Applying the Big Data of Electronic Tickets to Understand the Behaviors of Passengers with Senior Cards and with Non-Senior Cards in Public Transport – A Case Study of Taichung City Bus

Cheng-Yuan Ho
Department of Computer Science and Information Engineering, College of Information and Electrical Engineering, Asia University, Taiwan;
Big Data Research Center, Asia University, Taiwan;
Taichung City Smart Transportation Big Data Research Center, Asia University, Taiwan,
tommyho@asia.edu.tw

Yao-Nan Lien
Department of Photonics and Communication Engineering, College of Information and Electrical Engineering, Asia University, Taiwan;
Taichung City Smart Transportation Big Data Research Center, Asia University, Taiwan,
yaonanlien@asia.edu.tw

Shu-Chuan Liao
Department of Social Work, College of Humanities and Social Sciences, Asia University, Taiwan;
Asia University Library, Asia University, Taiwan;
Taichung City Smart Transportation Big Data Research Center, Asia University, Taiwan,
shuchuan9@asia.edu.tw

Abstract   In order to determine passengers' behaviors when taking buses, more than 82 million records of electronic ticket transactions from Taichung City Bus's 2015 data were analyzed. First, about 5.26 million electronic ticket users received benefits from Taichung City Government's policy of a free bus ride within 10 kilometers when using an electronic ticket; however, less than 10% of electronic ticket users took buses as their major form of transportation. Second, among the five electronic ticket types, the full-fare ticket was the most popular, representing; 92.62% of ticket types, and had a utilization rate of 89.17%. Finally, there was a significant difference between the bus stops at which passengers with senior cards and passengers with non-senior cards alighted. The former usually alighted near traditional markets, hospitals, and department stores, while passengers with non-senior cards alighted near high schools and universities, shopping areas, and transfer stations.

Keywords   Big Data; Senior; Electronic Ticket; Passenger Behaviors; Ticket Usages; Public Transport; Bus; Taichung City Bus

1. Introduction

Developed countries not only develop public transportation systems (PTSs) but also integrate related transportation systems. This is because PTSs are also shared transport services; providing energy saving, reductions air pollution and traffic congestion, and enhanced convenience, while at the same time tackling the deteriorating traffic of private transportation. In order to make public transportation the major transport for people, PTSs have to be seamlessly integrated, and thus improve people's willingness to use them. Consequently, in order to establish a comprehensive public transport network and increase the service coverage ratio, Taichung City Government has aggressively enhanced its smart transport services and promoted the policy of a free bus ride within 10 kilometers with an electronic ticket [1].

In the past, it was difficult to collect passengers' thoughts and feedback through telephone interviews, roadside interviews, simple surveys, or household visits. These methods were not only costly but also had biasing problems and there was a large gap between research and the real world. Fortunately, with the progress of science and technology, the charging system has been changed from coin-based to an electronic ticket-based system. In the future, the charging system may include third party payments and mobile payments. Currently, all buses in Taiwan are equipped with electronic ticket readers in support of electronic ticket payment. In addition, according to the statistics from EasyCard Corporation (2000~2016) [2], the number of EasyCards in March 2012 exceeded 30 million, and by April 2016, the number of EasyCards exceeded 60 million in Taiwan. Similarly, according to the statistics from iPASS Corporation (2008~2017) [3], the number of iPass in 2014 exceeded 5 million, and by 2017, the number of iPass had risen to over 12 million. The statistics from these two corporations show that the use of electronic tickets is gradually increasing every year.

The electronic ticket itself implies the identity of a user, such as general/full-fare, student, preferential/half-fare, senior, and concessionaire; while a transaction record of an electronic ticket used for public transport implies the user's boarding record. The information may include the type of transportation used, route number, boarding or alighting station (depending on the charging method) and so on. More information can be obtained through statistical analysis, such as the number of passengers getting on and off the bus/train, and the type of passengers in terms of electronic ticket used. These are valuable data for developing traffic and city management policies. Therefore, this has become an important focus of research in recent years. In this article, the electronic ticket transaction records from 2015, provided by Taichung City Bus, and totaling 82,820,553 records were analyzed in order to understand electronic ticket usages and the behaviors of passengers with senior cards and with non-senior cards.

The remainder of this article is organized as follows. Section 2 briefly describes the background of Taichung City Bus and the classification of electronic tickets. A literature review is presented in Section 3. Section 4 describes a case study and provides an analysis of the behaviors of those passengers with senior cards and those with non-senior cards. Finally, Section 5 concludes the article with a brief summary.

2. Background

In this Section, we give a brief overview of Taichung City Bus and the classification of electronic tickets. Furthermore, service areas, bus fares, and the free bus ride policy of Taichung City Bus are described in subsection one, with the five electronic ticket types being introduced in subsection two.

2.1. Taichung City Bus

Taichung City Bus, managed by the Transportation Bureau of Taichung City Government in Taichung City, Taiwan, covers at least 200 bus routes. These are numbered from Route 1 to Route 999 and are operated by different bus companies[1]. Furthermore, Taichung City Bus provides major services in both the downtown area and in rural or remote areas around Taichung City. Minor services are also supplied to connect different counties, such as Changhua and Nantou Counties, to the south of Taichung, and Miaoli County, to the north of Taichung.

The bus fare is calculated by distance. The basic fare is NT$20 for 8 km, and the extended fare is calculated as NT$2.431*(1+5% tax) per km and rounded to the nearest integer. Due to the policy of Taichung City Government, from July 1st, 2015 to date, a passenger with an electronic ticket (i.e., either an EasyCard or an iPass) can take bus journeys for free below 10 km[2] when the route numbers of buses are between Route 1 and Route 999.

2.2. Classification of Electronic Tickets

There are five types of electronic tickets in "Taichung City Smart Transportation Big Data Database," which is provided by the Bureau of Transportation. The electronic ticket types and their owners' qualifications are as follows:

- Taichung City Senior Card: 1) A person aged 65 or over who has established his/her household registration in Taichung and 2) A Taiwanese aborigine aged 55 or over who has established his/her household registration in Taichung.
- Other City/County Senior Card: A senior card not issued by the Taichung City Government. This means a person/Taiwanese aborigine aged 65/55 or over, but who has established his/her household registration in another city/county, not in Taichung.
- Half-fare Card: 1) Children between the ages of 6 and 12 years old, 2) Elderly people over 65 years old who do not have a Senior Card, and 3) A person with a disability and one of his/her companions.
- Full-fare Card: A person who does not meet the above criteria.
- Token: A passenger who pays for a bus journey with cash, i.e., without using an electronic ticket. In practice, when a passenger gets on the bus, the driver will issue a token to the passenger. When the passenger wants to get off the bus, he/she needs to check the fare by tapping the token to the electronic ticket reader, then pay the fare by cash, and return the token to the driver.

   In the following Sections, "Taichung City Senior Card" and "Other City/County Senior Card" will be represented by "Senior Card" for short. Similarly, other card types, e.g., "Half-fare Card," "Full-fare Card," and "Token," will be described as "Non-Senior Card" for short.

3. Literature Review

This section will introduce relevant research on the application of electronic ticket data in public transport.

   Bagchi and White [4] used the origin and destination records in the electronic ticket data to adjust the transportation service and so increased the performance and improved the quality of the transportation service.

   Chapleau and Chu [5] used electronic ticket data to analyze variation in the number of passengers and thus determine changes in passenger carrying capacity on specific routes.

   Seaborn et al. [6] developed a method based on the maximum elapsed time to explain the transfer behaviors of passengers traveling on London public transport. This transfer behavior was divided into pure transfer, incidental activity transfer, and non-transfer.

   Wang et al. [7] used an Automatic Data Collection System (ADCS) to collect electronic ticket data to deduce passengers' destinations and analyze transfer service information, such as the transfer waiting time.

   Pelletier et al. [8] divided the use of electronic ticket data in public transport into three levels: (1) strategic level: setting a long-term plan; (2) tactical level: dynamically arranging the most suitable shifts to improve the quality of service; and (3) operational level: estimating various indicators of the public transport network.

   Alsger et al. [9] used South East Queensland (SEQ) data to study the effect of different data sample sizes on the accuracy level of the generated public transport O-D matrices and to quantify the sample size required for a certain level of accuracy.

4. Case Study and Analytic Results

In this Section, 82,260,553 electronic ticket transaction records of Taichung City Bus from 2015 were analyzed and classified by the number and utilization of electronic ticket type, monthly passenger carrying capacity, missing data, and the behaviors of passengers with different electronic ticket types.

4.1. Analysis of the Type of Electronic Ticket

By classifying the number of tickets (i.e., no matter how many times an electronic ticket is used), it can be found that the preferential policy for the free 10 km with an electronic ticket supplied by the Bureau of Transportation, Taichung City Government has been achieved a certain result. There are about 5.26 million electronic ticket cards and, as shown in Figure 1, 99.57% of passengers use an electronic ticket to take buses while only

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1 In practice, there are 15 bus companies to date: Taichung Bus, Fengyuan Bus, Ubus, Renyou Bus, Chuan Hang Bus, Geya Bus, South-east Bus, Chang Hua Bus, Green Transit, Ho Hsin Bus, Central Taiwan Bus, Miaoli Bus, Nantou Bus, Sifang Bus, and Jieshun Bus.

2 From June 1st, 2011 to June 30th, 2015, the benefit was only for 8 km with the route numbers under 300.
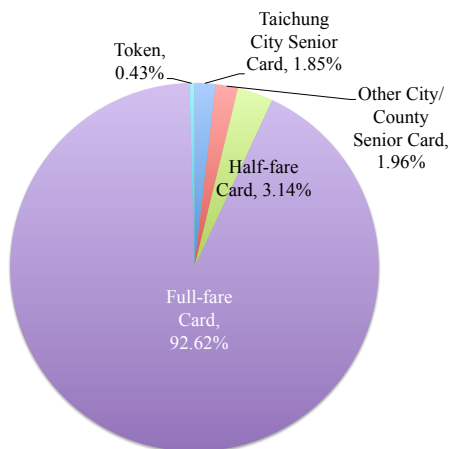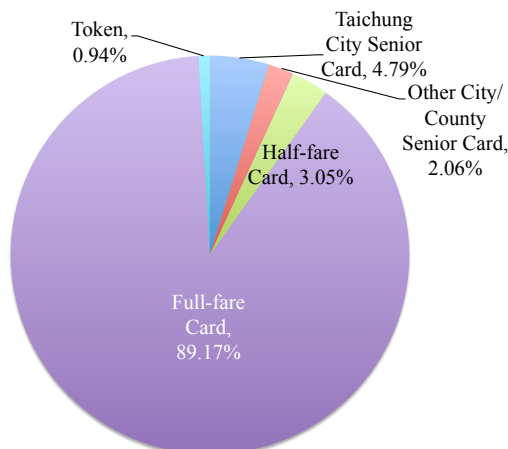
Figure 1. Number of electronic ticket type

Figure 2. Electronic ticket type utilization

0.43% of passengers use cash. There are three common reasons for using cash: (1) the monetary balance on the electronic ticket is zero or negative, (2) the electronic ticket does not belong to any series of EasyCard and iPass, and (3) the passenger is a first-time bus-user in Taichung City and he/she does not have an electronic ticket.

According to the electronic ticket type utilization, as shown in Figure 2, the full-fare card utilization rate is 89.17% of the total number of utilizations, equaling 73.85 million rides. It is interesting to note that there are fewer Taichung City Senior Cards than Other City/County Senior Cards, but utilization of the Taichung City Senior Card is much higher than that of Other City/County Senior Cards. This indicates that seniors who have established their household registrations in Taichung have a greater number of transport opportunities than other seniors.

However, from the data in Figures 3 to 6; less than 10% of electronic ticket holders use buses as their major form of transportation, regardless of the kind of electronic ticket they have.

4.2. Monthly Passenger Carrying Capacity and Missing Data

Table 1 shows the monthly passenger carrying capacity and missing data of boarding and/or alighting at a bus stop. The missing data indicates that in an electronic ticket trans-action record, there is no bus stop boarding, alighting, or both boarding and alighting in-formation.

From Table 1; the highest passenger carrying capacity is in December while the lowest carrying capacity is in June. Furthermore, out of the four seasons: winter (Nov. ~ Jan.) and the middle of summer to middle of fall (Jun. ~ Sep.) have the highest and lowest passenger carrying capacities, respectively. In fact, the carrying capacity in May is much higher than that in April or June. The weather may be a possible reason because, in Taiwan, May is a rainy season while winter is colder than other seasons.

The percentage of missing data is relatively small, so it will not influence the results of the analysis. For example, the highest missing data rate is in July and is 3.96%, 0.24%, and 0.06% for the missing alighting, boarding, and both boarding and alighting, respectively. For the total records, the missing data rates are about 1.75%, 0.10%, and 0.44% for the missing alighting, boarding, and both boarding and alighting, respectively.

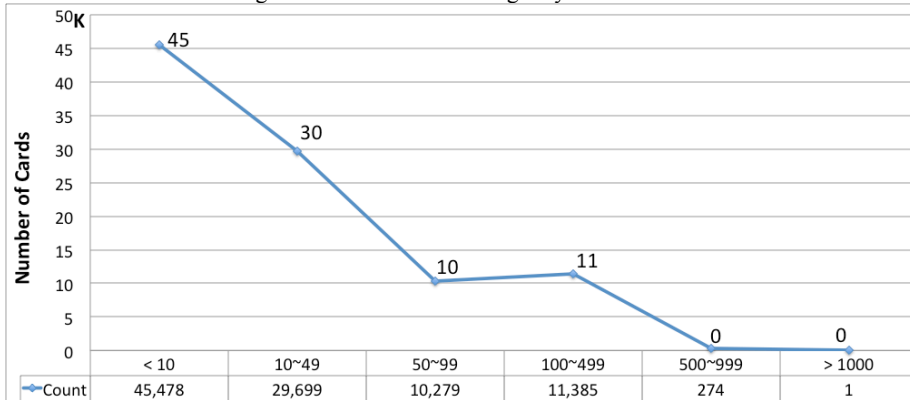
Figure 3. Times for Taichung City Senior Card

	< 10	10~49	50~99	100~499	500~999	> 1000
Count	45,478	29,699	10,279	11,385	274	1

Figure 4. Times for Other City/County Senior Card

	< 10	10~49	50~99	100~499	500~999	> 1000
Count	69,118	25,504	4,955	3,263	39	3
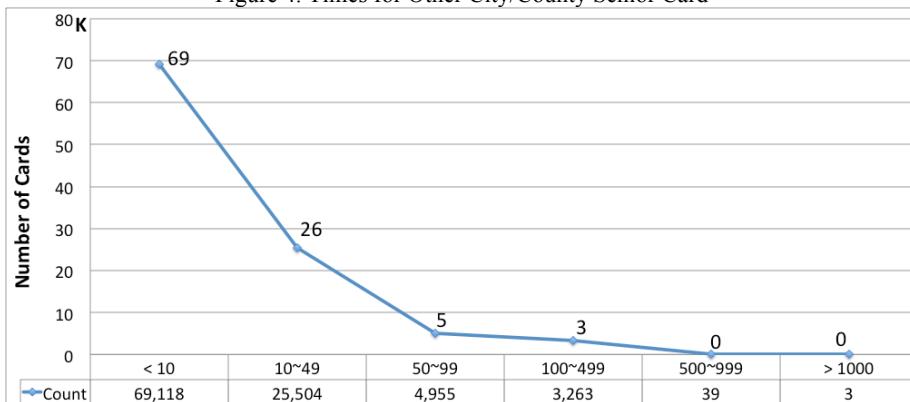
Figure 5. Times for Full-fare Card

	< 10	10~49	50~99	100~499	500~999	1000~1999	2000~2999	3000~3999	> 4000
Count	3,607,477	905,382	197,552	159,857	2,297	79	2	0	1
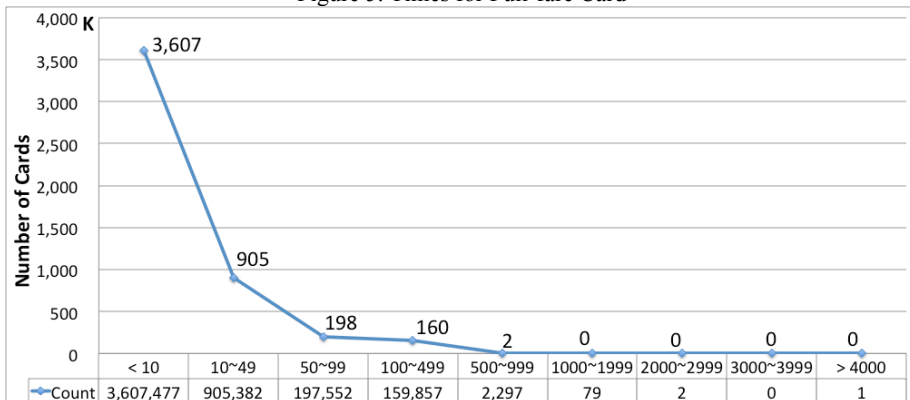
Figure 6. Times for Half-fare Card

	< 10	10~49	50~99	100~499	500~999	1000~1999	> 2000
Count	121,772	31,664	6,647	5,073	141	14	1

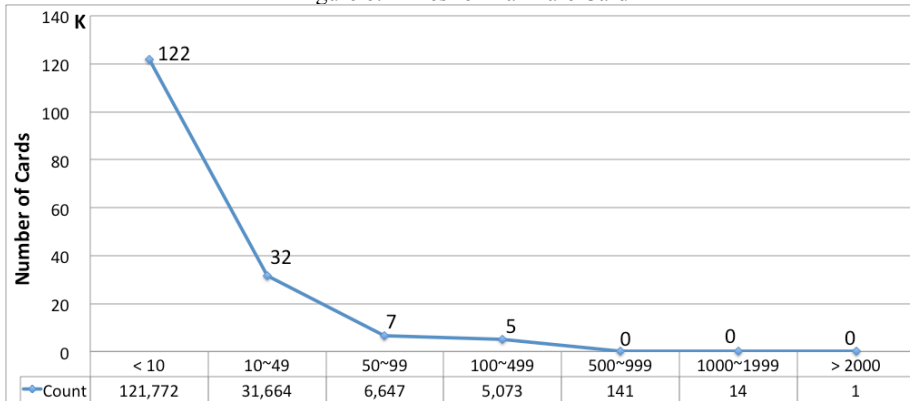Table 1. Monthly passenger carrying capacity and missing data

Month	Carrying Capacity	Missing Alighting Bus Stop		Missing Boarding Bus Stop		Missing Boarding and Alighting Bus Stop	
		Count	Ratio	Count	Ratio	Count	Ratio
Jan.	9,276,813	63,222	6.82E-03	809	8.72E-05	8	8.62E-07
Feb.	6,483,469	54,411	8.39E-03	1,071	1.65E-04	3	4.63E-07
Mar.	5,542,962	49,089	8.86E-03	4,159	7.50E-04	41	7.40E-06
Apr.	7,725,663	53,986	6.99E-03	1,037	1.34E-04	2	2.59E-07
May	9,133,647	61,876	6.77E-03	10,884	1.19E-03	2,226	2.44E-04
Jun.	3,975,473	60,288	1.52E-02	5,792	1.46E-03	2,164	5.44E-04
Jul.	4,370,136	173,054	3.96E-02	10,445	2.39E-03	2,685	6.14E-04
Aug.	4,133,795	153,679	3.72E-02	4,975	1.20E-03	4,140	1.00E-03
Sep.	4,517,969	161,586	3.58E-02	8,249	1.83E-03	20,555	4.55E-03
Oct.	9,004,345	162,494	1.80E-02	8,682	9.64E-04	332,990	3.70E-02
Nov.	9,213,997	227,909	2.47E-02	14,751	1.60E-03	364	3.95E-05
Dec.	9,442,284	227,804	2.41E-02	11,133	1.18E-03	341	3.61E-05
Sum	82,820,553	1,449,398	1.75E-02	81,987	9.90E-04	365,519	4.41E-03

4.3. Behavior of Passengers with a Senior Card and a Non-Senior Card

The data in Table 2 shows that the bus stops that passengers with senior cards and passengers with non-senior cards alight at are different, except for the Taichung Station stop, which is the number one for both groups of passengers. Otherwise, passengers with senior cards usually alight near traditional markets, such as Gancheng Station, Dongshi, and Yixin Market, while the passengers with non-senior cards alight near schools, such as National Taichung University of Science and Technology, Overseas Chinese University, and Providence University. Similarly, passengers with senior cards alight near hospitals, and department stores while passengers with non-senior cards alight near shopping areas, and transfer stations.

5. Conclusion

In this article, more than 82 million records of electronic ticket transactions from Taichung City Bus's 2015 data were analyzed. The summary results are as follows: 1) About 5.26 million electronic ticket users benefited from Taichung City Government's policy; however, less than 10% of users took buses as their major form of transportation. 2)

Table 2. Top 25 hop-off bus stops

Senior Card		Non-Senior Card	
Count	Hop-off bus stop	Count	Hop-off bus stop
244,567	Taichung Station	3,953,509	Taichung Station
69,434	Gancheng Station	2,362,017	National Taichung University of Science and Technology
58,920	Dongshi	1,247,107	Chungyo Department Store
55,147	Chungyo Department Store	1,114,733	Shin Kong Mitsukoshi/Top City Dept. Store
46,327	National Taichung University of Science and Technology	766,443	Overseas Chinese University
44,872	Yixin Market	743,824	Maple Garden
44,515	3rd Market	626,998	Gancheng Station
38,099	Taichung Veterans General Hospital/Tunghai University	595,454	Providence University
37,021	Fengyuan	589,174	Yixin Market
34,655	HSR Taichung Station	580,974	HSR Taichung Station
34,293	Fengyuan Post Office	557,072	National Museum of Natural Science
33,085	Wufong	555,686	Donghai Villa
32,832	China Medical University	529,322	Taichung Veterans General Hospital/Tunghai University
32,824	Shin Kong Mitsukoshi/Top City Dept. Store	513,909	Fuxing-Xian Intersection
32,344	Wuquan-Xueshi Intersection	434,022	Taichung 1st High School
29,084	Mazu Temple	413,922	Wuquan-Xueshi Intersection
25,149	Dajia Railway Station	355,201	Feng Chia University
23,232	Shuinan Market	350,153	3rd Market
21,944	Kuang Tien General Hospital	330,083	Chung Shan Meducal University
21,874	Chunghsing Hall	328,400	Taichung Industrial H.S. (Gaogong Rd)
20,553	Guang Fu El. School (Sanming Rd.)	321,984	Chiao Tai H.S. (Gaogong Rd.)
18,933	Motor Vehicles Office Stop	288,658	Chunghsing Hall
18,542	Taichung 2nd H.S.	274,901	Cheng Ching Hospital
17,898	Nanpingli	273,067	Taichung City Hall
17,133	Dakengkou	267,273	Wufong

Among the five electronic ticket types, the full-fare ticket type was found to be the most popular type, as the ratios of the quantity and its transaction records were the highest, 92.62% and 89.17%, respectively. 3) Passengers with senior cards usually alighted near traditional markets, hospitals, and department stores while those with non-senior cards usually alighted near schools, shopping areas, and transfer stations. In future analysis, the electronic ticket transaction data of Taichung City Bus, within a specific application, district, area, or bus route will be analyzed to create more value, as well as develop relevant applications for the 'smart city'.

Acknowledgment

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