Multipurpose Key Chain with Lock Device

Junting Lou | Yaming Tang |Lida Zhu

Introduction

Title: Multipurpose Key Chain with Lock Device

Despite the improvement in the variety of locking devices available in market, including electronic keycards and fingerprint recognition, mechanical locks still play a significant role in our everyday life. Such locks inevitably create problems to lots of people. More than often, one always tries to remember whether he or she locks the door when leaving the apartment. You have to either go back to check it or just live with the anxiety. Remember the time when you stand outside of your office or laboratory with a bunch of similar or identical ones, from which you have to find the correct one? Or the time you try so hard where you leave the keys in your room? Such trivial but annoying problems can be surprisingly painful and costly. We aim to solve these problems with a key chain that is easily to use.

Objectives

The key chain that we aim to build can carry a considerable number (Around 8 to 20) of keys with LED indicators attached to each of them. Every lock is installed with a corresponding device as well. Whenever the status of a certain lock (locked or unlocked) changes, the information will be updated to the key chain via Bluetooth and stored. This information can be triggered to be displayed anytime from anywhere via the LED indicators. When someone is near to a door, moving the key chain close to the lock will light up the LED corresponding to the right key and this is accomplished using RFID. A siren installed on the key chain can be triggered by any door device if in range and produce sound to be tracked. Last but not least, via the internet router, the lock can be remotely locked with the help of a smart phone or computer.

Benefits

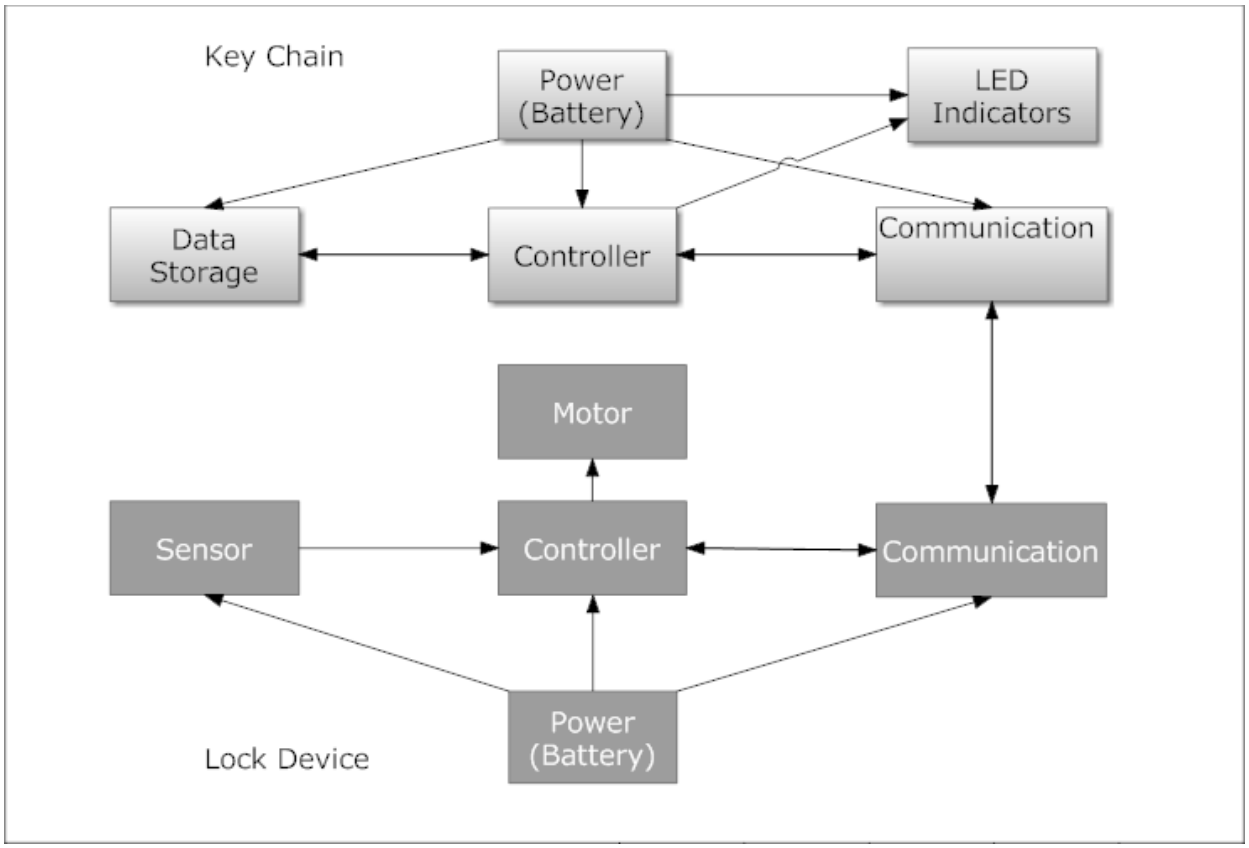
- Instantaneous access to lock information and remotely control it.
- Save time and troubles by detecting corresponding key to nearest lock.
- Able to track keys within range of a registered lock.

Features

- Light, portable, easy to carry and easy to use.
- Bluetooth and RFID communication interfaces.
- LED indicators.
- Long battery life and easy to change battery.
- Easy to setup or add new keys and locks.
- Reliable and accurate detection.

Design

Block Diagram



Block Descriptions

Power Supply (Key Chain):

Button cells or dry cell batteries will be used depending on the actual power requirement and miniaturization considerations. This part supplies power to the entire circuit in the keychain including the controller, the memory, the LEDs and wireless communication modules. They should be miniaturized but to keep up with the power requirements.

Controller (Key Chain):

The controller in the key chain controls individual LED by reading corresponding data from the memory. It also processes data received via the communication interface to be stored. It coordinates data and inputs from various parts of the circuit and generates information to be sent to the lock device. It will be built preferably using an Arduino ATmega168 IC chip with associated devices such as a resonator and so on. The processing speed must be faster than that of data transmission to ensure no data is lost or left unprocessed.

Data Storage:

This is the memory unit of the key chain which is responsible for storing status and corresponding codes of the lock key pairs. An SD card will be used in this part of the circuit which the controller has direct access to. As suggested, part of the memory will be occupied by up to date status of all locks registered on the device and the other will hold codes distinguishing among lock key pairs. The memory size needs not to be large. The reading and writing processes must be fast.

Wireless Communication (Key Chain and Lock Device):

Both the key chain and the lock device will have a wireless communication interface which sends and receives data via Bluetooth and RFID. Bluetooth will be enabled using a Bluetooth modem and the RFID device can be built from scratch. The Bluetooth interface is in charge of all communications between the devices except when trying to identify the correct key to the nearest lock. This is accomplished through RFID because it depends on distance between devices.

LED Indicators (with Alarm System):

The LEDs installed on the key chain together with the siren or alarm will be the user interface of this key chain through which users can visualize the status of the door, identify the correct key or find them. This component is directly controlled by the microcontroller based on input command and stored information in the memory.

Power Supply (Lock Device):

The power supply on the lock device is in analogy with that on the key chain in the way that it supplies enough power to the entire circuit. However, it has a greater tolerance in terms of size because it is attached to the door instead of being carried around. It is going to be built from a few dry cell batteries.

Sensors:

The sensor on the lock device is to detect at any moment whether the lock is locked or unlocked. Since we are dealing with mechanical locks, the sensor can be built using a simple circuit detecting whether the latch in the door is in locked position or unlocked position. Once the status changes, signals will be generated and updated to the key chain via Bluetooth.

Controller (Lock Device):

The controller on the lock device is similar to that on the key chain, except that it has a extra functionality of controlling a stepper motor attached to the door's latch. Remotely controlling the door requires precise control of the stepper motor to rotate in the correct direction with correct distance.

Requirements and Verifications

Requirements

- Instantaneous (<0.5s) response after triggering control button.
- Correct and accurate information about status of locks.
- Consistently able to detect the absolute nearest lock in range.
- Able to trigger siren on key chain from any lock device within a certain range (<20m).
- Able to accurately perform lock or unlock anywhere using internet with the control of a stepper motor.
- Considerable battery lifetime. (>2 months battery life with reasonable daily usage)

Verifications (Testing Procedures)

Power Supply:

The requirement for the power supply is that it can last for more than 2 months with normal daily uses. First, we will leave all components on and record the time that the devices could last up to. Then based on a reasonable estimate of usage daily, we estimate the battery life of the device. Miniaturization and battery life should compromise each other to produce best result.

Wireless Communication:

Exchange of data should be completed between devices instantaneously and reliably. The wireless interface could be built on a bread board first and verify its reliability and efficiency through a large number of tests of exchanging data. This could be accomplished using software sending serial data or pinging them at a fast rate via mobile devices or computers. These tests need to be carried out at various distances within required range to ensure reliability.

Memory:

The reliability of the device greatly depends on whether correct data is decoded and stored into the memory card. This could be verified by writing randomly generated data and read them to

compare. No errors can be tolerated if given the wireless interface works properly, meaning data can be successfully exchanged.

Controller:

The correct functionality depends on the controller module if all data is transmitted, received and stored properly. We want to make sure that with the right command being sent or received, the controller can accomplish all tasks required in this project. This could be tested by passing different commands, codes or data to the controller and monitor the output from it. The correct output must be generated every time for the correct operation to make sure it works fine.

Sensors:

A big part of this project is to detect the status of the lock and hence the sensor has to work properly. The sensor can be easily built from scratch and tested using a simple mechanical lock. With a considerable and reasonable number of tries on locking or unlocking the door, the output from the sensor has to match the correct state (locked or not).

Tolerance Analysis

The most important block in our design would be the controller module. It processes information that is being sent between devices. The functionality and reliability of the device greatly depends on the control module. Our group will perform extensive testing on this part of the project.

One of the main objectives of this project is to provide up-to-date and accurate information to users. The controller must be able to response to inputs and changes instantaneously (<0.5s). This includes the process of updating status, as well as identifies the correct key.

The other concern would be to make the controller coordinate with all other components in the circuit. We want to build a control module that best integrates other components with the data being exchanged among them. The most important of this would be to make sure that all data is processed by the controller. This could potentially fail with a fast rate of data transfer and this will be one of the most important part of testing involved in this project to ensure 100% accuracy and reliability.

Cost and Schedule

Cost Analysis

Labor:

Members	$/Hour	Hours/Week	Number of Weeks	Total/Person	*Multiplier (2.5)
Junting Lou	30	15	12	5400	13500
Yaming Tang	30	15	12	5400	13500
Lida Zhu	30	15	12	5400	13500

Total cost of labor is $40500.

Parts:

Parts	Price/Unit	Quantity	Cost
CR2032 3V Lithium Button Cell (Pack of 5)	$0.99	1	$0.99
Energizer AAAA 1.5V Alkaline Battery (Pack of 2)	$2.95	2	$5.90
Arduino ATmega328-AU Microcontroller	$7.85	2	$15.70
4GB Micro SD card + Adapter	$0.99	1	$0.99
TransFlash Micro SD card Socket	$1.49	1	$1.49
Multi-color RGB LED lights (Pack of 4)	$1.59	4	$6.36
Bluetooth Transceiver Modules	$3.99	2	$7.98
125KHz RFID Proximity Tokens (Pack of 5)	$1.89	1	$1.89
PCB and Other Circuit Elements (Resistors, Wires and etc.)	$25.00	1	$25.00
		Total	$66.30

Total Cost:

Total cost including labor and parts: $40566.30

Schedule

Week	Task	Member
9/16	Background research involving wireless communication components	Yaming Tang, Junting Lou
	Background research and basic design for controller module	Lida Zhu
9/23	Sign up and prepare for Design Review	All
	Finalize and order parts	Junting Lou
	Testing wireless modules and make sure they work up to the required standards	Yaming Tang
9/30	Test, verify and build power circuits including LED and wireless interfaces.	Junting Lou
10/7	Finalize motor selection and test to verify its operations.	Yaming Tang
10/14	Design controller module with the considerations of existing components.	Lida Zhu
10/21	Prepare for individual progress report.	All
	Research and build online remote control protocol.	Lida Zhu
10/28	Test controller module.	Junting Lou
	Test remote control protocol.	Lida Zhu
11/4	Integrate entire circuit and build working prototype on bread board.	Yaming Tang
11/11	Identify existing problems and debugging.	Lida Zhu
11/18	Final power circuit testing and verification.	Yaming Tang
	Final testing of wireless communication interface.	Junting Lou
11/25	Final testing and verification	All