Serviceological View of the Development of a Person Trip Survey Application

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Abstract
We are planning to introduce a new public transportation system, called the Smart Access Vehicle (SAV) system, to Hakodate city. For this purpose, since November 2012 we have been conducting a PT survey in which people run the dedicated smartphone application that we are developing. The process of developing the application forms the so-called 'design-service loop', consisting of design by simulation, implementation in the real world, and analysing/modelling. Up to now, we have iterated the loop twice: from December 2012 to February 2013, and February 2013 to April 2013. In this paper, we present the phenomena occurring within the loops and the actions we have taken in response to these phenomena.

Keywords:
Person Trip Survey, application development, design-service loop

1 INTRODUCTION

In this paper, we present the development of a smartphone application for a person trip (PT) survey from the viewpoint of Serviceology.

We are planning to introduce a new public transportation system, called the Smart Access Vehicle (SAV) system, to Hakodate city [4]. For this purpose, since December 2012 we have been conducting a PT survey in which people run the dedicated smartphone application that we are developing. The application provides users with a special function by which they can enter their destinations and their reasons for travelling to these destinations at any time. The data obtained from the PT survey will be used as the basis for generating the traffic demands in the simulation of demand-responsive transportation in the Hakodate area.

The design issues in developing the PT survey application include (1) co-design of the functions and the operation method of the PT survey application and (2) coping with the trade-off between the user input requirements and the accuracy of input data. Since it is difficult to solve these issues effectively using the waterfall method, we therefore decided to approach the goal through the design-service loop. The design-service loop comprises the following circular steps: service design by simulation, providing the service to users in the real world, observation and analysing/modelling, and again, service design by simulation (Fig. 1) [3]. Through the loop, the PT survey application has been continuously and efficiently refined.

In the paper, we describe the changes to the functions that we provide for the PT survey application, those of users' behaviour, and those of the quality of person trip data we obtained, as the loop was repeated. We evaluate the effects of the design-service loop in developing the PT survey application.

2 RELATED WORK

There have been many attempts at trip surveys and position logging using the GPS. One of the most prevalent ways of conducting trip surveys is the person trip (PT) survey. In the PT survey, the data, including "who", "when", "origin and destination", "mode of transport", "purpose", are usually collected using questionnaires. The results may be used for accident prevention, welfare, medical care and so on. The ambiguous, lacking, possibly even incorrect memories of users may confuse the questionnaire results and make data cleansing difficult. As filling out a questionnaire correctly is a time-consuming job, it is difficult to maintain subjects' motivation. Since the PT survey is therefore carried out on a certain day in a town, or occasionally a big city, it is suitable for obtaining a large amount of snapshot data about the usage of transportation. Thus, it is not suitable for tracking individuals' usage of transportation in the long term.

There is another simple type of trip survey called a probe person (PP) survey [2], in which a subject always carries a portable device, such as a GPS logger or a smartphone. A dedicated application running on a portable device records the subject's information and behaviour such as latitude/longitude, departure time, arrival time and mode of transportation, possibly with having a subject enter some additional information. Since the PP survey does not burden the subject with high input overhead, the PP survey is suitable for tracking his/her behaviour in the mid-to-long term.

Analysing the collected data together with climate information and the temporal changes of the data, we expect to create a more detailed simulation model in which an agent can select an appropriate mode of transportation. However, we think that, to acquire accurate information from a subject, a subject should also learn and develop a better usage of the PT survey application. Since a subject in our PT survey uses a smartphone with a GPS positioning function for a mid-to-long term with low user input, our PT survey can be viewed as a PP survey.

Participatory design is a design methodology which emerged in the 1960s in which end users are actively involved in the development process of a product with researchers and developers [5]. Throughout the process, the functions and shape of a product are being examined, improved and fixed. The development process of our PT survey application can be viewed as an implementation of participatory design over a prolonged but un-predetermined period. In contrast, in the design-service loop (Fig. 1), users become accustomed to the application, while they invent ingenious ways of using it.

3 PERSON TRIP SURVEY IN HAKODATE

3.1 Goal and plan

In the Hakodate area, the traffic situation changes greatly season by season. For example, more than 2 million people visit tourist spots in the summer, and much snow falls in the winter. Thus, from 2012 to 2013, we planned two PT surveys, each lasting four months: December

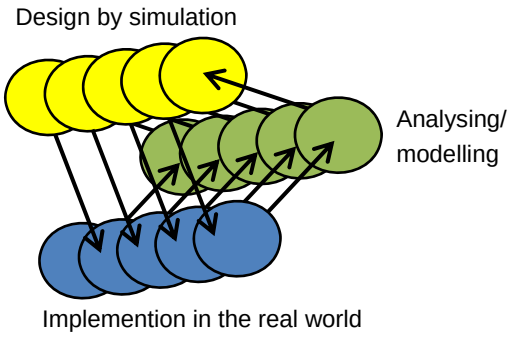

Figure 1 Design-service loop

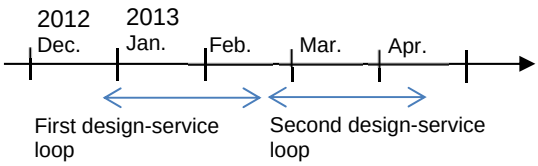

Figure 2 Survey schedule

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4.1

through April and June through September (Fig. 2). A unique feature of our PT survey is that the term is four months, while that of conventional PT/PP surveys is much shorter. During the survey periods, subjects are always equipped with a smartphone application to record their behaviour in relation to transportation. From the recorded data we extract the information needed to form the basis for generating the traffic demands in the simulation of demand-responsive transportation (SAV, described above) in the Hakodate area. It is supposed that the basis acts as a realistic passenger model that makes decisions in selecting the mode of transportation. Therefore, the design issues in developing the PT survey application include co-design of the functions and operation method of the PT survey application, and coping with the trade-off between user input requirements and the accuracy of input data. Since it is difficult to solve these issues effectively using the waterfall method, we therefore decided to approach the goal through the design-service loop.

4.2 Smartphone application

We have been developing the smartphone application with GPS installed, and a user operates it to enter his/her destinations and the reasons for travelling to these destinations (Fig. 3). At the very first stage of research, the authors began with trial use of the prototype for a month, and decided that the application should provide the following functions:

- Entry of travel plan

  A user clicks the PLAN button shown in Fig. 3 (A) to start inputting the details of purpose (B), destination (C), and mode of transportation (D) all at one time. Initially, we provided the following options for purpose, destination, and mode of transportation:

  - Purpose – Go home, Work, Learn, Play, Shopping, Leisure etc.
  - Destination – Home, Workplace, School, Restaurant, Supermarket, Hospital, etc.
  - Mode of transportation – Walk, Bike, Motorbike, Private car, Taxi, Bus, Train, Tram, Airplane, etc.

- Registration of trip patterns

  Frequently-used trip patterns are usually fixed to some extent; such as in the case of office workers, many of who may commute between home and the office on weekdays and go out for shopping or for recreation at the weekend.

  To achieve minimum input requirements, we enable a user to enter required information collectively in advance. The application provides a function enabling a user to register the frequently-used trip pattern of purpose, destination, and mode of transportation as a triplet.

- Acquisition of location data

  To inform users of the status of GPS and respect users' privacy, we provide the START and END buttons shown in Fig. 3 (A); the START button starts GPS tracking to get the user's location every 30 seconds, and the END button stops GPS tracking. A user can use these buttons at any time.

- Sound recording

  We provide a speech input option as another general-purpose input method with low overhead (the RECORDING button in Fig. 3 (A)). A user can use this function at any time for recording any information.

In the case of clicking a series of buttons starting with PLAN, or using registered patterns, a user can click these buttons at any time and any number of times. Once a button is clicked, the colour of the button is inverted in order to notify a user that it has been selected. A function for cancelling the registered trip plans is not provided, for the sake of simplicity.

4.3 Conducting the survey

Using the smartphone application, we have been conducting the PT surveys. Since the location data obtained by GPS with ID information are highly personal, we introduce an agent between subjects and us so that we do not directly handle the location data with ID information. Actually, the agent is an NPO, the main functions of which are managing subjects and anonymizing the data. Once a month, the agent downloads the data directly from the smartphone of each subject. We have 20 subjects and 20 smartphones on which the application for the PT survey has been installed. The subjects are chosen to approximately reflect the population distribution in Hakodate city. Using questionnaires, we also obtain the information of age, sex,

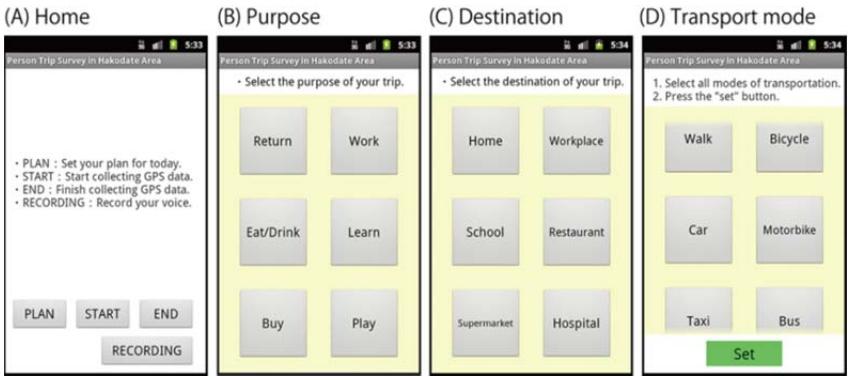


Figure 3 Plan entry pages for smartphone application

whether or not the subject holds a driving licence, frequency of driving etc.; the subjects range from people in their 20's to 70's.

5 FIRST DESIGN-SERVICE LOOP

5.1 Registering of trip data

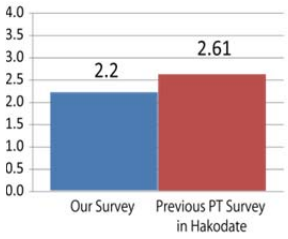
The instruction given to subjects was that they may input as many trip plans as they have in mind at the beginning of the day, in order to prevent them from missing inputs, although subjects can input the triplet at any time. Also, on trips during the daytime, a subject can add unexpected trips and any that a subject forgot to input earlier. In reality, 15 subjects out of 20 entered their trip plans collectively in advance before the start of the first trip, and the remaining 5 subjects entered the trip plans on-the-fly during trips. The data inputted on-the-fly probably included changes to the entered trip plans. Although the sound recording function was introduced to promote simple, frequent inputting, it has been used significantly less than expected because it is an unexpectedly delicate, troublesome job to speak a short message to a smartphone while riding on public transportation.

5.2 Analysis and justification of data

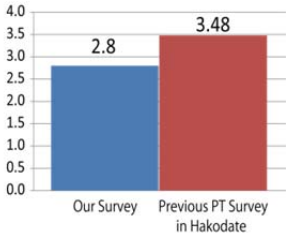
The main aim of the first design-service loop from December 2012 through February 2013 is to study the feasibility of the PT survey through the design by simulation and implementation phases (in the first design-service loop) (Fig. 1). To check if our PT survey can stably obtain correct data over a long period of time, we compare the data from our PT survey with data from an existing reliable survey. We take the PT survey conducted in the Hakodate area (Hakodate and the adjacent three cities) in 1999 (Tab. 1) [1] and focus on the average number of trips and the trends in the mode of transportation.

Table 1 Comparison of our survey with previous one

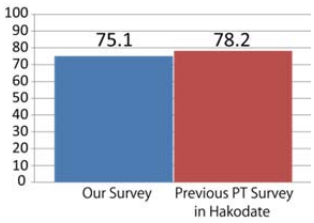
	Our Survey	Previous PT Survey in Hakodate
Term	Dec. 2012 to Apr. 2013	A day in 1999
Num. of Subjects	20	14,400 (Population = 360K, Sampling Ration = 4%)
Car-ownership Rate	85.0%	56.8%



(a) Num. of trips per person per day



(b) Num. of trips per person per day (only on day with trips)



(c) Trip rate

Figure 4 Number of average trips

5.3 Number of trips

Fig. 4 depicts the data for trips per person per day. Fig. 4 (a) shows the average number of trips across all the days of the survey, and (b) the average number of trips only on the days when subjects made trips. Fig. 4 (c) shows the rate of days on which people had more than one trip. In our PT survey, since a subject was given the instruction to enter a whole plan in advance of the trip, the day on which the subject entered a plan could be judged as one with more than one trip. Thus, if a subject neglected to enter a plan, the day was regarded as one without trips. In Figs. 2 (a) and (b), the average numbers of trips within a day in our survey are 15% to 20% less than those in the previous one. On the other hand, in Fig. 4 (c), the trip rates are almost the same as each other.

A possible reason for this was that incomplete or incorrect data were entered by a subject. There were cases in which subjects simply forgot or omitted to enter plans for the day. It was often the case that subjects neglected to enter the journey of "return to home" although subjects realized that this journey is a part of a whole trip. For another example, by checking entered trip plans against the corresponding GPS data, we have found that when a subject should have entered "purpose: 'others', destination: 'others', mode of transportation: '...'" twice or more, we have found that the subject entered it only once in reality. This is probably because the colours of buttons were inverted once pressed and a subject took it that these buttons could no longer be clicked. Analysing the GPS data with the entered trip plans revealed that at most three trips were actually made, while a single trip plan was entered.

Next, Fig. 5 depicts the data of the purpose of travel and mode of transportation obtained in the first design-service loop. The pie charts show the principal transportation mode according to purpose, which is "work", "return home", "private", and "all purposes", respectively. The principal transportation mode means the main transportation mode used in a series of transit trips. As in conventional PT surveys, transportation modes are ranked in order of importance as follows: train, bus, car, motorcycle, and walk. As an example of a commute, suppose that a subject takes a car from home to the nearest railway station, gets on a train, and walks from their destination station to an office; in this case, the principal transportation mode is the train. In Fig. 5, purposes other than "work" and "return home" are regarded as "private." As shown, for each purpose, the percentage of car use is larger than that of motorcycle and walk. This trend may coincide with the high car ownership rate, which is 85% as shown in Tab. 1.

Taking into account the comparison data in Figs. 4 and 5 and the above discussion, we suppose the application for our PT survey can collect data that sufficiently approximates real trips. These discussions correspond to the analysis in the design-service loop (Fig. 1).

6 SECOND DESIGN-SERVICE LOOP

6.1 Technical issues to be solved

In the previous section, we have presented each phase of the first design-service loop. At the same time, we obtained feedback from the agent and the subjects, and based on the feedback, the main technical issue to be dealt with in the second design-service loop was found to

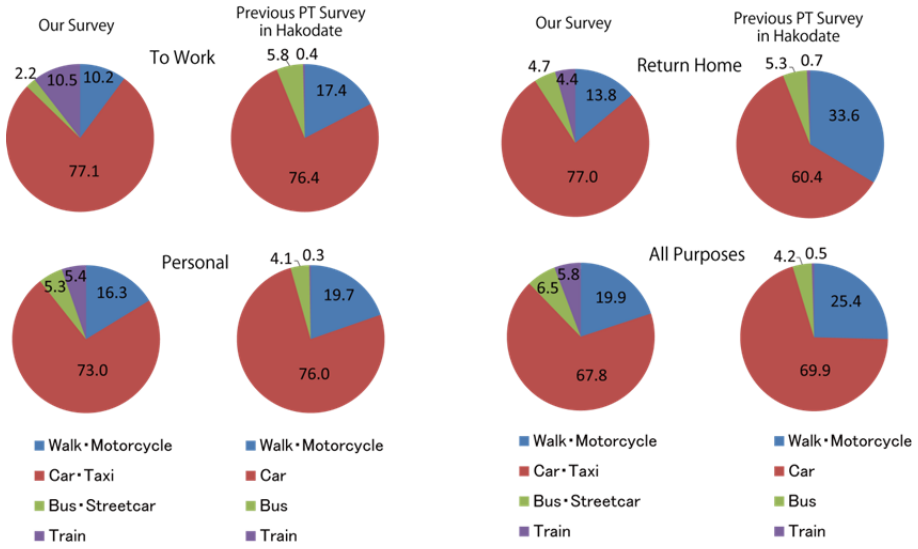


Figure 5 Mode and Purpose for Traffic transportation

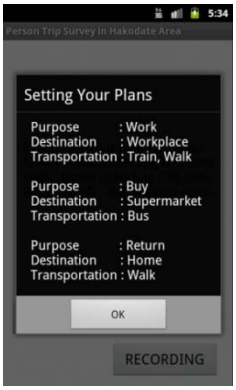


Figure 6 Popup window for confirming input data

be incomplete or incorrect input data, although we had anticipated several other problems before beginning the survey. Incomplete or incorrect input data was unavoidable because subjects could not correctly recognize how precisely they should enter trip plans.

Moreover, it is preferable to tolerate incomplete or incorrect input data, in terms of low input requirements. Thus, we examined how much of the trip data we could recover by manual post-processing together with the GPS data, time-stamp, and the map information. However, it seemed quite difficult to recover. Therefore, we decided that the main technical issue in the second loop was mitigation of incomplete or incorrect input data, which started the new design-service loop in the second loop.

6.2 Coping with Incomplete or incorrect input data

First of all, every subject was again instructed to enter all trip plans in advance, without omitting anything. As a result, the total number of trip plans increased by 25.3%, compared to that of the first loop, excluding the subjects whose plans increased by more than 50% (5 people out of 20 were excluded). We could have compelled subjects to use the sound recording function as a supplementary tool for entering missed or unexpected trip plans. Nevertheless, due to the importance of the spontaneous co-design of function and operation, we left subjects as they were, whether developing new methods of operation by themselves or declining to use the sound recording function. We thus found the new trade-off between preserving the user-learning aspect and improving the overall performance.

6.3 Responding to user critique

The major criticisms from subjects were (1) the lack of a function for confirming input data and (2) that the option items displayed for purpose, destination, and mode of transportation were too limited. For (1), it was observed that subjects repeated entering the same trip plan because they could not be sure of correct input. In response to this, we introduced a popup window for confirmation (Fig. 6). For (2), when a subject had difficulty choosing appropriate option items from among lists, a subject tended to select "others" more. Therefore, we added frequent activity items, such as "eat/drink", and introduced items with wider coverage, such as "return" instead of "go home." As a result, the percentage of "others" being selected for "Purpose" decreased from 26.9% in the first loop to 11.6% in the second loop. These responses to user criticisms were viewed as the implementation phase in the second loop.

7 CONCLUDING REMARKS

Design implication is as follows: in our PT survey, there are diverse users who share the information of application usage, and we developers, who share with users the information about the functions provided. We recognize that it is difficult for users to operate the application as we instruct them and it takes time for them to learn how to use the application effectively. Actually, it was not effective to prescribe a fixed function and a uniform usage of the application for all users. Therefore, to achieve both the co-design and coping with the trade-off, we think the semi-permanent design-service loop is indispensable in the development of function and operation.

Future work will involve continuing the experiment in order that the subjects' can gain further skills for operating the application and, at the same time, to overcome the problem of incomplete or incorrect input data. Moreover, subjects will be expanded to include sightseers in order to obtain more realistic data.

ACKNOWLEDGMENT

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