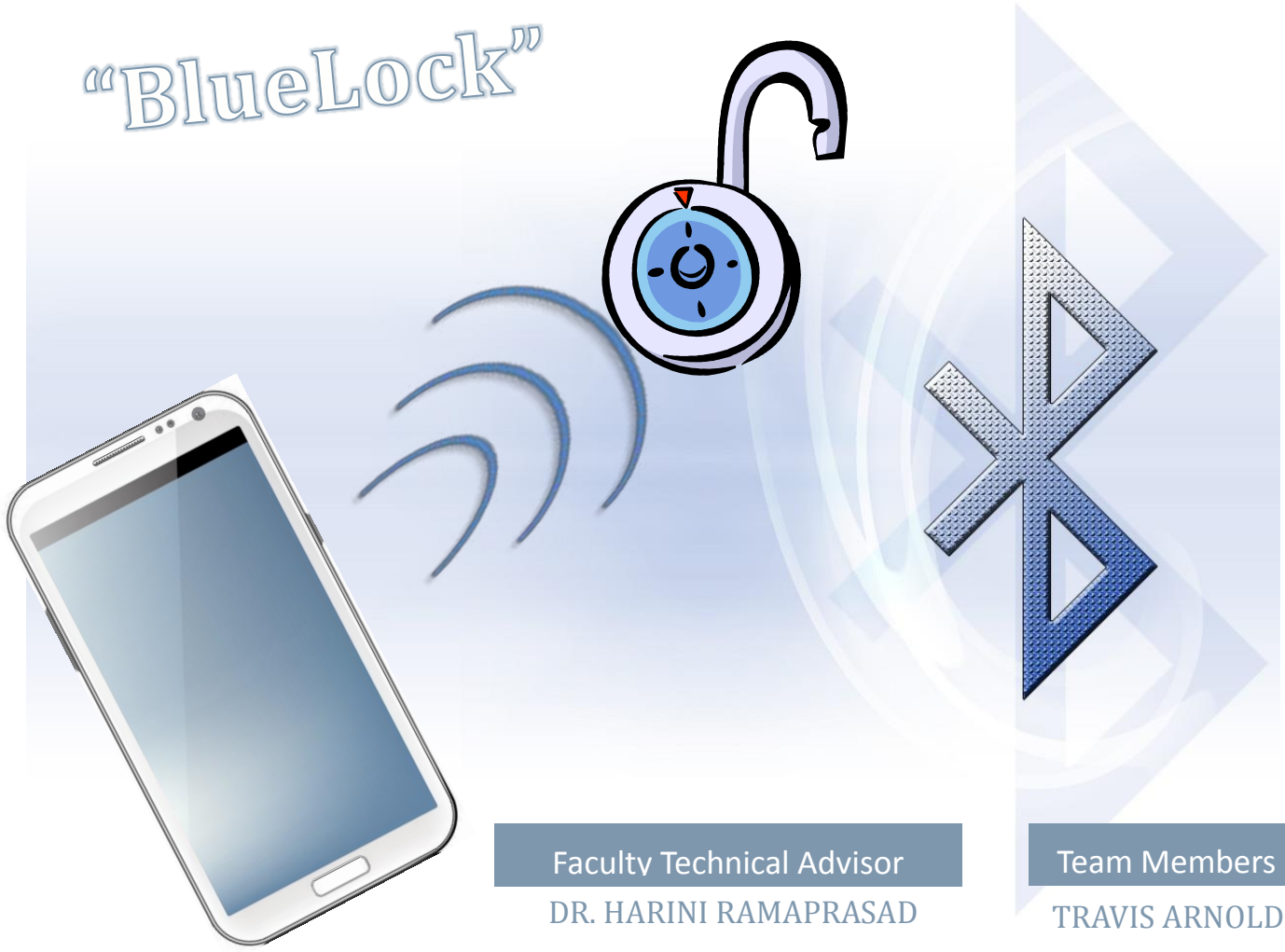
Project Proposal
Generic Wireless Lock

SALUKI ENGINEERING COMPANY, SEC
TEAM 44
PROJECT NUMBER: F13-44-GLCK



Faculty Technical Advisor

DR. HARINI RAMAPRASAD

Team Members

TRAVIS ARNOLD

BAKER ALOTAIBI

FAHAD ALOTAIBI

RICHARD POSADA

DEVIN SCARBOROUGH

Project Proposal:

Generic Wireless Lock

“Bluelock”

Faculty Advisor:

Dr. Harini Ramaprasad

Prepared By:

Team 44 F13-44-GLCK

Saluki Engineering Company, SEC

Southern Illinois University

Carbondale, IL

Members:

Travis Arnold

Baker Alotaibi

Fahad Alotaibi

Richard Posada

Devin Scarborough

May 2nd, 2013

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April 7th. 2013
BlueLock team s13-44-GLCK
Southern Illinois University
1230 Lincoln Drive
Carbondale, IL, 62901
(270)816-5309, slyyke66@siu.edu

Client Representative
Innovative Designs
123 New Design Street
New York, NY

Transmittal Letter

Dear Innovative Designs Representative,

My team, here at the Saluki Engineering Company, would like to sincerely thank you for including us in the bidder list for the Bluelock generic wireless lock system. The proposal for research, system design, construction, and prototype experimentation follows to show in more detail future plans to complete the project.

We have plans for a unique yet useful design. The project itself will encompass a phone application controlled Bluetooth lock accessible by the majority of smartphones on the market at an affordable cost to the end user.

Again, thank you for the opportunity to bid on your project.

Best Regards,

Travis Arnold

Travis Arnold, Team Leader

Non-Disclosure Agreement

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Executive Summary

Project Description

Part one of the project involves creating an electronic battery powered lock. The lock itself will consist of a few sub-systems. The first is a microcontroller which will be responsible for taking all input/output information and carrying out the corresponding task. The second is a transmitter/receiver. The transmitter/receiver is responsible for the communication aspect of our wireless bluetooth lock. The third is the locking mechanism itself. For this purpose solenoids will be used for a pin type locking mechanism. The final sub-system of this part of the project is the battery. It will be integrated on a chipboard so that we can use a rechargeable button battery to power the microcontroller, receiver, and locking mechanism.

Part two consists of the software side of our device. We will be using Eclipse to develop and deploy an android java based application that will control our lock.

For experimentation we will test the application with various android phones to lock/unlock the lock system. We will also test the mechanical components to make sure they lock and unlock properly with and without failsafe (in case power fails).

Total Estimated Cost of Materials:

<300$

Work Period: 16 weeks

Beginning: August 19, 2013

Ending: December 13, 2013

Literature Review

(TA & BA)

A basic lock requires either a key to lock and unlock it or a method by which to remember a combination code to operate it. The current method of inserting key, unlocking lock or shifting combination, and unlocking lock, is inconvenient and outdated. This study proposes to create an application for a cell phone that controls a lock. The app should be simple and straightforward-- download and install the application from a website or application store, then "pair" the phone with the lock device. The device must be state-of-the-art and convenient. An in-depth literature review of the following components will be conducted to determine the limitations of the existing device: application design, source of power, transmission types, physical lock design, electromechanical interaction, and overall design.

OVERALL DESIGN (RP)

One device has already been released and is very similar to proposed study. The purpose of the project is to lock and unlock a generic lock, using an app on a mobile phone. An existing design, the Lockitron resembles the proposed idea. Lockitron is a device that mounts on top of a deadbolt, like on a door, and has a transmission receiver. The purpose of this device is to unlock or lock a door with the push of a button on a smartphone. Lockitron is powered by an application which can transmit through either Bluetooth or WiFi. This device also allows a person to see if a door is locked without being present.

The Lockitron has the capability of sending a notification to the smartphone when someone is trying to unlock the door with a phone or with a key. It is compatible with any smartphone, Iphone, Android, Windows phone, or Blackberry as well as with older phones. It is controlled by an older phone through use of text command lines.

The batteries on the Lockitron last up to one year and when batteries are low, a notification is sent to the phone showing a low battery signal. It is also programmable since it uses an Arduino compatible ATMega processor.

Even though there was no specification sheet, information on the company website showed that the proposed project is very similar to the Lockitron. We investigated it in order to understand how it works and what design criteria were used in order to develop. There are endless ideas that have similarities, but this one happened to have similarities with the idea behind the proposed project. [23]

PHYSICAL LOCK DESIGN (BA)

The Mechanical Lock

The mechanical lock forms the heart of the security system and is available in a variety of designs. A pin tumbler lock is proposed for the heart of the locking mechanism. In the pin tumbler lock, the key fits into a rotatable tube, called a plug, which sits within a fixed cylinder known as the shell. Rotating the plug within the shell operates the locking mechanism. When the lock is locked, the plug is prevented from rotating by little pins of metal under spring pressure that protrude from the plug into the shell. Each stick, known as a pin stack, is cut into two (or more) pieces (pins) at one or more of a standard, discrete set of positions. When the lock has no key inserted, the cuts in the pin stacks sit inside the plug and the ends of the outermost pins protrude into the shell. When a correct key is inserted, each pin stack is lifted to a height so that the cut is precisely aligned with the boundary between the plug and shell. This enables the plug to turn and operate the mechanism [1].

The design of the electromechanical lock utilizes solenoid as the main power in order to activate the lifting mechanism of the pin stack. Solenoid, in general, creates linear motion due to its force stroke characteristics. Energy efficient and forceful operation of the solenoid is vital for proper operation and longevity of the lock. The solenoid exerts maximum force when the stroke length reaches zero (no air gap).

Key Features of the Mechanical Lock

The door lock is to be provided with two modes which are fail safe and fail secure mode. The fail safe mode of a lock is the mode in which the door can be opened by the lock doorknob when power to the lock is turned off or malfunctions. The fail secure mode is the mode in which the door cannot be opened by the doorknob when power to the lock is off or malfunction. The user must be able to set the mode of choice by a toggle switch or a jumper to fail safe or fail secure based on requirement [7, 8].

The locking mechanism should also be equipped with a mechanical override system, which enables manual release of the lock in the event of a power failure. While the normal operation of the system would be from the equipment or building where the lock is installed, the lock design should take advantage of a back-up power system which would enable the electrical operation of the lock during power outage situations. Low power designs for operation of the lock are vital.

The lock should also have a memory feature which should be backed up with a power supply. This would enable security checks for access control to be carried out at all times even in the case of power failure. Even if the option of manual opening of the door exists, the same must be possible only after proper access control checks. The lock should also have an indicator for the current status.

Advanced Security Features

Depending on the level of security desired to be established in the locking arrangement, a number of additional sensors can be used in combination with the lock. A proximity detector can generate a signal sending a specific SMS to the remote mobile. This can also activate a video recorder and transmit the same to the remote mobile. This can be done if the remote station mobile has data transmission capability. Depending on the criticality of the locking arrangement, alarms in the form SMS messages can also be sent to the nearest police station and at least one trusted number as indicated by the owner. This will ensure that a trusted friend or a person from the neighborhood is alerted along with the police even as an intrusion attempt is occurring.

SOURCE OF POWER (FA)

This study found the different types of rechargeable batteries that could be used as a power source for this project. Rechargeable batteries are reliable power source that has lower total cost and environmental impact than one-use batteries. Rechargeable batteries have higher original cost, but can be recharged and used many times.

According to Vanderstraeten and Wiaux, the rechargeable battery is made of electrochemical cells that convert chemical energy to electrical energy. Also, they are known as secondary cells because their electrochemical reactions are reversible. Reversible means they are rechargeable. Furthermore, rechargeable batteries are available in different sizes and shapes and each type of battery has different chemical combinations such as Nickel-Metal Hydride (Ni-MH) and Silver-Zinc (Ag2O-Zn). Many choices of rechargeable battery can be used in this project and this research will show the most common and reliable batteries depending on efficiency and rechargeability [5].

Hsiung and Ritz note that the rechargeable lead acid batteries are used in cars and in other heavy-duty equipment. This type of battery has a maximum of 12 V output. Nickel-Metal Hydride batteries, offer up to 50% more energy than conventional batteries. Moreover, the Nickel-Cadmium battery is reliable and works in extreme temperatures and conditions. Also, the Nickel-Cadmium battery is durable in terms of long life service. Finally, the Lithium-Ion battery is lightest of all materials used in modern batteries and has the greatest electrochemical potential. The Li-ion battery provides the largest energy density among primary sources of material. Table 1 is a comparison of the different batteries. The Lithium-Ion or Li-Polymer batteries are the best choice for efficiency and rechargeability [4].

Table 1 – Battery Sources [5]

Recharge Type	Voltage/ Cell	Memory Effect	Life Cycle (80%)	Environ Issue	Self-Dis/ Month	Cost	Application	Internal	Load Current
Lead-Acid	2V	Yes/Low	200-300	Yes	5%	$25/ 6V	Hospital Equipment, Wheelchair UPS		0.2C
Reusable Alkaline	1.5V	Yes	50	None	0.3%	$5/ 9V	Portable Device, Flashlight	200-2KΩ/ 6V	0.5C
NiCd	1.25V	Yes	500-1000	Yes/ High	20%	$50/ 7.2V	Bio Equipment, Video Game, Power Tools	100-200Ω/ 6V	1C
NiHM	1.25V	None	250-500	None	30%	$60/ 7.2V	Cell Phone, Video Game, Laptop Computer	200-300Ω/ 6V	0.5C
Li-ion	3.6V	None	500-1000	None	10%		Cell Phone, Video Game, Laptop Computer	150-250Ω/ 7.2V	>2C
Li-Polymer	3.6V	None	300-500	None	10%		Cell Phone, Video Game, Digital Camera	200-300Ω/ 7.2V	>2C

Life cycle refers to percent of recovery of the battery related to the number of time it is recharged.

TRANSMISSION TYPES (RP)

A variety of wireless technologies allow electronic devices to inter-connect and communicate with each other. Radio waves are electromagnetic waves with different frequencies. Some of those frequencies can be analogue radio or FM radio. Certain wireless technologies act very similar to those frequencies. For instance, Bluetooth works on 2.45GHz frequency, and WiFi works in two frequency bands, which are 2.4 and 5GHz. WiMAX works in two different frequencies, 2 – 11, and 10 – 66GHz. Bluetooth is very popular on many electronic devices such as mobile devices, computers, and even in cars. It is meant to handle both data and voice transmissions. Bluetooth provides many options for innovative solutions, for example, sending data from one phone to another, hands-free headsets, and synchronization between PCs. Bluetooth is very cost and power efficient making it ideal for many portable devices and those designed for short range communication. Bluetooth also consumes less power than most other transmission types and that is why it is best suited for small battery powered and portable devices. There is an adaptive frequency functionality that allows Bluetooth to reduce interference between wireless technologies sharing the 2.4 GHz spectrum. Bluetooth can also allow for a wireless Personal Area Network (PAN) with its short range.

WiFi has a wide range of about 100m, hence, it allows faster data transfer between 1 to greater than 54 Mbps. The base standard set by IEEE is 802.11. There are four different wireless standards under WiFi: 802.11a, 802.11b, 802.11g, and 802.11n. WiFi is used to create wireless Local Area Networks (LAN). In table 2is a comparison of the different transmission standards. 802.11b may be interfered on the unregulated frequency band by certain home appliances. Since 802.11a has a higher frequency than 802.11b, the signals may have more difficulty penetrating walls and other obstructions which leads to a shorter signal and can be obstructed easily. 802.11n is the best from the four standards since not only will it have the fast maximum speed, but the signal range is good and is not easily obstructed.

Worldwide Interoperability for Microwave Access (WiMax), is a telecommunications technology that offers transmission of wireless data via a number of transmission

methods. The standard for WiMAX is 802.16 and it falls under the category of wireless Metropolitan Area Network (WMAN). WiMAX has a range of approximately 50km and has a greater speed than the other wireless frequencies. It supports low latency applications such as video, voice, and internet access at the same time. WiMAX can also route data to WiFi, however it is very expensive because of the infrastructure.

Table 2 – Transmission Options [2, 3]

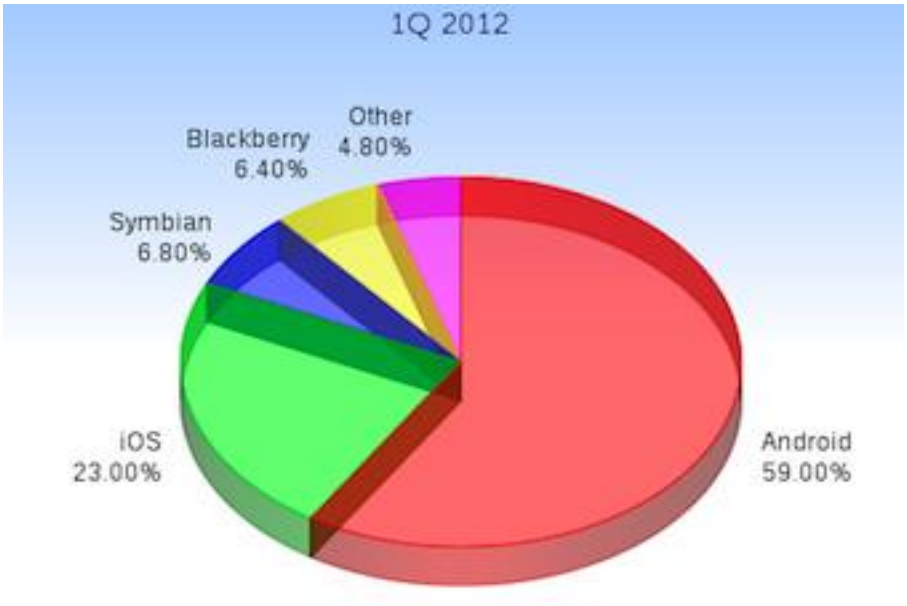
	Bluetooth	WiFi(a)	Wifi(b)	WiFi(g)	WiFi(n)	WiMAX
Standard	802.15	802.11a	802.11b	802.11g	802.11n	802.16
Frequency (GHz)	2.45	5	2.4	2.4	2.4	2 through 66
Speed (Mbps)	0.72	54	11	54	Up to 600	80
Range	10m	50m	100m	100m	250m	50km
Advantages	Low Cost, power	Speed	Low Cost	Speed	Speed, Range	Speed, Range
Disadvantages	Range	Cost	Speed	Cost, Range	Cost, power	Cost, power

APPLICATION DESIGN (TA)

The three parts to designing a cell phone application for any device are an App basis, coding language, and code compiler. The application basis is fairly straight forward. The application basis involves all development decisions behind the application and the function of the app. Developers use this so that the application can be broken down into pieces and more easily developed. This is usually done in teams of coders working for a company or over time by a single developer.

The coding language and the code compiler often merge because each compiler supports only certain coding languages, leaving the two choices linked. Existing coding languages include C / C++, Java, Python, Perl, Ruby, C#, and NASM as well as many coding compilers and development suites such as visual studio, and eclipse. Since an App by nature is for a mobile device, there is a need to know how the application can be made platform-independent (any smartphone) before the coding language and compiler can be chosen. Figure 1 Mobile Phone Market Share [20] shows the different platforms and representation by market share.

Figure 1: Mobile Phone Market Share [20]



Based on Figure 1, while coding, the App should be made to work with android and apple phones, in particular. Viswanathan states the Android OS uses mainly Java, which is the common programming language used by developers. Hence, developing Android is simpler for most developers. The iPhone OS uses Apple's Objective-C language, which can be unraveled by application developers who are already familiar with C and C++. Since it is a different programming language, it is a development obstacle for most developers who are not proficient in other programming languages. This is mainly true for performance/speed sensitive applications, especially those that deal with HD quality video and audio rendering and playback. [21].

Cross-Platform Design

Tools for multi-platform application development exist but may not be effective in actually displaying the original information and functionality on another mobile OS. Mobile game developers especially find cross-platforming a major challenge. Hence, the only viable, long-term solution is to rewrite the app in the device's own native language [21].

Application Deployment

The best way to control the most initial market share and create a successful product is to create an application using the Java platform so that it is compatible with the majority of devices. This is also good because Eclipse is a widely used and a free java development compiler, as well as the Java JDK (Java Development Kit and libraries) are free and open to the public. It is possible to also code the application for Iphone and Blackberry in future development of a product making it more multi-platform accessible.

ELECTROMECHANICAL OPERATION (DS)

There are many options for electromechanical motion devices including solenoids, DC motor, stepper motors or a stepped linear actuator. The solenoid and DC motor would be more feasible because they do not require any specific controller.

Solenoids

Solenoids are actuators capable of linear or rotary motion. When energized they will produce motion over a certain range or angle. Both linear and rotary when not energized need another influence to return to their initial position. This may be done by means of a spring or the movement of another actuator. Some solenoid packages are double acting and have another solenoid built in to the pack allowing for a push and pull in a linear, and in both directions of rotation for a rotary solenoid. Solenoids can only work when current is going through them. A drawback to the solenoid is that it can overheat and possibly fail if powered for too long. This should not be a problem as this lock should not rely on a solenoid being powered on long. Since solenoids have high inductance, one can expect a short lived but very high power voltage spike to occur. Solenoids can be used as a lock or used as an electromagnetic device that provides the mechanical energy that opens and closes the lock [15].

DC Motors

The DC motor can be used for a rotary or linear actuator. Rotary motion of the motor can be converted to linear motion by means of a rack and pinion or geared to a screw drive. It could be used as a lock which locks for one direction of current decided by an ECM (Electronically Commutated Motor) and can unlock for opposite direction. The mechanical advantage of the DC motor over the lock could be an issue. If enough mechanical advantage is needed to actuate the lock it could possibly be hard to move back or forth with a key or whatever failsafe is used. Therefore, some form of mechanical disconnect between the motor and lock may be needed in conjunction with the failsafe [16].

Stepper Motors

A stepper motor is a brushless and synchronous electric motor which can convert digital pulses into mechanical shaft rotation. This can be rotated very precisely in the angle needed without the use of any mechanism feedback. Stepper motors have the capability of high holding torque which means the ability to self-lock when the rotor is stationary. The way to control a stepper motor is to generate a stepping sequence which is a controlled switching of the motor coils. It becomes an electromagnet when the coil is on and when the current is flowing through the coil's wires. The downside to the stepper motor is that a special controller is required to provide the sequence of pulses needed to make it rotate [17].

Stepped Linear Actuators

Stepped linear actuators make a push pull motion much like that of the dual acting solenoid. These can be used as or in conjunction with a locking mechanism to lock and unlock a door or whatever needed. These actuators work much like that of the stepper motor requiring a stepped input, however they also use a special controller making it more engineering intensive to use. The brush and brushless versions of linear actuators both require the stepped input. Hence they can stop and hold at many points within the length of their stroke [18].

MICROCONTROLLERS (RP)

Microcontrollers are in any controllable product or device. They have a microprocessor inside and they are programmable. Microcontrollers are used for embedded applications. The main purpose of a microcontroller is to obtain inputs from certain sensors. This then will process that input into a set of actions which can then be programmed to do whatever any person would like it to do. The microcontroller will then use the output from the microcontroller to achieve what was programmed to do. Microcontrollers are flexible through the software aspect since anyone can change the code of the design to virtually anything the microcontroller is capable of. There are countless of microcontrollers but only three will be talked about in this review. Those three microcontrollers are: Arduino, MSP430, and the RFduino.

The Arduino Uno is one of the most popular microcontrollers today. The reason why that is so is because it is user friendly. It is user friendly because it is open source. The software for Arduinos are free from the Arduino web page. The programming language is Arduino and uses a variant of C programming language. The processor speed of the Arduino Uno is 16 MHz. There are 6 analog pins and 14 digital pins. 6 of those pins are PWM (Pulse Width Modulation). The operating voltage of the Arduino Uno board is 5V and the input voltage is 7 – 12 V. The microcontroller in the Arduino board is the Atmega328 which has a flash memory of 32 KB. It also has 2 KB of SRAM and 1 KB of EEPROM. The price for an Arduino board is typically $29.99 without any shields. The Arduino can be operated through batteries. The board draws roughly about 42 mA and the power consumption is about 0.29 W. When it is on sleep mode it will draw around 10 mA and the power consumption would be roughly about 0.07 W. To determine how long the Arduino can last through regular use or standby mode will all depend on how much amp hours are in the batteries. Arduino is great for many applications and very affordable. It is a little bulky and even more bulky with shields. [24]

The MSP430 series are very popular microcontrollers made from Texas Instruments (TI). According to the TI web page, the MSP430s are the world's lowest power microcontrollers. The ultra-low power makes the battery life last a lot longer

because it will only draw about 0.1 uA – 10 uA. It also has a flexible clocking system which allows it to enable or disable certain closks and oscillators to make it enter certain low power modes. This is what makes it optimize the current consumption by only allowing certain clocks at an appropriate given time. It has a 16-bit architecture and only a 16 KB flash memory. The MSP430 is very affordable if bought as a launchpad kit. The MSP430 series also have open source software to program it. Overall it is a small microcontroller and very affordable and great power consumption. The MSP430 series can also use batteries as its power source. [25]

The Rfduino is the last microcontroller that will be mentioned in this review. This microcontroller is a kickstarter project which was completed and going to ship out this summer. It is an open source microcontroller. It uses the same software and programming language as the Arduino. It pretty much is the same thing as an Arduino except it is a lot smaller in size. It is small enough to fit pretty much anywhere with no issue. It has built in low-energy Bluetooth 4.0 on the module but it is also backward compatible with older versions of Bluetooth as well. It uses a 32-bit Arm processor. There are a variety of shields that be used such as a USB, RGB, push-button, servo, AAA battery, and coin battery shield. The price is very cheap which is around $20 for the microcontroller and it is user friendly since the USB shield makes it easy to interface to a computer to program it since it uses open source software and libraries from the Arduino web page. The RFduino uses the RFD51822 module as its transceiver. It has an integrated on-board chip antenna. Uses the on-board 32-bit ARM Cortex M0--based processor and is 2.4 GHz wireless system-on-chip. [26]

These microcontrollers have their pros and cons. Most of them work perfect for any design but some are constricted due to either size, power consumption, cost, or capability. Best for wireless communication and for portability would be the RFduino, since it has built in Bluetooth. Best for memory and easy interfaces would be the Arduino. And for cost would be the MSP430.

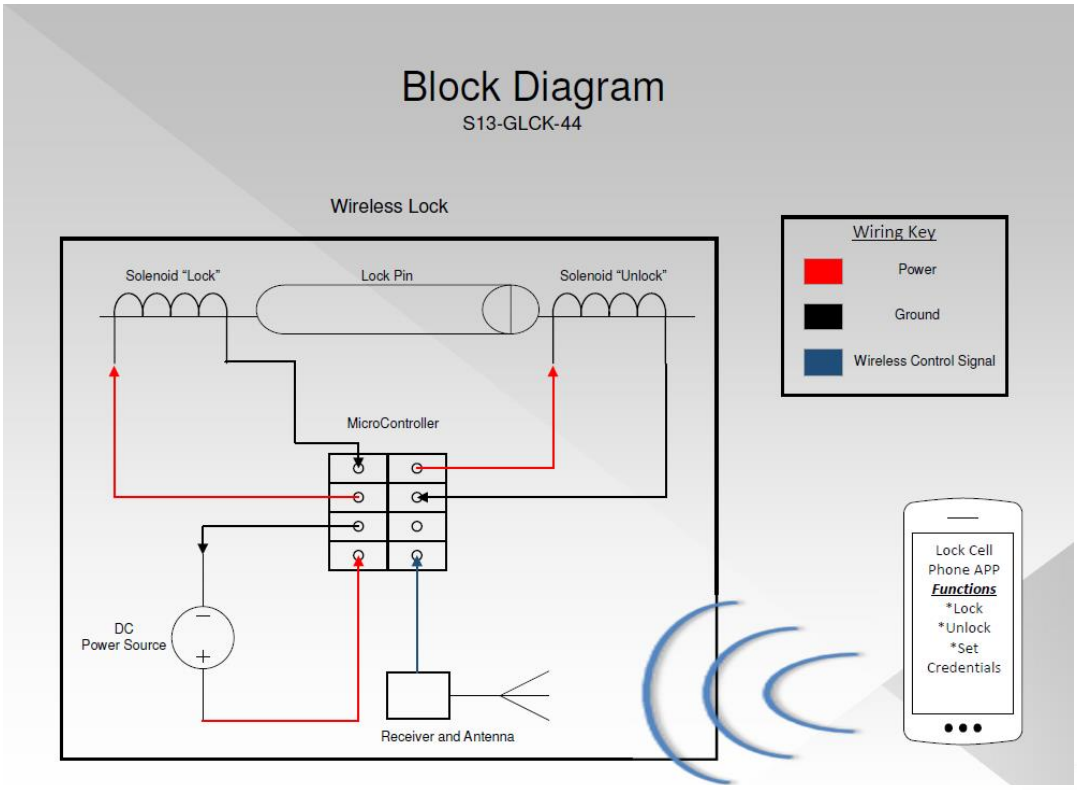
(BA)

Advancements in telecommunications and information technology in the past two decades have simplified the process of developing a remote operated security mechanism. The implementation of multiple security features has also been made possible with these advancements. The final frontier of security is the very basic mechanical lock, the origins of which can be traced back as early as the 1000BC to the ancient Egyptians or to as recent as the [AD] 1889 patent for a Yale Lock.

Project Description

The purpose of this project is to construct a generic lock that can be activated through a phone application. This system varies from other existing lock mechanisms because not only will it be activated through a phone application, but also by using solenoids which engages and disengage the locking mechanism. The way it will be activated will be through Bluetooth. The phone will have an application that will have a lock and unlock feature, transmit via Bluetooth, and the microcontroller will work as the receiver. This then will control the solenoid which is being used as the locking mechanism. There will also be a fail-safe to the design in case of power failure. The primary design includes the locking mechanism, microcontroller, power system, and phone app. The block diagram of the main system is shown below.

Figure 2: Block Diagram



Design Basis

#	Title	Date Used (Mo./Yr.)
1	Request for Proposal	02/2013
2	Saluki Engineering Company Standards (Management Meetings)	Semester Long
3	S.E.C. Specifications	3/2013
4	Order Parts	3-5/2013
5	Design Prototype	3-5/2013
	Build/Test Prototype	8-11/2013

TABLE 3: DESIGN BASIS

Specifications

Primary: To be achieved first

1. Lock will be no larger than 4X4X2 inches (LXWXH)
2. Lock will be controlled by Bluetooth version 4.0
3. Lock portion must not be able to be cut by standard wired cutters
    a. Note does not include industrial lock cutters(less than 5 kilonewtons of force)
4. Lock must be able to be unlocked via an Android application
5. Lock must have a failsafe “physical” way to open the lock
6. Lock battery must last no less than two months of continuous use
    a. Lock will have a “sleep” mode
7. Lock app must be able to be used on standard Android phones
    a. Will support Android version 3.0 Honeycomb and higher
    b. Phone must have Bluetooth capability
8. Lock should cost no more than 50$ for the consumer

Secondary: To be achieved after all primary have been met

1. Lock optimized to 3X3X1 inches (LXWXH)
2. Lock backwards compatibility with older versions of Bluetooth
3. Lock application ported to Apple OS
4. Lock application ported to Blackberry OS
5. Lock battery tested for continuous use of over a month without tampering
6. Lock app better compatibility with standard Android phones
    a. Support of older versions of Android OS
    b. Phone must have Bluetooth capability is still a requirement

Tertiary: To be achieved after all secondary have been met

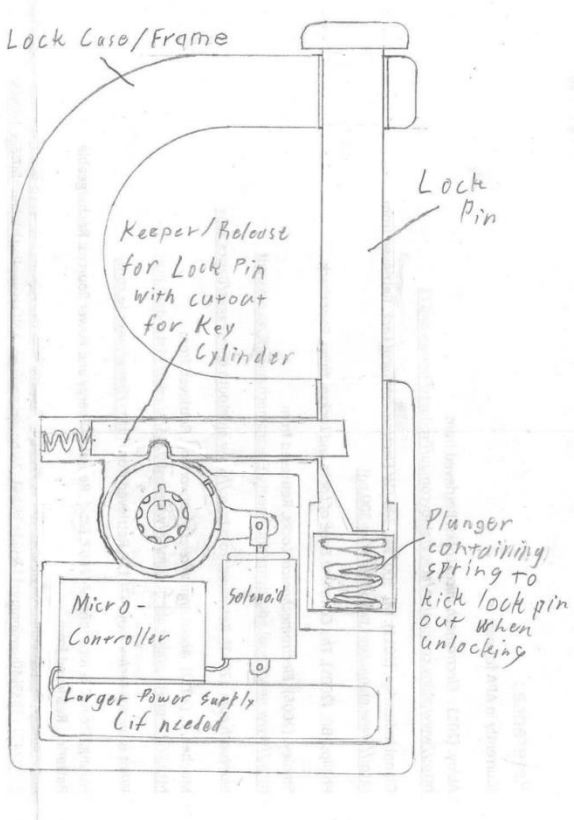
1. GPS tracking capability added
2. Tampering sensor tracking, with ability to upload to smartphone
3. Rechargeable battery lasting more than 3 months
4. Other transmission options such as WiFi added to device and app

Subsystem Overview

LOCKING MECHANISM SUBSYSTEM (DS)

The proposed lock mechanism is a basic pin lock mechanism. It is easy to manufacture, operate, and control. The three main components of this mechanism are the lock pin, keeper/ release pin, and key cylinder. When the keeper/release pin is moved out of the lock pin it is then free to move and as in the following example a spring loaded plunger would push it out. To lock it again the user simply pushes the pin back into the case and the keeper slides back from the taper and then into place when the notch is met.

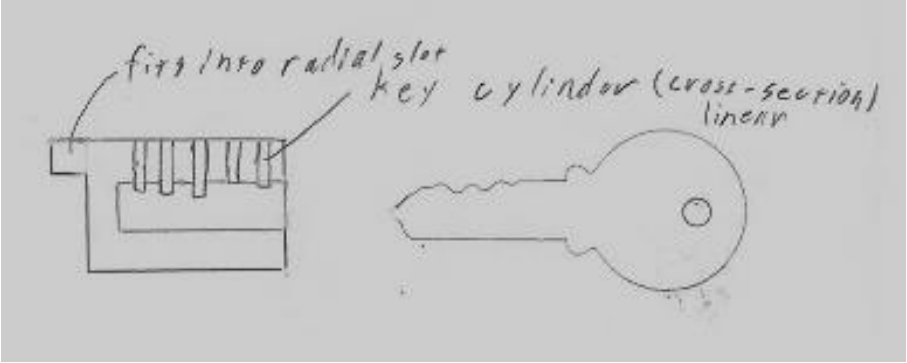
Figure 3 Proposed Mechanism Linkage and Components



To decide on exact specifications of this device a prototype will be constructed and some testing will be done. The solenoid required to operate the lock will have to be decided on after using a prototype and different spring setups. Obviously a set up where the lock could be struck with a hammer and then the pin pulled out would be pointless. After all the point of a lock is something that would in the least make it much harder for a perpetrator to break in to.

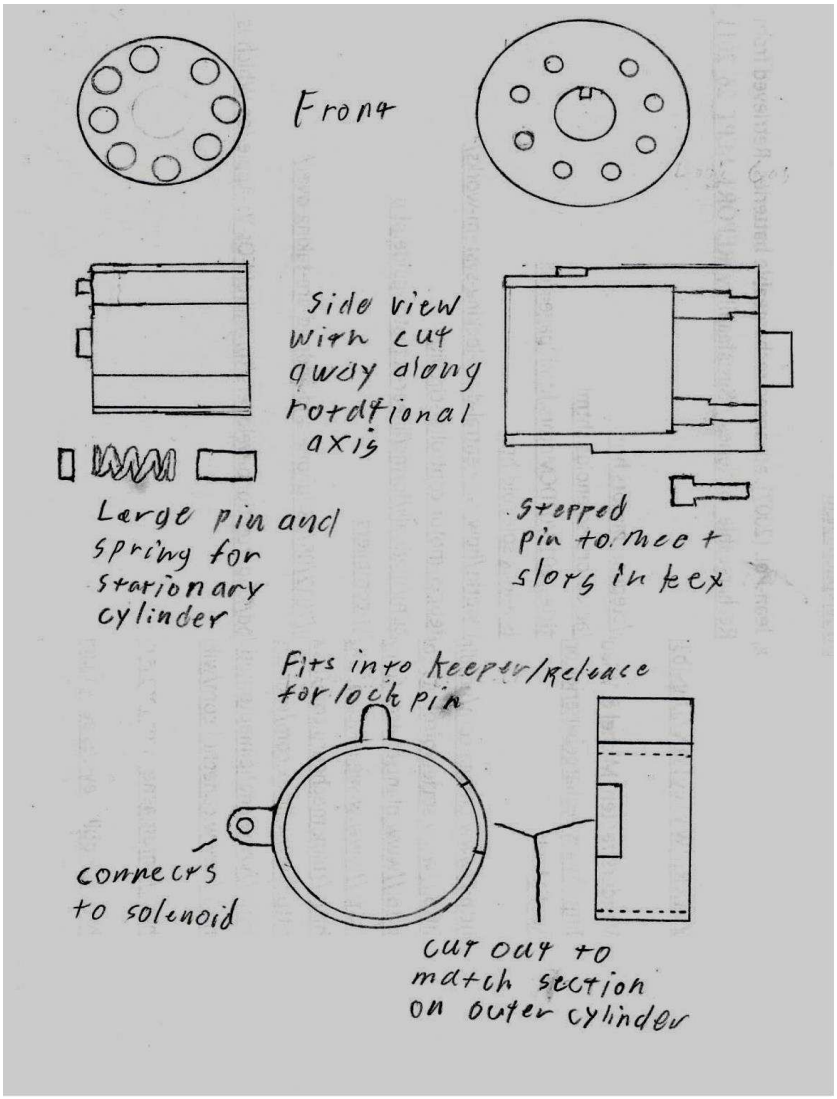
The lock cylinder in this had to be made more “bump proof”. One very popular way to get into a lock is by making a so called bump key. One can make a bump key by getting a blank key the same as that used by the lock and filing the cutouts down to the same as the lowest point of the original key. The bump key is inserted into the lock almost all the way in just up to the point where the last cut out is about to push the pins up. It is at this point the back of the key is struck while lightly trying to turn it. When the key is hit, all of the pins bounce up and as they all come back into the key cylinder for an instant they could all line up and the cylinder is able to be turned. This is possible because manufacturers have all their pin depths in the cylinder at the same level. If the key cylinder was made with the pins at different depths in the cylinder they could not be struck in the manner described like that of the bump key.

Figure 4 Typical Key and Cylinder with Pin Depth Modification



Another type of key mechanism that is a drill-proof key. The problem with most key cylinders that use pins for all the detents in the key is that they can be easily drilled out and then opened with most anything. Once the hole is drilled the pins or tumblers just fall out of place and the cylinder is easily turned. The drill-proof is a key lock cylinder combination that has a key that is a sort of small cylinder shape.

Figure 5 Tube/Barrel Key with Linkage to Pin Lock



The lock cylinder in this case has pins that are placed axially and the key has cut outs that match the depth where each pin needs to be to allow rotation of the lock cylinder. These are termed drill-proof because for the most part one cannot drill them out with a conventional drill with a bit smaller than the cylinder. The only way to drill past this kind of lock key combination is to drill a hole large enough that all of the lock cylinder is removed.

The construction of this is relatively simple and could be adapted to a sort of padlock if necessary. The biggest advantage of having a mounted device as opposed to one that is taken off like a padlock is that it is harder to tamper with it if it is mounted. The reason is it gives you the option of a device that could operate with close tolerances where it separates making it harder to break.

The case for the lock could be made of virtually anything. For the lock case, a stainless steel alloy is preferred because of corrosion resistance. In the end the strength requirements would have the most influence on the choice of the case material. For this lock the case would probably be machined from a block of material. If a device like this one ever went into production another method for case construction should be used unless CNC manufacturing is cheaper. It would take much time to machine the entire case and mechanism components. This device could be made in many different ways, however a prototype made out of aluminum or brass would be easier and less time intensive to fabricate. In this situation it is good because there is a very limited prototype development time.

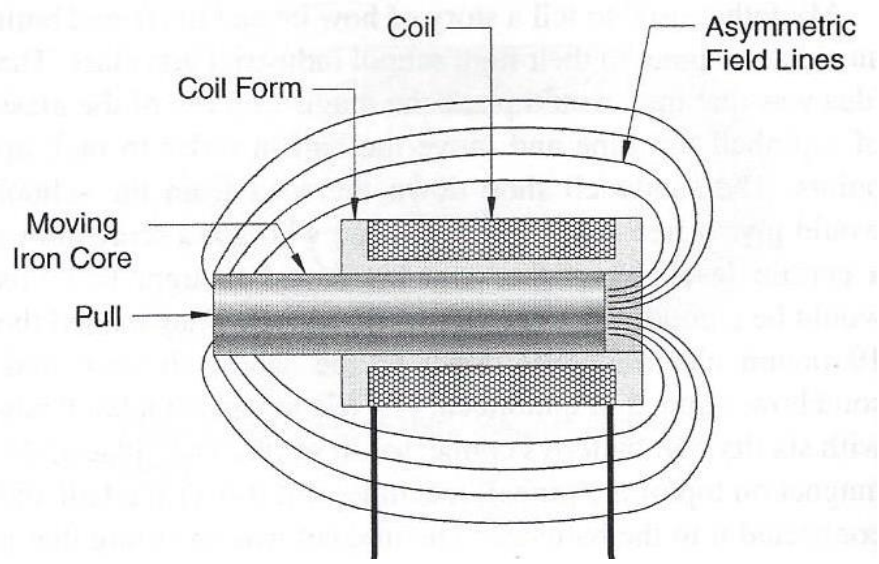
As for the moving components of the lock mechanism, the gear and matching rack would not have to be any material with extraordinary properties. This is because the gear and rack would only be utilized when the key cylinder is used to unlock or lock the device. The case itself would protect the lock mechanism components from the majority of harm.

The cost of the case and mechanism materials could vary depending on what the strength of these components needs to be. Stainless steel is expensive but is the best kind

of material for the case. If this were to go to production along with a stainless case, this could be done with CNC or powder metallurgy.

Software and computers to be used will be on hand. The use of solenoids would be the easiest way to operate the lock. The solenoid could be attached directly with the parts of the lock to operate. Depending on the size of the device and power limitations the solenoid could be chosen. The solenoid could be limited by the nature of the controller and or power source. Depending on the size of the lock and the power needs to operate it, a relay could be placed between the solenoid and controller but the power source would have to stand up to a significant amount of operation by the solenoids.

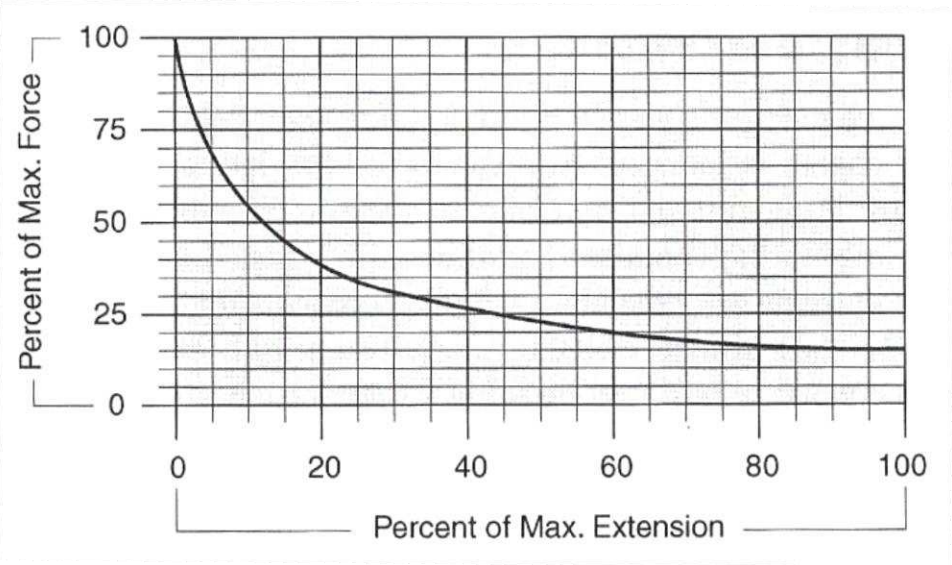
Figure 6 Solenoid Diagram



To determine what size of solenoid is needed, a measure of the stroke length and force required would have to be conducted. For this a prototype could be constructed to find this data. Since we are trying to make this device as small as possible we need a stroke length of less than 1", no shorter than 0.5" for a container mounted device. If the

device is chosen to be one that resembles a padlock and not mounted, the stroke could be much shorter maybe 0.125". In this manner the solenoid could just pull the keeper out of a metal loop much like that of the padlock. The downfall of a solenoid is that its force exponentially decreases as the plunger is farther from the magnetic field made by the wire coil body. So for solenoid use, the operation should stay as close to a range by zero extension as possible meaning we want to keep the solenoid in a range where it has the highest forces.

Figure 7 Relation of Solenoid Plunger extension versus Force [15]



POWER SUBSYSTEM (BA)

The power source in this project will be batteries. The batteries will supply power to the microcontroller, and the microcontroller will supply power and control the solenoid and the Bluetooth device. Furthermore, the microcontroller supports AAA batteries. The lithium-ion battery will be used, because it's designed for similar devices.

- Batteries will be used as a power source
- Will supply power to the microcontroller
- Element:
    - AAA Batteries

Figure 8 – AAA Battery Support [26]

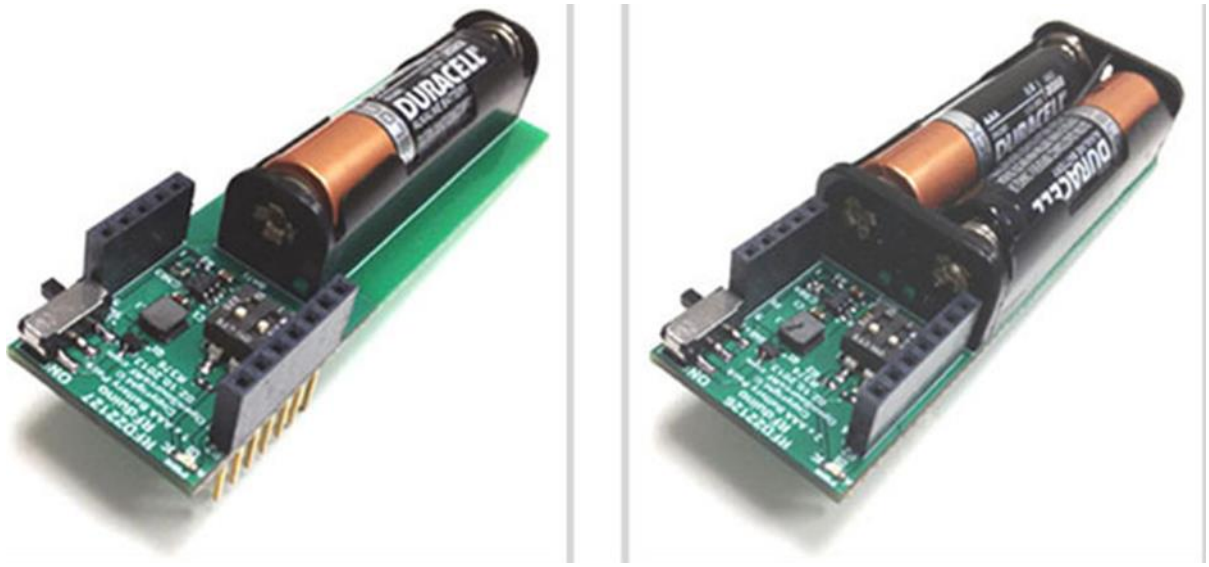
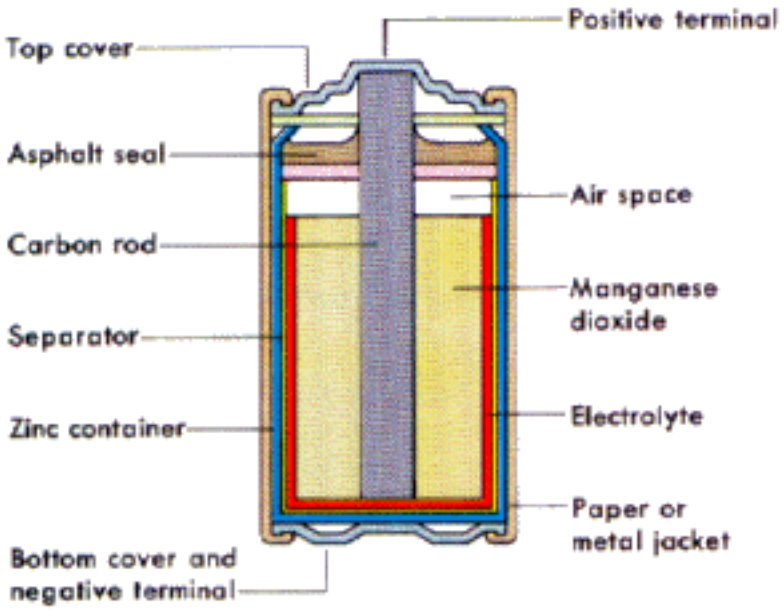


Figure 9 – Battery Overview [5]



MICROCONTROLLER SUBSYSTEM (RP)

- Will provide connection between the phone application and locking mechanism.
- Will control the solenoids once the user chooses whether to lock or unlock on the phone app.
- Will also work as the receiver for the Bluetooth signal.

Elements:

- Micro Rfduino and shields

Deliverables:

- control circuit prototype
- transmission receiver

ARDUINO software will be used to program the microcontroller since the rfduino uses the same programming language as the arduino uno or arduino duo so no new programming language is needed to work the microcontroller in this project. The microcontroller that will be used will be the rfduino. This microcontroller has Bluetooth low energy built in and this is what will enable it to talk to any wireless device which has Bluetooth 4.0. The rfduino has very similarities to the previous Arduinos such as the uno or duo. This microcontroller does not have a need for a wireless shield since it is already

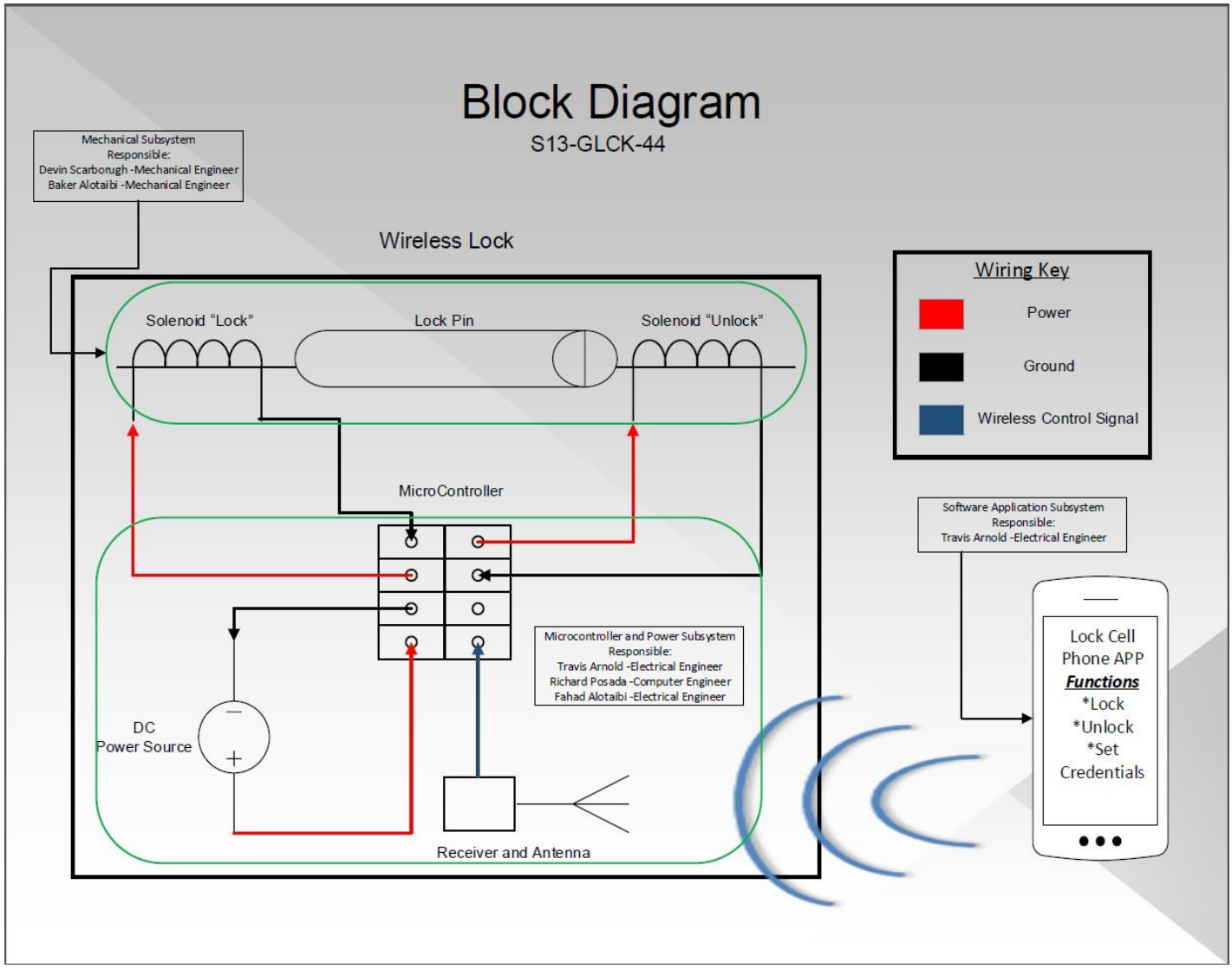
built in. The reason why a microcontroller is needed for this project is due to the connection needed for the phone application to control the locking mechanism, whether it locks or unlocks it via Bluetooth. It is also a coin sized microcontroller which makes it ideal for controlling the lock. The microcontroller will act as the receiver to the lock which will be controlling the solenoids which will lock or unlock it. This will also have its own power source which does not have much power consumption. The design itself will not be hard to implement since the rfduino takes care of many components that we need for this project.

PHONE APPLICATION SUBSYSTEM (TA)

The phone application subsystem will consist of two parts. Part one is the initial programming of the phone application. The phone application will be java based and programmed in the free to use Eclipse development suite for Java and mobile devices. After programming is done, it will need to best tested with the other systems to verify precision. This step will include multiple iterations of improving efficiency and ease of use.

The second part is to get approval to deployment over Google Play, which is the standard android deployment suite. There is also the option of deploying it via Amazon application store, or even a personal website. It should not be difficult to get it on Google Play though, and once deployed, tests will be conducted on multiple different cellular devices with Bluetooth capability to further test the subsystem, and total system prototype.

Project Organization chart



Action Item List

Project: Generic Wireless Lock								Sec Ref #: S13-44-GLCK
	Action Item List							**Hrs. Worked are on the second sheet**
Team Members:								
TA	Travis Arnold							
DS	Devin Scarborough				**Date:**	**Fall**		
FA	Fahad Alotaibi					**2013**		
BA	Baker Alotaibi							
RP	Richard Posada							
GM	Group Meeting							

#	Activity	Person	Assigned	Due	New Due	Status	Due Date Com	Tasks for Each Activity
1	Verify Specifcations	GM	8/19/13	8/26/13				
2	Final subsystem design Prototype overview	GM	8/19/13	8/26/13				
3	Micro-controller subsystem	TA,FA,RP	8/19/13	9/2/13				Build and program
4	Application subsystem	TA	8/19/13	9/2/13				Build and program
5	Power subsystem build	FA	8/19/13	9/2/13				Build
6	Mechanical Mechanism Subsystem	BA,DS	8/19/13	9/2/13				Build
7	Subsystem test	GM	9/2/13	9/9/13				Test each subsystem
8	Review subsystem	GM	9/9/13	9/23/13				Iterate system changes
9	Perfect Subsystem	GM	9/9/13	9/23/13				
10	Assemble Prototype	GM	9/23/13	10/7/13				
11	Prototype test	GM	9/23/13	10/7/13				
12	Perfect Prototype	GM	10/7/13	11/4/13				
13	Documentation Draft	GM	10/21/13	11/25/13				
14	Revise Device Documentation	GM	10/21/13	11/25/13				
15	Final Documentation	GM	10/21/13	11/25/13				
16	Finalize prototype	GM	10/21/13	11/25/13				Ready for production line

Project Timeline

Timeline for SEC Project #: S13-44-glck

Activity	19-Aug	26-Aug	2-Sep	9-Sep	16-Sep	23-Sep	30-Sep	7-Oct	14-Oct	21-Oct	28-Oct	4-Nov	11-Nov	18-Nov	25-Nov
Verify Specifcations															
Design subsystems															
:Micro-controller															
:App Design															
:Power Source Design															
:Mechanical Mech. Design															
Design Reviews			△						△						
Build subsystems															
Review build design															
Progress Report						△									
Perfect subsystems															
Assemble Prototype															
1st System Test								△							
Perfect device															
Documentation Draft															
Revise Documentation															
Final Documentation															

Legend:

	As bid:	As worked:	Revised:
Activity:			
Milestone:	△	▲	

Required Resources

The following is a list of estimated material to complete the project:

- Hardware
  - 1 rfArduino w/shields - 139.99
    - 1 rfArduino battery shield
    - 1 rfArduino usb programming shield
    - 1 rfArduino bluetooth shield
  - 1 smartphone with java application support – free (Will use Travis' HTC Droid DNA)
  - 1 computer – free (on hand)
  - 6 AAA rechargeable batteries - 7.99$
  - Lock case material for prototype 49.99$
  - 1 lock mechanism and pin – free (on hand)
  - 1 toolkit- free (on hand)
    - Standard set (screwdriver, pliers, etc)
  - Voltmeter - free (on hand)
- Software
  - Eclipse IDE for Java and DSL Developers (http://www.eclipse.org) - free
  - Eclipse for Mobile Developers (http://www.eclipse.org) - free
  - Rfduino programming suite – free

Total Cost Estimated: 197.97$

Data Analysis, Experimentation, and Simulation

DATA ANALYSIS

No current data

EXPERIMENTATION (ALL)

To be done:

- Test battery after locking and unlocking to determine the maximum number of uses without charging the batteries.
- Test battery after leaving locked in standby mode to verify the life of batteries.
- Testing of locking mechanism.
    - Testing for feature functionality (Lock and Unlock)
- Testing of safety of lock in the locked position.
- Testing the lock safety to end user.
- Test lock strength and security.
- Test microcontroller transmit receive function.
    - Distance of send/receive viability
- Test microcontroller lock/unlock control function.
- Test microcontroller standby mode function.
- Test phone application with transmit/receive function.

EXPERIMENTATION

No current data

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Appendix

CONTACT INFORMATION

TRAVIS ARNOLD PROJECT MANAGER ELECTRICAL ENGINEER	RICHARD POSADA MICROCONTROLLER DESIGN COMPUTER ENGINEER	BAKER ALOTAIBI MECHANICAL DESIGN MECHANICAL ENGINEER
Slyyke66@siu.edu	**Richardposada@siu.edu**	**B.alotaibi@siu.edu**

FAHAD ALOTAIBI POWER SYSTEM DESIGN ELECTRICAL ENGINEER	DEVIN SCARBOROUGH MECHANICAL DESIGN MECHANICAL ENGINEER
Fahad@siu.edu	**Imdifferent78@hotmail.com**

RESUME'S

- Resume's for each team member have been attached to this appendix and are up to date as of 4/10/2013

CompTIA A+ Certified IT Technician

1314 Meadowview Lane
Metropolis, Illinois 62960
Phone (270) 816-5310
Cell (270) 816-5309
E-mail slyyke66@siu.edu
Currently enrolled in Southern Illinois University Carbondale

Travis Arnold

Objective

The opportunity to receive another intern experience with Lafarge utilizing, maintaining, and heightening my skills and experiences; specifically in engineering and working with people in a corporate environment.

Education

August 2009-Current Southern Illinois University Carbondale, Illinois
(Current Senior Obtaining Degree in Electrical Engineering)

Awards Received

- Earned the privilege of joining SIUC University Honors Program
- Earned the privilege to represent State of Missouri at the Skills USA National competition
- CompTIA A+ Certified IT Technician (ID number COMP001007457286)
- Honor graduate with an A GPA from St. Mary High School May 2009
- Earned the rank of an Eagle Scout in March 2007
- Inducted into National Honor Society in 2006-09
- Inducted into National Junior Honor Society in 2004-05
- Earned the privilege of an "A" Honor Roll student at Fort Osage High School

Interests and Activities

Boy Scouts, Tennis, Basketball, Reading, Computers, Personal fitness, Personal Nutrition, Friends, Chess, stocks

Work experience

September 2010-Present(ongoing during college semester)

College Student Worker

- Working as a technical support worker for the college of Engineering at Southern Illinois University Carbondale. I worked as a Lab overseer, Computer repair, office calls, lab calls, among numerous other duties.

July 2012-August 2012

Summer Intern Lafarge North America

- Continued to work with Lafarge on the Greenbook operation for oil well cements. A team of engineers, businessmen, and managers including myself were tasked with creating a step by step guide on how to create the different oil well cements. We decided to make a more user friendly version and (15-25 pages) of the original green book. It was meant as a field manual. Whereas the original Greenbook was more of a textbook style. Also helped pioneer idea of creating an app that did the same thing, for mobile view in the field.

May 2011-August 2011

Summer Intern Lafarge North America

- Worked with Lafarge to create the "Greenbook" for oil well cements. A team of engineers, businessmen, and managers including myself were tasked with creating a step by step guide on how to create the different oil well cements. (Grade A-H) My role was to learn about oil well cements, chemistry of oil well cements, and how to run and use statistical analysis software (SAS 9). I then reported my findings to the team as well as the results of my statistical analyses.

May 2011-August 2011

Summer Tennis Instructor

- Worked as a tennis instructor for Paul Rowton's indoor tennis center in Paducah, KY. Tennis skill was essential, however from a business standpoint I learned a lot about managing people, and how to get different types of people to do the same thing (tennis). Everyone learns differently and responds differently to different input. I taught all ages ranging from 5 years old to adults.

December 2010-January 2011

Lafarge Winter help

- Worked with Lafarge to compile sensitive lab data into a usable spreadsheet format. Software involved included Microsoft Word, Powerpoint, and Excel. I converted and imported over 250 individual spreadsheets and combined them into one usable database table format.

June-July 2010; Go blue Construction; Silverthorne, Colorado

Summer Construction worker

- Worked an all-around position, including tiling, painting, building, and other manual labor with or without supervision.

May 2008-Aug. 2008; Diamond Computers; Independence, Missouri

Summer Intern IT technician

- In-store service technician. Built machines from the ground up including hardware, software, and other specified tasks such as anti-virus and other computer maintenance routines.

Aug. 2007-May 2008; Fort Osage Career and Technology Center; Independence, Missouri

In School IT technician

- As part of the core curriculum for Computer Support I at Fort Osage CTC, one of our tasks besides the actual course was to maintain, support, and troubleshoot all onsite computers for the duration of our course (this included over 250 computers wired and wireless).

References

Mr. Steve Arnold - Manager and Co-owner of Go Blue construction
(970) 389-2582

Mr. Chris Whitehill - Manager and owner of Floor-it Carpeting
(816) 985-1637

Mr. Don Schlaegal - Teacher of Computer Support Specialist Classes at Fort Osage Career and Technology center
(816) 650-7180

Mr. John Brajkovich – Head IT Technician for SIUC College of Engineering
(618) 203-3021

Mr. Nathan Rowton – Manager, owner, and professional tennis instructor at Paul Rowton's Indoor Tennis center
(270) 519-0098

Richard Posada

richardposada1@gmail.com
3640 N. Tripp Avenue
Chicago, IL 60641
(773) 961-9883

Objective: An internship in Computer Engineering beginning summer (May-August) 2013.

Education:

Bachelor of Science in Computer Engineering, December 2013
Minor: Mathematics
Southern Illinois University, Carbondale 62901
G.P.A.: 3.3/4.0

Relevant Coursework:

- Digital VLSI
- Comp Design
- Digital Signal Processing
- Data Communication Network
- VHDL and Verilog Design
- FPGA Design
- C++

Experience:

Receptionist, Amigo Driving School May-August 2012

- Provided excellent service and support to customers
- Created and maintained spreadsheets
- Greeted customers
- Handled incoming phone calls and scheduled meetings

Skills:

- Microsoft Visual Studio 2010 professional
- Cadence Virtuoso Analog Design Environment
- Matlab
- Orcad Pspice
- Xilinx ISE Design Suite
- Microsoft Office
- Fluent in Spanish

Activities:

- Treasurer, ATMAE, Southern Illinois University Carbondale
- Latino Cultural Association, Southern Illinois University Carbondale

Baker Alotaibi

1101 East Grand Ave. E10. Carbondale, IL 62901 bsmt11@yahoo.com
Phone # 6183037866

Objective: To obtain an entry-level position in mechanical engineering field where system development skills will be utilized.

Education: Bachelor of Science in Mechanical Engineering, December 2013
Southern Illinois University, Carbondale, Il 62901
G.P.A.: 3.0/4.0

Senior design project "Generic Lock (Remote-controlled Mechanical)"

Related course work:

- Fluid mechanics.
- Mechanics of materials.
- Hydraulics and pneumatics.
- Applied Mechanics
- Applied Thermodynamics

Skills:

- MatLab
- Auto CAD
- C++

Alotaibi, Fahad
1101 E, Grand Avenue
Carbondale, Il 62901
Phone: (618)303-6728
Email: fmfo@hotmail.com

Objective:

To obtain an entry-level position in electrical engineering

Education:

Bachelor of Science, Electrical Engineering
Southern Illinois University, Carbondale, IL
Expected Graduation:
GPA: 2.5

Technical Courses:

- Introduction to Biomedical Imaging
- Computer Organization and Design
- Programmable ASICs Design
- Senior Design

Skills:

- Familiar with Matlab
- Familiar with C++
- Familiar with Xilinx ISE

Devin Scarborough

8780 State Route 147
Simpson, Il 62985
dscarborough78@gmail.com
(618)771-2886

Objective

Obtain an entry-level position in mechanical engineering to apply automotive-related skills

Skills and Qualifications

- Much experience with drafting, modeling, programming; Microsoft Office programs; manufacturing techniques such as machining and welding.

- Designed and produced modified components of the frame, drivetrain, and suspension for mainly motorbikes and some automobiles.

Education

B. S., Mechanical Engineering, December 2013
Southern Illinois University Carbondale, IL

A.A.S., Automotive Technology, August 1999
Shawnee Community College, Ullin, IL

- **Senior Design Project** "Generic Mechanical Lock." Collaboration on designing and manufacturing
the mechanical lock.

Work Experience

May 2012-Jan. 2013 **Welder/Fabricator at Carterville Railcar Repair**
- Fabricated and replaced parts for railcars which often involved welding

July 2011-May 2012 **Technician at Auffenberg Chrysler in Herrin Illinois**
Sept. 1998-Aug. 1999 **Technician at Royal Oaks Chevrolet in Paducah Kentucky**
- Maintained, diagnosed, and repaired automobiles

Nov. 2003-Feb. 2009 **Maintenance at Southern Illinois Railcar in Carterville Illinois**
- Maintained and repaired tools and equipment for the company

Reference available upon request