Assessing Future Traveller Information Systems

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ABSTRACT
Future traveller information systems (FTIS) supported by pervasive computing are being considered as the next generation of traveller information systems. However, large scale deployments of pervasive computing environments do not yet exist. Building models or mock-ups of FTIS is expensive and time-consuming. This paper introduces current research at Newcastle University which is investigating the impacts of FTIS scenarios on modal shift away from the car to public transport. The adopted methodology is a combination of conventional research methods incorporating textual descriptions of the hypothetical FTIS scenario and an innovative approach involving rapid prototyping using immersive video and a simulated infrastructure to create a realistic environment to explore user experience of FTIS scenarios.

KEYWORDS
Pervasive computing; traveller information; immersive video; rapid prototyping; modal shift

1 INTRODUCTION
Increased car use in many urban areas has led to growing traffic congestion, which not only threatens economic growth but also results in poor air quality, noise and global warming (Bell, 2006; Banister, 2005). Traffic emissions pose as the major threat to clean air. According to COMEAP (1998), these emissions, which include carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide, hydrocarbons (HN) and particulate matter, have deleterious effects on health, visibility, buildings and local ecology. Traffic noise affects all city life by affecting their ability to concentrate, reducing performance, increasing the level of annoyance, stress, and the risk of accidents. Failure in tackling rising car use may jeopardise the UK's ability to achieve its climate change targets and undermine the quality of life for everyone (Begg and Gray, 2004; DfT, 2004)

The Integrated Transport White Paper (ITWP), which was published by the Government in 1998, sets out a vision of a fully integrated transport policy to tackle congestion and pollution. Since the publication of the ITWP, encouraging a significant modal shift away from the car to public transport has been seen as a key element in balancing the need to travel with the need to improve quality of life. Fiscal and regulatory measures (also knows as hard measures) such as fuel taxes,

speed limits, emission standards and road use charging, as well as a range of marketing and management measures (also known as soft measures) have been piloted in various areas in the UK. These measures include travel awareness campaigns, workplace and school travel plans, personalised travel planning and public transport information and marketing. They usually seek to reduce the level of car use by offering better information and opportunities to influence the choice of transport mode made by individuals. Empirical studies suggest that soft measures can have a significant effect on individual travel choices when individuals or particular groups are targeted and tailored information is provided based on individual journey characteristics. However, severe constraints emerge when considering large-scale of implementations of such systems.

The key problem relating to the provision of better information and opportunities is that: within a transport society, the locations and contexts that travellers find themselves in are constantly changing, thus their information needs are both immediate and highly context sensitive. However, a large-scale implementation, which collects a full set of travel-related information in real-time, and disseminates such information in a context aware manner, is not possible within the existing information infrastructure.

Emerging technologies can help us to solve the problem by bringing us towards a pervasive computing era where many computers serve one person. Minute computers will be embedded into everyday objects. Through wireless networks, everything and everyone is connected with everything and everyone else. Users will be able to access personalised information and receive unprompted support (Weiser, 1996; SARC, 2005). In the transport domain, pervasive computing can altogether open up new ways to improve the provision of traveller information. However, such scenarios raise two important questions:

- How do people perceive such intelligent FTISs?
- Do the FTISs have the potential to bring about a significant impact on modal shift away from the car?

The aim of this research, therefore, is to investigate whether the intelligent FTISs could encourage a greater modal shift away from the car to public transport. Also, there is the opportunity to examine whether the methodology adopted in this research is appropriate and robust for the evaluation of future systems.

The rest of this paper is organised as follows: section 2 presents the methodology adopted for this research. Results from the preliminary study are presented in section 3. Finally, section 4 presents future work planned for this research.

2 METHODOLOGY

For the purpose of this research, two sets of data need to be collected, one regarding the use of current TISs and the other one regarding the use of future systems. At the moment, the internet-based traveller information systems (TISs) have gained enormous developments in recent years. More and more traveller information services are available on the Internet. Some of them are frequently used by the travelling public, but others are not. A better understanding of how people make their choices of transport mode as a result of using the current TISs will lay the groundwork for the evaluation of FTISs. Therefore, two studies are conducted, a preliminary study of current Internet-based TISs and a main study of FTISs.

The preliminary study aims to understand (a) user perceptions and use of current Internet-based TISs and (b) choices of transport mode for the journey. The main study aims to understand (a) potential users' perceptions and likely use of the FTISs, and (b) the likely modal shift away from the car as a result of using the FTISs. The comparisons between the two sets of data permit an investigation of the significance of the influence of FTISs on the individual mode choices. An evaluation of the methodology will be carried out after the two studies.

2.1 The Preliminary Study

2.1.1 Data Collection Method

The preliminary study focuses on a behaviour that has been completed, i.e. data are collected based on respondents' experience. A number of methods are available for the data collection – mail survey, Internet survey, telephone survey and face-to-face survey. Due to the nature of the systems that were studied (i.e. Internet-based), the survey was undertaken by using an online survey method, namely Computer-Assisted Self Interviewing (CASI). An interviewing program guides respondents through the questionnaire. The completed questionnaires are automatically recorded into a database residing in the server containing the survey and are retrieved later for analysis. The online survey offers more anonymity and privacy than face-to-face interview and allows respondents to complete the questionnaire at a time and place that is convenient for them. Hence the validity of questions on issues that are generally related to personal view and experience can be expected to be higher than in case of interviewing methods (Wermuth, Sommer and Kreitz, 2003). Because of the automation, it is also more cost-effective, less time-consuming and less labour-intensive comparing with other methods. Furthermore, it permits dynamic control over the profiles of respondents. The disadvantage of this method is the requirement that respondents should have access to an Internet-enabled computer. For this study, it turns to be an advantage because non-Internet users who had no experience of the Internet-based TISs are excluded from the survey automatically.

A number of free online data systems are available for use. Freeonlinesurvey.com, a self-administered survey system was selected as the venue to launch the online-questionnaire. This system did not require a trained individual to administer or supervise the operation. A "Survey Wizard" was offered to create the online survey and self-controls were contained to add, edit and reorder questions without having to resort to any complex programming. A completed survey was stored automatically as soon as it was submitted for later analysis. The link of the questionnaire was generated spontaneously as long as the survey was established.

2.1.2 Questionnaires

It should be noted that the perceptions of TISs tend to be context sensitive. The user opinions depend on a number of factors, such as the purposes of the journey, the time and cost constrains of the journey, the origin and destination of the journey, and the user's personal preferences, etc. Two questionnaires were developed for the preliminary study. The first one questioned the participants' view on the last use of the Internet-based TISs to gain a better understanding of user perceptions of the current systems in general and the mode choices (http://freeonlinesurveys.com/rendersurvey.asp?id=134892). The second one questioned the respondents' view on the use of Traveline Wales, an Internet-based system providing impartial information on planning journeys by bus, coach or train or any combination of the

three, to gain a better understanding of user perceptions of this system and the influence on mode choices (http://freeonlinesurveys.com/rendersurvey.asp?sid=w719phj2m189i4u141245). Data collected from this survey will be compared with those collected from a similar survey conducted for Transport Direct. The comparison between them helps to identify performance gaps between one system, which only allows provide information on public transport, and the other system, which enable people to compare car journey with public transport via a single request.

2.2 The Main Study

2.2.1 Data Requirements

The following data are needed for the main study: (a) the crucial information and functions for users to make a choice decision between the car and public transport; (b) user perceptions and the likely use of FTISs; (c) individual behavioural changes for various journeys as a result of using FTISs; and (d) profiles of respondents. A list of crucial information contents and a list of the system functions that will be provided by FTISs are developed (see Table 1 and 2). The lists include not just travel time and costs, but also information and knowledge regarding comfort, convenience, flexibility, independence, environmental impacts and ways to offset car emissions. By providing all these information and functions, FTISs aim to enhance users' knowledge of public transport services and the invisible environmental risks associated with the car use, and enable public transport passengers to travel with ease, comfort and confidence. The journey categories used for the customer satisfaction survey for Transport Direct is adopted for this study (see Table 3).

The perceived usefulness of FTISs, the likelihood of using FTISs and the likely frequency of using FTISs for various types of journey are recorded on a five-point Likert semantic differential scale, which ranges from 'very useful' to 'not at all useful', 'very likely' to 'not at all likely' and 'very often' to 'never'. A set of hypothetical choice statements is developed to describe the plausible future situations. By asking respondents to pick up their choices for different types of journey as a result of the use of FTISs, the likely influence on modal shift can be identified. For each type of journey, respondents are requested to indicate their behavioural changes in mode choice specified by a list of statements (see Table 4).

2.2.2 Data Collection Methods

The ideal way to explore modal shifts as a result of using TIS is through observations, i.e. allowing users to interact with the system as part of their everyday travel routine, such as commuting, shopping and recreation, and recording their actual mode choices. This is so-called Revealed Preference (RP) method. However, FTISs supported by pervasive computing is still very much an aspiration as large scale deployments of pervasive computing environments do not exist. Building a physical mock-up of FTIS is prohibitively expensive and time-consuming. Hence, recording real choices made by individuals for each specific journey as a result of using the actual system is not possible. As an alternative, the Sated Preference method is applied for the data collection. The Stated Preference (SP) method differs fundamentally from the RP method. According to Polak and Jones (1997), the SP method consists of the use of hypothetical choice scenarios in order to lead individuals to express their preferences. During a SP survey, people are placed in hypothetical situations and asked to make a choice as to how they would act under certain conditions. The stated responses obtained from the survey can be interpreted as stated behavioural intentions.

2.2.3 The Hypothetical Choice Scenarios

The basis of the SP method is the collection of behavioural choices by confronting respondents with hypothetical situations. There are a variety of ways to describe hypothetical choice scenarios to respondents. Using written stories to represent the scenarios is the most widely used method and encourages active imaginations from respondents. Comic strips and multimedia presentations are commonly used to construct visually oriented scenarios. The growth in the use of computer-aided simulations was boosted considerably in recent years and enables more visual and complex scenarios to be constructed. This method allows the designer to quickly test the performance of the simulated systems, enables the subject to interact with the simulated systems, provides feedback to the sequent activities and minimises experimental and scale-up efforts. Based upon the available human and technical resources, two methods are planned to introduce the hypothetical choice scenarios to participants in this research. Each method works with different data collection technique(s).

- **Textual descriptions with visual aids** Textual narratives are used to describe the operation of the system and user experience. To some extent this can be seen as an advantage as the attendant ambiguity means that users are not distracted by the detailed design of actual system or specific user interfaces. Visual aids are added carefully to mirror the texts but not to restrict the imaginations. This method is suitable for almost all data collection techniques – either self-administered or interview-based.
- **Rapid Prototyping using Immersive Video** Synchronised footage is captured at key locations within an intended usage scenario to create an immersive video (with surround sound and a simulated infrastructure) in a virtual reality lab (see Figure 1). The immersive video can then be used to establish a realistic sense of a user's experience of an application and allow participants to interact with a simulated system in a virtual reality lab. Due to the complexity of the design and the manipulation required, this method is only suitable for interview-based data collection techniques.

Figure 1: Rapid Prototype

2.2.4 Data Collection Stages

There are a number of options regarding data collection for a SP survey, from self-administered questionnaires, verbal interviewing, organised group discussions (focus groups) to making experiments. Each requires different measures and contributes in different ways to the aim of the study. The advantages of self-administered questionnaire data are the efficient, low resource usage and potentially large sample size, which permits a quantitative study. However, to use self-administered questionnaire in a SP survey, Thorpe (2005) reminds that the hypothetical scenarios need to be easy for the respondents to understand and the reply-form should be straightforward to complete. Furthermore, self-administered questionnaire doesn't allow the tailoring of SP choices

to individuals' circumstances. Hence, focus groups are more commonly applied in advance of the self-administered questionnaire.

2.2.4.1 Focus Groups

Focus groups can yield rich and varied qualitative data and allow experiential insights into participants' behavioural choices. During the organised group discussion, interaction is employed to generate data and as a source of data for analysis. Participants engaged in the discussion with each other. The interaction opens their mind and enables them to evaluate and consider their own understandings of specific experiences carefully. Therefore, focus groups are applied prior to the self-administered questionnaire. Focus groups aim to collect the following data: (a) participants' view on the textual descriptions of hypothetical scenarios; (b) types of crucial information and functions needed for a modal shift away from the car; (c) participants' view on the scales used to rate user perceptions and likely usefulness; (d) participants' view on the hypothetical choice statements; (e) participants' view on the two methods chosen to introduce FTIS scenarios. As a qualitative study, focus groups don't require a large sample size. At this stage, 5 groups of 6 are adequate for a variety of diverse exposure. Each group member is offered sufficient opportunities to share his/her knowledge and understandings with each other. Each group discussion session is planned to be one hour long and tape-recorded.

2.2.4.2 Self-Administered Questionnaire

According to the main issues raised during the organised group discussions, the textual descriptions of the hypothetical scenario and the questionnaire are finalised. Following this, the modified questionnaire is launched via Freeonlinesurvey.com, which was also used for the preliminary study. The link of the online questionnaire is to be emailed to those who had participated in the preliminary study and offered a valid email address. However, this group of people cannot represent the general public because majority of them were students and members of staff of the University. For the purpose of this research, the main target group should be those people who can have choices between the car and public transport. Hence more participants are required for a better generalisation. Respondents should read the textual scenario prior to completing the questionnaire.

The survey is to be conducted in Tyne and Wear. A number of wards along the North Tyneside Coast would be ideal for the study, namely: Monkseaton North, Mnkseaton South, Whitley Bay, Cullercoats and Tynemouth. Being among the richest wards in Tyne and Wear, all these areas have good public transport access, pleasant walking environments and very high levels of car ownership. Paper-based questionnaires will be distributed to the letter box of these households.

2.2.4.3 Rapid Prototyping Using Immersive Video

In the future, intelligent personal travel assistance provided by FTISs should be available everywhere or any time and thus are heavily influenced by contextual factors, such as differing roles, varied locations, times and situations. In this research, immersive video as a rapid prototyping tool is applied to enable subjects capturing the sensory experiences in a virtual environment. Three video cameras, setting up to cover the scene with a 150-degree view angle, are used to take synchronised footage at key locations within an intended usage scenario. The synchronised footage then will be replayed on the three screens to set up a three walled CAVE[1]-

[1] CAVE: Cave Automatic Virtual Environment.

based display, which enables a totally immersive surround environment and provides subjects with a sense that they are in some way truly immersed in an environment where FTISs have been implemented. Two types of personal devices are used to test user preferences, a PDA symbolizes future mobile devices and a head-mounted display symbolizes future wearable computers. The process of the interaction between the subject and the simulated system will be filmed.

A face-to-face interview is carried out after the experiment. Whilst watching the film of the interaction process together, the filmed subject and the interviewer discuss about the subject's experience in details. The following questions are asked during the face-to-face discussions: (1) How useful do you think such a system would be to support your personal travel for various types of journey and why? (2) Would the availability of such a system influence your mode choices and why? (3) Do you have any other requirements for the traveller information systems in order to motivate you to make more use of public transport for various types of journey and why? It is the depth and the quality of the data rather than the width and the quantity of the data that are more interested at this stage. A small sample size (about 20-30 subjects) is expected. Among these subjects, half of them are to be selected from those who have attended the focus group discussions. They will be asked to compare their feelings about the textual scenarios with those about this experiment.

3 RESULTS FROM THE PRELIMINARY STUDY

In total, 139 participated in the survey. Of all of them, 129 were the students and the members of staff of the University, 10 were from outside of the University. There were an approximately even proportion of male and female respondents, whilst the age of the sample was heavily skewed towards those aged between 16 and 54, particular those aged between 25 and 44. Of these respondents, 49 were students, 90 were non-students. Regarding the ability to use the Internet, KW test suggests that age has an effect on it. The younger the respondents were, the higher the ability they had (see Table 5). MW Test suggests that the male respondents had higher ability than the female respondents (see Table 6).

In relation to modal choices, it has been found that frequent car users only visited those information sources that dedicated for travelling by the car. Among the respondents, only 6 compared car journey with public transport. All visited a number of websites to compare travel costs, 5 compared journey durations, 3 compared departure/arrival times and 1 compared comparative hassle of each transport mode. Gratifyingly, 5 of 6 finally undertook their journeys by public transport. It was more likely that the information they obtained facilitated them to give up their primary intention to drive. However, frequent car users (i.e. habitual car users) were unlikely to look for information on public transport services. In this survey, 4 respondents were frequency car users. None of them looked at public transport related information.

Figure 2 shows the chosen frequency of those items listed in question 16 (check the online questionnaire for details). From the results it can be seen that the most important aspect of an Internet-based system was easy to use. This included easy to browse on the website, input required information (date, time,

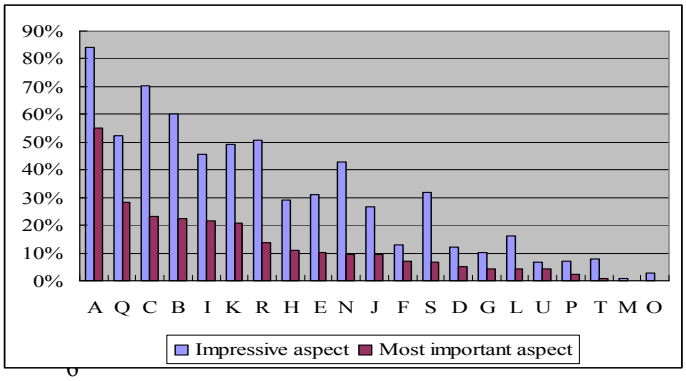

Figure 2. Chosen Frequency

address/location), compare various travel options and understand journey itineraries available to them. A number of other items, such as the convenience of booking and ticketing at the time planning the journey, information accuracy, email confirmation of an-online payment and sufficient integration of relevant information were the next most important aspects. Many respondents highlighted that being able to find the best deal was important.

Among the 139 participants, 133 had a mobile device. More than 50% of respondents thought that TISs available on mobile devices were useful or fairly useful. About 40% would like to use them on their mobile devices with 29% claimed "don't know". From this sample, the effects of age and gender on the likely use of TIS on mobile devices are not significant.

4 FUTURE WORK PLANNED FOR THIS RESEARCH

The survey for Traveline Wales is ongoing. So far, 60 completed and valid questionnaires have been received. More responses for a sounder analysis are expected. At the same time, focus groups have been conducting for the main study. Textual descriptions of the hypothetical scenarios and the self-administered questionnaire are modifying based upon the findings from the focus groups. In September, questionnaires will be distributed to the selected areas. Whilst waiting for the return of the completed questionnaires, the experiments using simulated infrastructure and immersive video will be carried out in the Virtual Reality Suite in Newcastle University. A demo of the immersive video will be presented on the World Congress on ITS.

5 TABLES

Table 1. The List of Crucial Information

1	walking time
2	in-vehicle times based on live information of transport networks
3	overall journey times based on live information of transport networks
4	travel costs based on live information of transport networks
5	number of interchanges
6	public transport service availability (via timetables or journey planners)
7	public transport service reliability
8	real-time information on departure/arrival/delays
9	live traffic conditions
10	amount of car emissions and the number of trees (or amount of money needed) to offset the emissions
11	services at interchanges (e.g. luggage storage, toilets, catering, seating and waiting area, etc)
12	services on board (e.g. catering, toilet, luggage storage, seating and power supply, etc)
13	appearance of the public transport vehicles and drivers/conductors
14	seat quality and spacing
15	seat availability
16	private transport (e.g. parking space, taxi stand, bicycle shed and bicycle rent, etc)
17	prompt and accurate weather forecasting

Table 2. The List of Crucial Functions

1	e-booking and e-ticketing which enable a seat, parking space or a ticket to be booked/paid electronically
2	ability to be aware of the user's context and preferences when delivering information/services to the user
3	ability to seek a lift for the user whenever needed
4	ability to offer alternative options when journey disruption happens
5	ability to guide the user from origin to destination or on part of the journey whenever required

6	ability to provide prompt and accurate information to the user at any time or any place

Table 3. Journey Categories

Commuting to work	Going to entertainment (e.g. cinema, shopping)
Business trip	Going on a holiday
Going to school/college	Going on a day trip
Visiting friends/family	Travelling to public transport terminals/airports

Table 4. Hypothetical Choice Statements

1	I will only **use public transport** for this journey.
2	I will **make more use of public transport** for this journey.
3	I will **make less use of my car** for this journey by share a car, walking or cycling.
4	I will **always consult the system** before I make a choice of transport mode for this journey.
5	I will still **use a car** for this journey.

Table 5. KW Test for Effects of Age

Ranks	Age	N	Mean Rank
Ability to use Internet	16-24	29	73.98
	25-44	80	72.01
	45-54	22	65.39
	55-64	7	35.21

Kruskal-Wallis Test	
Grouping Variable: age	Ability to use Internet
Chi-Square	8.569
Degree of freedom	3
Asymp. Sig.	0.036

Table 6. MW Test for Effects of Gender

Ranks	Gender	N	Mean Rank	Sum of Ranks
Ability to use Internet	M	73	76.58	5590
	F	66	62.73	4140
	Total	139		

Grouping Variable: Gender	Ability to use Internet
Mann-Whitney U	1929
Wilcoxon W	4140
Asymp. Sig. (2-tailed)	0.016

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