University of Nevada, Reno

CODE Lock – Cellular On-Demand Enclosure Lock

A thesis submitted in partial fulfillment
of the requirements for the degree of

BACHEOLOR OF SCIENCE, ELETRICAL ENGINEERING

by

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be accepted in partial fulfillment of the
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Background

CODE Lock is an electrically motivated locking mechanism intended to replace mechanically motivated locks for various security enclosures. CODE Lock eliminates keys and combinations and enhances user control and interest by internally generating and transmitting a personal, time-sensitive, single-use passkey to the end-users cell-phone.

To ensure that the passkey stays personal, it is delivered directly from the enclosure to the user cell phone via text message. CODE Lock invalidates passkeys after 2 minutes, for added security. CODE Lock also mitigates maintenance costs to clients, as reduced personal are required to rekey locks when keys are lost, and provide manual override access to users who forget their lock combination.

These objectives are realized using a microprocessor to acquire and validate passkeys, a solenoid to act as a mechanical obstruction to act as a key, necessary user interface equipment, such as a keypad for input and LCD screen for output, and of course an enclosure for the physical security of property.

The CODE Lock offers multiple revenue streams, such as direct sale of product, charge per use, advertisements, and even the hosting of servers on which CODE Lock sends texts.

CODE Lock shows promise in the personal security enclosure space. No other product currently on the market uses a self-generated, time sensitive, one time use passkey. The CODE Lock offers the same mechanical quality of security as other types of enclosures, but unlike other enclosures, CODE Lock offers a more secure ways of generating, delivering, and validating the passkey.

Introduction

Security of property has always been, and always will be, a matter of high importance. Existing lock architectures are old and uninteresting. The problems with existing locking mechanisms include the following:

- Dealing with Keys
- Remembering Combinations
- Unintended users acquiring passkeys
- Impersonally acquired passkeys
- High maintenance and component replacement costs

While other companies have attempted to mitigate some of these problems, the current market lacks a time sensitive, single use, secure passkey device. The goal of this project was to address these problems by develop a novel locking device in which physical keys are replaced with a five-digit, time sensitive code, transmitted via text message to the user's cell phone. CODE Lock invalidates passkeys after 2 minutes, to ensure unintended users have little to no time to utilize codes. CODE Lock also mitigates maintenance costs to clients, as reduced personal are required to rekey locks when keys are lost, and provide manual override access to users who forget their lock combination.

This design opens room for various features not previously possible before. Users will no longer need to remember combinations or carry around extra keys while clients will be able to track data on their customers as well as open up a new market of advertisements.

Business Plan

Personal safety enclosures are present in many areas across the US, and the world. CODE Lock is a cost effective and practical alternative to various locker systems. The CODE Lock offers multiple revenue streams. Some of these may even be utilized in parallel. The business model will follow three main paths, which will be discussed below.

Path 1 is charge per use or charge per time. Under this business model, enclosures will be built and sold to clients at subsidized rates, or given away for free. Revenue will then be generated by charging users each time they use the product, or for the duration of time that the enclosure has been in use. This will be CODE Lock's initial source of revenue generation. Costs are summarized in Table 1 below.

An alternative revenue stream will be advertisement based machines. Similarly, this method would call for subsidized or free enclosures to clients. Advertisements would be sent to users with the access code. Ads would be location based, allowing clients to target deals to users at nearby locations.

Server hosting is an integral component to the advertisement agenda. Bad Students LLC would be responsible for hosting the servers on which the CODE Lock sends texts. This would allow the company to have complete control over advertisement services, as well as track data on use of lockers. There are several benefits to this course of action.

For one, Bad Students LLC would have control over the network on which CODE Lock operates. This would create a more reliable network. This would also all the company to charge for the service of running the network, allowing yet another source of revenue. Another advantage to server hosting is that this approach allows the company to gather data on how the lockers are used. Data tracking would allow information to be generated and ads could be target based on usage, age, and other factors. This information will be used to consult with clients and develop better targeted ads. Some ad based devices will be given to institutions for free to test the profitability of this market.

Direct sale of product is also a possible revenue stream for CODE Lock. It is projected that client adoption for this method would be a less attainable goal, and that it would probably yield a less lucrative profit than the other possibilities. However, with refined versions and reduced cost of CODE Lock, this could become a stronger source of revenue for Bad Students, LLC in the future.

Market entrance Strategy

Charge per time testing:

Several models of CODE Lock will be offered at no charge for analysis of potential market. These machines will be research and development machines to test client and user adoption. The research and development phase will last until 2014. During this time, technical imperfections will be worked out to reduce the cost of CODE Lock. Testing will begin with amusement parks, while client base will expand with each phase of the market entrance, to include colleges, malls gyms, airports, and Laundromats, among others.

Charge per time profitable / advertisement testing:

At the beginning of 2014 market ready enclosures will be produced. These units will have application specific components and reduced cost and power consumption. During this time, the main source of revenue will be charge per use, or charge per time pricing models. Advertisement research and development will begin during this phase. Conservative projected costs are shown in the table below, but are expected to decrease with revision of the CODE Lock.

Component	Cost
Arduino UNO	$50
Arduino Ethernet shield	$50
MSP430 Microcontroller	$10
DC Solenoid	$5
Power Conditioner	$30
Enclosure	$20
Misc. Circuit components	$20
Total Unit cost	$195

Table 1: Unit Cost Summarization

Assuming 100 sets of 18 lockers in the first year, the estimated cost of manufacture is $400,000. With an initial price of $1 per hour of use 400,000 hrs are needed to break even. With 1800 locker in the field, this averages to about 0.6hrs per locker per day. This goal seems very achievable. If each locker is in use for just 1.5 hrs per day, approximately $985,500 of revenue could be generated. This implies a profit of $585,500 annually.

Mass production / server hosting / advertisements:

Server hosting is projected to begin sometime in 2015. At this point, advertisements will become a much more integral component to CODE Lock's overall revenue stream. Once CODE Lock has become an established player in the securing enclosure market, mass production of the product will begin. This will decrease cost of manufacture.

While profitability in the server and advertisements spaces are still vague, it is a rough estimation that CODE Locks profitability will increase by 75% with the addition of server hosting and advertisements.

Low traffic installations:

Once production costs have decreased substantially, and security features have reached a point safe for Utility companies and municipalities, locks will be produced for clients with low traffic installations. This will allow these clients to have more control and knowledge of who and when there areas are accessed. Some of these uses include power plant substations, safes in stores, post office boxes. This will increase the sale of product revenue stream of CODE Lock.

Technical Focus

The CODE Lock device has been selected for development to exploit several factors, which generate an interesting market for personal security enclosures. These factors include, but are not limited to, the widespread use of text-message-friendly personal cellular telephones and internet connectivity, as well as the availability of inexpensive electronic development kits. These are employed to replace existing, mechanically motivated locking mechanisms with modern, interesting, electrically motivated locking mechanisms.

The primary benefit of CODE Lock is cost mitigation, made available to owners of the device through reduced maintenance personnel and component replacement. The secondary benefit of CODE Lock is enhanced user interest where enclosures have suffered aging and disuse.

CODE Lock features a 12-digit keypad which enables users to instigate and enter information to the device, as well as an LCD screen which enables users to receive promptings from the device and confirm actions.

The distinguishing features of CODE Lock include generation, transmission, and authentication of a randomly generated, time-sensitive, single-use passkey. The user requests the passkey, enters their text-message-friendly cellular telephone number, receives the passkey as generated and transmitted by the CODE Lock device, and enters the passkey using the keypad. The device stores the entered value(s) and compares the data to the previously generated passkey. CODE Lock rejects incorrect or expired passkeys, and changes state upon successful user entry.

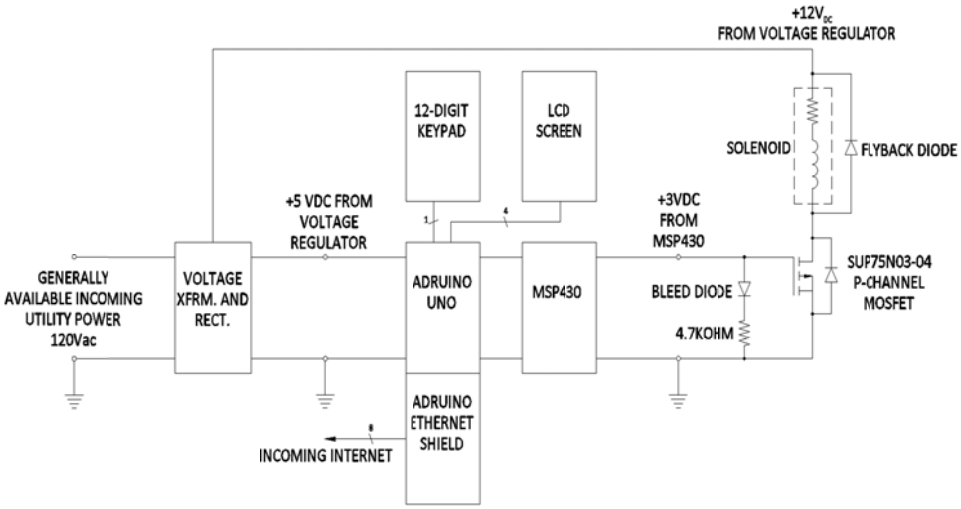

Figure 1: Electrical Schematic of CODE Lock

Major Components

To accomplish the objectives, several major components have been selected. Figure 1 shows how the components are configured. Figure 2 summarizes the pin out configuration between the Arduino UNO, Ethernet shield, key pad, and LCD screen.

Arudino UNO:

The main processor of the device is responsible for interfacing with the other components, including the keypad, LCD, and Ethernet shield. A single Arduino Uno/Ethernet shield combination is capable of providing CODE Lock service to many individual enclosures.

Ethernet Shield:

The Arduino Uno connects via SPI with the Arduino Ethernet shield in order to connect to an SMTP server and transmit a simple email message containing the entry password to the cellphone of the user. Through knowing the cellphone number and provider of the user's cellphone the email can be received by the user's phone as a text message. Texting the password to the user was seen as the best option due to the prevalence of text capable cellphones.

MSP430:

Serves to instigate the solenoid locking mechanism and compare user entry to the appropriate passkey; featured at individual enclosures.

12-Digit Keypad:

Due to limitations on the number of pins available on the Arduino Uno, the 12-digit keypad was interfaced with by using a single analog to digital pin on the Arduino Uno and a resistor ladder (fig 2) on

the keypad with selected resistance values that dive each key press its own unique digital value corresponding to the output voltage of the resistor ladder.

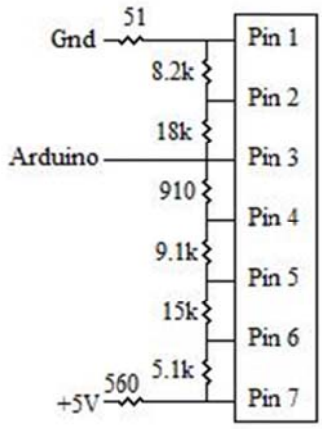

Figure 2: Resistor ladder used to compensate for lack of output pins

LCD Screen:
Prompts user and perform display.

Linear Solenoid:
The linear solenoid provides mechanical obstruction between swinging door and enclosure frame.

CODE Lock Architecture:
CODE Lock will make use of existing electrical hardware, proprietary software, and mechanical components to perform the stated operations. The Arduino Uno motivates the interaction, generates the pass-key, generates a timer, receives and stores the 10-digit telephone number, and performs code confirmation. The microprocessor circuit serves as a switch to an electric circuit which motivates the mechanical latch. The motor driven mechanical latch places an obstruction between enclosure door and locker frame.

Development began with a platform on which the device operates, the Arduino Uno single-board microcontroller. Internet access is accomplished by interfacing with the Arduino Ethernet Shield, which is physically connected to the internet. Incoming 120 Volt AC power (generally available from utility) is conditioned (transformed and rectified) and applied to the microcontroller and the latching motor. The latching motor circuit instigates the lock and mechanical holding device.

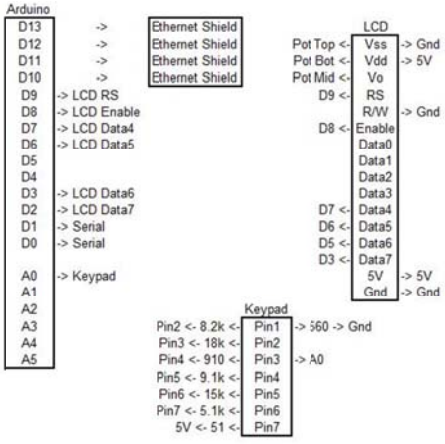

Figure 3: Pin out configuration of major components

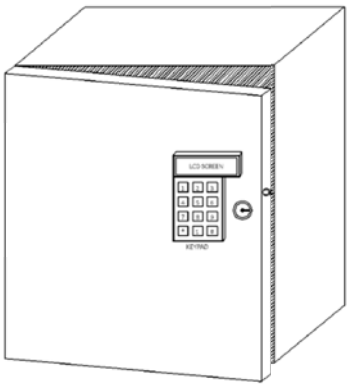

Figure 4: Concept of enclosure

Market-Ready generations of the CODE Lock will be self-contained within sheet metal enclosures which are easily mounted to existing enclosures. The product will feature an LCD prompting screen, visible to the user on the front-panel of the security enclosure, and a standardized 12-button (10-digit plus star and pound) keypad for user entry, also mounted on the front-panel of the security enclosure.

Future Efforts:
Client expansion will offer CODE Lock much space to grow. While the initial version of CODE Lock is intended to offer public citizens in public space as secure space to keep belongings, the application of CODE Lock goes above and beyond this purpose. Private organizations will find CODE Lock's control over secure spaces invaluable. Organizations will be able control to exactly who has access to a secure space, and when they will have access to this space without having to deal with the transfer of physical keys form person to person. CODE Lock's time sensitive passkey will make it difficult for people to give out passkeys to unintended users, even intentionally. And its one time use feature can assure intended users are in and out, period. Possible clients that would value this function include business with safes in which employees need access to periodically; or utility organizations which may need maintenance on sensitive equipment, such as substations for a power company.

CODE Lock offers much room for improvement. Hardware will no doubly become less cumbersome, more robust, cheaper, and efficient. Power consumption will also be reduced with future models of the product. ASIC integration will lead many of these advances within the next few years. Once production levels have reached a level to make ASIC development profitable, productions costs will quickly decline.

Advertisement improvements will come naturally to the manner in which CODE Lock is used. Having the ability to send location-based texts to with offers from surrounding businesses will no doubly become one of CODE Lock's strongest assets. Testing of the product will lead to code development in this area.

Data tracking offers CODE Lock the greatest room for improvement and innovation in the personal security space. Data tracking will help CODE Lock become maximally profitable, by allowing dynamic charges per time use. Frequent users of CODE Lock will also be able to be rewarded for loyal use. Combined with advertisements, data tracking will help CODE Lock dominate the personal security space.

Management and Team Profile

George Jensen – CEO: Responsible for overviewing project and other employees. He also makes executive decisions regarding all matters of Bad Students LLC. George is also the primary engineer focused on the development of solenoid functionality and mechanical obstruction mechanisms.

Cliff Uber – CTO: Cliff Uber is the Chief Technical Officer. He is mainly responsible for all technical designs and problems. Cliff is the primary software engineer that deals with arduino UNO interfacing with the SMTP server. He will be in charge of setting up and managing, along with integrating the Bad Students LLC owned SMTP server.

Samuel Breen – Business Manager: Samuel Breen is the Business Manager. He is responsible for generating revenue streams and making business plans to create these revenue streams. He also aids Dylan Cockerham with financial analysis to make more informed business plans.

Dylan Cockerham – CFO: Dylan is the Chief Financial officer. He is responsible for analyzing purposed revenue streams and verifying their profitability. He also aids Cliff Uber with technical problems, and is the chief programmer for the arduino microprocessor, and designs how the user interface components interact with the Arduino Uno, including the LCD and keypad.

Michael Scharosch – Marketing Expert: Michael Scharosch is the Marketing expert. He deals with public opinion of CODE Lock. He also is responsible for making decisions on advertisements, and making posters to inform the public on the operation of CODE Lock. On top of this, he has also developed CODE Lock's User Interface. He also keeps the product logo up to date.

Conclusion

CODE Lock truly shows promise in the personal security enclosure space. No other product currently on the market, or in the patent system, uses a self-generated, time sensitive, one time use passkey. The CODE Lock offers the same mechanical quality of security as other types of enclosures, but unlike other enclosures, CODE Lock offers a more secure ways of generating, delivering, and validating the passkey. The manner in which CODE Lock handles the passkey increases security by ensuring that passkeys are only delivered to intended users, and invalidated before an unintended user most likely have time to use it. The system is also cost effective, since it reduces maintenance cost to clients by never needing to be rekeyed. It is also easily installed, needing only power and internet hookups.

Facilities, Equipment, and other Resources

Bad Students LLC has primarily the space and equipment at capstone lounge at University of Nevada Reno, and assistance of the following personal:

Dr. Nelson Publicover

Dr. Yanto Shen

Tony Piazzo

Alex Bajanov

Their own personal under development lab and recording studio (for demonstration video and advertisement recoding) located at 497 E ninth street, Reno NV has also been utilized during the development of CODE Lock.