpoint. We successfully produced a keypad with dynamic display screens and the functionality to input special characters. The technology is definitively feasible and useful. However, many improvements need to be made before it is marketable and economically viable.

The proof of concept model of the Omega Key lacked the accompanying key choosing software for end users to define their own personal key layouts and functionalities. Definitely, for this to be usable by a wide range of consumers, they need to be able to customize the Omega Key for their own unique needs. Such software would be difficult and time consuming to produce, but would be possible since it's essentially an automated and user friendly version of how we defined our preset key layouts.

To be economically viable, the cost of production must be reduced. The display screens we used were suitable for a proof of concept, but not for large scale production due to their relatively high cost. Instead, more evaluation needs to be done in order to decide on a better method of dynamic displays. Perhaps a future model would use the smaller and cheaper display screens we initially wanted to use, or design a new display screen model purpose build for the Omega Key. Alternatively, an entire new design for the switch bed could be developed to utilize a single large display screen for all the keys. Doing this would require invention of an entirely new key switch design that is hollow in the center to view the underlying screen. The mechanical components of the switch would be located on the perimeter. Having a single screen would greatly reduce cost.

Finally, we need to do market research to see if consumers would prefer a full sized Omega Key keyboard with 104 keys or a helper keyboard like the proof of concept with around 12 keys. A 12 key model would just supplement a traditional keyboard. It is debatable if the increased functionality of a full keyboard would justify the increased cost over a small, helper version.

Ultimately, the Omega Key has great market potential, but will require investors to support the development costs and facilities.

Appendix A: Self reflection

David Pallmann

Capstone was absolutely exhausting. I have never had a project course like this at SFU but after this experience I wish there was more. I not only learned how to integrate some of the vital courses I took during my degree but learned things that the other courses could have not possibly taught me.

For example the mechanical designs I created were definitely helped from my knowledge of ENSC 230 and ENSC 489 but instead of having to create a Solidworks of an existing part I had to design the parts by scratch to strict specifications with little to no room for error. It was also my first time creating a part from 3D printing realising the flaws, adjust the design and 3D print again. This process of trial and error was so gratifying in the end when you come up with your finished product. Some of the other mechanical design elements I learned were how to properly allow for all components to fit. In my first iteration of the switch bed I had only allowed enough room for the switches to have a 1cm gap between them, however when I made the final design I realized that the keycaps had to go on top of the switches meaning I had to allow for a much larger space and figure out the center of keycaps in relation to the switches.

The documentation in this course allowed me to become more efficient at project management. From seeing what a functional specification looks like to how to format formal meeting minutes the knowledge gained from the documents was extremely useful.

Finally the skills I learnt from being project leader will be something that I will take with me throughout my career. This was probably my favourite aspect of this course, being able to manage timelines, communicate with various group members, and help solve problems that arise was all really fun. This was a role I naturally took on as it was my idea originally so I had a big head start on thinking about a lot of the problems that I compared to the other members of the group. Having said that I am pretty sure that project management is what I want to get into after university, it allows me to create amazing systems while still being able to communicate and work closely with other people.

Overall this course has been one of my favourites at SFU and I wish that there was more like them. I think that a critical part of an engineer's degree is to learn how to integrate the skills they have learned together and this course allowed my group and I to do just that.

Frank Tran

In the past 4 months, I have been able to consolidate my previously acquired technical knowledge as well as further my interpersonal skills while working through the project. Over the semester, I have experienced more about programming firmware for Arduino microcontroller and the many small detail intricacies that I previously had not been clear about. One major problem regarding the Arduino that I had overcome is the SRAM running out of memory when running the program. This prompted me to look up various online guide and articles about Arduino memory and ways to remedy it. This knowledge will be useful for me in the future since the memory problem is not limited to Arduino microcontroller but is also a general problem for embedded systems. Various miscellaneous problems also occurred when interfacing the Arduino with the OLED displays or interfacing communication between 2 microcontrollers. The experience has been rewarding and allowing me to consolidate my knowledge of electronic circuits.

I also obtained a great deal of interpersonal skills when it comes to team management and cooperating with other team member during various phases of the project. I learned to be able to better manage my time to complete my own assigned task and to be ready for integration with other parts of the development process. This semester has been one of the busiest in my time at SFU and I believe it would help me prepare for dealing with pressure and deadline in the future. I also learned the importance of teamwork as the total amount of work for the project is quite large such that no single person can finish everything within the 4 months allotted time. When tasks are divided between each member, the work progressed much smoother.

Although we did not ideally meet our original goal for our proof of concept product, I still feel a sense of accomplishment for what we have done for this semester.

Chase Kwak

Even though there was only 4 months given to do a project for the capstone course, the time spent with my teammates was invaluable to me. I was able to learn both technical and interpersonal skills working with my teammates and moreover I really enjoyed working in a fun and encouraging atmosphere.

I had a doubt at first when we decided to develop a keyboard because I thought developing a keyboard was not ambitious enough to be capstone project. However, when I recalled when I was frustrated with looking for mathematical symbols for my technical report I was convinced that there was a need for improvement for the existing keyboard. Also, I thought being able to type in multiple languages could be very attractive option to people who speak multiple languages.

My roles in Breakthrough Innovations Group were a systems engineer and communication liaison. I participated in the hardware design and facilitated the communication between hardware team & software team. As a Systems engineer, I worked on the hardware design for the connection between OLED screens and Arduino mega. During this process, I learned about I2C communication protocol and how components will be connected to each other in order to communicate and function.

One of the biggest challenges I had was to look for a right connector to connect OLED screen to the controller. We thought we could hand solder with machine provided in SFU but later we realized such connection can only be made with high precision tool which we did not have access to. From this experience, I learned it is important to consider the compatibility of each part with others to reduce the time wasted for re-ordering parts.

Throughout the term, I was able to learn design process, team dynamics, soldering, hardware development and writing skills. I feel very lucky about doing a project with people who have different skills. Even though I did not participate directly in the software development, I learned very useful knowledge from our software team members. I am now confident enough to initiate myself to do my own Arduino project.

If I had given more time to work on this project, I would like to make a keyboard that is close to marketable product. I want to design our own PCB to reduce the cluster of wires used for our proof of concept model. Also I would like to enhance the typing experience of Omega Key as the keys right now are a bit wiggly. I can improve that by adopting new switch mechanism or redesigning the keys and switch bed.

Steven Luu

During the past semester I've had the pleasure of working with five other talented engineers in Breakthrough Innovations Group on the Omega Key. The project has been great in gaining hands on experience in project works, and in team dynamics. Our group formed at the end of previous semester, and meeting up and discussing the project before this semester gave a glimpse of the work ethics and the skills of each member.

At the beginning of the project I was assigned to the hardware team and kept track of our meetings and organized some of our documents. I worked closely with the hardware team where we discussed at great length on the mechanical designs, materials, and solutions to hardware issues. My responsibilities included hardware development, system integration, and acquiring most of the components. My role evolved into being the financial director which became challenging as we made several changes to our design, mainly replacing the OLED displays. Fortunately I had ordered a test display which we used as the new displays, this allowed the software team to keep the code without making changes. However ordering the OLEDs was challenging as the displays had to be purchased from American site, shipped to a friend's house, and then mailed to my address to arrive promptly. As the system approached its integration phase I utilized my hardware skills to solder wires to the breadboard, securing components, and wiring the system.

From this experience the most important thing I've learned is that team communication can make or break a project. The problems we have encountered would be a greater issue if we were not able to explain our issues and quickly come up with solutions. Additionally I've learned the difficulties of project planning and design as we were fairly close to our deadlines in our documents and building our system.

Though we were able to successfully build our system there are several area where I feel that I could have performed better. First, I should have taken up the role of financial director myself so we could have started putting together the hardware much earlier. Additionally I felt that I did not contribute as much as I could have in terms of hardware design even though I did learn to use Corel Draw for laser cutting designs. Overall the group could have save a lot of time if we noticed the main issue with the OLED displays before ordering them, and managed our time better.

The members of Breakthrough Innovations Group were a great team to experience this project with. We have very little conflicts and the problems we ran into were solved promptly. Our group have varying personalities that is good for keeping us focused on our goals while maintaining a positive attitude. I am thankful to have worked with this group and the going through this project experience with them.

Steven Timotius

During these last 4 months, I had the pleasure of working with the 5 other fine individuals of Breakthrough Innovations Group. It was fun to get to know and become good friends with new people of varying personalities. Many laughs were had since 3 of us had the same first name. From a teamwork perspective, it was a good experience.

While developing the Omega Key, I was able to learn new things and improve my skill set. During the design, I examined the different kinds of prototyping boards, including Arduino, Raspberry Pi, and Zedboard, to determine which was suitable for our project. I was surprised by the different specifications for all the boards, including chipset, processor frequency, memory and number of IO ports. Developing software for the Arduino was actually a first time experience for me. I was impressed at how straightforward the integrated development environment for the Arduino was. The supporting documentation was clear and detailed.

Most of the challenges I personally faced were during the software development. The most stimulating part of the development process was designing the software architecture for the Omega Key system. Different design patterns for detecting a change in key switch state were considered, including interrupts and polling. I chose polling since it was easier and more reliable. I designed a simple yet robust protocol for communication between the Leonardo and Mega board. We also identified that the Arduino Mega board does not have any file system, so image files have to be translated to constants in code. Also, in image files, each pixel takes 3 bytes, but since our images are black and white, it can be reduced by 1/24 to 1 bit. I learned to write a script using the Python language to convert 12 images into compressed binary data as constants in C code. I used similar techniques to store the key input data. One interesting problem we anticipated was signal bouncing, as when a key is pressed, the resulting signal may not be stable right away. This problem was also stimulating to solve, which involved the use of timers to record the last change in signal.

I am grateful that I had the chance to use the skills I learned in computer engineering in a practical setting. The things I learned from undertaking this project will definitely be useful in my future career. I do wish I had the chance to use FPGAs for a marketable product, since I don't really see their application when compared to the speed of the latest general purpose processors. If given a longer time for this project, I would like to have used a printed circuit board to reduce the complexity and length of wiring. None of the courses I've taken have had us design a PCB, which I find to be a lacking topic. In summary, I have enjoyed this course, learning practical skills and improving interpersonal skills with my teammates. Breakthrough Innovations Group will always be remembered as a milestone in my undergraduate career.

Steven Liu

Although a semester is only 4 months long, this group has been formed 5 months ago in early December of 2015. Many of us have known each other and collaborated with each other in previous courses. Here in Capstone, we have the opportunity to once again put our knowledge into use to form the Breakthrough Innovations Group.

Our team worked with excellent teamwork and efficiency. With various strengths, personalities, and talents in the group, we had absolutely no team dynamic issues. All of challenges were caused by technology - which is what engineering is about. Therefore, it was an extreme pleasure working with everyone, grinding time in the lab, grinding time in the shop, grinding time in the library, and grinding time in the pub.

I was able to learn a lot throughout this project in time management, hardware development, machining, and system integration. As someone who has not been heavily exposed to microcontrollers outside the classroom, I was able to pick up valuable knowledge from our software team. Furthermore, I had the opportunity to be exposed to various machining equipment such as 3D printers, laser cutters, and control software associated with those equipment. Also, i was able to gain additional knowledge in electrical circuitry as well as large circuitry assembly.

Being on the hardware team, my biggest challenge was on the circuitry side. The need to fit our entire system into a box was a major challenge. Despite the fact that I made the casing box significantly larger than a typical keypad, we still faced issues trying to force a big cluster of wires, breadboards, and microcontrollers into the container. Not only must these fit properly, we had to exercise caution so we do not destroy any connections or solder joints. To solve a major part of this problem, my team and I elected to heavily used specially made wire connectors instead of solder joints. This yields a more robust connection which can withstand more strain as well as provides an easy fix should any connections come undone.

The experience and knowledge gained from this project are priceless. It will significantly improve my performance once I am out in the workforce. Although there are many technologies I would have like to experiment with, time and resources did not allow such. For example, the problem of big wire and hardware clusters can be easily solved using a PCB. However, designing and printing a PCB for this project was out of reach for our budget and equipment availability. Moreover, ribbon connectors would have allowed us to use smaller OLED screens which will generate a much smaller and neater keyboard. Since we did not have any available inventory for such connectors, we had to opt for a bulkier design. The above technologies would have been amazing to have and to integrate into our project.

Overall, it had been an unforgettable experience working with my team juggling this project and many other high level engineering courses. The past 4 months had been a blast of fun and work!

Appendix B: Agenda

January 19, 2016

Attendance: All here

Agenda: Proposal Powerpoint

- Finalize proposal powerpoint contents

-> Next meeting: Friday January 22, 2016

-> Discuss proposal & speak to Andrew

January 22, 2016

Attendance: All here

Agenda: Proposal

- Discussed proposal meetings
- Spoke with Andrew about the difficulty of wiring of our project

Proposal:

- Add resume to proposal
- Finish draft of proposal by Sunday night
- Pre-read draft before Monday evening meeting
- Wrap up conclusion on Monday
- Scope: Chase
- Benefits: David
- Risk: Timotius
- Quote cheaper LCD

-> Next meeting: Monday January 25, 2016 @ 6:30 pm

-> Wrap up proposal

January 25, 2016

Attendance: All here

Agenda:Finalize Proposal

- Wrap up proposal

Proposal:

- Component diagram
- Logo design
- Company name
- Combine individual sections
- References

-> Next meeting: Friday January 29, 2016

-> Assign roles

January 29, 2016

Attendance: No Steven Liu

Agenda: Assign roles

Roles:

-all around: David Pallmann
-code for microcontroller: Steven Timotius, Frank Tran, Chase Kwak
-ordering parts: Steven Liu
-Starting functional specifications: Steven Luu, Chase Kwak, David Pallmann

Goals:

-parts ordered by Wednesday
-draft of functional specifications by Friday

-> Next meeting: Wednesday February 4, 2016 @ 6:30pm

-> Confirm progress on goals

February 3, 2016

Attendance: All except Frank Tran

Agenda: Discuss parts to order and progress

-discussed basic keycap design

Parts to order: -Blue PCB mounted switches from wasdkeyboard
-0.66" oled displays from buydisplay
-approx. 2 week shipping
-extra test display to work with from Amazon
-approx. 2 days shipping

-> Next meeting: Monday February 15, 2016 @ 10am

February 15, 2016

Attendance: All here

Agenda: Wrap up functional specification, meeting with Andrew and Steve Whitmore

-finished up functional specification
-met with Andrew and Steve Whitmore to discuss documentation

-> Next meeting: Thursday February 18, 2016 @ 11:00am

February 18, 2016

Attendance: All here

Agenda: Design review presentation

-assigned part to presentation
-practiced presentation
-obtained positive feedback from presentation

-> Next meeting: Friday February 19, 2016 @ 8:30am

March 4, 2016

Attendance: All here

Agenda: Design specification and Progress Update

-display arrived
-code is progressing well
-decided to order 10 more displays and 10 more switches

-> Next meeting: Tuesday March 8, 2016

March 8, 2016

Attendance: All here

Agenda: Design Specification and Progress Update

-worked on design specification
-firmware is done
-discussed display connections

->Next Meeting: Wednesday March 9, 2016

March 9, 2016

Attendance: All here

Agenda: Finish up Design Specification

-finished detail on design specification

-> Next Meeting: Wednesday March 16, 2016

March 16, 2016

Attendance: Hardware guys

Agenda: Find solution to display issues

Potential solutions: -find appropriate connection for displays
-buy new displays

-> Next Meeting: Friday March 18, 2016

March 18, 2016

Attendance: All here

Agenda: Display Solution

- decided to buy new displays, solderable breadboard, return old displays
- discussed power requirements for displays

-> Next Meeting: Thursday March 24, 2016

March 24, 2016

Attendance: All here Except Luu

Agenda: Progress Report

-worked on progress report and test plan
-discussed returning old displays

-> Next Meeting: Thursday March 31, 2016

March 31, 2016

Attendance: All here

Agenda: Progress Status

-keycaps are done
-firmware is functional
-discussed next steps in hardware and integration

-> Next Meeting: Wednesday April 6, 2016

April 6, 2016

Attendance: Hardware Only

Agenda: Hardware Integration and remaining hardware components

-final displays have arrived
-discussed how keycaps, switches, and switch bed will be connected
-discussed switch bed material and protective screen material
-decided to laser cut switch bed out of wood
-need to use Corel Draw to laser cut switch bed

-> Next Meeting: Wednesday April 11, 2016

April 11, 2016

Attendance: Hardware Only

Agenda: Laser Cut Material and Finalize Designs

-Used the laser cutter to cut out the switch bed
-discussed potential power issues with the displays
-finalized the casing design

-> Next Meeting: Thursday April 14, 2016

April 14, 2016

Attendance: All here

Agenda: Acquire Final Material and Progress Update

-discussed heat issue with arduino Mega when powering OLED displays
-discussed padding keycaps to properly engage the switch
-purchased casing material and acrylic for protective screen
-worked out firmware bugs

-> Next Meeting: Friday April 15, 2016

April 15, 2016

Attendance: Hardware Only

Agenda: Preliminary Hardware Integration

-soldered switches to wires
-soldered jumper wires to breadboard
-used laser cutter to cut out protective screens
-decided to use jumper wires as connectors for the OLED displays
-decided to use a carbon fibre wrap for the casing

-> Next Meeting: Sunday April 17, 2016

April 17, 2016

Attendance: Luu, Chase, David

Agenda: Keycap Integration

-secured keycaps with OLED displays
-secured protective screen onto key caps
-started on presentation and post mortem
-discussed presentation details

-> Next Meeting: Monday April 18, 2016

April 18, 2016

Attendance: Hardware Only

Agenda: Hardware Wiring and Integration

-secured switches to keycaps
-secured switches to switch board
-soldered any broken switch connections
-fixed errors in switch connections to keycap
-fixed errors in protective screen connections
-wired switches and displays to microcontrollers and breadboard
-placed components and wiring into casing

-> Next Meeting: Tuesday April 19, 2016

April 19, 2016

Attendance: All here

Agenda: Final Integration and Testing

-tested connections of the system
-rewired system due to connection errors and issues
-wrapped casing in a carbon fibre wrap
-fixed errors in keycaps connections
-tested system multiple times
-remedied software issues
-placed components and wiring into casing
-secured switch bed onto casing
-worked on presentation and post mortem

-> Next Meeting: Wednesday April 20, 2016

April 20, 2016

Attendance: All here

Agenda: Post Mortem and Presentation

-wrap up Post Mortem
-discussed presentation roles and order
-discussed presentation attire
-discussed presentation refreshments
-wrap up final documentations

-> Final Meeting: Thursday April 21, 2016

April 21, 2016

Attendance: All here

Agenda: Presentation Preparation

-practice presentation
-prepare presentation refreshments
-set up presentation
-try to impress Andrew and Steve
-celebrate