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Redesigning the Keyfinder

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Abstract

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This project takes a look at redesigning a helpful device called the Keyfinder. The device is used to locate small objects that are typically lost. Items such as keys, remotes, and wallets are some example items that tend to get lost frequently. However the current models of the Keyfinder generally receive poor reviews for subpar performance and lack of usability. In an effort to remedy the situation, I looked to redesign and improve the system so the device would be useful in households.

The initial design of the system consisted of a base that could communicate with 5 different receiving modules by using switches and a LCD screen to make the system user friendly. Researching materials led to several considerations on what to use to develop a prototype of the system. In the end, the Arduino boards were used to act as the base and receiving modules, with XBee units being used to allow the Arduino boards to communicate wirelessly.

After building a prototype of the system, tests of the device showed positive results. However the assembly of a more finalized product came to a halt as power issues arose. During prototype testing, the devices were powered through outlets or the computers. However when testing with batteries, it was found out that power consumption was not being done correctly and thus resulted in a failure to design the receivers. In the end a final product for the base was made but the receivers were still left in a prototype stage.

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I. Introduction

As a child, my parents would have fits with me for my carelessness which consisted of me losing many small objects around the house. However I was not the only person who was losing objects around the house. My whole family lost things around the house. Items like television remotes, telephones, wallets, glasses, and keys were always missing, causing us to be late for appointments or school whenever we were in a rush. Clearly we needed a solution to find small objects around the house.

However there are some products out there that can already locate small items like keys. The most common one is the key finder. It uses the simple concept of one transmitter and one receiver that emits a sound when activated. The product works great, but it can only locate one object. To locate multiple small objects, multiple key finders would be needed meaning we would have many transmitter and many receivers. However having so many transmitters will be hard to keep track of, thus making the key finder inefficient in finding multiple small objects at a time. Also keyfinders cannot communicate over a large distance and tend not to be user friendly.

The objective of my project is to redesign the keyfinder and improve the system. It needs to be able to communicate with multiple receivers while being able to keep track of which receiver is which, be more user friendly than existing devices, and the receivers need to be able to communicate over a larger distance than existing devices. This would allow the system to have one transmitter for multiple receivers and be more user friendly for the customers.

This report will first give a background on keyfinders and what has been done in the past that are similar to this project. The background will also consist of how this product could help society and go over the goals of the project more in depth. Following the background, the report will then discuss the design requirements considered when designing the system as well as possible design alternatives and my preliminary proposed design.

II. Background

Over the years there have been several devices developed which were used to locate small objects. More specifically these devices were used to locate car keys or house keys. The devices that were specifically designed to locate keys were called key finders. The first generation key finders were based on sound. The device was a small circuit that utilized noise recognition. This device would be attached to the keys and it would wait for a clap, a whistle, or a sequence of those sounds before it activated. When activated the circuit would emit a beep or a noise to help the user locate the keys. This type of detection is based on sonar, where the human listens for the sound to locate the keys. A picture of this type of key finder can be seen in Figure 1.

i

Figure 1: Example of a first generation key finder, in this case a remote finder. [i]

However the first generation of key finders had two problems. The first problem was that they were fairly large compared to the key finders of today. Due to the girth of the product, they were not appealing and considered intrusive. The other problem that was presented was the inability of the device to correctly identify whether the noise it receives was a clap, a whistle, or just a random noise. Due to this problem, the device would have many false alarms which led to poor performance. With the

devices inability to correctly identify the noises which caused unintended alarms to occur at the wrong time, these devices were quickly discarded.

With technology becoming smaller, the second generation of key finders utilized this smaller technology to become less intrusive. Also the second generation key finders used receivers to wait for a radio signal to activate. This eliminated the problem of the first generation key finders which was the inability to identify when the alarm should be sounding to find the lost keys. Using a transmitter to activate the receiver which would start the alarm, the second generation key finders seemed to be the perfect fix to finding lost keys. An example of a second generation key finder can be seen in Figure 2.

ii

Figure 2: Example of a second generation key finder. [ii]

Unfortunately, as good as the second generation key finders appeared there was still one major flaw that hampered this system. The major flaw was solving the problem of what happened when the user lost the transmitter that sent out the signal to the receiver to find the keys? Once the transmitter was lost, then the receiver would be pointless seeing as the receiver would not be able to get a signal to trigger the alarm.

Today's key finder uses a system that no longer uses a separate "base". Rather it is based on a peer-to-peer system that can find all the others individually. An example would be a wallet could be

used to find the missing keys or vice versa. Since all of the objects would have transmitters attached to them, the missing objects could reply by radio as well as beep and flash a light. Essentially they are all using transceivers. A picture of this can be seen in Figure 3 below.

iii

Figure 3: Example of third generation key finder. **[iii]**

Although the third generation key finders are deemed successful, I still feel the system can be improved. For instance, what happens when all the objects that have the transceivers on them are lost? If all of the transceivers are lost, then the system would be completely pointless and the person who lost all of the items would be back to square one. Even though this system is deemed successful in terms of being a viable system, performance ratings on sites such as Amazon has shown that users are generally unhappy with the product. The main concern being that the range of the device was poor.

With the previous generations of key finders being deemed poor, it became clear that designing a new system would be beneficial to me and others out there. However before designing and building a new system, it was necessary to consider some issues that pertain to key finders.

Health and Safety Issues

Although this device has the potential to be helpful to anyone who loses objects around the house, there are always health and safety issues that could follow. For instance, is it safe to be carrying a device in your pocket that is constantly waiting for a signal to trigger the alarm? Considering that the device is wireless, this could cause alarm from users like the health scares for cell phone users. In any cases cell phones and computers have been generally accepted by society even with this kind of health issue so this won't be a problem I believe.

Social

Assuming I manage to successfully do this project, this could potentially help many people around the world locate their small objects that are commonly lost around the house. For the deaf, the blinking on the LED and the external device will be useful in finding their lost objects. However for the blind, this system may not prove to be helpful. For everyone else, all of the features will prove useful in looking for the lost objects. Overall, this device has the potential to be very useful to anyone who loses objects around the household often.

Economic

Products like these have never had that great of an impact on the economy. This was due to faulty designs and poor products. To design a prototype of this product it may prove to be costly at the beginning. However in the long run the finished product may prove to be as cheap or cheaper than the competitors. To build the prototype, multiple components are needed to make a working prototype that would work with 5 different receiving modules. An estimate of how much the prototype cost can be seen in Table 1[iv].

Item	***Quantity***	***Cost per item***
Arduino Duemilanove	3	$29.95
Arduino Pro Mini	5	$18.95
XBee 1 mW Chip Antenna	6	$22.95
Vibration Motor	5	$4.95
LCD Screen	1	$14.95

Coin Cell Battery Holder	10	$1.50
Coin Cell Battery	10	$1.95
Basic Breakout to program Arduino Pro Mini	1	$14.95
Wall Adapter for Arduino	1	$5.95
Cable to program Arduino Pro Mini	1	$17.95

Table 1: Prices for prototype components.

The total estimated value for the prototype is around $400, but with a final product the cost could be reduced to a much more reasonable value of around $75 considering if we discard breakout boards and other components that were only needed for testing purposes like the extra Arduino Duemilanove.

Marketability

With a product like this, the shelf life will be great as long as the system works smoothly. The market for this product will mainly consist of elderly folks as well as parents who tend to lose objects around the house. Although it may be a small market, it is a product that could prove to be very successful with those from the older generations as they would be able to locate their small objects faster.

Manufacturability

The materials needed to build this product can be found on websites like sparkfun by any consumer. However these parts are custom made, meaning a consumer will not be finding these parts on any shelf in their house. Also it takes a good amount of knowledge on how electronics work for someone to manufacture this product from scratch.

III. Design Requirements

To have this device be successful on the market, it needs to meet or surpass certain different design requirements. These requirements can be broken down into two different sections. The

functional requirements define what the system does while the non-functional requirements define other aspects of the system such as pricing and physical design.

Fundamental Requirements

There are four fundamental requirements that needed to be accounted for. These requirements were distance, interference, user friendliness, and power. Each of these requirements are important in making the system better than the previous generation of key finders.

i. Distance

The most important requirement for the system was that it needed to be able to communicate with the receiving modules over a long distance. A distance that could cover a common household was desired for when designing the system. With doing research, it was determined that the system needed to be able to communicate at least 50 feet, the average length of a house. This would allow the base to be able to communicate with all receiving modules in the house wherever they are. In order to accomplish this, wireless communication module needed to be strong enough to communicate with other devices while also taking into consideration walls of a house and other objects that could weaken the wireless capabilities of the device.

ii. Interference

Another requirement for the system was that it needed to communicate with only one receiving module at a time. Essentially the system should not get interference from other modules besides the one that is being looked for. However it should be possible to turn on multiple receivers at a time, just that they can only be activated one at a time.

iii. User Friendly

Improving the user friendliness of the system was another requirement that needed to be met. For this, the system I designed had to provide ample user feedback to make the system easier to use and understand. To do this, a LCD screen was chosen to be used to give the user feedback. The display

would allow users to know which device was in action which could be useful in a variety of situations. For instance, if a device is on and the customer does not know which one it is, an LCD screen saying which one is on would work well into letting the customer know which one to shut off.

iv. Power

Finally the last fundamental requirement for this system was that it needed to be as power efficient as possible. This meant that the power life of the receiving modules needed to last for a long time without having to switch the batteries constantly. Ideally having the power supply last for a month or so would be ideal so users will not have to constantly switch the batteries. As for the base, a wall adapter was considered so that power efficiency with that module would not be as important. Of course making the base as efficient as possible was still a goal since as it would be no good if the base used too much power.

Non-Fundamental Requirements

Just as important as fundamental requirements are the non-fundamental requirements. The non-fundamental requirements include the cost of the system, size of the system, and the user friendly design of the system.

i. Cost

The most important requirement was that the product would need to be affordable for people. This is an important requirement since an expensive product would not sell well. Also if the price is kept down, it would mean that testing the prototype would not be so costly to us. Since we are the ones purchasing the materials to build and test the system, keeping the cost down was a major requirement for this project.

ii. Size

The second most important non-fundamental requirement for this system was that the receiving modules needed to be small and portable. Having a receiving module big and chunky would

not appeal to customers as they would not want the size of the receiving module to be a hindrance. This meant that the components selected would need to be powerful enough to do what was needed but small enough so that the device would not be too big.

iii. User Friendly

Another important requirement was that the device needed to be more user friendly than what it was before. This meant that the design of the system needed to be easy for all customers to figure out how to use. Arranging the buttons of the “base” in a logical order or using a LCD screen to give the customer feedback are just some ways to improve the system to be more user friendly. Considering that the market for this product would be adults to grandparents, the system needed to be user friendly while not being too flashy.

Finally the last requirement for the system was that the “base” needed to be designed in a way so that it would be big enough that it would not be lost but small enough so that it would not take up too much space wherever it was placed. It was also necessary to take into consideration the components that were being used to make the system work properly. With a bigger “base”, the system can have everything on it spaced out nicely to make it user friendly as well.

IV. Design Alternatives

The alternatives for this system can be broken down into three sections. These sections are communication alternatives, hardware alternatives, and software alternatives. Each section will play into the other such as the hardware used will affect the software used for programming the system.

Protocol Alternatives

The main part of this project is the ability to communicate with objects without the use of wires. However when it comes to wireless communications, everything is based on radio signals. Cell phones, wireless internet, televisions, and radios are all based on radio signals [[v]]. This meant that there were no

other alternatives available for communicating wirelessly except for using radio signals. However there are different protocols that could be used for communicating wirelessly. The protocols that were considered are 802.11, Wi-Fi, and ZigBee protocols that all communicate wirelessly.

i. 802.11

Protocol 802.11 is the set of standards that implements wireless local area network (WLAN) communication at different frequency bands. This protocol functions in either 2.4, 3.6, or 5 GHz frequency bands and it is maintained by the IEEE LAN/MAN Standards Committee. The radio frequency spectrum used by 802.11 however varies with countries making this a non-ideal choice.

ii. Wi-Fi

The Wi-Fi protocol is a superset of the 802.11 protocol. This means that Wi-Fi is contained, or a part of, the 802.11 protocol. Today it is one of the most commonly used forms of wireless communication as personal computers, gaming devices, MP3 players, and other widely used electronics use Wi-Fi protocol to communicate wirelessly with other devices or to the Internet. Although Wi-Fi seemed to be a good choice, I opted not to use Wi-Fi because I felt another protocol better suited my project.

iii. ZigBee

The ZigBee protocol uses small, low-power digital radios to communicate. It is based on the IEEE 802.15.4-2003 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs). This protocol is typically used for devices such as wireless light switches with lamps, electrical meters with in-home displays, etc. Based on my research, the ZigBee protocol seemed to be the best route to go since low-powered digital radios would not be costly and be able to communicate over the 50 ft. desired for the project.

Hardware Alternatives

Choosing the ZigBee protocol meant that I would need to use hardware compatible with the protocol. In my system I chose to go with the XBee units for wireless communication, the Arduino Duemilanove for the "base" to run the system, and the Arduino Pro Mini to control the receivers. Had I chosen to use a different protocol to communicate wirelessly, I would have been able to choose different hardware to implement the system.

Alternatives for the hardware used to communicate wirelessly consist of the many transmitters and receivers out there that would work similarly to the XBee units. XBee's are small radios that can communicate with each other and be programmed while transmitters[vi] and receivers[vii] can either only send information or receive information. However with the XBee, I am allowed to send and receive information while the transmitters and receivers cannot. Another alternative that could be considered for communication are transceivers. They would be able to send and receive information like the XBee as well. A price comparison of alternatives can be seen in Table 2.

Transmitter and Receiver/Transceiver	***Cost (per device)***
2.4GHz Transceiver IC - nRF2401A	$4.75
Breakout Board for RF-24G Transceiver	$1.95
FM Radio Transmitter Module - NS73M and FM Receiver Module	$9.95 and $9.95
XBee 1 mW Chip Antenna	$22.95

Table 2: Prices for possible transceivers, transmitters and receivers, and XBee units.

Although the alternatives are cheaper, the XBee units are easier to code and integrate with my current system. Also pricewise they are still relatively cheap, helping lead to the decision of going with the XBee units over any of the other alternatives.

Looking at the hardware of the system, there are many alternatives that could have been used for the system. Instead of the Arduino boards, 8051 microcontrollers could have been used for the project. The 8051 microcontroller[viii] is capable of performing the same functions that the Arduino does for the system. A quick comparison of prices can be found in Table 3.

Microcontroller	***Cost***

Arduino	$29.95
8051	$50.00

Table 3: Prices for development boards.

Based on the prices, the Arduino development board is much cheaper than the 8051 microcontroller development board. The chips used in both development boards are both relatively cheap as well. With a low price and the knowledge that the XBee's are functional with the Arduino made it an easy choice to select the Arduino boards for the hardware of the system.

The other hardware components used in the system had no other alternatives that I could find. This consisted of the LCD screen, LEDs which were provided by the school, a wall adapter to power the base module, toggle switches which were also provided by the school, and the vibration motors. There is only one type of vibration motors available that I could find, while the LCD screen alternatives mainly consisted of changing the colors or upgrading on the amount of characters the screen can display. It should be noted that the initial plan for the system was to have it contain speakers on the receivers as well. However I could not find speakers in a small enough size so I decided against putting speakers into the system.

Software Alternatives

With the Arduino boards selected as the hardware for the system, the software chosen for programming became the Arduino environment as well. However other software could have been used for programming but that could have led to many difficulties when trying to adapt the code for the Arduino board. As long as the alternative software could work with C programming, theoretically there probably would not have been a problem.

V. Preliminary Design Implementation

In redesigning the keyfinder, a prototype design was first made. This prototype block diagram design can be perceived as the proposed design for now. A block diagram showing how the system

should work can be seen in Figure 4 while the proposed design of how the system should look like and how it should function can be seen in Figure 5.

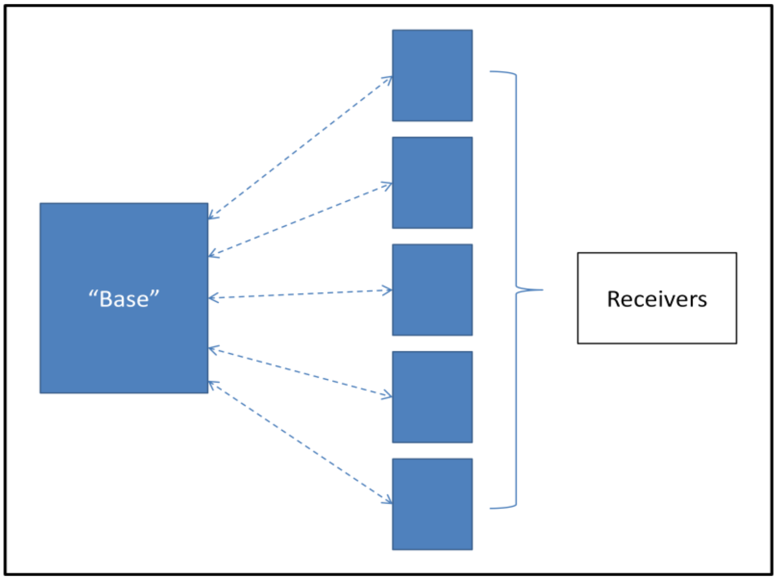

Figure 4: Block diagram of how the system will be expected to work.

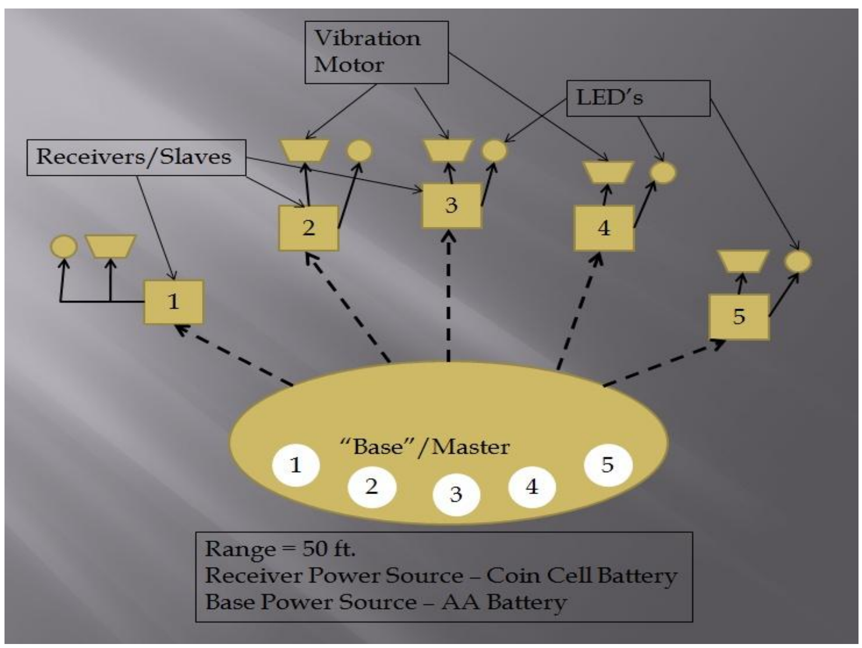

Figure 5: The proposed design of the system and how it works.

The block diagram in Figure 4 shows the main parts/blocks of the system. It should be able to communicate with 5 different receivers and the 5 receivers should be able to communicate with the "base" as well. Figure 5 shows a more detailed design of how the system will work and how it may look

shape wise. The base will have 5 different buttons, each button corresponding to a different receiver. With the receivers, there will be one LED and one vibration motor attached to each one. When a signal is received that tells the receiver to turn on, the LED and vibration motor will activate until another signal is received to tell the receiver to shut off.

Not shown on the figures is how the devices will be powered. For the receivers, coin cell batteries will be used to power the devices which should allow the receivers to be very small in size. The “base” on the other hand will draw power from a wall adapter while also having AA batteries for a backup supply of power. Also not shown on diagrams is the LCD screen that will be used to indicate the status of each receiver. The LCD screen will be placed on the base as well, right around where it says “Base”/Master in Figure 5.

The coding for the system however works differently than one might expect. Instead of the “base” sending a signal to only one receiver, the “base” will send a signal to all receivers when a button is pressed. It will be up to each receiver to act accordingly depending on the signal received. A simple example of this would be to say if button 1 is pressed, then a signal will be sent that sends the serial data “a” to all of the receivers. Each receiver will obtain this serial data and then based on this data it will act accordingly. For the first receiver, it should recognize that it received the serial data, ”a”, and that means it should activate the LED and vibration motor. The other receivers will also realize it received “a”, but these receivers will do nothing as it is not the correct serial data to get the system running.

Coding for the receivers also needs to notify the “base” when a signal has been received and it has activated. Essentially when the correct command to turn on the receiver is received, the receiver in turn will send to the “base” a code to tell it that the receiver module has been activated. This also means that when the “base” receives this new data, it needs to update the LCD screen to show that something has happened.

Currently the coding for the system has progressed to the point where two receivers have been programmed to correctly send and receive messages to and from the "base". The "base" has also been successfully integrated with the LCD screen to display whether or not a receiver has been activated or not. The project so far can be seen in Figure 6.

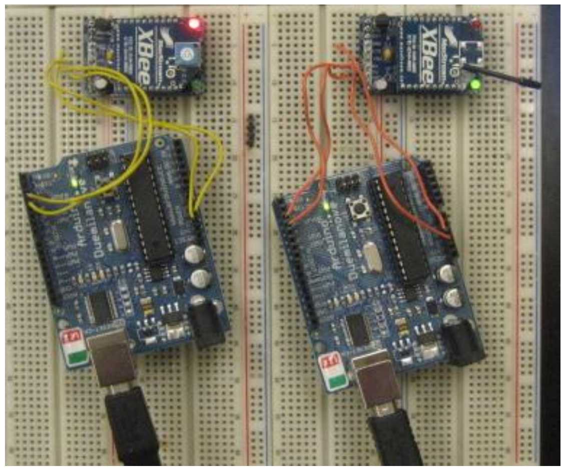

Figure 6: The project so far.

Although it is not noticeable, the Arduino on the left currently is programmed to act like the "base" while the Arduino on the right acts like the receiver. Not shown here are the LCD screen and the other receiving module that has been programmed. The receivers correctly send a message to the "base" only when the correct message was sent to them. Whatever message is received by the receivers is then correctly displayed on the LCD screen.

Although it seems the project is almost done, there are still many steps left before a finished prototype will be ready. For instance the buttons have yet to be successfully integrated with the system. Also the system is only in the early testing stages with using Arduino Duemilanove's as receivers when the Arduino Pro Mini will be the ones used as the receivers with their small stature. Finally there are possible upgrades to the design that could be made such as including an LCD touchscreen to make the system user friendly and speakers to allow the receivers be found more easily. A tentative schedule for completing the project during winter term can be seen on the next page.

VI. Final Design and Implementation

Compared to the preliminary design and implementation, the final design and implementation had very little changed. The system maintained having a "base" that communicated with 5 different receivers which would be triggered depending on which switch is toggled. However the shape of the base changed from being elliptical to being rectangular. Also instead of the base powered by AA batteries, the base is now powered by a wall adapter at 9V DC. A more detailed look at the design can be seen in Figure 7.

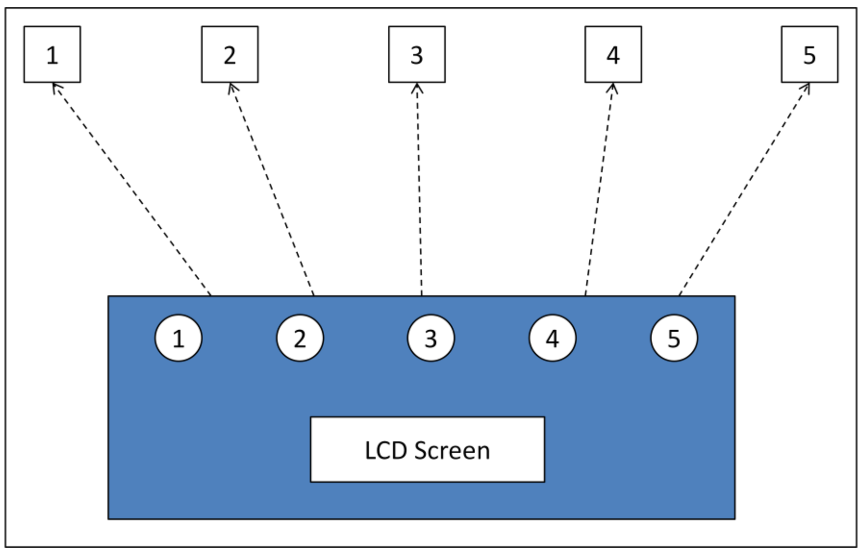

Figure 7: The final design of the system.

Having the LCD screen on the bottom of the base seems odd, but the enclosure I chose to use constrained how I could set the LCD screen into the base. Ultimately the design still works well. To give a better look into the final design and implementation of the system, it is necessary to look at each module individually before looking at the system as a whole. More specifically, each module looked at will be split into two sections where we will look at the hardware aspect and then the software aspect.

Base

The "base" of the system needed to communicate with 5 different receivers and at the same time. Also the "base" needed to be user friendly in terms of the physical design and implementation of the algorithm that would be controlling the module. To gain the best possible understanding of the

design and implementation of this module, we will split the discussion by first looking at the hardware and then the software for the "base".

i. Hardware

In order to understand the base, it is necessary to understand the wiring of the base and how it is working. Figure 8 shows the base and how exactly the base will work.

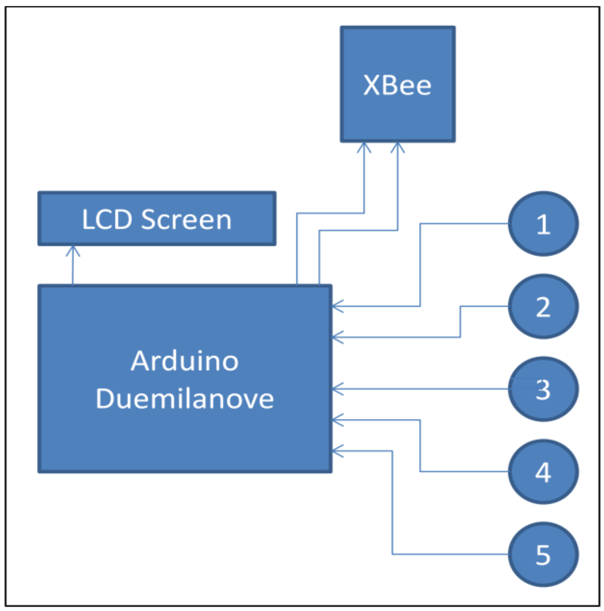

Figure 8: Design of Base

The numbers 1-5 represents the 5 switches that are wired to the Arduino Duemilanove that controls the "base". For my system, the 5 switches will act as the inputs which the Arduino will interpret and perform the necessary task. Also attached to the Duemilanove are an XBee unit and a LCD screen. Both components will be the outputs for the Arduino Duemilanove where the XBee will be sending and receiving signals and the LCD screen will print out statuses of the receivers based on the signals received by the XBee unit. Not shown in the figure is the power source for the Arduino. Since this is the "base", the power will be coming from a wall adapter that plugs into the board. It should also be noted that the LCD screen and the XBee unit both need a power source, which was provided by the Arduino board. Another thing that should be noted was that the enclosure chosen had to be able to contain all of the

components of the "base" comfortably while not being too big. The final enclosure chosen will be seen in the Results section. In order to understand the design of the base completely, the software design, i.e. the code for the base, needs to be explained as well.

ii. Software

To best understand the algorithm of the "base" unit, an algorithmic flow chart representing the module's behavior has been made. This can be seen in Figure 9.

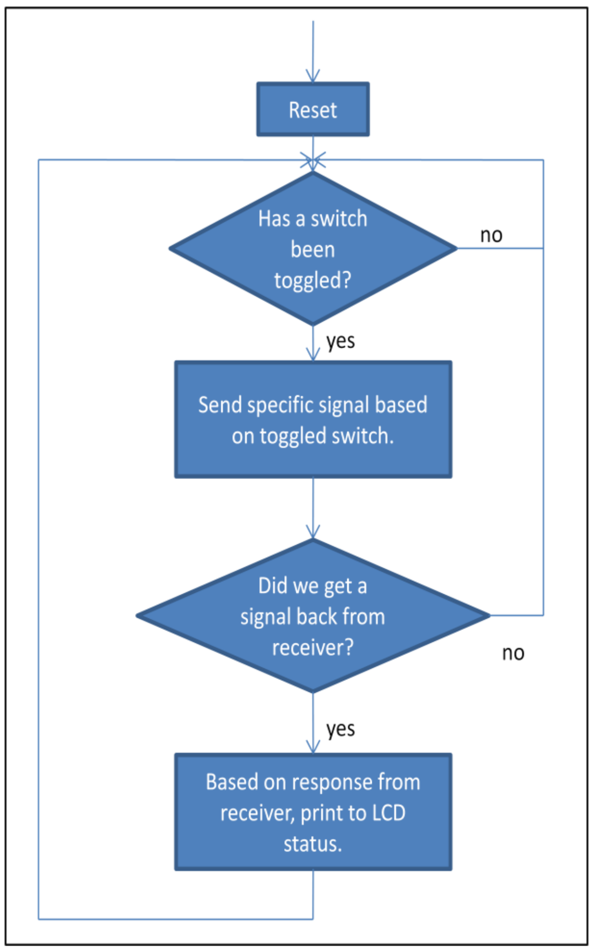

Figure 9: Algorithmic flow chart of base.

When the base is turned on, it will reset itself and then wait for the user to toggle a switch. Once a switch is toggled, the "base" will send out a specific signal that only one of the receivers will be programmed to respond too. The "base" will then wait for the response of the desired receiving

module. If the receiver is not heard from, then the “base” will go back to waiting for a toggle to be switched. However if the receiver is heard from, then the “base” will print to the LCD to let the user know that a receiving module has been activated or deactivated based on the response of the receiver. Once printed to the LCD, the “base” will then once again wait for the user to toggle a switch. The code for this module can be seen in Appendix A. This code for the base is around 300 lines long including comments and was written in the Arduino environment which is a form of C language.

Receiver

There needed to be 5 receivers made that only responded to a specific switch from the “base”. Physically the receiver needed to be small and unobtrusive, but it still needed to be able to catch the attention of the user when activated. To gain a better understanding of the receiver, we will again split the discussion by first discussing the hardware for the receiver and then the software.

i. Hardware

To gain a better understanding of the receiver, we will look at a diagram of a receiver and how it should be wired together. This can be seen in Figure 10.

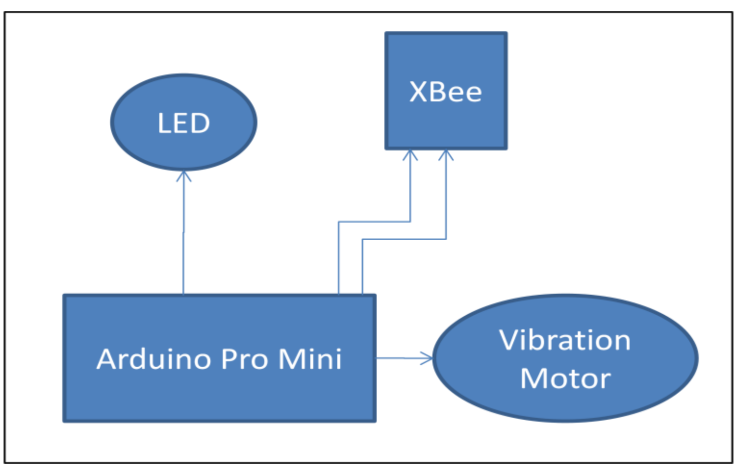

Figure 10: Design of Receiver

The design of the receiver is simpler where there are just three components attached. Since the receiver has to be small, the Arduino Pro Mini was chosen to be the Arduino board that controls the receiver.

The XBee unit attached allows the receiver to communicate with the “base”, with the LED and vibration motor acting as outputs for the Arduino Pro Mini. Based on the signal received by the XBee, the receiver will either send a response back and turn the vibration motor and LED on or send no response at all. To understand how this occurs, a look into the software of the receiver is needed.

ii. Software

To understand the algorithm implemented for the receiver, we need to look at the algorithmic flow chart of the receiver. This can be seen in Figure 11.

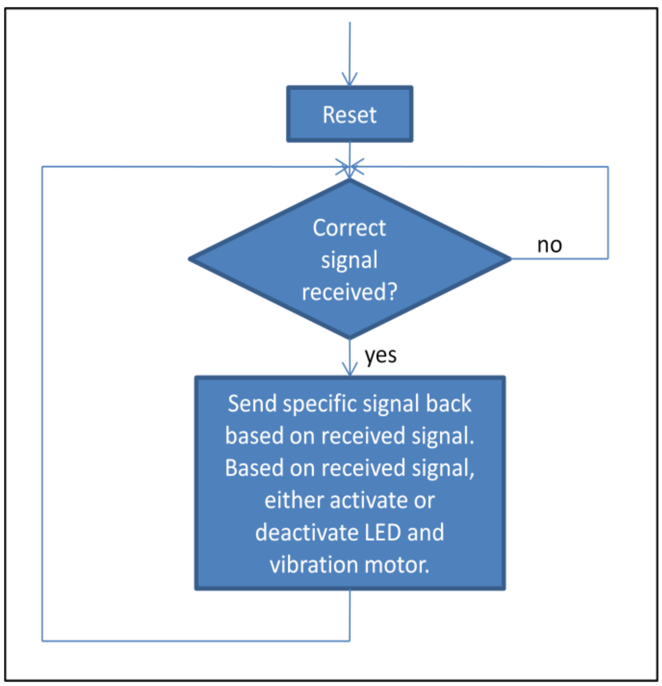

Figure 11: Algorithmic flow chart of receiver.

The receiver, once powered on, will reset and then wait for a specific signal to be sent from the base. When the receiver is reset, it will automatically have the LED and vibration motor turned off and then waits for a specific signal to be sent. If a signal is sent but it is not the one the receiver is waiting for, then the receiver will do nothing and it will just continue to wait for the correct signal. Once the receiver receives the specific signal, the receiver will flash the LED and turn the vibration motor to help the user locate the missing item the receiver is attached too. Also the receiver will send a signal back to the

“base” to indicate that it has been activated and then wait for another specific signal. Once this new specific signal is sent to the receiver, the module will then deactivate the LED and vibration motor and send a signal back to indicate it has been shut off. This cycle repeats until the battery of the receiver is drained or the module is lost. The code for this module can be seen in Appendix B. The code for the receiver is about 60 lines long with comments.

VII. Performance Estimates and Results

In this section we discuss the performance of the final implemented system and compare it to our preliminary design criteria. First we will discuss the performance of the system when the receivers were powered through the computer and then the results when powered through the coin cell batteries. Throughout we will compare the results with our estimated performance and the goals of the project. At the end we will take a look at the overall performance of the system and compare them to the goals set out at the beginning of the project.

Powered by Computer

Since the testing stages of the system had the receivers powered through the computer, I felt it would be good to show the results of what happened and compare it to estimates and the project objectives. Essentially the main result we were looking for at this point was the maximum distance we could have for the receiver and base to be able to communicate with one another. Table 4 shows the results we obtained at certain ranges.

Range (ft.)	Results
10	Successful
20	Successful
30	Successful
40	Successful
50	Successful
60	Unsuccessful

Table 4: Results for receiver when powered by computer.

It should be noted that the testing was done in the house I live at where I measured the distance of the receiver from the base before I tested each time. I found that communication was lost at 60 ft. apart. When compared to the estimated range, which was 300 ft. according to the makers of the XBee modules [[ix]], the results fall well short. However when compared to the initial goal of 50 ft., the results successfully reached the required distance. Although I would have preferred the range to be a bit better, I was still satisfied with the results from the testing and proceeded to minimize the receivers by powering them by coin cell batteries.

Powered by Coin Cell Batteries

The results of the receiver powered by the Coin Cell batteries were mixed. The results of the receiver powered by the batteries can be seen in Table 5.

Range (ft.)	Battery Fully Charged?	Results
10	Yes	Successful
10	No	Successful
20	Yes	Successful
20	No	Successful
30	Yes	Successful
30	No	Unsuccessful

Table 5: Results of receiver powered by batteries.

With the receivers being powered by coin cell batteries, the receiver severely underperformed compared to the results when powered by the computer. When the batteries were fresh, i.e. have not been used, the receiver could barely communicate with the base from 30 ft. and also power the vibration motor and LED. The longer the batteries were used, the shorter the range became where eventually the system would not be able to communicate with one another when just a foot apart. Again these results underperform when compared to the estimated 300 ft. from the makers of XBee and the results also underperform when compared to the goal of the project.

Overall Results

Besides the range of communication, there were still many other goals that needed to be met. Although the range of the device failed due to the power issue with batteries, the system overall met the criteria that was set out at the beginning of the project. This can be seen in Table 6.

Goal/Criteria	Result
Communicate with 5 receivers?	Yes
Communicate with multiple receivers at the same time?	Yes, multiple receivers can be activated at the same time.
Range of 50 ft.	Depends on the power supply of the receiver. When using batteries the range is limited based on the battery life.
Battery life of the receiver	Using 3 3V coin cell battery provides enough power to the receiver to work, however for only a short amount of time.
User friendly?	The LCD screen works and displays information to help the user. The layout of the base is simple to understand.
Receiver size goal?	Undetermined because of the issue to power the receiver was still present.

Table 6: Overall Results

With the batteries causing issues, I chose to test the system while several receivers were being powered by computers. Through testing my system I found that it was capable to communicate with 5 different receivers correctly and at the same time as desired. Also the range was around 50 ft. and the system itself was pretty user friendly. However due to the power issue, I found that I could not meet the criteria I had set out for the battery life of the receiver and the size of the receiver since I could not create a finalized prototype without a good power source being available for the receiver. Although a final prototype of the receiver was never made, a final prototype of the base was made and can be seen in Figure 12.

Figure 12: Picture of final prototype of base.

VIII. Production Schedule

In this section we will look at the production schedule of the project. Essentially it is the summary of my work throughout the past two terms on the project.

When Things Were Done.	What I Did…
Week 1 & 2 9/6 – 9/19	• Researched components to use for project. • Ordered parts for project once research for components was done. • Began learning Arduino environment and programmed Arduino board we already had.
Week 3 & 4 9/20 – 10/3	• Worked on IEF paper. • Worked on soldering XBee kits. • Began interfacing Arduino and XBee units.
Week 5 10/4 – 10/10	• Worked on getting XBee units to successfully communicate with one another.
Week 6 & Week 7 10/11 – 10/24	• Worked on presentation for ECE 498. • Researched more about XBee communication to help with the programming.
Week 8 10/25 – 10/31	• Begin interfacing LED's with the receiver. • Test LED with receiver.

	• Test receiver to only respond to certain signals. • Began getting another receiver up and running.
Week 9 11/1 – 11/7	• Finished getting a second receiver up and running. • Began interfacing a switch to the base. • Began paper for ECE 498.
Week 10 11/8 – 11/14	• Worked on ECE 498 paper.
-------------	Winter Break
Week 11 1/3 – 1/9	• Continued interfacing switch with system.
Week 12 1/10 – 1/16	• Finally interfaced the switches to the system correctly. This was done through plenty of research on the problems I was having. • Interfaced the vibration motor to the receivers and began the website for the project.
Week 13 & Week 14 1/17 – 1/30	• Tried swapping out switches with pushbuttons but found that switches worked better. • Began programming the Arduino Pro Mini boards to be the receivers. Only one of them was successfully programmed at this time. • Added another receiver which meant a third switch was added. However the new receiver gave me problems.
Week 15 & 16 1/31 – 2/13	• Figured out the third receiver. • Attempted to alter wiring of LCD to use less wires, made things worst. Eventually I fixed the LCD to work with fewer wires. • Got the fourth and fifth receivers up and running as well.
Week 17 2/14 – 2/20	• Worked on the power issue of the Arduino Pro Mini. Could not resolve issue however. • Tested out system with what I had. Continued debugging problems. • Worked on building prototype of “base” module. • Began work on the Poster.
Week 18 & 19 2/21 – 3/6	• Presentation, poster and website were all worked on. • Finished up what I could with project. • Made finalized prototype of the base.
Week 20 3/7 – 3/13	• Paper and website.

Although I was able to finish the project and get the system up and running, there are still some changes to the schedule that would have been helpful. For instance I wish I had saved up some time to try and solve the power issue. When I finally ran into the power issue, it was too late to do much about

it as it occurred within the final few weeks. Other than the power issue, the schedule seemed to work well for me.

IX. Cost Analysis

In this section we will take a look at the cost of the project. Here is a table that shows the cost for all of the major components needed for this project and the cost per item. Also in the table it will say the number of each item that was used for the project.

Item	Quantity	Cost ($)
Arduino Duemilanove	1	29.95
Arduino Pro Mini	5	18.95
XBee kits	6	10.00
XBee 1mW Wired Antenna	1	22.95
XBee 1mW Chip Antenna	5	22.95
9V DC 650 mA Wall Adapter	1	5.95
Switches	5	4.67
Vibration Motor	5	4.95
Coin Cell Battery	10	1.95
Coin Cell Holder	10	1.50
LCD Screen	1	24.95
LED	5	0.35
Enclosure	1	3.99

Table 7: Item cost

Using the table above, the total cost of this project comes out to be around $450.00. When compared to systems out there, this is significantly higher than desired. However the cost for this system can be significantly reduced by cutting out the pre-made boards used for the XBee's and Arduino board which uses an ATMEGA328 microcontroller chip.

X. User Manual

In order to use the system, follow these steps:

1. Plug system into power outlet with wall adapter.
2. Place batteries into receivers and attach to objects that tend to be lost.
3. When receiver goes missing, flip corresponding switch on base.
   - If LCD screen does not display that the receiver has been activated it means that the lost object is out of the range of the base which means it is not present within the range of the base.
   - If LCD screen displays that the receiver has been activated, it should mean that the receiver has been activated and that it is within the range of the base.
4. Once receiver is found with object, return to base and flip the corresponding switch back. This should result in the receiver to deactivate and the LCD screen should display that the receiver has been turned off.

If problems occur with this system, plug into computer and reload program for corresponding module. The code for the base and each receiver will be provided in Appendix A and B.

XI. Conclusion

In conclusion the purpose of this project was to redesign the key finder system and improve it. The final design, while it made several improvements to the system by solving issues of the previous generations made, ultimately was deemed as incomplete due to the power issue of the receiver. The

implementation of the system works correctly and the range was there. However the power issue prevented the receivers to work as well as I had hoped. But with any project, improvements can always be made in the future.

Future Work

Although this system met practically every goal that was set initially, there is still future work that can be done on this project. Besides resolving the power issue of the receivers, adding more features to the system would seem to be the next step for this project. Adding a touchscreen LCD and speakers to the receivers are just two new features that could be added to a system like this. Also finding a way to increase the range would be nice for those who have houses bigger than the average household.

XII. Acknowledgements

The author would like to thank the following people:

- Professor Shane Cotter, for being the advisor for this project the past two terms and for all of the additional help that was provided.
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- My fellow ECE students and friends, for keeping me in line and helping me to never give up on myself.
- Union College, for 4 great years.

XIII. References

Most of my resources for this project came from the help site from Arduino while the history information on key finders came from Wikipedia. The other sites were either used to find prices or details about components, reviews on previous key finders, or to help with some coding.

Adafruit Industries, http://www.adafruit.com

Amazon, http://www.amazon.com

Arduino, http://www.arduino.cc/en/Tutorial/Switch

Faludi, Rob. "Wireless Communication with XBee Radios", http://www.faludi.com/itp_coursework/meshnetworking/XBee/XBee_example.html

PromoPeddler, http://www.promopeddler.com/01-59/sonic-key-finder-flash-beep-loud-noise-qqp338872.htm

Sparkfun Electronics, http://www.sparkfun.com

Wikipedia, http://www.wikipedia.org

XIV. Appendices

The following items are contained within the Appendices:

- Appendix A – Code for Base
- Appendix B – Code for Receivers
- Appendix C – IEF Proposal

Appendix A

```
#include <NewSoftSerial.h>
#include <LiquidCrystal.h>
#include <SoftwareSerial.h>

//Testing with different LCD setup.
//ID for XBee is 2226.
//5 switches now...
//working...
#define txPin 6
NewSoftSerial mySerial =  NewSoftSerial(2, 3);

char x = 0;
char y = 0;
int j = 0;
int k = 0;
int l = 0;
int m = 0;
int n = 0;
int count = 0;
int count2 = 0;
int count3 = 0;
int count4 = 0;
int count5 = 0;
int pwrPin = 7;
int switchPin = 8;     //Receiver 2
int switchPin2 = 9;    //Receiver 1
int switchPin3 = 10;   //Receiver 3
int switchPin4 = 11;   //Receiver 4
int switchPin5 = 12;   //Receiver 5
SoftwareSerial LCD = SoftwareSerial(0, txPin);

void setup()  {
  pinMode(switchPin, INPUT);
  pinMode(switchPin2, INPUT);
  pinMode(switchPin3, INPUT);
  pinMode(switchPin4, INPUT);
  pinMode(switchPin5, INPUT);
  pinMode(pwrPin, OUTPUT);
  pinMode(txPin, OUTPUT);
  digitalWrite(pwrPin, HIGH);
  LCD.begin(9600);
  clearLCD();
  delay(100);
  selectLineOne();
  delay(100);
  LCD.print("Alex's New");
  delay(50);
```

```
  selectLineTwo();
  delay(50);
  LCD.print("Keyfinder");
  delay(3000);
  clearLCD();
  delay(50);
  selectLineOne();
  delay(50);
  LCD.print("Welcome!");
  delay(100);
  Serial.begin(9600);
  mySerial.begin(9600);
}



void loop()                    // run over and over again
{
  j = digitalRead(switchPin);
  k = digitalRead(switchPin2);
  l = digitalRead(switchPin3);
  m = digitalRead(switchPin4);
  n = digitalRead(switchPin5);


  if (mySerial.available()) {    // This if statement allows the device to read in information.
     y = (char)mySerial.read();
     if (y == 'c') {
      Serial.print("Receiver 1 Activated");
      delay(50);
      clearLCD();
      delay(50);
      selectLineOne();
      delay(50);
      LCD.print("Receiver 1");
      delay(50);
      selectLineTwo();
      delay(50);
      LCD.print("Activated");
      delay(50);
     }
     if (y == 'd') {
      Serial.print("Receiver 1 Deactivated");
      delay(50);
      clearLCD();
      delay(50);
      selectLineOne();
      delay(50);
```

```
  LCD.print("Receiver 1");
  delay(50);
  selectLineTwo();
  delay(50);
  LCD.print("Deactivated");
  delay(50);
 }
 if (y == 'g') {
  Serial.print("Receiver 2 Activated");
  delay(50);
  clearLCD();
  delay(50);
  selectLineOne();
  delay(50);
  LCD.print("Receiver 2");
  delay(50);
  selectLineTwo();
  delay(50);
  LCD.print("Activated");
 }
 if (y == 'h') {
  Serial.print("Receiver 2 Deactivated");
  delay(50);
  clearLCD();
  delay(50);
  selectLineOne();
  delay(50);
  LCD.print("Receiver 2");
  delay(50);
  selectLineTwo();
  delay(50);
  LCD.print("Deactivated");
  delay(50);
 }
 if (y == 'k') {
  Serial.print("Receiver 3 Activated");
  delay(50);
  clearLCD();
  delay(50);
  selectLineOne();
  delay(50);
  LCD.print("Receiver 3");
  delay(50);
  selectLineTwo();
  delay(50);
  LCD.print("Activated");
  delay(50);
 }
```

```
if (y == 'l') {
 Serial.print("Receiver 3 Deactivated");
 delay(50);
 clearLCD();
 delay(50);
 selectLineOne();
 delay(50);
 LCD.print("Receiver 3");
 delay(50);
 selectLineTwo();
 delay(50);
 LCD.print("Deactivated");
 delay(50);
}
if (y == 'o') {
 Serial.print("Receiver 4 Activated");
 delay(50);
 clearLCD();
 delay(50);
 selectLineOne();
 delay(50);
 LCD.print("Receiver 4");
 delay(50);
 selectLineTwo();
 delay(50);
 LCD.print("Activated");
 delay(50);
}
if (y == 'p') {
 Serial.print("Receiver 4 Deactivated");
 delay(50);
 clearLCD();
 delay(50);
 selectLineOne();
 delay(50);
 LCD.print("Receiver 4");
 delay(50);
 selectLineTwo();
 delay(50);
 LCD.print("Deactivated");
 delay(50);
}
if (y == 's') {
 Serial.print("Receiver 5 Activated");
 delay(50);
 clearLCD();
 delay(50);
 selectLineOne();
```

```
      delay(50);
      LCD.print("Receiver 5");
      delay(50);
      selectLineTwo();
      delay(50);
      LCD.print("Activated");
      delay(50);
     }
     if (y == 't') {
      Serial.print("Receiver 5 Deactivated");
      delay(50);
      clearLCD();
      delay(50);
      selectLineOne();
      delay(50);
      LCD.print("Receiver 5");
      delay(50);
      selectLineTwo();
      delay(50);
      LCD.print("Deactivated");
      delay(50);
     }
  }
  if (j == 1 && count == 0 ) {
     x = (char)'e';
     mySerial.print(x);
     delay(50);
     count = 1;
   }
  if (j == 0 && count == 1) {
     x = (char)'f';
     mySerial.print(x);
     delay(50);
     count = 0;
   }

  if (k == 1 && count2 == 0 ) {
     x = (char)'a';
     mySerial.print(x);
     delay(50);
     count2 = 1;
   }
  if (k == 0 && count2 == 1) {
     x = (char)'b';
     mySerial.print(x);
     delay(50);
     count2 = 0;
   }
```

```
 if (l == 1 && count3 == 0 ) {
    x = (char)'i';
    mySerial.print(x);
    delay(100);
    count3 = 1;
  }
 if (l == 0 && count3 == 1) {
    x = (char)'j';
    mySerial.print(x);
    delay(100);
    count3 = 0;
  }

 if (m == 1 && count4 == 0 ) {
    x = (char)'m';
    mySerial.print(x);
    delay(100);
    count4 = 1;
  }
 if (m == 0 && count4 == 1) {
    x = (char)'n';
    mySerial.print(x);
    delay(100);
    count4 = 0;
  }
 if (n == 1 && count5 == 0 ) {
    x = (char)'q';
    mySerial.print(x);
    delay(100);
    count5 = 1;
  }
 if (n == 0 && count5 == 1) {
    x = (char)'r';
    mySerial.print(x);
    delay(100);
    count5 = 0;
  }
 if (x == 'z') {
  //lcd.clear();
  clearLCD();
  delay(100);
  //lcd.print("Hello, World!");
  LCD.print("Hello, World!");
  delay(100);
 }
 delay(100);
}
```

```
void selectLineOne(){     //Set cursor to line 1 character 0.
  LCD.print(0xFE, BYTE);   //command flag
  LCD.print(128, BYTE);    //position
}

void selectLineTwo(){  //Set cursor to line 2 character 0.
   LCD.print(0xFE, BYTE);   //command flag
   LCD.print(192, BYTE);    //position
}

void clearLCD(){
   LCD.print(0xFE, BYTE);   //command flag
   LCD.print(0x01, BYTE);   //clear command.
}
void backlightOn(){  //turns on the backlight
    LCD.print(0x7C, BYTE);   //command flag for backlight stuff
    LCD.print(157, BYTE);    //light level.
}
void backlightOff(){  //turns off the backlight
    LCD.print(0x7C, BYTE);   //command flag for backlight stuff
    LCD.print(128, BYTE);     //light level for off.
}
void serCommand(){   //a general function to call the command flag for issuing all other commands
  LCD.print(0xFE, BYTE);
}
```

Appendix B

The code pasted here will be for one of the receivers. The other receivers are programmed the say way except they are waiting for a different signal to be sent to them.

```
#include <NewSoftSerial.h>
//This one works, use for now.
//Receiver 5

NewSoftSerial mySerial =  NewSoftSerial(2, 3);

char x = 0;
const int ledPin = 7;
const int vibPin = 8;

void setup()  {
  pinMode(13, OUTPUT);
  pinMode(ledPin, OUTPUT);
  pinMode(vibPin, OUTPUT);
  digitalWrite(vibPin, LOW);
  digitalWrite(ledPin, LOW);
  Serial.begin(9600);
  //Serial.println("Goodnight moon!");
  // set the data rate for the SoftwareSerial port
  mySerial.begin(9600);
  //mySerial.println("Hello, world?");
}

void loop()                    // run over and over again
{
  if (mySerial.available()) {     // This if statement allows device to read in information.
      x = (char)mySerial.read();
      Serial.print((char)x);
      if (x == 'q') {
        delay(50);
        mySerial.print("s");
        while (x == 'q') {
          digitalWrite(vibPin, HIGH);
          digitalWrite(ledPin, HIGH);
          delay(50);
          digitalWrite(ledPin, LOW);
          delay(50);
          if (mySerial.available()) {
            x = (char)mySerial.read();
            if (x == 'r') {
              digitalWrite(vibPin, LOW);
              digitalWrite(ledPin, LOW);
              mySerial.print("t");
              break;
```

```
          }
          else {
            x = 'q';
          }
        }
      }
    }
  }
}
```

Appendix C

Research Proposal – Redesign of the Keyfinder

Specific Goals

In today's generation, everyone always seems to be in a rush and there are many instances where objects like keys get lost around the house, resulting in the person being delayed. To solve this problem, there have been three different generations of key finders designed, each having their own set of problems based on their respective designs. Although each system has their own pros and cons, there still remains no ideal solution to the problem of finding lost objects faster. Thus, the aim of my project will be to redesign, improve, and add features to the already existing key finder that can locate multiple small objects. My design will consist of a base that can communicate with 5 different locators. These locators, when activated, will blink a light and vibrate. Hopefully with the completion of this project, this product will be a simple enough device to help everyone who has a tendency of losing any type of small objects around the house.

Goal 1: Get a working prototype of my design working. Instead of having 5 locators working though, I will first focus on getting two working and then go from there.

Goal 2: Build smaller devices in a more compact and portable version.

Background

Over the years there have been several devices developed which were used to locate small objects. More specifically these devices were used to locate car keys or house keys. The devices that were specifically designed to locate keys were called key finders. The first generation key finders were based on sound. The device was a small circuit that utilized noise recognition. This device would be attached to the keys and it would wait for a clap, a whistle, or a sequence of those sounds before it activated. When activated the circuit would emit a beep or a noise to help the user locate where the keys were. However, this system had problems in deciphering when it should sound the alarm or not.

The second generation key finder, with technology becoming smaller and smaller, was based on transmitters and receivers. With this method, this system was able to overcome the first generation's problem. Unfortunately this system also had the problem on what would one do when the transmitting device was lost since it was just as small as the receiving module.

Today's key finder uses a system that no longer uses a separate "base". Rather it is based on a peer-to-peer system that can find all the others individually. An example would be a wallet could be used to find the missing keys or vice versa. Since all of the objects would have transmitters attached to them, the missing objects could reply by radio as well as beep and

flash a light. Essentially they are all using transceivers, making this system the least problematic out of them all.

Although the third generation key finders are deemed successful, I still feel the system can be improved. For instance, what happens when all the objects that have the transceivers on them are lost? If all of the transceivers are lost, then the system would be completely pointless and the person who lost all of the items would be back to square one. Even though this system is deemed successful, there is always room for improvement in a system such as this one. Some improvements that I have in mind are to create a base to communicate with multiple receivers, improve UI by adding a LCD touchscreen to the base, minimize the receivers, and make it more powerful to make the receiver more noticeable when activated.

Reasoning

Funding is being sought for this project in order to purchase the necessary components to test and build a prototype of my design. The funding of this project will allow me to complete my project in a timely and more efficient manner since it will allow me to take my ideas and actually implement a design that could prove beneficial for many people but mainly the elderly as this system will be geared to be louder and more noticeable seeing as those are the major complaints for devices such as these[x]. If the funding is provided, it will allow me to get the necessary components to implement my design efficiently.

The Arduino Duemilanove is necessary to program the prototype to work correctly. This microcontroller will act as the home base for the prototype of my design. The 2 Arduino Pro Minis are needed to build the receiving device as the receivers in my prototype need to be able to decipher when a signal is sent and what it should do when that signal is received. Plus the Arduino Pro Mini will be small enough to make the receiver unobtrusive to the users. The 3 XBee 1 mW chip antenna devices are needed in order for the Arduino microcontrollers to be able to send data and signals wirelessly which is necessary for the prototype to be deemed successful. Also I would need a LCD/touchscreen which will be used for the base to control which receivers are activated and to improve the UI for this product. Battery holders will also be necessary to power the devices as well as batteries. The rechargeable coin cell batteries would work great with the receivers and the coin cell holder for it would fit perfectly. As for the base, regular AA batteries would work well with an AA battery holder. Finally the two vibration motors are necessary in order to be able to get the receivers to vibrate when told to.

Budget

Item	Cost
1 Arduino Duemilanove	$25.00
2 Arduino Pro Mini	$37.90
3 XBee 1 mW chip antenna	$68.85
Graphic LCD 128x64 CFAX w/ EL Backlight and Touchscreen	$39.95
2 Coin Cell Battery Rechargeable - 24.5mm	$9.90
2 Coin Cell Holder – 24.5mm	$1.90
Battery Holder 2xAA with Cover and Switch	$1.50
2 Vibration Motors	$9.90
Total	$195.20

XV. Endnotes

[i] http://www.amysgifts.co.uk/images/supersize/novelties/remote-control-key-finder-whistle.jpg
[ii] http://jabdelra27.files.wordpress.com/2009/05/keyfinder1.jpg
[iii] http://www.coolest-gadgets.com/wp-content/uploads/fofasystembl.jpg
[iv] http://www.sparkfun.com/
[v] http://computer.howstuffworks.com/wireless-network1.htm
[vi] http://en.wikipedia.org/wiki/Transmitter
[vii] http://en.wikipedia.org/wiki/Receiver_(radio)
[viii] http://en.wikipedia.org/wiki/Intel_MCS-51
[ix] http://www.sparkfun.com/products/8664
[x] http://www.amazon.com/Brookstone-Wireless-Key-Finder/product-reviews/B001EN77E4/ref=dp_top_cm_cr_acr_txt?ie=UTF8&showViewpoints=1