

A Study On Cost- Effective and Eco-Friendly Bicycle Sharing System For Developing Countries

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A Study on Cost-Effective and Eco-friendly Bicycle Sharing System for Developing Countries


Larsson Bajracharya, Tirta Mulya, Ayi Purbasari and Mintae Hwang

Abstract As part of the development of information technologies for eco-friendly transportation system, we performed a study on cost-effective bicycle sharing system feasible for developing countries. The sharing system will work based on online registration and real-time monitoring system, using smart phone and passcode. A low budget Kiosk system for bicycle access from the station will be used. This provides efficiency to users as well as the system for smooth and easy operation.

Keywords Bicycle-share · Cost-effective · IoT · Passcode


1 Introduction


The current digital age has helped us to apply technological reforms in various day to day activities, and it is thus necessary for the application of technology to create a greener, environment-friendly reforms in transportation infrastructures. However, even when implementing changes in transport-based rules and vehicle management system, it is impossible to bring a striking change when it comes to green energy

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and eco-friendly transport system. Therefore, a shared bicycle-system may have a potential for significant change when it comes to addressing this matter.

Bicycle sharing system is a rental system that is usually established in a commercial basis, which allows users to rent a bicycle from specific station and return it to any rental station, within the same city. The purpose is to provide public with cheap access of bicycle for a short period of time, as an alternative to motorized transportation [1].

The following guidelines are applicable to efficiently share bicycles [2]. First, try to calculate the city size, population density and topography and climate of a city, which helps in efficient placement of stations. Second, consider the technology being used for the system as well as capital and operating cost. Third, try maintaining a feasible security system for the bicycles and stations, as well as a status monitoring system. This paper contributes to study on a cost-effective globally feasible bicycle sharing system, that can optimize the use of public bicycles to maintain an eco-friendly environment.

The paper is organized as follows. Chapter 2 introduces a related research on bicycle sharing system as well as IoT technology, Chap. 3 briefly introduces the main idea on overview of bicycle-sharing system, and Chap. 4 presents the challenges that the system might face in a developing country's real environment. Finally, Chap. 5 presents the conclusion of this paper.

2 Related Research

We are all familiar with growing population of the world, eventually increasing the use of transport facilities. Increasing number of these vehicles have seen a lot of problems in the cities like air and noise pollution. Moreover, narrow roads and unplanned city transportation system has made the problems even severe. This is making bicycle use more important than ever before.

Study on Internet of Things states it as a paradigm that is rapidly gaining ground around in the scenario of modern communication. The idea is to bring together various things around us which through unique addressing schemes, will be able to interact with each other [3]. This paradigm sees the application in different fields, such as home automation, industrial areas, medical assistance, elderly assistance, traffic management and many others. The main idea of an IoT system is to create a smarter way of life using computing tasks instead of everyday mechanical tasks.

Another study analyzing the IoT based system [4] discussed the urban IoT architecture being used, based on web servers, various link layer architectures and the devices that are essential to realize an urban IoT. It also discussed on backend server and database management for IoT based systems.

A study on sustainable mobility in urban areas [2] discussed an optimized network to anticipate asymmetric travel demands of large cities. For example, people would love to come down a hill with a bicycle but would not climb up with one. Therefore, dedicated vehicles for redistribution of bicycles are necessary. But even though

dedicated vehicles for bicycle redistribution is possible, large number of redistribution would cause latency and inconvenience. Therefore, discount for bicycles being returned to stations with higher elevation can be introduced.

Also, a study on social and environmental sustainability [5] discussed socio-cultural practices that play a vital part in bicycle sharing system. During this study, various key experts that were affiliated with bicycle sharing systems around Europe were interviewed, helping us to get an in-depth knowledge on political and social practices, as well as systemic and legislative changes necessary for a successful bicycle share system.

Moreover, study on bicycle share strategies and environmental sustainability [6] show current measures being used for bicycle security and management. Despite physical damages done by the users, it is important to know how securely bicycles can be left in a certain area. Instead of a physical locking system, Kiosk-based system [7] seems to be popular and highly secure.

3 Basic Architecture of the Bicycle-Sharing System

Research and implementation of various bicycle sharing systems are currently present at large, aiming to resolve various socio-economic as well as environmental problems. The architecture of this system holds similarity in features and performance with any other system, but light weight technology and cost effectiveness will make it feasible for developing countries. As in Fig. 1, we can view the architecture of this system.

The user and bicycle related data will be stored and managed in the server database, and it is thus possible to search anytime and anywhere using a mobile-based application. As shown in the figure, there will be a two-way communication between the server and application, as well as the bicycles present in the docks of the station via kiosk control box. The communication will help to know the whereabouts of bicycles and the position of users.

In this paper, a mobile and IoT based bicycle-share system is proposed to target public transport users. The whole system can be mainly separated into two categories, i.e. mobile application and station/server system.

3.1 Mobile Application System

As our main idea is based on a mobile based sharing, an application for a hand-held device is proposed. The application will run in a suitable operating system environment, helping the user to get the passcode for desired bicycle he/she wishes to rent. But before the bicycle is rented, the application verifies whether the user is valid to rent, i.e. he/she should have an account to login with an id and password as well as valid date in his account. Validity date can be extended by recharging the

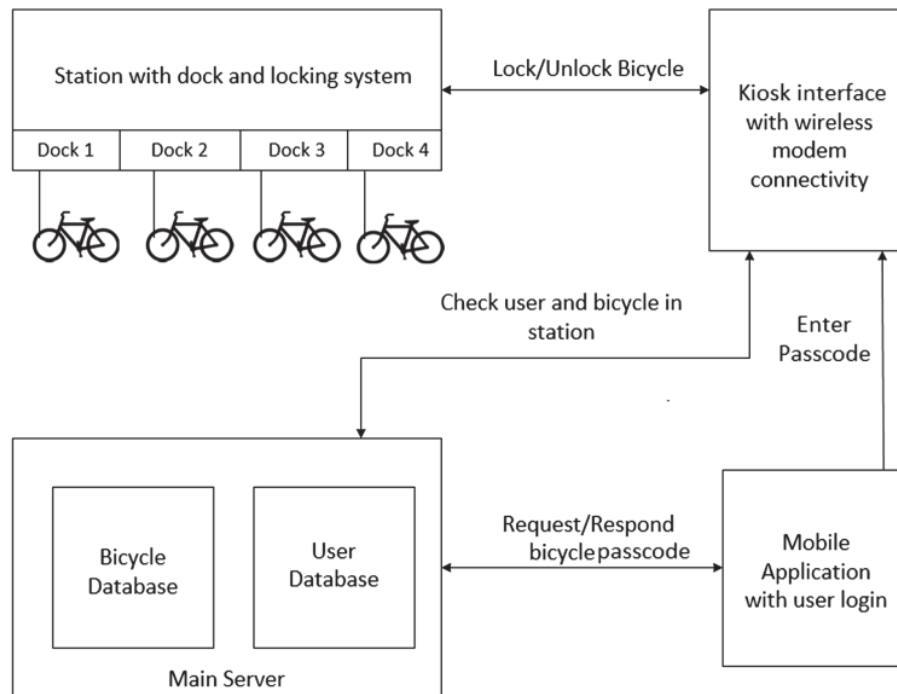
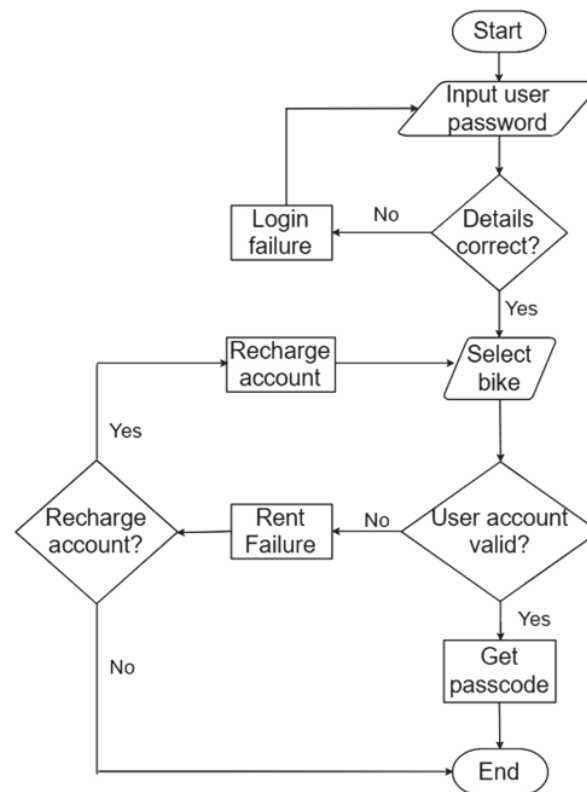


Fig. 1 Simple architecture of bicycle sharing system

account. Figure 2 below shows a flowchart of the implementation idea of a mobile-based bicycle-share application.

The application will have multiple services targeted towards the user for safe and easy riding experience. Users will be able to book desired bicycles online irrespective of place or time. He/she will receive a passcode that can be used to unlock as well as park the bicycle in any desired station with a free dock. The booked bicycle will be reserved for the specific user for 15–20 min without anyone else being able to access it. If he/she fails to unlock the bicycle from the station, the passcode received earlier will be invalid and an alert message stating that the time period has been expired will be sent and the bicycle will be available for other users to book. As account recharge for online system is always a hurdle, the system will therefore be able to accept any online payment methods, i.e. domestic or international cards using a payment gateway or a simple bank transfer selecting the desired bank from the application itself. Integration of google maps in the application will help the user to search the nearest station for bicycle rent, parking or choosing a feasible route. To keep track of one's rental records or details of total distance covered, a graphical table with charts will be presented to the customers. In case of any emergency, the customer will be able to search for the nearest mechanic, hospital or police station using the emergency features available in the application. This application will also help the bicycle system to create its own community in social media. Communication

Fig. 2 Flowchart of a mobile-based bicycle-share application



between fellow bicycle enthusiasts, social events as well as any discomfort regarding the bicycle service or any station around the city can be discussed to improve the system. Figure 3 shows the various discussed services provided by the application.

3.2 Station/Server System

Server for the system will be maintained in a remote location along with a periodic back up system. A database management system (MSSQL or MySQL) will be used to maintain the system data. The server will also consist of a wireless network system (3G or 4G) to communicate with the remote stations as well as the users. Likewise, each station around the city will consist of a low budget Kiosk system for bicycle rental or parking, developed using various IoT based components like Arduino, Raspberry Pi, GPS locator, motors, LCDs, touch pad etc. The Kiosk system in each station needs to run a specific integrated set of programs so that it can receive and transmit the instructions, as well as perform the required task, as requested by the server. Each of these programs running will be different or will be modified with

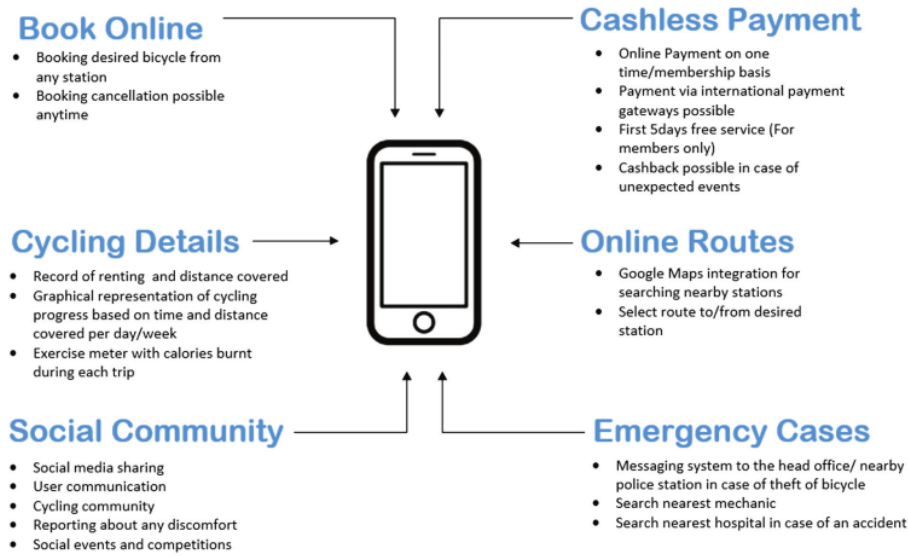


Fig. 3 Various services provided by the application

time, depending upon the number of bicycle docks added. For data communication, 4G network can be used where available, whereas GSM or 3G network can also be used where 4G services are not yet available. To make the system eco-friendly, solar panels will be maintained in each station, along with a backup battery to power up the control box (Kiosk) along with all the other hardware components. Figure 4 below shows a flowchart of the data processing in each station, after the user requests using the Kiosk system interface and Fig. 5 shows a detailed workflow of the system numbered from 1 to 14, starting from user request for passcode from the servers.

4 Challenges for the Proposed System

As our system mostly targets developing countries, issues like budget, topography, social awareness about use of new technology are major challenges. Moreover, using a wireless communication interface for data transmission holds higher threat in these countries, as the network security and stability is still in its infant stage. Also, when we use IoT sensors and actuators, it is highly possible that hardware failure or corruption occurs. Some of the major challenges of the proposed system are:

- Lack of knowledge about technology
Most of the developing countries are not familiar with use of information technology for commercial purpose. Lack of technological advancement and being used to perform most of the tasks in traditional manner may cause people to think twice before using an application and IoT based system.

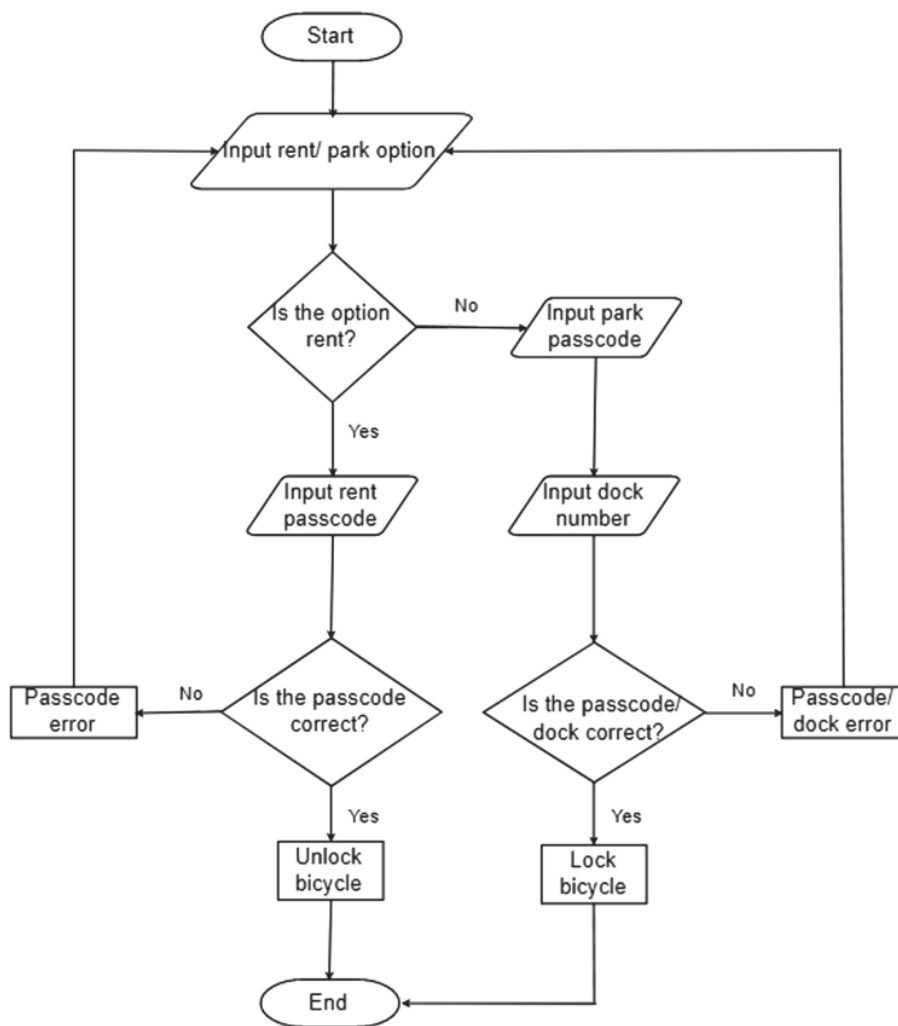


Fig. 4 Flowchart of data flow and processing in the station

- Budget for the system

A public bicycle sharing system might be bit of a hurdle for governments in developing countries to implement soon. Management of various stations, bicycles, regular maintenance as well as automated pay system for transportation is a challenge. Moreover, a proper bicycle lane is also required everywhere around the city.

- Topography of the city

As every city around the world has different topography, it is challenging to well plan the network of bicycle stations around. Also, implementation of IoT based sharing means network needs to be maintained actively all the time. Topography

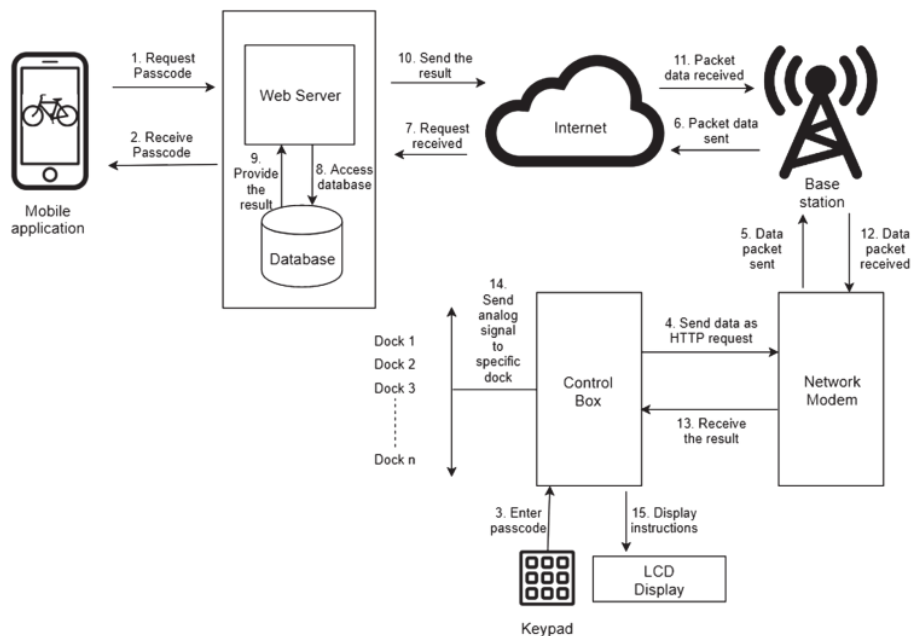


Fig. 5 Detailed workflow of the bicycle sharing system

and lack of better resources to maintain stable network may be a huge challenge to overcome. Moreover, poor traffic management plays a major setback to implement the system. Therefore, study on GIS (Geographic Information System) is necessary for better overall result.

- **Data Corruption**

Sometimes the attacker may try to change the transmitted data. This is done by transmitting valid frequencies of data spectrum at correct time. Time can be calculated if attacker has good knowledge of modulation scheme and coding. As data security in developing countries are low, the system needs to develop a data encryption program to prevent threat from the intruders.

5 Conclusion

The population today is growing every day and the city transportation system is not being able to meet the demands of public. To tackle these problems and make the city eco-friendly, we studied about a Cost-Effective Bicycle Sharing System implementing IoT and mobile application. We discussed that use of technology like IoT and application-based sharing system is possible in cities across the world with lower budget, so that people travel more on bicycles and use less public or private means of transportation. We also discussed various challenges this system might face

which might make it difficult for developing countries. Therefore, discussion for an effective way of implementing good telecommunication and IoT based system in those countries are very necessary.

IoT being used in developing countries in bicycle sharing might lead to overall change in conventional lifestyle as well. Bicycle sharing systems being used by other countries have seen a lot of positive impact in their society. Even though a lot of challenges need to be resolved for this system, but an economically feasible bicycle sharing system may provide a solution to many of the problems faced today in cities around the world concerned with environment and means of transportation. In future, introducing system like NFC cards for payment and lock/unlock verification system will further help to enhance efficiency and secure transaction.

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