Motivating Urban Cycling Through a Blockchain-Based Financial Incentives System

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Abstract

As cities become increasingly dense, they must turn to novel technologies and frameworks to address the mobility challenges that will arise. 50% of trips in the U.S. are less than 3 miles, and could be replaced by a more sustainable and space-efficient mode of transportation, such as bicycling, if effective policies and incentives were implemented.

This abstract presents a financial incentives system to increase the prevalence of urban cycling. The blockchain-based system allows cyclists to receive financial compensation from organizations, such as city governments or local businesses, that would like to sponsor cyclists. Using bicycle-powered sensors, cyclists collect and redeem their activity data through smart contracts stored and executed on an Ethereum blockchain. The use of blockchain technology makes transactions secure, trustworthy, and timely.

This project envisions expanding this data platform to include additional bicycle-based sensors that cyclists use to collect and sell data, monetizing their commuting habits, and building a scalable and stable solution for encouraging sustainable transportation in cities.

Author Keywords

Blockchain; location tracking; activity tracking; bicycles; behavioral psychology; financial incentives

CCS Concepts

•Human-centered computing → **Ubiquitous and mobile computing systems and tools;** Empirical studies in collaborative and social computing; **•Social and professional topics** → *Sustainability;* **•Hardware** → *Testing with distributed and parallel systems;*

Introduction

The United Nations predicts that urban populations will nearly double by mid-century, growing from 3.4 billion in 2009 to 6.3 billion in 2050 [1]. As cities become increasingly dense, they must turn to novel solutions to address the imminent environmental, mobility, and public health issues that will arise. In particular, Single Occupancy Vehicles trips, which make up 76% of trips in the U.S., are a major contributor to pollution, traffic, and sedentary lifestyles. However, there is hope for change: 50% of trips in the U.S. are less than 3 miles, and could likely be replaced by a more sustainable mode of transportation, like cycling, if effective policies and incentives were implemented [5]. Bicycling is a cheap, healthy, and space-efficient mode of transportation with the potential for beneficial economic and health impacts [7].

Transit mode choice is influenced by policy, infrastructure, and individual qualities such as attitudes and habits [6]. Drawing upon established research in transit mode choice, and behavioral economics studies on "nudging", this work presents a novel sociotechnical system that encourages the choice of cycling through the use of financial incentives [9].

In this work, the incentives for cyclists come from organizations—such as city governments, health insurance companies, or local businesses—that would like to encourage sustainable transportation behavior because increased cycling will result in a tangible benefit for the organization itself. For example, city governments might want to sponsor cycling because it mitigates traffic and urban pollution. While the positive economic and health benefits of cycling are relatively well-documented, they are rarely rewarded outright [4]. Our framework allows organizations to internalize the positive externalities of urban cycling. The system is designed to provide strong incentives to both cyclists and organizations in order to increase cycling in a way that is self-sustaining and engaging.

The technical implementation of this system uses GPS tracking and a blockchain database to allow cyclists to redeem their cycling activity for financial rewards. The blockchain database facilitates anonymous payments between cyclists and sponsoring organizations. These transactions occur in a robust, transparent, and accessible network without the need for a trusted intermediary. Ultimately, this research envisions an expansive data exchange platform, where bicycles equipped with additional sensors (e.g. air quality, traffic) allow cyclists to collect and monetize geo-located data. In this vision, the incentives system and blockchain application comprise a scalable microentrepreneurship ecosystem that promotes the use of sustainable urban transportation.

Motivation

The positive externalities of cycling are well-documented. From a pollution standpoint, bicycles are a zero emission transportation mode. From a public health perspective, the benefits of regular exercise are clear: the recent Surgeon General's report states that 30-45 minutes of daily physical activity "will reduce...risks of developing coronary heart disease, hypertension...and diabetes" [3]. Finally, the bicycle provides a flexible and affordable form of mobility: while only 10% of the world's population can afford a car, 80% can afford a bike [2].

Despite an understanding of the benefits of cycling, they are rarely factored into the calculus around national health and transportation [4]. This research envisions a way to internalize the positive externalities of cycling by uniting ideas from transportation research and behavioral psychology with the technologies of sensor networks and blockchain. The lightweight sociotechnical system presented in this abstract fuses bottom-up and top-down approaches, by empowering the individual cyclist to monetize their cycling behavior, while giving companies, governments, and organizations a secure method of incentivizing sustainable transportation behavior.

In addition to presenting a novel social incentives system, this work explores the use of a blockchain database with a distributed sensor network. There has been great interest in this combination of technologies, but few actual implementations [8]. Thus, this research positions itself as an exploratory effort that allows us to contribute to the growing literature around blockchain applications.

Procedure

We prepared and tested a proof-of-concept deployment of this system, which consisted of a network of bicycle-mounted sensor devices and traditional desktop hardware that share an Ethereum blockchain database and interface via smart contracts running on that blockchain network.

Blockchain Database & Smart Contracts

Central to our project implementation is an Ethereum blockchain, which provides a mechanism to execute logic and manage node interactions via smart contracts. Embedded devices (e.g. bicycle GPS sensors) run power- and space-efficient light clients while the desktop hardware operated by sponsoring organizations run full clients. Nodes share a blockchain database and communicate over the blockchain

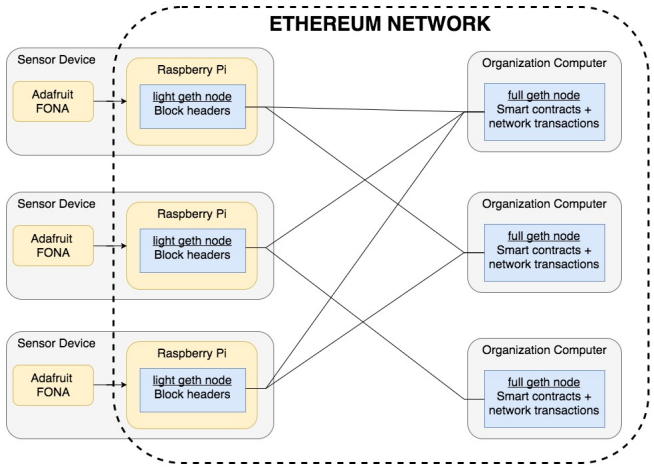

Figure 1: High-level system architecture design diagram.

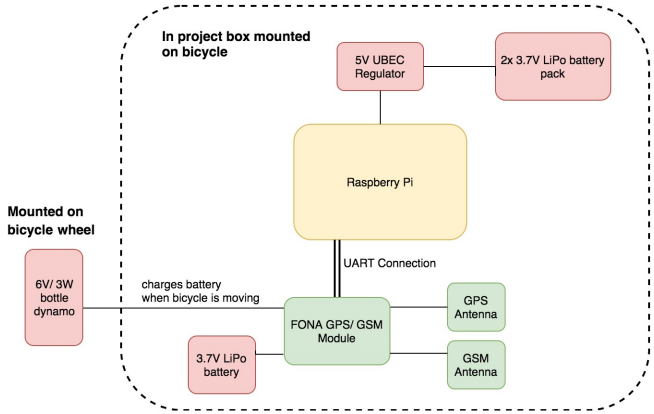

Figure 2: Hardware architecture diagram.

network. Each system user is represented by an instance of a smart contract, which encodes and executes the logic of the financial incentives program.

Sensor Device
The bicycle sensor device consists of a single-board computer that runs an Ethereum light client and interfaces with a GPS/ GSM module to collect cyclists' activity data and connect to the blockchain network over a cellular connection. Our implementation uses a Raspberry Pi and an Adafruit FONA board, which contains a SIM808 GPS/ GSM module.

Power Supply & Data Validation
The sensor device is powered by two regulated Lithium Ion battery packs (one each for the Raspberry Pi and the Adafruit FONA). A generator affixed to the bicycle wheel recharges they batteries when the bicycle is moving. Additionally, the ability to detect when the bicycle is in motion (e.g. when it is generating power) allows us to validate the activity data the sensor collects.

Contribution

The contributions of this work are to: (1) design a blockchain protocol that supports a financial incentives system for cyclists; (2) build and deploy a proof-of-concept implementation of the GPS sensor device and blockchain application; and (3) evaluate the protocol from a technical standpoint. By drawing on ideas from behavioral psychology and urban studies to create an automated financial incentives system for cyclists, this work comprises both a novel engineering contribution and a societal one. This work lays the technical groundwork for a blockchain-based system that manages data generated by distributed urban sensing networks. We see this work as a building block for a new paradigm around urban data collection and monetization, and as a powerful tool for rewarding and incentivizing sustainable behavior.

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