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A New Approach for Developing Bike Sharing Network System

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Abstract An inherent demand of developed and industrialized countries is widespread transportation system. The current research considers developing of a bike sharing network system to add to public transport services with all the details related to this system. In order to develop a successful bicycle sharing system in a city or urban area, transportation studies should be performed to know the demand for bicycle in order to balance with supply. It consists of six step including inventory, land-use forecast, trip generation, trip distribution, modal split and network assignment. All these six steps were discussed in detail so that their role in developing a bike-sharing system was clearly recognized.

Keywords Public Transportation, Civil Engineering, Environmental Engineering, Network System, Transportation System, Environment, Bike Sharing System

1. Introduction

It is anticipated that using the bike sharing system will increase in next few decades since the environmental fans encourage the governments to develop more environmental friendly transport systems [1-8]. So, it is reasonable to have good knowledge around all details of bike sharing system as one of the environmental friendly transport systems [9, 10].

The current research considers developing of a bike sharing network system to add to public transport services with all the details related to this system or in another word: how can we set such a system up? What are the problems related to this systems when it is developed? What kind of research need to develop such a system? How can we redistribute bikes among the stations? Which stations need redistribution? How can we find these stations? What are the costs of developing the system? What kind of partnership these systems can have?

Bicycle sharing systems (also known as: community bicycle programs, on-street bike rental, yellow bicycle programs, white bicycle programs, public bikes, or free bikes) can be defined in two different ways [11]. The first definition describes number of bicycles made available for short-term shared use at unattended urban locations to individuals who do not own them [12]. The second, more widespread and more familiar, definition of bike-sharing system is public transportation using bicycles [13, 15, 16, and 18]. As these definitions are dependent to each other, the best definition is coming from combination of these two definitions [13-23]. Finally, bike sharing can be defined as a system which is designed to increase mobility in urban settings by offering the user one-way, short-distance transportation between point A and point B.

Over the past 45 years, three generations of bike-sharing systems have been developed [24-29]. The first generation of bike sharing system, named as Witte Fietsen or White Bikes, was developed on 28 July, 1965 in Amsterdam [30]. This generation was provided for public use which means that a person could find a bike, ride it to his or her destination, and leave it for the next user [31-35]. The first generation had many disadvantages such as bikes appropriated for private use, experienced theft and the most important ones was unreliability of this system for users. Finally, this generation collapsed after a few days [36, 37]. Since Amsterdam's White Bikes, other first generation programs have been attempted in cities such as Portland, Oregon, and Boulder, Colorado [38]. All of these systems collapsed after a few years because of high rate of vandalism (Bike-sharing Paul DeMaio 2009 and Andersen, L., P. Schnohr, M Schroll, and H.O. Hein 2000. All-cause mortality associated with physical activity during leisure time, work, sports, and cycling).

The second generation of bike-sharing program was born in Farsø and Grenå, and Nakskov, Denmark, in 1991 and 1993, respectively. Although these programs were small, as Nakskov had 26 bikes at 4 stations, the first large scale example of the second generation of bike sharing program was developed in Copenhagen, 1995, named as Bycyklen or city bikes, with many improvements in compare with the first generation [35-40]. Solid rubber tires and wheels with advertising plates were the components of Copenhagen bikes;

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also people should pick up and returned the bikes at specific locations throughout the central city with a coin deposit [39]. Although this system was technological and a non-profit organization was operated the program, the bikes still experienced theft [40]. This problem leads to a new generation of bike-sharing with improved customer tracking [41]. Bycyklen is one of the few second-generation programs that still operate today, but it is most well known for its role in giving rise to third-generation bike-share (DeMaio 2003, 2004 and DeMaio 2009).

In 1996, the third generation of bike-sharing program was born at Portsmouth University, England, by the name of Bikeabout [42]. The following third generation became smarter due to technological improvements including electronically-locking racks or bike locks, telecommunication systems, smartcards and fobs, mobile phone access and on-board computers [41, 42].

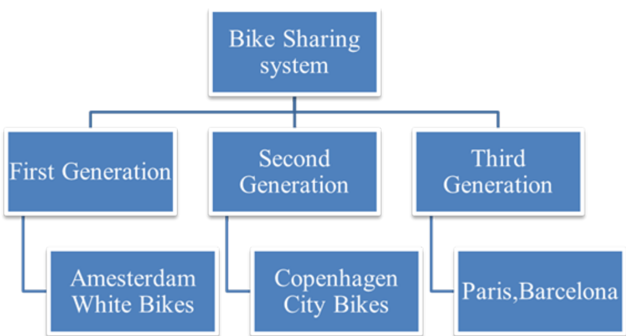
Table 1 summarizes the main differences between each generation in addition to the properties of each generation. By briefly looking at this table, the differences, properties and advantages of each generation will be simply understood by reader [41, 42].

Table 1. Comparison of each Generation

First Generation		
No-tech	Low Expense	Free to use
Second Generation		
Low-tech	Moderate Expense	Coin Deposite
Third Generation		
High-tech	Expensive	Smart Card technology

Further, the first example of each generation and the country it was born is listed in Table 2.

Table 2. The First countries which were raised each generation



Early, the bike-sharing program was slowly grew up, with one or two programs launching annually, such as Rennes' (France) Vélo à la Carte in 1998 and Munich's Call a Bike in 2000 (Optimizing Bike Sharing in European Cities 2009a).

By the end of 2007, there were about 60 numbers of third generation programs globally (DeMaio2007) and by the end of 2008, there were about 92 programs (DeMaio2008a). Currently, there are about 120 programs with existing third generation programs are shown with a cyclist icon and planned programs are shown with a question mark icon (MetroBike 2009).

2. Developing Bike Sharing System

In order to develop a successful bicycle sharing system in a city or urban area, transportation studies should be performed to know the demand for bicycle in order to balance with supply. As all transportation engineers know, the actual transportation planning process comprises a sequence of six steps as:

1. Inventory
2. Land-use forecast
3. Trip generation
4. Trip distribution
5. Modal split
6. Network assignment

3. Results and Discussion

Basically, the inventory comprises the development of a data base for evaluating existing travel demand and existing transportation performance, and a basis for predicting demand and future system requirements (Urban transportation modeling and planning, Peter R. Stopher and Arnim H. Meyburg, 1975). This step is required to apply for planning of urban transport design since the reliable or real data is the base of our planning for future travel demand. Also, there are some commuters that may shift from another mode to new mode which should be considered on our calculation.

The second step of urban transportation study is forecasting the future urban systems, as transportation system is to be designed to serve. By doing this step, the future location or demand center for bicycle will be appear. Therefore, transport engineer can predict to apply the infrastructure of bike sharing system in order to answer the request.

It is used to estimate the number of trips generated and attracted by each areal unit, and these are set up as a function of the socioeconomic and location structure. On the other word, the demand for trips will be determined by doing this step. This step is so important in order to know the demand centers for locating the bicycle station and fleet size.

To model the way in which trips generated or attracted to zones are linked. In other words, each zone is taken one at a time, and a determination made of the zones to which its product trips will be attracted (Urban transportation modeling and planning, Peter R. Stopher and Arnim H. Meyburg, 1975).

After this step, the destination of our trips will be determined to put our stations for bikes which want to end their trips in those stations.

Till now, the number of demands, demand centers, and the destinations of trips are defined as the main part of our bike sharing system since the station location and fleet size are determined.

Effectively attempt to distribute trips between the various modes available. This step is so important since the outcome of this step shows the number of trips by each mode. Further, we can understand that how many commuters change their mode to bike sharing mode and we should consider this part of people in our calculation.

The final travel forecasting model of conventional planning process comprises an assignment, specific to each mode, of trips on the network of links and nodes. As routes are known, the suitable facility should be provided for these routes. Design standards for bicycle facilities and networks are primarily generated from the *American Association of State Highway and Transportation Official's (AASHTO) Guide for the Development of Bicycle Facilities* and the Federal Highway Administration's *Manual on Uniform Traffic Control Devices* (*MUTCD*).

By doing these steps, the number of demands, their destinations, and the utilized routes are defined for bike sharing system but the communities looking to implement a bike sharing system must provide sufficient time to adequately plan and test their system before its launch.

Planners should be careful to avoid the fashionable appeal of bike sharing systems, and make sure the concept is right for their community and if so, they select the type of system that best fits their particular context. Developing a successful bike sharing system is much more than simply purchasing hardware and hiring personnel. In order to evaluate our community, we should go through these steps (Bike share Program investigation, Metrolinks 2009):

1. Examine community needs;
2. Assess and define target groups and service area;
3. Identify and approach supporting/partnering stakeholders and local champion (e.g. mayor, celebrity);
4. Assess necessary preconditions for successful implementation;
5. Municipal commitment to sustainable transportation (policies and budgets);
6. Safe and convenient bicycle infrastructure or at a minimum, a commitment of resources to provide favorable conditions for urban cycling;
7. Ensure that there are sufficient resources;
8. Ensure that there is sufficient space for racks/parking/ stations to guarantee accessibility;
9. Conduct best practice research;
10. Look at economics and available budgets;
11. Consider logistical issues;
12. Select a technology and system; and
13. Develop a business strategy.

After evaluating, examining our community and deciding to implement this system for our community, the next steps in order to develop.

4. Conclusions

If we want to maximize the potential of bike sharing system, the lead agency needs to have the support of stakeholders and partners.

These stakeholders may be including:

1. Local municipality (funding and space);
2. Public transit operators; or
3. User association, other groups (e.g. car sharing companies)

Public bike use should be simple and fast; so, systems should maximize ease-of-use and convenience. By knowing the properties of our community, we can select the suitable generation of bicycle sharing system which are explained earlier. The best system offer multiple options to register and pay for use, such as on-line, phone, kiosk or coin, since they discriminate against the fewest potential users. It is ideal to integrate the system's smartcard with a public transit pass, as is possible with the Vélib system in Paris (Bike share Program investigation, Metrolinks, 2009).

By knowing the number of demands, which is the outcome of trip generation and distribution, we can easily calculate the fleet size that we need for each station. Public bicycles should be distinctive and clearly branded since not only the commuter can easily see and attract to use this system, but also the system is easily identifiable and to ensure that stolen bikes stand out and can be more easily recovered.

The density of the station network must be high enough to make one-way bike trips convenient (the optimal station spacing is between 300 and 500 meters) (Bike share Program investigation, Metrolinks, 2009).

Also by knowing the demand centers and their destinations, we can estimate the station locations. However, in order to determine the station locations, we should consider the following approaches (although these things will be defined in generation and distribution steps):

1. Population density;
2. Employment density;
3. Proximity to transit stations;
4. Proximity to bicycle routes;
5. Proximity to educational institutions; and
6. Proximity to museums, parks, libraries, and other public facilities.

The outcome of network assignment is the route which each mode will use to catch its destination by having this information we consider enough facility for cyclist by defining special lane for bicycles in order to attract commuters to use bicycle. Design standards for bicycle facilities and networks are primarily generated from the *American Association of State Highway and Transportation Official's* (*AASHTO*) *Guide for the Development of Bicycle*

Facilities and the Federal Highway Administration's *Manual on Uniform Traffic Control Devices* (*MUTCD*).

To choose the appropriate bike sharing system for our city, the cost of implementing the system also should be considered.

One of the main encountering problems for transport engineers is redistribution of bikes between the stations. It means each station should have not only enough bikes, but also enough empty places for commuters to pick up a bike or to deliver the bike to the stations. There are different methods to deal with this problem but transport engineer, initially, should find critical stations which will have the redistribution problem.

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