# Wi-Fi Connected Locker Access System

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Faculty Mentor and Client: Lee Harker

Team Members: Nathan Castek, Corey Cazzato, Nathan Lafferty, Priyank Patel, Mohammad Syazwan

# Introduction

Team Lead: Nathan Castek (EE)

WebMaster: Corey Cazzato (CPRE)

Team Communicator: Nathan Lafferty (CPRE)

Key Concept Holder: Priyank Patel (EE)

Technical Lead: Mohammad Syazwan (EE)

# Problem Statement

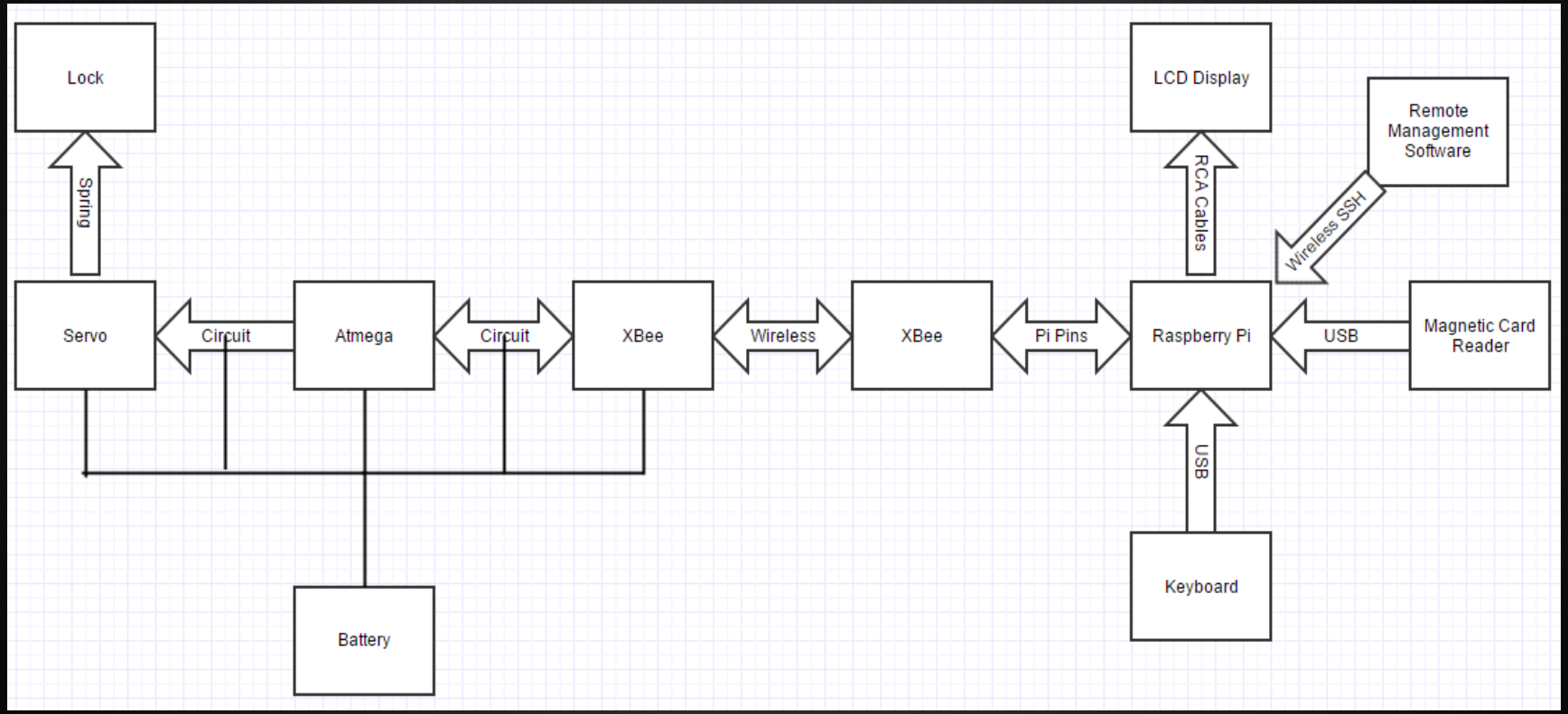
- Current Lockers are:
  - Difficult to manage
    - Must manually assign lockers, rearrange locks
    - High administrative overhead to adding new users
  - Insecure
    - Padlocks w/ same lock shared year by year

# Proposed Solution

- Wi-Fi connected locker access system
  - Remotely-Managed
  - Battery-powered
  - Significantly Reduced administrative overhead
  - Secure

Detailed within this presentation

# Conceptual Sketch



# Functional Decomposition

1. MCU and LCU
2. Power System
3. Communication Platform
4. Locking System
5. CLI (Command Line Interface)

# Functional Requirements

- Read student’s ISU ID Card
- Keyboard
- Allow administrative functionality
- Wireless transmitters
- LCU (“Locker Control Unit”) shall be secure
- The MCU must store usernames/passwords/groups of users, and be easy to remotely manage to alter information
- The MCU must be “locked-down”

# 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 LCU, low-power, red LED shall illuminate every 5 seconds when batteries are below 10% power
- The LCU green LED shall illuminate when the locker has been unlocked.
- 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 shall have a physical key that will manually unlock the lockers for cases in which batteries have died

- The LCD display on the MCU shall display when locker batteries are below 20% and are in need of replacement
- 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

# Technical Constraints/Considerations

- Power
  - Source (See scenario calculations in references)
  - Sleep functions
- Size
- Timing
  - Circuitry delays

# Market Survey

- Similar items currently on market
  - automated keyless access
  - ID card , scanner
  - LCD screen
  - AC power sockets
- Not remotely managed
- Expensive
- Not tied to Iowa State’s Network

# Potential Risks & Mitigations

- Public Wi-Fi
  - Security Risks, MitM attacks, brute-force crypto-hacking
- The cost of the project
- Physical damage to the components
  - wear and tear of locker, abuse of MCU
- Transmissions over wireless
- Electrical equipment may be subject to failure
- Battery-Life Duration

# Resource Cost & Estimate

- Labor
  - 5 Engineers (~30hrs/week)
- Parts - LCU
  - Each unit will cost around $50 (see BOM on next slide)
- Parts - MCU
  - One main control unit will cost around $125 (see BOM on next slide)

Total cost for 30 locker system: $1625

# Resource Cost & Estimate (Cont.)

| Locker Control Unit BOM | | | |
|---|---|---|---|
| Quantity | Part Number | Part Name | Price ($)/Unit |
| 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 |

| 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 |

# Project Milestones & Schedule

| Task Name | Duration | Start | Finish |
|---|---|---|---|
| Research and Design System | 50 days | Mon 9/8/14 | Fri 11/14/14 |
| Sub-system Testing | 24 days | Wed 10/1/14 | Sat 11/1/14 |
| System Testing | 101 days | Sun 11/2/14 | Fri 3/20/15 |
| Prove System will Function with 3 Units | 20 days | Mon 11/24/14 | Fri 12/19/14 |
| Order Parts | 17 days | Sat 12/20/14 | Sun 1/11/15 |
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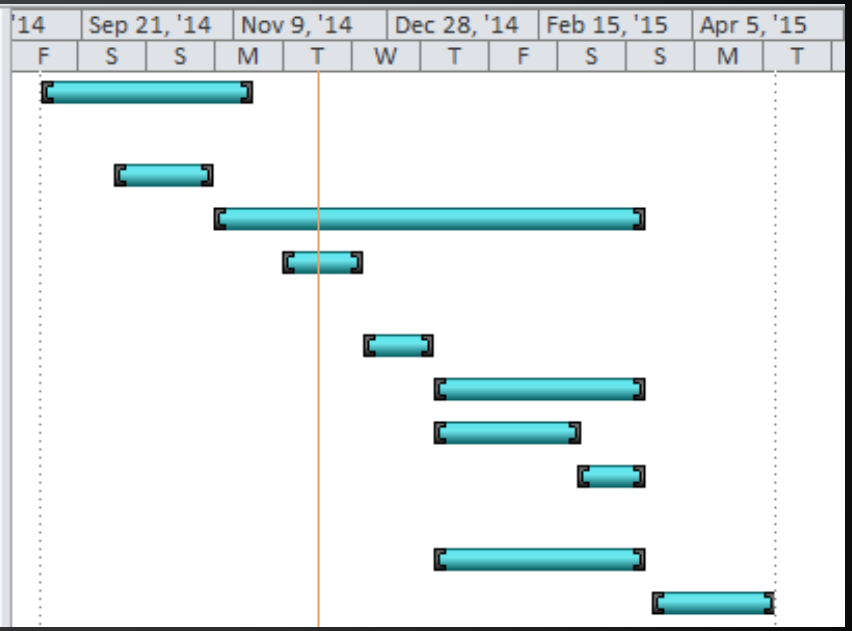
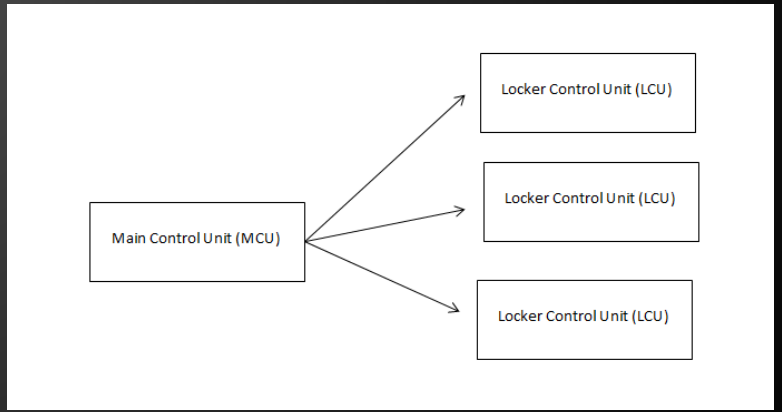


# System Design

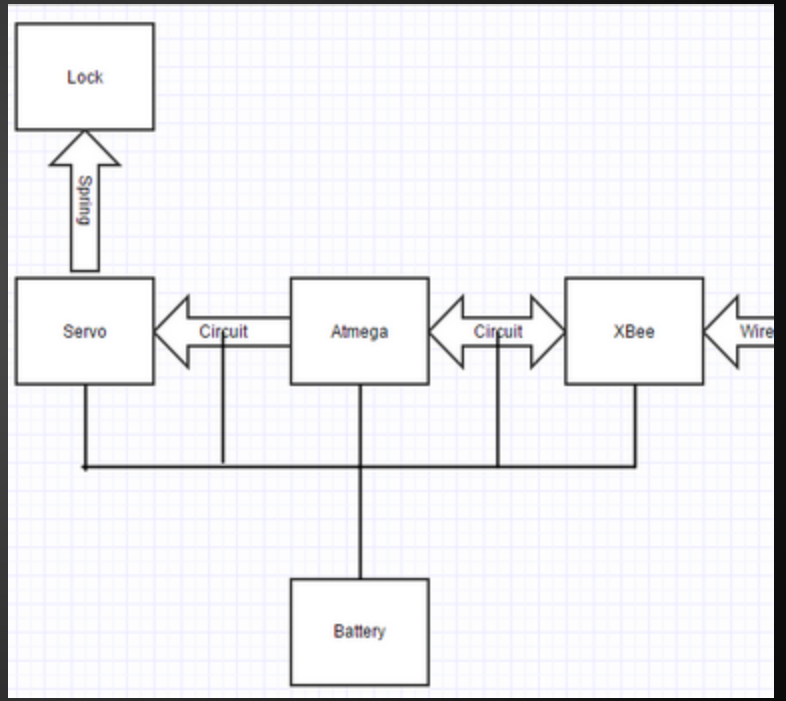
MCU and LCU

- LCU units “slaved” to MCU
- Single MCU “master”

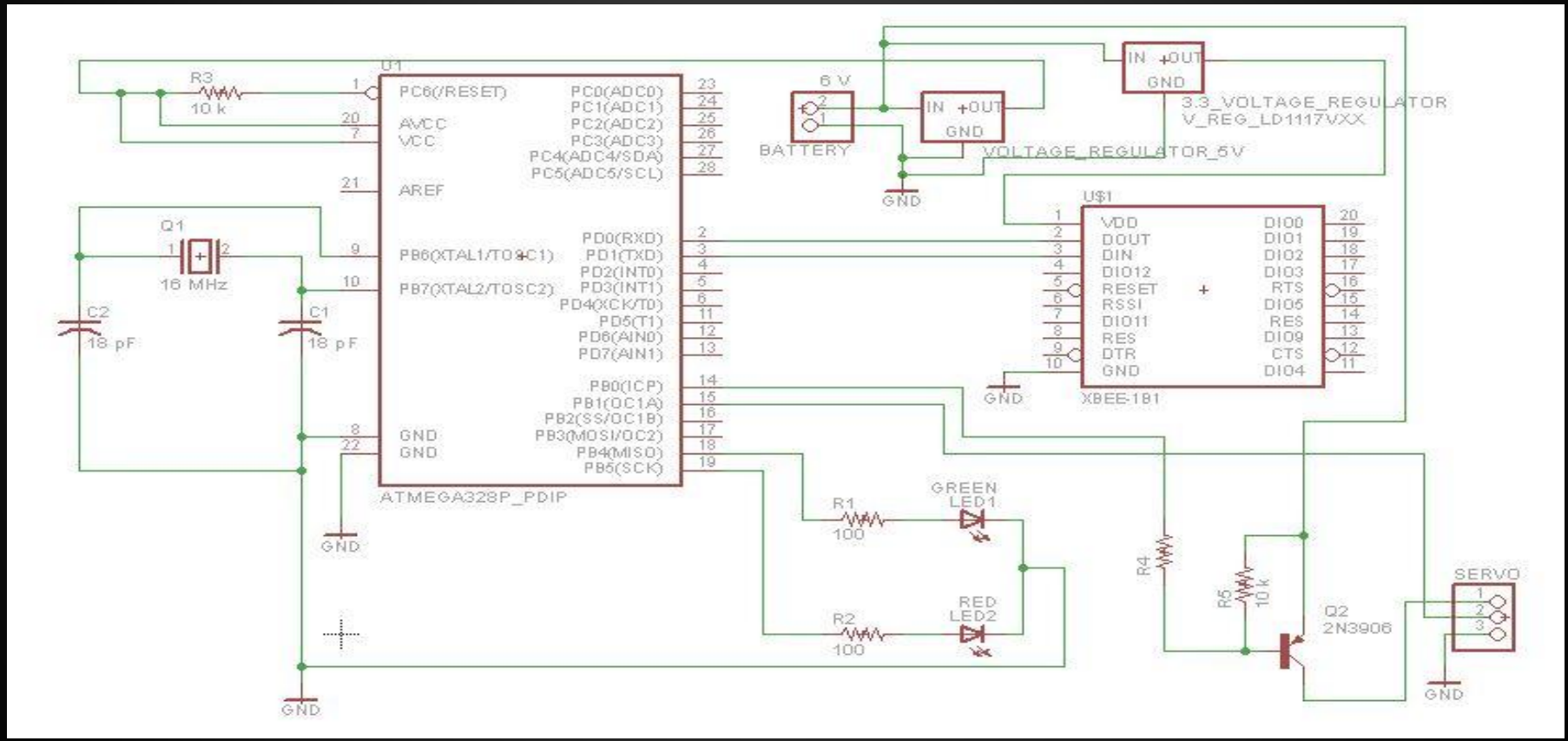


# System Design (LCU)

- Atmega328 processor
- XBee series 1
- Servo motor
- Bi-LED
- Battery pack
- Lock



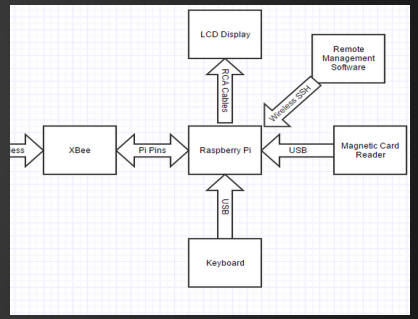
# Detailed Design LCU



# System Design (MCU)

Hardware and Software components

- Designed around simplicity
  - Raspberry Pi Model B+
    - Running “Rasbian” OS
  - Xbee (defined earlier)
  - Generic QWERTY Keyboard
  - Generic RCA LCD screen (also supports HDMI)
  - Remotely Managed with SSH and Command Line Interface



# Detailed Design (MCU)

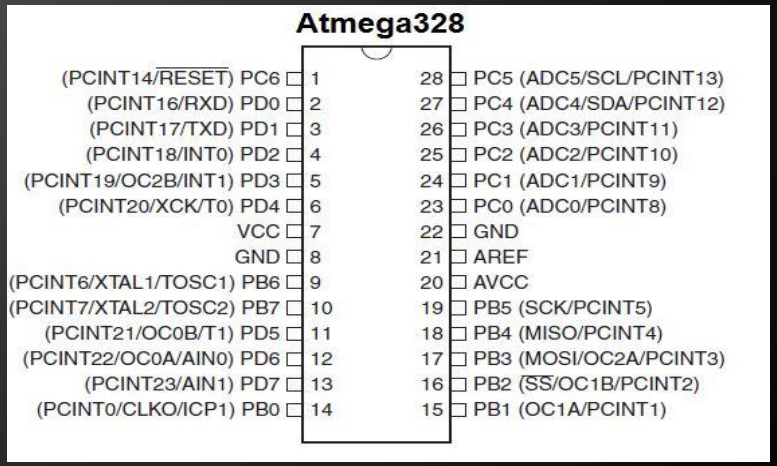
- No Graphical User Interface
- LCD renders simple form with text input
- Card swipe will emit an audible sound on valid card swipe
- Remote Management Software
  - Connected over SSH
  - Ran over command-line interface
    - a/e, “add-user lafferty 012345678 randomPassword”

# Software Technology

- Still debating on benefits of data design
  - Database vs text stores
- Schema is a form of REST
  - add-user, update-user, remove-user, add-group, remove-group
- Remote-Management security provided with SSH
- MCU <-> LCU communication secured using SSL
- Actual code is written in Python scripting
  - Rasbian comes default with Python
  - Can interface with XBee units with ease
  - Easy to access data stores and serial interfaces

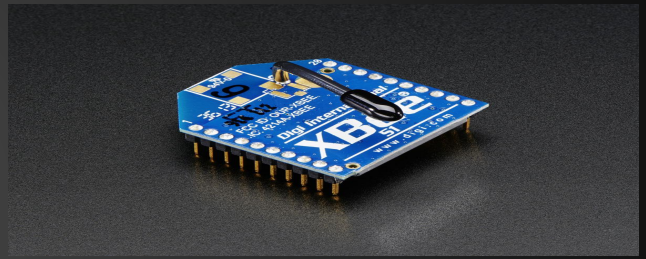
# Hardware Technology

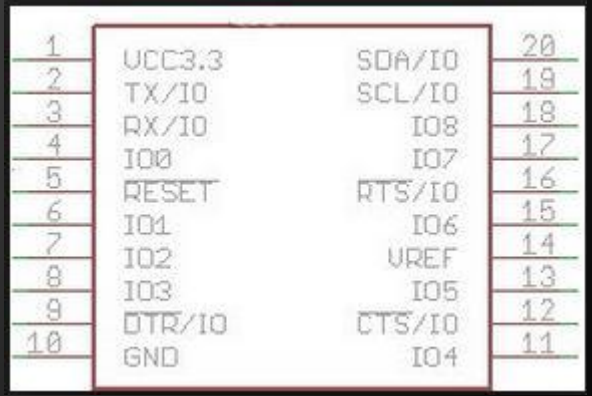
- Atmega328
  - 8-bit microcontroller
  - control servo, XBee, LED
  - 1.8 to 5.5V



# Hardware Technology

- Xbee Series 1
  - Low power
  - Low cost
  - 300 feet range
  - 3.3 V

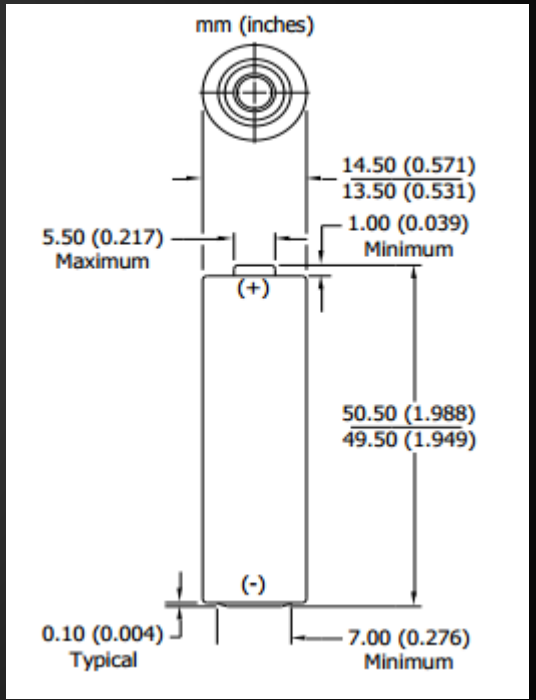




# Hardware Technology

- Battery
  - Energizer (AA)
  - supply voltage to LCU

| Battery Types | Type | Voltage | Capacity(mAh) | Cost/8 pk | Capacity/cost |
|---|---|---|---|---|---|
| Energizer Ultimate lithium | Lithium/Iron Disulfide (Li/FeS2) | 1.5 V | 3000 | $18.99 | 157.9778831 |
| Energizer max | Alkline | 1.5 V | 2779 | $6.39 | 434.8982786 |
| Energizer power plus(rechargable) | NiMH (nickel-metal hydride) | 1.2 V | 2300 | $33.94 | 67.76664702 |



# References

## Power Calculations

| | 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 |

| | 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 |

# Power Calculations (cont.)

| | 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 |

| | 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 |

| | 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 |

| | 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 |

# Hardware Technology

- Servo
  - turn 0 - 180 degrees
  - operate from 4 to 6 V range
  - 140 +- 50 mA current draw

# Hardware Technology

- Lock
  - spring loaded
  - can be operate using key

# Hardware Technology

- Bi-LED
  - Green (unlocked)
  - Red (battery replacement)
  - 5V

# Testing Plan

- Hardware
  - Rigourously test to verify Servo + Equipment performs under modest stress conditions
- Electronics
  - Mathematically verify circuit functions properly
  - Simulate circuit using computer software
    - “Eagle” software
  - Given circuit edge-values, verify individual circuits function appropriately
- Software
  - Test all edge cases with input, physically verify transmissions are secure

# Prototype Information

Demonstration

# Current Project Status

| Task Name | Duration | Start | Finish |
|---|---|---|---|
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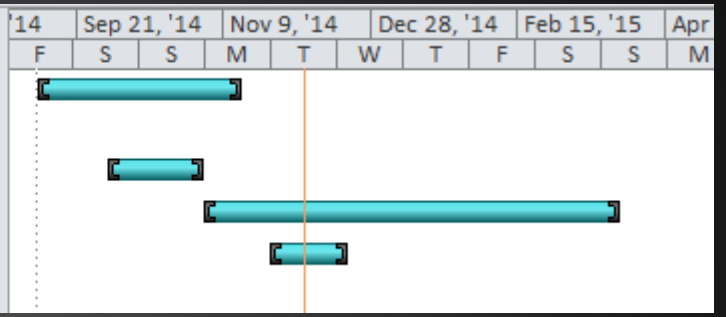


- Proved system concept with 3 LCU's
  - Card swipe → Wireless Signal → Open Correct Locker

# Contributions Per Person

- Computer Engineers
  - Corey
    - LCU design and construction
    - Webmaster (Keeping website up to date and functional)
  - Lafferty
    - MCU design and construction
    - Communication (Writing up documents, taking weekly minutes, submitting various forms and

# Contributions Per Person

- Electrical Engineers
  - Castek
    - Team Leader (Manage project deadlines)
    - Hardware Specialist (Design and build locking mechanism)
    - Assisted other Electrical Engineers in research and development of circuits
  - Priyank
    - Battery and Power specialist
    - Assisted other Electrical Engineers in research and development of circuits
  - Mohammad
    - PCB Design Specialist & Computer Simulation Specialist
    - Translated circuits into computer simulations for testing
    - Assisted other Electrical Engineers in research and development of circuits

# Plan for next semester

| Task Name | Duration | Start | Finish |
|---|---|---|---|
| Order Parts | 17 days | Sat 12/20/14 | Sun 1/11/15 |
| Mechanical Design | 50 days | Mon 1/12/15 | Fri 3/20/15 |
| Admin Controls and UI | 35 days | Mon 1/12/15 | Fri 2/27/15 |
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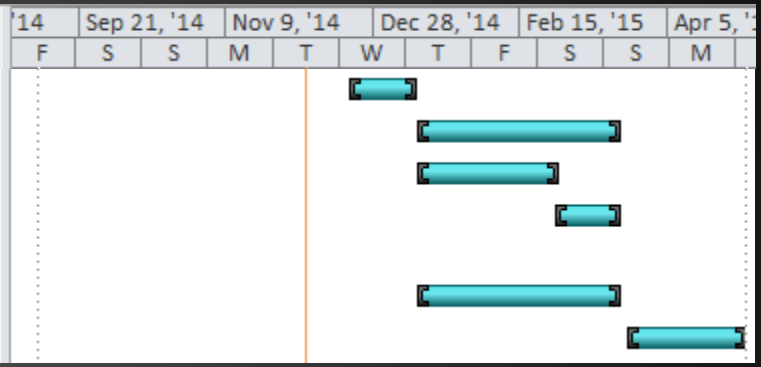


- Mechanical Design, Admin Controls, UI, Security, Power Savings, Documentation

# Q/A

Questions?