# RED BAR

## By Team BIKES

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**Abstract**: In order to create a functioning stationless bikeshare, the team will create a Smartlock that bikeshare operators can permanently attach to the bicycles in the bikeshare. These Smartlocks will provide security for the bicycle that other systems find in docking stations. The main focuses of designing the lock are theft prevention, ease of implementation and use. Therefore, the lock will rely on RFID technology, reliable communication via the Zigbee mesh network, and ergonomic physical design. The successful implementation of a stationless bikeshare program and the benefits it brings to campus, hinges on the creation of a reasonably priced Smartlock. To achieve this goal, the team will complete the necessary research and the resulting product development amongst four subgroups: lock design, access control, geolocation, and marketing. The division of work among four subgroups listed below will allow members of the team to each become an expert in the specific field of their research and yield a better product. Weekly, each subgroup briefs the team on current research progress, such that every member will have a general understanding of the project at all times without needing to be concerned about specific details of every component. The research process for each subgroup is described separately in further detail below.

# Lock Design

## Research Question

What is the most effective way of locking a bicycle for a stationless bikeshare system?

## Methodology

The locking subgroup has researched different methods of securing bicycles based on existing studies and experimentation on existing locks. The types of testing done on the existing locks include: (1) tension test, to mimic a thief leveraging the lock, and (2) shear test, which compresses bolt cutters through the lock. These tests will determine the most effective lock material, design, and lock placement that can withstand most attacks by a thief using readily available hand tools. Based on test data, the locking subgroup is designing and manufacturing an optimal lock for the system.

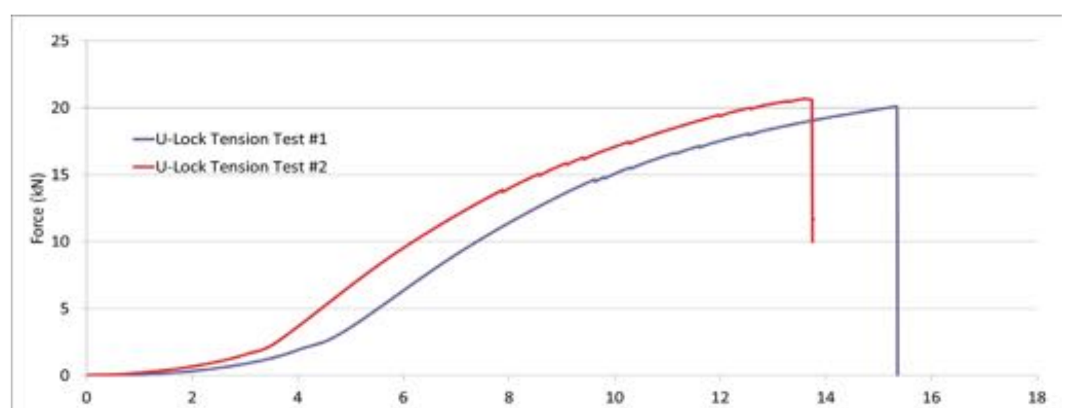
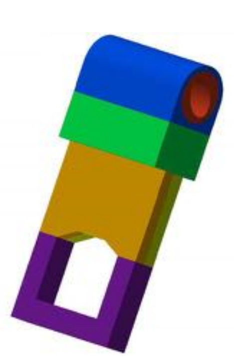
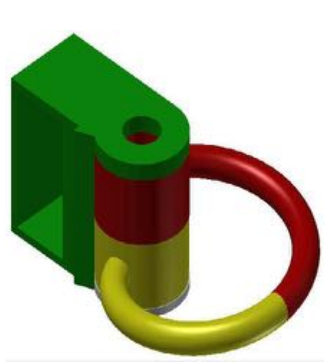



**Figure 1:** U-Lock tension test results.

## Current Progress

The locking subgroup is finishing testing on the U-Lock, Bordo Lock, and Cable Lock. Two lock designs (loop lock and modified u-lock) have been 3-D printed as proof of concept designs for functionality testing. The two lock designs resemble a U-lock due to the fact that the University of Maryland recommends the use of a quality U-lock to secure bicycles. From the 3-D models, the subgroup made modifications to improve ease of use and lock security.





## Future Research

In the future, the locking subgroup plans to analyze the data from the lock tests, make adjustments to the new lock designs once they have been machined, and incorporate the electronics into the lock. Adding the electrical components for the locking mechanism and security is the primary goal moving forward towards a completed lock.

# Access Control

## Research Question

How can a user-friendly access system be realized and integrated with internal network connectivity modules while maintaining sustainable net power consumption?

**Why RFID?** When considering the simplicity of the system, radio frequency identification access was a clear choice. Users can simply tap an RFID tag to a reader and unlock a bicycle. Also, the access industry, particularly as it relates to public transportation, is increasingly moving towards RFID and NFC systems which improves the likelihood that consumers will be familiar with the system[1].

## Methodology

**RFID Module Tests:**

- **Power Consumption**:
  A voltmeter was used to determine the voltage and current draw during operation and sleep modes. The measurements were taken repeatedly guarantee consistent results
- **Range**:
  An RFID antenna was held stationary with the flat of the antenna facing parallel to a level surface. The passive component was then moved back from the antenna 5mm at a time until the antenna could no longer read the passive tag. The range was ensured by holding the passive tag at the observed distance and changing the orientation. At the maximum length the system will not read the tag if it's face is not parallel with the reader.
- **Physical Attributes:**
  Each RFID module was assessed based on its size and antenna characteristics. Antennas attached via a long wire provide more flexibility in the configuration of the electronics. All modules involved a shield with the same footprint as the Arduino system on which they operate, and the size of the modules less the size of the Arduino ranged from about 16cm² to 35cm².

## Current Progress

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| Module: | Range: | Operating Voltage & Current | Antenna Size | External antenna |
|---|---|---|---|---|
| PN532 NFC RFID Module | 3.2cm | 3.3V or 5V<br>70mA | 42.7mm x 40.4mm | Yes |
| Adafruit PN532 NFC/RFID Controller Shield | 5.7cm | 5V | 65.1mm x 53.3mm | No |
| NFC Shield V2.0 | 5 cm | 5V<br>100mA | 30.48mm x 27.94mm | Yes |

## Future Research

- **Integration of electronics:**
  AES Encryption on both the RFID module and the network utilizes a series of keys that are reset daily to safely transfer data between local storage and the network where most information will be stored. The only information stored on the Arduino will be the current location and last user. Having minimal information stored ensures maximum security in case of theft and maximizes available memory space.
- **Power:**
  The team will test systems for charging the onboard battery with solar panels. In the process, the solar panels' voltage and current output and durability will be tested under different lighting conditions.

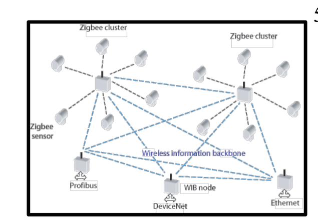
# Geolocation

## Research Question

When stations are removed from a bikeshare, what is the best technical framework to ensure reliable, real-time communication among system components? What method enables secure transfer of personally identifiable information (PII)?

## Methodology

**ZigBee Network – Campus-wide Wireless Communication**



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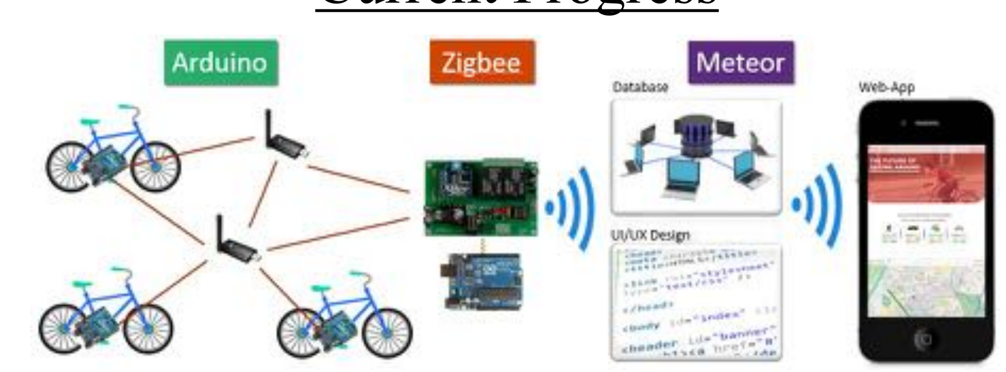
ZigBee mesh network operates at low power, requires minimal maintenance, and uses self-healing capabilities in the event of a failure. The network offers a secure platform for data collection in an easily expandable fashion.

**Meteor Framework – User Interface and Database**

METEOR

The web application developed using Meteor provides an accessible platform for users, administrators, and mechanics of the bikeshare. The app interacts with MongoDB database to display a wide variety of information.

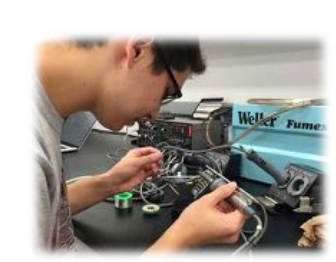
## Current Progress




Currently, the team is developing the web application, configuring the hardware (ZigBee routers, Arduino microcontrollers, etc.) and establishing connectivity between the three main components of the geolocation system – on-bike modules, wireless mesh network, and Meteor framework– as well as integrating with the access control system. Once the system is fully configured, the team will perform optimization tests to ensure high quality of service.

## Future Research

Potential areas that can be further researched include extending web application capabilities, iterating with focus group feedback, and conducting stress test with full size database for optimization.



# Marketing

## Research Question

How can RedBar be a successful bikeshare system on the University of Maryland campus?

## Methodology

To be successful, RedBar must gain the approval of students and the administration.

**Business Model**

Background research and data collection will allow the subteam to construct a model that appeals to the concerns of the administration. The team will need to determine the size of the system, the estimated start-up cost, and operating cost.

**Student Focus Group**

The team will conduct focus groups with current underclassmen to discuss the functionality, interest, and pricing structure of the bikeshare system. This will allow the team to gauge if the program will be welcomed by students and what improvements need to be made.

## Current Progress

The subgroup is in the process of searching for focus group participants. The focus group will occur at the end of April.

**Sample Survey Questions:**

- How much do you think this service would cost you?
- How often would you use this system?
- If you had to make an improvement on the lock, what would you change?
- If you were to explain the bikeshare to someone else, what would you say?

The team will use the results from the focus group to gauge on-campus interest as well as note possible improvements in the web application and locking system design.

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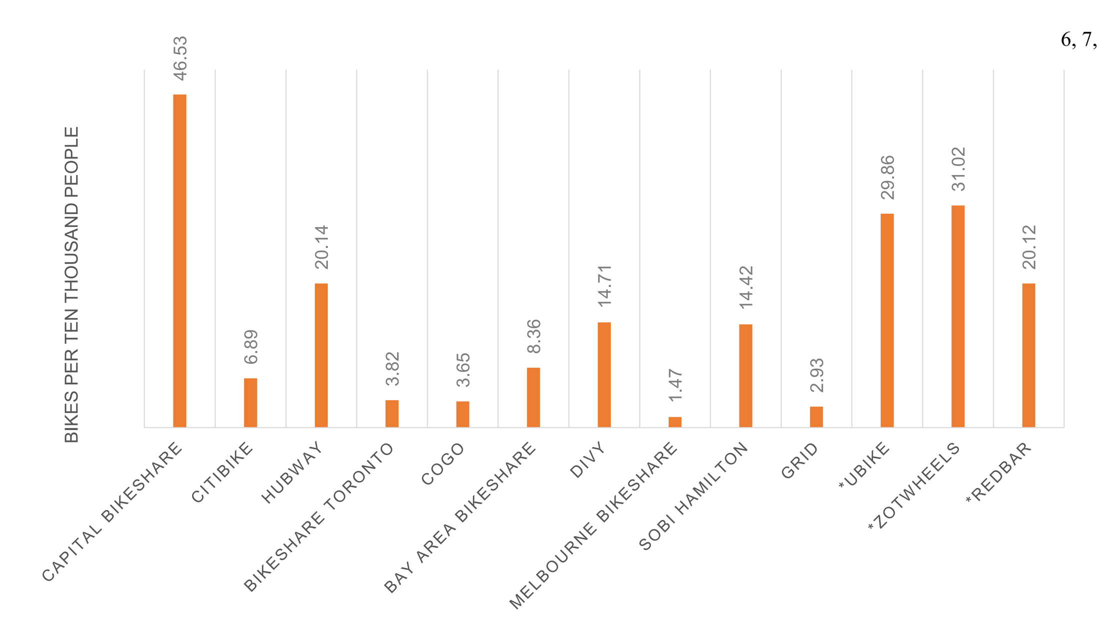


**Figure 2:** Location and size of bikeshares across the world. The last three systems are college bikeshares. Maryland's campus population is approximately 40,000. Based on this data, the system would need around 75 bikes.

## Future Research

The team will analyze the responses from the focus group and compare prices to current college bikeshares to determine a possible pricing structure.

## Timeline of Remaining Tasks

| May 2015 | Summer 2015 | Fall 2015 | Spring 2016 |
|---|---|---|---|
| Finish lock; Test bike unlocking and locating; Host focus group | Prepare for Fall testing; On campus test with five bikes | Work on proposal and drafting business model and company values | Thesis conference |

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## Conclusion

The team ultimately plans to integrate all of the subgroup research to create an innovative Smartlock accompanied with online/mobile application to provide a proof of concept that University of Maryland campus is able to host a stationless bikeshare.