CPRE/EE 491
MAY15-25
Project Design Document

Advisor: Lee Harker
Client: Lee Harker / Department of Electrical and Computer Engineering
Project Title: Wi-Fi Connected Locker Access System

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Revision History

Date	Revision	Description
10/15/2014	0.1	Initial Plan Formatting
10/27/2014	1.0	Finalized Plan Formatting
12/5/2014	2.0	Final 491 Edits

Executive Summary

The goal for this project is to provide an easy to use system for electronic access to senior design lockers. The current lockers are currently inadequate for several reasons, as detailed below. Our group feels that these may be improved in many ways, primarily by introducing an element of logic to the system. By the end of the year we plan to deliver a new electronic locker control access system to the ECPE department with a control panel, three complete locking units, and a users manual.

Problem Statement

This project is to solve the problem of security and management of the storage and lockers in the senior design lab in Coover 1301. Currently, the lockers are being secured by padlocks, where the same locks are reused semester after semester. This is an issue as previous students may tamper with current student's projects, as well as the maintenance overhead of manually assigning lockers to students, or removing identifying information on the physical locks to attempt to prevent security issues.

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System Level Design

System Requirements

Functional Requirements

- System shall read student's ISU ID Card, providing access on a single swipe
- System shall have a keyboard failback, such that students without ID Cards may still access the system
- System shall allow administrative functionality, both local and remote, including altering access lists and overriding functionality
- Wireless transmitters should securely transmit data, ensuring only secure access to lockers
- LCU ("Locker Control Unit") shall be secure, in that only a valid signal from the MCU ("Main Control Unit") will open the lock
- The MCU must store usernames/passwords/groups of users, and be easy to remotely manage to alter information
- The MCU must be "locked-down", such that non-administrative users cannot alter or access any information

Non-Functional Requirements

- LCU shall be battery-powered and last a minimum of two full semesters
- The LCU batteries should supply at least 4 volts of power until shutdown event
- The LCD display on the MCU shall display when locker batteries are below 20% and are in need of replacement

- The LCU, low-power, red LED shall illuminate every 5 seconds when batteries are below 10% power
- The servo should be able to hold open the lock for at least 10 seconds
- The locker shall re-lock 10 seconds after it has been unlocked.
- The LCU green LED shall illuminate when the locker has been unlocked.
- The MCU must connect to Iowa State public Wi-Fi, and must automatically connect after a reboot
- The MCU must allow incoming SSH connections
- The MCU must reject foreign input
- The MCU must display a status report on valid administrative SSH login
- The MCU must be able to control lockers a maximum of the distance of the room
- The LCU shall have a physical key that will manually unlock the lockers for cases in which batteries have died

Operating Environment

The operating environment of the LCU and the locker units would be a type of classroom or workplace. Users would be able to safely store personal items in a designated locker with an automated lock. This lock would be controlled by the swipe of an id card. The user would be able to either swipe their personal card or type their id number in a corresponding card-reader. This control of access to the lockers is determined by the credentials stored on the MCU located in the room. Additionally, we are assuming a stable operating environment in a temperature-controller room, and we are already assuming physical security. As such, no physical security shall be implemented to the controlling units beyond a standard casing unit. Additionally, we are assuming the environment will be weather-controlled and will not be exposed to the elements.

In more detail, the following environmental conditions are assumed:

- Temperature ranging from 65 degrees fahrenheit to 75 degrees fahrenheit
- Locker dimensions 4’ x 5.5’ x 17’’
- Room dimensions 44’ x 28’
- Several room obstacles, hindrances, and blockages of varying materials

Intended Users and Uses

The intended users for this product are students enrolled into Senior Design for the ECPE department at Iowa State University. Additionally users include management staff, who will remote into the MCU (“Main Control Unit”) to manage the system by adding/removing user accounts to lockers, and managing battery supply units.

The lockers themselves will be “Bolt-Cutter safe”, in that they are designed around the same difficulty as bringing a pair of bolt cutters into the room and cutting the doors off manually. As such, the lockers are intended to be secure from most standard means of digital cracking, and they shall also be physically safe from all but the persistent in physical damage.

Block Diagrams of the Concept

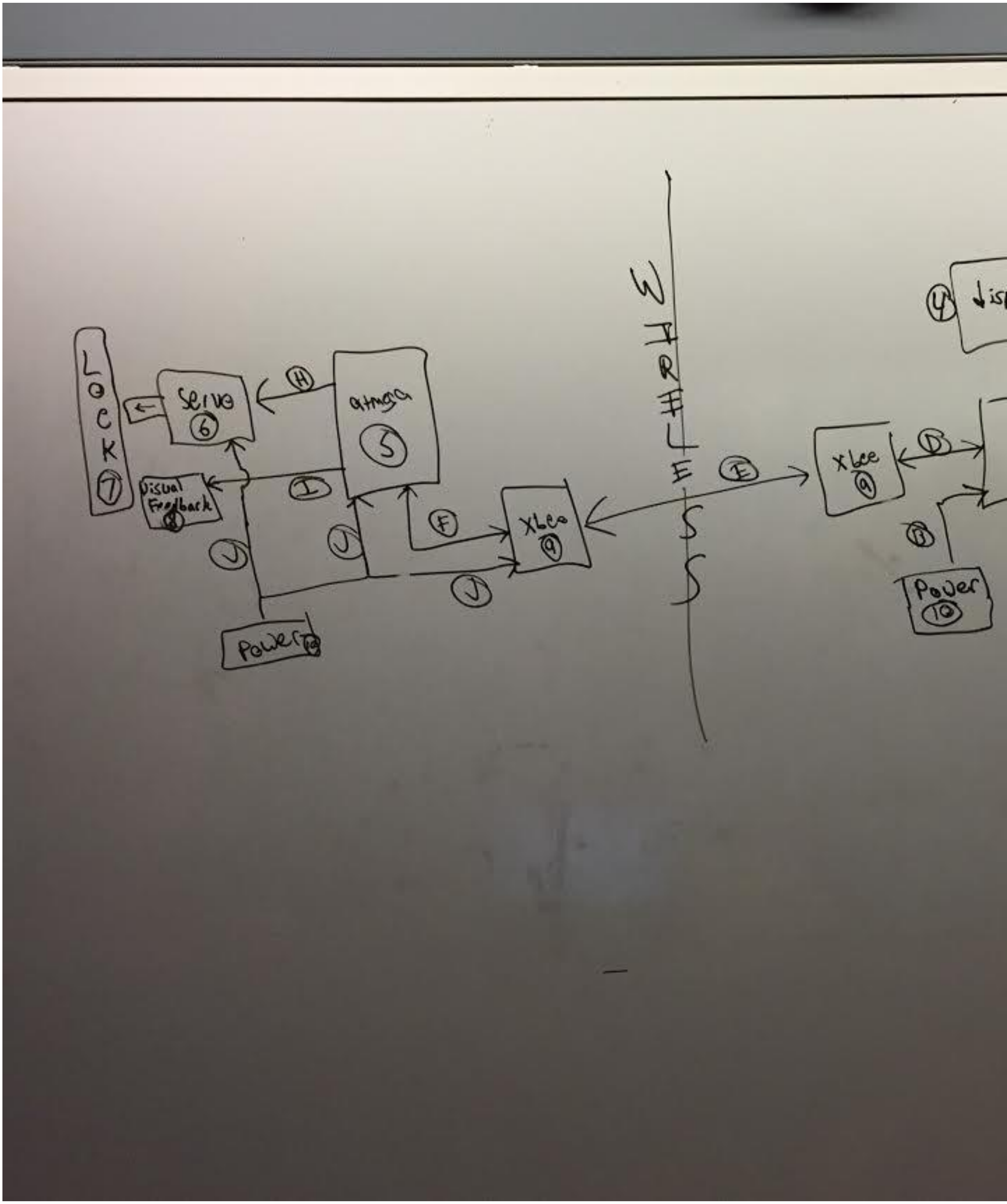

LOCK
7
Servo
6
atmega
5
Visual Feedback
8
Xbee
9
Power
10
WIRELESS
H
I
J
F
E
D
B
4
Xbee
9
Power
10

Figure 1, Concept Block Diagram of Project

All components to the left of "WIRELESS" are considered parts of the LCU and all components to the right of "WIRELESS" are considered parts of the MCU

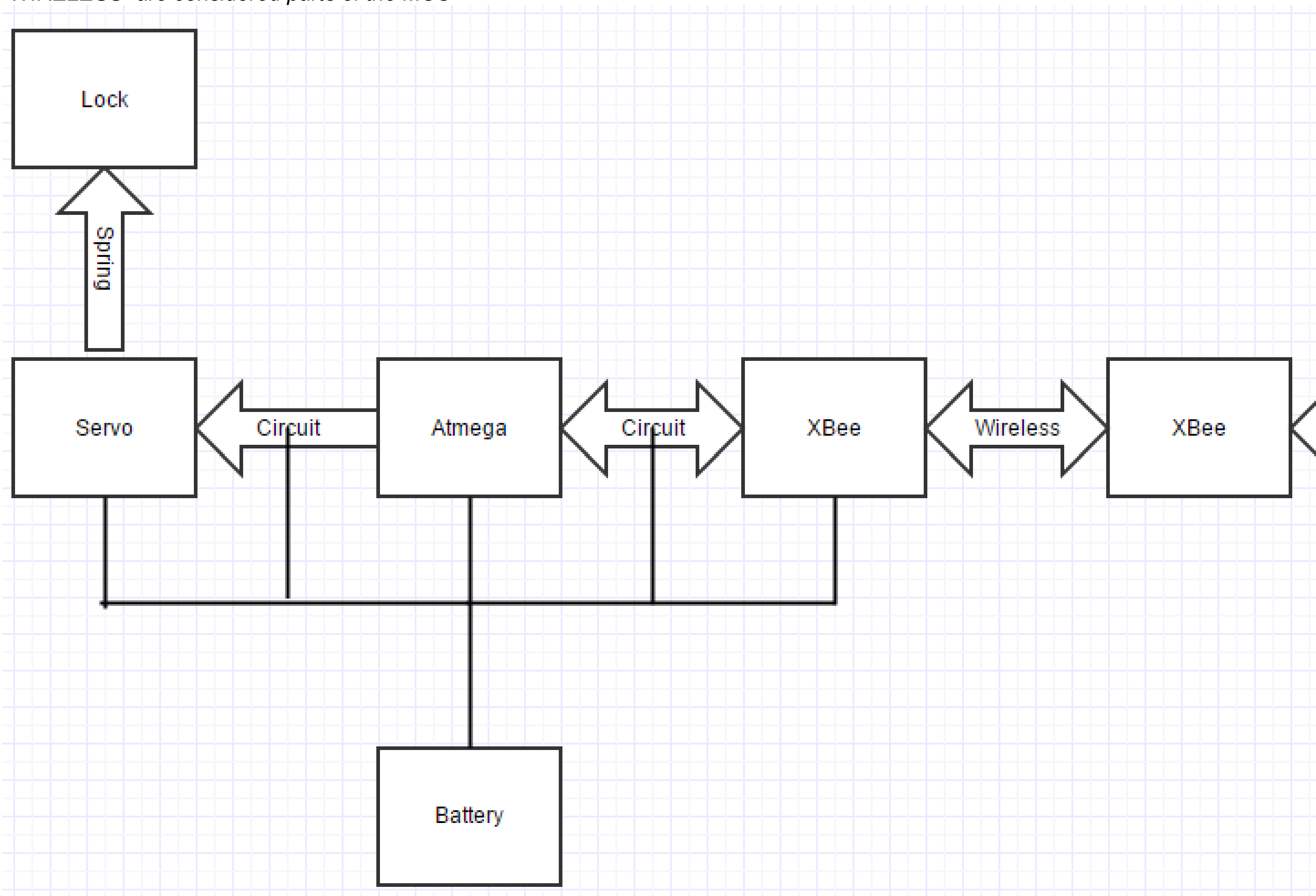


Figure 2, Block Diagram of Project with interconnections

All components to the left of "WIRELESS" are considered parts of the LCU and all components to the right of "WIRELESS" are considered parts of the MCU

Detailed Implementation

I/O Specification

Our input and output shall be as follow:

Output:

- LCD display on the MCU ("Main Control Unit") shall render username/password information, and display success/fail on opening a locker
- LCD display on the MCU shall render, specifically, which LCU's have critical battery levels

- When the LCU receives a correct signal from the MCU, the corresponding locker should unlock for 10 seconds and a green LED should illuminate during this time to indicate that the locker can be opened
- When battery power is at 10% a red LED shall illuminate, every five seconds, on the LCU to indicate that batteries are critically low and need to be replaced.

Input:

- Magnetic-strip card reader
    - Reads ISU ID Card, providing information on magnetic strip
- Full qwerty-style keyboard for username/password entry
- Remote-SSH management input

Interface Specifications

Our hardware interface shall be designed with human-usability in mind, such that the lockers are easy to unlock/open. Additionally, the MCU shall be constructed in such a way that the keyboard is easily accessible and typable, and that the LCD is using a large enough font to be legible. The LCD interface itself shall be as simple as two textboxes, one for username and one for password, as well as relevant success/fail messages. The remote management software shall be a series of scripts runnable from the CLI (“Command Line Interface”) and as such no true GUI (“Graphical User Interface”) for the remote-management is required.

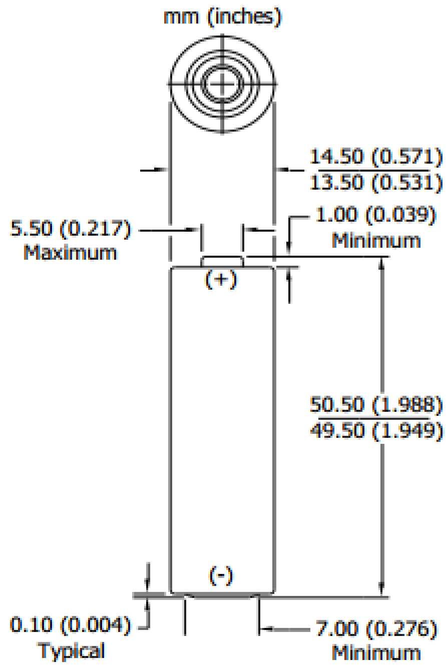
Circuit Specifications

Power Circuit and Design

The power sources for the LCU (“Locker Control Unit”) are batteries. The project will be using four 1.5 V Energizer max AA batteries to power the ATmega328, servo, and Xbee units. From our current draw calculation we calculated the required mAh we need to keep running our system. We compared the results with three different types of batteries, one was Energizer ultimate lithium, second was Energizer Max, and the third was Energizer rechargeable. The reason why we choose this specific battery type was that it was cheaper than other two types of batteries, and has the capability to run our system for more than two semesters.

Battery Types	Type	Voltage	Capacity(mAh)	Cost/8 pk	Capacity/c
Energizer Ultimate lithium	Lithium/Iron Disulfide (Li/FeS2)	1.5 V	3000	$18.99	157.9778
Energizer max	Alkline	1.5 V	2779	$6.39	434.898
Energizer power plus(rechargable)	NiMH (nickel-metal hydride)	1.2 V	2300	$33.94	67.7666

The battery we choose has a 7 year shelf life at 21 degrees celsius. The typical weight is 23 grams, and typical volume is 8.1 cubic centimeters. It can operate at 0 degrees F to 130 degrees F. Below are the battery dimensions:



Atmega to Servo Circuit Specification

The I/O of the servo is controlled by the ATMEGA328. The servo is powered from the batteries, through a transistor, to conserve power. When the ATMEGA receives the command to move the servo, it sends a signal out pin 15 which is a PWM pin, on the ATMEGA328. The ATMEGA is programmed to rotate the servo to the desired location depending on the width of the pulse the ATMEGA sends out of pin 15. Furthermore, when the servo receives the command to move, a 5V signal is sent out of pin 14 to switch on the transistor. When the servo is not sent a signal to move, pin 14 is left floating and the 10k pull up resistor pulls the PNP base voltage up to 6V, which turns the transistor off. Therefore, we are only providing power to the servo when we are instructing it to move.

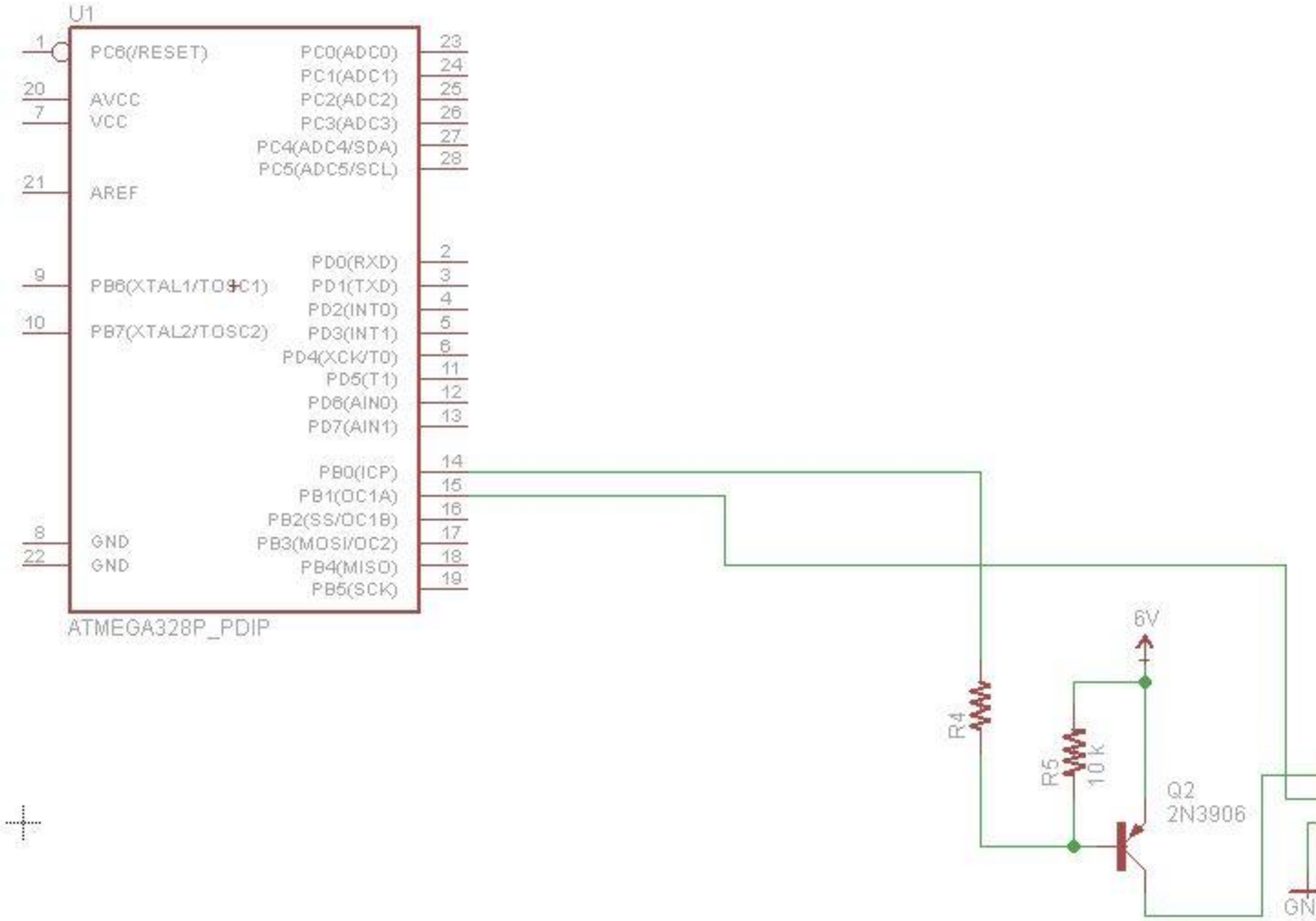


Figure 3, Atmega to Servo Circuit Schematic

Atmega to Visual Output Specification

The visual output (Bi-LED) will be controlled by pins 18 and 19 of the ATMEGA328. When the ATMEGA receives the signal to illuminate the green LED it will send a signal out pin 18. Furthermore, when the ATMEGA receives the signal to illuminate the red LED it will send a signal out pin 19.

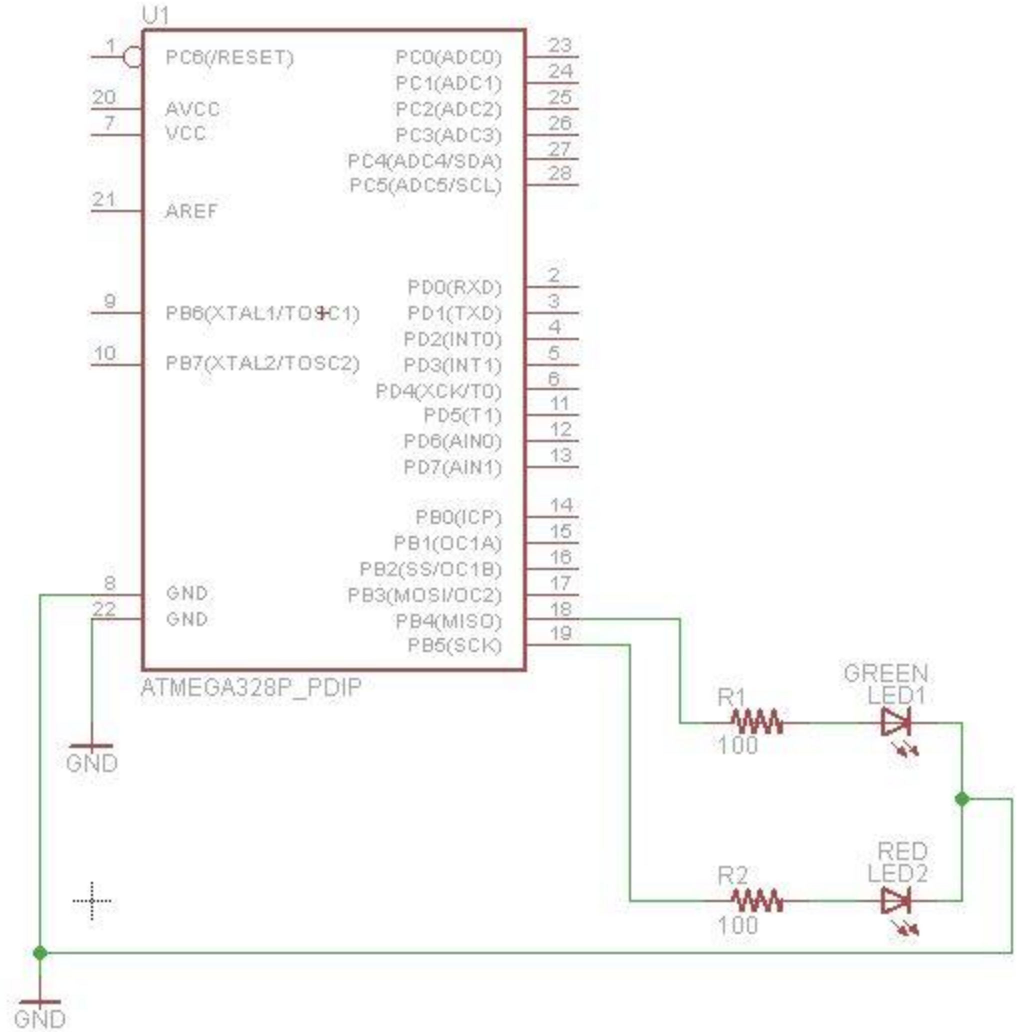


Figure 4, Atmega to Visual Output Circuit

Atmega to XBee Circuit Specification

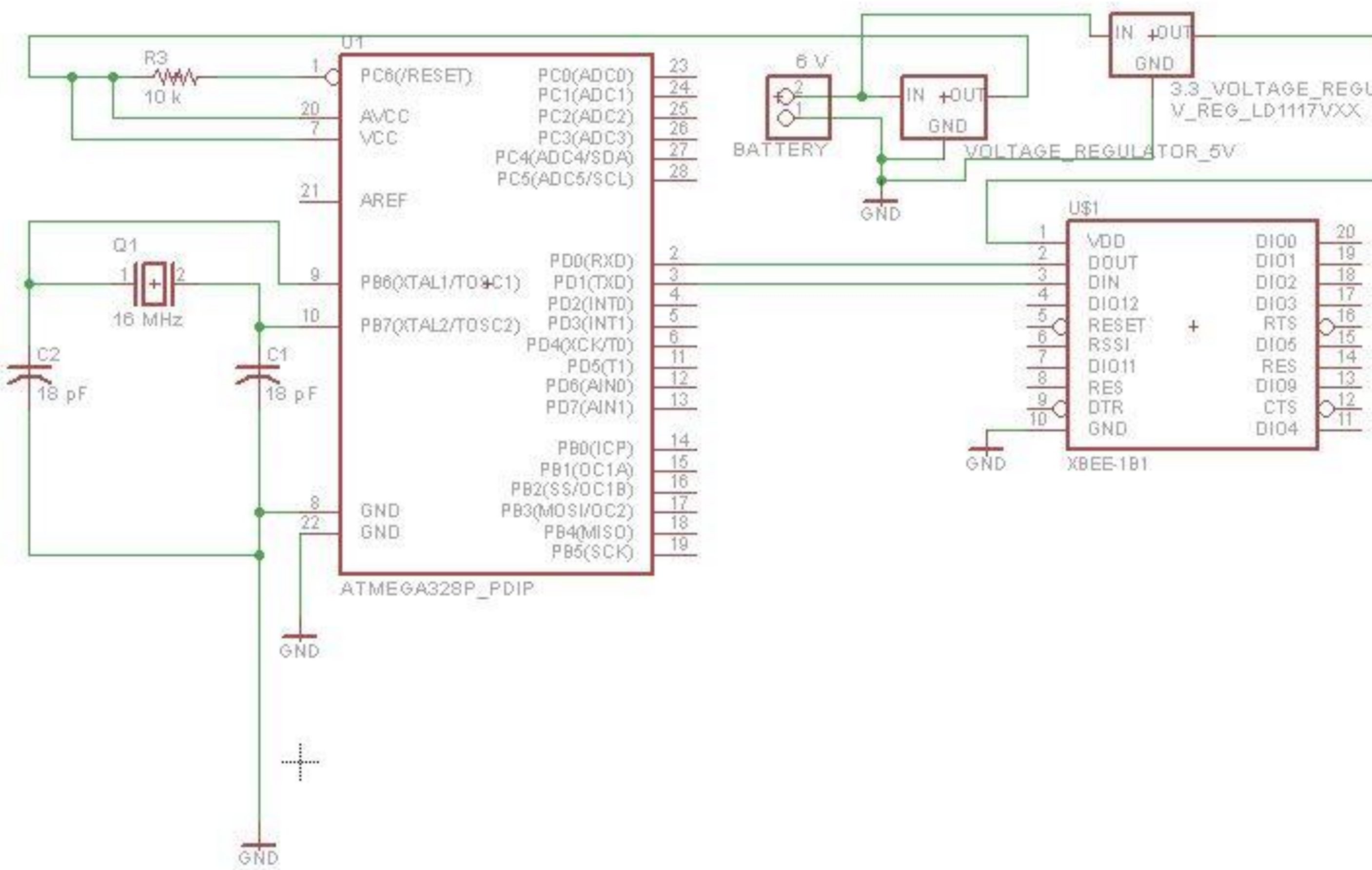


Figure 5, Atmega to XBee pin layout

There are only two pins of Atmega328 connected to the two pins of the Xbee. The pins of Atmega328 are PD0 (RXD) and PD1 (TXD) whereas the pins of the Xbee are 'Dout' and 'Din'. The Atmega328 and Xbee will be connected to the 5V ('Pin' VCC) and 3.3V ('Pin' VDD) voltage supply respectively.

Pi to XBee Circuit Specification

The raspberry pi and the xbee unit are connected to each other with a single micro-usb cable. This registers with the raspberry pi operating system, such that we may interface with the XBee directly using python's serial programming interface.

Pi to Display Connection Specification

The raspberry pi and the LCD Display module connect using a standard RCA cable. Power to the LCD display is connected using a wall-outlet and a special converter.

XBee to XBee Specification

XBee modules are embedded solutions providing wireless end-point connectivity to devices. These modules use the IEEE 802.15.4 networking protocol for fast point-to-multipoint or peer-to-peer networking.They are designed for high-throughput applications requiring low latency and predictable communication timing. XBee modules are ideal for low-power, low-cost applications.

Xbee can be used for wireless communication with low power consumption. It talks with well known UART interface and makes it easy to use. It is simple and straightforward if you only use 2 Xbee for communication. Xbee can communicate up to 300ft and operate on 3.3V @ 50mA. The board contains 6 10-bit ADC input pins and 8 digital I/O pins. Xbee also allows for 128-bit encryption.

Once connected to the XBee with the serial tool, the configuration process can begin. Because there are lots of parameters that can be set on the XBee, here are the most common problems:

- the 2 XBee are not in the same network
- one XBee is using encryption while the other isn’t
- both are using encryption but the encryption keys are invalid

Pin Number	Description	Function
1	VCC	Power Supply
2	DOUT	UART Data Out
3	DIN/CONFIG	UART Data In
4	DO8*	Digital Output 8
5	RESET	Module Reset
6	PWM0/RSSI	PWM Output 0/RX signal Strength
7	PWM1	PMW Output 1
8	[RESERVED]	Do not connect
9	DTR/SLEEP_RQ/DI8	Pin Sleep Control Line or Digital Input 8
10	GND	Ground
11	AD4/DIO4	Analog Input 4 or Ditital I/O 4
12	CTS/DIO7	Clear-to-Send Flow Control or Digital I/O 7
13	CN/SLEEP	Module Status Indicator
14	VREF	Voltage Reference for A/D Inputs
15	ASSOCIATE/AD5/DIO5	Associated Indicator, Analog Input 5 or Digital I/O 5
16	RTS/AD6/DIO6	Request-to-Send Flow Control, Analog Input 6 or Digital I/O 6
17	AD3/DIO3	Analog Input 3 or Ditital I/O 3
18	AD2/DIO2	Analog Input 2 or Ditital I/O 2
19	AD1/DIO1	Analog Input 1 or Ditital I/O 1
20	AD0/DIO0	analog Input 0 or Ditital I/O 0

Figure 6/7, XBee pin layout diagram

Xbee consists of 20 pins. 8 digital I/O pins that allow the device to function with input or output set by software. Of these digital pins 6 can function to give ADC input. 1 pin is designated for digital output only. 2 pins VCC and GND, provide power to the device. 1 pin also allows for voltage reference. The other 8 pins allow the Xbee to perform further functionality. 2 pins allow for UART data in and UART data out. 2 pins can function to allow PWM output. 3 pins are set to either control sleep or reset, one of which allows for a sleep indicator. And the final pin is reserved.

USB Connection Specification

The keyboard and card reader will be connected to the Pi using USB connection. The keyboard used is a qwerty keyboard normally used for desktops and laptops. The keyboard will give input of number and alphabet character (ISU ID number and Password of the locker) to the Pi in order to be processed and then send the appropriate information to open the respective locker.

Hardware Specifications

Locking Unit Specification

Servo Motor

The motor being used to control the locking and unlocking of the lock is a Parallax Standard Servo (#900-00005). This servo has interface capability with PWM capable devices and can hold any position from 0 to 180 degrees. The servo can apply 38 oz-in torque at 6VDC and can operate in the range of 4-6V. The servo also has a maximum current draw of 140+/-50mA at 6VDC and draws 15mA under static conditions.

Figure 8, Parallax Standard Servo

The I/O of the servo motor is connected to the ATMEGA328 via a transistor. When the ATMEGA sends a signal to move the position of the servo, the increase in voltage causes the transistor to power the servo and move it to its desired location. When the servo does not receive a signal from the ATMEGA, it stays at its current location and operates under static current conditions. The servo is independently powered from the battery source in an order to avoid current spikes.

Lock

The lock being used is a Master Lock (1714) that is commonly used in athletic locker room lockers. The lock contains a 5-pin tumbler cylinder for supreme security and is key operated. The lock is spring loaded with its resting position in the locked position. The lock is controlled by the servo motor, which is connected to the lock via metal fasteners. When the servo moves, it pulls the lock into the unlocked position and then moves the lock back into the locked position once the unlocking time has expired. The spring loading capabilities of the lock make it so the lock can be in the locked position when the locker is open, then when one wants to close the locker, the lock is compressed to fit back in the locker and then expanded once fully in the locker.

Figure 9, Master Lock

Bi-LED (160-1057-ND)

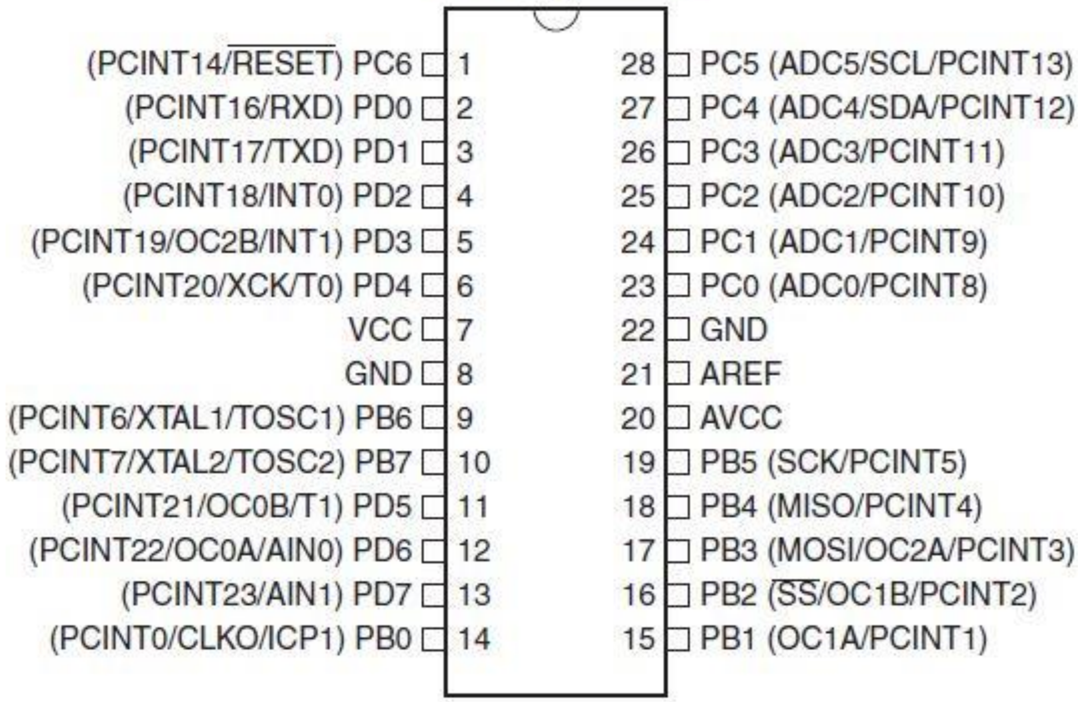
A bi-colored (red/green) LED is used to provide the user feedback of the status of the locker. A green light indicates that the locker has been unlocked. A red light indicates that the battery in the locker needs to be replaced. The LED is 5mm and operates on a 5V power source from the ATMEGA328.

Figure 10, Bi-LED

Atmega328 Microcontroller Specification

The Atmega328 is a microcontroller chip produced by Atmel. It is an 8-bit microcontroller that has 32K of flash memory, 1K of EEPROM, and 2K of internal SRAM. The Atmega328 has 28 pins. It has 14 digital I/O pins, of which 6 can be used as PWM outputs and 6 analog input pins. These I/O pins account for 20 of the pins.

Atmega328


(PCINT14/RESET) PC6 1
(PCINT16/RXD) PD0 2
(PCINT17/TXD) PD1 3
(PCINT18/INT0) PD2 4
(PCINT19/OC2B/INT1) PD3 5
(PCINT20/XCK/T0) PD4 6
VCC 7
GND 8
(PCINT6/XTAL1/TOSC1) PB6 9
(PCINT7/XTAL2/TOSC2) PB7 10
(PCINT21/OC0B/T1) PD5 11
(PCINT22/OC0A/AIN0) PD6 12
(PCINT23/AIN1) PD7 13
(PCINT0/CLKO/ICP1) PB0 14
28 PC5 (ADC5/SCL/PCINT13)
27 PC4 (ADC4/SDA/PCINT12)
26 PC3 (ADC3/PCINT11)
25 PC2 (ADC2/PCINT10)
24 PC1 (ADC1/PCINT9)
23 PC0 (ADC0/PCINT8)
22 GND
21 AREF
20 AVCC
19 PB5 (SCK/PCINT5)
18 PB4 (MISO/PCINT4)
17 PB3 (MOSI/OC2A/PCINT3)
16 PB2 (SS/OC1B/PCINT2)
15 PB1 (OC1A/PCINT1)

Pin Number	Description	Function
1	PC6	Reset
2	PD0	Digital Pin (RX)
3	PD1	Digital Pin (TX)
4	PD2	Digital Pin
5	PD3	Digital Pin (PWM)
6	PD4	Digital Pin
7	Vcc	Positive Voltage (Power)
8	GND	Ground
9	XTAL 1	Crystal Oscillator
10	XTAL 2	Crystal Oscillator
11	PD5	Digital Pin (PWM)
12	PD6	Digital Pin (PWM)
13	PD7	Digital Pin
14	PB0	Digital Pin
15	PB1	Digital Pin (PWM)
16	PB2	Digital Pin (PWM)
17	PB3	Digital Pin (PWM)
18	PB4	Digital Pin
19	PB5	Digital Pin
20	AVcc	Positive voltage for ADC (power)
21	AREF	Reference Voltage
22	GND	Ground
23	PC0	Analog Input
24	PC1	Analog Input
25	PC2	Analog Input
26	PC3	Analog Input
27	PC4	Analog Input
28	PC5	Analog Input

Figure 11/12, Atmega Pin Diagram

20 of the pins function as I/O ports, meaning they can function as an input to the circuit or as output, set by software. 14 of the pins are digital pins, of which 6 can function to give PWM output. 6 of the pins are for analog input/output. 2 of the pins are for the crystal oscillator, providing a clock pulse for the Atmega chip. A clock pulse is used to synchronize the communication between the microcontroller and the device(s) it is connected to. 2 of the pins, Vcc and GND, provide power to the microcontroller. The Atmega328 is a low-power chip, so it only needs between 1.8-5.5V of power to operate. The ADC has 3 pins set aside for it to function- AVCC, AREF, and GND. AVCC is the power supply, positive voltage, that for the ADC. GND is the power supply ground. AREF is the reference voltage that the ADC uses to convert an analog signal to its corresponding digital value. The last pin is the RESET pin.

Locker Control Unit - Bill of Materials

Locker Control Unit BOM			
Quantity	Part Number	Part Name	Price ($)/Ur
1	ATMEGA328-PU-ND	ATMEGA328	2.74
1	160-1057-ND	Bi-Colored LED	0.28
2	CF14JT100RTR-ND	100Ω Resistors	0.005
1	CF14JT10K0TR-ND	10kΩ Resistor	0.004
1	CTX1085-ND	16MHz Crystal	0.27
2	BC1034CT-ND	18pF Capacitors	0.25
2	CF14JT100RTR-ND	Resistors (servo tran)	0.005
1	900-00005-ND	Servo	12.99
1	2N3906-APCT-ND	PNP Transistor	0.15
1	MC7805CT-BPMS-ND	Voltage Regulator L7805	0.35
1	497-12822-5-ND	Voltage Regulator LD1117V33	0.63
1	80-C330C334K5R	0.33µF Capacitor	0.49
1	P4725-ND	0.1µF Capacitor	0.19
1	P14373-ND	100µF Capacitor	0.15
1	P10425TB-ND	10µF Capacitor	0.04
1	XB24-AWI-001-ND	Xbee Series 1	19
1	T97B440003	Lock	7.7
AR	N/A	Wire	0
AR	N/A	Metal Fasteners	0
1	ID830	Battery Pack	2.95
4	N/A	AA Alkaline Energizer M AX Batteries	0.8
		Total Price	51.644

MCU Mount Specification

The MCU shall be housed in a casing unit, and a mounting unit shall securely hold it in place onto the lockers. This mount must support a modest amount of weight, and shall allow a 60 degree inclined keyboard.

Pi Controller Specification

The raspberry pi model we are using is the model B unit, which comes with 512 MB of ram, 2 usb ports, an ethernet port, and composite video. The processing speed and the RAM available will be more-than-sufficient for our tasks, and will be capable of withstanding any additional tasks future engineers may wish to have the device perform.

Additionally, a 16 gb micro-sd card will be used to store relevant data, and a usb splitter will also be required to connect the keyboard, wireless transmitter, and the card-reader.

Main Control Unit - Bill of Materials

Main Control Unit BOM		
Quantity	Part Name	Price ($)/unit
1	Raspberry PI	40
1	Keyboard	12
1	Card Reader	12
1	Display	30
1	Xbee Series 1	19
1	Wi-Fi Chip	10
	Total Price	$123

Software Specifications

Atmega Microcontroller Software Specification

The ATmega328 is loaded with a bootloader that allows for the user to upload new code without the use of an external hardware programmer. The user can load the ATmega328 on an Arduino board and while using the open-source Arduino environment can easily write and upload code on to the microprocessor. The Arduino environment runs on windows, Mac OSX, and Linux. The environment is written in Java and based on processing, avr-gcc, and other open source software.

The ATmega328 contains 32 Kbytes On-chip In-System Reprogrammable Flash memory for program storage. Since all AVR instructions are 32 bits wide, the Flash is organized as16K x 16. For software security, the Flash Program memory space is divided into two sections, Boot Loader Section and Application Program.

Pi Controller Software Specification

The raspberry Pi shall be loaded with RASBIAN operating system to minimize development costs and to improve future usability and maintainability. The operating system features a full C-standard library, as well as additional scripting languages as necessary.

The core application shall be written in C-standard code, and the code can be either written directly onto the device using a keyboard, or remotely using Secure Shell or Secure-File-Transfer-Protocol. Additionally, the remote-management software shall be a series of scripts ran from the CLI (“Command-Line Interface”) which will handle all administrative functions.

Power Consumption

To ensure that we met the requirement of having the batteries in the LCU last for two full semesters, we performed a series of power consumption calculations under various scenarios. Below one can see the table defining all six scenarios. All scenario definitions were decided based on conversations with our client about expected system operation.

	Scenario Definitions		
	LCU looks for signal from MCU every 'x'	LCU Checks Battery Status Every 'x'	Locker Opens Every 'x'
Scenario 1	5 seconds	1/week	0/week
Scenario 2	5 seconds	1/week	2/week
Scenario 3	5 seconds	1/week	6/week
Scenario 4	5 seconds	1/week	8/week
Scenario 5	5 seconds	1/week	14/week
Scenario 6	5 seconds	1/week	28/week

Each scenario was calculated by summing together the mAh total for each of the four main components (ATMEGA, Xbee, Servo, Bi-LED) in the locker control unit under each scenario. A summary of the calculations can be seen in the table below, where one can see that all six scenarios meet the requirement of LCU batteries shall last at least two academic semesters.

	Scenario Calculations			
	Current Draw (mA)	Time (hours)	Electric Power Over Time (mAh)	How many academic semesters with 4AA battaries?
Scenario 1	0.155904514	2688	419.0713347	25.77126877
Scenario 2	1.006373505	2688	2705.131981	3.992411489
Scenario 3	1.027328477	2688	2761.458947	3.91097612
Scenario 4	1.037805964	2688	2789.622431	3.871491669
Scenario 5	1.069238426	2688	2874.11289	3.757681209
Scenario 6	1.142580835	2688	3071.257284	3.516475176

Below one can see the detailed results for the four main components in the locker control unit.

	ATMEGA328 Calculations		
	Current Draw (mA)	Time (hours)	Electric Power Over Time (mAh)
Scenario 1	3.50529E-09	2688	9.4222E-06
Scenario 2	0.840006967	2688	2257.93873
Scenario 3	0.840020195	2688	2257.97428
Scenario 4	0.840026808	2688	2257.99206
Scenario 5	0.84004665	2688	2258.04539
Scenario 6	0.840092946	2688	2258.16984

	Xbee Calculations		
	Current Draw (mA)	Time (hours)	Electric Power Over Time (mAh)
Scenario 1	0.155895665	2688	419.047548
Scenario 2	0.155895665	2688	419.047548
Scenario 3	0.155895665	2688	419.047548
Scenario 4	0.155895665	2688	419.047548
Scenario 5	0.155895665	2688	419.047548
Scenario 6	0.155895665	2688	419.047548

	Bi-LED Calculations		
	Current Draw (mA)	Time (hours)	Electric Power Over Time (mAh)
Scenario 1	0.535	0.044444444	0.023777778
Scenario 2	0.535	0.088888889	0.047555556
Scenario 3	0.535	0.266666667	0.142666667
Scenario 4	0.535	0.355555556	0.190222222
Scenario 5	0.535	0.622222222	0.332888889
Scenario 6	0.535	1.244444444	0.665777778

	Servo Calculations		
	Current Draw (mA)	Time (hours)	Electric Power Over Time (mAh)
Scenario 1	0	2688	0
Scenario 2	0.010453181	2688	28.09815
Scenario 3	0.031359542	2688	84.29445
Scenario 4	0.041812723	2688	112.3926
Scenario 5	0.073172269	2688	196.68706
Scenario 6	0.146344539	2688	393.37412

Simulations and Modeling

Implementation

To simulate our system, we will ran each sub-component of the system through a series of simulations on a breadboard. First, we simulated the ATMEGA by sending the command to power the servo and unlock the lock. When we run this simulation we are looking to see if the servo is moving in a smooth manner (no jittery behavior) and that the servo is moving the exact number of degrees we instructed it to. Furthermore, we will make sure that the servo is able to lock and unlock upon command. Next, we simulate the different LED colors on a breadboard by sending a signal from the ATMEGA to light each color of the LED.

We also will simulate the student ID card swipe to verify we are able to open the locker via Wi-Fi (data transfer from/to the Xbee of Pi controller to/from the Xbee of Atmega at the locker unit). Furthermore, we will verify that the LCD shows user information and the battery status.

Issues/Challenges

The biggest issue and challenge of this project is producing a valid solution which is capable of running on battery-power for two consecutive semesters. Regulating power and minimizing use with power-hungry modules is quite a challenge. Likewise, balancing between components that we already have and components that would enhance the project with our budget has proved to be an interesting problem. Otherwise, the design is fairly straightforward.

Testing Procedures and Specifications

Electrical Component Testing/Procedures/Specifications

All electrical components ATmega, Xbee, and servo will be tested on breadboard first and then it will be implemented into PCB layout. The voltage supply for the Atmega, Xbee and the servo need to be met in order to make sure the components work perfectly. The Xbee is tested to make sure that it can receive and transmit data in a certain range.

Hardware Components Testing/Procedures/Specifications

All hardware components will be tested to ensure that they meet our high level system requirements. First, the servo will be tested by sending a signal, from the ATMEGA, to move a corresponding number of degrees. Then, we will verify that the servo did move the intended number of degrees. Next, the LED will be tested to ensure that the correct color lights are being shown at each time. A signal will be sent from the ATMEGA to power the red, green, or no color light, and one will verify the color of the light being shown to ensure that it is indeed the correct color.

Software Components Testing/Procedures/Specifications

All software for this project will be tested rigorously. In particular, specific emphasis will be given to testing security and secure information transfer. This testing will ensure that no outside force will reasonably be able to infect our system, and gain unwarranted access. This testing will occur by probing the communication sent between XBee's and then rigorously attempt to decode any data contained therein.

Conclusion

Our system will be a great addition to the ECPE department. It will provide students a safe way to store their materials for their senior design projects and they will not have to worry about other students breaking into their lockers. Furthermore, administrators will benefit from this new system because they will not have to keep track of locker combinations, they can just wirelessly administer who should have access and who should not. Overall, this system will be a great addition to the ECPE department and will benefit them for many years to come.

Additional Information

Electronic Data Sheets

Atmega328 Datasheet

The ATmega48PA/88PA/168PA/328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega48PA/88PA/168PA/328P achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

http://www.atmel.com/Images/doc8161.pdf

Xbee Datasheet

The XBee family of embedded RF modules provides OEMs with a common footprint shared by multiple platforms, including multipoint and ZigBee/Mesh topologies, and both 2.4 GHz and 900 MHz solutions. OEMs deploying the XBee can substitute one XBee for another, depending upon dynamic application needs, with minimal development, reduced risk and shorter time-tomarket.

https://www.sparkfun.com/datasheets/Wireless/Zigbee/XBee-Datasheet.pdf