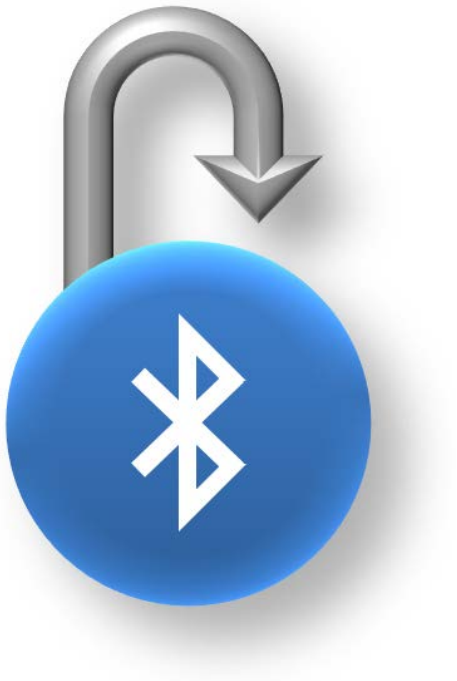
The BlueLock Project



Sohail Sangha
Sam Liu
Matt Kim
Ryker Indjic

MSE 102 / MSE 101W
Simon Fraser University
February 5, 2014

Executive Summary

The BlueLock project was a successful attempt to integrate an electronic system into a portable locking mechanism that can wirelessly communicate with a smartphone in order to unlock the device. This means that as long as the user has a smartphone the lock will be easily accessible without the need for a key.

Using CAD software, 3D printers and existing electronic technology our team created a working prototype of the lock. The prototype Consists of a 3D printed locking mechanism operated by an Arduino micro controller unit, Bluetooth slave and a small electric servomotor. Now that we have a working prototype it is possible to move forward with production of the BlueLock.

Our team completed the BlueLock before our estimated deadline of April 14th with no major setbacks. We were able to do this by assigning each group member a specific task to carry out on his or her own. This way all the team members were able to work in parallel to meet a common endpoint.

The BlueLock prototype cost approximately $90 to produce. This is well under the projected cost estimate of $180. This is due to cost efficient project planning and having minimal component failure throughout the development process. One cost impacting event occurred when a servomotor failed and had to be replaced, other then this project was carried out according to the proposal. By our estimates it would now be possible to move into production of a real lock with bulk sourced parts at approximately $40 per a unit.

Table of contents

I. Background

The BlueLock project addresses the need for a wireless portable and secure locking system. As it stands today the most common portable locking systems are restricted to one of two categories, combination locks or Key locks. These systems can be very inconvenient as they require a physical interaction to allow access to the locked environment and if the key is lost or the combination is forgotten then you cannot access the lock at all. This can be a major problem in certain industrial applications where multiple people often need access to a locked environment, but only a few people hold the key or combination. Our product overcomes these issues by allowing the lock to be accessed wirelessly from a smartphone, as well as physically via a USB connection. This will allow for maximum convenience without compromising security.

Through this project we had also planned to increase security by adding some additional features to the functionality of the locking system. We had planned to generate access codes that were virtually impossible to predict, resulting in a more secure locking system. As well as implement a system that will allow the owner of the lock the ability to permit other people to access the lock via smartphone by giving them consent over the app. But we were not able to accomplish this within the allotted time limit. This is something that can be easily developed and integrated into the lock in the future through a downloadable update.

II. Introduction

The aim of this project was to develop a keyless portable locking solution. In order to cultivate this product our team used existing electronic technology and embedded it into a mechanical locking system. More specifically, we integrated an Arduino MCU with Bluetooth technology to operate an electric servomotor. A lithium polymer battery was used to power these components.

The Arduino MCU communicates wirelessly with a smartphone via a Bluetooth connection. When the system receives an unlock command from the smartphone the MCU operates an electronic servo to disengage the locking mechanism.

In the event that the battery dies the lock has an integrated USB port that can be connected to the smartphone via a USB cable. Once the lock is connected the charging process will begin and the locking mechanism can be disengaged.

III. Objectives

The overall goal of this project was to meet the demand for a high-tech padlock by developing a Bluetooth controlled, cell phone rechargeable padlock. The product provides the market and consumers a fundamentally different option for a padlock.

Our primary objective was to build a fully functional prototype including a rechargeable battery, Bluetooth and USB Support. The prototype falls into line with the goals we set out to achieve. The hardware parts of this prototype are an appropriate size to conform to the conventional lock size profile. On top of this all parts are low in power consumption and cost.

The software was developed using the java programing language and is currently only available for android systems, but it is to left open ended for easy integration of a cross platform version in the future.

IV. Methods

The requirements covered under this project were to produce a fully functional prototype, which will provide the basic architecture for future products. The prototype is modeled on a possible topline product.

The system is a mechatronics product; therefore it requires integration of electrical and mechanical systems. Following is a set of requirements as well as precautions for each part type.

Prototype version:

1. Hardware: Constructed using rapid prototyping techniques, as well as Plexiglas components for ease of demonstration.
2. Software: Arduino MCU programmed appropriately and an android app to communicate with the lock.
3. Actuator: low power linear or rotary actuator for engaging or disengaging locking mechanism.
4. Microcontroller: low power MCU programmed using Arduino libraries to reduce prototyping time.
5. Battery Charging Circuit: inbuilt in the Arduino chipset for ease of expansion.
6. Bluetooth Chipset: fully developed Bluetooth chipset solution, integrated with MCU.
7. Rechargeable Battery: Li polymer battery with large enough capacity for demonstration purposes.

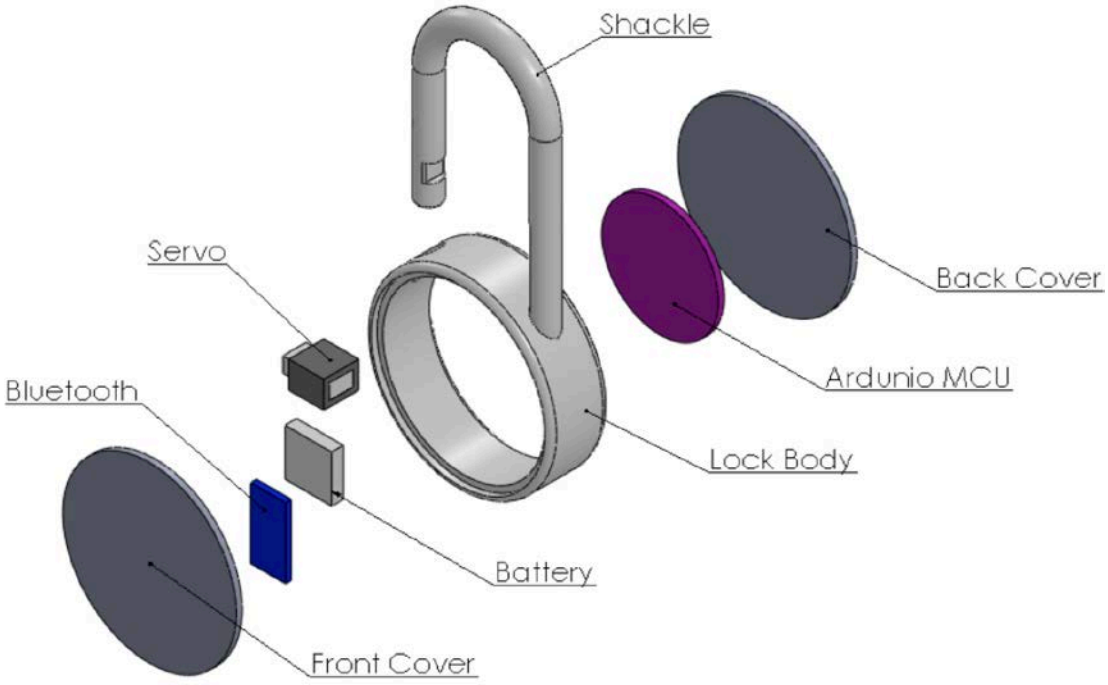


Figure showing components of the BlueLock

The development process was carried out both individually at home and in a team setting at university through group meetings. The Desirables were agreed upon at the start of the project and roles were assigned depending on group the strengths of individual group members. The project was then carried out in parallel between group whilst coming together periodically to meet and discuss certain integration of particular aspects of the project, such as mechanical and electrical systems.

V. Outcomes / Discussion

When The BlueLock project began our team agreed upon certain deliverables that were required for the final product. These deliverables included having a fully functioning battery powered prototype that could be unlocked via a smartphone Bluetooth connection and charged via a USB cable. Additionally, we made a second list of certain functionalities that would be a bonus if we could integrate them in the finished product within the allotted time before the project deadline. Some of these items include, but are not limited to, lock sharing – being able to share the virtual key to the lock across devices, lock tracking – being able to keep track of what phone is accessing the lock and an IOS version of the app for apple devices. As the project commenced we divided up these tasks between group members and carried out the work in parallel with each other. For example, one person built the mechanical structure while another worked on the electrical systems. This work routine allowed our team to achieve our main desirables

before the project deadline in order to successfully designed a working Bluetooth lock. However, the bonus functions were not completed in time, yet the systems that have been designed can easily accommodate the bonus functionalities if they were to be developed in the future.

Our group had also set a healthy overhead for our budget at the start of the project to account for possible setbacks such as component failure and replacement. Very few complications occurred during the development of this lock. A total of two component failures account for the majority of complications faced throughout the project. We had a bad Bluetooth module that did not power on out of the box and a servo motor failure. Both these parts were promptly replaced for a minor cost and then successfully integrated into the locking system. Even after replacing these failed parts our total project expenses were still far below our initial budget by nearly 50%. The total cost of production for the prototype minus the expenses for replacing failed parts accurately lines up with the projected production cost of the lock at approximately $40.

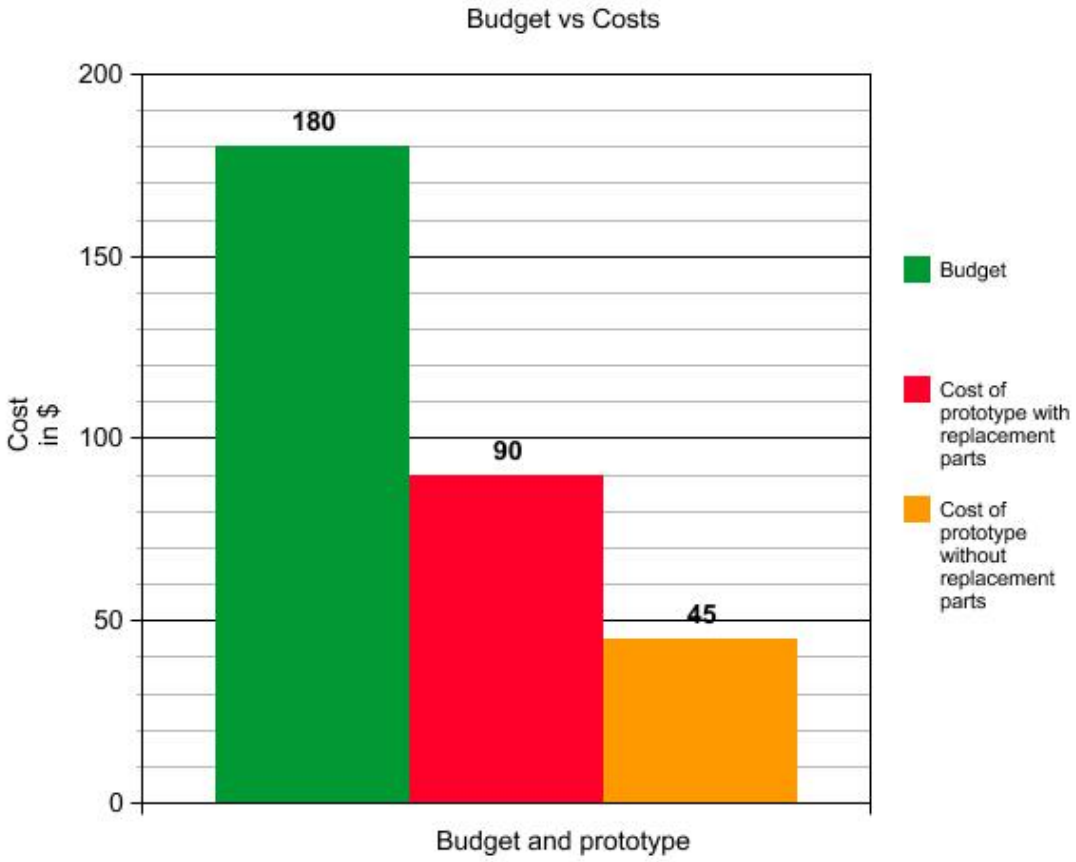


Figure showing Budget compared to actual costs.

VI. Conclusion

The BlueLock project has been carried out with proper planning and execution to produce a working prototype that satisfies the base conditions stated in the proposal. The lock is fully functional and able to connect via Bluetooth to an android smart phone to be operated. Additionally the prototype costs are well under the projected budget and match more precisely to estimate production costs for the lock.

This prototype is a fundamental step in the right direction towards a market ready smart lock. It sets up a platform that can be easily developed to include further functionality to make the lock more universal. Some possible features that could be developed into the prototype before production include lock sharing, lock tracking, cross-platform compatible app and a toggle switch for initiating electrical system in order to save batter power. These functions are not very difficult to develop and can easily be integrated into the current locking system.

As it stands the lock itself is functional enough to operate in real world applications, although certain functions may want to be developed further before implementing the lock in specific purposes. This project has created an open ended working product that can be developed to meet specific needs of the consumer market with numerous possibilities for future development.

VII. Recommendations

Although the BlueLock works as is, there are further developments that can be implemented to improve the locks ease of use and functionality. We had discussed programming an app capable of creating a 64- bit hex code that could be used as a digital key for the lock. This digital key would be virtually impossible to break and thus would increase the security of the lock. Additionally the app would have been able to share this key with select people to give them digital access to your lock if the lock owner deemed it appropriate.

Another concept that had been discussed was a mechanical button or switch that could be implemented externally on the lock to operate power to the electrical circuit. This way when the user does not want to unlock the system he or she could power it off to enhance the battery life.

It is also possible to make certain portions of the programming for the lock open sourced in order to allow users to create their own custom functions and share them over a public network where other lock users could adopt the custom functions and implement them in their own locking applications. Similar to how people can develop and share apps for smartphones.