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DEVELOPMENT OF BIKE-SHARING STATIONS BY APPLYING SMART CARD TECHNOLOGY

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ABSTRACT

Bike-sharing is an eco-friendly public transportation program in the form of an integrated bike fleet networking, and turns into a feeder for other public transportation systems. The presence of bike-sharing may hopefully become an alternative means of city transportation that reduces the uses of public transportation and hence pollution levels. It may trigger improvements in people's' mobility, health, productivity, and happiness, subsequently increasing a city's livability index. The development of bike-sharing stations by applying a third generation technology in Indonesia is still very limited so far and thus needs to improve. Therefore, in the present research, we endeavoured to develop bike-sharing stations by applying the latest technology, NFC smart card. It is the first research and development of its kind in Indonesia.

Keywords: Bike-sharing; NFC; Smart Card; Research and Development

1. INTRODUCTION

Bicycling is one of the efficient ways with minimum impact for people to move across a city. In addition to being a means of transportation, bicycling may also become a recreational and sport means (Oxford 1989). Bicycles (bikes) have been widely used in major cities around the world, brought about by a system well known as *Bicycle Sharing* or *Bike-sharing*. Bike-sharing is one of the eco-friendly public transportation programs in the form of an integrated fleet of bikes and turns into a feeder for other public transportation systems. Bike-sharing system has been known since 1965 in Amsterdam, The Netherlands, where there were white bikes, or *Witte Fietsen*, made available by the municipal government, which could be used by public. Bike-sharing system has been steadily developing year by year and in 2005 it underwent a significant progress, when a more modern, mode efficient bike-sharing system, *3rd Generation Bike-Sharing System*, was introduced in Lyon, France (DeMaio 2003, 2004).

The presence of bike-sharing may expectantly become an alternative means of city transportation that reduces the uses of public transportation and hence air and sound pollutions. Moreover, it may encourage improvements in people' mobility, health, productivity, and happiness, and in turn increasing the city's livability index. Furthermore, using bicycles as a transportation mode may contribute to increase the uses of public transportation, where bike *share mode* is 1.0 – 1.5 percent in urban areas (DeMaio 2009). For example, in Barcelona city, Spain, bike share mode raised by 1.76% two years after the launching of bike-sharing in the city (Romero 2008). In addition, an increase in bike share mode also took place in Pairs, France, i.e., 2.5 percent in 2007, from only 1 percent in 2001 (Nadal 2001; City of Paris 2007).

In Bandung city, it started in October 2011, when Ridwan Kamil initiated a bike-sharing pilot project to implement in Bandung. Operating since June 2012 by a very simple bike-rent system, it has been funded voluntarily by people. In just 2 years, the program,

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called 'bike.bdg', has successfully encouraged Bandung's citizens to practice a culture of riding bike as a means of transportation.

Over time, 'bike.bdg' was renamed *Bicycling Bandung Banapolis Foundation*, and built a Prototype 1.0 of 3rd Generation Bike-Sharing System, the first in Indonesia. The infrastructure planning, designing, and production processes were worked out entirely by local human resources and experts from ITB's department of civil engineering and urban area planning. The research and development of bike-sharing in Bandung city was based on an evaluation of bike.bdg pilot project operating since 2012 by a bike-rent system. A difference between the 3rd Generation Bike-Sharing System and other bike-sharing systems is that the former is an information technology-based system that enables effective and efficient operations, where the stations are connected with one another, enabling the users to return the bicycle at any station as long as it is in the service area network.

Figure 1 Prototype 1.0 as Displayed during Asia Africa Smart City Summit in Bandung, 22-23 April 2015

While a bike-rent system uses cash for transactions and the rent bikes should be returned to the renting station, in the 3rd Generation Bike-Sharing System, a networked stations system is applied, where bike users may rent a bike from one station and return it at another station within the station network built in the service area. Rental transaction uses a contactless-card for the users by a Near Field Communication (NFC) system that serves as a membership card to access any bike-sharing facility.

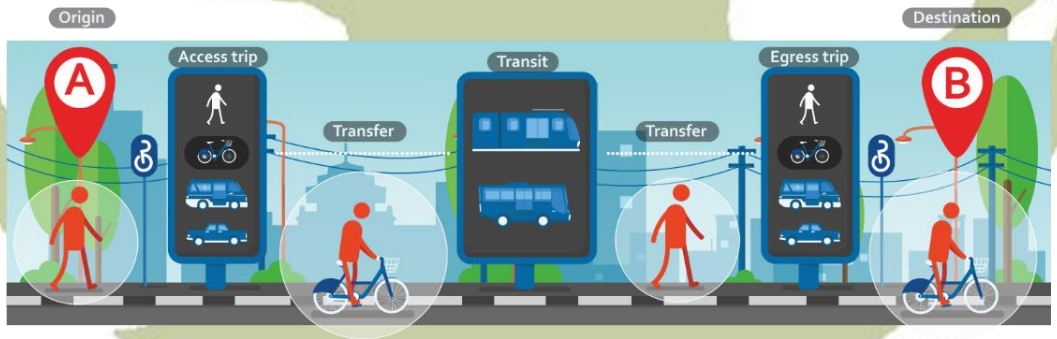

Figure 2 Position and Function of Bike-Sharing in an Urban Public Transportation System

Prototype 1.0 adopts the 3rd Generation Bike-Sharing System, featuring an IT-based system with an automatic bike locking, consisting of two major parts, namely a terminal that serves as the 'brain' and user transaction media, and a docking, serving as the bike locking media.

Based on an evaluation of Prototype 1.0, it includes bikes, docking stations, and kiosks/terminals. The developmental activities to perform are divided into three main

activities: upgrade of terminal system design, upgrade of dock system design, and quality assurance test.

2. METHODOLOGY

The implementation phase was divided into five major stages, namely: (1) Preparation; (2) Identification of Issues and problems of field condition; (3) Data Processing and Analysis; (4) Creative; and (5) Design Outcome.

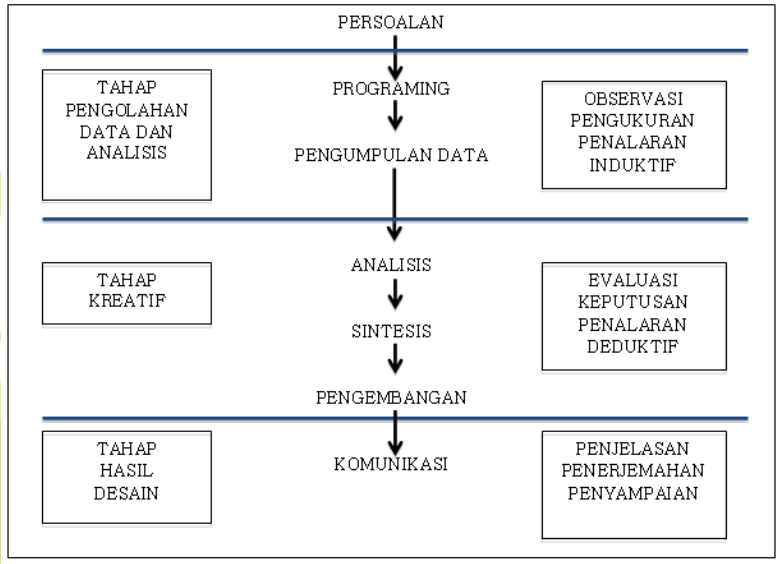

Figure 3 A Design Process Flowchart

Each stage is briefly described below:

1. Preparatory stage; this stage consisted of two processes, (a) initial integration of site study and (b) ergonomics of elements at stations. In the initial integration process with a site study, current conditions and anything needed in building a bike-sharing station could be seen. Then, by comparing it with the existing bike-sharing station that had been performed to prototype 1.0, we searched for its advantages that might be suitable to apply in Bandung, particularly in terms of security and feasibility. The sizes and uses of elements in stations, such as kiosk/terminal, docking, and bikes, were determined by conducting a standard ergonomic study for the size of stations to be more effective and efficient during the implementation.
2. Identification-of-issues stage; on the basis of the input of site data and the result of comparative study, the issues that potentially arise in the processes of developing bike-sharing station infrastructure in Bandung were sought.
3. Data Processing and Analysis Stage; data processing was carried out in stages so as to achieve the target, and thus resources could be spent effectively, and a guidance of station design and development was added.
4. Creative Stage; in this stage the developmental processes were divided into important elements in bike-sharing station design infrastructures, namely *baseplate*, docking and kiosk/terminal structures and bikes so that the whole development of elements could be mutually integrated with users and environment in Bandung area.

5. Design Outcome Stage; this is a stage of exposure or communication of the framework to be performed for obtaining a bike share station infrastructure design most suitable to implement in Bandung.

3. ANALYSIS OF SYSTEM REQUIREMENTS

Prototype 2.0 bike-sharing system needs four main systems for it to be functional, namely:

1. Terminal System
   Terminal system is one that serves as an interface with those users who want to perform a transaction. The system includes an LCD as screen, a keypad as the receiver of input from the users, a smartcard reader for recording and reading transaction data, a modem as a means of communication with server, and communication line to docking system. It has to respond quite rapidly to each transaction that the users perform so they do not wait for too long. In addition, the features provided in the system are designed such that they do not confuse the users. The system should also assure security by keeping the confidentiality of the users' personal data, including name, date and time of usage, balance, address, and other data contained in the card. The terminal should, in terms of shape, be easy to assemble and install for the convenience in the construction, have a simple display, and be easy to use.
2. Docking System
   Docking system is a system composed of several dockings (33 in maximum). A dock is the area where bikes are put. The system already includes bike sensors, locks, and docks where the bikes are locked.
3. Card Management System (CMS)
   Card Management System is a supplement that supports the operational of bike-sharing system. Where both terminal and docking are connected directly by the users, a CMS is a device which both administrator and operator employ. It is crucial for the management of users, particularly because it uses a smartcard.
4. Card
   A bike-sharing system uses two types of card, i.e., contactless card that the users use to perform a transaction and contact card as its encryption media. The transactions that take place at a terminal and CMS will be reflected on each user's card.

4. RESULTS OF THE SYSTEM WORKS

The workings of bike-sharing system are described as follows:

1. Registration
   Customers have to visit a registration center to register their personal data by presenting their identity card and depositing a specific amount of money. They will be asked to enter their own password to activate the card. Afterwards, the customers (users) are granted a smartcard that may immediately be used at every bike-sharing terminal.

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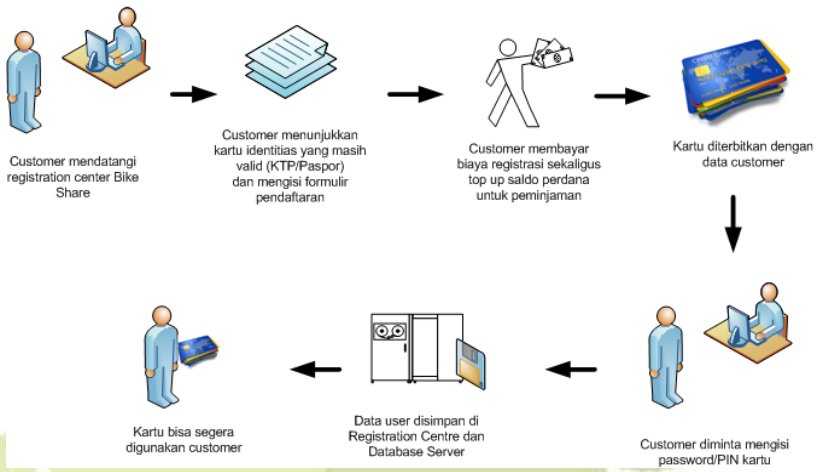

Figure 3 Mechanism of Membership Registration

2. Bike Rental

The users have to select menu *Rent a Bike* from a terminal after tapping the card and entering their own activated password. The terminal system will automatically search and determine a ready-to-access bike. If there is a ready-to-use bike, the terminal screen will display the number of docking the bike is in. The users then go to the specified docking, pressing the button on the docking to unlock the bike. Next, the bike is taken away and ridden till it is returned at a terminal.

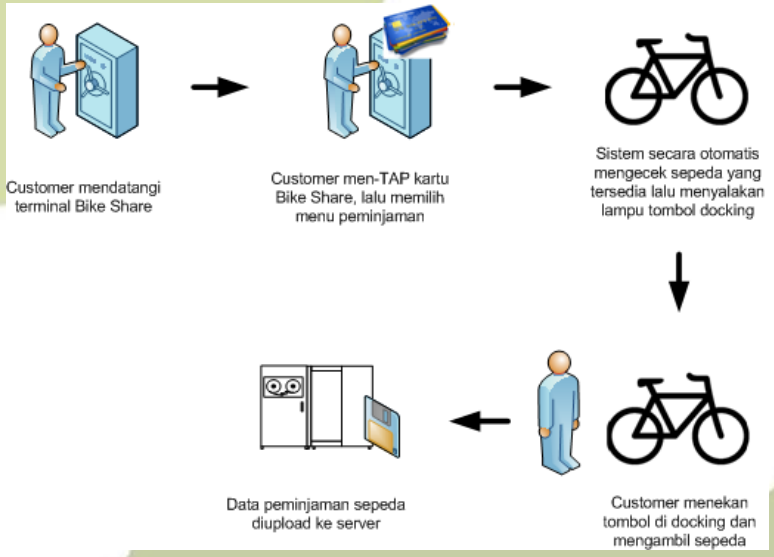

Figure 4 Bike Renting Mechanism

3. Bike Returning

The users (customers) have to firstly return the bike to an empty docking. Next, they select a transaction *Return a Bike* at a terminal after tapping their own card and entering their card password input. If the bike id is registered on the card in conformity with the bike at the docking, the returning transaction is successful and the card is renewed.

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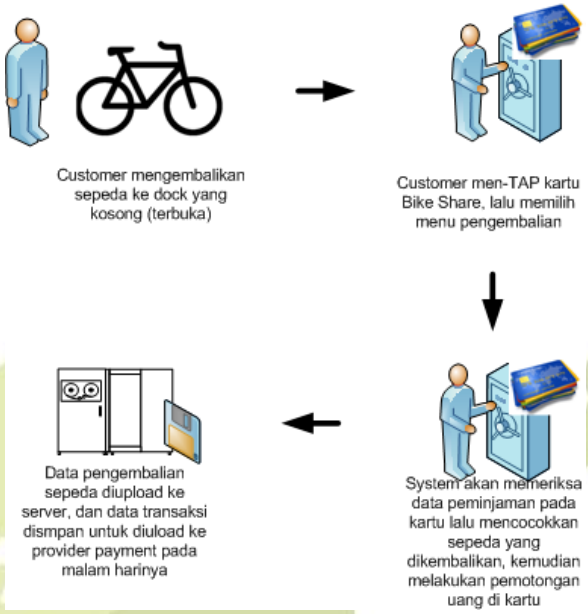

Figure 5 Bike Returning Mechanism

4. If a terminal system detects any problem or report from a user, a technician will go to the terminal and select menu *maintenance* after tapping a card and entering a password. Next, a worker will perform maintenance according to the applicable procedure.

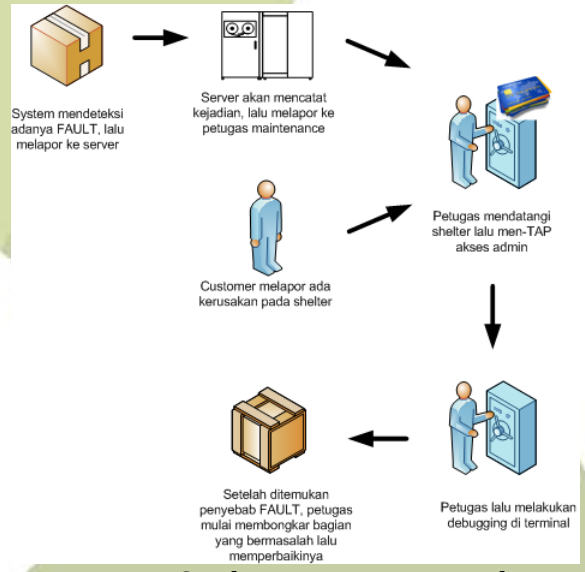

Figure 6 Bike Maintenance Mechanism

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Figure 7 Mini Scale Prototype 2.0 (Exhibition Property)

5. CONCLUSION

Prototype 1.0 adopts the 3rd Generation Bike-sharing System, featuring an IT-based system with an automatic bike locking, consisting of two major parts, namely a terminal that serves as the 'brain' and user transaction media, and a docking, serving as the bike locking media. During the testing process, it was found out that all the basic features have been successfully implemented. They all run as expected. However, there were some points to note: the terminal ceased to operate after several times of usage; locking has not yet been integrated due to the problem of noise it produced; a comprehensive test was not performed, particularly for the unit, memory leak, boundary, endurance, and stress test; bugs were still found in the course of operation; modem was still not implemented, so renting transactions were only recorded to file log and not recorded in the server; docking scalability was not secured yet because only two dockings were tested; tariff values were not implemented into a terminal; there was no documentation of software; and all program codes need to be tidied up to make it easy for further developments.

The development of this prototype 2.0 (Final) generated a physically well-prepared research product in the form of a system, generated a research product in the form of a solid final prototype, and met both feasibility rules and requirement for a mass production.

6. ACKNOWLEDGEMENT

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