A Proposed IoT-Based Bike Sharing System in Erbil City

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Doi: 10.23918/eajse.v7i1p97

Abstract: Currently, many countries are faced with many problems regarding the environment and the destruction to the planet's natural resources. In the long run, this will have a devastating effect on the well-being of mankind. As technology advances, and cities become over-populated, the damaging effects of air pollution, noise pollution, carbon monoxide from machinery and overcrowding could very well destroy the planet if countries don't take measures to minimise this damage, and focus on boosting biodiversity and fighting climate change, thereby making the city a healthier place for everyone. Many countries have implemented the bike sharing system to solve some of the problems caused by mechanised transportation. In this paper, an IoT-based bike sharing docked system is proposed for the city of Erbil. This proposal has looked at expected challenges and solutions.

Keywords: Bike-Sharing, IoT, Docked System, GPS

1. Introduction

Bicycles possess a high market value due to their flexibility, convenience, energy efficiency, and environmental friendliness (Liu, Ji, Xu, & Lu, 2019). A bike-sharing system (BSS) is a service that enables bikes easily accessibility for mutual use on a short-term basis. Bike-sharing systems have emerged as a critical component of urban transportation policies in the last decade due to the recent surge in the number of bicycles in circulation in the world's large cities.

This presents an active and practical alternative to the use of motorized vehicles for urban transportation, and thus contributes immensely to the reduction of carbon monoxide polluting the air, thereby actively demonstrating commitment to eco-friendliness (Cao & Shen, 2019; Leister, Vairo, Sims, & Bopp, 2018), reduction in noise pollution, and congestion issues facing the world's major cities by ensuring accessible access to bicycles. Adequate bicycles are needed in this project to make it viable and effective. The ease of use of the bike sharing system is one of the keys to its success. A standard scheme consists of a number of bike stations spread within a specific region and a specified number of bikes accessible to users. A user can pick up or drop off a bike in a completely automatic manner at one of the several stations located throughout the area. They are referred to as “docked BSS”. The payment can be made daily, weekly, monthly, or through an annual subscription that is instantly accessible at the station or via a mobile app. The bike-sharing model is based on the principle

Received: April 20, 2021
Accepted: June 10, 2021
Nurtayeva, T., Salim, M., Hamdoon, W.M., Taha, T.B., & & Omar, Y. (2021). A Proposed IoT-Based Bike Sharing System in Erbil City. *Eurasian Journal of Science & Engineering*, 7(1), 97-105.

of environmentally friendly commuting. This service can be used in conjunction with the city's public transportation system. They provide short and easy access, use diverse business models, and make use of applied technologies such as smart cards and/or cell phones.

Since the first bike-share scheme in Amsterdam (the Netherlands) in the 1960s, several related schemes have appeared in cities around the world (Hu, Zhang, Lamb, Zhang, & Jia, 2019). There are currently over 500 bike-sharing projects around the world, with over 500,000 bikes shared. Due to their positive impact on traffic, financial, and health matters, these services are becoming more prominent recently (Cao & Shen, 2019). A number of advantages have led to the growing popularity of bike-sharing networks: for example, Zhang and Mi (Zhang & Mi, 2018) discovered that in 2016, a bike-sharing scheme in Shanghai saved 8358 tons of fuel while reducing CO2 and NOX emissions by 25,240 and 64 tons, respectively.

A well-designed bike-sharing scheme will improve the appeal and awareness of cycling, while also shaping a healthier lifestyle among tourists and locals (J. Wang, Tsai, & Lin, 2016; X. Wang, Lindsey, Schoner, & Harrison, 2016). It has important implications for not only energy conservation but raising awareness of the importance of physical activity and exercise to one’s physical and mental health, especially being outdoors in the natural environment.

Unlike other modes of transportation such as the bus or subway, travel time, departure and arrival places are expressly registered in these schemes. This has been addressed in the following way: the Internet of Things (IoT) technology, which relates to “the interconnection of physical devices by outfitting them with sensors, actuators, and a way to communicate to the Internet,” has enabled these sharing networks to monitor travel time, etc (Dijkman, Sprenkels, Peeters, & Janssen, 2015). IoT technology allows users to borrow and return GPS-enabled bikes using a smartphone alone, bypassing common practices in earlier generations of bike-sharing schemes, such as returning borrowed bikes to particular locations (Li, Tian, Gao, & Batool, 2019; Mateo-Babiano, Kumar, & Mejia, 2017). For these applications, the number of users on any given day will vary greatly. The ability to predict the number of hourly users allows organizations who operate these networks, such as corporations and authorities, to manage them more reliably and cost-effectively. Monitoring shared biking is also essential for urban planning for organizations participating in shared bike systems in cities (Bikeshare, 2013).

Such systems have many benefits for consumers, including greater versatility in leaving and taking bicycles independent of docking stations, servicing more distant parts of a community, and reducing the need for the construction of costly stations with IT infrastructure. Bicycles are usually outfitted with GPS sensors, which allow them to detect movements and gain information, which can then be used for research studies or urban planning. In this article, it is suggested that using regression ensemble with IoT approaches to improve the management of self-service shared bike networks in Erbil, will also contribute to a green and sustainable community. In the case of strategically placed parking garages. This kind of implementation has already shown good results (Tekouabou, Cherif, & Silkan, 2020). Indeed, if the IoT allows for the collection of a wide range of data from the various dynamic sources connected with our BSS, the powerful ensemble methods could allow for the prediction of the number of shared bikes every hour, per day, every month, and so on, thereby allowing for the optimization and automation of the system's efficient management.

This paper aims to fulfill the integration of an IoT-based system in Erbil and particularly in the case of bike sharing. The goal is to analyze the motivations to use shared bikes in a context of an emerged

country. Section 2 presents a literature review for bike-sharing systems. In section three, there is provision made of a model of the bike-sharing system and its challenges with possible solutions, a flowchart, and a model with E-R. Finally, we conclude by highlighting the study's theoretical and applied contributions with future work.

2. Literature Review

Bike-sharing first appeared in Europe in the 1960s and its systems passed through four generations (Shen et al., 2018). The first generation sharing bicycle was launched in 1965 in Amsterdam, offering free bicycles to borrow and return from any place (Midgley, 2011).

The second generation shared bicycle (Bycyklen or City Bikes (Midgley, 2011)) was founded in Copenhagen in 1995, with many improvements over the prior generation. The bicycle had firm rubber tyres and wheels and could be borrowed and returned from any self-service bicycle stations in the city that took coins or smart cards (DeMaio, 2009).

In 2006, the third generation of shared bicycles was launched. In this generation, the Global Positioning System (GPS) was used to provide accurate coordinates, which was useful for improved bike tracking (DeMaio, 2009). Another breakthrough was to monitor the riding time and make it available to users at individual stations with the new data services (Shaheen, Guzman, & Zhang, 2010).

With the familiarisation of several new innovations, the fourth generation sharing bicycle, which is known to be one category of intelligent hardware, has evolved so rapidly in recent years. The public bicycle, which had not progressed smoothly in many cities during this time, was becoming popular in a new style called bicycle-sharing, especially with the introduction of the sharing economy like Uber in 2010 (Berger, Chen, & Frey, 2018). Mobike unveiled its smart bike sharing program in Shanghai in April 2016, aiming to expand mobile payments to shared bicycles (Shen et al., 2018). Through this method, users can quickly unlock the shared bicycle by scanning a QR code.

In cities where bike-sharing services have been in use for a long time, studies have been undertaken to gather knowledge about the efficiency of system operation from bike-sharing system users. Decision-makers may use this data to enhance the provision and functionality of the bike-sharing platform so that it can meet the needs of users to an optimal extent.

Thus far, research on the factors that influenced bike-sharing system utilization as well as the degree of satisfaction associated with bike-sharing system utilization have been performed (Guo, Zhou, Wu, & Li, 2017). The aim of this study was to identify the factors that contribute to Ningbo's low bike-sharing system use (China). Based on their findings, a few conclusions related to planning, engineering, and civic activism were discussed in order to improve the use of the city's bike-sharing scheme. A parallel study was conducted by L. Caggiani et al. (Caggiani, Camporeale, Marinelli, & Ottomanelli, 2019). They introduced an optimization model for determining how to use a given budget to improve a bike-sharing infrastructure while optimizing overall user satisfaction. C. Etienne and O. Latifa, in turn, suggested a framework for the Paris bike-sharing system (Etienne & Latifa, 2014). They founded a system that recognizes the latent factors that form the geography of trips, and the findings provide insights into the relationships between station community type and the created mobility trends. G. Manzi and G. Saibene (Manzi & Saibene, 2018) conducted surveys in Milan to assess the level of satisfaction with bike-sharing service use.

There are several scientific articles in the literature that aim to assess the degree of satisfaction of bike-sharing system use in different cities around the world, for example, F. Xin et al. (Xin, Chen, Wang, & Chen, 2018) performed this form of study for Shanghai, D. Efthymiou et al. (Efthymiou, Antoniou, & Waddell, 2013) for Greece, and J. Shi et al. (Shi, Si, Wu, Su, & Lan, 2018) for China. Considering these studies, it is possible to conclude that the approaches to conducting research were very different in the methodology of collecting data for evaluation, the number of research samples, the process of conducting studies, and the results reached.

3. Proposed Model

This paper is proposing an IoT based Bike Sharing System (BSS) to be applied in Erbil city to facilitate short-term bikes rentals from the 1st station to an additional two stations. Fig. 1 below shows the required stages to be applied to the proposed model of the docked bike sharing system in Erbil.

Figure 1: Stages of implementation of IoT Docked BSS in Erbil

There are two types of BSS, namely docked and dockless systems. The docked system has been chosen as it is the first time of this BSS to be implemented in the city of Erbil. IoT technology in the BSS context refers to equipping bikes with sensors such as GPS, and actuators such as an electric lock, and a device to connect to the Internet such as a micro controller. IoT allows users to rent bikes for a specified time, using only a smartphone; it is convenient, efficient, reliable and monitored regarding the place from where the bike is rented to where it is returned after use. Thus, the bike does not have to be returned to the same location from where it was rented. IoT technology enables BSS companies to track bike usage data and trace bikes for operational strategies. There are two types of BSSs: the first one is the dockless bike sharing system where there are no stations for storing the bikes, while the second type which is the docked bike sharing system where there is a specified storage station for the bikes. In the context of implementing this BSS in Erbil, it is recommended that the docked station be used because there are too many streets in Erbil to monitor and control the use of rented bikes - the highways and congestion of narrow streets is a big challenge to use a dockless system.

These docked systems are based on IoT where payment is by credit cards and a flexible pricing range which depends on the duration of the bike rental and the distance covered, as this would obviously affect the durability of the bike; costs of maintaining the bikes have to be budgeted for as well. The suggestion of the system is based on the authors' observations and revision of the literature. Figure 2 below shows the map taken from Google Maps application for the proposed locations for the two stations in Erbil city. Solar energy is the preferred choice of use at the station as it is the commitment to environmental sustainability and 'greening' the city.

Figure 2: Map of IoT docked BSS in Erbil

3.1 Challenges

There are many challenges in implementing a Bike Sharing System in Erbil city and these challenges vary according to different categories – these categories include environmental, technological, cultural, and governmental. The most critical challenge to be addressed here is approval from the Municipal authority. From this emanates a number of other challenges, namely, budgetary from the municipality, urban planning, civil engineering, technological design, cultural changes and environmental issues.

Approval by the Municipality of Erbil is the most challenging issue to be addressed. Firstly, the question of an adequate budget for this project is of paramount importance as there are many costs involved, as mentioned above.

- There has to be urban planning to decide where it would be most feasible and practical to have the central controlling station, separate lanes for the cyclists, the pay centres and the bike sharing stations.
- Civil engineers to plan the roads, where there are separate lanes for the bike users. The roads have to be asphalt, with no dirt roads with potholes to ensure durability and safety for bike users. Currently, most roads in Erbil are dirt roads with many potholes and water seeps. This is very dangerous for cyclists as a pothole will set them off course and they risk a major injury.
- Technological development for the smooth and efficient management of the bike sharing system – that is, the hiring of the bike, time allotted, payment system and online networking.
- Manufacturing of high quality and solid bicycles for users – they have to be durable, comfortable, user-friendly, and low maintenance.
- Solar power has to be used to avoid inconvenient and erratic power outages.
- There needs to be a massive awareness and educational drive to launch this system. Firstly, people have to be made aware of the benefits of bike sharing as a means of transport, not only for practically of their use, but how they will improve their physical and mental health by cycling and not being caught in traffic jams. They also need to be educated as to the hazards of air and noise pollution, which the use of bike sharing will reduce immensely – that is, people should be made to be more environmentally friendly.
- This system of bike sharing will pose cultural problems for certain people who are of the mindset that females should not be allowed to ride bikes, and other such reservations.

3.2 Solutions

In finding feasible, suitable, and practical solutions to the above-mentioned challenges, information from past studies and the literature review was used.

- A well-researched, informative, practical, and feasible proposal has to be presented to the relevant municipal authorities, taking into account the budget needed for this project. As it is the first time such a project is to be considered, thorough research has to be done regarding costs involved, as this is the critical issue for the municipality. Costing of urban planning, civil engineering, re-doing the roads, setting up the docking stations, introducing the credit card payment system and training of staff involved in all these areas.
- The solution for roads problem would be asphalt roads with separate lanes for bikes, which are demarcated, so that motorised vehicles adhere to the traffic regulations and don't inadvertently knock a cyclist. The bike users should also wear bike helmets to protect themselves from head injuries.
- In the public awareness and educational campaign, the adherence to the rules and regulations of road safety must be highlighted. Furthermore, anyone who transgresses these rules, will be liable to pay a fine, depending on the nature and severity of the transgression.
- The bike sharing stations need to be placed in convenient areas such as Park Sami surroundings as it has wide streets and sub-streets, and in areas which are congested for cars to access such as the Citadel streets.
- Solar energy has to be used to avoid power outages which will greatly affect the smooth and efficient service of BSS and its functionality.
- Strict security measures have to be implemented in the event of potential theft; the suggestion is the use of the GPS sensor. In addition, the bike stations should be installed in places that have a good security service and using surveillance cameras at the stations.
- The provision of adequate slots at each station to ensure the users' needs are met with adequate provision of bikes. Thus, a survey has to be done to estimate the number of bikes that would be needed.
- The installation of extra empty slots at each station to ensure there are enough slots for the return of the bikes at each station.
- A public awareness campaign and educational programmes have to be arranged to inform the public of this BSS and its benefits. In addition, potential users have to be trained in how the BSS works, along with payments, and other regulations that will ensure an efficient and reliable BSS.
- A massive drive on commitment to eco-friendliness, 'greening' the city, and making the public aware of the hazards of air and noise pollution. In addition, the health benefits - both physical and mental well-being - of cycling in the open.
- An endeavour to change the mindset of the culture where women cycling would not be acceptable. There will no doubt be certain people who would not find this acceptable. The training of people to undertake and manage these various challenges and proposed solutions.

3.3 BSS Model Flowchart and E-R Diagrams

To clarify the process of using our proposed Bike Sharing System which is an IoT-based system. Fig. 3 will illustrate the steps of using the proposed model of implementing the system. Firstly, a user will need to install a mobile application to scan the Tag code on the bike. The bike will then be unlocked if the user has enough credit on his application. Once the user commences his trip, a timer will be

activated on his/ her mobile's application to indicate the timer and to guide the user to the desired destination or station. On reaching the station to return the bike, the user will scan the available slot tag from the application and check if there is any additional payment to be made depending on the time it was used and if the bike was returned timeously or not.

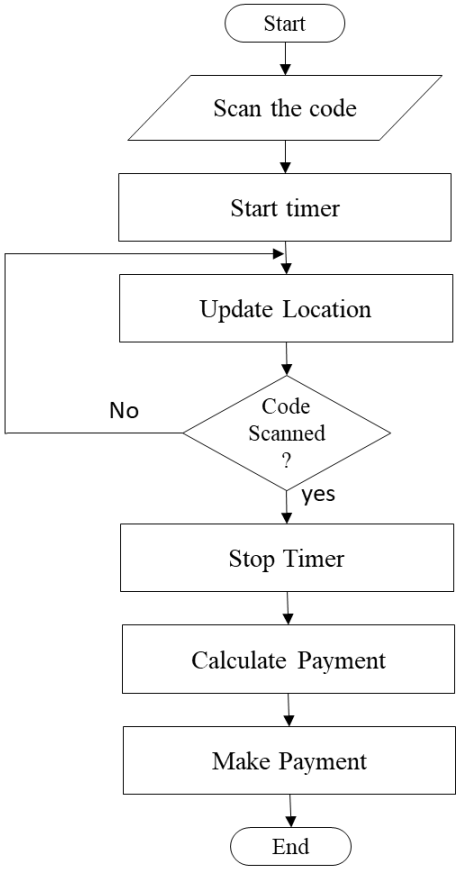

Figure 3: Flow chart of using BSS

Another diagram called the Entity- Relation (ER Diagram) was developed to show the inter-relationship amongst users, stations, and bikes in the proposed IoT based BSS system which is illustrated in Fig. 4. This diagram is helpful in providing insight into the implementation of the required mobile application for managing bike rentals. There are three entities in the ER diagram: the first one is the user or bike renter which is connected to the second entity named bike, and finally to the third entity called the station. Each one of the three entities has its own attributes, and all the three entities will be saved on an online database such as Firebase database. To develop the mobile application for this BSS model, Flutter framework could be used to build it. Flutter is a free open-source toolkit for developing cross-platform application that works on both Android and iOS from a single codebase.

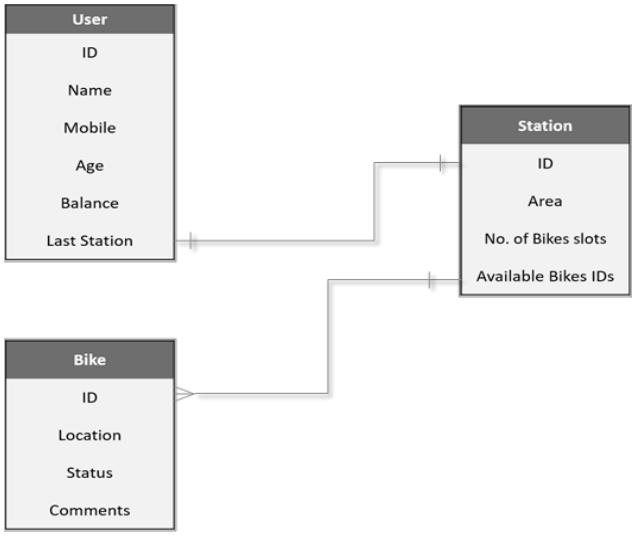

Figure 4: ER diagram for the BSS mobile application

4. Conclusion

This paper presented the potential role of IoT on docked BSS in the literature section and how it is to be implemented in the city of Erbil. Moreover, the paper provided many expected challenges and proposed solutions. In summary, this project was introduced, highlighting the key apparatus such as BSS and IoT, and a thorough literature review was given, where the BSS is being used effectively in other countries, and the different ways each one works. A model was then presented on how the BSS would be applied practically with the IoT for the city of Erbil where a map was provided as to where it would be strategic to install the stations. Regarding the way forward, it is proposed that this project and its benefits to the city of Erbil and its problems regarding traffic congestion, air and noise pollution, and the commitment to an eco-friendly city be considered with a positive mindset. Notwithstanding all the challenges, the main one being approval of the municipal authorities, it is believed that this system can work with the necessary funding and commitment.

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