Open Bike Initiative:
Air Quality Sensor Hub
Proposal

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Overview
The Open Bike Initiative (OBI) is a bike sharing model project based on open source software and hardware. The design implements a locking mechanism unit with GPS and cellular modules capable of attaching to any bicycle. The units communicate through client and server side software in order to manage the OBI system.

Our goal is to design a small, low cost, and self-contained board with sensors used to measure a bicycle riders' exposure to air pollution. It will collect and send real time air quality information over an RS232 interface as requested by the OBI system.

Additionally, through the use of a dynamo, we aim to provide a method to use rider effort to generate and provide power to the OBI unit.

Deliverables
- Functional air quality sensor prototype consisting of the fabricated PCB and sensors mounted in an enclosure will be delivered. The unit will be self-contained and capable of storing records on internal memory. It will be capable of communicating and passing dynamo power with future OBI "smart-locks" via RS232 communication using RJ45.
- Final report describing our design, functionality, testing and sample data.

Research: Air quality sensors
Primary urban air pollutants as defined by the EPA (http://www.epa.gov/air/emissions/index.htm) are ozone, nitrous oxides, sulfur dioxide, lead, particulate matter and carbon monoxide. Every day, bicycle riders are exposed to these pollutants with no reliable method of evaluating their level of intake. We aim to provide this information to riders and researchers in order to help create a map of pollution in the city, evaluate ideal paths of travel, best times to ride, as well as any other factors that can be used to minimize their exposure to pollutants.

Sensors to detect the ozone, nitrous oxides, sulfur dioxide, and lead are expensive, in the hundreds of dollars. Our design will focus on detecting particulate matter and carbon monoxide. In order to accomplish this, a low cost metal-oxide gas sensor for CO, as well as environmental sensors for particulate matter will be implemented into the system.

Metal oxide gas sensors are sensitive to other environmental factors such as temperature and humidity. These factors can also directly affect pollutant concentration in the air at any given time. Thus, implementing temperature and humidity sensors will provide context for the data as patterns start to emerge. In order to correlate the data with location, a global positioning sensor will also be implemented into the system. These sensors will be chosen based on reliability, durability, cost, and accuracy.

Sensor Unit Details
The system will be housed in an enclosure with openings to allow for copious airflow as required by the sensors. The box will have an RJ45 jack to connect to the main OBI unit, as well as a 2-pin header to pass AC power from the dynamo to the host system also via the RJ45 jack.

The box will be capable of communicating with the future OBI system through the RS232 interface. In accordance with sponsor specification the designed system will implement the following features:

1. System will be powered using a regulated rechargeable battery which will be turned on using a simple on and off switch.
2. System will have large amount of storage for sensor records. Data must be easily accessible, analyzable, and erasable.
3. GPS will be used to incorporate sensor data with location.

4. The system will implement a power-supply independent real time clock so that each record has a timestamp. The GPS will be able to set the real-time clock.
5. The system will be capable of getting new data every 2 to 3 seconds.
6. RJ45 for future OBI smart-lock communication and to pass dynamo power.
7. System will be cost effective.

Research: Power generation

The development of a usable rim dynamo for providing power to the OBI system was evaluated. Preliminary prototyping with rim mounted magnets and a “U” shaped coil did not produce usable amounts of power. The distance between the magnets and the wire and the non-ideal spatial configuration of the wire produced very small amounts of EMF which was not enough to provide the necessary 5V to the USB charger. Better results could be achieved using stronger magnets and more wire. However, this means higher cost and complex implementation. A better solution was determined to be a bottle or hub dynamo which can be mounted to virtually any bicycle without modification and produce relatively large amounts of power at low cost. While we recommend the use of a bottle or possibly even a hub dynamo as the power source, further optimization of the rim dynamo design can be researched if requested.

Parts

Please see an itemized list of parts below. Please note that this list is subject to change as development progresses. Overall cost of the project, including prototyping and testing, is estimated to be approximately $200.

- Arduino Uno (at least 2)
- Optical large particulate matter sensor
- Optical small particulate matter sensor
- Metal oxide Carbon Monoxide Sensor
- Humidity Temperature Sensor
- Global Positioning Sensor
- Material for enclosure
- PCB board fabrication
- Microcontroller IC (Atmega328)
- Real Time Clock
- Regulators
- 32kHz Crystal
- 16MHz Crystal
- SD Shield
- SD Card
- Capacitors, Resistors, Inductors, and transistors
- Batteries