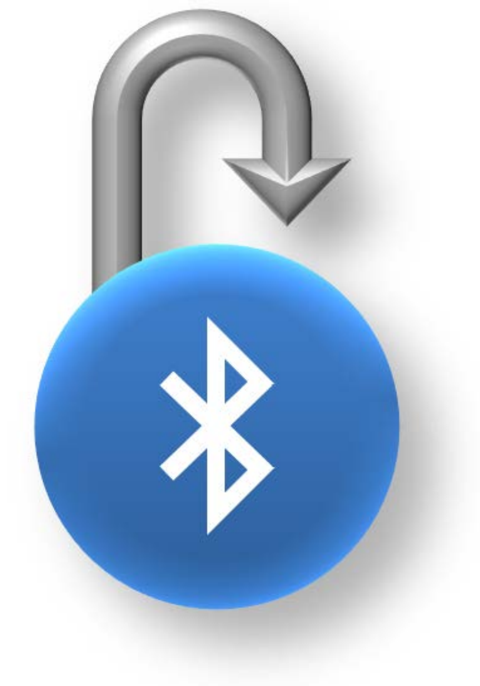
The BlueLock Project

A Proposal To Develop A Digitally Controlled Locking System



Sohail Sangha
Sam Liu
Matt Kim
Ryker Indjic

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EXCECUTIVE SUMMARY

It is human nature to protect our private belongings. Through the ages humanity has gone to great lengths to develop mechanical systems in order to aid us in doing so. The most common of these mechanisms is the key and lock. Historically the key and lock is one of the oldest and tried methods of protecting property from theft. The key and lock has been around for approximately 4000 years (Bellis, 2015). During this time society has had one common problem: how do we unlock our belongings if we lose the key? The BlueLock addresses this problem by using technology to eliminate the need for a key.

This project plans to reinvent the lock by integrating an electronic system into a portable locking mechanism that can wirelessly communicate with a smartphone in order to unlock the lock. This means that as long as the user has a smartphone the lock will be easily accessible without the need for a key providing the battery in the lock is charged. In addition, the user will be able to share access to the lock easily through the smart phone app and keep track of who is accessing the lock.

Using CAD software, 3D printers and existing electronic technology our team will create a working prototype of the lock. Once the prototype is finalized it will be possible to use CNC milling technology to create a steel locking mechanism based off the prototype. The prototype will consist of a 3D printed locking mechanism operated by an Arduino micro controller unit and a small electric servomotor. Once the prototype is finalized the electronic components can be transferred into a steel lock in order to produce a final product.

Our team plans to have the electronic systems functioning with a smartphone by March 1st and to have the mechanical locking system designed and printed by March 25th. Once these to goals are achieved the working prototype will be assembled by April 1st, allowing for an addition 2 weeks before the deadline of April 14th to compensate for setbacks. In order to reach these milestones we will have individual group members working in parallel on specific tasks to decrease production times.

When calculating the prototyping budget an overhead cost has been calculated into the estimate to compensate for setbacks that may arise due to component failure or human error. The initial prototyping cost estimate is $110. Once the prototype is complete and production of the working lock begins the estimated cost per unit is $45. The sizeable difference in price between manufacturing the final product and developing the prototype is due to the cost of off-the-shelf parts that will be used for the development of the prototype. Once the lock is in the manufacturing phase these parts can be purchased in bulk and as a result the price per unit will be reduced.

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I. Introduction

This project aims to develop a keyless portable locking solution. In order to cultivate this product our team plans to take existing electronic technology and embed it into a mechanical locking system. Our team will integrate an Arduino MCU with Bluetooth technology and run it along side a lithium polymer battery and electric servomotor. Once the electronics are developed the mechanical locking mechanism will be designed around the final electronic system.

The Arduino MCU will communicate wirelessly with a smartphone via blue tooth. When the system receives an unlock command from the smartphone the MCU will operate an electronic servo to unlock the lock.

In the event that the battery dies the lock will have an integrated USB port that can be hooked up to the smartphone via a USB cable. The lock will then be able to be charged and unlocked through a tethered connection.

II. Problem Statement

This Project addresses the need for a wireless portable and secure locking system. As it stands today 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 project will overcome 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 also plan to increase security by adding some additional features to the functionality of the locking system. With our locking software we plan to generate access codes that a virtually impossible to predict, meaning that no one else will be able to access the lock except for the owner. Additional we will 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. In environments where more than one person has permission to use the lock the owner will be able to keep track of who is accessing the locked environment and when.

III. Objectives

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

Our primary objective is to build a fully functional prototype. It has to have all the features including Bluetooth, Rechargeable Battery and USB Support. The prototype might be different from the product version due to demonstration purpose and budget. This will be further elaborated in the budget section.
The hardware parts of the prototype must be in appropriate size and weight. On top of this, all parts must be low in power consumption and the cost is in acceptable range.

IV. Technical Approach

A. Introduction

The requirement covered under this proposal is to produce a fully functional prototype, which will provide the basic architecture for any future products. The prototype will be modeled on the topline product. Following is an overview of the features planned for the prototype and any future products.

	Prototype	Topline Product	Baseline Product
USB Support	✓	✓	✓
Rechargeable Battery	✓	✓	✗
Bluetooth	✓	✓	✗

The system is a mechatronics product, requires design or integration of hardware, actuator, microcontroller, battery charging circuit, Bluetooth chipset, rechargeable battery. 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. Actuator: low power linear or rotary actuator for engaging or disengaging locking mechanism.
3. Microcontroller: low power MCU programmed using Arduino libraries to reduce prototyping time.
4. Battery Charging Circuit: inbuilt in the Arduino chipset for ease of expansion.
5. Bluetooth Chipset: fully developed Bluetooth chipset solution, integrated with MCU.
6. Rechargeable Battery: Li polymer battery with large enough capacity for demonstration purpose.

B. Deliverables

The product will be designed with baseline and topline model in mind. The topline model will be reproducable from the baseline model with expandable features to drive cost lower.

Prototype version:

1. Availing ease of use parts to design and build a functional prototype
2. Design will incorporate topline model in mind

Product version:

1. Built using dedicated hardware to lower costs, will borrow architecture from prototype to reduce prototype to product timeline and cost.
2. Various products ranging from baseline to topline, but all based on same base architecture.

Product Components:

1. Hardware: CNC hardware with structure borrowed from prototype.
2. Actuator: similar product as in prototype version.
3. Microcontroller: low power MCU with embedded Bluetooth, using personal code structure.
4. Battery Charging Circuit: Custom PCB board with support for charging circuit, USB port, MCU site etc.

Rechargeable Battery: Product similar to prototype or reconfigured based on tests.

C. Requirements

1. Hardware

The product version of BlueLock will be CNC out of high strength material modeled after the components designed for the prototype, for which, the lock casing will be rapid prototyped on a 3d printer, and the shackle will be resourced from existing padlocks. Further if permitted by design, the prototype will feature transparent front and back covers for better demonstration purposes.

2. Control System

The control system in both prototypes and the products will be based on a Microcontroller unit (MCU), running personally designed software with electronic security in mind. The prototype will feature rapid prototyping based MCU designed by companies such as Arduino, while the final product will run on dedicated MCU, which will be selected on basis of connectivity and power consumption criteria.
The requirements for the MCU will be to communicate to a remote system, such as cellphone, over USB or through Bluetooth, to receive and verify an alphanumeric key combination, and to lock or unlock the padlock using an actuator.

3. Actuator

Both product and prototype will feature the same actuator mechanism, which will be modeled on a rotating or linear servo. The selection criteria will depend upon low power consumption, as the hardware will be designed to transfer the stress from any forces acting on the shackle onto the locking latch, while the actuator simply acts to move the latch through stress bearing slots.

4. Battery

For prototype phase, the battery will be used on a test and trial purpose to verify the current consumption and one charge lifetime. The data accumulated during this stage will contribute towards optimized selection of battery for the final product.
The battery will be a small size rechargeable lithium polymer battery with broad power capacity and size requirements.

5. Bluetooth

The prototype will feature an external fully implemented Bluetooth solution. The MCU will be programmed to optimize the Bluetooth module for power consumption purposes. The final product will be aimed at incorporating MCU with inbuilt Bluetooth, such as Bluetooth Low Energy solution by Texas Instruments.

D. Safety considerations and Precautions

Foreseeable problems:

1. Actuator is not powerful enough to unlock the padlock or it consumes too much power for it to be a viable option.

2. Some of the parts our group acquired are not compatible with each other.

3. Android cellphones might not be able to act as a host to charge the padlock.

4. The final prototype our group assembled is too large for a padlock.

5. The 3D printer's resolution is not high enough to ensure the precision of its product.

Safety Measures:

Even though this project does not include any risky operations or dangerous parts that might cause physical damage to a person, the following safety precocious are taken in order to ensure both the safety for a person or a microchip.

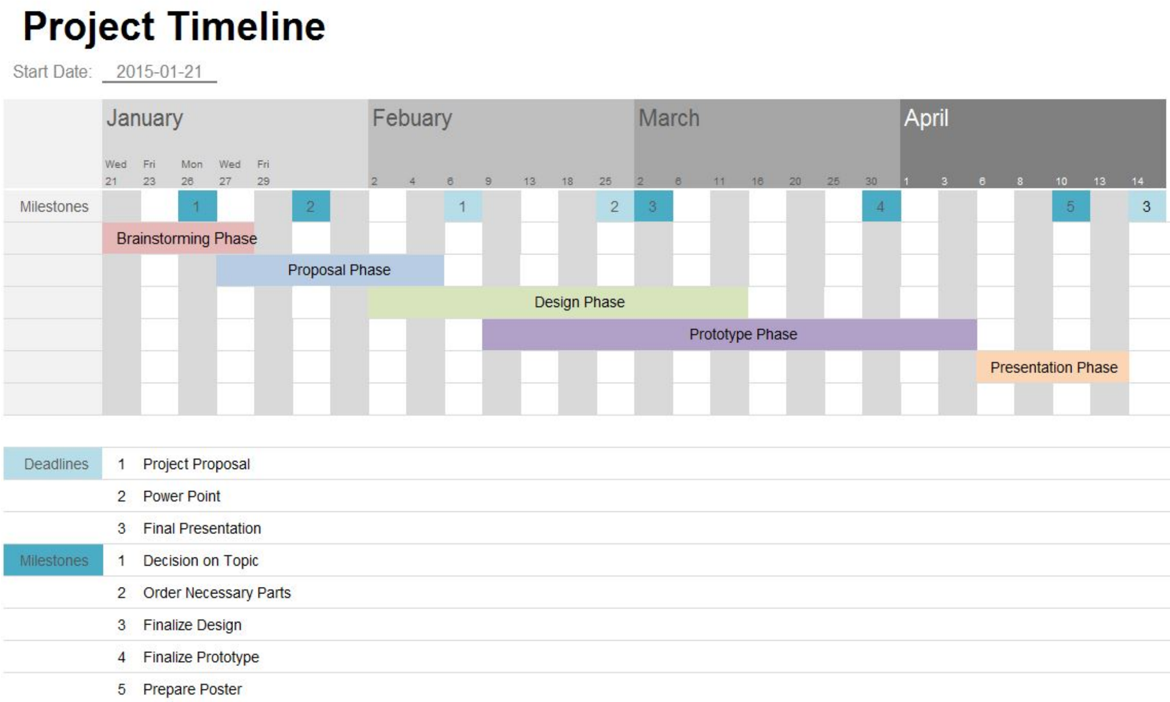
1. Since electric boards and microchips are fragile, all electrical components of the padlock will be handled very gently.

2. No wet hands are allowed when operating on an electrical board in order to prevent potential shortage.

3. All power sources are disconnected when there is a person operating on an electrical board.

4. Since there might be sharp edges on the 3D printed components that could cause physical injury, all 3D printed parts of the padlock are examined physically before handling it.

E. Project Schedule and Milestones



Milestones:

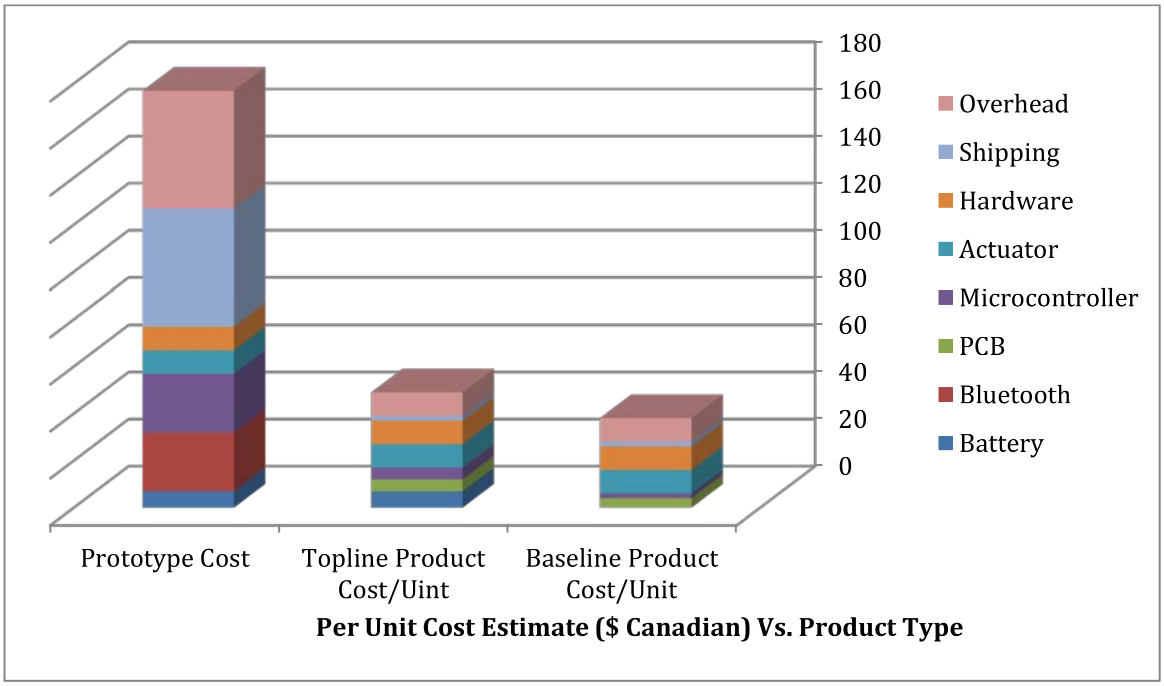
1. The first milestone was reached when our team made a final decision to move forward with the BlueLock project.
2. The second milestone is the completion of the inventory for required components and sourcing. Then ordering all of the parts required for the project.
3. The third milestone is finalization of electrical and mechanical design for the lock. This includes development of the electrical systems and production of the mechanical system.
4. The fourth milestone is the integration of the electrical systems into the mechanical system resulting in a working prototype.
5. The fifth milestone is completing a presentation for our prototype.

V. Budget

A. Project Budget

This section outlines the fund requirements for the production of prototype and products. Please note that while the budget requirement for the prototype is well defined. The price for final product is subjected to change, where the affecting parameters can be number of products to be produced, price adjustment by manufacturers, integration and assembly cost to name a few, and hence should only be taken as a guideline through the prototyping phase.

Following is a graphical representation of component based budgetary requirements for various products.



In the above chart the stark price difference between prototype and final products is owing to the development of the prototype using off-the-shelf and third part products. Shipping cost is the single most major fund sink in the prototype, but is predicted to decrease per unit in the final product as a result of bulk shipping. A healthy overhead cost has been included in the prototype so as to contain any setbacks due to component or integration failure.

For more detailed breakdown of components and prices, please see the following table.

B. Required Materials

Component	Description	Price ($ CAD)	Shipping ($ CAD)
Hardware	Resourced and rapid prototyped on personal 3D printer	10	0
Actuator	Low power linear servo used in RC toys	9.99	15
Microcontroller	Arduino Lilypad with USB	24.95	35
Bluetooth	Bluetooth module with antenna	24.95	0
Battery	Polymer Lithium Ion Battery	6.95	0
Total		66.84	50

C. Sourcing

All of the electrical components for this project will be off the shelf parts acquired from one of two websites. The actuator, battery and Bluetooth components will be acquired from www.hobbyking.com and the Arduino components will be sourced from www.robotshop.com.

Team members will supply the mechanical components for the prototype. The mechanical components for the final product will be sourced from steel manufacturers such as www.bobcometal.com.

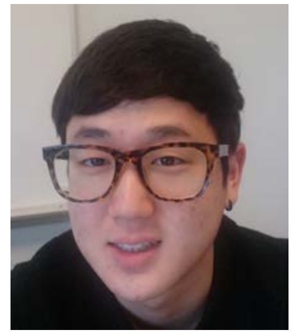
VI. Personnel and organizational capacity

A. Team member responsibility

Our team has divided all the necessary tasks required of the project evenly between team members. These roles have been methodically decided in an attempt to accomplish multiple project objectives simultaneously. Following is a list of responsibilities as they pertain to each team member.

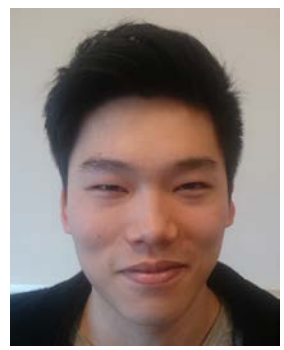
Name	**Responsibilities**
Sohail	-CAD modeling -Design of electrical systems
Ryker	-Smart phone app development -Phone/MCU integration
Sam	-Component sourcing -Project scheduling
Matt	-Design of mechanical systems -Project Scheduling
Shared Responsibilities	-Assembly of electrical components -Assembly of mechanical components -Budgeting -Project proposal -PowerPoint

B. Team member biography



Matt Kim
Student Number: 301252237
Email: dka50@sfu.ca

Matt Kim is originally from Republic of Korea and moved to Canada in 2006. Lived in Vancouver for the entire duration. He is a 2014 graduate of R.E. Mountain Secondary School in Langley. Matt is a first year student in Simon Fraser University, studying Mechatronics System Engineering. The reason he joined the Faculty of MSE is to explore and experience the diverse branches of engineering. His goal is to become an engineer in the software area.



Sam Liu
Student Number: 301233319
Email: hcliu@sfu.ca

Sam came to Canada in 2010 when he was 16 years old. He graduated from high school in Vancouver and got accepted by SFU in 2013. The reason why he chose to major in MSE is because it is a very diverse and attractive subject. Becoming a professional engineer is his main goal.

Sohail Sangha
Student Number:
Email: sohails@sfu.ca

Sohail is a fourth year student at Simon Fraser University with major in mechatronics systems engineering. His past experience involved various projects ranging in the fields of robotics, kinematics, image processing, embedded applications etc. as well as one year co-operative job with BlackBerry involving software development for embedded platforms. His concentration is towards robotics and automations, which he continuously works towards with his extracurricular projects.

Ryker Indjic
Student Number: 301246432
Email: rindic@sfu.ca

Ryker Indjic was born in Jasper, Alberta. He graduated from Jasper Jr./Sr. High School in 2007. From 2007 to 2012 Ryker worked in several industrial settings with experience in pipelining, oil extraction and welding. Ryker is a registered apprentice welder with 5 years of experience in the welding industry. In 2012 Ryker enrolled in a Bachelor of mechanical engineering degree at Auckland University in New Zealand. He completed 2 years of mechanical engineering before transferring into a Mechatronics engineering degree at Simon Fraser University in Vancouver, Canada. His current interests focus is towards robotics and software programming.

VI. Glossary

Arduino - Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures kits for building digital devices and interactive objects that can sense and control the physical world.

MCU - A microcontroller unit (MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

Servomotor - A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration.

Actuator - An actuator is a type of motor that is responsible for moving or controlling a mechanism or system.

USB - Universal Serial Bus (USB) is an industry standard that defines the cables, connectors and communications protocols used in a bus for connection, communication, and power supply between computers and electronic devices.

Bluetooth - Bluetooth is a wireless technology standard for exchanging data over short distances

Lithium Polymer battery - A lithium polymer battery is a rechargeable battery of lithium-ion technology

CNC milling - Computer numerical control (CNC) is the automation of machine tools that are operated by precisely programmed commands encoded on a storage medium, as opposed to controlled manually via hand wheels or levers, or mechanically automated via cams alone.

CAD software - Computer-aided design (CAD) is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design.

VIII. FIGURES AND TABLES

IX. References

Bellis, M. (2015). The History of Locks. About. Retrieved From https://owl.english.purdue.edu/owl/resource/560/10/

Pricing references:
www.hobbyking.com
www.robotshop.com