Investigating Mobile Quality of Experience in Public Transport

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Abstract
In recent years, mass adoption of increasingly powerful mobile devices and ubiquitous communication networks have paved the way to smart environments. Such environments allow for the collection of user and environment data with the final goal to improve users' experience. In this context a number of opportunities and challenges are presented to Human Computer Interaction. This poster explores Quality of Experience, a subjective aspect of interaction, informally defined as the degree to which a system meets users' expectations. Furthermore, a mobile application was developed for the collection of user and environment data and delivery of personalised services in the context of Public Transport. This application will be used in a real-world environment, to further investigate the factors that have an influence on User eXperience, as well as the delivery of relevant services with the potential to enhance users' journeys while in transit.

Author Keywords
Quality of Experience, User eXperience, Mobile Cloud Computing, Service Design

ACM Classification Keywords
H.1.2 [Information Systems]: Models and Principles—*User/Machine Systems*; H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction

In recent years the mass adoption of mobile devices and modern communication networks have contributed to a radical change in the way people interact with computer systems[14]. Moreover mobile cloud computing infrastructures have paved the way for the development of smart systems[1], whose goal is to provide an enhanced ubiquitous user experience based on environment and user sensed data[5]. Furthermore, the degree to which a system meets users' expectations is informally defined as Quality of Experience (QoE)[13].

In this context, two content streams flow permanently between users and the cloud: user-generated content on one direction and service delivery on the opposite one. There is, however, an evident disconnection between these two streams. The current range of available services, although extensive, does not address users' specific needs and preferences for the most part. In addition, service discovery is a cognitive demanding process and it may have detrimental consequences in User eXperience (UX)[7].

This poster presents the research being undertaken in the context of Public Transport (PT): the development of a mobile application for the collection of data and delivery of services, and the investigation of QoE in smart environments.

Cloud2Bubble Loop

Cloud2Bubble is a user-centric and systemic framework that aims at enhancing QoE in smart environments[6]. This framework proposes a loop of interaction to address the disconnection between user-generated content and delivery of relevant services. The aggregation of both data streams allows for user and environment modelling, and generation of user tailored actions to be delivered as personalised services. The main data flows between the different components are shown in Figure 1.

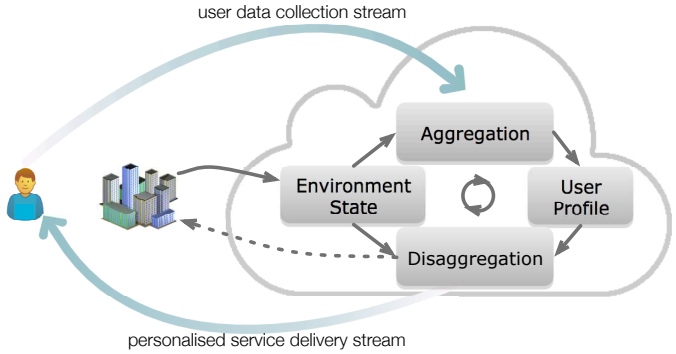

Figure 1: Cloud2Bubble Interaction Loop[6]

Service personalisation has the potential to enhance QoE and influence user behaviour, with benefits for both users and service providers. QoE is a subjective measure and, therefore, non trivial to assess. Moreover, UX is influenced by the context in which users experience a certain situation or activity. In order to capture this subjective nature, and taking advantage of the increasing opportunities to interact with users in smart environments, the notion of emotion was taken into account in the loop of interaction. This emotional dimension is introduced by Affective Computing (AC) as a way of broadening the spectrum of interaction with computer systems, otherwise limited by explicit interactions[12].

The Cloud2Bubble loop aims at collecting user-generated data, not limited to explicit interactions with user personal devices, but including other implicit aspects, such as emotional state and context. A first stage will

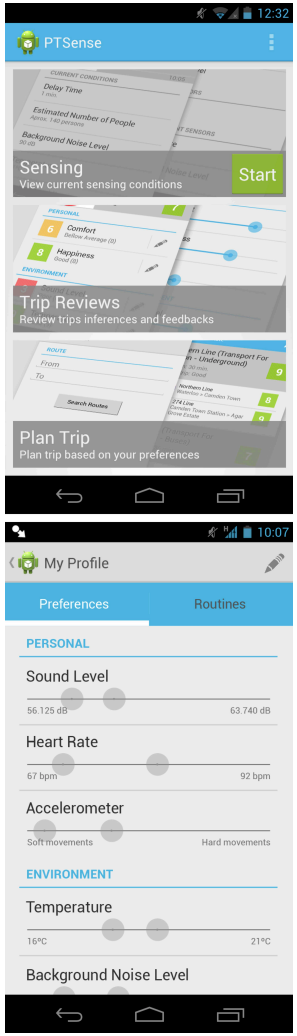

Figure 2: Mobile Application Prototype: a) Main Features, b) User Profile

explore the factors that have an influence on users' QoE, as well as exploring which services may have a positive impact on personal experiences. The delivery of such services, their effects on QoE and behaviour influencing will be further investigated on a second stage.

Investigating QoE in Public Transport

The proliferation of smart environments in different contexts opens a number of opportunities and challenges to leverage QoE, ranging from retailing to healthcare domains. The domain of PT provides a suitable case study. Modern PT systems provide a sensor-saturated environment as well as a large user base composed of travellers[10]. Furthermore the need for personalised services has been identified in this domain, known as Advanced Traveller Information Systems[2].

Individual journeys have a considerable impact on QoE in PT contexts. Thus, an experiment was devised in a real-world environment based on the work described in the previous section. The goal of this experiment is to assess the effects of delivering personalised services on QoE, specifically in the context of PT. This experiment will be divided into two main stages: the first stage focuses on the collection of data for determining what factors affect users' QoE while in transit, and which services may have a positive impact on their journeys; the second stage, to be carried out later, will focus on the delivery of a set of services and will allow for the assessment of its effects in users' QoE.

Mobile Application Prototype

A high-fidelity prototype was developed, based on the Cloud2Bubble loop (Figure 1), for the PT domain[16]. The mobile application prototype, developed for the Android platform, aims at providing an intuitive tool for the collection of personal data, using both explicit and implicit interactions[9, 8]. The application allows for the collection of feedback explicitly given by users, as well as environment conditions using the sensors present on the device. In addition, it provides a channel of communication with the user for the delivery of relevant services. This prototype implements different methods of service delivery, ranging from suggestions of route alternatives to notifications of low QoE, as shown in Figures 2, 3 and 4.

Main Features

The mobile application prototype implements three main features (Figure 2a): Sensing, Trip History and Plan Trip. The Sensing (Figures 3a and 4a) allows for the collection of contextual data, from both user and environment. This feature collects data from sensors available on users' devices and in the surrounding environment. The Trip History (Figure 4b) enables users to review the inferences generated by the system based on the collected data. The inference process results in an estimated QoE measure, corresponding to the level of satisfaction of a user in relation to an environment. In addition, users are allowed to update all the inferred QoE measures. Finally the Plan Trip (Figure 3b) allows users to plan a journey given an origin and destination. The results, in addition to usual information like duration and cost, are presented with an expected QoE measure. Finally, users may review their personal profile (Figure 2b), composed of their personal levels of comfort, and manually update them if necessary.

User Research

An interview session was organised for investigating the prototype performance in conveying the proposed concept and its overall usability. The session occurred in the beginning of April 2012 and was composed of a group of 6

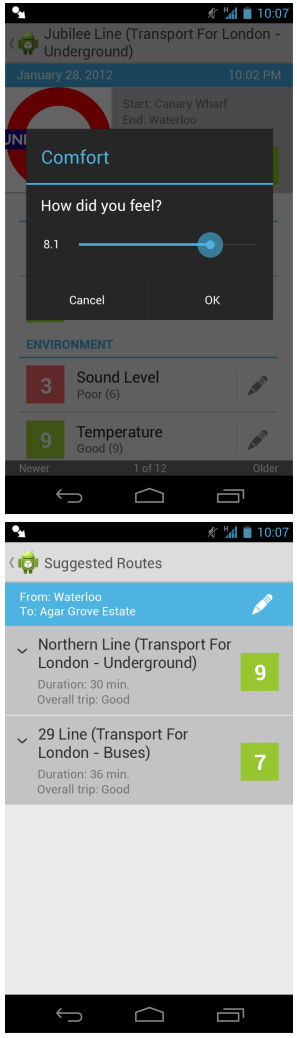

Figure 3: Mobile Application Prototype: a) Notification, b) Journey Alternatives

users with different professional backgrounds, recruited via word of mouth. Each user was presented with the concept and asked to perform a set of tasks while encouraged to think aloud. In addition the users were asked to answer a short pre- and post-questionnaire on their travelling habits as well as personal views on PT and the application. The sessions were anonymously recorded with the consent of participants, to whom a small reward was offered at the end.

Results

The results obtained at this stage were very positive and encouraging. Even though some of the participants felt initially confused in relation to the personalisation of services in a PT context, performing the tasks helped them understand how the service could be of value. All the participants agreed this type of services would greatly enhance their overall experience. Moreover, they found the prototype intuitive and useful, even when they were not familiar with the Android platform. Some of the aspects where there is a margin for improvement are related with more subjective concepts. For instance, the participants found the terms "happiness" and "stress" (Figure 4), present in the feedback form, to be somehow overlapped. Thus, the form will be revised, in order to provide a more clear indication of what type of feedback is expected. In addition, the numerical scale used in different aspects of the application, was confusing or unintuitive at times. For instance, the participants were unsure what a numerical value meant for stress or noise level. The suggested alternative was to use a qualitative scale with meaningful terms, for example, "relaxed" to "stressed" and "quiet" to "noisy". Some minor issues arose for participants not used to the platform, or used to older versions. The Android 4.0 platform introduces some disruptive UX elements, in comparison with previous versions, leading to some confusion. This initial confusion did not, however, have a significant impact on the performance of the application. The participants were able to successfully perform all of the requested tasks, ranging from journey planning to journey feedback, with little or no mistakes and in a timely fashion.

Exploring QoE in-situ

A working mobile application is being implemented, based on the prototype previously described and the findings obtained from user research. The application will be used for an experiment to be carried out in a real-world environment. This experiment will take place in the city of Porto, Portugal in the beginning of June 2012. The modern PT network serving the city is equipped with data collection mechanisms, such as ticketing information, real-time vehicle location and journey planning. This context enables the modelling of the environment in detail. In addition, usage of smartphones and connectivity is widespread.

Stage 1: Assessing QoE in Public Transport

The goal of the first stage of the experiment is to assess users' QoE. Specifically what are the factors that have an impact on their journey and which services may have potential to improve it. This experiment relies on the Experience Sampling Method (ESM), a technique from the field of psychology that allows for the collection of data in a real-usage context, rather than in a simulated environment[3, 4, 15]. Although ESM is a self-report technique, the no-recall feature reduces the cognitive biases associated with other recall-based self-report techniques such as interviews, traditional surveys, and diaries. In the context of this experiment, the ESM allows for the collection of relevant data while on journey and using personal devices, which increases the collection of

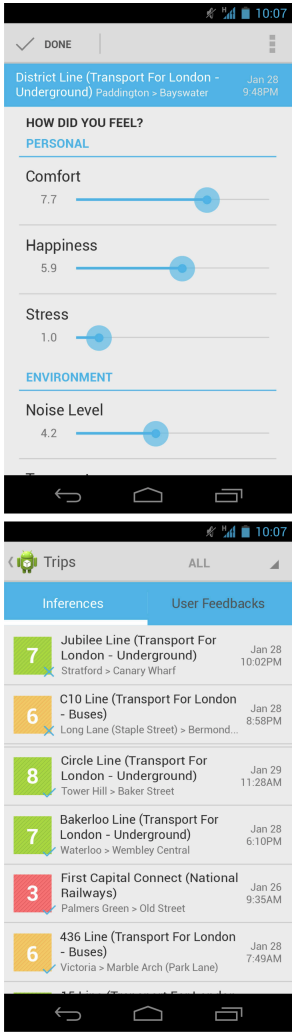

Figure 4: Mobile Application Prototype: a) User feedback, b) Qualified journeys

relevant events with a low barrier from a users' perspective.

A call for participation was distributed to the general public through the authors' contacts and social networks. The interested participants were asked to answer a short questionnaire, briefly describing their travelling behaviour, smartphone usage and demographic information. This questionnaire was then used for the selection of a representative group of participants, composed of travellers with different characteristics. The criteria for selection takes into account professional occupation, frequent PT usage and technology usage, among others.

This stage will run in the beginning of June 2012, with a target group of 10 travellers. The participants will be asked to install the application on their smartphone via Google Play, and to run a test journey to ensure the application is running properly and the process is clear. Specifically they will be asked to report their individual journeys qualitatively in terms of personal satisfaction, emotional state and ambience [11]. Furthermore, users will be asked to provide a suggestion of improvement for their journeys at will. The application will, simultaneously, sample the ambience with the available sensors on the phone. Following this period, individual semi-structured interviews will be conducted with the participants as to further explore the overall experience, as well as relevant reported journeys.

The aggregation of user and environment data, collected throughout the course of this experiment will be supported by the Cloud2Bubble framework. The environment data obtained from PT providers and other external sources, such as weather and transit is integrated and aggregated with personal data. This aggregation will enable the analysis and correlation between the perceived and actual conditions in PT, as well as the generation of personalised services in this context. The findings obtained at this stage will support the second stage of the experiments, where actual services will be delivered to users and further investigation into its effects on QoE will be carried out.

Stage 2: Enhancing QoE Through Personalised Services
The second stage of the experiment will focus on the delivery of a set of personalised services, identified as having potential to enhance QoE. The effects on QoE based on delivery of such services will be investigated in a real-world environment, as a continuation of the first stage. Furthermore, the user and environment data obtained will provide a platform for running a set of simulations in a controlled environment, that will allow for the further development of the platform in terms of system behaviour adaptation, generation of actions and building user profiles.

Conclusions

This poster presents the investigation of Quality of Experience in Public Transport. The research being carried out aims at exploring the aspects of mobility contexts that affect QoE, and services with the potential for enhancing UX. A mobile application was developed and tested with encouraging results. The application will be used for the collection of user and context data in a real-PT experiment. This experiment is based on the Experience Sampling Method, which allows for the collection of data and reporting of journeys in-situ. The results obtained at the first stage will then be used on a second stage, where the effects of delivering such personalised services will be further investigated. The findings will enable the investigation of Quality of Experience and the development of a set of services with the potential to enhance UX.

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