ATRANS
ASIAN TRANSPORTATION RESEARCH SOCIETY

Designing a school bus management system

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CHAPTER I INTRODUCTION

The school trips, one of major traffic purposes, are mostly decided by their parents. In many schools, especially leading schools, in Bangkok, most of parents prefer to drive their children to school which is similar to many parts of developing world (Choudhury et al., 2011). This causes traffic congestion around school, wastes fuels, deteriorates the environment, and gives high risk of accident to students. Replacing alternatives, e.g. walk, bicycle, bus, carpool, to driving to school helps to release the problem.

From the previous study, a case study of trips for the morning commute to school is researched at Roong Aroon School. Roong Aroon School is an alternative school applying a holistic approach for teaching. It is located in Bangkok suburban, Bangkhuntian District. It was set up based on Buddhist principle by a leading Thai academic, Prapapat Niyom since 1997. It has 1,192 students, ranging from kindergarten to upper secondary school level. At present, there is neither public transportation nor safe sidewalk for trips to school.

450 respondents out of 825 households answered the questionnaires in February 2013. It is found that 90% of them drive their children to school. Only 4% use school bus. The cycling and walking are 3% and 2% respectively. The reasons why parents drive their children to school are listed in Table 1.1 (Srisurapanon *et.al.*, 2014).

Table 1.1 Reasons why parents drive their children to school

Reason	Respondent	%
On the way to work/do other activities	130	43
Not in the service area of school bus*	51	17
Be able to stay close to their children	37	12
Inappropriate pick-up/drop-off station*	37	12
Not assured school bus service*	19	6
Living nearby school	10	3
A parent works at school.	5	2
Late school bus*	5	2
Others	10	3
Total	308	100

* Reasons relating to school bus.

In Table 1.1, it is observed that 37% of respondents choose driving school trips due to the reasons relating to school bus. This shows a high potential for their children to use school bus if the competent school bus system is adopted. At present, there are four school buses picking up and dropping off 51 students at home (Type A) while three school buses picking up 6-7 students at only one station point (Type B) located on the main road, Rama 2. Two types, Type A and Type B, of the school bus are shown in Fig. 1.1.
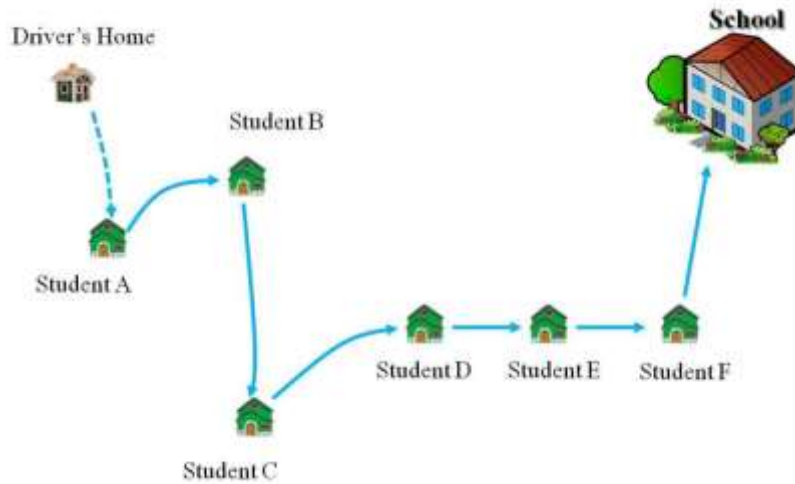
a) Type A: picking up students from their homes
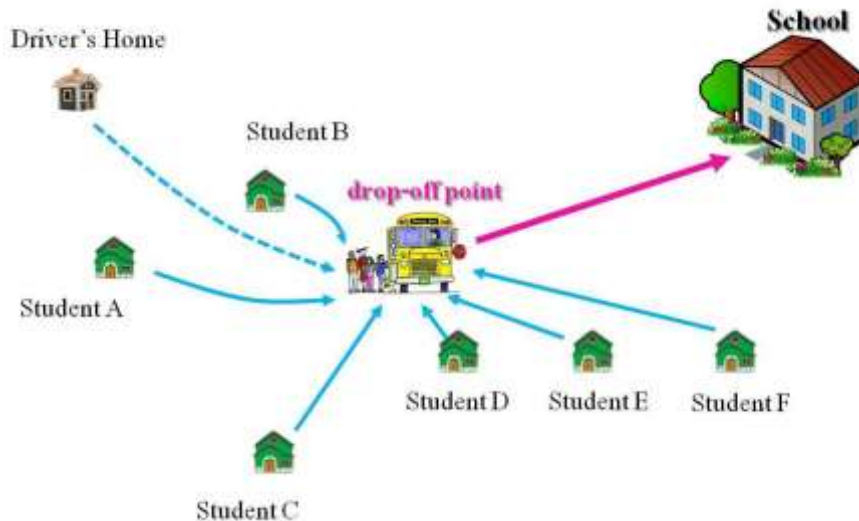
b) Type B: picking up students from drop-off point

Figure 1.1 Two types of taking students to school

From this study, it shows a high proportion, 62%, of respondents goes to work/ do other activities after dropping off their children at school. Of them, 25% go back to their home while the rest of them do some social activities at school. The travel mode decisions of many household members are known to be interrelated. When a household makes a shared trip, they link different trip purposes by making intermediate stops which is considered as household travel behavior (Dissanayake & Morikawa, 2010). Most of the parents, 43%, combine the school trip to their other activity trip. Many of them suggest other station points of school bus to drop off their children. This shows a possibility of replacing private car use with school bus.

1.1 Objective

1) Designing a school bus management system. Roong Aroon School is selected as a case study.

Case Study

Roong Aroon School is selected as a case study. There are four routes, Sukhumvit, Pracha-Uthit, Bangkae and Phetkasem, for Type A school bus as shown in Fig. 1.2. A number of students who use school bus type A is small. About 4% of parental respondents decide their children to use the school bus. Moreover a new route of school bus type B is established and tested for this study.
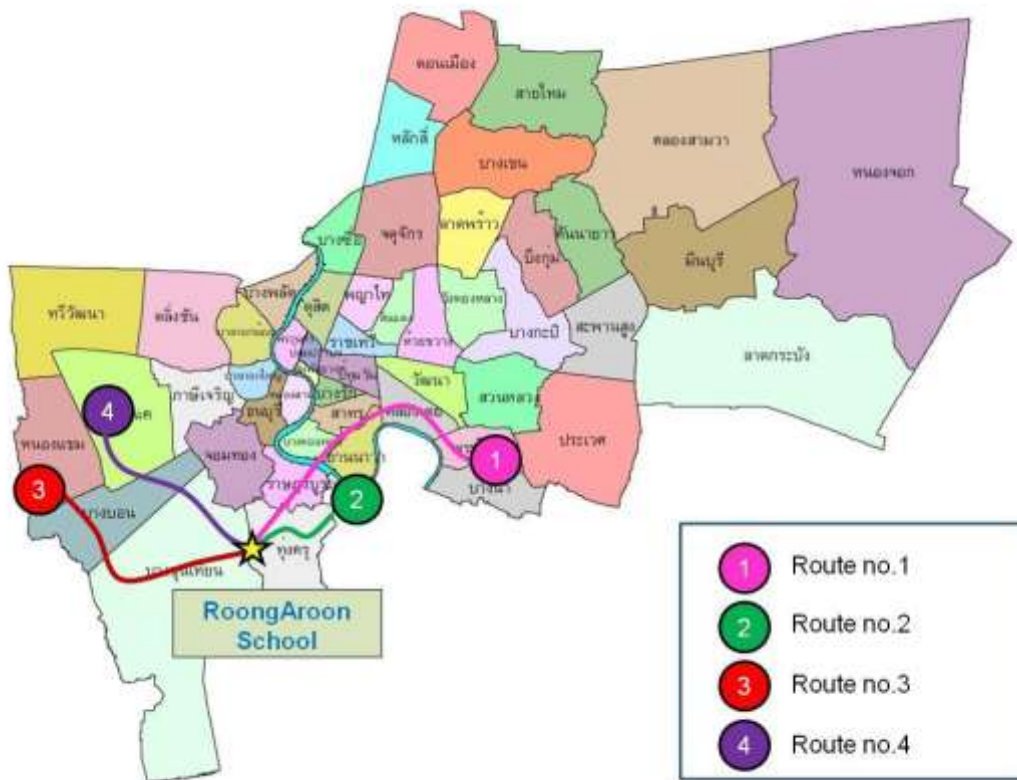
Figure 1.2 Four routes of Type A Roong Aroon school bus

The work of this study is to investigate the characteristics of parents and to find the factors influencing the parents' decision of allowing their children to use school bus. Moreover, the new school bus route is also opened for parents who drive to school to test the real school bus system.

CHAPTER 2 LITERATURE REVIEW

2.1 Roong Aroon school

Roong Aroon School (2014) is a famous Buddhist private school that has about 1,200 students. The school comprises three subsections, Kindergarten Level 1 - Level 3, Primary Level 1 - Level 6 and Secondary Level 1 - Level 6. The School has two types of school bus; the first type is the bus which picks up students from home to school (Type A). The second type is the bus which picks up students from parents at the drop-off point to school (Type B).

Figure 2.1 Roong Aroon school bus

2.2 School bus in THAILAND

Limmonthol and Rudjanakanoknad (2010) reveal parents' characteristics that are likely to use school bus, e.g. business owners or business employee, high level of education, more than one child in a particular school and high income. Examples of school buses from the study are shown in Figures 2.2-2.5. They also mention that schools could persuade parents through lower school bus charge and improvement of bus condition. However, it is hard to lower the school bus charge without cost/revenue consideration and it is necessary to investigate and design the overall school bus management system before promoting school bus. Three main reasons why parents like to drop-off/pick-up students themselves are living close to their school, feeling responsible, attentive, and protective to their child, and fearing of traffic accident.

Figure 2.2 Prachaniwet school bus

Figure 2.3 Tubtong school bus

Figure 2.4 Yaemsaard school bus

Figure 2.5 Chindanukul school bus

The Thai-Japanese Association School has a good school bus system. The school locates at Rama 9 Road in Bangkok. The school gives compulsory education for young Japanese children from Primary School to Junior High School. At present it has 2,083 students and 113 teachers. More than 90 percent of students use school bus, from home to school in the morning and from school to home in the evening (Thai-Japanese Association School, 2014).

Figure 2.6 Thai-Japanese Association school bus

Another good practice of school bus system is at Bangkok Patana School, the international school, located on La Salle Road (Sukhumvit Soi 105) in Bangkok. The school provides learning from Foundation Stage to Senior Studies for 2,200 students, aged between 2 -18 years. The school also provides transport service with more than 200 buses for pick-up and sending 1,200 students every day (Bangkok Patana School, 2014).

The Transport Department is able to provide the following services.

- Round Trip (to school and to home).
- Morning Trip (home to school).
- Afternoon Trip (school to home).
- Special orders or single trip only (Depending on seat availability and normal route).

Figure 2.7 Bangkok Patana School Bus

2.3 School bus in aboard

Ganzhorn (2013) used RFID technology for school bus system. The "Safeway2school" system shows the route to the next stop, distance to the next stop. It can show a list of who are expected to board, details about the passengers, etc. The Safeway2school serves in Austria, Germany, Italy, Poland and Sweden.

Red bus = delay
Green bus = on time
Blue bus = early
Delay in mins

Figure 2.8 Safeway2school system

Oloufa (2003) designed school bus tracking system in Florida. The system consists of hardware and software for acquiring GPS signals, and sending school bus position to a central data server.
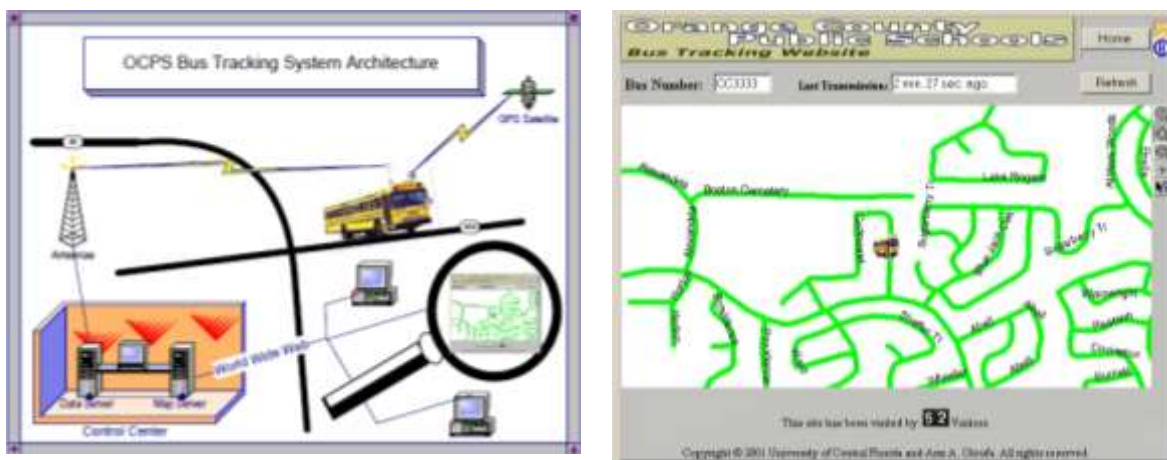

Figure 2.9 System architecture and web-based bus location

2.4   Components of the school bus system

The components of the school bus system (modified from Vuchic, 2007) are:

- Vehicles
- Way/route
- Station
- Depots/terminal
- Drivers
- Monitors
- ITS
- Network
- Operator
- School/Parent association

To accomplish the objective of this study, all components of the school bus system need to be manipulated in the appropriate way.

The Safe Routes to School (2014) suggests the characteristics of school bus stop:

- Choose school bus stop that students must not cross multi-lane roads.
- Have lighting at pick-up locations.
- Protect location from weather such as snow.
- Effect from environment around bus stop

The Safe Routes to School (2014) guides methods to improve the safety and efficiency of the drop-off and pick-up area:

- Encouraging walking, bicycling and carpooling.
- Curb striping and other pavement markings.
- Signage.
- Separating motor vehicles from pedestrians and bicyclists.
- Adding a drop-off and pick-up lane.
- Assistants to help students exit and enter motor vehicles.
- Education, including maps and newsletters.
- Monitoring and enforcement of drop-off and pick-up policies.

Figure 2.10 Double parking

Figure 2.11 Drop students in the
middle of the street

Choudhury et al. (2011) analyze the factors that affect the choice of school buses in Dhaka. A Multinomial Logit (MNL) mode choice model for school trips has been developed using Stated Preference (SP) surveys conducted among parents of students. The results show the key factors influencing to the decision of parents are cost and time sensitivities as well as a significant preference for increased comfort levels. The significant market segmentation also exists households that have non-working mothers and/or very high incomes.

CHAPTER 3 PARENTS' CHARACTERISTICS

There are two types of data collection before piloting a new school bus. One is collected by sending the parental questionnaires via the school bus drivers. The other one is collected by interviewing the parents who drive to pick up their child at school.

3.1 Parent characteristics and their satisfactions of using school bus

For the first data collection, 22 out of 37 distributed questionnaires are sent back through the school bus drivers. Fifteen of them have one child using the school bus while the other seven families have two children using the school bus. These include 29 students. The total number of students who use the school bus is 49. The questionnaire includes the characteristics of students, parents and trips; such as number of children using the school bus, paid rate of school bus, grade, route of the school bus, household income, parental career, preference of using GPS tracking, perception and attitude of using school bus and so on. 72 percent of students use the school bus both to school in the morning and back home in the afternoon. Most of parents are business employees, business owners and housewives and have the household income higher than 60,000 baht per month. All of parents, except one, satisfy the current school bus. Moreover it is observed that 86 percent of them are interested in GPS tracking.
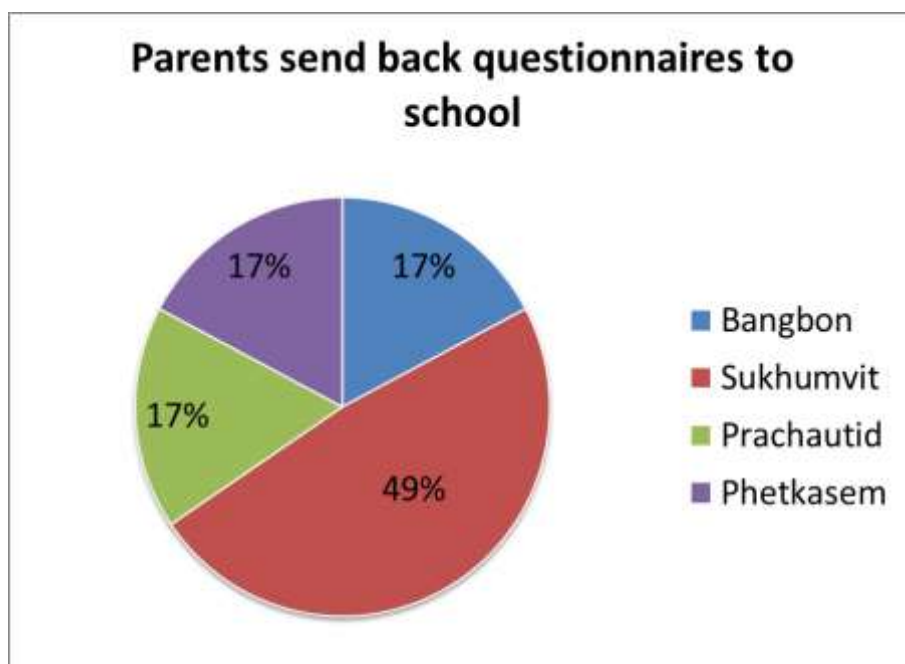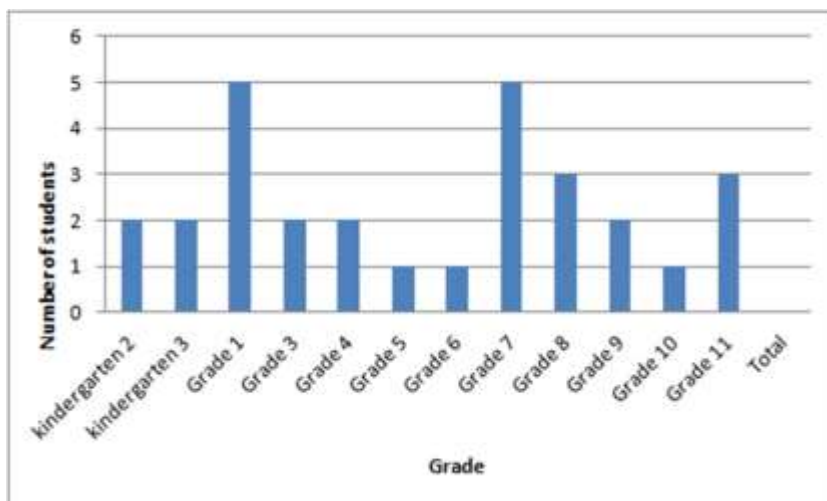

Figure 3.1 Students by route

Figure 3.2 Students by grade
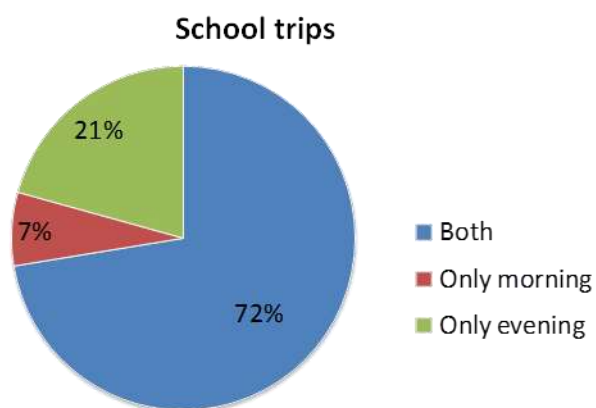
Figure 3.3 Students by school trip
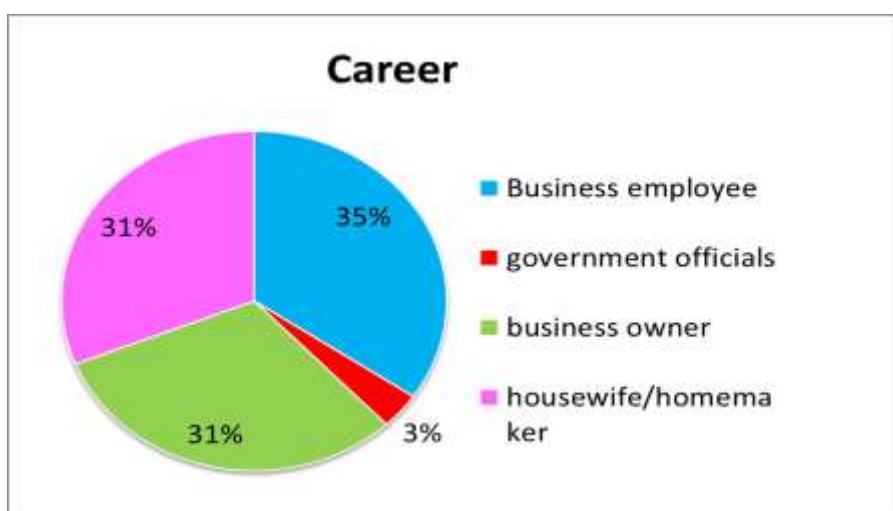
Figure 3.4 Students by parental career
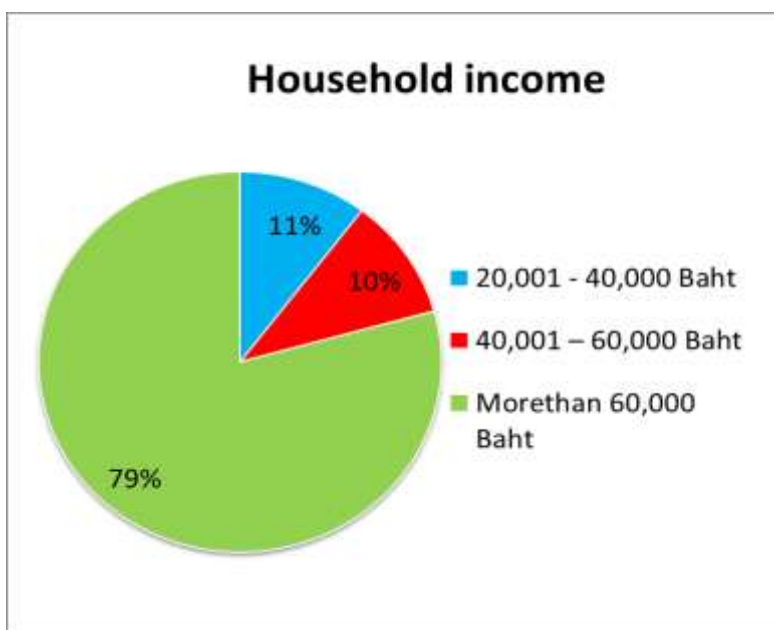
Household income

Figure 3.5 Students by parental household income

perception of time to school

Figure 3.6 Time to school perceptions
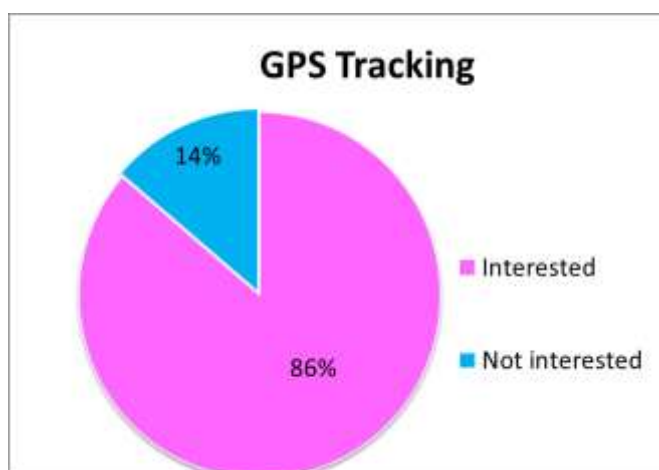
GPS Tracking

Figure 3.7 Attitude of GPS tracking
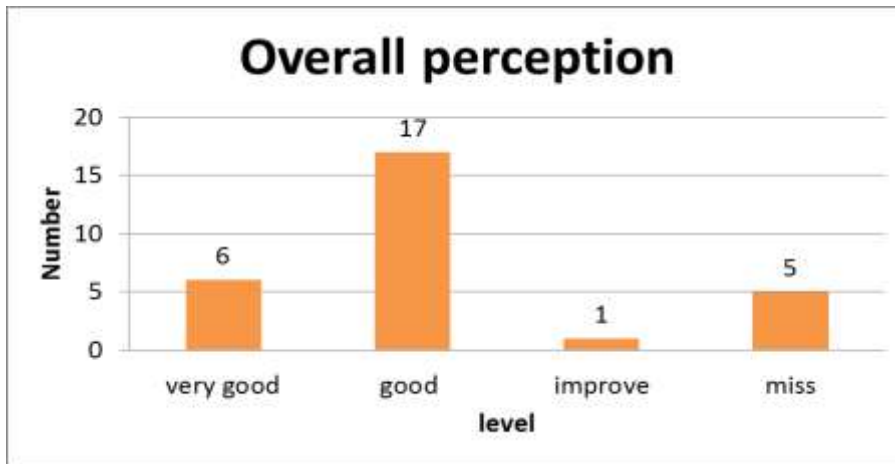
Figure 3.8 Overall perceptions

3.2   Characteristics of parents who drive to school

For the second data collection, 104 of parents who drive to pick up their children at school are interviewed. The information includes characteristics of students, parents; such as educational level of students, parental age, household income and occupation and so on. Most of parents are between 41 and 50 years old, business employees and business owners, and have the household income between 40,000 and 60,000 baht per month. , Moreover it is observed that 65 percent of them are interested in GPS tracking if their children use the school bus.

Figure 3.9 Students by grade

Figure 3.10 Parental characteristics

Figure 3.11 Parental interest in GPS tracking

3.3 Mode Choice of School Travel

From the previous study, more than 90 percent of parents drive to school while only 5 percent of them decide to use school bus to pick up their children to school. From the interview, 58 percent of parents who dr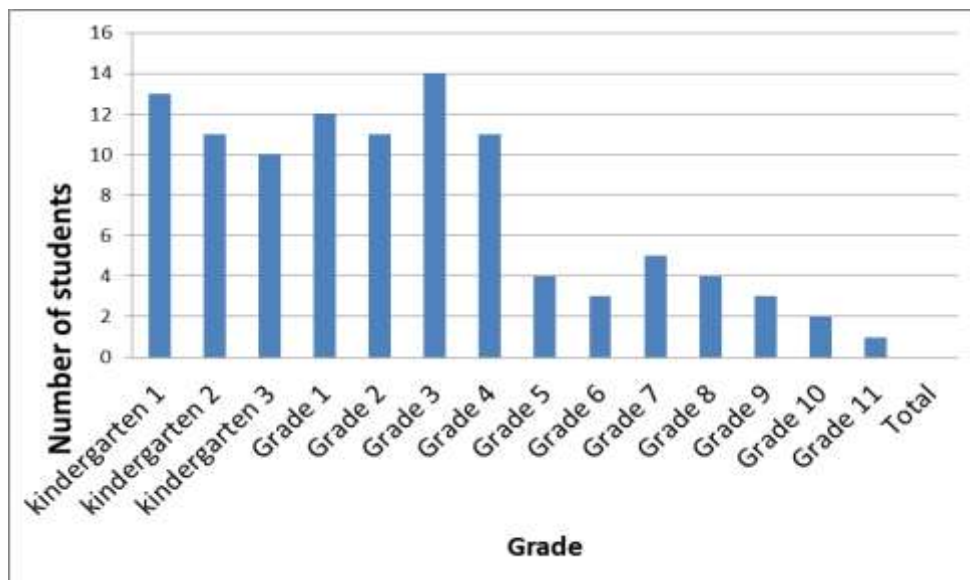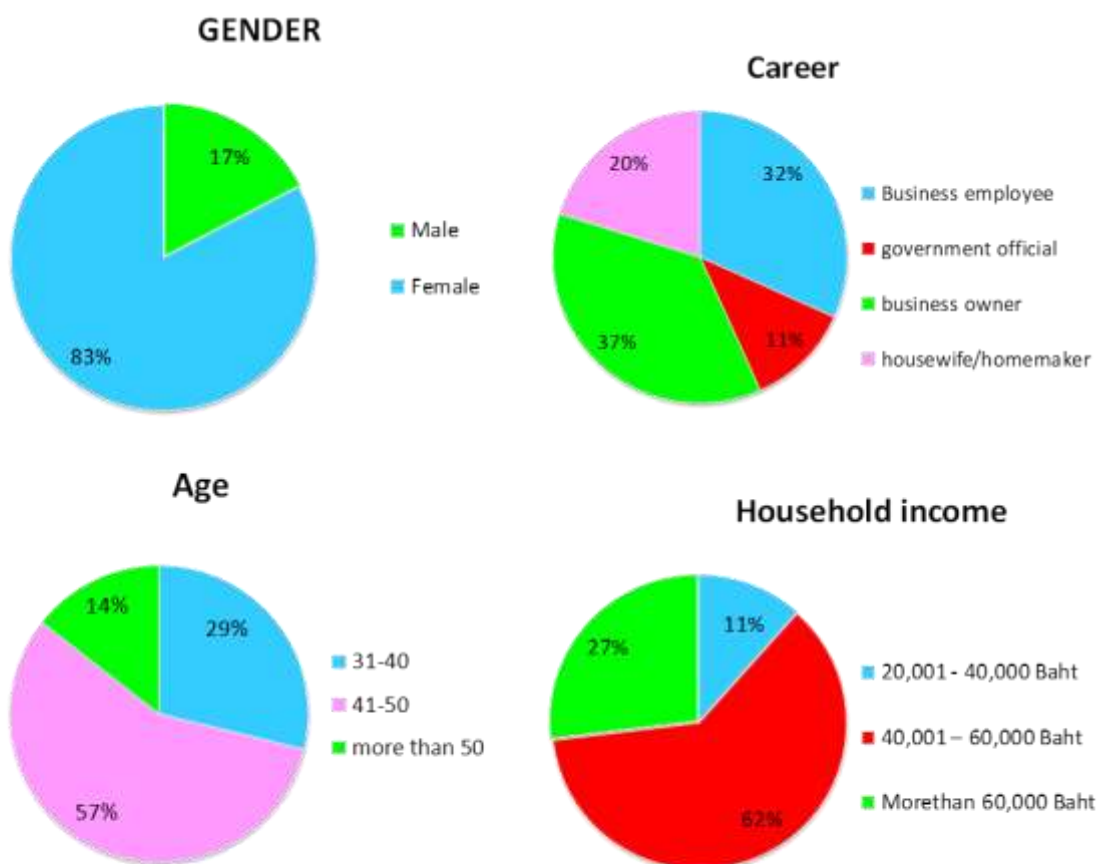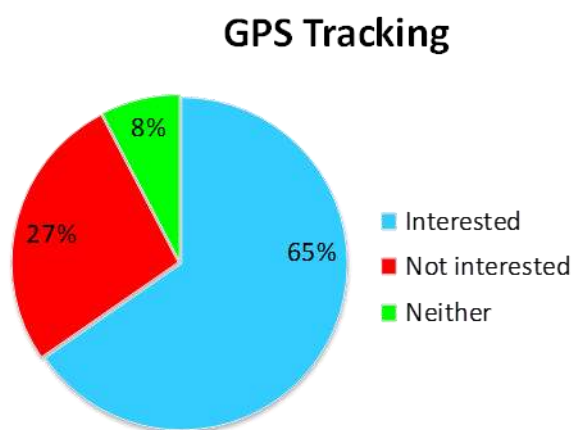ive to school are interested in school bus. This shows a high possibility to send students to school by school bus if they do not drive to school. There is a way to reduce traffic congestion nearby school by shifting some students to use school bus replacing driving to school.

The major task of this study is to investigate the factors influencing mode choice of school travel. Six factors, cost, time, safety, GPS tracking, comfort, bus size, are considered for constructing the mode choice model of school travel. For this study, the binary logit model is developed by using the stated preference (SP) method. Two utility functions, for school bus and private car, are as follows.

$$U_{SCHOOL\ BUS} = \beta_1 * cost_{bus} + \beta_2 * time_{bus} + \beta_3 * safety_{bus}$$
$$+\beta_4 * tracking_{bus} + \beta_5 * comfort_{bus} + \beta_6 * size_{bus}$$

$$U_{CAR} = ASC1 + \beta_1 * cost_{car} + \beta_2 * time_{car} + \beta_3 * safety_{car}$$
$$+\beta_4 * tracking_{car} + \beta_5 * comfort_{car} + \beta_6 * size_{car}$$

where

cost	:	refers to the monthly fee of school bus service (round trip) per student, in baht
time	:	refers to the time to pick-up children from home to school.
safety	:	refers to a monitor in school bus, a teacher or an assistant.
tracking	:	refers to the GPS application for parents to know the position of school bus and the arrival time of school bus.
comfort	:	refers to the comfort level of the school bus.
size	:	refers to the school bus size.
Beta (β)	:	refers to the sensitivity associated with each parameter.
ASC	:	refers to the specific constants relevant to school bus mode.

The results show time and cost are the significant attributes of the mode choice model as below and the coefficients of the model are shown in Table 3.1.

$$U_{SCHOOL\ BUS} = \beta_1 * cost_{bus} + \beta_3 * time_{bus}$$

$$U_{CAR} = ASC1 + \beta_2 * cost_{car} + \beta_4 * time_{car}$$

Table 3.1 Coefficients

MODEL	1		2	
	Coefficient	z	Coefficient	z
ASC1	-5.98275	-14.20	-6.30208	-15.49
β_1	-0.00142	-9.50	-0.00181	-16.53
β_2	0.00040	2.99	-	-
β_3	-0.21095	-9.21	-0.20944	-9.18
β_4	-0.22180	-8.52	-0.21863	-9.41
ρ^2	0.1825		0.1785	

Table 3.2 Mode shares using model 2

SITUATION	MODE	COST	TIME	SHARE
1	BUS	1500	35	84.84
	CAR	2000	25	15.16
2	BUS	2000	35	69.37
	CAR	2000	25	30.63
3	BUS	2500	35	47.81
	CAR	3000	25	52.19
4	BUS	3000	35	27.04
	CAR	4000	25	72.96
5	BUS	3500	35	13.04
	CAR	4000	25	86.96
6	BUS	4000	35	5.72
	CAR	2000	25	94.28

From the sensitivity of cost, it can be observed that monthly fee of school bus significantly influence to the mode share of school travel. The lower the school bus fee is, the higher number of students will shift to use the school bus. At present, the minimum fee is 2,800 baht per month. It seems to be high so there are not so many students using school bus. The school should consider how to find a budget to subsidize the school bus. Perhaps it should collect some fees from parents who drive to school. This is a critical issue that should be discussed.

CHAPTER 4 ASSESSING ROONG AROON SCHOOL BUS

There are two types of school bus; the first type is a bus which transports students from home to school (Type A). There are 4 routes — the first route is Phetkasem, the second route is Pracha-Uthit, the third is Bangkae, and the fourth route is Sukhumvit. School bus drivers serving each district must live in that district in order to pick up their students on time in the morning. In the evening, drivers pick up students from school and take them to their homes. The second type, the school shuttle bus (Type B), travels only one direction from the drop-off point at a Petronas fuel station where parents drop off their children only in the morning. The second one is closed by the end of year 2014 because of a few passengers.

4.1 Characteristics of school bus service

The bus route numbers 1, 2 and 3 serve students who live in sub-urban by ordinary roads while the bus route number 4 serves students who live in the central city at Sukhumvit by expressway. Therefore the average speed of the bus route number 4 is higher than other routes as shown in Table 4.1.

Table 4.1 Travel distance and travel time of the current school buses

Route	Morning trip			Afternoon trip		
	Distance (km)	Time (min)	Speed (Kph)	Distance (km)	Time (min)	Speed (Kph)
1 Phetkasem	28	90	18.7	28	100	16.8
2 Pracha-Uthit	10	50	12.0	17	85	12.0
3 Bangkae	33	100	19.8	*	95	*
4 Sukhumvit	22	40	33.6	22	50	26.8

* data is not available

The capacity of the bus is 15 including the driver. The number of students who use the school buses is shown in Table 4.2. Considering the maximum number of drops (9 drops), the maximum number of students in a bus (12 students) and a seat for bus monitor, some students can be added for bus route numbers 1-3, especially for the morning trips as shown in Table 4.3. However, for the bus route number 4, it serves students with full capacity without a bus monitor.

Table 4.2 Number of students who use school buses

Route	Only morning trip	Only afternoon trip	Round trip	Total Number
1 Phetkasem	2	7	4	13
2 Pracha-Uthit	-	4	7	11
3 Bangkae	3	6	4	13
4 Sukhumvit	*	*	*	*

* data is not available

Table 4.3 Number of drops and seats occupied by students

Route	No. of drops		No. of seats occupied		No. of free seats	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
1 Phetkasem	5	8	6	11	4	1
2 Pracha-Uthit	5	7	7	11	4	1
3 Bangkae	6	9	7	10	3	-
4 Sukhumvit	*	*	14**	12	-	-

* data is not available

** full capacity, no seat left for bus monitor

4.2 Service

The minimum school bus service fees is set to be 2,500 Baht per month and 2,280 Baht per month for one way trip and round trip respectively. Comparing to taxi service fees, it seems rather high. The average service fee is 1,623 Baht per student-trip. By increasing the number of students to its capacity, the average service fee can be reduced to 1,319 Baht per student-trip as shown in Table 4.5. Referring to the logit model analyzed in Chapter 3, the number of school bus users will increase if the service fee is decreased.

Table 4.4 Monthly service fees

Unit: Baht per month

Route	One child		Two children		Total fees
	Minimum*	Maximum	Minimum	Maximum	
1 Phetkasem	2,000	3,500	3,500	5,000	31,300
2 Pracha-Uthit	2,500	3,500	4,500	4,500	27,800
3 Bangkae	1,800	3,000	5,000	5,000	29,800
4 Sukhumvit	2,500	2,800	5,000	5,500	37,700

*2,500 Baht per month is set for one way trip and 2,800 Baht per month is set for round trip.

Table 4.5 Average service fees

Route	Total fees (Baht per month)	Present average fee		Full capacity	
		No. of trips (Student-trip)	Average (Baht/trip)	No. of trips (Student-trip)	Average (Baht/trip)
1 Phetkasem	31,300	17	1,841	24	1,304
2 Pracha-Uthit	27,800	18	1,544	24	1,158
3 Bangkae	29,800	17	1,753	24	1,242
4 Sukhumvit	37,700	26	1,450	24	1,571
Total	126,600	78	1,623	96	1,319

The payments to the drivers vary with the total service fees collected by school. The net balance of payments is 5,100 Baht per month as shown in Table 4.6.

Table 4.6 Balance of payments

Unit: Baht per month

Route	Revenue	Payment	Balance
1 Phetkasem	31,300	29,500	+1,800
2 Pracha-Uthit	27,800	27,000	+800
3 Bangkae	29,800	30,000	-200
4 Sukhumvit	37,700	35,000	+2,700
Total	126,600	121,500	+5,100

Each bus has a bus monitor except the bus route number 4. Each school bus driver pays 4,000 Baht per month for a bus monitor. For the Sukhumvit route, the driver pays 2,200 Baht per month for expressway tolls. The payments and net receives of school bus drivers are shown in Table 4.7. These vary from 23,000 to 32,800 Baht per month. It is quite unreasonable for the bus route number 4 which has the lowest travel time and no cost for bus monitor but the driver receives the highest payment.

Table 4.7 Net driver receives

Unit: Baht per month

Route	Payment	Bus Monitor	Expressway	Net receive
1 Phetkasem	29,500	4,000	0	25,500
2 Pracha-Uthit	27,000	4,000	0	23,000
3 Bangkae	30,000	4,000	0	26,000
4 Sukhumvit	35,000	0	2,200	32,800
Total	121,500	12,000	2,200	107,300

CHAPTER 5 TESTS OF SCHOOL BUS TYPE B

For this study, a new school bus route is pilot as a prototype of the Type-B school bus. This route serves from 19 January 2015 to 31 March 2015. The objective of this test is to learn how to manage resources for satisfying the expected service by parents. After 17 students use this bus service, 11 parents will be interviewed.

5.1 The new school bus route

From the previous study, it was found that a lot of parents drive private cars from home using Rama 2 Road. It is more convenient for parents to drop-off their children at school bus stop instead of driving to school by themselves. These can save lot of energy as well as parents' times. An idea of pooling students into a new school bus route is proposed for this study. The route and the locations of two bus stations are depicted in Figure 5.1 and 5.2. The school bus route and bus station no.1 are opened on 19 January 2015 following by the bus station no.2 at Wat-Yai-Rom market opened on 5 March 2015.

Figure 5.1 A new school bus route

a) Bus station 1: Holland Beer factory on Rama 2 road

b) Bus station 2: Wat-Yai-Rom market

Figure 5.2 School bus stations

5.2   Members of school bus Type B

The test of new Type-B school bus route is done for 49 days. The daily number of passengers is shown in Figure 5.3. We went to introduce this project to parents at school before starting the test. During the first 32 days, 5 families as shown in Figure 5.4 continuously join the test and the maximum number of passengers is 8. After promoting the reliability of bus operation on 3 March 2015, the number of memberships increases doubly. Two sizes of bus are used for the test. At the beginning of the operation, the first 15 days, the 15-seat van is used and the 27-seat minibus is used for the rest.
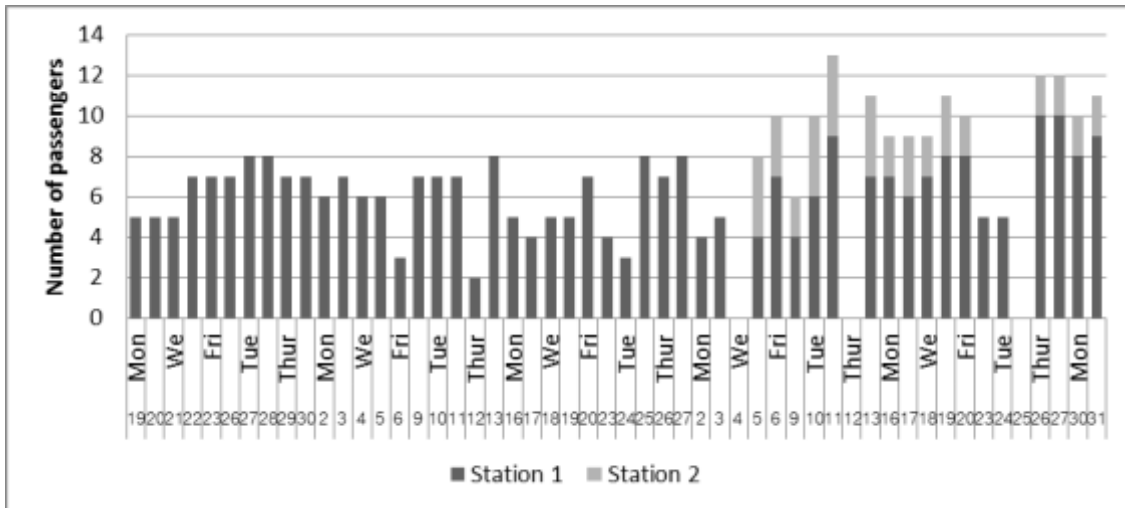

Figure 5.3 Daily ridership of the Type-B school bus

Figure 5.4 Students from five families use the school bus on 27 February 2015

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The school bus team goes to promote by distributing a pamphlet at school on 3 March 2015. Parents who used to send their children to the school bus go to confirm the reliability of the bus operation. We announce the bus station no.2 at Wat-Yai-Rom market. After the promotion day, the number of school bus families increases doubly, from 5 to 11 families and the number of student membership increases from 8 to 17.

a) Explaining the operation of Type-B school bus with a pamphlet

b) A parent confirms the reliability of school bus

Figure 5.5 Promoting school bus at school on 3 March 2015

5.3   The operation of school bus Type B

A monitor has to confirm use of school bus with parents every evening. In the morning a school bus stands by at Holland Beer Factory around 6:30 and departs at 7:00. The school bus also has a brief stop at Wat-Yai-Rom Market and wait for the reserved school bus use until 7:20. In case of no student reserves the service, school bus pass the market without stopping. A monitor checks use of all safety belts during the trip. In addition the monitor takes photos and a video clip when students get off the school bus as shown in Figure 5.6. This is for parents to reconfirm their children arriving to school via social media, Roong Aroon School Bus Group Line. After the complete trip, a monitor has to submit a daily report to the school bus manager. The example of daily report is depicted in Figure 5.7. Moreover school bus meeting is held every week for discussing problems and trying to find ways to improve the school bus service.

Figure 5.6 Operators communicate with parents via Roong Aroon School Bus Group Line

Figure 5.7 Daily report

Figure 5.8 Nine students and their parents at bus station no.1

Figure 5.9 Eleven students and a parent at bus station no.2

5.4   Costs, revenues and consumers' surplus

5.4.1 Costs

The costs of school bus service compose of vehicle cost, driver cost and bus monitor cost. For the test, they cost 1,000 Baht per trip: 500 Baht for rental bus including a driver and 500 Baht for 2 bus monitors, respectively. There are two bus stations. A bus monitor is provided for each bus station. For practical use, only a bus monitor is required for a school bus. Therefore the total cost can be reduced to 750 Baht per bus-trip.

5.4.2 Revenues

In the workshop, the bus service fees are proposed as follows.
- The family which has one child accepts 25 Baht per trip.
- The family which has two children accepts 40 Baht per trip.
- The family which has three children accepts 50 Baht per trip.

With the proposed service fees, the revenues are 280 Baht per bus-trip and 525 Baht per bus-trip for 15-seat bus and 27-seat bus, respectively, as shown in Table 5.1. It is observed that the revenue is lower than the cost so it needs to find other sources of budgets to share the costs.

Table 5.1 Revenues

No. of children per family	Service fee (Baht per trip)	15-seat bus		27-seat bus	
		No. of family	Revenue	No. of family	Revenue
1	25	6	150	11	275
2	40	2	80	5	200
3	50	1	50	1	50
Total	-	9	280	17	525

5.4.3 Consumers' surplus

From the questionnaires, each parent who drives to school can save 8 km and 40 minutes per trip averagely. Considering 5 Baht per km and 1.50 Baht per minute, the generalized saving cost is 100 Baht per parent-trip. The consumers' surplus is estimated to be 310 and 587 Baht per trip for 15-seat bus and 27-seat bus, respectively, as shown in Table 5.2.

Table 5.2 Consumers' surplus

No. of children per family	Service fee (Baht per trip)	15-seat bus		27-seat bus	
		No. of family	Surplus	No. of family	Surplus
1	25	6	225	11	412
2	40	2	60	5	150
3	50	1	25	1	25
Total	-	9	310	17	587

Comparing costs, revenues and consumers' surplus, 27-seat bus has benefits much higher than 15-seat bus.

5.5   The discussion of school bus Type B

The workshop is organized at Roong Aroon School on 17 March 2015. Parents, researchers, teachers including the school director attend the meeting. The Type B school bus operation and its sustainability are presented.

a) Presentation of the Type B school bus performance

b) Discussing the sustainability of the Type B school bus

Figure 5.10 Workshop at Roong Aroon School

CHAPTER 6 INCREASING SHARE OF SCHOOL BUS

From the 49-days test of school bus type B, the maximum number of users is 13 even though the service fee is not collected yet. From the previous study, it is confirmed by simulation model that the traffic in school will be less congested if the number of parents who drive to school is decreased. Therefore it is reasonable to collect money from the drivers who still keep on driving to school.

A Proposed Scheme: Provide school bus Type B (Pick-up students from the drop-off stations) with collecting tolls from private cars

- Current data

Number of Roong Aroon School students: 1,200
Number of parents who drive to school: 600

- Expected data

The expected parents who drive to school decide to stop driving to school: 90
The expected number of students who use the shuttle buses: 120

- Impact analysis

One month has 22 working days. The required number of buses is 6. Each costs 850 Baht. Therefore, the operating cost is 112,200 Baht per month.

Management costs 8,000 Baht per month.

The service fees are as shown in Table 6.1. The revenues from service fees are 69,300 Baht per month.

510 Parents who keep on driving to school have to pay for toll 110 Baht per month equal to 5 Baht per trip. The collected toll is 56,100 Baht per month used for subsidizing the school buses.

If this scheme is implemented, parents who decide their children to shift mode can save times and fuel. Parents who decide to stop driving will save 64,350 Baht per month. This is the consumers' surplus as shown in Table 6.3.

In addition, the traffic in school will be less congested if the number of school bus users increases. It is estimated that parents who keep on driving to school can save 4

minutes per trip. The time value is 2 Baht per minute. Therefore, the surplus is 16,830 Baht per month.

The net benefits are 86,380 Baht per month as shown in Table 6.3.

Table 6.1 Revenues of shuttle bus system

No. of children per family	Service fee (Baht per trip)	No. of family	Revenue (Baht per day)
1	30	60	1,800
2	45	30	1,350
Total	-	90	3,150

Table 6.2 Consumers' surplus of shuttle bus system

No. of children per family	Service fee (Baht per trip)	15-seat bus	
		No. of family	Surplus (Baht per day)
1	30	60	2,100
2	45	30	825
Total	-	90	2,925

Table 6.3 Impacts of providing school bus Type B

Unit: Baht per month

Impact	School	Parents who decide to stop driving	Parents who keep on driving	Total
Operating cost	-112,200			
Management cost	-8,000			
Revenues	69,300			
Consumers' surplus		64,350	16,830	
Tolls	56,100			
Total	5,200	64,350	16,830	86,380

CHAPTER 7 CONCLUSIONS

The service fee is a key factor influencing the share of school bus use. From the previous survey, only 4 percent of respondents allow their children to use school bus. At present, there are 4 school bus (Type A) routes to pick up students from homes to school. To cover all costs of the service, the minimum service fee is set to 2,500 Baht per month and 2,800 Baht per month for one way trip and round trip respectively. Comparing to the taxi rates, it seems rather high. From the observation, it is found that the morning load factors of route numbers 1, 2 and 3 are less than 60 percent which is about 6-7 students per a school bus, and the average service fee is 1,623 Baht per month. The average service fee can be reduced to 1,319 Baht per month if the number of students is 12 for each school bus. To make it more incentive, the service fee should be set lower. From the analyzed Logit Model, it is found that the share of school bus will increase doubly if the monthly service fee can be reduced 500 Baht. It is reasonable to collect tolls from parents who drive to school to share costs of school bus system because they will also gain benefits, saving times in school, when some students shift to use school bus.

From the test of school shuttle bus (Type B), almost all parents satisfy and like to allow their children to use the school bus Type B. From a proposed scheme, providing 6 school shuttle buses combining with the collected tolls from private car users in school, it generates 86,380 Baht per month as the net benefit. This benefits to not only for parents but also to all drivers around school. Therefore the local government should provide some budgets to subsidize the school bus management system.

It is possible to combine some technology, e.g. tracking the school bus by GPS which is shown in Appendix A. However, it does not much affect to parents' decision of allowing their children to use the school bus.

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Appendix A   School Bus Tracking

1. Features for School bus Tracking System

The system is able to perform the following tasks:
1. Can track a school bus and display the location on a mobile phone device. Right now, only Andriod phones are supported.
2. Can view a snapshot image taken inside the schoolbus every 5 minutes.
3. Can give an estimated time when the school bus will arrive to the school or the pick-up/drop-off points for each individual parent.

2. System Architecture Design

The system has three major parts as shown in Figure 1.
1. Schoolbus device

   The function of the schoolbus device is to periodically report its locations every few minutes to the server.

2. Server

The server is equipped with the Internet connection and has an access to road traffic information such as Google map. The server connects to the system database that keeps two information items:
- The locations of each school bus and their past movement history
- The information about the individual parents such as login username and password, pick-up and drop-off locations, pick-up and drop-off times, children name/ID, and their status (on-board vs. get-off).

   When the server receives the GPS data from the schoolbus, it stores the current bus location.
   In addtion, the server can return the current bus location to the parent device when beign requested.

3. Parent device

The parent device is simply a smartphone that receives notification messages from the server about the estimated pick-up time and the estimated arrival time, and can track the bus location by asking for the bus location from the server.
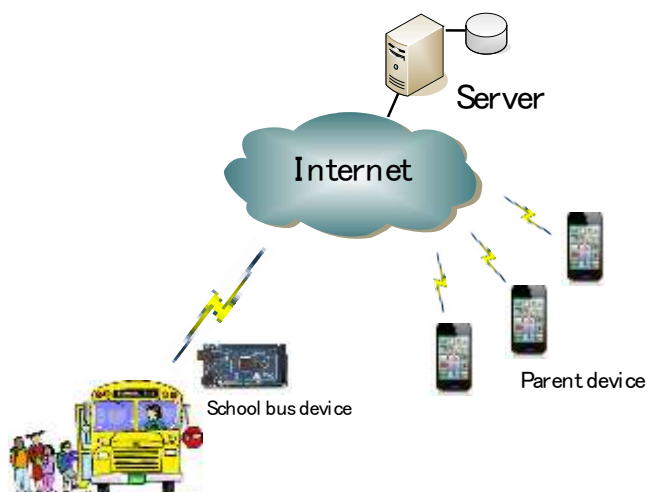

Figure A1 System Architecture

3. Software Operations

We have created a Web page at 202.44.12.105/WebRegis.aspx for parents to register their username, password, children information, and pick-up locations. These information will be stored in the server. When the parent starts the mobile client program, the registered username and password must be entered and verified with those in the server for authentication as shown in Fig.2. Then, the parents can start using the program.
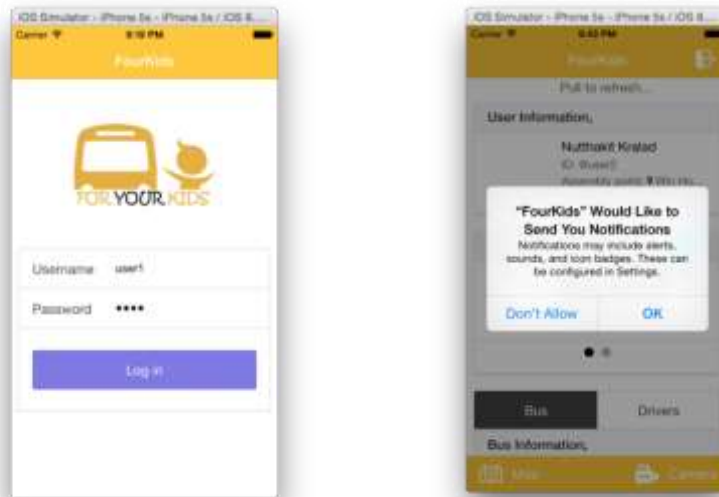

Figure A2 Username and password authentication when starting the client program

If the entered username and password matches the information stored in the server, the program will load the data and walks user to the dashboard. The user might see a notification prompt for asking permission to receive notification messages from the server.

After successfully logging in, the user will see all his/her registered information, students bus and driver information as shown in Fig.3. There are one menu [Logoff] on the right top corner and two menus [Maps and Camera] on both left and right below corners. If the parent has registered for several students, the user can swipes right or left by following the bullet point below.
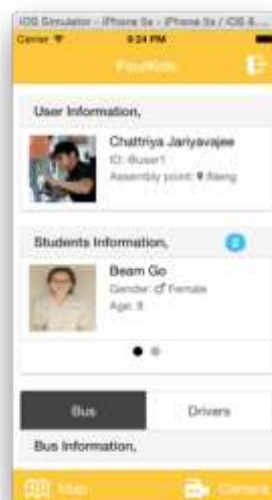

Figure A3 User and student information shown after successful login

Tapping on the [Bus and Driver] menu allows the user see the bus information or driver information as shown in Fig. 4.
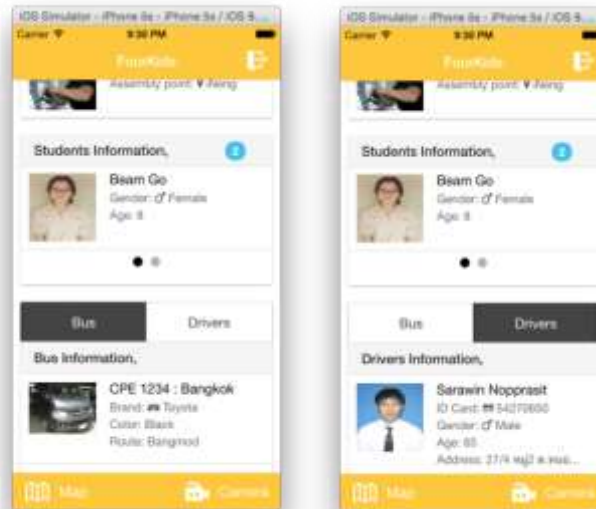

Figure A4 Bus and driver information

From the main screen, tapping the "Map" menu on the bottom left corner will change the display to the current location of the school bus as the green icon. The current user location is shown in Purple icon and the pickup point is shown in Red icon. On the bus location screen, the user can reload the data by tapping "Find the bus" menu on the left below corner. The user can zoom in, zoom out, and change to the satellite map view by tapping menu on the map.
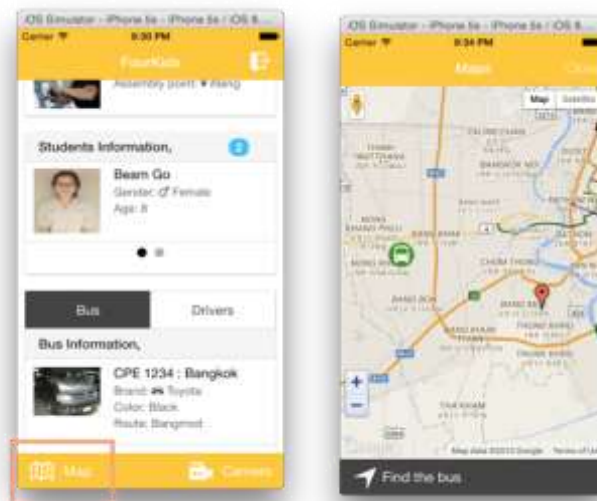

Figure A5 Bus location screen shows the registered pick-up location (Red icon) and the locations of user and school bus in real-time (Purple and Green icons respectively)

The user can see the snapshot image taken on the school bus by tapping the "Camera" menu on the right below corner as shown in Fig.6. The user can reload the data by tapping "Re Snapshot" menu on the left below corner.
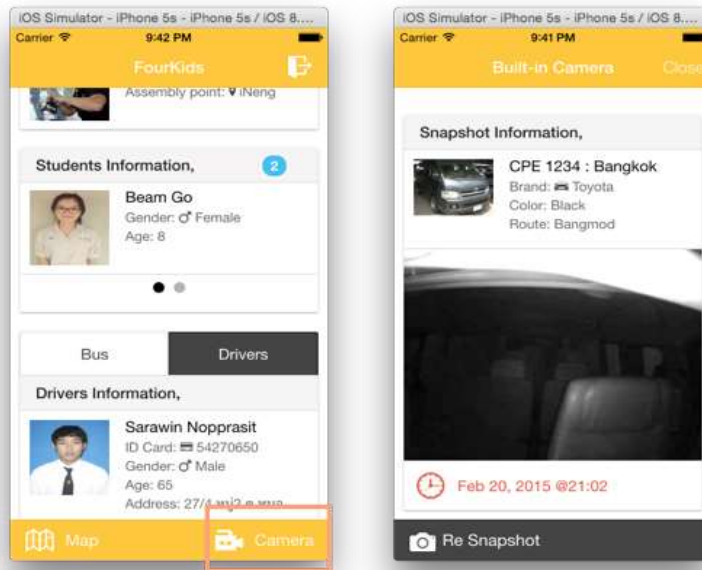

Figure A6 Snapshot image on the school bus

If the user wants to log out the application, he/she can tap "Logoff" menu on the right top corner and the confirm message will be prompted. The application will logout the current user session and walks the user back to the login page in Fig. 1.
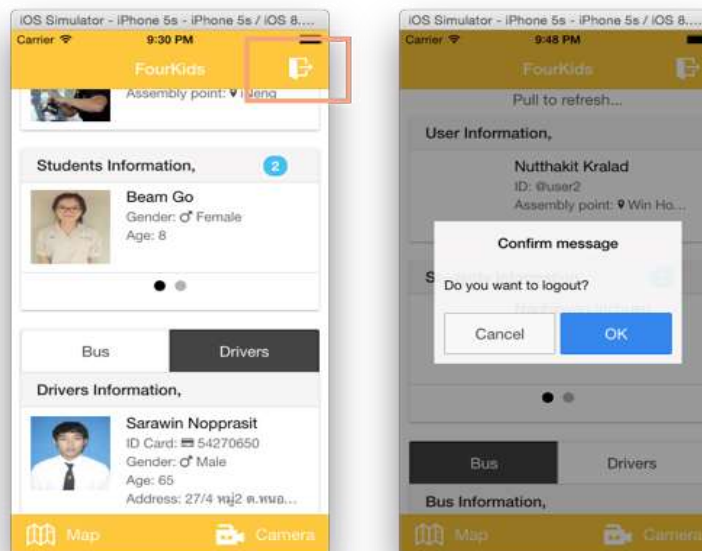

Figure A7 Logging out the application will bring the user back to the login screen

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